

Copper-Cobalt Flora of Upper Katanga and Copperbelt

Field Guide

Over 400 plants, 1,000 photographs and 500 drawings

François Malaisse
Michel Schaijes
Claire D'Outreligne



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Books edited by François MALAISSE

Leblanc M. & Malaisse F., 1978. *Lubumbashi, un écosystème urbain tropical*. Centre international de Sémiologie, Université nationale du Zaïre. 166 p., 31 planches, 13 fig., 89 photos (dont 4 en couleur).

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New taxon : *Cheilanthes perlanata* (Pic. Serm.) Kornaś var. *kwatebalaensis* Malaisse. p. 86.

New combinations : *Euphorbia lorifolia* (P.R.O. Bally) Malaisse. p. 180.
Oxalis semiloba Sond. subsp. *angustifolia* (R.E.Fries) Bamps & Malaisse. p. 254.

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Editors



Such wood burning steam traction engines transported over 2,800 tonnes of rough copper between 1908 and 1914 from Kansanshi to Kabwe and to Mikola railheads on the Katanga railway. This photo was taken at Kansanshi mine in February 2001. A photograph of a similar engine reaching Etoile mine in 1909 has been published by R.R. Sharp (1956, p. 81).



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TABLE OF CONTENTS

| | |
|--|-----|
| List of authors | 7 |
| Preface (A.J.M. BAKER) | 9 |
| Acknowledgements (F. MALAISSE & M. SCHAIJES) | 11 |
| Book genesis (F. MALAISSE & M. SCHAIJES) | 13 |
| Traditional copper metallurgy (F. MALAISSE & M. SCHAIJES) | 16 |
| Early European geology explorations (F. MALAISSE & M. SCHAIJES) | 18 |
| The environment (B. LETEINTURIER & F. MALAISSE) | 19 |
| Methodology of species choice (F. MALAISSE & M. SCHAIJES) | 23 |
| Analysis of the content of copper, cobalt and other elements in plant leaves (A. VAN DER ENT) | 25 |
| Ten years of research on copper-cobalt ecosystems in southeastern D.R. Congo (S. LE STRADIC, S. BOISSON, M-P. FAUCON, M. SÉLECK & G. MAHY) | 27 |
| List of copper-cobalt sites (F. MALAISSE & M. SCHAIJES) | 38 |
| List of collectors on copper-cobalt sites and abbreviations used in the guide (B. LETEINTURIER & F. MALAISSE) | 41 |
| <i>Cyanoprocarvota</i> (P. COMPÈRE) | 44 |
| <i>Lichenized Fungi</i> (D. ERTZ) | 46 |
| <i>Antherocerotophyta</i> (H. STIEPERAERE) | 53 |
| <i>Marchantiophyta</i> (H. STIEPERAERE) | 56 |
| <i>Bryophyta</i> (H. STIEPERAERE) | 58 |
| <i>Lycophyta</i> (B. LETEINTURIER & F. MALAISSE) | 62 |
| <i>Monilophyta</i> (B. LETEINTURIER & F. MALAISSE) | 63 |
| <i>Magnoliopsida</i> (F. MALAISSE & M. SCHAIJES) | 90 |
| <i>Liliopsida</i> (C. D'OUTRELIGNE, M. SCHAIJES & F. MALAISSE) | 296 |
| Bibliography | 403 |
| Index | 417 |



Claire D'OUTRELIGNE on 23th of August 1986 along Mamfwe road, taking notes on plant diversity.



© M. Schajjes

Claire D'OUTRELIGNE on 15th of March 1987 along Mamfwe road. Note the presence of *Knifophia benguellensis*, the robust perennial herb 2.5 m high, as well as the clump of *Sopybia lanata* var. *densiflora* in front.



Claire D'OUTRELIGNE on 10th of September 1988 along Mamfwe road, taking a photograph of a clump of *Gnidia kraussiana* var. *kraussiana*.

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François MALAISE collecting *Pityrogramma calomelanos* var. *aureoflava* at Ushi dam, Kitwe (Zambia) on November 2014.



Michel SCHAJES in the bush.



From left to right: Claire D'OUTRELIGNE, Henk SCHAT, Alan BAKER and Robert BROOKS, at Mindigi, April 1990.

PREFACE

Alan J.M. BAKER

Soils that have become enriched or polluted with heavy metals and metalloids, either naturally through mineralisation or as a result of anthropogenic activities, have been the focus of much attention over the last century by plant ecologists, plant physiologists, evolutionary biologists, soil scientists and soil microbiologists. The reason for this is that they represent an extreme environment where the toxicities and nutrient imbalances the experience are readily measurable and act as very powerful and clear-cut agents of natural selection on the organisms, determining species composition, population and ecosystem structure.

The vegetation developed on the naturally metal-enriched soils over copper-cobalt mineralisation in Upper Katanga and the Copperbelt in D.R. Congo and Zambia is probably one of the most unique and floristically-rich and distinct anywhere in the world. It is not surprising then, that it has attracted several outstanding plant scientists interested in documenting the flora and gaining insights into the processes of speciation which have occurred and the adaptive responses of the heavy-metal-tolerant flora to the metal toxicities in the shallow soils over mineral outcrops. The primary author of this Field Guide, Professor François MALAISSE, has spent nearly 50 years of his long and productive research career bioprospecting the Copper Hills and associated mineral-rich areas of D.R. Congo and Zambia. Indeed, his enthusiasm for work in this region has inspired colleagues and many young scientists alike to continue and develop his pioneering research. The recognition of the very high degree of endemism in this flora is a result of his meticulous recording of the taxa present on individual mineral outcrops and has led to the documentation of many new species and subspecies in the local flora. The Field Guide brings together all current floristic and ecological knowledge on the copper-cobalt flora in a concise and copiously illustrated way, presenting each taxon in a standardised format. It is thus easy to use in order to identify individual plants collected in the field. The references provided also allow the interested reader to follow up background information in the published literature.

It is extremely timely that this definitive work has now been published as the copper-cobalt vegetation of this region is under a continued threat of extinction through ongoing large-scale mining activities due to an increasing world demand for copper and cobalt. It has been estimated that four endemic taxa have already been lost, occurring formerly on only one mineral outcrop which have acted as ecological 'islands'. A biodiversity and genetic resource has therefore been lost

in these instances and at least 11 others are critically endangered. At least some of the mining companies currently operating in the country now realise the value of these plant resources and are taking active steps to conserve them. All these pre-adapted species are vital for the reinstatement and ecological restoration of new mining lands in the region. This line of action is very much in tune with current global mining policy in most regions of the developed and developing world.

At a personal level, I have to thank Professor MALAISSE for his mentoring on this fascinating and unique flora and for the support he has given during my only exploration of the area with him in 1990 and subsequently. The Field Guide is surely a 'tour de force' and I congratulate the authors, photographers and illustrators in producing this seminal work.



The Tilwezembe copper outcrop in March 1991. This is the site where hundreds of *Euphorbia cupricola* were counted and observed.



The Tilwezembe mine in August 2004 during the period of industrial exploitation that stopped in 2008.

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François MALAISSE & Michel SCHAJES

The present guide would not have been possible without the precious collaboration of many contacts in Katanga as well as in Zambia and Belgium.

First Michel SCHAJES would like to pay a special homage to his wife Claire D'OUTRELIGNE (†). She took part in all their botanical excursions, preparing all what was necessary to camp in the middle of nowhere; sometimes even going alone in order to collect and photograph specimens when Michel was not available. She also photographed and painted in water colors flowering plants, dried their voucher specimens and drew up their excursions reports. He deeply regrets she will not share the achievement that this guide publication represents.

Secondly François MALAISSE would like to thank the laboratory workers and technicians at the Botany and Ecology Laboratory (1968-1997) of Lubumbashi University that have contributed to this study. He would like to address special thanks to Mr. KISIMBA Kibuya Emile and Mr. MUZINGA Yumba Laurent, who accompanied him on the field during 47 and 19 years respectively. Their presence on the field and assistance to handle and dry the vouchers specimens was fantastic, "un grand merci de tout cœur".

Authorizations to copy plates published or housed in diverse Institutions were obtained. A first set is the "Property of the Belgian State, on permanent loan to the Botanic Garden Meise", a second set comes from the Bulletin du Jardin Botanique de l'État at Meise. Both are here quoted with © Botanic Garden Meise. A third set of figures has been published by the Royal Botanical Society of Belgium. Provenances are always clearly quoted.

François MALAISSE had the opportunity to train one Congolese artist. May Mr. NGOY Lunda Abidja of the Lubumbashi University be thanked for its excellent and meticulous drawings. Ms. Christiane VAN MARSENILLE also did fine original line drawings. Finally, Prof. Eberhard FISHER also allowed us to use five of his drawings. We thank those three collaborators for their input and availability.

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Prof. Alan BAKER agreed to write the preface, whilst Dr. Sylvain BOISSON, Dr. Pierre COMPÈRE, Dr. Damien ERTZ, Madame Claire D'OUTRELIGNE (†), Ass. Prof. Michel-Pierre FAUCON, Dr. Soizig LE STRADIC, Dr. Béatrice LETEINTURIER, Prof. Grégory MAHY, Prof. François MALAISSE, Civil Mining Ir. (Master)

Michel SCHAIJES, Ir. Maxime SÉLECK, Dr. Herman STIEPERAERE (†) and Dr. Anthony VAN DER ENT kindly agreed to write chapters of this guide.

A special word of thanks to the following individuals that have provide several slides at our disposition (in alphabetic order): Prof. Alan J.M. BAKER, Ir. Paul BAMPS, Dr. Frieda BILLIET, Ms Anne BODENGHIE, Prof. Robert BROOKS (†), Dr. Peter ERSKINE, Dr. Damien ERTZ, Dr. Guy DE PLAEN, Mr. Gaston DE WITTE, Dr. Michel-Pierre FAUCON, Ir. Arielle GUILLAUME, Ir. Anne GUYOT, Ir. Handjila MINENGO, Ir. Edouard ILUNGA, Mr. KALAMBAYI, Mr. KALAMBO, Ir. Julie LEBRUN (40 ph.), Ir. Jean-Michel LECRON, Mr. Léon LEMAIRE (†), Dr. Béatrice LETEINTURIER, Prof. Grégory MAHY, Dr. Jolanta MESJASZ-PRZYLYLOWICZ, Dr. Nathalie MOULAERT, Dr. Ingrid PARMENTIER (35 ph.), Ir. Julien PIQUERAY (10 ph.), Ir. Jacques RAYNES, Prof. Elmar ROBBRECHT, Prof. Henk SCHAT, Ir. Maxime SÉLECK (20 ph.), Ir. Bruno SENTERRE, Ir. Ezana SEMEREAB, Dr. Antony VAN DER ENT, Ir. B. VAN DE VIJVE and Ir. Aurélie WILLEM.

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From 1986, one of us has got the opportunity to pay more than twenty visits on the area of concern. For taking in charge the cost of travels and local facilities we thank the Ecology Laboratory of Gembloux Agricultural University (1986-1999) and the Biodiversity and Landscape Axis of Agro-Bio Tech, Liège University (2000-2015).

Some data were collected during a development program (1995-1998) financed by the European Union and focusing on the Copperbelt Province vegetation, in Zambia. François MALAISSE is thankful for the help he received from Joseph MATERA and Marie-Claire WABNIK.

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BOOK GENESIS

François MALAISSE & Michel SCHAJES

The flora of the copper deposits of Upper Katanga has been the subject of much attention by explorers, geologists and botanists during the last century.

If the first collection of plant material dates from 1911 and was the fact of the Swedish R.E. FRIES at Bwana Mkubwa in Zambia, the first paper dealing with this flora was published only in 1932 by Walter ROBYNS.

A next tremendous step was conducted by Paul DUVIGNEAUD, which paid several visits to Upper Katanga and to the Zambian Copperbelt. He published several papers, and notably two main contributions in 1958 and 1963. This last paper, "Cuivre et végétation au Katanga", remains a turning point.

LETEINTURIER and MALAISSE (2003) have presented the history of the discovery of this flora, as well commenting on the people that were involved in it and have listed their respective botanical collections. Consequently, many publications dealing with this subject have been produced. The titles of most of them are listed in references at the end of this book.

In 2002, LETEINTURIER estimated that the rich copper flora of Upper Katanga numbered about 500 plants. At that time, color photographs as well as drawings of some of them were available, but no effort had been done to collate this kind of information in an easily accessible way, with the exception of a set of 30 color postcards, each accompanied by a short note, published in 1984 by the Gecamines mining company. This pioneering publication is out of print since many years.

The aim of the present Guide is to offer a valuable support for easy field identification of a large number of plant species observed on the copper-cobalt deposits of Upper Katanga and the Copperbelt. We hope it will make it easy for scientists and laymen alike to identify a large number of plants in the field, the Katangan copper flora being still imperfectly known.

Several sites have never been explored from a botanical point of view, whilst others need further visits during the diverse seasons that occur in the area of concern. At least some 170 copper sites have been recognized. Unfortunately, several of them have now been totally destroyed and many others are partially destroyed (LETEINTURIER, 2002).

Our Guide results from a collegial work, concerning, as well field explorations, photographs of plants, drawings related to them and written comments. F. MALAISSE has been fortunate to have the opportunity of prospecting the copper-cobalt outcrops from 1968 to 2014. In addition, he has been involved in the first visits of a number of colleagues and

fellow scientists, including A.J.M. BAKER, F. BILLIET, A. BODENGHEN, R.R. BROOKS (†), K. CLOETE, A. EMPAIN, P. ERSKINE, A. GUILLAUME, C. LEFÈBVRE (†), B. LETEINTURIER, G. MAHY, I. PARMENTIER, E. ROBBRECHT, H. SCHAT, B. SENTERRE and A. VAN DER ENT.

This book is supported by an impressive collection of color photographs that has been built up by Claire D'OUTRELIGNE (†) and Michel SCHAIJES during 24 years (1967-1991). Together they have supplied 410 photographs. Others were taken in the field by François MALAISSE from 1974 to 2014 as well as by a lot of other collaborators (see Acknowledgments).

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A selection of photographs as well as drawings are reproduced on the pages devoted to each plant. Some data were assembled by the respective authors taking into account the literature available. These data are presented concisely together with information on:

- Scientific denomination and family, eventual synonymy;
- Habit, including a short description of some organs, mostly those used in determination keys;
- Ecology, including response to Cu-Co content of soil as well as soil moisture conditions;
- General distribution of the taxon involved;
- Katangan and Zambian copper sites (supported by the vouchers deposited at BR and BRLU) where the plant (or taxon) involved has been collected. The number of sites is always given, whereas the complete list of sites is only sometimes enumerated. At least, one site is always reported. Sometimes the plant may no longer exist in some sites quoted but could exist on sites not mentioned, because there is still so much to learn about the copper-cobalt flora of Katanga and Zambia, notably the precise distribution of many taxa;
- Phytogeochemistry: mainly Cu and Co content of leaves, including accumulator status; old values however frequently need to be confirmed (see VAN DER ENT, in this book);
- References to description published in diverse Floras.

The authors will be very pleased to receive any additional information in order to complete, improve and/or correct the content of this book.



The Dikulushi mine in April 1984.



The Fungurume outcrop, from left to right: hill VI, hill V South-West and hill V North, in May 1980.



The Kazinyanga site in November 2001.

TRADITIONAL COPPER METALLURGY

François MALAÏSSE & Michel SCHAIJES

The antiquity and importance of indigenous metallurgical activity is attested by numerous observations and has been the subject of many and varied comments. As far as Africa is concerned, the actuality of this theme is confirmed by the 67 pages of references published some years ago (MILLER & MAGGS, 1994). Precolonial copper metallurgy is not an outdated subject, notably ongoing studies in D.R. Congo, Congo Republic, Nigeria, etc. (NIKIS, 2015). For our region, copper crosses, furnaces, “mangeurs de cuivre”, are topics that have fed stories and books from the beginning of the colonial era.

Rarer are phytogeochemical approaches related to this ancient activity (DE PLAEN et al., 1982). Already in 1989, BAKER and BROOKS listed 85 plant species said to indicate specific types of mineralization and it is particularly significant that more than 30% are from the copper-cobalt deposits of Katanga and Northern Zambia.

The latest archeological findings suggest that malachite outcrops have been mined as early as the vth century A.C. in Garengaze, a province known nowadays as Katanga. The pre-Bayeke tribes used to seasonally mine these outcrops and cast copper crosses that were used as exchange goods and have been found all over the African continent even reaching Europe as early as the xvth century through trade with the Portuguese and the Dutch Oud West Indische Company (PIRARD, 2010). The first explicit mention of copper in European texts is said to date back to March 22nd 1798 in a report made by the pombeiros (afro-portuguese metis) to the hence governor of Rios de Sena (Mozambique) Francesco José Maria DE LACERDA E ALMEIDA.

The native metallurgists have widely used the local ores, focusing mainly on the mining and smelting of copper carbonates, primarily malachite. Temporary furnaces were constructed on the slope of termites mounds near malachite deposits. Charcoal was produced from the wood of *Pterocarpus tinctorius* Welw. The native smelters and coppersmiths were organized in guilds with their own initiation rituals and tutelary spirits. They constituted a “bwanga”, a sacred sect. The owners of this technology were the Bayeke or, for other authors the Basanga wich initiated the Bayeke, coming in early 1820 from the kingdom of Baha (presently South Burundi), to the copper ore smelting art. At the beginning of the cold dry season the chief said “*tuya tukadie mukuba*” that is “go eating copper”, or “let’s go, to eat the copper”, which is also expressed in the French naming of “*mangeurs de cuivre*”. A film about the Katangan traditional copper metallurgy has been carried out by DE BOE in 1956 and presented by the “*Union minière du Haut-Katanga*”. Its title is “*Katanga, pays du cuivre*”.



Remains of a native copper smelting furnace on the side of a termite mound.



Appearance of a traditional copper smelting furnace.



Left: Typical artefacts from sites of ancient copper smelting furnaces and from ancient tombs. The copper artefacts are from the Kafubu area and date back to the 18th and 19th centuries. The larger object is about one meter high. From left to right the weights range from 12 to 36 kg. Right: Copper casting and recent cross.



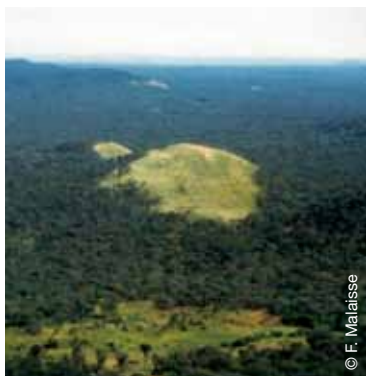
EARLY EUROPEAN GEOLOGICAL EXPLORATIONS

François MALAISSE & Michel SCHAIJES

We will shortly give an account of the first steps of geological exploration in Katanga. Several papers and books furnish pertinent and rigorous information.

According to our knowledge, the first comments on the existence of mineralized sites in Katanga were published by REICHARD (1885) and CAPELLO & INVENS (1886).

Already in February 1892, BIA and CORNET pushed on as far as Kambove in order to search for gold as indicated by the old chief M'SIRI. On 11th of August 1892, Jules CORNET discovered the sites of Likasi and Shituru. From Likasi hill, CORNET examining the surroundings, writes "I saw that this hillock was part of a row of isolates hills, whose naked summits clearly stand out against the ocean of greenery that, seen from this height, seems to cover the country" (see photograph below and page 22). In fact, he was observing the deposits of Chinkolobwe, Kasolo and Tantara; and, in the other direction, he quoted a conical high hill, the Kalabi deposit. Next day, they visit for the second time the Kambove outcrop. In 1894, CORNET reported that he visited seven copper sites, namely Lusuichi, Kimbui-Inambuloa, Kioabana, Kiola, Kitubu, Kambove and Kamaia. On 25th of August 1892, CORNET reached the Luishia outcrop, the 30th of August the malachite site of Shiwana, on 2nd of September the copper mine of Kimbui (Kimbwe) and Nambulkwa (Nijamburur). Finally on 6th and 7th of September 1892, CORNET did a detail study of the Lusuishi (Luiswishi) outcrop. He also paid a visit to the Kimbi-Imbi mine, then leaving Poapa on 10th of September, took a look on Kipushi site (CORNET, 1894). Some comments concerning Kambove outcrop are also of interest (CORNET, 1902).



Sokoroshe I in March 1980.



Shabara and Lumata in April 1990.

THE ENVIRONMENT

Béatrice LETEINTURIER & François MALAISSE

The area of concern is located in the South-East of the Democratic Republic of Congo and in the Copperbelt and the North-Western Provinces of Zambia (see map page 40).

Climate

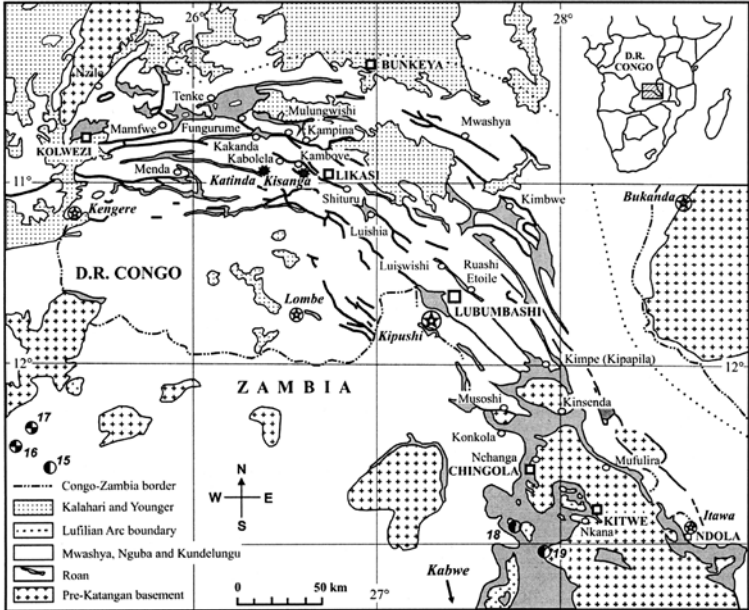
The regional climate has been summarized by MALAISSE (2010). It has been defined differently depending on the authors, notably Cws6 according to KÖPPEN (1936) or tropical climate with summer showers (II2c) according to WALTER & LIETH (1960). Most authors recognize a dry, and a wet season, frequently with two months of transition. In fact five seasons have to be recognize: cold dry season (May-July), hot dry season (August-September), early rain season (October-November), main rain season (December-February) and late rain season (March-April) (MALAISSE, 1974). The average yearly precipitations reach 1,230 mm, and variations from the average are minor ($\sigma = 12\%$). About 3 weeks differences are observed from Kolwezi to Kasumbalesa for the beginning of the early rain season.

The geology of South Katanga and of the Zambian Copperbelt

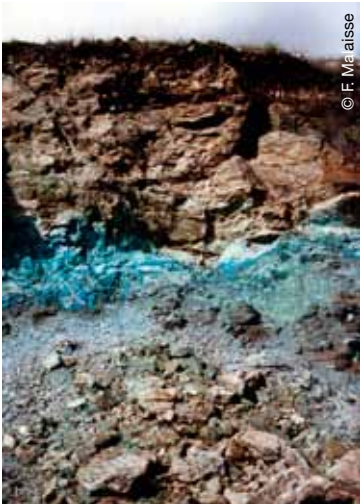
Naming of geological formations, notably the sediment-hosted Cu-Co deposits in the Central African Copperbelt, differs on both sides of the Congolese-Zambian border, but also according to periods, the 60th versus the ten last years. KAMPUNZU et al. (2009) have produced a fine synthesis, that has been recalled frequently recently (notably MUYUMBA et al., 2015) and that we will shortly present. The debate on the Katangan tectonic is outside the scope of this book.

The world-class stratiform Cu-Co mineralization of the Central African Copperbelt still needs to be described holistically and their relationship with the polymetallic (Zn-Pb-Cu-V-Cd-Ag) carbonate-hosted deposits is still poorly understood (KAMPUNZU et al., 2009). The Lufilian Arc of the Central African Copperbelt is a northward-convex Pan-African orogenic belt consisting of Neoproterozoic metasedimentary rocks of the Katanga supergroup. This last is commonly subdivided into three lithostratigraphic groups: the basal Roan, the middle Nguba (formerly Lower Kundelungu) and the Kundelungu (formerly Upper Kundelungu) at the top. The Roan Group in c unit, consists of a basal siliciclastic unit (Mindola subgroup), a middle carbonate and siliciclastic unit (Kitwe subgroup) and an uppermost carbonate unit (Kirlalombwe subgroup). These units correspond to the R.A.T. ("Roches Argilo-Talqueuses"), Mines and Dipeta subgroup, respectively in D.R. Congo. The Mwashya subgroup is regarded as the top of the Roan Group (Map 1). The subgroup Mines (R2) has at its basis the Kamoto formation (R2.1) which lithology comprises stromatolitic dolomite

(R.S.C.), silicified/arenitic dolomites (R.S.F./D.Strat.), grey argillaceous dolomitic siltstone at the base (Grey R.A.T.) and pseudomorphs after evaporates at the contact with R.A.T.



Location of mineralizations and the main ore deposits in South central Africa (KAMPUNZU et al., 2009), (see also page 40).



Azurite at Kasombo mine (1981).



Malachite at Shabara mine (1981).

Phytogeography

From a phytogeographical point of view this area belongs to the Zambezi regional center of endemism as defined by WHITE (1983). In our area the most widespread vegetation unit is the Zambezi miombo open forest, more precisely the western group of the wet miombo subtype (MALAÏSSE, 2010). On the metalliferous soil, steppes, steppe-savannas, or even grasslands are observed.

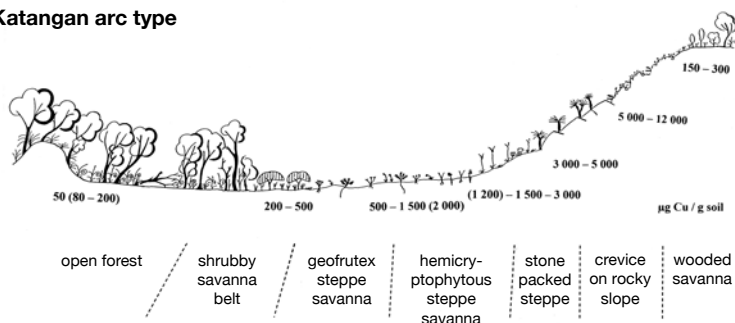
Vegetation units on copper-cobalt rich soils

Recognition of vegetation units on copper-cobalt sites has been commented in chapter 11 of BROOKS et al. (1985) and summarized by LETEINTURIER (1999; 2002). As quoted, it started in 1926 with W. ROBYNS survey of five mines sites in Katanga; these results have been published in 1932. DUVIGNEAUD (1958) and DUVIGNEAUD & DENAEYER-DE SMET (1963) bring a tremendous progress on this subject. Publications of SCHMITZ (1963) and MALAÏSSE and its collaborators (1977-2012) are also of interest. The approach starts from the concepts of biological types and their areal coverage. They are illustrated by schematic drawings and their location in the two transects represented below.

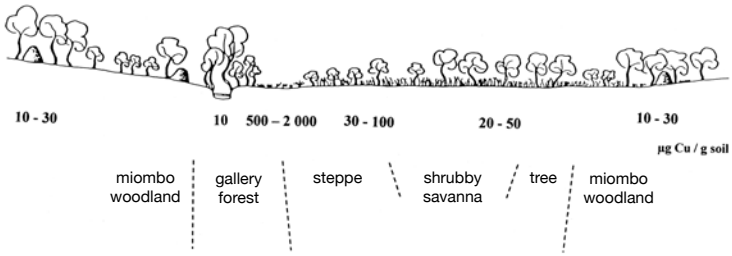
As far as Katangan copper arc type is concerned, copper-cobalt sites mostly are of hill type. They allow to distinguish, from summit to bottom: A.- Wooded savanna, B.- Crevices on rocky slopes, C.- Stone packed steppe, D.- Hemicyptophytous steppe-savanna, E.- Geofrutex steppe-savanna, F.- Shrubby savanna belt and G.- Open forest (of miombo type). This type is restricted to Katanga, with the exception of Kansanshi site (LETEINTURIER et al., 2001).

Regarding the Copperbelt type, besides miombo woodlands and sometimes gallery forests, the presence of mineralization is expressed through steppe-savanna, shrubby savanna and tree savanna. This type is observed in nearly all the sites located in Zambia, but also in Southern Katanga, near the Zambian border as well as at Dikulushi (see photo page 13).

Katangan arc type



Copperbelt type



Rocky *Xerophyta* steppe near the summit of Kwatebala hill in November, 1987.



Uapaca robynssii belt at Shinkolobwe milestone XIII in March, 1990.



Bulbostylis pseudoperennis sward in the vicinity of Kasobantu dam in January, 2005.

METHODOLOGY OF SPECIES CHOICE

François MALAISSE & Michel SCHAJES

The choice of the taxa retained for the present book was not an easy task. In order to obtain a suitable sampling of the flora diversity several approaches were considered.

A first set of some thirty plants consists in the endemics to the copper-cobalt outcrops of Katangan Copper Bow and the Copperbelt. We tried to collect photographs and(or) drawings of the presently 32 taxa considered as South-Central African copper endemics. It should be noted that about half of them are only known from one to three copper sites. Altogether 26 of the 32 copper-cobalt endemics and 19 of the 24 broad endemics are here presented, that is 82%.

A second set consists of plants that are well known to be dominant and to occur on numerous copper-cobalt orebodies in the diverse vegetation units; moreover they are not at all restricted to these sites. It is a pleasure to be able to name those plants frequently observed. This set amounts 128 taxa, notably 7 Pteridophyta, 81 Magnoliopsida and 40 Liliopsida.

Another set of plants is known to occur (mostly rarely) on the sandy Kalahari high plateau steppe-savannas but that are not rare on the copper steppe-savannas. A large number of this group were also selected. For all those plants we have given priority to the nature and quality of the iconography available. We also took attention to illustrate as most as possible diverse branches of the flora, as well as a wide range of families of Magnoliophyta.

On the other hand illustrating all the taxa of large families appears difficult. Nevertheless diversity of some genera, families received more attention according to previous studies of the authors (Pteridophyta, Orchidaceae, Campanulaceae, *Buchnera*, etc.). Outstanding floral architecture or of leaf morphology, beauty of flowers regarding the iconography were also sampled.

From a total of about 750 plant species presently listed as occurring on the copper sites involved in the present study, more than 400 are here presented.

We also selected one to three species of some taxa mostly under-collected; just to pinpoint that an important collection effort still remain to be carried out on this flora regarding its diversity. They are presented at the beginning of the plates; such are the Cyanoprocarvota, the lichenized Ascomycotina, Anthocerotophyta, Marchantiophyta and Bryophyta.

Regarding Anthocerotophyta and Marchantiophyta, no taxa have been quoted concerning copper-cobalt sites before 1979. Indeed the study devoted to the "Exploration hydrobiologique du bassin du

Lac Bangweolo et du Luapula” of VANDEN BERGHEM (1972) lists some 87 taxa, but collected in other ecological conditions. MALAISSE et al. (1979) comment on 7 taxa observed at Fungurume, hill V. Five taxa have been selected for the present Guide.

Bryophyta on copper-cobalt outcrops have been studied by EMPAIN (1985). His chapter on heavy metals in Bryophyta from Shaba Province constitutes a first fine approach. Six Cu-Co sites were visited and sampling allows to quote four taxa. Three species, including two of them, have been selected for the present Guide.



Aspect of the copper-cobalt hills from Kwatebala in June, 1987.



The Swambo outcrop, in front, Mindigi outcrop in the back in April, 1990.

ANALYSIS OF THE CONTENT OF COPPER, COBALT AND OTHER ELEMENTS IN PLANT LEAVES

Antony VAN DER ENT

Determining the concentrations of copper, cobalt and other elements in plant leaves from metallophytes of the Copper Flora is of primary interest to advance the understanding of their unique ecophysiology. In the past, plant leaves were collected in the field, brought to the laboratory, oven-dried and then digested with concentrated acid followed by analysis with Atomic Absorption Spectroscopy (AAS). The majority of plant analyses undertaken from the 1950s through to the 1990s have been undertaken this way. Although the sensitivity of AAS is excellent, this method can only determine one element at the time, and is hence impracticable for analysis of a comprehensive range of different elements. As such, for many metallophytes from the Copper Flora we only have concentration values of copper and/or cobalt. However, in order to understand how foliar elements are regulated and how this relates to the ecophysiology of a plant species, it is necessary to measure as many different elements as possible, including macro and trace elements. The same process of plant collection and laboratory preparation, but followed by analysis with Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) permits the same elemental sensitivity as AAS but the ability to measure over 20 elements simultaneously. For a pioneering study reports the results of the analysis of over 800 plant specimens from the Copper Flora by ICP-AES see BROOKS et al. (1987). Other methods, such as Neutron activation analysis (NAA), have historically been used for analysis of plant material, but are now obsolete. Recently, the technological advances in X-Ray Fluorescence (XRF), using new types of detectors and miniature X-Ray tubes, permit the analysis of dried plant leaves at limits of detection sufficient for identifying plants accumulating even moderate concentrations (> 100 ppm) of trace elements, such as copper and cobalt. The XRF method is fast and multi-element sensitive – in 90 seconds up to 40 different elements can be determined – and it does not require time-consuming sample preparation such as acid digestion.

The main problem for elemental analysis of plant material from the Copper Flora is the contamination with soil dust. The very high soil copper-cobalt concentrations (often > 10,000 ppm) means that even milligram quantities of micron-sized dust adhered to leaf surfaces will cause massively abhorrent analytical results. The fact that many metallophytes have hairy and waxy leaf surfaces exacerbates this problem and means that any dust contamination is extremely difficult to remove by washing methods in the laboratory. Dust contamination cannot be entirely avoided when analyzing wild-collected plant

material (only in cultured plants can this be reliably excluded), but the multi-element stoichiometry can inform about the likelihood presence of contamination. Specifically, concomitant relatively high concentrations of chromium and titanium (in relation to iron and silica), the first set of elements not taken up by plants in any appreciable quantities, are a strong indication of soil contamination. Historical analytical data of plant material from metallophytes must be treated with caution, as the level of any sample soil dust contamination cannot be ascertained.

XRF enables non-destructive analysis of plant material, and because devices are small and portable (<2 kg) they can be taken into the field to perform instantaneous measurements of live plants in the natural habitat. This is particularly useful for ecologists to rapidly measure plants in the field and to perform biogeochemical surveys. This also mitigates the lack of a field spot test for copper and cobalt applicable to plant materials, as has been used very successfully for nickel in the form of dimethylglyoxime DMG test paper. As with other analytical methods, soil dust contamination will significantly affect the measurement results of XRF, but contamination can be gauged to a certain degree by assessing elemental stoichiometry as mentioned earlier. XRF also has the ability to perform mass measurements of tens of thousands of herbarium specimens in a relatively short time span at low cost. This has made it possible to perform screening for hyperaccumulator plants of a wide range of trace elements from specimens held at global herbaria. As such, this approach has the potential to acquire systematic information on the copper and cobalt concentrations in plant species across phylogenetic lineages.



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Prospection on Mindigi mine in April 1990 by the Tropmetex team (BAKER, BROOKS, MALAISSE & SCHAT). The endemic metallophyte *Silene cobalticola* is restricted to this unique site.

TEN YEARS OF RESEARCH ON COPPER-COBALT ECOSYSTEMS IN SOUTHEASTERN D.R. CONGO

Soizig LE STRADIC, Sylvain BOISSON, Michel-Pierre FAUCON,
Maxime SÉLECK & Grégory MAHY

Introduction

Since almost one decade, the research team of the Biodiversity and Landscape Unit (Gembloux Agro-Bio Tech, University of Liège) collaborates with a mining company, Tenke Fungurume Mining, in order to plan conservation and restoration actions for the copper-cobalt (Cu-Co) ecosystems in southeastern Democratic Republic of Congo (DRC). These original habitats, discovered at the beginning of the 20th century (SHARP, 1956) and first described fifty years ago (DUVIGNEAUD & DENAEYER-DE SMET, 1963; MALAISSE et al., 1979; MALAISSE, 1983; MALAISSE et al., 1994), occurred on highly mineralized copper cobalt (Cu-Co) outcrops, scattered on the landscape matrix formed by the miombo forest, throughout the region. They host unique plant communities established on Cu-Co outcrops according to copper-cobalt gradients from the top to the bottom of the outcrop (SAAD et al., 2012; SÉLECK et al., 2013). Around 600 plant species occur on metalliferous soils (i.e. metallophytes), including numerous endemic metallophyte species (LETEINTURIER, 2002; FAUCON et al., 2010; Copperflora.org, 2012). Most of these metallophytes are threatened by mining activities creating an urgent need of conservation and restoration of these characteristics communities (FAUCON et al., 2010). In order to improve these actions, the team collaborates with research laboratories in Belgium, France and D.R.C. working on distinct aspects of these vegetations including plant ecology, plant-metal physiology, plant evolutionary processes and plant-soil relationship. Here, we have summarized the main results of ten years of collaboration between research laboratories of the University of Liège, the Polytechnic Institut LaSalle-Beauvais (ISAB-IGAL), the University Libre de Bruxelles (ULB) and the University of Lubumbashi (UNILU), which aim is to understand the functioning of the Cu-Co communities.

Species composition and endemism in Cu-Co communities

At the landscape scale, these communities are scattered in the open deciduous forest of wetter miombo type (DUVIGNEAUD & DENAEYER-DE SMET, 1963; MALAISSE, 1978) and the spatial configuration of Cu-Co outcrops (e.g. site surface or geographical distance between sites) is of primary importance for Cu-Co species richness. Based on the theory of island biogeography of MACARTHUR and WILSON (1967), a recent study of 34 Cu-Co outcrops, varying in size (0.2 ha to 27.3 ha) and geographical

isolation, in a 30 × 20 km landscape, demonstrated that Cu-Co endemic richness is positively correlated to site surface, which might be associated with a higher habitat diversity (Ilunga et al., unpublished results). Using species accumulation curves, it was demonstrated that the three largest outcrops encapsulate the total Cu-Co endemic richness (25 taxa) of the landscape, whereas at least 15 small Cu-Co outcrops are necessary to reach the same endemic richness.

At outcrop scale, Cu and Co concentrations are a primary determinant of plant species richness since vegetation varies in physiognomies on Cu-Co outcrops from the top to the bottom along a topographical gradient corresponding roughly to the copper-cobalt gradient. At the top, chasmophytic vegetation colonize the cracks and fissures of low mineralized rock (i.e. with Cu concentration comprises between 250 and 900 mg kg⁻¹). Then steppe vegetation colonizes the upper part of the outcrop slopes with highest Cu soil concentrations (ranging from 3,500 to 10,000 mg.kg⁻¹). Finally, steppe savanna vegetation develops on the intermediate and foothill slopes at the bottom of the outcrops, characterized by lower Cu soil concentration (i.e. with Cu concentrations varying from 100 to 3,500 mg.kg⁻¹) (SAAD et al., 2012; ILUNGA et al., 2013; SÉLECK et al., 2013). Outcrops with the highest Cu and Co concentrations in soil support the lowest total plant species richness (DUVIGNEAUD & DENAEYER-DE SMET, 1963; SAAD et al., 2012; SÉLECK et al., 2013) but present the most important endemic metallophyte richness which usually rises with increasing Cu and Co concentration in soil (SAAD et al., 2012; SÉLECK et al., 2013). Amongst the c. 600 species of the copper flora of southeastern DRC, there are 32 strict endemic plant species of Cu-Co outcrops in southeastern DRC, i.e., endemic metallophytes occurring exclusively on Cu-Co-rich soils (EM) and 23 broad endemics, i.e., with more than 75% of occurrence on Cu-Co-rich soils (FAUCON et al., 2010). Currently 10% of strict endemics are extinct and 65% are critically endangered by mining activities (FAUCON et al., 2010). However, vegetation proved to be more complex than a simple succession of physiognomic plant formations along correlated Cu and Co gradients. More detailed studies revealed a mosaic of plant communities differing in species assemblages within and among Cu-Co outcrops (SAAD et al., 2012; ILUNGA et al., 2013; SÉLECK et al., 2013).

Low proportion of endemics (c. 5%) are observed in the Cu-Co flora (FAUCON et al., 2010). This could be due to recent age of exposure of metalliferous outcrops in DRC, recent evolutionary divergences between populations isolated on the Cu-Co outcrops, the relatively low total surface of mineralized soils in DRC or an overestimation of ecological isolation and selective forces acting on populations occurring on Cu-Co-rich soils (FAUCON et al., 2015) As the result of the complex interactions among physiological, ecological and evolutionary factors, the ecological niches of endemic metallophytes

from southeastern DRC vary widely (FAUCON et al., 2011; FAUCON et al., 2012b); Cu and Co tolerances extend from 50 to 11,000 mg.kg⁻¹ and 4 to 1,500 mg.kg⁻¹ of soil, respectively. Congeneric species may present very distinct edaphic niches, as, for example the endemic metallophyte *Crepidorhopalon perennis* (P.A.Duvign.) Eb.Fisch. (Linderniaceae) which occurs on soils richer in Cu compared with its pseudometallophyte congener *C. tenuis* (S.Moore) Eb.Fisch. (FAUCON et al., 2011; FAUCON et al., 2012a). On another hand, BOISSON et al. (pers. comm.) have recently demonstrated that, among eight endemic metallophyte species present on the same Cu-Co outcrops, five have their niche optimum in the lowest concentrations of copper (<300 mg Cu.kg⁻¹) and cobalt (55 mg Co.kg⁻¹) and only two have their niche optimum in the highest concentration of copper (> 5,000 mg Cu.kg⁻¹). Species with their optimum in the higher Cu/Co concentrations also present the largest copper-cobalt niche width. ILUNGA et al. (2013) found a similar pattern for non-endemic tolerant species on a Cu-Co outcrop of southeastern DRC. Results obtained by BOISSON et al. (pers. comm.) on the endemic metallophytes variation in ecological niches means that conservation strategies needs to be species-specific and cannot be *generalizable* for all endemic metallophytes.

Abiotic and biotic factors structuring Cu-Co communities

Contrary to other metalliferous soils, Cu-Co soils in southeastern Congo are not devoid in essential elements like N, P, Ca, and Mg (SAAD et al., 2012; ILUNGA et al., 2013; SÉLECK et al., 2013). In Cu-Co outcrops, P does not contribute to variation in plant species diversity, contrary to Cu and Co (SÉLECK et al., 2013), which imply that selection pressure may be more influenced by metal toxicity than by high variation of nutrient content and that the extractable Cu and Co soil concentrations are the main factors explaining the variation between plant communities (SÉLECK et al., 2013). CHIPENG et al. (2010) have shown that biomass and fitness of metallophyte species increase with Cu concentrations in soils, implying a certain copper requirement of these species to Cu and Co. Besides Cu and Co soil concentration, other soil elements also play a role in community differentiation (SAAD et al., 2012; SÉLECK et al., 2013; POURRET et al., 2015a). The pH is the third significant factor influencing the plant community composition (SÉLECK et al., 2013). Some of other edaphic factors, such as C, Ca, Mn could contribute to the floristic variation and heterogeneity of plant communities because these edaphic factors influence Cu and Co availability (LANGE et al., 2014; POURRET et al., 2015b). A recent study has addressed the characterization of metal speciation in soils and has underlined a strong relationship between Cu and Co speciation in soils and structure of plant communities (LANGE et al., 2014).

Recent studies have also stated that biotic factors could play a major role in the endemic distribution (BOISSON, unpublished results;

FAUCON et al., 2012b). For example, the restricted distribution of the strict endemic *Crepidorhopalon perennis* is not exclusively linked to a physiological need to copper in contrast to *Haumaniastrum katangense* (S.Moore) P.A.Duvign. & Plancke (CHIPENG et al., 2010). Based on the theory that low density and diversity of pathogens and herbivores occur on metal-rich soils, the restricted distribution of metallophyte species on soils rich in metals could be due to the low resistance to pathogens; endemic metallophytes may be disadvantaged in non-metalliferous habitats compared with other plants occurring on non-metalliferous soils. In another hand, as copper in soil may limit the development of pathogens by acting as a natural fungicide, the metallophytes may have lost their pathogen-resistance mechanisms. As consequence, metallophyte species might not be able to colonize non-metalliferous habitats or to resist to the plant species competition in non-metalliferous soils. However, tests in controlled conditions showed that endemic metallophyte were able to germinate and growth on non-metal enriched substrate (BOISSON, unpublished results; LETEINTURIER, 2002; FAUCON et al., 2012b; GODEFROID et al., 2013).

Cu-Co tolerance of metallophytes

Harsh edaphic conditions present on Cu-Co outcrops have selected traits like drought tolerance during dry season, tolerance to seasonal fires and a high Cu requirement (CHIPENG et al., 2010; FAUCON et al., 2012b). Species occurring in highest Cu-Co concentrations have developed physiological mechanisms to tolerate the excess of available metal in soils (CHIPENG et al., 2010; FAUCON et al., 2012b). Studies performed in controlled conditions, have underlined tolerance mechanisms (i.e. exclusion, indicator and hyperaccumulator) of some Cu-Co species. It has been shown that *Crepidorhopalon perennis* (FAUCON et al., 2012b) and *Haumaniastrum katangense* (CHIPENG et al., 2010) present exclusion mechanism, i.e. Cu remains partly blocked in the roots. Thus, Cu concentrations in roots are higher than in aerial parts. Consequently, non-tolerant or less tolerant populations to Cu concentration in soil present higher concentrations in the aerial part that tolerant populations (FAUCON et al., 2012a). Some of these studies also highlighted than the combination of metals in the soil has an effect on the metal tolerance and accumulation of some species as *C. tenuis*, *Anisopappus chinensis* (L.) Hook & Arn., *H. katangense* (CHIPENG et al., 2010; FAUCON et al., 2012b; LANGE et al., 2014).

Important copper and cobalt concentrations in soil generate a diversity of trait responses for the different species. Delhaye et al. (*in press*) showed that growing soil metal concentrations would favor species substitution rather than intraspecific variation, which imply that species from these habitats present a low phenotypic plasticity. At the community-level, different functional groups are present in Cu-Co communities and variations of functional traits along the gradient

generated by copper concentrations in soils have been underlined (DAUBIE, 2010). Xylopod species (i.e. with underground storage organs) are dominant in the lower part of the Cu-Co outcrops, in communities occurring on deeper soils, less rich in metal concentration, whereas annual species are dominant in the upper part of Cu-Co outcrop, in communities located on more shallow soils, with high metal concentrations (DAUBIE, 2010; SÉLECK et al., 2013).

Resilience, conservation and restauration of Cu-Co ecosystems

Edaphic factors are essential for structuring and Cu-Co communities (SAAD et al., 2012; ILUNGA et al., 2013; SÉLECK et al., 2013; LANGE et al., 2014; POURRET et al., 2015a) and strong alteration and/or modifications of edaphic conditions of Cu-Co outcrops have important impacts on vegetation composition and structure. As most of old-growth grasslands (VELDMAN et al., 2015), Cu-Co communities present poor colonization ability, low success at establishing from seed, rather, they rely on strong growing again capacity and investment in underground storage organs (WILLEM, 2011). Plant communities of Cu-Co outcrops are, therefore, poorly or not resilient to strong anthropogenic disturbances such as mineral extraction made either by artisanal miners or mining companies. Studies highlighted that even 30 years after the degradation by mining activities, Cu-Co communities did not regenerate or re-colonize degraded or disturbed areas (LETEINTURIER et al., 1999; FAUCON et al., 2011; ILUNGA WA ILUNGA et al., 2015). It is thus, crucial to consider conservation of edaphic factors, to conserve or restore Cu-Co communities including endemic metallophytes (BOISSON et al., unpublished results).

In southeastern DRC, Cu-Co outcrops are located on private mining concessions, leased to commercial mining companies, which have to exploit all viable reserves within the concession. In such context the *in situ* conservation of large patches of pristine Cu-Co ecosystem is not a realistic option. The conservation of Cu-Co communities has to be considered through their *ex situ* conservation (LE STRADIC et al., 2015) and in future ecological restoration of waste dumps and open pits (FAUCON et al., 2012a; SAAD et al., 2012; LE STRADIC et al., 2015). General conservation programs need to be set up to plan conservation and restoration actions before, during and after extraction phase and know-hows need to be developed and transferred to mining companies.

Since 2007, Gembloux Agro Bio Tech, University of Liège, supports a mining company to conserve plant communities occurring on Cu-Co outcrops, through different conservation actions (Copperflora.org, 2012). Actions include *in situ* conservation such as (a) setting aside and protect smaller Plant Micro-Reserves (PMRs) in areas located in areas not affected by short-term footprint of the project, and *ex situ* conservation like (b) protecting and conserving particular species including endemics and hyperaccumulators (species of concern) in

areas beyond the immediate project footprint through the creation of a botanical garden, (c) translocating critical habitat and species of concern using topsoil and vegetation translocation (LE STRADIC et al., 2015), (d) conserving Cu-Co species using species translocation, direct seeding, collect of plants, seeds and other propagation material for multiplication in nursery, (e) conserving species through seed bank (GODEFROID et al., 2013), (f) improving scientific knowledge on the occurrence and range of Cu-Co communities. Aims of such actions are (1) to temporarily store and conserve native Cu-Co plant diversity in order to reestablish it on post-mining sites and (2) to gain information on the feasibility of restoration program for Cu-Co communities.

Implementation of Plant Micro-Reserves (PMR) is limited since pristine areas are regularly impacted by illegal miners or mine operations; PMR became therefore very fragile and isolated with time due to expansion of mine operations. Several operations of species translocation were carried out in other copper clearing, in reconstructed ecosystems (i.e. habitat translocation) and in a botanical garden. Results are highly species-dependent and species with a well-developed underground system, commonly found in this kind of grasslands, may be more sensitive to translocation due to the unavoidable disturbance of the root system. Translocation of individuals in a botanical garden were up to date quite successful for numerous species with important underground system (e.g. *Acalypha cupricola* W.Robyns ex G.A.Levin, *Dissotis derriksiana* P.A.Duvign., *Ocimum vanderystii* (De Wild.) A.J. Paton), especially because the root system was excavated deeply and because management such as weed removal and watering individuals, have been set up. Direct seedlings were first carried out in order to improve number of species occurring on transferred topsoil, but results were not very good with few germination emergence. New direct seeding trials including other species have been tested and have showed encouraging results with numerous emergences and establishment of structuring Cu-Co species.

Habitat translocation using topsoil and vegetation mats translocation, intend to move to rescue, out of harm's way, communities that would otherwise have been completely destroyed by civil engineering, mining activities or excavation projects, and has appeared rapidly as a valuable alternative to *in-situ* conservation. Indeed, among all actions implemented, habitat translocation allows to conserve entire habitats and not only some specific species. First results of these translocations show that vegetation mat translocation is the most efficient method to preserve biodiversity of Cu-Co outcrops compared to topsoil transfer (LE STRADIC et al., 2015), and steppe communities (i.e. communities occurring in the upper part of the hill, characterized by shallow soils with high metal concentrations, 3,500-10,000 mg Cu.kg soil⁻¹) tend to translocate better than steppe savanna communities (i.e. communities located along the lower slopes

on deeper soils with lower metal concentrations, 1,000-3,500 mg Cu.kg soil⁻¹). The seed bank is usually quite poor in species and seeds, little emergence of target species (i.e. copper flora species) occurs in the topsoil while ruderal species quickly colonize bare ground areas. Results are encouraging for the steppe communities, given that high metal concentrations appear to limit the development of ruderal species and the greater number of annual species provides a more rapid vegetation cover from the first year. In addition, steppe community present shallow soils, favoring the transfer of the community without root damages. However, some structuring species (i.e. dominant species) with important underground systems, such as *Cryptosepalum maraviense* Oliv. (Fabaceae), a xylopod species present in the steppic savanna, failed to be transferred through vegetation mat translocation. As consequences, competition relationships within the community are modified, which lead to the dominance of some species of Poaceae.

Phytostabilization and conservation

Mining activities have also consequences on the public health and environment (MANDA et al., 2010; VRANKEN et al., 2013). Since 1999, phytoremediation appears as a valuable solution to rehabilitate polluted areas (LETEINTURIER & MALAISE, 1999; LETEINTURIER et al., 2001; LETEINTURIER, 2002). Then, SHUTCHA et al. (2010; 2015) and BOISSON et al. (2015) have shown that some copper tolerant grasses could be used in phytostabilization of polluted soils in the region. Phytostabilization which is include in phytoremediation strategies, is employed to reduce the bioavailability and the mobility of metals in contaminated soil and pollution spread by erosion, water percolation, leaching and wind dispersal of toxic dust by the establishment of a persistent plant cover (LETEINTURIER & MALAISE, 1999; SHUTCHA et al., 2010; BOISSON et al., 2015). The current challenge is therefore, to identify potential candidate for phytostabilization program, within the c.a. 600 plant species composing the vegetation of southeastern DRC. To be selected, species need to fit to specific criteria such as to be native to the region that needs to be depolluted, grow quickly, have dense root and shoot systems preventing heavy metal dispersion by water and/or wind erosion, have a large quantity of available propagules and should preferentially disperse by seeds to allow the implementation of phytostabilization on a large scale (SHUTCHA et al., 2010; BOISSON et al., 2015). In addition, species have to be able to promote soil development process by a long-term succession in the polluted areas. Based on these criteria, a first Poaceae species, *Microchloa altera* (Rendle) Stapf, has been highlighted as good candidate for phytostabilization program (SHUTCHA et al., 2010). Recently, BOISSON et al. (2015), have pointed out three other candidate species, *Andropogon shirensis* A.Rich., *Eragrostis racemosa* (Thunb.) Steud. and *Loudetia simplex* (Nees) C.E.Hubb., which could be useful to improve phytostabilisation project in southeastern DRC.

To date, the restoration of the conserved plant material seems to be difficult because the mining activities are operating (see previous section). However, phytostabilized areas with copper tolerant grasses offer opportunities to conserve endemic metallophytes occurring in the Cu-Co outcrops. Indeed, available copper concentrations in polluted soils can reach 9,000 mg.kg⁻¹ (SHUTCHA et al., 2015), that are similar to the steppe of the Cu-Co outcrops. Combining the conservation of metallophytes with the phytostabilization of polluted could also be permitted to increase the species richness in phytostabilized areas. Recent study showed that perennial species could be easily sown in a *Microchloa altera* cover, and, were able to grow again one year later (BOISSON et al., pers. comm.). In other hands, seed mixes of copper tolerant grasses and endemic metallophyte should also be regenerated in waste dumps or other polluted soils.

CopperFlora.org, a database dedicated to the conservation of Cu-Co communities

Storage and accessibility to structured data are essential in all fields of scientific research, to make data available for research collaborators and for managers if you work in collaboration with land managers or private companies. In recent years, online databases concerning climate, species traits and distribution have been developed at broader scale but few offer a comprehensive tool helping for the management of threatened species at all conservation steps. In the case of Cu-Co communities, part of the research is carried out in collaboration with a mining company, and it is important to transfer to the company data and know-hows. In this context, the Copperflora database was created including a part available for public and a part available only for collaborators and specific managers. The part on the website, available for everybody presents the rich biodiversity of communities occurring on Cu-Co outcrops, including 430 species up to now and aims to divulgate research on Cu-Co outcrops. The most restricted part of the database (i.e. only available for restricted number of persons) was created in order to include a diversity of information about species occurring in Cu-Co communities (e.g. taxonomy, habitats, phenology, pictures, and distribution) but also information concerning seeds collection for seed bank, conservation status for each species, annual monitoring of habitat translocations and germination tests realized on most threatened species. Copperflora is meant to be an interactive and an evolutionary project favoring the exchange of data between the university and the managers of the mining company and all data collected by the university are directly available for managers. In the same time, the project also contributes to the advance in the understanding of metallophyte communities' conservation and restoration projects.

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Luiswishi site in May 1980. This site was visited by Walter ROBYNS in March 1926, its vegetation has been the object of a paper (MALAISSE et al., 1999), and further studied by LEFÉBVRE and LETEINTURIER in November 2001. This hill host an ecotype of *Pandiaka carsonii* with very narrow leaves that has been called “var. *linearifolia*” by HAUMAN.



The former Katanga Province (left) to which we refer several times in the present Field Guide has been subdivided into four Provinces since July 2015 (right), namely L = Lualaba, H-L = Haut-Lomami, T = Tanganyika and H-K = Haut-Katanga.

LIST OF COPPER-COBALT SITES

François MALAÏSSE & Michel SCHAÏJES

| Nr | Sites | Latitude (South) | Longitude (East) |
|----|------------------------------------|------------------|------------------|
| 1 | Dikulushi | 08°53' | 28°16' |
| 2 | Dikuluwe | 10°45' | 25°22' |
| 3 | Kilamusembo | 10°43' | 25°23' |
| 4 | Mupine | 10°42' | 25°24' |
| 5 | Mashamba East | 10°45' | 25°23' |
| 6 | Kamoto | 10°43' | 25°24' |
| 7 | Kananga East | 10°41' | 25°28' |
| 8 | Kingamyambo | 10°42' | 25°27' |
| 9 | KOV (Kamoto IV, Oliveira, Virgule) | 10°43' | 25°27' |
| 10 | Mutoshi (= Ruwe) | 10°40' | 25°33' |
| 11 | Punguluwe | 10°37' | 25°45' |
| 12 | Bona | 10°38' | 25°49' |
| 13 | Kasankaita | 10°37' | 25°53' |
| 14 | Kalukundi Kinshasa | 10°38' | 25°55' |
| 15 | Kalukundi Kii | 10°38' | 25°56' |
| 16 | Kalukundi | 10°37' | 25°56' |
| 17 | Kalukundi principal | 10°39' | 25°55' |
| 18 | Myunga Kalumbwe I | 10°47' | 26°00' |
| 19 | Myunga Kalumbwe II | 10°46' | 25°56' |
| 20 | Tilwezembe | 10°47' | 25°42' |
| 21 | Kabwima | 10°44' | 25°46' |
| 22 | Kansuki | 10°44' | 25°49' |
| 23 | Shitamba | 10°44' | 25°51' |
| 24 | Shabara | 10°44' | 25°51' |
| 25 | Kakontolwa | 10°44' | 25°52' |
| 26 | Safwe | 10°41' | 25°54' |
| 27 | Kasompi | 10°59' | 25°53' |
| 28 | Menda | 10°58' | 25°56' |
| 29 | Pumpi XI | 10°38' | 26°03' |
| 30 | Zikule | 10°39' | 26°14' |

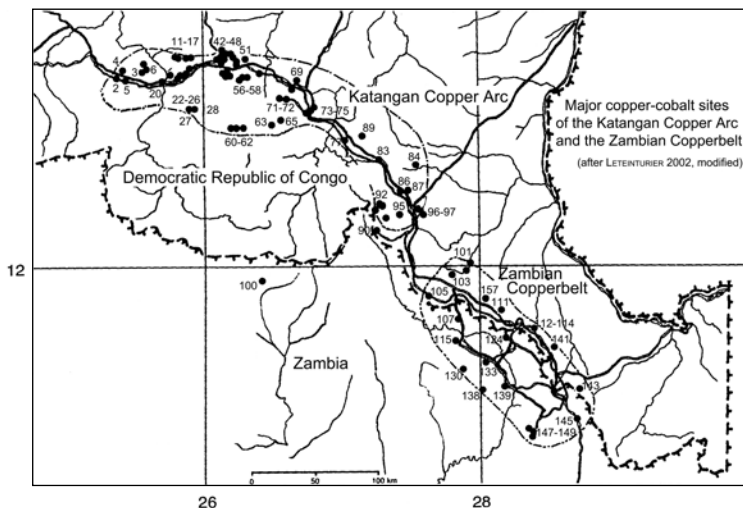
| Nr | Sites | Latitude (South) | Longitude (East) |
|----|--------------------------|------------------|------------------|
| 31 | Kakavilondo (= Apostolo) | 10°37' | 26°08' |
| 32 | Tenke (= Orthodoxe) | 10°36' | 26°08' |
| 33 | Goma central | 10°33' | 26°08' |
| 34 | Kabwelunono | 10°36' | 26°08' |
| 35 | Shimbidi | 10°36' | 26°09' |
| 36 | Kakavilondo | 10°37' | 26°07' |
| 37 | Iko | 10°37' | 26°07' |
| 38 | Kakalalwe | 10°37' | 26°08' |
| 39 | Kamakoka | 10°39' | 26°06' |
| 40 | Kamalondo | 10°37' | 26°10' |
| 41 | Katuto | 10°37' | 26°08' |
| 42 | Kavifwafwaulu | 10°35' | 26°09' |
| 43 | Mwinansefu | 10°35' | 26°11' |
| 44 | Shinkusu | 10°35' | 26°10' |
| 45 | Kwatebala | 10°35' | 26°12' |
| 46 | Leta | 10°37' | 26°08' |
| 47 | Mwadikomba | 10°36' | 26°13' |
| 48 | Shadiranzoro | 10°36' | 26°15' |
| 49 | Kazinyanga | 10°38' | 26°15' |
| 50 | Mambilima | 10°37' | 26°14' |
| 51 | Kansalawile | 10°37' | 26°13' |
| 51 | Fungurume | 10°37' | 26°17' |
| 52 | Kela | 10°45' | 26°12' |
| 53 | Mupapala | 10°45' | 26°17' |
| 54 | Lufomboshi | 10°45' | 26°18' |
| 55 | Disele | 10°45' | 26°15' |
| 56 | Kankeru | 10°45' | 26°15' |
| 57 | Kahumbwe | 10°44' | 26°17' |
| 58 | Luita | 10°44' | 26°18' |
| 59 | Kakanda | 10°44' | 26°25' |
| 60 | Mindigi (= Mindingi) | 11°05' | 26°11' |

| Nr | Sites | Latitude (South) | Longitude (East) |
|----|-------------------------------|------------------|------------------|
| 61 | Mirungwe | 11°05' | 26°12' |
| 62 | Swambo | 11°05' | 26°38' |
| 63 | Tantara | 11°04' | 26°29' |
| 64 | Shinkolobwe principal | 11°02' | 26°34' |
| 65 | Shinkolobwe hill | 11°04' | 26°34' |
| 66 | Shinkolobwe II | 11°04' | 26°37' |
| 67 | Shinkolobwe milestone XIII | 11°03' | 26°35' |
| 68 | Mitonte | 11°05' | 26°13' |
| 69 | Kalabi | 10°47' | 26°43' |
| 70 | Shangolowe | 10°48' | 26°34' |
| 71 | Kambove | 10°53' | 26°36' |
| 72 | Kamoya II | 10°53' | 26°34' |
| 73 | Kamatanda | 10°57' | 26°47' |
| 74 | Shituru | 11°01' | 26°46' |
| 75 | Likasi | 11°00' | 26°45' |
| 76 | Kasongwe | 11°09' | 26°59' |
| 77 | Luishia | 11°10' | 27°00' |
| 78 | Malundwe (Lumwana I) | 11°46' | 25°19' |
| 79 | Chiliwungo-Lumwana II | 11°50' | 25°33' |
| 80 | Kesho | 10°39' | 25°56' |
| 81 | Kalongwe | 11°02' | 25°22' |
| 82 | Shandwe | 11°10' | 27°06' |
| 83 | Sokoroshe I (Kibanda we pala) | 11°19' | 27°16' |
| 84 | Kinsevere | 11°22' | 27°35' |
| 85 | Kalumines | 11°36' | 27°16' |
| 86 | Lukuni | 11°30' | 27°25' |
| 87 | Luiswishi | 11°31' | 27°26' |
| 88 | Luiswishi East | 11°31' | 27°27' |
| 89 | Kamwali | 11°08' | 27°11' |
| 90 | Kipushi | 11°46' | 27°15' |
| 91 | Kasonta | 11°36' | 27°17' |
| 92 | Lupoto | 11°36' | 27°16' |
| 93 | Niamumenda | 11°36' | 27°18' |
| 94 | Kasombo | 11°40' | 27°19' |
| 95 | Karavia | 11°39' | 27°25' |

| Nr | Sites | Latitude (South) | Longitude (East) |
|-----|-------------------------|------------------|------------------|
| 96 | Ruashi | 11°37' | 27°32' |
| 97 | Etoile (= Kalukuluku) | 11°38' | 27°35' |
| 98 | Mukandjila | 13°04' | 28°16' |
| 99 | Kishiba | 13°10' | 28°57' |
| 100 | Kansanshi | 12°05' | 26°25' |
| 101 | Kipapila | 12°02' | 27°54' |
| 102 | Kimpe | 12°01' | 27°54' |
| 103 | Mabaya | 12°03' | 27°47' |
| 104 | Kapapa | 11°59' | 27°45' |
| 105 | Musoshi | 12°15' | 27°39' |
| 106 | Konkola North | 12°17' | 27°48' |
| 107 | Konkola (Chililabombwe) | 12°18' | 27°50' |
| 108 | Konkola II | 12°19' | 27°50' |
| 109 | Konkola III | 12°18' | 27°52' |
| 110 | Fitwaola | 12°21' | 27°55' |
| 111 | Lubembe | 12°20' | 28°07' |
| 112 | Luansobe | 12°21' | 28°09' |
| 113 | Luansobe II | 12°22' | 28°09' |
| 114 | Luansobe III | 12°23' | 28°10' |
| 115 | Nchanga I | 12°25' | 27°50' |
| 116 | Nchanga II | 12°25' | 27°54' |
| 117 | Chingola I | 12°26' | 27°52' |
| 118 | Chingola II | 12°27' | 27°51' |
| 119 | Chingola III | 12°28' | 27°50' |
| 120 | Chingola IV | 12°28' | 27°49' |
| 121 | Chingola V | 12°29' | 27°49' |
| 122 | Chingola VI | 12°30' | 27°49' |
| 123 | Kasaria | 12°25' | 28°03' |
| 124 | Mopani (=Mufulira) | 12°33' | 28°13' |
| 125 | Mokambo | 12°24' | 28°22' |
| 126 | Mimbula I | 12°33' | 27°51' |
| 127 | Mimbula II | 12°34' | 27°53' |
| 128 | Fitula I | 12°36' | 27°53' |
| 129 | Fitula II | 12°37' | 27°54' |
| 130 | Samba | 12°40' | 27°50' |
| 131 | Mwambashi A | 12°37' | 27°58' |

| Nr | Sites | Latitude (South) | Longitude (East) |
|-----|---------------------------|------------------|------------------|
| 132 | Pitanda | 12°35' | 28°00' |
| 133 | Chambishi | 12°41' | 28°03' |
| 134 | Mwambashi B | 12°40' | 27°59' |
| 135 | Chambishi South-East I | 12°35' | 28°03' |
| 136 | Chambishi South-East II | 12°36' | 28°05' |
| 137 | Chibuluma West | 12°47' | 28°05' |
| 138 | Chibuluma | 12°47' | 28°07' |
| 139 | Nkana-Mindola | 12°46' | 28°11' |
| 140 | Chibuluma South | 12°54' | 28°04' |
| 141 | Frontier | 12°45' | 28.29' |
| 142 | Mwekera | 12°52' | 28°16' |
| 143 | Ndola West | 12°57' | 28°36' |
| 144 | Itawa | 12°57' | 28°42' |
| 145 | Bwana Mkubwa | 13°02' | 28°42' |
| 146 | Baluba | 13°03' | 28°31' |
| 147 | Roan Antelope (extension) | 13°09' | 28°21' |
| 148 | Lufubu South | 13°09' | 28°15' |
| 149 | Luanshya | 13°08' | 28°24' |

| Nr | Sites | Latitude (South) | Longitude (East) |
|-----|-------------------|------------------|------------------|
| 150 | Mufulira | 12°28' | 28°17' |
| 151 | Kibutu | 11°25' | 27°05' |
| 152 | Libembe | 12°21' | 28°07' |
| 153 | Mutanda | 11°47' | 25°49' |
| 154 | Kishiba | 12°44' | 28°28' |
| 155 | Kabolela | 10°51' | 26°29' |
| 156 | Kamfundwa | 10°49' | 26°35' |
| 157 | Kinsenda | 12°12' | 27°48' |
| 158 | Kipoi | 11°09' | 27°11' |
| 159 | Msesa | 10°51' | 26°36' |
| 160 | Mukondo | 10°43' | 26°21' |
| 161 | Musonoi | 10°43' | 25°24' |
| 162 | Luamata | 11°50' | 24°28' |
| 163 | Mutoshi | 10°40' | 25°32' |
| 164 | Mokambo | 12°25' | 28°25' |
| 165 | Lonshi | 13°11' | 28°57' |
| 166 | Kisanfu | 10°41' | 25°57' |
| 167 | Kitwe | 12°50' | 28°13' |
| 168 | Kimbwe | 11°10' | 27°27' |
| 169 | Ushi East (Kitwe) | 12°49' | 28°14' |



LIST OF COLLECTORS ON COPPER-COBALT SITES AND ABBREVIATIONS USED IN THE GUIDE

Béatrice LETEINTURIER & François MALAISSE

| Abbr. | Collector |
|-------------|--------------------------------|
| Ba | Bodenghien Anne |
| Bf | Billiet Frieda |
| Bh | Breyne Herman |
| Bi | Bercovitz Irène |
| Bj | Burt Davy Joseph |
| Bk | Baker Alan J.M. |
| Bp | Bamps Paul |
| Br | Brooks Robert R. |
| Bs | Cole Monica Mary |
| By | Boisson Sylvain |
| Cj | Collignon Julien |
| Ck | Cloete Karen |
| Cs | Christolofi Sara |
| Da | Damblon Jean |
| Db | De Bilde Jacqueline |
| Dc | D'Outreligne Claire |
| De | Derricks Jean-Marie, Joseph |
| Dg | Delevoy Gaston |
| Dh | Delhaye Guillaume |
| DKM | Dn, Kk & My |
| Di | Daubie Isaline |
| Dj | Delvaux Jacques |
| Dn | Dikumbwa N'landu |
| Dp | Duvigneaud Paul |
| Ds | De Giorgi Stephano |
| Ea | Empain Alain |
| Ec | Evrard Carlos |
| Ep | Erskine Peter |
| Fd | Fanshawe Dennys B. |
| Fm | Faucon Michel-Pierre |
| FMMM | Fm, Mf, Mp & Mo |

| Abbr. | Collector |
|------------|--------------------------|
| Fr | Fries Robert E. |
| Ga | Guillaume Arielle |
| Gj | Grégoire Jacques |
| Gp | Goetghebeur Paul |
| He | Hoffman E. |
| Hg | Handjila Guylain |
| Hh | Humbert Henri |
| Hs | Hooper Sheila |
| Ie | Ilunga Edouard |
| ISl | Ie, Sx & Iw |
| Iw | Ilunga Tshibangu William |
| Kk | Kisimba Kibuye Emile |
| Km | Kisimba Munyanta |
| Kp | Kila Patrick |
| KSM | Kk, Sl & Mf |
| Lb | Leteinturier Béatrice |
| Lc | Lefèbvre Claude |
| Ld | Le Docte Jacques |
| Le | Lejoly Jean |
| Lj | Léonard Jean |
| LLM | Lc, Lb & Mf |
| LMM | Lb, Mf & Mj |
| Lr | Lebrun Julie |
| Ls | Lisowski Stanislas |
| Ly | Lumuna Kasongo Yolande |
| Lz | Le Stradic Sozig |
| Ma | Mbenza Muaka Anselme |
| Mal | Mf, Lj, Ra, Kk & Hg |
| Mb | Mbuyi Albert |
| Me | Milne-Redhead Edgard |
| Mf | Malaisse François P. |
| Mg | Mahy Grégory |

| Abbr. | Collector |
|--------------|-------------------------------------|
| MHK | Mf, Hg & Kk |
| Mj | Matera Joseph |
| MKM | MF, Kk & My |
| MKS | Mf, Kk & SI |
| Mm | Matubila Mulindwa Stéphane |
| MMK | Mf, Mg & Kk |
| Mo | Mongoli Bruno |
| Mp | Meerts Pierre |
| MP | Mesjasz-Przybyłowicz Jolanta |
| Ms | M'Baku Sala Biaku Adrien Nicaise |
| MSH | Mf, Se & Hg |
| MSK | Mf, Sb & Kk |
| My | Muzinga Yumba |
| Nn | Ndjele Nianda-Bungi Léopold |
| Pi | Parmentier Ingrid |
| Pj | Plancke Jacqueline |
| PKS | Pi, Kk & Sk |
| PI | Pauwels Luc |
| Py | Piqueray Julien |
| Qp | Quarré Paul |
| Ra | Rensonnet Audrey |
| Re | Robbrecht Elmar |
| Rf | Rogers Frederick Arundel |
| Rj | Romeux Jean |
| RHI | Ra, Hg & Iw |
| Rm | Robert Maurice |
| RSHI | Ra, Se, Hg & Iw |
| Rw | Robyns Walter |

| Abbr. | Collector |
|--------------|---|
| Sa | Schmitz André |
| Sb | Senterre Bruno |
| SDI | Sm, Dh, Ie |
| SDS | Sj, Db & Sf |
| Se | Semereab Ezana |
| Sf | Schwind F. |
| SFS | Priests from Saint- François-de-Salles |
| Sh | Schat Henk |
| SIIW | Sx, Ie, Iw & Wa |
| Sj | Symoens Jean-Jacques |
| Sk | Sahato wa Kalumba Florent |
| SI | Saad Layla |
| Sm | Schajjes Michel |
| Sp | Schrooten P. |
| St | Streel Maurice |
| Sw | Shewry Peter R. |
| SWT | Sw, Wh & Tk |
| Sx | Séleck Maxime |
| Tc | Townsend Cliff |
| Tj | Timperman Jules |
| Tk | Thompson Kenneth |
| Tr | Tropmetex (Bk, Br, Mf & Sh) |
| Va | van der Ent Antony |
| Vr | Vinya Royd |
| Wa | Willem Aurélie |
| Wh | Woolhouse Harold William |
| Wr | Wechuyzen Ronny |
| Z | Mf, Va, Ep, MP, Ck, Vr |

Cyanoprocarvota

by Pierre COMPÈRE

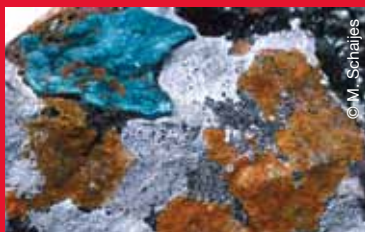


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Porphyrosiphon notarisii

Lichenized **Fungi**

by Damien ERTZ



© M. Schajfes

Caloplaca cinnabarina

Anthocerotophyta

by Herman STIEPERAERE



© O. Van de Kerckhove

Anthoceros caucasicus

Marchantiophyta

by Herman STIEPERAERE



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Plagiochasma eximium

Bryophyta

by Herman STIEPERAERE



© F. Malaisse

Leucobryum madagassum

Porphyrosiphon notarisii Kütz. ex Gomont

[Phormidiaceae]

Holotype: de Notaris in Herb. Thuret (PC).

Copper specimens: Mf 16575, 16577, 16641, 16642; Mf-Kk 812; Mf-SI 14, 43; MKS 768; MMK 28.

Habit: Thallus tomentose, woolly, tufted, expanded, purple-brown to brownish red, rarely blue-green. Filaments densely aggregated and entangled, up to 25 µm wide. Sheaths firm, brown-red to purple-red, attenuated and generally one trichome, very rarely two. Trichome blue-green, 8–12 µm wide, barely constricted at the cross-walls. Cells 1/3 to 1 time as long as large, contents granular. Apical cell widely rounded or barely attenuated.

Ecology: Aerophytic or subaerophytic forming widely expanded crusts on wet soils. *Porphyrosiphon notarisii* is the main component of the blackish crusts. It was often accompanied by *Scytonema ocellatum* Lyngb. ex Born. & Flah., *Schizothrix lardacea* Gomont and other Cyanoprocaryota species.

General distribution: Probably cosmopolitan distribution; temperate as well as tropical and subtropical regions. In Africa, from Senegal to Sudan, southwards from Angola to D.R. Congo and Madagascar.

Distribution on Katangan copper sites (15 sites): Tilwezembe (20), Pumpi XI (29), Zikule (30), Kakavilondo (31), Goma (33), Kabwelunono (34), Kavifwafwaulu (42), Mwinansefu (43), Kwatebala (45), Mwadikomba (47), Shadirandzoro (48), Kazinyanga (49), Mambilima (50), Fungurume (51), Luiswishi (87).

Distribution on Zambian copper sites (2 sites): Bwana Mkubwa (145), Kitwe (167).

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

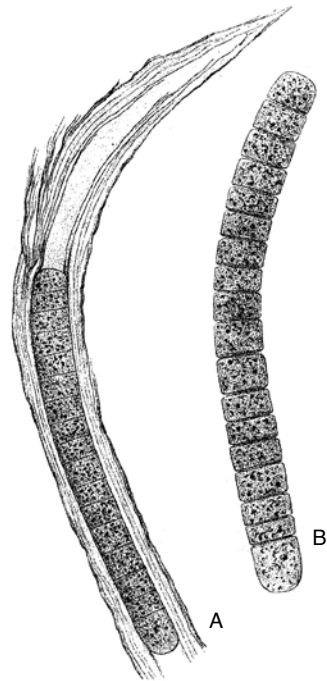
| | | | |
|--------|---|-----|--|
| dry | | | |
| medium | X | (X) | |
| wet | X | | |

→ oligocuproresistant

References:

DUVIGNEAUD, SYMOENS [1951].
KOMAREK, ANAGNOSTIDIS [2005].

Note: Such cyanophycean crusts dominated by *Porphyrosiphon notarisii* have already been described by Duvigneaud & Symoens (1951) from diverse herbaceous formations of the southern part of D.R. Congo.



A. Filament coming with a trichome surrounded by its sheath (x 400) – B. Isolated trichome, out of its sheath (hormogony) (x 400). [GOMONT, 1892]



Kwatebala (wet season)



Kazinyanga (dry season)



Lichenized Fungi

Copper and cobalt mineralizations (sulphides and secondary oxides ores) have taken place in several rock layers (orebodies) belonging to the R2 group of the Katangan Mines Serie of the Lower Roan. Those rocks locally show on the surface and undergo alterations due to abiotic factors as well as biotic organisms. This is the beginning of a succession of vegetation stages, known as chalcosere (Brooks, Malaisse, 1985). Lichenized fungi are the major living group involved in this first step of the succession.

A lichen is a symbiosis between a fungus and an organism capable of photosynthesis. The name of the lichen is always the one of the fungus. This latter can associate with a green algae or a cyanobacteria, or sometimes both. This symbiosis has been successful in the evolution of life as the lichens represent now a large group with species very diverse in size, form and colour. They are found from the poles to the tropics on every kind of substrates like tree bark, leaves, rocks and soil. Some species are able to survive in very extreme environments.

The number of lichenized fungi is estimated at ca 18,000 species, compared to ca 13,500 currently accepted species. Tropical areas represent regions to be explored in priority in view of the high destruction rate of their primary natural habitats and as they obviously host a large number of the "missing" lichens (Sipman, Aptroot, 2001). Tropical Africa has been so far a very neglected region for lichen studies. Only one study on the genus *Usnea* is available for the Katanga and includes the description of three new species for science, all epiphytes

(*U. alsteeniana*, *U. katangensis* and *U. barbelata*) (Duvigneaud, 1953). No study seems to be available for the saxicolous species in the area of the Field Guide.

The lichens might be classified in categories related to the growth forms. The main categories are:

- foliose = lichens with a more or less flattened thallus with easily distinguished upper and lower surfaces;
- fruticose = lichens grow erect or are pendent; the thalli have no clearly distinguishable upper and lower surfaces;
- crustose = lichens that simply form crusts on their substrates.

The larger lichens are found in the categories "foliose" and "fruticose" and can be easily collected using a knife. The crustose lichens must be collected with the substrate; with the bark using a knife for the corticolous lichens and with the rock using a chisel and a hammer for the saxicolous lichens.

Many species, some probably undescribed, remain to be found amongst saxicolous lichens of the Katangan region. Indeed, the lichen flora of that region has never been studied in detail and no species is recorded in the area of the Field Guide despite the obvious high diversity of the group on those outcrops. The lichens represent a very neglected group that is therefore promising for future research projects.



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Kakalalwe



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Kwatebala

Parmotrema tinctorum (Nyl.) Hale

[Parmeliaceae]

Copper specimen: Mf 16590.

Habit: Thallus foliose, corticated above and below, membranaceous to coriaceous, loosely attached to substrate, pale grey to grey-green. Photobiont green. Lobes up to 2 cm wide, rounded, entire or crenate. Marginal cilia absent. Upper side emaculate, shiny, becoming dull towards the centre, cortex sometimes cracking and flaking. Medulla white.

Under side black, with a white, brown, naked marginal zone, rhizines fairly coarse, in scattered groups; isidia sparse to abundant, laminal, confluent or in scattered groups, brown tipped or concolorous with the thallus, simple or branched, usually coarse and irregularly inflated, sometimes dissolved into granular soredia. Apothecia

laminal, substipitate, disc dark brown, imperforate, or with a small perforation. Ascospores colourless, simple, ellipsoid, 13-15 x 7-8 μ m.

Chemistry: Lecanoric acid (C+red), atranorin.

Ecology: Corticolous, rarely saxicolous, common from sea level to 2,700 m altitude.

General distribution: Widespread in tropical and temperate regions. In continental Africa, known from Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Zimbabwe and South Africa. Here reported as new for D.R. Congo.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Reference: SWINSCOW, KROG [1988].



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Kwatebala

Parmotrema zollingeri (Hepp) Hale

[Parmeliaceae]

Copper specimen: Mf 16592.

Habit: Thallus foliose, corticated above and below, loosely attached to substrate, pale grey. Photobiont green. Lobes 1-1.5 cm wide, rounded, entire or weakly crenate, central lobes more or less lacinate. Marginal cilia absent. Upper side emaculate, smooth, slightly rugose in older parts. Medulla white. Under side black, with a dark brown marginal zone, rhizines short, sparse, situated in central parts of the thallus. Isidia and soredia absent. Apothecia laminal, cupuliform, shortly stipitate, disc imperforate. Ascospores colourless, simple ellipsoid, 18-22 (-24) x 8-10 µm.

Chemistry: Thallus P+ orange-red. TLC: protocetraric acid, ± fatty acids, atranorin.

Ecology: On trees in lowland woodland, more rarely on rocks.

General distribution: Widespread in the tropics. In continental Africa, known from Kenya, Tanzania and South Africa. Here reported as new for D.R. Congo.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Reference: SWINSCOW, KROG [1988].



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Kwatebala



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Kwatebala

Usnea sp.

[Parmeliaceae]

Copper specimen: Mf 16590.

Habit: Thallus fruticose, shrub-like, small, less than 5 cm tall, attached to substrate by a basal holdfast. Photobiont green. Branches greenish grey, terete, not swollen, not narrowed at joints, differentiated into cortex, medulla, and cartilaginous axis. Spinules up to 3 mm long and fibrils numerous; fibrils longer than spinules, and may develop from spinules. Pseudocyphellae numerous on branches and fibrils. Axis pale, thick. Isidia abundant on pseudocyphellae. Soredia absent. Apothecia present, terminal on branches; thalline margin bearing a fringe of fibrils. Ascospores simple.

Chemistry: The chemistry of the genus is complex. TLC of the copper specimen (psoromic and two additional yellow unidentified substances).

Ecology: Saxicolous. Abundant, luxuriant and well developed on the rocky crest of Kwatebala.

Distribution on Katangan copper sites (3 sites): Kakalalwe (38), Kwatebala (45), Fungurume (51).

Reference: SWINSCOW, KROG [1988].

Note: The genus *Usnea* contains circa 300 species worldwide. Swinscow & Krog (1988) accepted 41 species for East Africa, but the taxonomy of the genus is difficult because of a high degree of polymorphism and a complex chemistry. The genus is in need of a taxonomic revision for tropical Africa.



Fungurume



Kwatebala



Kwatebala

Heterodermia hypoleuca (Ach.) Trevis.

[Physciaceae]

Holotype: Mühlenburg 33-2.
Copper specimen: Mf 16589.

Habit: Thallus foliose. Lobes radiating, slightly disjunct or adjacent, more or less plane, not ascending, with short lateral lobes, white, greyish or brownish; upper cortex of periclinial hyphae and of uneven thickness; under side non-corticate, white. Medulla white. Rhizines branched, pale to dark brown, marginally situated. Photobiont chlorococcoid. Isidia and soredia absent. Apothecia sessile to substipitate, margin of thalline exciple crenulate. Ascospores brown, 1-septate, thick walled, 23-31 (-35) x 11-15 μm .

Chemistry: Thallus K+ yellow, C-, P-; atranorin and zeorin detected by TLC.

Ecology: Open woodland on trees (boles, large branches or twigs), on wood or more rarely on rocks.

General distribution: Africa (Ethiopia, Kenya, Tanzania, Uganda), Asia and North America. New for D.R. Congo.

Distribution on Katangan copper sites (2 sites): Katuto (41), Kwatebala (45).

Reference: SWINSCOW, KROG [1988].



Kwatebala



Kwatebala

Caloplaca cinnabarina (Ach.) Zahlbr. [Teloschistaceae]

Holotype: Forström s.n. (H-Ach 1242).
Copper specimen: Mf 16582.

Habit: Thallus crustose, reddish orange to orange, areolate, thin, 50-130 μm thick, surface smooth or slightly rugose in older parts; marginal areoles slightly elongated, usually with abruptly delimited edges; areoles flat, rarely convex. Photobiont trebouxoid. Isidia and soredia absent. Cortex paraplectenchymatous. Apothecia immersed or more or less raised in central areoles, 1-3 per areole, 100-400 μm diam., disc slightly darker orange than thallus, algae present in margin. Hymenium 40-55 μm tall. Paraphyses not or a few with branches; apex not or slightly enlarged. Asci 8-spored. Ascospores hyaline, 8.5-11 x 4 μm ; isthmus 2-3 μm .

Chemistry: Thallus K⁺ red. TLC: parietin (major), emodin, teloschistin, fallacinal, xanthorin and parietinic acid.

Ecology: On exposed and acidic rocks (foliate siliceous rocks).

General distribution: Widespread in subtropical and tropical regions (America, Africa, Asia and Australia).

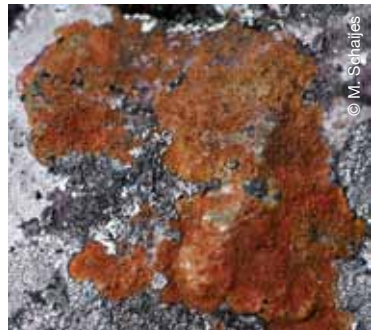
| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | XXX | X | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

In Africa, known from Côte d'Ivoire, Sudan, Swaziland, Zimbabwe and South Africa. Here reported as new for D.R. Congo.

Distribution on Katangan copper sites (12 sites): Notably Kalukundi Kii (15).

Reference: KÄRNEFELT [2003].



Kwatebala



Kakalalwe

Anthoceros caucasicus Steph. in Woronow

[Anthocerotaceae]

Holotype: Ju.N. Woronow s.n.
Copper specimens: Mf 9529, 16637a.
Syn.: *Anthoceros mandonii* Steph.

Habit: Thallus dull green, irregularly dissected into lobes, cavernous, forming partial rosettes up to 2.0 mm in diam. Monoecious. Capsule ca 1-3 cm long. Spores black, distal face with sinuate and shortly branched lamellae, proximal face with conspicuous trilete ridges bordered by a smooth band ca. 5 µm wide, lacking ornamentation, otherwise with sinuate lamellae.

Ecology: Pioneer on wet soils, e.g. under overhanging rock, near water; also small caverns in cellular

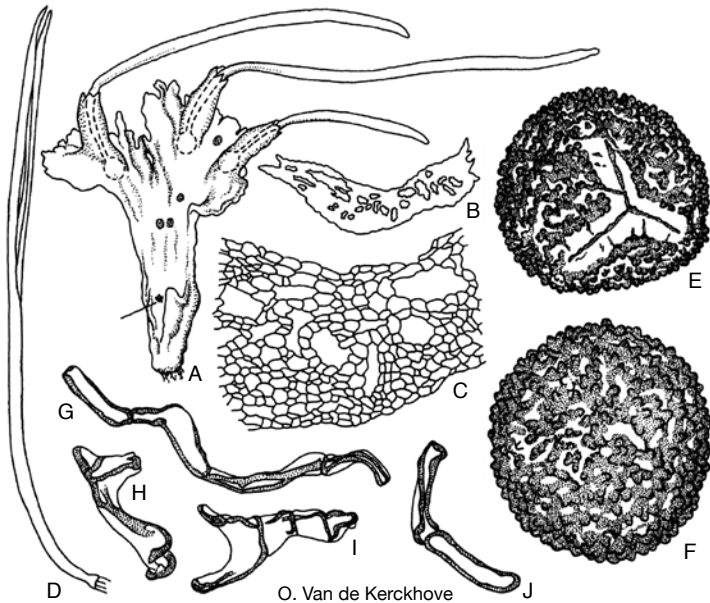
siliceous rocks (R.S.C.) with low copper content.

General distribution: Quite common in the Caucasus, Canarian Islands, Açores and Madeira. In continental Africa, only known from the Loma Mountains, Sierra Leone and Katanga (D.R. Congo).

Distribution on Katangan copper sites (1 site): Fungurume (51).

Reference: WIGGINTON (Ed.) [2004].

Note: The trilete mark, bordered by a broad smooth zone on the proximal face of the spore is a key character.



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A. Thallus with capsules and androecia (x 7.2) – B. Thallus cross-section (x 14.4) – C. Detail of thallus cross-section (x 65.5) – D. Capsule (x 11) – E. Spore, proximal face (x 680) – F. Spore, distal face (x 680) – G–J. Pseudolaters (x 250). [WIGGINTON, 2004]

Plagiochasma eximium (Schiffn.) Steph.

[Aytoniaceae]

Holotype: Preuss 731.

Copper specimen: Mf 9529.

Syn.: *Aitonia eximia* Schiffn.

Habit: Thallus robust, in gregarious patches; yellow-green, finely and irregularly areolate, air pores faintly visible, margins narrowly dark red, scalloped and undulate. Branche simple or once pseudododichotomously furcate, 16.5–22 x 5–8.5 mm, in section 7–11 times wider than thick, apex notched, with lanceolate, reddish pink or dark red scale appendages. Scales in 2 ventral rows, asymmetric, obtusely triangular. Monoecious, but male and female receptacles sometimes on separate plants. Androecia medianly at base of apical innovation of leading branch, kidney- or sausage-shaped. Gynoecial receptacles medianly near apex of branch, enclosed by arching, hyaline, tapering paleae.

Ecology: Shady kloofs, on muddy rock faces or on soil covering rocks.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | |
| | 800 | 5,000 | 5,000 | |

dry

medium X (X)

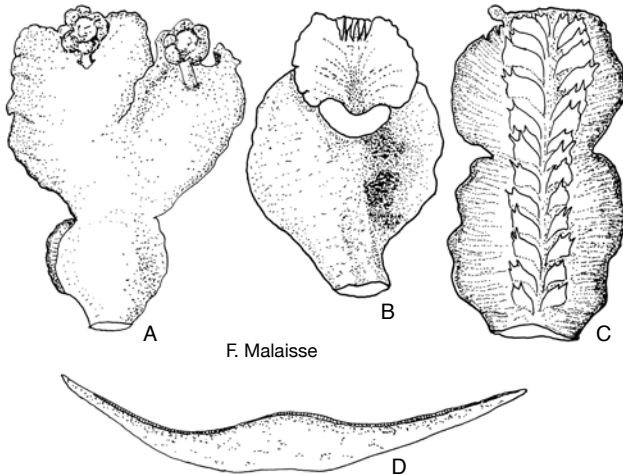
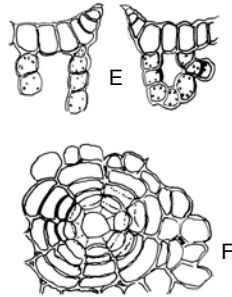
wet

→ oligocuproresistant

General distribution: Tropical Africa (from Sierra Leone to Southern Africa) extending to Arabian peninsula.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Reference: PEROLD [1999].



F. Malaisse

A. Thallus with two carpocephala (x 2.5) – B. Thallus with androecium (x 2.5) – C. Thallus ventral face (x 2.5) – D. Thallus cross section (x 11) – E. Air pore, cross section (x 50) – F. Air pore, from above (x 50).

[Drawn after PEROLD, 1999]

Cyathodium africanum Mitt.

[Cyathodiaceae]

Holotype: Hannington s.n.

Copper specimens: Mf 16636, 16639, 16640.

Syn.: *Cyathodium caverarum* Kunze (fide Srivastava & Dixit, 1996).

Habit: Thallus very thin and delicate, when fresh of a brilliant luminous green, when dry with a pearly gloss; thallus with pores, without midrib, 1-2 mm broad, repeatedly dichotomous, overlapping, making rosettes 2-4 mm radius, the ultimate lobes circa 1 mm wide. Sporangium enclosed in an involucre; female involucre beneath the sinus, smooth, lacking hairs.

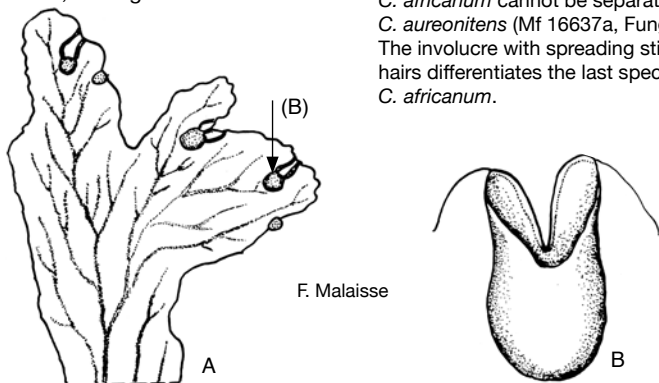
Ecology: On soil in wet nutrient-rich habitats, especially in man-made habitats. Ephemeral in regions with a strong dry season.

General distribution: Very widely distributed in West and East Africa, absent from Southern Africa.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Reference: WIGGINTON [2004].

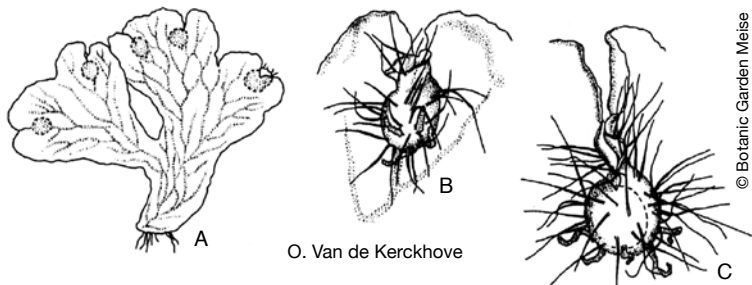
Note: *Riccia membranacea* Gott. & Lindenb. has a thallus of similar structure, but lacks the distinctive pores of *Cyathodium*. Sterile plants of *C. africanum* cannot be separated from *C. aureonitens* (Mf 16637a, Fungurume). The involucre with spreading stiff white hairs differentiates the last species from *C. africanum*.



A. Thallus dorsal view with male and female receptacles (x 14) – B. Saccate involucre *in situ* (x 34). [Drawn after G. Gondy in WIGGINTON, 2004]

Cyathodium aureonitens (Griff.) Mitt.

[Cyathodiaceae]



A. Female thallus in dorsal view with involucre (x 3) – B.C. Involucre in ventral view, with ventral scales (x 11). [WIGGINTON, 2004]

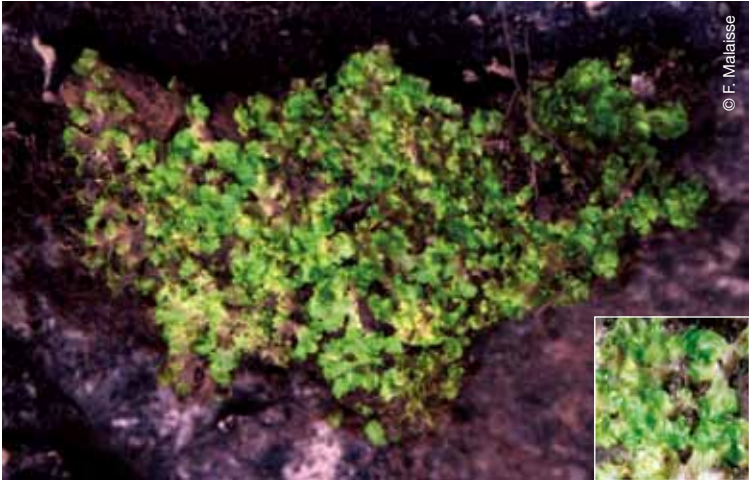
MARCHANTIOPHYTA



© F. Malaisse

Fungurume

Plagiochasma eximium



© F. Malaisse

Fungurume

Cyathodium africanum



© F. Malaisse

Fungurume

Targionia hypophylla

Targionia hypophylla L.

[Targioniaceae]

Holotype: Iralia, Hispania, Constantinopoli.
Copper specimen: Mf 9529.

Habit: Thallus medium-sized, in crowded patches; dark green, rather leathery, faintly areolate, air pore large, white-encircled, margins purple and entire to somewhat crenate. Branches simple to repeatedly furcate or with ventrolateral or apical innovations, linear to ligulate, up to 30 x 2.7-3.5 mm; in section 5 or 6 times wider than thick, apex slightly notched or entire. Androecia terminal on short, ventrolateral branches, sessile discs; antheridia embedded, opening into conical protuberances. Gynoecia ventrally displaced below thallus apex.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

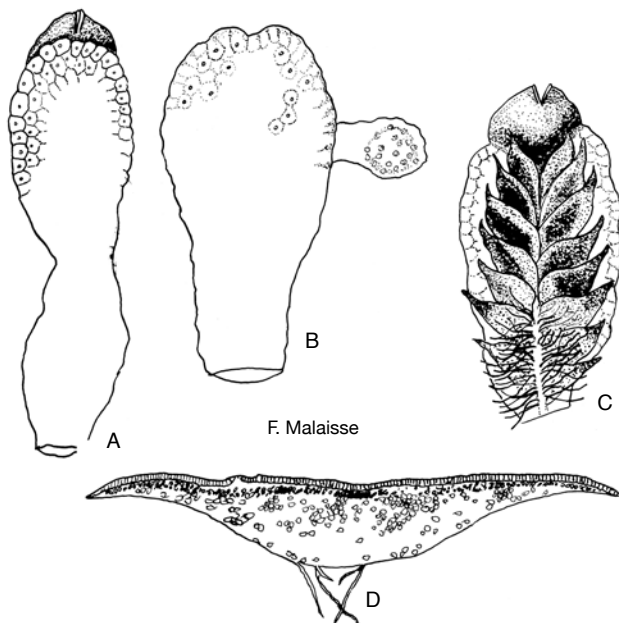
Ecology: On soil in rock crevices, on rock outcrops.

General distribution: Almost cosmopolitan, occurring mostly in temperate and seasonally dry areas.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: No evident interest.

Reference: PEROLD [1999].



A. Thallus dorsal face with tip of involucre protruding at apex (x 6.5) – B. Thallus dorsal face with short ventrally innovating branch bearing terminal disc with antheridia (x 6.5) – C. Thallus ventral face with pouch-like involucre at apex and two rows of ventral scales (x 6.5) – D. Thallus cross section (x 17).
[Drawn after PEROLD, 1999]

Brachymenium acuminatum Harv.

[Bryaceae]

Holotype: Wallich s.n.
Copper specimen: Ea 1088.

Habit: Plants minute, rather glossy. Stems short and slender, sparsely branched by subfloral innovations. Leaves closely imbricate, patent, broadly ovate to ovate-lanceolate, acuminate from below mid-leaf, about 0.6-0.9 x 0.2-0.4 mm; nerve rather strong, percurrent to shortly excurrent; margin entire, reflexed below, mid leaf and apical cells narrow, elongate rhomboidal, becoming abruptly shorter and broader nearly quadrate at the basal leaf angles. Dioicous; male plants smaller than female, perigonal leaves shorter than stem leaves; female plants with perichaetial

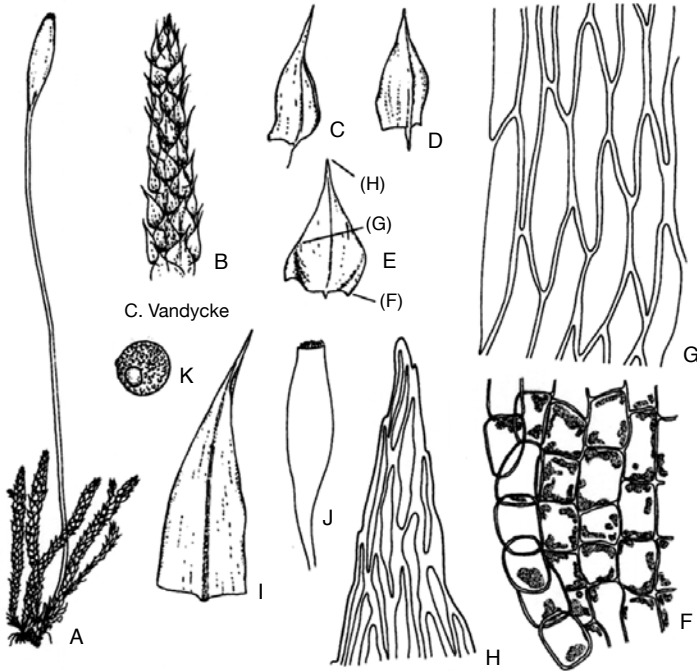
leaves longer than stem leaves. Seta 20-30 mm long; capsule erect to inclined, elongate ellipsoidal to clavate, 2.5-3.5 x 0.8-1.1 mm.

Ecology: Terricolous on earth slopes and thin soil on rocks.

General distribution: Widespread in tropical Africa, southern Africa, the East African Islands, South America, India, southeast Asia and tropical Australia.

Distribution on Katangan copper sites (1 site): Etoile (97).

References:
DE SLOOVER [2003].
MAGILL [1981].



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A. Habit (x 3.5) – B. Twig tip (x 15) – C.D.E. Leaves (x 33) – F.G.H. Leaf cells details of fig. E (x 375) – I. Perichetial leaf (x 33) – J. Capsule (x 7) – K. Spore (x 375). [DE SLOOVER, 2003]

Holotype: Hildebrandts s.n.
Copper specimen: Ea 1429.

Habit: Plant small to medium-sized, in cushions or turfs, silvery white; rhizoids red-brown; tubers absent; stems julaceous. Leaves crowded, imbricate when wet or dry, concave, broadly oval to obovate, 0.5-1.5 mm long; apex hyaline, apiculate; nerve aristate, awn to 0.85 mm long, reflexed, hyaline, denticulate. Propagula in leaf axils.

Ecology: Saxicolous, terricolous.

General distribution: Cosmopolite; in Africa, widespread in savannas.

Distribution on Katangan copper sites (1 site): Luiswishi (87).

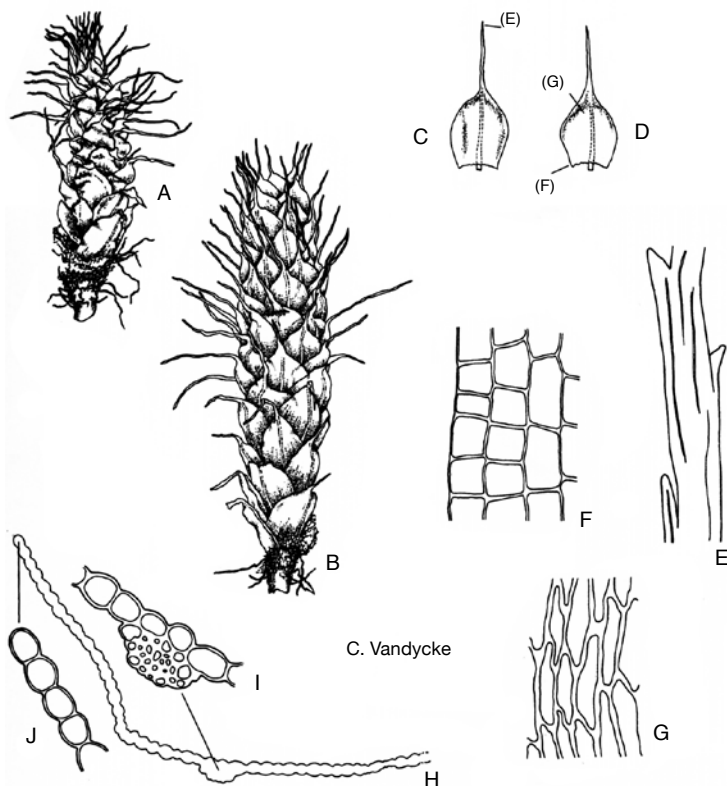
References:

DE SLOOVER [2003].

EMPAIN [1985].

MAGILL [1981].

Note: Many authors (e.g. Magill, 1981) treat these plants as a form of the cosmopolitan *Bryum argenteum* Hedw.



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C. Vandycke

A. Habit, dry plant (x 12) – B. Habit, wet season (x 12) – C.D. Leaves (x 12) – E. Detail of fig. C (x 300) – F.G. Details of fig. D (x 300) – H. Leaf cross section (x 110) – I.J. Leaf cells details of fig. H (x 300). [DE SLOOVER, 2003]

Leucobryum boryanum Besch.

[Leucobryaceae]

Holotype: Frappier s.n.

Syn.: *L. madagassum* Besch.

Copper specimen: MSK 348.

Habit: Plants large to robust, in dense cushions, glaucous-green. Stems up to 40 mm long, irregularly branched. Leaves crowded, thickened, fleshy, broadly lanceolate to oblong; lamina narrow, restricted to base, hyaline; nerve filling upper leaf, distal section with 5-8 layers of large, hyaline leucocysts, enclosing the median chlorocysts.

Ecology: Saxicolous, rocky slopes in miombo open forests of Xerobrachystegion type and around Cu-Co outcrops.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XX | (X) | | |

→ oligocuproresistant

General distribution: In Africa known from central Africa, East Africa, the East African islands and southern Africa.

Distribution on Katangan copper sites (4 sites): Notably Kwatebala (45), Kazinyanga (49).

Reference: MAGILL [1981].



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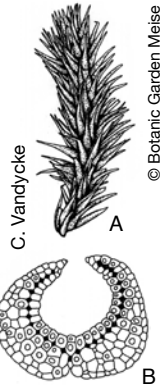


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Kwatebala



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C. Vandycke

A. Habit (x 1) –
B. Leaf transversal
section (x 42).
[DE SLOOVER, 2003]



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Kwatebala South

Lycophyta

Selaginellales

by François MALAISSE
and Béatrice LETEINTURIER



Selaginella tenerrima

Monilophyta

by François MALAISSE
and Béatrice LETEINTURIER

Ophioglossales



Ophioglossum reticulatum



Equisetum ramosissimum

Equisetales

Schizeales



Anemia angolensis

Cyatheaales



Cyathea dregei

Polypodiales



Oleandra distenta

***Selaginella goudotiana* Spring var. *abyssinica* Bizzarri**
[Selaginellaceae]

Holotype: Quantin Dillon 9.
Copper specimens: Ba-Mf 887, 2067;
Mal 126; Mf 7691, 7746; Mf-Gj 32;
Pl 5355; Tr 135.

Habit: Moss-like plant, delicate, yellowish-green, semi-erect to procumbent, not rooting along the stem, sometimes stoloniferous from the stem base, generally arranged on only one plane, elliptic in outline, 8-25 x 2.5-16 cm. Branches divided repeatedly, primary branches narrowly triangular to lanceolate; secondary branches with 2-4 branchlets, 0.5-1.0 cm long. Leaves heteromorphic; lateral leaves spreading, 1.5-3 x 0.5-2 mm, ovate to narrowly lanceolate, acute, sessile; median leaves appressed along the upper surface of the stem and branches, 0.75-2 x 0.25-1 mm, ovate to elliptic-lanceolate, acuminate to apiculate, margins ciliate-denticulate. Strobili 4-5 x 2 mm, terminal on ultimate branchlets. Sporophylls dimorphic.

Ecology: Riparian and ravine dense forests, occasionally on copper outcrops (rocky slopes in slight shade).

General distribution: Widespread in tropical Africa, from Ghana to Zimbabwe.

Distribution on Katangan copper sites (3 sites): Shadiranzoro (48), Fungurume (51), Luita (58).



Nzilo-Kyamasumba road

© M. Schallies

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |

| | |
|--------|-----|
| dry | |
| medium | (X) |
| wet | XXX |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 3-21, Co = 10-18 µg/g D.M.

Rehabilitation: No evident interest.

References:

BIZZARRI [1985].
BURROWS [1990].

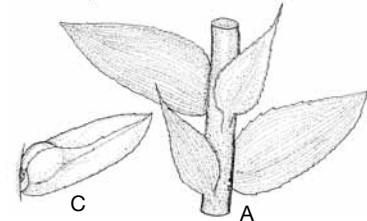


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Fungurume



F. Malaisse



A. Dorsal view of the stem with lateral and median leaves (x 9) – B. Strobilus, ventral view (x 5) – C. Sporophyll and megasporangium (x 9).

[Drawn after BIZZARRI, 1975]

Ophioglossum lancifolium

C. Presl

Holotype: Petit-Thouars s.n.
 Copper specimens: Mf 7718, 16503;
 Mf-Kk 225, 235; Sj 12207.
 Syn.: *O. lusoaffricanum* Welw.

Habit: Terrestrial fern. Rhizome linear erect; leaf single; stipe to 8 cm long; trophophore firmly herbaceous.

General distribution: Mali, Uganda, Kenya, Tanzania, Angola, D.R. Congo, Zambia, Malawi, Zimbabwe, R.S.A., Madagascar.

Distribution on Katangan copper sites (5 sites): Notably Kavifwafwaulu (42), Luiswishi (87), Kasonta (91).

Ecology (both taxa): Shallow soils overlying rocks, seasonally wet sites.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XXX | XX | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation (both taxa):

No evident interest.

Ophioglossum lancifolium pictures



Katuto

Etoile

Etoile

© F. Billiet

Ophioglossum thomasi

R.T.Clausen

[Ophioglossaceae]

Holotype: Thomas 1903.
 Copper specimen: Ba-Mf 302.

Habit: Terrestrial fern. Rhizome minute, 1-4 mm long, leaf one, almost prostrate on the ground, petiole 2-5 mm long.

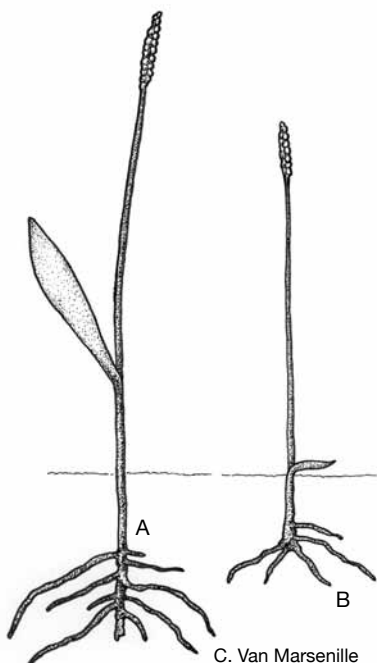
General distribution: Liberia, Côte d'Ivoire, Niger, Cameroon, Uganda, Tanzania, D.R. Congo, Zambia, Malawi, Zimbabwe, R.S.A., Madagascar.

Distribution on Katangan copper sites (1 site): Etoile (97).

References (both taxa):

BURROWS [1990].

KORNAŠ et al. [2000].



C. Van Marsenille

A. *Ophioglossum lancifolium*, habit (x 0.5) –
 B. *Ophioglossum thomasi*, habit (x 0.7).

[Original plate]

***Ophioglossum reticulatum* L.**

[Ophioglossaceae]

Iconotype: Plumier s.n.
Copper specimen: MHK 288.

Habit: Rhizome linear to oval, 10-22 mm long, arising from a strong, horizontal root. Leaves base not persistent. Leaves 1-(2), held well above ground level, usually 70-30 degrees from the horizontal; petiole 6-16 cm long, 25-50% of its length subterranean; sterile lamina orbicular to broadly ovate, base cordate, truncate in immature specimens, apex broadly acute with a short mucro or obtuse; texture coriaceous, fleshy. Fertile spike 8-25 cm long, inserted at the lamina base, or on a flared petiole 2 cm below the base sinus; sporangia 20-45 pairs, apex sharply acute to apiculate.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | (X) | (X) | | |
| medium | X | | | |
| wet | X | | | |

→ oligocuprophyte

Ecology: Seasonally wet sites, forest margins, rocky outcrops, salt site.

General distribution: Pantropical, but sporadic distribution. Widespread in tropical Africa, South Africa and Mauritius.

Distribution on Katangan copper sites (1 site): Katuto (41).

References:

BURROWS [1990].
KORNAŚ et al. [2000].



Katuto



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Equisetum ramosissimum Desf. subsp. ***ramosissimum***
[Equisetaceae]

Holotype: Desfontaines s.n.
Copper specimens: Ba-Mf 26; Mf 6579,
7167, 16115, 16186; Sj 13430.

Habit: Perennial fern; subterranean stems blackish, usually branching into horizontal stems; aerial portion of the stems hollow, conspicuously longitudinally ribbed, usually 50 cm tall; leaves reduced to a short sheath above each node, 1 cm long, consisting of fused vascular strands and subtended by 12-16 scale-like teeth situated in whorls. Strobili terminal on the main axis, more frequently on the branches, generally rarely produced in our area, up to 23 x 8 mm with a blunt, conical apex.

Ecology: Usually along streams and rivers in sandy soils, in seasonally flooded sites.

General distribution: Southern and Central Europe; Africa, with diverse gaps; temperate warm and sub-tropical Asia as far as Japan.

Distribution on Katangan copper sites: The taxon occurs in Katanga on heavy metals wet polluted sandy soils along river banks, down stream of copper plants (Lubumbashi, Musonoi).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 66, Co = 59 µg/g D.M.

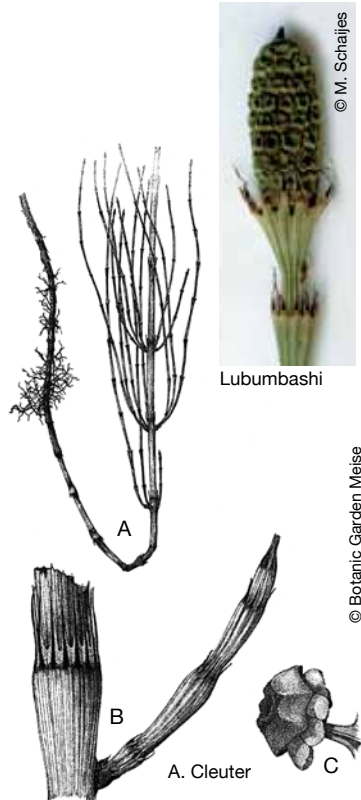
Rehabilitation: Of great interest for wet, seasonally flooded, heavy metal polluted sites.

Reference: LAWALRÉE [1969b].



Musonoi river

© F. Malakse



Lubumbashi

© M. Schatjies

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A. Portion of stem (x 0.2) – B. Foliar sheet (x 2) – C. Sporophyll (x 6).

[LAWALRÉE, 1969]

Anemia angolensis Alston

[Anemiaceae]

Holotype: Welwitsch 164.
Copper specimens: Ba-Mf 819;
Mf 10227, 10338.

Habit: Horizontal rhizome bearing chestnut to auburn hairs. Fronds 15–40 cm, tufted, erect. Sterile fronds 7–17 cm long, triangular, subcoriaceous, with 13–29 primary divisions. Fertile pinnae 3-pinnate.

Ecology: Usually among rocks and on termite mounds.

General distribution: From Angola to Tanzania, and southwards to Zimbabwe.

Distribution on Katangan copper sites (14 sites): Kalukundi (16), Tilwezembe (20), Menda (28), Kwatebala (45), Fungurume (51), Luita (58), Shinkolobwe (67), Kambove (71), Kamoya (72), Luishia (77), Kipushi (90), Karavia (95), Etoile (97), Kimpe (102).

Phytochemochemistry: Cu-Co content of leaves (2 samples): Cu = 8–9, Co = 36–97 µg/g D.M.

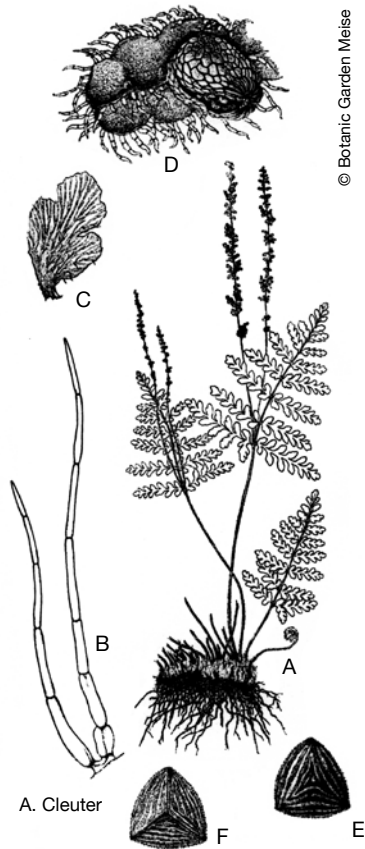


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Nzilo-Kyamasumba road

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XXX | XX | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: No evident interest.**Reference:** LAWALRÉE [1970].

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A. Habit (x 0.25) – B. Rhizome hair (x 25) – C. Part of sterile frond, upper face (x 0.2) – D. Part of fertile frond, with sporangia (x 25) – E–F. Spores (x 100).

[LAWALRÉE, 1970]

Mohria lepigera (Baker) Baker

[Schizeaceae]

Holotype: Kirk s.n.

Copper specimens: Ba-Mf 372bis, 374, 886, 904, 905; Mf 10235; MKS 81.

Syn.: *Notholaena lepigera* Baker

Habit: Perennial fern; rhizome shortly creeping, 5 mm in diam., with closely spaced, erect fronds. Rhizome scales up to 2 mm long, ovate-lanceolate, pale brown, entire. Stipe 5-130 mm long, pale brown, set with broad whitish scales. Lamina elliptic to oblanceolate, 13-48 x 2-5.5 cm; 2-pinnate to 3-pinnatifid; pinnae narrowly oblong, ultimate segments incised into crenate lobes, under-surface set with broad, whitish, lanceolate scales; frequently covering all the lower surface. Sporangia solitary, sub-marginal, in each lobe serration.

Ecology: Rocky slopes, mostly copper steppe savannas.

General distribution: D.R. Congo, Zambia, Malawi, Mozambique, Zimbabwe.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X | <X | | |
| | 800 | 5,000 | | |
| dry | X | XX | (X) | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (10 sites): Shabara (24), Kwatebala (45), Kazinyanga (49), Fungurume (51), Kela (52), Kankuru (56), Luita (58), Mindigi (60), Shinkolobwe (67), Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 17-455, Co = 143-196 µg/g D.M.

Rehabilitation: No evident interest.

References:

BURROWS [1990].

LAWALRÉE [1970a].



Kwatebala



Shadirandzoro



Dikuluwe

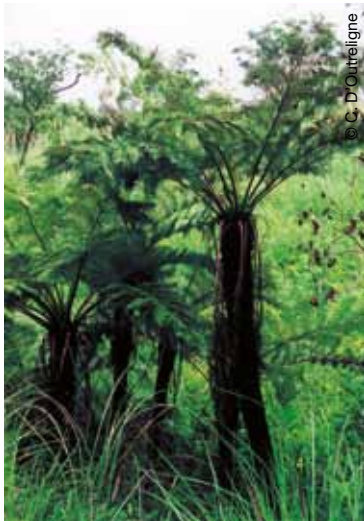
Cyathea dregei Kunze

[Cyatheaceae]

Holotype: Drège s.n.
Copper specimen: Tr 305.

Habit: Arborescent plant with an erect stout caudex (trunk), up to 45 cm in diam. and 5 m tall, topped by whorls of fronds, arching, thinly to thickly coriaceous. Stipe 30–45 cm long, pale matt brown, slightly rough to the touch and densely clothed around the base in long, brown, shiny, twisted scales with long, attenuate apices; lamina up to 2 m long, 3-pinnatifid to 3-pinnate; pinnae narrowly oblong, acute up to 56 x 19 cm, with the ultimate lobes adnate along the costules; ultimate lobes narrowly oblong, acute, somewhat falcate, margins entire to minutely crenate, rachis pale brown, smooth. Sori round, 1 mm in diam., cup-shaped, with the sporangia rather like many little eggs in an egg-cup, borne in two rows along each side of the costule, up to 10 sori per lobe; indusium shallowly to deeply cupuliform.

Ecology: Riverine forests, open stream-banks, rarely in full sun.



Kolwezi-Musokatanda road

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | | |
| medium | X | | |
| wet | XX | | |

→ oligocuproresistant

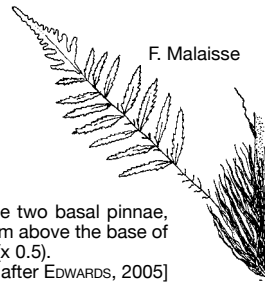
General distribution: Guinea, Sierra Leone, Ghana, Nigeria, Bioko, Cameroon, Congo, Burundi, Uganda, Tanzania, Angola, D.R. Congo, Zambia, Malawi, Zimbabwe, Mozambique, Swaziland, Lesotho, R.S.A., Madagascar.

Distribution on Katangan copper sites (1 site): Swambo (62).

Rehabilitation: No evident interest.

References:

- BURROWS [1990].
KORNAŚ et al. [2000].
SCHELPE, ANTHONY [1986].



One of the two basal pinnae, from 10 cm above the base of the stipe (x 0.5).

[Drawn after EDWARDS, 2005]



Manika plateau

Actiniopteris kornasii Medwecka-Kornas

[Actiniopteridaceae]

Holotype: Mf 11751.

Copper specimens: Ba-Mf 822;

Dp 5437 Pt; Mf 11751; Mf-Re 2070;

Tr 278, 296.

Habit: Dwarf compact caespitose fern. Rhizome-scales narrowly triangular, concolorous, thin, fully membranous. Fertile and sterile fronds of similar shape, 17–40 mm length, stipe 11–25 mm length, lamina 0.6–1.6 mm length, lamina narrowly flabellate with 1–4 segments; apex acute, obtuse or with 2 teeth.

Ecology: Shady rock crevices and vertical rock faces, with copper mineralization.

General distribution: Restricted to the central part of the Katangan Copper Belt.

Distribution on Katangan copper sites (2 sites): Mindigi (60), Shinkolobwe (67).

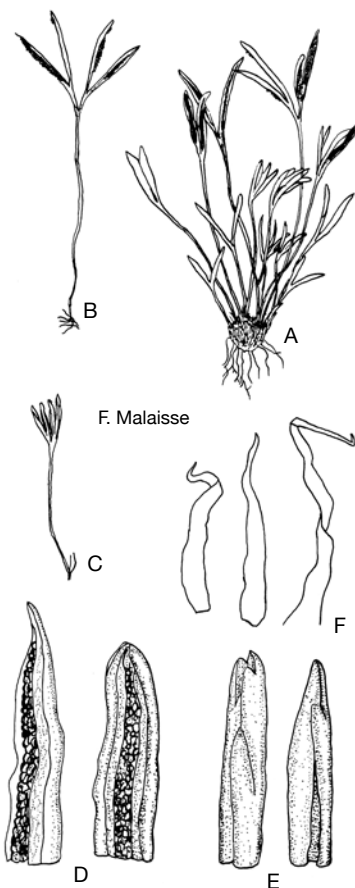
Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = (83) 2,600–3,500, Co = 15–98 µg/g D.M. Copper hyperaccumulator; needs confirmation.

Rehabilitation: No evident interest.

Reference: MEDWECKA-KORNAS [1999].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-----|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| dry | X | XX | X | |
| medium | | | | |
| wet | | | | |

→ polycuprophyte



Shinkolobwe milestone XIII

A. Habit (x 1) – B. Fertile frond (x 1.2) – C. Sterile frond (x 1.2) – D. Apex fertile frond (x 7) – E. Apex sterile frond (x 8) – F. Rhizome scales (x 5.5).

[Drawn after MEDWECKA-KORNAS, 1999]

Actiniopteris pauciloba Pic.Serm.

[Actiniopteridaceae]

Holotype: Welwitsch 79.

Copper specimens: Bo-Mf 2061;

Mf 10358.

Habit: Dwarf compact caespitose fern. Rhizome creeping, with densely tufted fronds and numerous old persistent stipe bases; rhizome scales linear, attenuate, entire, black, with or without a pale margin, up to 4.5 mm long; fronds strongly dimorphous, the fertile fronds being about twice as long as the sterile fronds, sterile fronds with stipe 25-120 mm long, straw-coloured, blackish basally, glabrous; lamina pseudo-palmate, up to 45 mm long and 80 mm wide, dividing dichotomously into 8-13 narrow segments, each segment terminating in an obtuse apex which is finely toothed; fertile fronds with stipe 90-260 mm long; lamina similar to the sterile frond, up to 50 mm long and 100 mm wide, dividing into 8-16 segments, each segment ending in a single, attenuate point; sori linear along each segment, sub-marginal, indusiate.

Ecology: Lithophyte, on rocky slopes and on siliceous cellular rocks.

General distribution: Angola, D.R. Congo (Katanga), Tanzania, Zambia, Zimbabwe.

Distribution on Katangan copper sites (5 sites): Dikuluwe (2), Kavifwafwaulu (42), Fungurume (51), Kakanda (59), Kamoya (72).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 8-28, Co = 7-56 µg/g D.M.

Rehabilitation: No evident interest.

Note: The copper specimens are referred to *A. pauciloba* var. *stricta* Medwecka-Kornaś by Kornaś et al. [1999].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | XX | X | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

References:

KORNAŚ et al. [2000].

MEDWECKA-KORNAŚ [1999].



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Kavifwafwaulu

Adiantum lunulatum Burm.f.

[Adiantaceae]

Holotype: Sloane 163.
Copper specimens: Mf 10344;
Mf-Re 2151.
Syn.: *A. philippense* L.

Habit: Rhizome erect or prostrate with tufted fronds; stipe up to 20 cm long, shiny dark brown or black, glabrous; lamina lanceolate, up to 36 x 11 cm, pinnate, with up to 15 pairs of pinnae, either with a terminal pinna or with a proliferating bud on apical extension of the rachis; pinnae petiolate, lunulate, up to 5 x 2 cm, glabrous, texture membranous, margins entire but incised, petiole slender, black, up to 2 cm long, sori along the distal margins; indusium entire, glabrous, not apparent when the sori are mature.

Ecology: Terrestrial or lithophyte, in several habitats, often on termite mounds; also on copper siliceous cellular rocks.

General distribution: From West Africa throughout tropical Asia and the East Indies.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | (X) | | |
| medium | X | | | |
| wet | X | | | |

→ oligocuprophyte

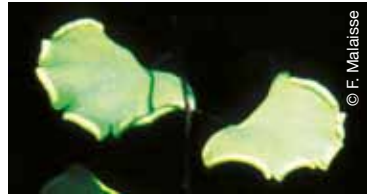
Distribution on Katangan copper sites (1 site): Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 70, Co = 25 µg/g D.M.

Rehabilitation: No evident interest.

References:

BURROWS [1990].
KORNAŠ et al. [2000].



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Near Fungurume



A. Habit (x 0.2) – B. Pinna (x 0.5).

[Original plate]

Pellaea longipilosa Bonap.

[Adiantaceae]

Holotype: Schantz 944.

Copper specimens: Ba-Mf 815, 890;
Mf-Gj 83; MKS 961; MMK 9; Tr 282.

Habit: Perennial, rhizome up to 8 mm in diam., short, creeping, with tufted fronds and with narrowly linear subentire dark-brown rhizome-scales 4-5 mm long with paler margins. Stipe castaneous to ebenous, up to 25 cm long, terete. Frond erect coriaceous. Lamina up to 39 x 12 cm, simply pinnate or 2-pinnate; pinnae and pinnules of lower pinnae in 2-pinnate fronds, linear to lanceolate or oblong, entire with cordate bases, up to 5.5 x 1 cm, articulated at the apex of the petiole or petiolule.

Ecology: Lithophyte, on or between rocks and boulders, on rocky slopes, mostly in open woodlands, also in rocky sites of copper steppe savannas; often in full sunlight.

General distribution: Sudan, Uganda, Kenya, Tanzania, D.R. Congo, Zambia, Malawi, Mozambique, Zimbabwe.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | X | |
| medium | | | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (6 sites): Kavifwafwaulu (42), Kwatebala (45), Shadirandzoro (48), Fungurume (51), Luita (58), Shinkolobwe (67).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 6, Co = 14 µg/g D.M.

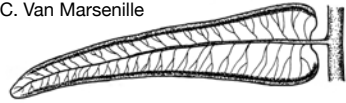
References:

BURROWS [1990].

KORNAŚ et al. [2000].

SCHELPE [1973].

C. Van Marsenille



Fertile pinna (x 1).

[Original plate]



Shadirandzoro



Kavifwafwaulu



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Pellaea pectiniformis Baker

[Adiantaceae]

Holotype: Welwitsch 191.
Copper specimens: Ba-Mf 820, 884,
2060; DKM 341; Mf 7744, 10336,
10448; Mf-Re 2385; Pl 5554.
Syn.: *P. goudotii* C.Chr.

Habit: Perennial fern; rhizome prostrate to shortly creeping, circa 5 mm thick, with tufted fronds; rhizome scales brown, subentire, narrowly lanceolate, minutely serrulate, up to 3 mm long. Stipe atrocastaneous, up to 25 cm long, terete, thinly pubescent with short appressed hairs and a few pale subulate scales, becoming subglabrous with age. Frond erect thinly coriaceous. Lamina very narrowly elliptic to lanceolate, 10-30 x 4-9 cm, pinnate, 9-40 pairs of narrowly lanceolate to linear pinnae. Pinnae up to 5 x 0.4 cm, with a cordate base, glabrous above, sparsely pilose below mainly along the costae, petiolulate, articulated, venation obscure. Sori marginal, in a continuous line at maturity; indusium continuous, erose, membranous.

Ecology: Lithophytic, on or between rocks and boulders, on rocky slopes,



Chibuli hill (Zambia)

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | X | |
| medium | X | | |
| wet | | | |

→ oligocuproresistant

mostly in open woodlands, rarely in rocky sites of copper steppe savannas.

General distribution: Tropical Africa (from Gabon to Tanzania) and southwards to Namibia and R.S.A., Madagascar and Comoro Islands.

Distribution on Katangan copper sites (11 sites): Notably Dikuluwe (2), Fungurume (51), Disele (55), Luita (58), Shinkolobwe (67), Sokoroshe (83), Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 5-266, Co = 7-40 µg/g D.M.

Rehabilitation: No evident interest.

Note: A dwarf form characterized by a reduced number of pinnules (≤ 12) and their length/width ratio below 5 has been observed in many sites of the Tenke area, notably Kakavilondo hill.

References:

BURROWS [1990].
SCHELPE [1973].



Mambilima



Kakavilondo

Pityrogramma calomelanos (Sw.) Link. var. ***aureoflava***
(Hook.) Weath. ex Bailey [Adiantaceae]

Holotype: Seemann 948.

Copper specimens: LMM 53, 213, 222, 259, 452; Mf-Kk 177; Tr 187.

Habit: Rhizome erect to procumbent, up to 10 mm thick, with tufted, arching fronds rhizome scales pale brown, linear, entire, up to 4 mm long; stipe 60-360 mm long, black; lamina 140-370 x 70-140 mm, ovate to lanceolate in outline, 2-pinnatifid to 3-pinnatifid on the proximal portion of the basal pinnae; pinnae oblong-lanceolate to narrowly lanceolate, lobe margins shallowly serrated, dark green above, covered with a yellow powder below, glabrous on both surfaces; rachis as for stipe; sori ca 3 mm long, set along the veins in the outer half of the lamina between costule and margin, often obscure by the yellow farina, exindusiate.

Ecology: Terrestrial, on open rocky slopes, including disturbed copper sites.

General distribution: Native of South and Central America, but currently naturalized in Southern Africa and many other tropical areas.

Distribution on Katangan copper sites (4 sites): Mupine (4), KOV (9), Myunga (18), Luita (58).

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | 800 | 5,000 | |
| wet | X | X | |

→ oligocuproresistant

Also on copper polluted wet sites (Kingamyambo).

Distribution on Zambian copper sites (3 sites): Bwana Mkubwa (145), Roan Antelope (147), Luanshya (149).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 27, Co = 18 µg/g D.M.

Rehabilitation: No evident interest.

References:

BURROWS [1990].

KORNAŠ et al. [1990].



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Luanshya mine



Musonoi river

Asplenium buettneri Hiern

[Aspleniaceae]

Holotype: Baumann 42.
Copper specimens: Mf-Gj 87;
Mf-Kk 762.

Habit: Rhizome creeping, with subulate dark-brown entire rhizome-scales. Frond erect, not proliferous, thinly coriaceous. Stipe up to 18 cm long, set with dark clathrate lanceolate scales. Lamina up to 25 x 12 cm, narrowly oblong to triangular-ovate in outline, acute. Pinnae up to 7 x 3.5 cm, rhombic above, serrate segments at the base. Rachis black dorsally, green and sulcate ventrally. Sori up to 8 mm long, linear; indusium linear, membranous, entire.

Ecology: Lithophytic on rocky outcrops, terrestrial and epiphyte in dry evergreen forests and forest galleries.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | XX | | | |

→ oligocuproresistant

General distribution: Guinea, Ghana, Togo, Cameroon, Nigeria, Gabon, Tanzania, D.R. Congo, Zambia, Malawi, Zimbabwe and Mozambique.

Distribution on Katangan copper sites (2 sites): Zikule (30), Fungurume (51).

Reference: SCHELPE [1970].



Kamakonka



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Zikule



Asplenium formosum Willd.

[Aspleniaceae]

Holotype: Willdenow 19908.

Copper specimens: MSK 350; SMS 4760.

Habit: Rhizome 3 mm in diam., erect, with tufted fronds and with brown lanceolate attenuate rhizome-scales up to 3 mm long, with a dark central stripe and pale entire borders. Frond slightly arching, not proliferous, chartaceous. Stipe atrocastaneous, short, with the reduced basal pinnae almost reaching the rhizome. Lamina very narrowly lanceolate to linear, 10-31 x 1.5-3.5 cm, pinnate to 2-pinnatifid. Pinnae up to 1.8 x 0.7 cm, up to 48 pairs which gradually taper in size to the base; pinnae shortly petiolate, narrowly oblong-rhomboid, straight and entire on the basiscopic margins and deeply incised on the acroscopic margins, glabrous on both sides. Rachis glabrous, blackish, with a narrow green wing running along each side. Sori up to 3 mm long, 1-3 per segment, oblong, all facing acroscopically; indusium narrow-elliptic, membranous, entire.



Mambilima

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | X | | |
| wet | X | (X) | |

→ oligocuproresistant

Ecology: Lithophytic or terrestrial, on vertical rock faces, in forest galleries, ravine dry evergreen forest; banks of forest galleries; rare on rocks of cupriferous sites overhanging permanent streams.

General distribution: Widespread in Central and South tropical America, tropical Africa (Guinea, Liberia, Sierra Leone, Côte d'Ivoire, Togo, Nigeria, Cameroon, Angola, D.R. Congo, Burundi, Kenya, Tanzania, Zambia, Malawi, Zimbabwe and Mozambique), Madagascar, India and Sri Lanka.

Distribution on Katangan copper sites (1 site): Mambilima (50).

Rehabilitation: No evident interest.

References:

BURROWS [1990].

ROUX [2001].

SCHELPE [1970].



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Holotype: Zeyher s.n.

Copper specimen: Pi-Kk 4611.

Habit: Rhizome widely creeping, branched, up to 4 mm thick, with long filiform roots and widely-spaced fronds, densely clothed in scales; rhizome scales appressed, shining, light brown, with a darker area at the point of the attachment, narrowly lanceolate, up to 7 mm long, margins ciliate; fronds arching to rarely erect, deciduous; stipe 10–60 mm long, pale brown, distinctly articulated near the base, variously covered with scattered scales, similar to those on the rhizome, but smaller; lamina simple, linear-lanceolate to oblong-elliptic, 14–300 x 5–53 mm, apex caudate, rarely acute, base oblique or cuneate, margins subentire but irregular, undulate; texture thinly membranous when dry, glabrous on both surfaces, venation obvious, finely parallel, free; midrib raised below; sori in a rather irregular row up each side the midrib, within the inner half of the lamina, 2–6 mm distant from the midrib, round, 1–2.5 mm

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | | 5,000 |
| | | 800 | 5,000 | |
| dry | X | (X) | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

in diam. at dehiscence; indusium reniform, dark brown, round, entire, drawn into the sori at maturity.

Ecology: Riparian and ravine forests, lithophyte on rock faces, very rarely on cellular siliceous rocks (RSC) type.

General distribution: Tropical Africa, Madagascar, the Mascarene Islands, Seychelles and the Comoro Islands.

Distribution on Katangan copper sites (2 sites): Pumpi (29), Katuto (41).

References:

BURROWS [1990].

KORNAŚ et al. [1990].

SHELPE [1970].



Katuto



© F. Malaisse

Pteridium aquilinum* (L.) Kuhn subsp. *centrali-africanum

Hieron.

[Dennstaedtiaceae]

Syntypes: From Angola, Congo, Tanzania and Zambia.

Copper specimens: Ba-Mf 806; Mf 5395, 10774.

Habit: Rhizome ca 1 cm in diam., creeping, subterranean. Stipe woody, brown, swollen just above ground level. Fronds erect, 0.4-1.5 m tall, with basal pinnae about as long as the lamina; largest pinnule segments pinnatifid and long-caudate or linear entire; frond 3-pinnate to 4-pinnatifid; the pinnae in the upper half of the frond mostly 2-pinnate with long, narrow terminal segments at the tip of each pinna; lower surface subglabrous to pubescent.

Ecology: Open miombo woodlands, also on fringe of copper steppe savannas.

General distribution: Angola, D.R. Congo, Kenya, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (3 sites): Swambo (62), Shinkolobwe (67), Luiswishi (87).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 24, Co = 7 µg/g D.M.

Rehabilitation: No evident interest.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XXX | X | | |

→ oligocuproresistant

References:

BROOKS, MALAISSE [1985].

BURROWS [1990].

SCHELPE [1970].



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Shadirandzoro



Near Musonoi river



Arthropteris anniana Lawalrée

[Nephrolepidaceae]

Holotype: Antun-Gupffert 933.
Copper specimen: MKS 988.
Syn.: *A. monocarpa* Auct. non
(Cordem.) C.Chr.

Habit: Rhizome ca 2.5 mm in diam., widely creeping. Fronds arching, thinly herbaceous, green greyish. Stipe up to 23 cm long, articulated in the lower half; lamina 11-48 x 5-17 cm, oblong-lanceolate. Second division lanceolate, up to 16 on each side, up to 1 x 0.3 cm; median nerve with an angle of 50-60° with the median nerve of first division.

Ecology: Lithophyte, on rocky slopes and on siliceous cellular rocks.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | XX | (X) | | |
| medium | | | | |
| wet | | | | |

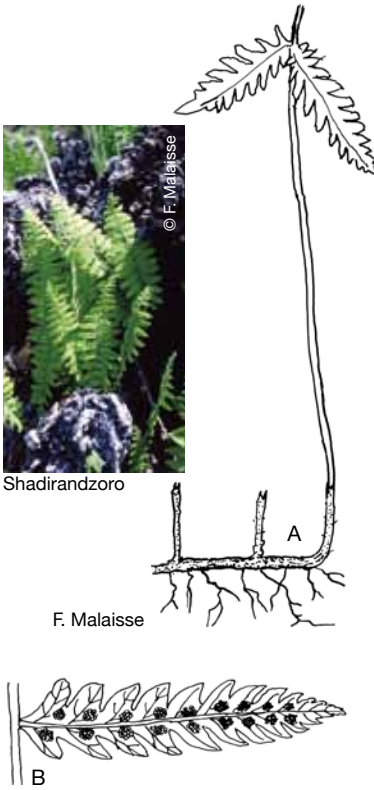
→ oligocuproresistant

General distribution: From Guinea to Ethiopia and southwards to Zimbabwe and Malawi, Madagascar.

Distribution on Katangan copper sites (2 sites): Shadiranzoro (48), Mambilima (50).

Rehabilitation: No evident interest.

Reference: LAWALRÉE [1990].



Shadiranzoro

F. Malaisse

A. Habit (x 0.7) – B. Fertile pinna (x 2).

[Drawn after SCHELPE, 1970]



Shadiranzoro

Nephrolepis undulata (Afzel. ex Sw.) J.Sm.

[Nephrolepidaceae]

Holotype: Afzelius in herb. Swartz.

Copper specimens: Ba-Mf 811; Mf 10345, 10660, 10783; MKS 663; Sj 13979; Tr 78.

Syn.: *N. cordifolia* Auct. non (L.) Presl.

Habit: Perennial fern; rhizome very short, stoloniferous, with the roots forming tubers up to 25 mm long. Fronds erect or arching, stipe up to 16 cm long; lamina pinnate, linear in outline; pinnae closely spaced or overlapping, narrowly oblong, attenuate-acute, margins entire or crenate towards the pinna apex, texture thin membranaceous, glabrous on both surfaces. Sori lunate to reniform, 1.5 mm wide; indusium entire, opening towards the pinna apex.

Ecology: Terrestrial or low level epiphyte, from fringing forests to miombo woodlands, mainly on high termite mounds, also on disturbed copper polluted soils.

General distribution: Tropical Africa.

Distribution on Katangan copper sites (7 sites): Kabwelunono (34), Mambilima (50), Fungurume (51),

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

Swambo (62), Shinkolobwe (67), Kasongwe (76), Lukuni (86). Also on old furnace sites (Luishia, Mwanamumba).

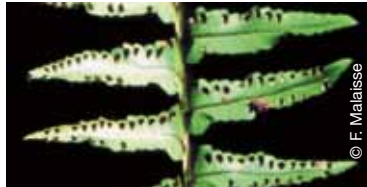
Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 13-98, Co = 9-45 µg/g D.M.

Rehabilitation: Of some interest for open heavy metal polluted sites.

References:

BURROWS [1990].

LAWALRÉE [2000].



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Near Fungurume



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A. Indusium (x 7)
– B. Sporangium (x 90).

[LAWALRÉE, 2000] Near Fungurume



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Nzilo-Kyamasumba road

Lepisorus excavatus (Bory ex Willd.) Ching

[Polypodiaceae]

Holotype: Willdenow 19619.

Copper specimen: MHK 289.

Syn.: *Pleopeltis excavata* (Bory ex Willd.) Sledge

Habit: Rhizome widely creeping, up to 5 mm thick, with a whitish, waxy covering. Rhizome scales shiny, brown, with slightly paler, entire margins, lanceolate, acuminate, up to 4 mm long; fronds spaced ca 1 cm apart, erect, deciduous; stipe yellowish, 2-9 cm long, subglabrous with occasional, scattered, small brown scales; lamina simple, 15-35 x 1.3-4 cm, very narrowly oblong-elliptic to lanceolate, apex acute to acuminate, base narrowly cuneate, margins entire to wavy, texture thinly membranous, glabrous on both surfaces. Sori round, 1.5-3 mm, situated in the distal half of the lamina, exindusiate.

Ecology: Epiphytic, occasionally lithophytic; in fringing, riparian, swamp and ravine evergreen

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | (X) | |
| wet | XX | | |

→ oligocuproresistant

forests, miombo open forests and woodlands, rocky outcrops and scarps, including copper sites.

General distribution: Most of tropical Africa, as far south as Zimbabwe, Mozambique and the eastern Transvaal, Indian Ocean Islands, Madagascar.

Distribution on Katangan copper sites (2 sites): Katuto (41), Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.

References:

BURROWS [1990].

KORNAŠ et al. [2000].



Kavifwafwaulu



Katuto



© F. Matisse

***Pteris vittata* L.**

[Pteridaceae]

Holotype: Osbeck s.n.

Copper specimens: Ba-Mf 1605; LMM 9; Mf-Re 66; Nn 1099; Sj 13043; Tr 56.

Habit: Rhizome creeping, up to 8 mm in diam., set with linear-lanceolate, pale brown rhizome-scales. Fronds spaced up to 1 cm apart, erect to arching; stipe pale brown, terete, up to 12 cm long; lamina elliptic oblong, up to 120 x 4 cm, simply pinnate, tapering towards base, pinnae linear-attenuate, up to 16 x 1.4 cm, glabrous; veins free. Sori in sub-marginal lines; indusium membranous, subentire.

Ecology: Terrestrial, rarely lithophyte, in riparian and swamp forests; also in some old copper mines, mostly in rock crevices.

General distribution: Angola, D.R. Congo (Katanga), Tanzania, Zambia, Malawi, Northern Zimbabwe.

Distribution on Katangan copper sites (5 sites): Goma (33), Swambo (62), Tantara (63), Lukuni (86), Etoile (97). Also on wet heavy metal polluted soils (Kinganyambo, Luilu river banks, surroundings Etoile mine).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | X | | |
| medium | X | | | |
| wet | XX | X | | |

→ oligocuproresistant

Distribution on Zambian copper sites (1 site): Roan Antelope (147).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 32-76, Co = 5-22 µg/g D.M.

Rehabilitation: This metallophyte fern is of great interest for wet heavy metal polluted sites. It is dynamic, develops a close vegetation mat, with high landscape value and good ability for soil stabilization. Hyperaccumulation of arsenic and colonisation of arsenic mine dumps (Zimbabwe) and of wastes of gold mines (Ghana) has been reported for this fern.

Reference: MA et al. [2001].



Roan Antelope

© B. Letintungr

Cheilanthes angustifrondosa Alston [Sinopteridaceae]

Holotype: Milne-Redhead 4074.
Copper specimens: Ba-Mf 1144, 2057;
Mf 10340; MKS 98; Mf-Re 2158.

Habit: Rhizome 1 cm in diam., creeping, with tufted fronds and brown subulate rhizome-scales 5 mm long, with a dark central stripe and pale margins. Stipe castaneous to black, up to 14 cm long, glabrous, very shallowly sulcate. Frond erect, firmly herbaceous. Lamina up to 49 x 8.5 cm, very narrowly elliptic in outline, 2-pinnatifid to 3-pinnatifid; pinnae up to 6 x 2.8 cm, broadly lanceolate, acute-acuminate; pinnae segments up to 1 x 0.35 cm, narrowly oblong, obtuse, crenate, sinuate to pinnatifid, glabrous, veins obscure; rachis and costae in lower half of pinnae, castaneous, glabrous. Sori minute, less than 1 mm in diam., on the margins of the pinna segments; indusium minute, membranous entire.

Ecology: Mostly lithophytic, on rocky slopes, among rocky blocks, on cupriferous siliceous cellular rocks.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | (X) | |
| medium | | | |
| wet | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Mozambique.

Distribution on Katangan copper sites (4 sites): Pumpi (29), Katuto (41), Fungurume (51), Shinkolobwe (67).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 17, Co = 14 µg/g D.M.

References:
KORNAŚ et al. [2000].
SCHELPE [1970].



Fungurume



Katuto

© F. Malaisse

Cheilanthes inaequalis (Kunze) Mett. [Sinopteridaceae]

Holotype: Burke s.n.

Copper specimens: Mal 526; MSK 107.

Habit: Rhizome 5 mm in diam., short, with tufted fronds and narrowly linear attenuate entire concolorous reddish-brown rhizome-scales up to 1.4 cm long. Stipe terete, atrocastaneous, thinly pubescent when young with short white hairs or ferruginous scales similar to those at the base of the rhizome. Fronds erect, herbaceous to coriaceous. Lamina up to 22 x 11 cm, narrowly oblong to ovate-deltate in outline (deltate in juveniles), 2-pinnate towards the apex, 3-pinnatifid at the base; pinnae narrowly to broadly, unequally to almost equally deltate, lower pinnae usually much developed basiscopically; pinna segments oblong, subentire, crenate or pinnatifid, obtuse, pilose to densely tomentose on the dorsal surface with long soft hairs, white at first, becoming ferruginous with age; ventral surface thinly pubescent or pilose; rachis terete, atrocastaneous, thinly pubescent at first, later becoming glabrous. Sori marginal discrete

but forming a continuous soral line at maturity; indusium continuous, narrow, ciliate, membranous.

Ecology: Mostly lithophytic, on rocky slopes, among rocky blocks, on cupriferous siliceous cellular rocks.

General distribution: Tropical Africa.

Distribution on Katangan copper sites (3 sites): Notably Katuto (41).

Reference: SCHELPE [1970].



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Kalukundi



Mambilima



Katuto



© F. Malaisse

Cheilanthes perlanata (Pic.Serm.) Kornašvar. ***kwatebalaensis*** Malaisse

[Sinopteridaceae]

Holotype: Malaisse 10927.

Copper specimens: LLM 104;

Mf 10927, 11843, 16617; Mf-SI 24;

MKS 875.

Cheilanthes perlanata (Pic.Serm.)Kornaš var. ***kwatebalaensis*** Malaissevar. nov., var. *perlanata* proxima, sed

22 cm versus 12 cm alta, frondes

verticali nunc arcuati, lamina ad 13 cm

versus minor 6 cm longa, lanceolata

nunc triangularis, pilique breviter valde

differt.

Habit: Perennial fern up to 22 cm high. Rhizome vertical, up to 1.5 cm in diam., with erect, tufted fronds.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-----|-----|---|
| | normal | 200 | 800 | > |
| dry | (X) | X | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Fronds uniform; stipe black to dark castaneous, 5-9 cm long; lamina



© F. Malaisse



Pumpi

Kwatebala

Cheilanthes perlanata* (Pic.Serm.) Kornaś**var. ***kwatebalaensis Malaisse

[Sinopteridaceae]

Continuation of page 85.

up to 13 x 3 cm, boat-shaped to lanceolate in outline, apex obtuse; up to 20 pinna, 2-pinnatifid in the upper lamina to 3-pinnatifid in the lowest pinnae. Stipe and lamina on both surfaces covered with soft hairs, 1-1.5 mm long, pale-brown to russet, becoming grey with age.

Ecology: Rocky outcrops, rocky caves, vertical walls, mostly with low copper content.

General distribution: Restricted to few rocky sites, mainly copper sites of Upper Katanga.

Distribution on Katangan copper sites (3 sites): Pumpi (29), Kwatebala (45), Mwadikomba (47).

Rehabilitation: Stabilizer of vertical rocky walls, notably in prospecting trenches.

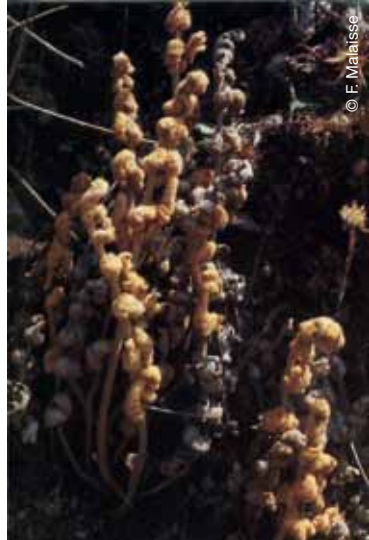
Note: The *Cheilanthes perlanata* complex is discussed in Kornaś et al. [2000]. The following comments by J. Kornaś are quoted: "Apart of small ferns conformable to *Cheilanthes perlanata* (Pic.Serm.) Kornaś, some taller

voucher specimens (up to 22 cm long) exist. They differ in having longer fronds, which are oblong, basiscopically not developed". This form is here recognized as a new variety.

References:

KORNAŚ et al. [2000].

PICHI SERMOLLI [1972].



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Kwatebala



The rocky *Xerophyta* steppe near the summit of Kwatebala hill where the new variety of *Cheilanthes* occurs

Cheilanthes perlanata (Pic.Serm.) Kornaś var. ***perlanata***
[Sinopteridaceae]

Holotype: Schmitz 1855.

Copper specimens: LMM 165;

Mf-Re 2386; Sa 1855, 1855A.

Syn.: *Notholaena perlanata* Pic.Serm.

Habit: Perennial fern, up to 12 cm high. Rhizome oblique or subhorizontal, short, densely covered with paleas. Palea 3.5–4 x 0.15–0.25 mm, rufous, margin minutely denticulate. Fronds uniform; blade pinnately ternate, basicopically developed, covered with wealth of long lanate and thin hairs.

Ecology: Lithophyte, rocky outcrops, rocky caves, also on copper sites.

General distribution: Burundi, D.R. Congo (Upper Katanga), Zambia.

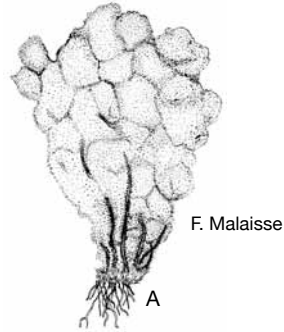
Distribution on Katangan copper sites (2 sites): Dikuluwe (2), Lupoto (92).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

References:

KORNAŚ et al. [2000].

PICHI SERMOLLI [1972].



A. Habit (x 0.4) – B. Summit of palea from rhizome (x 40) – C. Hair from blade (x 2.7).
[Drawn after PICHI SERMOLLI, 1972]



Nzilo-Kyamasumba road



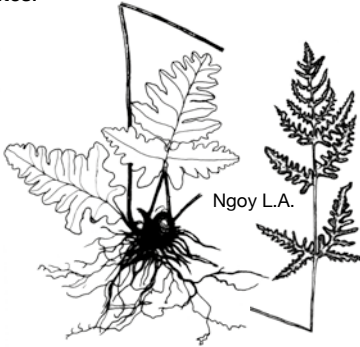
Cheilanthes similis F.Ballard

[Sinopteridaceae]

Holotype: Minle-Redhead 4351.
Copper specimen: MKS 865.

Habit: Perennial, rhizome 8 mm in diam., short, creeping, with tufted fronds and light-brown linear entire concolorous rhizome scales up to 10 x 1 mm. Fronds dimorphous, thinly coriaceous, the fertile more dissected. Stipes castaneous, thinly pubescent with pale hairs 1-2 mm long, up to 1.7 cm in sterile fronds and 12-22 cm in fertile fronds. Sterile lamina up to 6.5 x 5.7 cm, triangular in outline, deeply pinnatifid above becoming pinnate at the base. Fertile lamina up to 10.7 x 7.6 cm, triangular in outline, pinnate above to pinnatifid below. Sori small, submarginal, discrete developing into a soral line later.

Ecology: Lithophyte on rocky slopes in woodlands, rarely on copper rocky sites.



Habit (x 0.6).

[Original plate]

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XX | (X) | | |
| medium | X | | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Restricted to Upper Katanga and Northern and Western Zambia.

Distribution on Katangan copper sites (3 sites): Pumpi (29), Kwatebala (45), Kazinyanga (49).

Rehabilitation: No evident interest.

References:

KORNAŚ et al. [2000].

SCHELPE [1970].

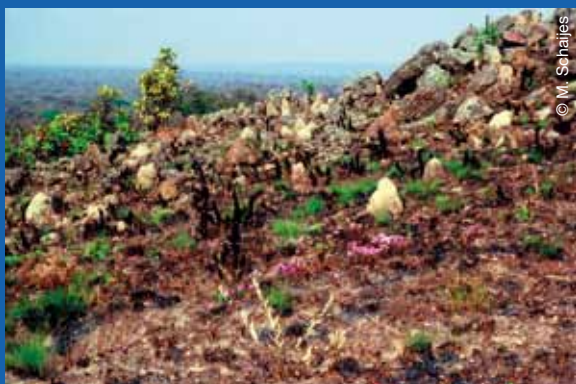


Nzilo-Kyamasumba road

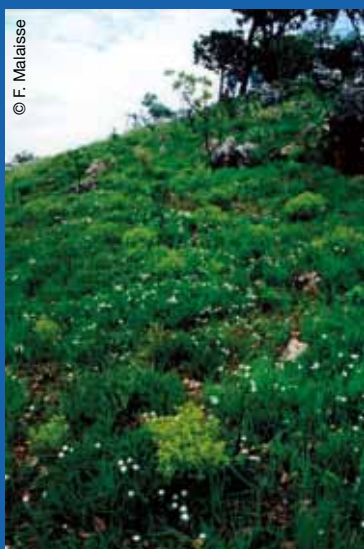


Pumpi



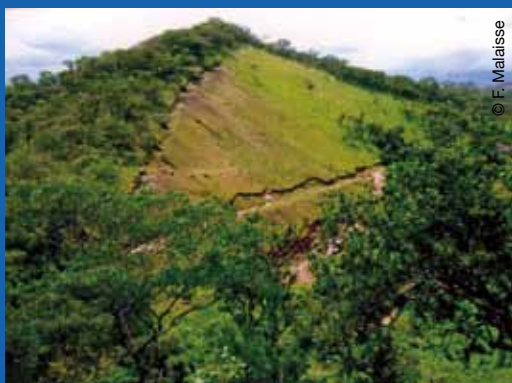


Shabara



Katuto

Magnoliopsida
by François MALAISSE
and Michel SCHAIJES



Mwadikomba

Barleria descampsii Lindau

[Acanthaceae]

Holotype: Descamps s.n.
 Copper specimens: Mf 10266;
 Mf-Gj 76; MKM 40; Rw 1715; Tr 44.
 Syn.: *B. variabilis* Robyns *nomen nudum*

Habit: Perennial suffrutex; erect, 50-75 cm high, branched, several stems from a woody rootstock (up to 5 cm in diam.), numerous fibrous roots 2 mm in diam. Whole plant yellow villous-hairy. Leaves opposite, ovate, short petiolate, 6-9 x 2-3 cm, discolorous, velutinous, upper surface of lamina green to dark-green, lower face of lamina grey-green to whitish. Flowers solitary in the axils, simulating a terminal spike; bracteoles lanceolate; exceeding 13 mm in length. Calyx up to 24 x 9 mm, woolly, anterior segment 2-lobed. Corolla pale lilac, 45 mm long; tube 22 mm, petal lobes 22 mm. Ovary hairy at tip.

Ecology: Woodlands, high plateau steppe savannas, also on ecotone to copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | | |
|--------|-----|-----|--|--|
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

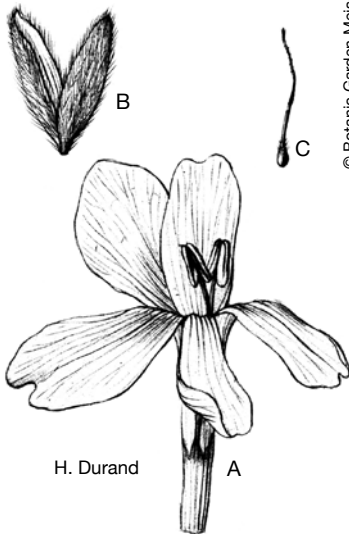
General distribution: Restricted to Katanga and Northern Zambia.

Distribution on Katangan copper sites (5 sites): Kwatebala (45), Fungurume (51), Kambove (71), Sokoroshe I (83), Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 17-49, Co = 10-230 µg/g D.M.

Rehabilitation: Pleasant habit, fine chamephyte for copper ecotone belt, as well as rocky soils with low copper content.

Reference: MALAISSE et al. [1979].



A. Flower (x 1.6) – B. Calyx (x 1.4) –
 C. Gynostegium (x 1.4). [Original plate]



Sokoroshe

Barleria lobelioides Champl.

[Acanthaceae]

Holotype: Malaisse & Goetghebeur 515. Copper specimens: Dp 3023; Mf 7732, 10524; Mf-Gj 123; Mf-Gp 515; MKM 19, 50; Tr 148.

Habit: Suffrutescent, ± prostrate plant. Lamina of leaves ovate to ovate-elliptic, cuneate to subrounded at base, acute at the apex, 2.5-4.8 x 1.2-2.5 cm; petiole 1-5 mm long. Inflorescence capitate or in dense short spikes, terminal or on short lateral shoots subtended by leaves; bracts, bracteoles and calyx covered with long fine adpressed hairs and glandular hairs; bracts elliptic, 2.5-3.7 x 1.2-1.8 cm, acuminate; corolla white, 3.5-5 cm long, tube 23-30 x 8-9 mm, lobes elliptic to suborbicular; fertile stamens 2, filament 16 mm long, black anther 3-4 mm long.

Ecology: Copper steppe savannas.

General distribution: Restricted to copper sites in Upper Katanga.

Distribution on Katangan copper sites (11 sites): Notably Tilwezembe (20), Tenke (32), Kabwelunono (34), Kwatebala (45), Shadirandzoro (48).

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-----|---------|
| | 200 | 800 | > 5,000 |
| normal | <X< | <X< | > 5,000 |
| dry | X | X | |
| medium | X | | |
| wet | | | |

→ mesocuprophyte

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 97, Co = 45 µg/g D.M.

Rehabilitation: Facilitator aptitude.

Reference: CHAMPLUVIER [2011].



Tilwezembe

© H. Schat



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Kabwelunono

Barleria velutina Champl.

[Acanthaceae]

Holotype: Malaisse & Goetghebeur 885.
Copper specimens: Dp 2933B, 3218B;
Ld 6; Mf 11800.

Habit: Suffrutescent plant without spines. Stem pubescent-hirsute. Leaves subsessile or petiole up to 5 mm long; lamina ovate or elliptic, ± coriaceous, tip acute, base cuneate to subcordate, with prominent nerves below, villous above, silky-wooly below, 1.7-4.5 x 0.9-2.8 cm. Inflorescences in heads or short spikes 2-10 cm long, terminal or sometimes also on short lateral shoots; bracteoles linear-elliptic, acuminate, 10-15 mm long, up to 2 mm wide. Flowers white or pale to deep pink, or mauve, or pale blue to blue-violet. Calyx lobes ovate-elliptic to ovate, toothed, 20-30 x 15-20 mm, accrescent, papyraceous, 25-35 x 15-25 mm in fruit, silky-wooly outside, more sparsely hairy inside. Corolla 3-4 cm long, without upper lobes or these strongly reduced; tube 3-5 mm wide at throat. Lateral and median lobes provided outside with numerous long thin glandular multicellular hairs. Stamens with filament 15-20 mm long, glabrous; anthers black-violet, 4-5 mm long; style 18-25 mm long, provided with scattered short glandular hairs; stigma capitate. Capsule ellipsoid, blackish, glabrous, 17x 5 mm, 2-seeded.

Ecology: Miombo, steppe savannas on heavy metal (Cu, Co, Ni, U) soils.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | X | | |
| medium | XX | X | | |
| wet | (X) | X | | |

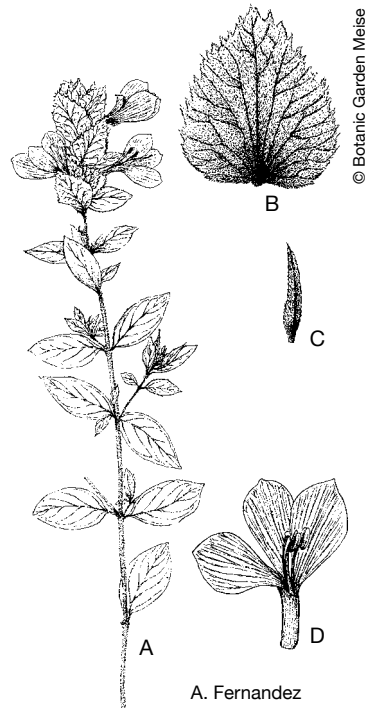
→ mesocuproresistant

General distribution: D.R. Congo (Upper Katanga), Zambia.

Distribution on Katangan copper sites (4 sites): Mutoshi (10), Kasompi (27), Menda (28), Shinkolobwe (67).

Rehabilitation: Facilitator aptitude.

Reference: CHAMPLUVIER [2011].



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Luilu

A. Habit (x 0.3) – B. Posticous calyx lobe (x 0.9) – C. Lateral calyx lobe (x 0.9) – D. One-lipped corolla (x 0.6).

[CHAMPLUVIER, 2011]

Holotype: von Mechow 109.
Copper specimens: Dp 3014 B2;
MHK 71.

Habit: Erect or procumbent annual, perennial or shrubby plant with a woody rootstock; stems up to 1.25 m high. Leaves often greyish beneath, largest pair more than 5 times longer than smaller pair; lamina of larger lanceolate to elliptic, 5-22 x 0.5-3.2 cm, margin toothed. Heads capitulate, sessile or peduncle up to 8 cm long. Corolla pale blue to bright blue or bluish purple, 17-54 mm long of which the tube 5-11 mm; limb obovate, 6-26 mm wide, 3-lobed. Capsule 10-13 mm long.

Ecology: Miombo on sandy to stony soil, roadsides, rarely in steppe savannas with low copper content, ruderal.

General distribution: Angola, D.R. Congo, Burundi, Tanzania, Zambia.

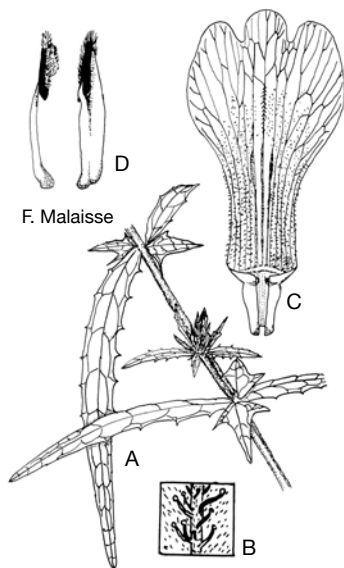
Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: Pleasant habit, but becoming weed around villages.

Reference: VOLLESEN [2000].

| Hydration | Copper content of soil (in μg per g of soil) | | |
|-----------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | (X) | |
| wet | X | | |

→ oligocuprophyte



A. Habit (x 0.3) – B. Detail of surface of floral leaf (x 5) – C. Corolla opened, stamens removed (x 1.3) – D. Stamens (x 1.5).

[Drawn after M. Tebbs in VOLLESEN, 2000]



Nzilo-Kyamasumba road



Biano plateau

© M. Schaefer

Blepharis cuanzensis* S.Moore subsp. *cuanzensis

[Acanthaceae]

Holotype: Welwitsch 5101.

Copper specimens: Dp 3116 B, 3210, 3500 B; Mf 10923, 11447, 11749; Mf-Re 2191; MKM 37, 91; Sm 4689; Tr 221. Syn.: *B. homblei* De Wild.

Habit: Perennial herb; annual suberect to creeping stems from a woody rootstock. Leaves linear up to 14 x 0.15-0.6 cm or elliptic up to 8 x 0.8-1.6 cm. Spikes solitary or 2-3 closely approximated. Calyx segments dissimilar, the upper segment 2-3.3 cm long with a very broad oblong tip, the anterior and lateral segments of similar length, up to 2.9 cm long with a long attenuate tip; corolla yellow.

Ecology: Steppe savannas developed on Kalahari sands and mostly on copper rich soils.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (9 sites): Notably Dikuluwe



Manika plateau

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| dry | | | |
|--------|---|----|-----|
| medium | X | XX | (X) |
| wet | | | |

→ oligocuproresistant

(2), Mupine (4), Kasompi (27), Kavifwafwaulu (42), Mwinansefu (43), Mindigi (60).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 23-34, Co = 950-1030 µg/g D.M. Cobalt hyperaccumulator.

Reference: VOLLESEN [2000].



Mwinansefu



Shabara

Blepharis glumacea S.Moore

[Acanthaceae]

Holotype: Welwitsch 5052.
Copper specimens: MKS 168, 278.
Syn.: *B. kassneri* S.Moore.

Habit: Annual slender, flexuous herb. Short pivotate root 4-5 cm long, 2 mm in diam. Leaves entire, sessile, narrowed at either end, in distant whorls of 4; outer pair 1.6-3.2 x 0.2-0.3 cm, inner pair up to 12 x 0.4-1.1 cm. Spikes reduced, one-flowered branches solitary, glabrous or with the calyx puberulous; bracteoles none. Every flower with 3-6 sterile bracts below it. Posticous calyx-segments 1.6 cm long. Corolla 2 cm long, bluish.

Ecology: Miombo, open woodlands, open rocky sites sometimes seasonally wet, rarely in steppe savannas on copper rich soils.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X(X) | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo, Tanzania.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Rehabilitation: No evident interest.

Reference: VOLLESEN [2000].



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Kavifwafwaulu

Crabbea kaessneri S.Moore

[Acanthaceae]

Holotype: Kässner 2337.

Copper specimens: Mf 13073;

Mf-Gp 1129.

Habit: Subacaulescent perennial herb, with a vertical taproot, 3-8 mm in diam.; several secondary running roots, up to 20 cm long, 1-1.5 mm in diam. Leaves 4-(6), prostrate in rosette on soil, ovate to suborbiculate, 6-10 x 4-8 cm. Cymes sessile, many-flowered; bracts numerous, ovate to oblong-lanceolate, margin denticulate, ciliate. Corolla whitish; tube up to 20 mm long, 2 mm diam. at base, 6 mm diam. at apex; lobes 6 x 7 mm. Disk lobate, 1 mm high. Ovary glabrous.

Ecology: Miombo on sandy soils, shrub savannas on gravely soils, rare in copper steppe savannas.

General distribution: D.R. Congo (Katanga), Zambia.

Distribution on Katangan copper sites (2 sites): Shinkolobwe (67), Mabaya (103).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 13, Co = 32 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | | 5,000 |
| | 800 | 5,000 | | |
| dry | X | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: No evident interest.**Reference:** MOORE [1910].

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Mamfwe road



© M. Schajles

Tenke-Kando road

Dicliptera capitata Milne-Redh.

Holotype: Milne-Redhead 493.
Copper specimens: Mf 10877; Mf-Gp 1069.

Habit: Annual erect herb, 10-35 cm high. Leaves discolorous, oblong-lanceolate, 5.5 x 0.5 cm. Inflorescences terminal, capitate, up to 15 x 23 mm; bracts 2 opposite, lanceolate, Corolla pink to violet; upper lip 5.5 x 2.3 mm; lower lip triangular, obtuse.

Ecology: Miombo, wooded savannas, grasslands, sometimes in copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia, Tanzania.

Distribution on Katangan copper sites (4 sites): Notably Shabara (24).

Dicliptera carvalhoi Lindau subsp. ***nemorum*** (Milne-Redh.) Darbyshire [Acanthaceae]

Holotype: Milne-Redhead 712.
Copper specimen: Mf-Kk 8.

Habit: Perennial herb, up to 60 cm tall. Leaves ovate to ovate-lanceolate. Inflorescences terminal or axillary, capitate, up to 20 x 20 mm; bracts ovate. Corolla pink; apex upper lip shortly 3-dentate; lower lip triangular.

Ecology: Woodlands and grasslands, rare in copper steppe savannas.

General distribution: Restricted to Upper Katanga and Northern Zambia.

Distribution on Katangan copper sites (1 site): Kingamyambo (8).

Reference (for both species): MILNE-REDHEAD [1937].



Biano plateau



Nzilo-Kyamasumba road

Justicia bequaertii De

Wild.

Holotype: Bequaert 108.

Copper specimens: LLM 30; Mf 9582.

Habit: Perennial plant, often much branched, erect annual stems up to 40 cm high; internodes 4.5-8 cm long. Petiole 0-2 mm long. Lamina oblong to obovate, apex subacute, base cuneate. Corolla yellow to pale green, purplish spotted.

Ecology: Open forests, savannas, rare on copper steppe savannas.

General distribution: Restricted to S-E of D.R. Congo.

Distribution on Katangan copper sites (3 sites): Notably Lupoto (92).

Reference: DE WILDEMAN [1913].



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Mamfwe road



Kwatebala



© F. Malaisse

Justicia betonica L.

[Acanthaceae]

Holotype: Hermann s.n.

Copper specimen: RKI 547.

Habit: Perennial shrubby plant, nearly glabrous. Leaves 8 x 3.5 mm, ovate, acuminate at apex, shortly acuminate at base; petiole 13-20 mm long. Spikes 11 x 2 cm, strobilate; bracts 4-ranked, 14 x 10 mm, ovate, acute, white, green nerved; bracteoles 9 x 6 mm, similar to the bracts. Sepals linear, pubescent. Corolla 12-15 mm long, white, rose-spotted. Filaments glabrous, dilated at the top; one anther-cell below the other, very long-tailed. Pollen triporate, trema area psilate, traversed by 2 raised bands. Capsule 13 x 5 mm, retrorsely hairy, 4-seeded; stalk 4 mm long, solid, stout. Seeds rugose.

Ecology: Open forests, savannas, dembo, very rare on copper steppe savannas.

General distribution: Paleotropical.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Reference: CLARKE [1900].



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Fungurume

Holotype: Rand 508.
Copper specimens: Dp-Tj 2611J; Mf 7927, 10981; Mf-Gp 315, 1051; Sm 4711; Tr 34, 59.
Syn.: *J. cupricola* Robyns *nomen nudum*.

Habit: Perennial herb, often much branched, with erect to prostrate annual stems from a woody rootstock. Stems up to 25 cm long, glabrous to very densely covered with hairs. Leaves with lamina narrowly lanceolate to broadly ovate, attenuate at the base, obtuse at the apex, entire. Flowers few together in leaf axils. Calyx-lobes lanceolate to triangular. Corolla crimson to purple, 10.2-14.5 mm long, with a purple-white pattern at lower lip near throat. Capsule 5.5-8.2 x 2.1-2.8 mm.

Ecology: Dembo, woodlands, often also on Kalahari sands and copper steppe savannas.

General distribution: D.R. Congo (Katanga), Zambia, Malawi, Mozambique, Zimbabwe.

Distribution on Katangan copper sites (9 sites): Mabaya (A3), Fungurume (51), Mindigi (60), Kalongwe (81), Luiswishi (87), Kasonta (91), Lupoto (92), Etoile (97), Kimpe (102).

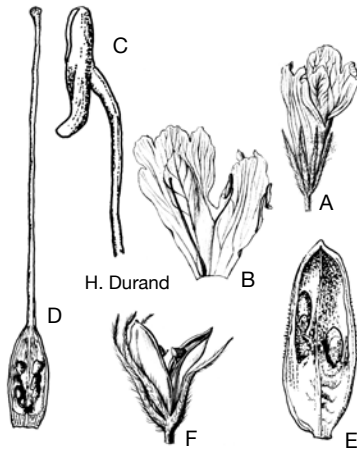
Distribution on Zambian copper sites (1 site): Muliashi (173).

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | XX | XX | |
| wet | | | | |

→ mesocuproresistant

Rehabilitation: No evident interest.

Reference: HEDRÉN [1990].



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A. Flower (x 1.5) – B. Opened corolla (x 1.5) – C. Anther (x 8) – D. Pistil (x 11) – E. Capsule, longitudinal section (x 3.5) – F. Opened fruit and calyx (x 2).

[Original plate]



© F. Malaisse

Shabara

Justicia metallorum P.A.Duvign.

[Acanthaceae]

Holotype: Duvigneaud & Timperman 2047 A.

Copper specimens: Dp 2201, 5455; Dp-Tj 2047A, 2055, 2219; Mf 9874; Wr 819, 820.

Habit: Perennial low shrub, partly subterranean stems, 5-10 cm tall. Stems up to 2-6 mm in diam., with prominent leaf-scars. Leaves clustered in rosettes at stem apices, narrowly oblanceolate, attenuate at the base, obtuse at the apex, slightly yellowish green above. Flowers few together in leaf axils. Bracts oblanceolate, 5.5-18 x 1.8-2.7 mm. Calyx-lobes triangular-lanceolate, 9-11 mm long, up to 11 x 0.8 mm in fruit, with a distinct hyaline margin, sparsely to densely pubescent. Corolla crimson to purple, 11.7-17.2 mm long.

Ecology: Kalahari sands and copper steppe savannas.

General distribution: D.R. Congo (Katanga).

Distribution on Katangan copper sites (5 sites): Kasompi (27), Menda (28), Mindigi (60), Swambo (62), Mitonte (68).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

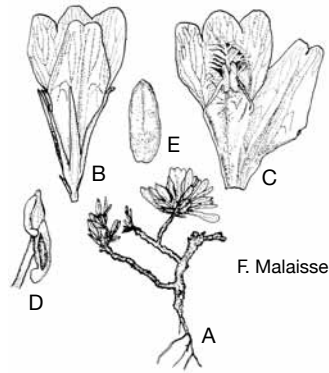
| dry | | | |
|--------|---|---|---|
| medium | X | X | X |
| wet | | | |

→ mesocuproresistant

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 24, Co = 213 µg/g D.M.

Rehabilitation: No evident interest.

Reference: HEDRÉN [1990].



A. Habit (x 0.1) – B. Corolla (x 1.9)
– C. Opened corolla (x 1.9) –
D. Anther (x 1.9) – E. Capsule
(x 1.3). [Drawn after HEDRÉN,

1990]



Biano plateau



Mindigi

Phaulopsis johnstonii C.B. Clarke

Holotype: Newton s.n.
Copper specimen: Mf-Gp 1128.

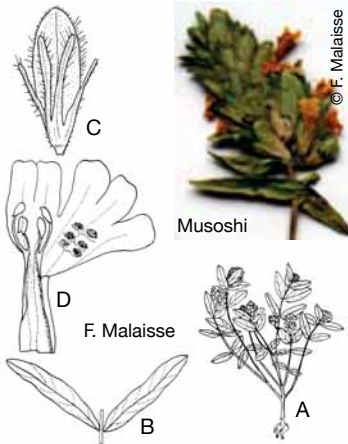
Habit: Perennial herb, up to 80 cm tall. Leaves sessile, elliptic, isophyllous, with acute to obtuse apex. Inflorescence mainly terminal, distinctly strobilate, with glandular hairs. Flowers in monochasia, up to 9 per cyme. Corolla 11-19 mm long, white with purple markings. Capsule 7.0-8.5 mm long.

Ecology: Savanna woodlands, steppe savannas with low copper content.

General distribution: Angola, D.R. Congo, Zambia, Tanzania.

Distribution on Katangan copper sites (1 site): Mabaya (103).

Reference: MANKTELOW [1996].



A. Habit (x 0.12) – B. Leaves (x 0.25) – C. Calyx (x 1.5) – D. Opened corolla (x 1.5).
[Drawn after MANKTELOW, 1996]



Lubumbashi-Likasi road, near Luafi

Strobilianthopsis linifolia
(T.Anderson ex C.B.Clarke)
Milne-Redh. [Acanthaceae]

Holotype: Kirk s.n.
Copper specimens: Mf 9583, 11030;
Mf-Gp 1041; Qp 4894.
Syn.: *Dyschoriste linifolia* (T.Anderson ex C.B.Clarke) C.B.Clarke

Habit: Shrub or suffrutex, up to 2 m high. Leaves very variable. Calyx glandular, up to 18 mm long, with linear strap-shaped segments; calyx-segments free almost to the base, calyx-tube 1.5 mm long, segments about 16.5 mm long. Corolla mauve to blue, regular, with upright subequal lobes.

Ecology: Rare in copper steppe savannas, restricted to ecotones.

General distribution: Angola, D.R. Congo, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (9 sites): Notably Kimpe (102).

Rehabilitation: No evident interest.

Reference: MILNE-REDHEAD [1932].



Musoshi



Kavifwafwaulu



Nzilo-Kyamasumba road

Thunbergia graminifolia De Wild.

[Acanthaceae]

Holotype: Verdick s.n.
Copper specimen: LMM 196.

Habit: Perennial herb, several stems up to 60 cm long, 2-4 mm in diam. at base, subquadrangular, from a woody rootstock. Leaves green, petiole 0-1 mm long, glabrous; lamina linear to linear-lanceolate, up to 6-16 x 0.2-0.7 mm, more than 10 times as long as wide, apex acuminate, base attenuate, margin entire, glabrous. Flowers solitary, pedicels 1.5-4 cm long, glabrous; bracteoles green or dark green or tinged dull purple, ovale-elliptic, 2.3-3.8 x 0.6-1.2 cm, acute, glabrous. Calyx minutely puberulous, 2-3 mm high. Corolla limb and upper part of tube pale blue to blue or pale mauve, lower part of tube white to pale yellow, throat yellow; tube 3-4.5 cm long, 1.2-1.7 cm in diam. at mouth. Style glabrous. Capsule 12-15 mm in diam., beak 18-25 mm long. Seed

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| medium | <X< | <X< | 5,000 |
| wet | 800 | 5,000 | |

dry
medium **XX** (X)
wet

→ oligocuresistant

chestnut brown, 10-12 mm in diam, smooth on back, with a few spinules near the apex, entire or lacinate lateral wing.

Ecology: Miombo, grasslands, very rare in copper steppe savannas.

General distribution: Tanzania, D.R. Congo, Zambia, Malawi.

Distribution on Zambian copper sites (1 site): Kansanshi (100).

Rehabilitation: Pleasant habit.

Reference: VOLLESSEN [2008].



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Kolwezi-Luilu road



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Mamfwe road



© M. Schajjes

Kasapa road

Thunbergia kirkiana T.Anderson

[Acanthaceae]

Holotype: Kirk s.n.

Copper specimens: LLM 29; Mf 10027 bis.

Habit: Perennial herb, with stems up to 50 cm long from a creeping woody rootstock. Leaves with petiole 1.2-2.7 cm long; lamina ovate to triangular, up to 3.5-8.5 x 1.5-5.7 cm, less than 3 times longer than wide, apex acute, base truncate with rounded hastate lobes, margin entire. Flowers axillary, solitary; pedicels 4-11 cm long, bracteoles leathery, green with brownish often rib-like veins, narrowly ovate or oblong. Corolla white to lemon yellow with yellow to dark yellow centre. Capsule densely puberulous, subglobose, 9-11 mm in diam., beak narrowly triangular, 13-15 mm long.

Ecology: Open forests, grasslands, red lateritic soils, copper steppe savannas.

General distribution: From Angola to Tanzania, Zambia and Mozambique.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (5 sites): Notably Etoile (97).

Reference: VOLLESEN [2008].

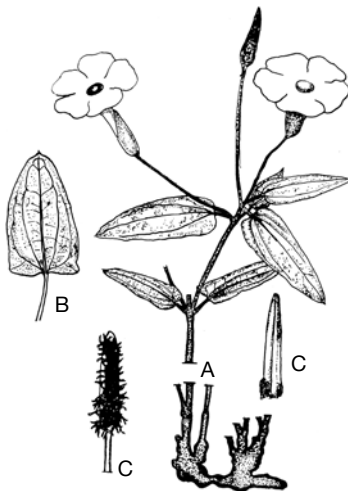


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Kipopo



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F. Malaisse

A. Habit (x 0.3) – B. Leaf (x 0.3) – C. Stamens (x 3.5).

[Drawn after M. Tebbs in VOLLESEN, 2008]

Kolwezi-Nzilo road

Thunbergia rogersii Turrill

[Acanthaceae]

Syntypes: Rogers 150, 185.

Copper specimens: DKM 3596; LMM 57; Mf 7921, 9316, 12126; Sm 4847; Tr 39.

Habit: Perennial herb, several subquadrangular hairy stems, up to 45 cm long, from a woody rootstock. Leaf-blade elliptic to oval, 1.3-3.7 x 0.6-2.2 cm, apex acute, base cunat-subrounded; 5-nerved; distinctly ciliate with \pm long, white yellowish hairs. Flowers solitary; bracteoles ovate 1.5-2 x 0.8-1 cm, hairy outside, glabrous inside. Calyx very short, 0.5-1.5 mm high. Corolla limb and upper part of tube white, mauve or violet, lower part of tube yellow; tube 1.5-3.2 cm long and 6.5-13 mm large at throat; lower median lobe 6-13 x 8-10 mm; upper lobes 6-8.5 x 7-9 mm, all truncate at summit. Stamens with glabrous subequal or \pm didynamous filaments; short filaments 4.5-7 mm

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | (X) | X | | |
| wet | | | | |

→ oligocuprophyte

long; long filaments 7-10 mm long. Style 8-15 mm long, glandulose.

Ecology: Copper steppe savannas, very rarely other steppe savannas.

General distribution: D.R. Congo (Upper Katanga).

Distribution on Katangan copper sites (5 sites): Notably Luiswishi (87), Kasonta (91), Lupoto (92).

Rehabilitation: Excellent facilitator.

Reference: CHAMPLUVIER [2011].



Shabara



Etoile mine



Lupoto



Etoile mine

Isotype: Mechow 235.

Copper specimens: Dp 4125 M, 4493 M.

Habit: Perennial suffrutex, with numerous erect, slender, annual stems, 12-30 cm tall, from a stout, woody rootstock. Stems striate with pale raised lines. Leaves numerous, opposite, subopposite or some alternate, broadly elliptic to very narrow and subfiliform, 10-45 x 4-12 mm, with a pale cartilaginous border, mucronate, glabrous to densely furnished with multicellular hairs. Inflorescence capitata, globose or hemispherical, 1.2-1.6 cm in diam., the axis somewhat elongated in fruit (to circa 2.3 cm); axis deeply sulcate. Bracts ovate to lanceolate-ovate, 2-3 mm, shortly pubescent along the margins, stramineous or sometimes reddish-tinged, the darker midrib excurrent in a very short mucro. Bracteoles oblong-ovate to ovate, usually ciliate, 2.5-3.0 mm long. Perianth bright crimson. Outer 2 petals narrowly oblong, 5-6 mm long, margins hyaline, inflexed above. Inner 3 tepals slightly shorter, gradually narrower and less firm, more widely hyaline-margined above. Filaments 6 mm long; anthers narrowly oblong, 2.0-2.25 mm long, pseudostaminodes absent or small

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant

and tooth-like. Ovary obovoid, 2 mm long, glabrous at the extreme base, but densely lanate above; style 2.5 mm, pilose at the base. Capsule oblong-ovoid, 3 mm long, densely lanate except at the extreme base with whitish, multicellular hairs. Seeds subreniform, yellow to reddish, shining, 2.75 mm in diam.

Ecology: Clay loam or sandy soil in *Brachystegia* open forests, shrub and steppe savannas on Kalahari sands, rare on rocky copper steppes, more frequent on manganiferous soils.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (1 site): Dikuluwe (2).

Rehabilitation: Pleasant habit.

Reference: TOWNSEND [1988].



Manika plateau



Pandiaka carsonii (Baker) Clarke

[Amaranthaceae]

Holotype: Carson 8.

Copper specimens: Mf 9674, 11204,

11698, 11815; Mf-Gp 1044;

Mf-Re 2174; Qp 5213.

Syn.: *P. carsonii* var. *linearifolia* Hauman

Habit: Perennial geofrutex, numerous branched stems arising from the base; drying dark green to blackish. Rootstock a tuber, up to 1 cm long. Leaves very variable, from very narrowly linear or filiform to broadly obovate, sessile, 20-70 x 1-18 mm, acute to obtuse or apiculate at the apex. Inflorescences cylindrical, 1.5-8 x 1.2-1.8 cm, not involucrate, on a slender peduncle 1-15 cm long. Bracts very variable in size, deltoid-ovate to lanceolate, white, firm. Bracteoles deltoid-ovate, 1.5-3 mm long. Tepals equal in length, 5-7 mm long, pink with a narrow green central band, broadly white-bordered. Stamens 4-6 mm long; pseudostaminodes flabellate, 1-1.5 mm long; style slender, 3.5-4.5 mm long. Capsule oblong-ovoid with a narrower firm apex, 2.5-3 mm long. Seeds oblong-ovoid, 2.25-2.75 mm long, brown, shining.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium | X | | |
| wet | XX | | |

→ oligocuproresistant

Ecology: Dambos, high plateaux and also copper steppe savannas.

General distribution: D.R. Congo, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (20 sites): Notably Dikulushi (1), Tilwezembe (20), Shabara (24), Kahumbwe (57), Luita (58), Tantara (63), Kamoya (72), Luiswishi (87), Kimpe (102).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 72-2839, Co = 31-2131 µg/g D.M. Cu and Co hyperaccumulator. These values need confirmation.

Rehabilitation: Robust pioneer on copper man-made embankments.

Reference: TOWNSEND [1988].



Pumpi



Kwatebala



Shabara

Lannea edulis (Sond.) Engl.

[Anacardiaceae]

Holotype: Engler (B†).
Syntype: Zeyher 349.
Copper specimen: MKS 698.

Habit: Suffrutex with stems 3-30 cm high, with semi-procumbent, woody, perennial branchlets from a large woody underground rootstock. Leaves 3-7-foliolate, up to about 30 cm long. Leaflets obovate-oblong or oblong, rounded or obtuse at the apex, usually apiculate, narrowed to base, sessile; about 14 x 6.5 cm; glabrescent above except on nerves and midrib, ± densely tomentose beneath, whole plant when young densely clothed with thick, rusty tomentum composed entirely of flexuous, stellate hairs; adult leaves discolorous. Inflorescences almost at ground level, coming up some weeks after burning, before the leaves or with the young leaves, composed of panicles, with 3-10 cm long axis. Calyx segments red in dry state; petals yellowish to pink. Drupe bright to deep red, 9-11 x 8-9 x 6-7 mm, ovoid, compressed.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Widespread; often at edges of dambos and in some miombo woodlands; rare in copper steppe-savannas.

General distribution: Angola, D.R. Congo, Uganda, Tanzania, Zambia, Zimbabwe, R.S.A.

Distribution on Katangan copper sites (2 sites): Zikule (30), Kakavilondo (31).

Rehabilitation: No evident interest.

References:

- WHITE [1962].
- FERNANDES, FERNANDES [1966].



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Mamfwe road

Ozoroa reticulata (Baker f.) R. & A.Fern. [Anacardiaceae]

Holotype: Rand 64.

Copper specimens: Mf 12154, 16476;

Mf-Gj 28; MKS 318.

Syn.: *Heeria reticulata* (Baker f.) Engl.

Habit: A much branched tree up to 15 m tall or sometimes a shrub. Leaves alternate or in whorls of 3; petiole subterete, flattened at the base; lamina nearly concolorous to very discolorous, usually 2.5-4 times as long as broad, obtuse or acute and mucronate at the apex, rounded or acute at the base, subcoriaceous to coriaceous; reticulation \pm prominent beneath. Panicles terminal and axillary, up to 17 cm long, much branched, many-flowered. Pedicels 1-1.5 mm long; sepals 1.5-3.7 x 0.8-1.5 mm, ovate or ovate-triangular; petals whitish or yellowish, 2.2-4 x 1-2 mm, oblong, obtuse at the apex. Drupes black, shining, 7-8 x 9-11 mm, transversely ellipsoid, compressed, wrinkled.

Ecology: Rocky hillsides and outcrops, also on copper rocky shrubby steppe savannas.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | (X) | | |
| medium | X | | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Sudan, Kenya, Uganda, D.R. Congo, Tanzania, Zambia, Zimbabwe, Mozambique, Botswana.

Distribution on Katangan copper sites (6 sites): Goma central (33), Shinkusu (44), Kwatebala (45), Mwadikomba (47), Fungurume (51), Luita (58).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 16, Co = 2 $\mu\text{g/g}$ D.M.

Rehabilitation: Valuable shrub for copper ecotone belt.

Reference:

FERNANDES, FERNANDES [1966].



Kwatebala



Kwatebala



Kavifwafwaulu

© F. Malaisse

Annona stenophylla Engl. & Diels subsp. ***nana*** (Exell)

N. Robson

[Annonaceae]

Holotype: Scott Elliot 8287.

Copper specimen: Mf 14226.

Habit: Perennial rhizomatous shrublet, up to 50 cm high, with stems simples or ± branched, usually annual. Leaves petiolate, leaf-lamina 6-12 x 2.2-6.7 cm, mostly 2-3 times as long as broad, rounded to emarginated at the apex, rounded at the base. Flowers solitary or rarely paired. Sepals 3-4 mm long; petals cream-yellow; stamens linear to clavate 1.5-2 mm long; filament cuneate or oblong-orbicular. Fruit on a pedicel 15-40 mm long, syncarp 1.7-2.7 x 1.7-2.7 cm, ovoid or globose, orange or yellow. Seeds numerous, 7-9 mm long, cylindrical or flattened-ovoid, orange-brown; aril pectinate.

Ecology: Steppe savannas on Kalahari sands, rarely on copper soils.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo (Katanga), Zambia, Zimbabwe, Mozambique, Namibia.

Distribution on Katangan copper sites (1 site): Luiswishi (87).

Rehabilitation: Medium interest according to fruit edibility.

Reference:

ROBSON [1960].

Flower, petals and part of receptacle removed (x 1.5)

[Drawn after ROBSON, 1960]



F. Malaisse



Manika plateau



Salabwe



Manika plateau

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Diplophium marthozianum P.A.Duvign.

[Apiaceae]

Holotype: Duvigneaud & Timperman
2084 U.

Copper specimens: Dp-Tj 2045 D, 2084 U;
Mf 9205, 9213, 16597; MKS 38, 236.

Habit: Perennial herb, 50-70 cm high. Petiole of basal leaves 10-15 cm long; lamina 7-10 cm long, 10-15 cm wide, 2-3 pinnate; petiolule of main leaflets 2-4 cm long; ultimate segments 0.5-1 mm wide, triangular to subspinulate, 1-3 mm long. Sheathing bases of stem leaves reduce. Rays 10-20; bracteoles membranous, glabrous, strongly acuminate. Fruit with ten longitudinal ribs.

Ecology: Copper steppe savannas.

General distribution: D.R. Congo (Katanga).

| Hydration | Copper content of soil (in μg per g of soil) | | |
|-----------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | (X) | |
| wet | | | |

→ mesocuprophyte

Distribution on Katangan copper sites (10 sites): Notably Goma (33).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 12-166, Co = 435-915 $\mu\text{g/g}$ D.M. Cobalt accumulator. Values need confirmation.

Rehabilitation: Stabilizer.

Reference: DUVIGNEAUD [1959].



Fungurume



Kwatebala



Kwatebala

Diplolophium zambesianum Hiern

[Apiaceae]

Holotype: Kirk s.n.

Copper specimens: Bh 2386; Dp-Tj 2060 D, 2224 D; Mf 11780; MKM 124; Rw 1721.

Habit: Perennial herb, 60-250 cm high; hard woody rhizome. Plants glabrous, glaucous. Stem terete, rigid, solid, with numerous fine grooves. Leaves 5-40 cm long, 2-3 pinnate; ultimate segments 2-15 cm long, linear to filiform. Large sheathing bases, up to 5 cm long. Leaves gradually reduced upwards to a sheathing base with a short 3-fid lamina. Inflorescence of terminal and lateral compound umbels. Bracts greenish to creamy white, linear. Rays 5-16, 1.5-11 cm long, robust, pedicels 5-10 mm long. Petals white. Fruit up to 6 x 2.5 mm, densely covered with white to yellowish hairs.

Ecology: Grassland, savanna woodland and miombo, Kalahari and copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, southwards to Zimbabwe and Mozambique.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| medium | <X< | <X< | > | 5,000 |
| wet | 800 | 5,000 | | |

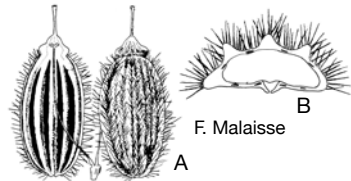
dry
medium **XXX** **X**
wet

→ oligocuproresistant

Distribution on Katangan copper sites (7 sites): Kasompi (27), Shimbidi (35), Kwatebala (45), Fungurume (51), Mindigi (60), Shinkolobwe (65), Kambove (71).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 12-166, Co = 435-915 µg/g D.M. Cobalt accumulator. Values need confirmation.

Reference: CANNON [1978].



A. Mericarps (x 2.7) – B. Mericarp, cross section (x 5.5). [Drawn after F. M. in CANNON, 1978]



Kwatebala

Lefebvrea abyssinica A.Rich.

[Apiaceae]

Holotype: Quartin Dillon s.n.

Copper specimens: MKS 316; MSH 375.

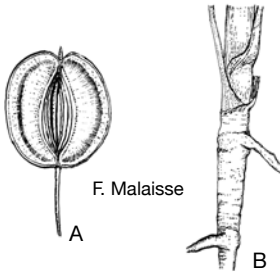
Syn.: *L. stuhlmannii* Engl.

Habit: Perennial herb, up to 3 m high. Stem terete, grooved. Leaves 2-ternate to 2-ternate-pinnate. Lamina up to 40 cm long. Leaflets up to 30 x 2 cm, linear, narrowly cuneate at the base, apex acute. Upper leaves reduced. Umbels terminal and lateral; rays 12-20 cm. Petals yellowish-cream. Fruit 10 x 7 mm, elliptic, lateral wings 2 mm wide. Umbels with slightly drooping fruit.

Ecology: Montane steppe savannas, rarely in copper steppe savannas.

General distribution: From Angola to East Africa and Mozambique.

Distribution on Katangan copper sites (3 sites): Goma (33), Kakalalwe (38), Kimpe (102).



A. Fruit (x 2) – B. Rootstock (x 0.4).
[Drawn after CANNON, 1970]



Kakalalwe

| Hydra- tation | Copper content of soil (in μg per g of soil) | | | |
|------------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: Ornamental value for soils with low copper content.

Reference:
CANNON [1970].



Goma

Physiotrichia muriculata

(Hiern.) Droop & Townsend

Holotype: Whyte 224.

Copper specimens: Mf 16496; Tr 276.

Syn.: *Peucedanum heracloudes* Baker**Habit:** Stout perennial herb, 0.3–1.2 m high. Stem bearing very fine muriculate spines. Basal leaves 10–50 x 9–19 cm, pinnate.**General distribution:** Angola, D.R. Congo, Tanzania, Zambia, Malawi.**Distribution on Katangan copper sites** (5 sites): Notably Kavifwafwaulu (42), Mwadikomba (47).**Reference** (for both species):

CANNON [1978].



Mambilima



Kavifwafwaulu

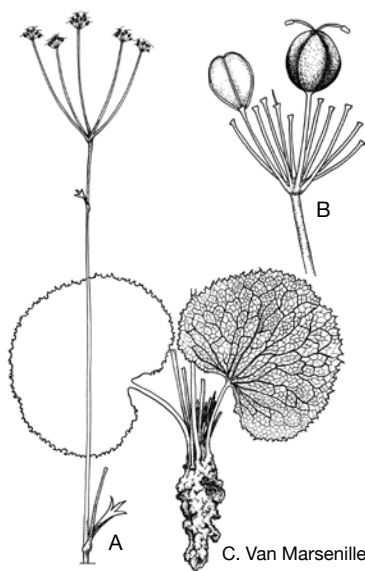
Pimpinella acutidentata

Norman

[Apiaceae]

Holotype: Homblé 1006.

Copper specimens: DKM 887; LLM 147.

Habit: Very slender perennial herb, 25–45 cm high. Basal leaf reniform, margin regularly denticulate.**General distribution:** Restricted to Upper Katanga and Western Zambia.**Distribution on Katangan copper sites** (7 sites): Notably Goma (33).

A. Habit (x 0.3) – B. Partial umbel with mature fruit (x 5.5). [Original plate]



Luiswishi

Pimpinella kassneri (H. Wolff) Cannon

[Apiaceae]

Holotype: Kassmer 2416.

Copper specimens: Lal 332; Mal 636.

Syn.: *Physotrichia kassneri* H. Wolff

Habit: Biennial herb c. 1 m tall, with a narrow fleshy taproot. Stems terete and finely grooved. Basal leaves ternate to partially 2-ternate, rarely with simple shortly trullate lamina and regularly dentate margins. Lobes of ternate leaves 2-6 cm long, linear to irregularly elliptic or oblanceolate; apices obtuse, bases narrowly cuneate, margins \pm regularly serrate to irregularly dentate with remote teeth. Petiole 5-15 cm long. Inflorescence much branched, with terminal and lateral umbels. Primary umbels with 4-6 \pm regular rays

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | X | | |
| wet | | | | |

→ oligocuproresistant

1.5-4 cm long. Partial umbels with 5-12 flowers on pedicels 3-5 mm long. Petals white to pale yellow-cream, with distinctly inturned apex.

Ecology: Grasslands, steppe savannas with low copper content.

General distribution: D.R. Congo, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (4 sites): Notably Kabwelunono (34), Kavifwafwaulu (42).

Reference: CANNON [1978].



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Kavifwafwaulu



Etoile mine (January 2006)

Steganotaenia araliacea Hochst.

[Apiaceae]

Holotype: Quartier Dillon s.n., Petit s.n.
Copper specimen: Mf-Kk 750.

Habit: Unbranched or sparsely-branched shrub, rarely small tree; young bark pale yellow-green, papery, peeling. Leaves crowded near ends of branchlets, simply pinnate, 15-40 cm long. Leaflets 3.5-12 x 2-7 cm, in 3-4 pairs plus a terminal one; apex acute, base rounded, margin serrate. Inflorescence of 7-10 compound umbels, about 16 cm in diam. Flowers small, petals yellowish, appearing before the leaves. Fruit obovate, dorsally compressed, 2-winged, straw-coloured, 12-13 x 6-8 mm. Mericarps with 3 distinct dorsal ribs.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Termite mounds, open woodlands, rarely copper steppe savannas.

General distribution: Tropical Africa, from W. Africa and Ethiopia southwards to northern R.S.A.

Distribution on Katangan copper sites (1 site): Zikule (30).

Rehabilitation: Pleasant habit for sites with low copper content, but slow growth.

Reference: CANNON [1978].



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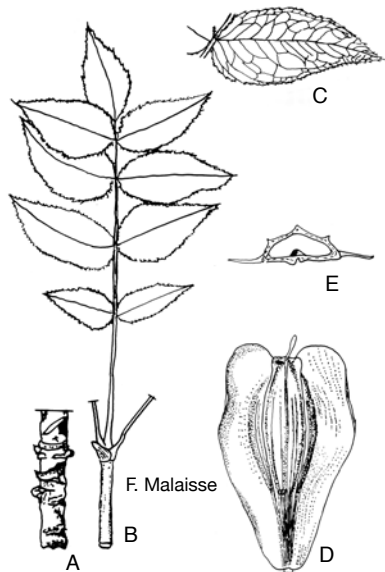
Shadiranzoro



© M. Scholtes



Mamfwe road



A. Twig (x 0.4) – B. Leaf (x 0.4) – C. Leaflet (x 0.25) – D. Mericarp, from exterior (x 2) – E. Mericarp in cross-section (x 2.3)

[Drawn after CANNON, 1978]

Brachystelma sp. nov.

[Apocynaceae]

Holotype: Malaisse et al. 397.
Copper specimen: Mal 397.

Habit: Perennial erect herb, 30-35 cm tall. Tuber yellow, about 90 mm in diam., 3 cm thick; rootlets many, 3-6 cm long, 1-1.5 mm thick, yellowish. Stem branching at 2-3 cm high. Leaves opposite, petiole 6 mm long, 2 mm thick, hairy; lamina lanceolate, unequal, 6-7 x 1-2 cm, mucronate at apex, attenuate at base, margin ciliate. Flowers solitary at the lower nodes and in raceme at the upper nodes. Sepals free; egg-shaped corolla,

4-5 mm long, shortly 5-lobed; tube ovoid-campanulate, slightly narrowed around the mouth, pale white-greenish outside, purple to dark purple inside; lobes triangular, free.

Ecology: Ecotone of copper steppe savanna with low copper content and Xerobrachystegion open forest.

General distribution: Only known by one collection at Shadirandzoro hill (Upper Katanga).

Distribution on Katangan copper sites (1 site): Shadirandzoro (48).



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Shadirandzoro

Ceropegia achtenii De
Wild. subsp. ***achtenii***

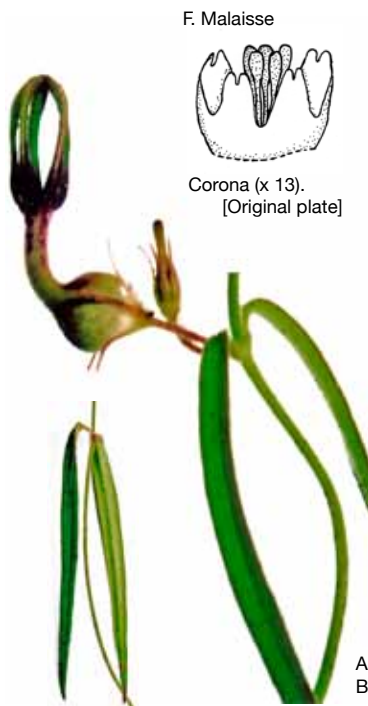
Holotype: Achten 589.
Copper specimen: MSH 305.

Habit: Climbing or erect herb, 20–35 cm tall. Tuber globose-depressed. Leaves sessile, lanceolate or linear, base cuneate. Cymes (sub) sessile, 1–3-flowered. Flower white greenish, corolla base inflated, tube 6–24 mm long, lobes 4–12 mm long, linear, purple outside, green inside. Outer corona with bifid triangular lobes, inner corona with erect longer lobes slightly spatulated at the apex.

Ecology: Open forest, rare on steppe savannas with low copper content.

General distribution: Angola, D.R. Congo, Tanzania, Zambia.

Distribution on Katangan copper site (1 site): Fungurume (51).



Fungurume

Ceropegia umbraticola
K.Schum. [Apocynaceae]

Neotype: Schmitz 1055.
Copper specimen: Mal 466.

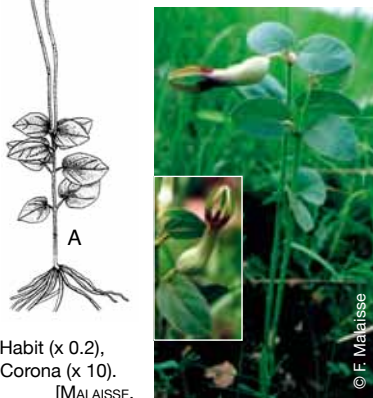
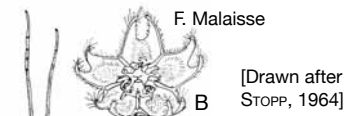
Habit: Perennial herb from a slender rhizome and a cluster of long thick cylindrical fleshy roots (15 cm x 2 mm). Stems 1–(2), erect, up to 40 cm high, bearing 1–5 flowers. Leaves succulent, 2–5-paired, ovate to elliptic. Corolla up to 4 cm long, base inflated, white-yellowish, corolla lobes joined at tip, green outside, purple inside. Outer corona with lobes divided into 2 linear to deltoid teeth. Follicle erect, narrowly fusiform, up to 40 cm long.

Ecology: Miombo, rarely grasslands.

General distribution: Angola, D.R. Congo (Upper Katanga), Tanzania, Zambia, Malawi.

Distribution on Katangan copper site (2 sites): Notably Katuto (41).

Reference (for both species):
MALAISSE, SCHAJES [1993].



A. Habit (x 0.2),
B. Corona (x 10).
[MALAISSE,
SCHAJES, 1993]

Katuto

Cryptolepis oblongifolia
(Meisn.) Schltr.

Isotype: Krauss 132.

Copper specimens: KK-Mf 367; MKS 975.

Habit: Erect branching shrub. Branches rather long, slender, reddish-brown, minutely scabrous. Leaves ascending, glabrous, pallid beneath, narrowly lanceolate to oblong-elliptic, 15-50 x 7-16 mm, acute or obtuse at apex, cuneate or rounded at the base. Cymes subaxillary, subsessile, 3-16-flowered. Corolla yellowish-green. Follicles diverging at an angle of about 80°.

Ecology: Miombo open forests, high plateau steppe savannas, woodlands, rare on copper sites.

General distribution: From Togo to Sudan, southwards to R.S.A. and Namibia.

Distribution on Katangan copper site (2 sites): Kakavilondo (31); Shadiranzoro (48).



Mutendele



Kando

Cynanchum praecox Schltr.
ex S.Moore [Apocynaceae]

Holotype: Rand 512.

Copper specimen: Pi-Kp 4651.

Habit: Perennial herb; rhizome 1.5-3 mm in diam. Stem erect 3-10 cm high. Latex white. Leaves linear 4-6 x 0.2-0.8 cm, rarely elliptic to ovate, absent at the time of flowering. Inflorescence botrychoid, 5-15-flowered. Bracts oblong-conical, pedicels 4-6 mm long, corolla yellowish-brown, lobes 6 mm long, curved inwards. Corona 2-4 mm long.

Ecology: Burnt savannas and grasslands.

General distribution: From Sierra Leone to Cameroon, Tanzania, D.R. Congo, Zambia, Zimbabwe.

Distribution on Katangan copper site (1 site): Kwatebala (45).

Reference: LIEDE [1996].



Kwatebala



Nzilo-Kyamasumba road

***Cynanchum viminale* (L.) L. subsp. *suberosum* (Meve & Liede) Malaisse comb. nov.** [Apocynaceae]

Holotype: Kirk 97.
 Copper specimen: Mf 8697.
 Syn.: *Sarcostemma viminale* R.Br.

Habit: Perennial vine, succulent, woody in the lower parts. Stems green, with glabrous internodes, 5-8 mm thick, leafless or with leaves scale-like, ovate triangular, 1.5-2.5 mm long. Inflorescences 10-15-flowered, sessile, lateral at the nodes or terminating short lateral shoots. Pedicels 4-10 mm long. Corolla rotate, greenish-white to yellowish; 5-lobed corolla lobes 3-6 x 1.5-2 mm, ovate-oblong. Outer corona arising 0.5 mm above the base of the staminal column, annular,

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | (X) | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

pentagonal. Inner corona of 5 laterally compressed erect lobes. Follicles 7-10 x 0.6-10 cm, linear-lanceolate, acuminate, glabrous, light brown.

Ecology: Rocky open woodlands, rare on copper cellular siliceous rocks.

General distribution: Eritrea, Somalia, Ethiopia, Kenya, Tanzania, D.R. Congo, Zimbabwe, R.S.A.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: No special interest.

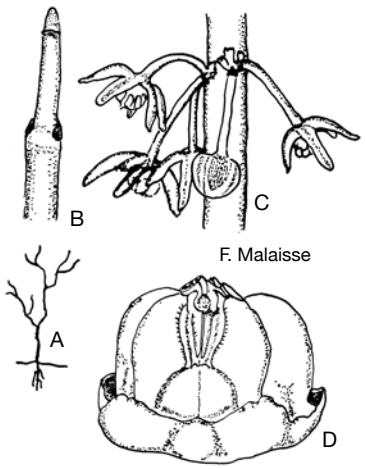
Reference: MEVE, LIEDE [1996].



Fungurume



Fungurume



A. Habit (x 0.01) – B. Apex of young shoot (x 0.5) – C. Flowering stem (x 0.7) – D. Gynostegium with corona (x 9).

[Drawn after MEVE & LIEDE, 1996]

Raphionacme angolensis

(K.Schum.) N.E.Br

Holotype: Welwitsch 4201.
Copper specimens: Mal 281, 368; MKS 635.

Distribution on Katangan copper sites (2 sites): Notably Katuto (41).

See upper pictures



Katuto



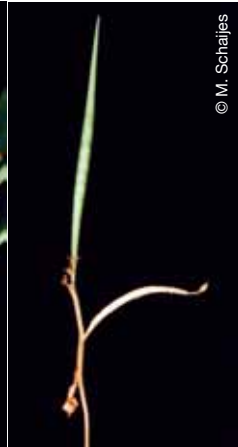
Mamfwe road



Shadirandzoro



Mamfwe road



Nzilo-Kyamasumba road

Raphionacme globosa

K.Schum. [Apocynaceae]

Holotype: Mechow 327.
Copper specimen: Mal 399.

Distribution on Katangan copper sites (3 sites): Notably Shadirandzoro (48).

See lower pictures



Nzilo-Kyamasumba road



Mamfwe road

Strophanthus welwitschii (Baill.) K.Schum. [Apocynaceae]

Holotype: Welwitsch 5991.

Copper specimens: Dj 269; Mf 11842;

Mf-Gj 57, 115.

Syn.: *S. verdickii* De Wild.

Habit: Perennial shrub, 0.6-5 m high, with ascending or scandent branches. Trunk dark brown or grey. Leaves petiolate, opposite; lamina dark green above, pale whitish-green beneath, ovate to narrowly elliptic, up to 8.5 x 4.2 cm, thinly coriaceous. Inflorescence 1-2 flowered. Flowers fragrant, borne in 1-3 flowered cymules at ends of short leafy, lateral shoots; corolla-tube funnel-shaped, purple-red above, and white below on outside, pale yellow with 10 purple-red stripes inside; petaloid appendages on throat triangular-lingulate, purple-red. Follicles \pm 20 cm long, purple-brown, divergent, angle 160-240°, with numerous buff-coloured lenticels. Seeds with grain bearing a coma.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | | 5,000 |
| | 800 | 5,000 | | |

| | | |
|--------|----|---|
| dry | X | X |
| medium | XX | |
| wet | | |

→ oligocuproresistant

Ecology: Miombo woodlands, often on rocky places, also on the ecotone of copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia.

Distribution on Katangan copper sites (8 sites): Notably Kambove (71).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 37-83, Co = 5-8 $\mu\text{g/g}$ D.M.

Rehabilitation: No evident interest.

Reference: BEENTJE [1982].



Nzilo-Kyamasumba road



© M. Schajles



© J. Parmentier

Fungurume

Trachycalymma foliosum (K.Schum.) Goyder

[Apocynaceae]

Holotype: Chevalier 24227.
Copper specimen: Mal 327.

Habit: Perennial herb, 1-3 annual stems, from one or more subglobose or napiform tubers. Stem erect, 40-60 high. Leaves pubescent, petiole 3 mm long; lamina linear to elliptic, 4-9 x 0.2-5 cm, acute, base cuneate. Inflorescences terminal or extra-axillary with 2-6 nodding flowers per umbel. Calyx lobes 3-5 x 1 mm, ovate to lanceolate. Corolla campanulate, white, frequently suffused with pink or purple, lobes 7-10 x 3-6 mm, ovate-oblong. Corona purple with white margins, lobes 2.5-4 mm long. Follicle erect, 20-25 x 0.5 cm, narrowly fusiform, with a stipe to 17 cm long.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Woodlands and savannas.

General distribution: From Ghana to Central African R., and Angola to Mozambique.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.

Reference: GOYDER [2001].



Kavifwafwaulu



Manika plateau



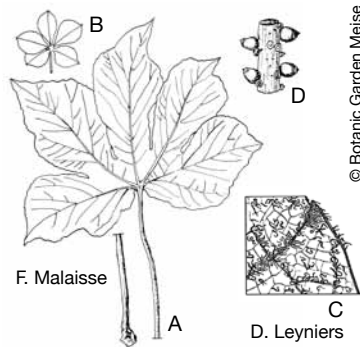
Cussonia arborea Hochst.
ex A.Rich.

Holotype: Schimper 13257.
Copper specimen: Mf s.n.

Habit: Tree or shrub; bark thick and fissured, dark-grey to reddish-grey.

Ecology: Open forests, rocky soils, rare in rocky steppe savannas.

General distribution: From Guinea-Bissau to Sudan, and southwards to Zimbabwe.



A. Young leaf (x 0.2) – B. More mature leaf showing deeper division of lamina (x 0.1) – C. Lamina lower face (x 4.6) – D. Portion of primary branch in inflorescence in fruit (x 0.9). [Drawn after O. Milne-Redhead in TENNANT, 1968]

© Botanic Garden Meise

Cussonia corbisieri
De Wild. [Araliaceae]

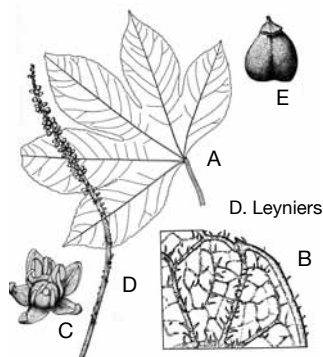
Holotype: Florent in Homblé 649.
Copper specimen: Mal 483.

Habit: Geofrutex with a nave-shaped rootstock.

Ecology: Woodlands, rare in steppe savannas with low copper content.

General distribution: D.R. Congo, Zambia.

Reference (for both species):
BAMPS [1974].



A. Leaf (x 0.1) – B. Lamina lower face (x 3.7) – C. Flower, two anthers removed (x 1.5) – D. Fruiting spike (x 0.1) – E. Fruit (x 1). [BAMPS, 1974]

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Kalukundi



Kipopo



Mamfweroad

Aristolochia heppii Merxm.

[Aristolochiaceae]

Holotype: Dehn R19.

Copper specimen: Mf 14235.

Habit: Perennial herb with annual stems from a fleshy rootstock. Stems decumbent to trailing, up to 40 cm long. Leaves 1.5-9 x 1-6 cm, ovate to ovate-oblong, obtuse at the apex, rounded at the base; lamina with 5 principal longitudinal veins from the base; petioles 2-10 mm long. Flowers solitary in leaf axils; bracts leaf-like, 4-12 x 1.5-7 mm elliptic. Perianth greenish in the lower part, dark purple to crimson-brown in upper part; constricted part below the utricle 1-2 mm long; inflated part (utricle) 2.5-7 mm in diam.; tube straight, 5-16 x 1-2 mm; limb 13-35 x 2-8 mm, oblong-elliptic. Fruit a 6-ribbed capsule, seeds creamy-yellow.

Ecology: Miombo open forests, rarely on copper steppe savannas.

General distribution: D.R. Congo, Zambia, Zimbabwe.

Distribution on Katangan copper sites (3 sites): Notably Luiswishi (87).

Rehabilitation: No evident interest.

Reference: STANNARD [1997].



Mamfwe road



Kipopo

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XX | (X) | | |

→ oligocuproresistant



L.A. Ngoy

A. Habit (x 0.25) – B. Flower (x 0.5) – C. Flower, basal part (x 0.9) – D. Fruit (x 0.5) – E. Fruit, transversal section (x 0.5) – F. Fruit, longitudinal section (x 0.5).

[Original plate]

Anisopappus chinensis (L.) Hook & Arn. subsp. **chinensis**

[Asteraceae]

Holotype: Osbeck s.n.
Copper specimens: Dp 2893 A;
Ls 84640; Mf 7888; Pj 73/1016;
Rw 1760; Sa 7226; Tr 49.
Syn.: *A. hoffmannianus* Hutch.

Habit: Perennial herb, 0.3-0.9 m high, stem erect, single, white-pilose. Leaves elliptic to ovate, 2-6.5 x 1-3.2 cm, base cuneate to hastate-cordate, margin crenate. Capitula 7-10 mm long; phyllaries 2-9 mm long, densely pilose and glandular. Tube of outer florets cylindrical, 0.8-1.8 mm long, ray 3.5-6 mm long; disc florets with tube cylindrical but narrowed just above the base, 2.5-3.4 mm long, lobes 0.5-1 mm. Achenes 1.5-2.2 mm long, short pilose on the ribs; pappus of unequal scales 0.3-1 mm long.

Ecology: Savannas, open forests, also on copper steppe savannas.

General distribution: Tropical Africa and tropical Asia, China.

Distribution on Katangan copper sites (4 sites): Fungurume (51), Kalongwe (81), Ruashi (96), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 258-1657, Co = 8-919 µg/g D.M. Copper hyperaccumulator, cobalt accumulator. Values need confirmation.

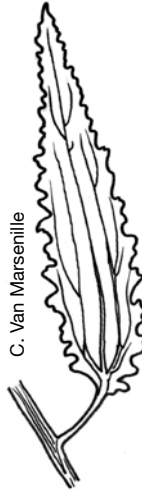
| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | XX | X | |
| wet | | | | |

→ mesocuproresistant

Rehabilitation: Pioneer on medium rich copper soils.

References:

LISOWSKI [1989].
BEENTJE [2002].



Leaf (x 0.9).
[Original plate]



Etoile mine



Mwera

subsp. **buchwaldii** (O. Hoffm.)
S. Ortiz, Paiva & Rodr.-Oubiña



Nzilo-Kyamasumba road

Anisopappus davyi S.Moore

[Asteraceae]

Holotype: Burt Davy 18041.
 Copper specimens: Dp 3004 A;
 Lb-Mf 217, 235; Mf-Gj 71; Mf-Re 2175;
 Sa 7130; Tr 280.

Habit: Perennial herb, with a small woody rootstock and annual stems, 0.6-1 m high; stems reddish, glabrous, leafy in lower part. Leaves green with reddish margins, petiole 0.5-2 cm long; blade linear to narrowly oblong, at least 4 time longer than wide, 2-6 x 0.15-0.6 cm, base attenuate, margins entire or dentate, apex obtuse or acute. Capitula 6-12 mm long, solitary or in lax, few-headed corymbs; stalks of individual capitula 3-9 cm long, slender; phyllaries pale green with reddish tips, ovate to lanceolate, 2-6 mm long, acute. Florets orange-yellow; outer florets ± 16, with tube cylindrical, 0.6-1.5 mm long; inner florets many, tube slightly infundibuliform. Achenes cylindrical, 1.6-1.7 mm long, sparsely pilose; pappus of squamae 0.3-0.7 mm long.

Ecology: Steppe savannas, often on copper/cobalt bearing soils.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia.

Distribution on Katangan copper sites (10 sites): Kazinyanga (49),

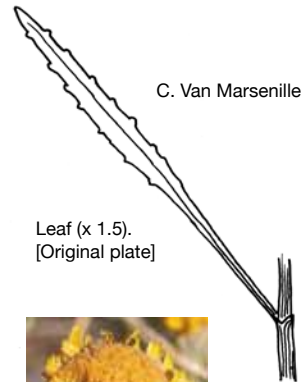
| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | X | |
| medium | XX | X | |
| wet | | | |

→ mesocuproresistant
 Mambilima (50), Fungurume (51), Mindigi (60), Swambo (62), Shinkolobwe (67), Mitonte (68), Kambove (71), Kasonta (91), Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 126-782, Co = 85-2782 µg/g D.M. Copper accumulator, cobalt hyperaccumulator. Values need confirmation.

Rehabilitation: No evident interest.

References:
 LISOWSKI [1989].
 BEENTJE [2002].



Leaf (x 1.5).
 [Original plate]

C. Van Marsenille



Kwatebala



© J. Parmentier

Aspilia mossambicensis
(Oliv.) Wild

Holotype: Grant s.n.
Copper specimens: Mf 10875; Mf-Re 2198.
Syn.: *A. natalensis* (Sond.) Wild

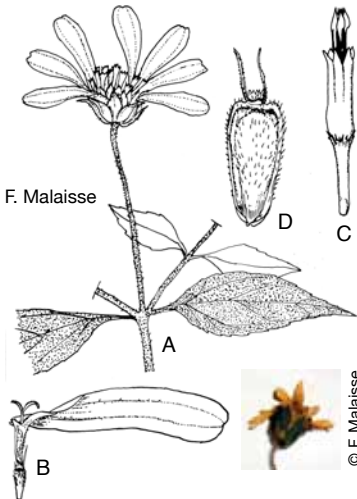
Habit: Perennial herb, 30–250 cm high, with a single or many stems from a rootstock. Leaves sessile or with petiole to 1 cm long, ovate to lanceolate, 2.5–20 x 1–8.5 cm, base rounded to cuneate, margins serrate or subentire, apex attenuate or acuminate; 3-veined from base. Capitula terminal and solitary or in few-headed racemes; stalks of individual capitula to 14 cm long; involucre ovoid, 2–3-seriate, 5–17 mm long. Ray and disk florets cream, yellow to orange. Achenes narrowly obovoid or sub-cylindrical, 2.5–5.5 mm long.

Ecology: Grasslands to woodlands, ruderal sites.

General distribution: From Somalia and Ethiopia southwards to R.S.A.

Distribution on Katangan copper sites (2 sites): Notably Shabara (24).

Reference: BEENTJE, HIND [2005].



A. Habit (x 0.6) – B. Ray floret (x 2) –
C. Disc floret, anthers showing (x 3.5) –
D. Achene (x 3).

[Drawn after J. Williamson in BEETJE &
HIND, 2005]

Bidens oligoflora (Klatt)
Wild [Asteraceae]

Holotype: Buchner 32.
Copper specimens: Lj 4624; Mf 10407.

Habit: Annual herb, 0.4–1 m high. Leaves pinnatifid or bipinnatifid, 3–20 x 2–6 cm. Capitula terminal, in lax corymbose cymes. Ray florets golden yellow to orange; disc florets yellow.

Ecology: Bushed grasslands.

General distribution: Cameroon, southwards to Zimbabwe.

Distribution on Katangan copper sites (4 sites): Notably Etoile (97).



Lusinga, Upemba National Park



Etoile mine

Centaurea praecox Oliv. & Hiern

[Asteraceae]

Holotype: Barter 1223.
Copper specimen: Mf-Kk 593.

Habit: Perennial herb, often caespitose, 1-several stems from a large semi-woody rootstock. Stems up to 40 cm high, erect, sparingly branched. Leaves sessile, 3-4 x 0.5-1.4 cm, oblong-elliptic to oblanceolate. Capitula precocious, 1-many borne at ground-level when produced before leaves, solitary and terminal on short stalk or foliose branches when produced later. Phyllaries many-seriate, imbricate, coriaceous. Receptacle densely setose. Florets glandular, glabrous; marginal florets neuter, corollas whitish; inner-florets hermaphrodite, corollas white, often purple-tinged.

Ecology: Open forests, grasslands, rarely copper steppe savannas.

General distribution: West Africa to Sudan, and southwards to Zimbabwe and Mozambique.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| medium | <X< | <X< | 5,000 | |
| wet | 800 | 5,000 | | |

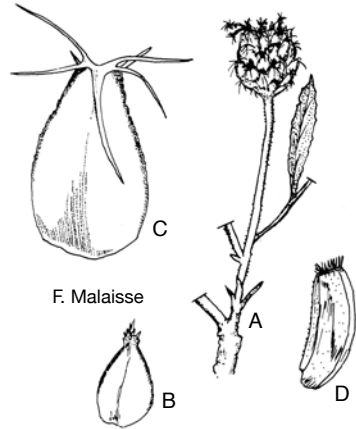
dry
medium **XXX (X)**
wet **X**

→ oligocuproresistant

Distribution on Katangan copper sites (1 site): Mwadikomba (47).

Rehabilitation: Robust stabilizer.

Reference: POPE [1992].



A. Habit, capitula in flower, young leaves (0.4) – B. Outer phyllary (x 1) – C. Middle phyllaries (x 3) – D. Achene (x 1.5).

[Drawn after E. Catherine in POPE, 1992]



Mwadikomba



Mamfwe road



Kipopo

Lectotype: Schimper 1479.
Copper specimens: Ba 377; Tr 105.
Syn.: *Microglossa angolensis* Oliv. & Hiern.

Habit: Shrub or woody herb, 0.4-3 m high, with 1-several stems from a woody rootstock. Stem striate, terete, densely pubescent. Leaves aromatic, sessile or briefly petiolate, blade elliptical or lanceolate, 2-9 x 0.3-3 cm, base cuneate to obtuse, margins entire to tendate, acute at the apex, scabrid above, pubescent and glandular beneath. Capitula 4-7 mm long, many in dense terminal leafy corymbs up to 20 cm in diam. Flowers sweet-scented; marginal flowers white or pale yellow, 30-40, tube 1.5-2.9 mm long, rays erect in buds, spreading at anthesis; central florets yellow, 5-17.

Ecology: Grasslands and bushlands, also copper steppe savannas with low copper content.

General distribution: From Nigeria to Sudan and Ethiopia, northwards to Egypt, southwards to D.R. Congo, Zambia and Malawi.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | | <X< | <X< | > |
| medium | XXX | X | | |
| wet | | | 800 | 5,000 |

→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Kamoya (72), Shituru (74), Lupoto (92).

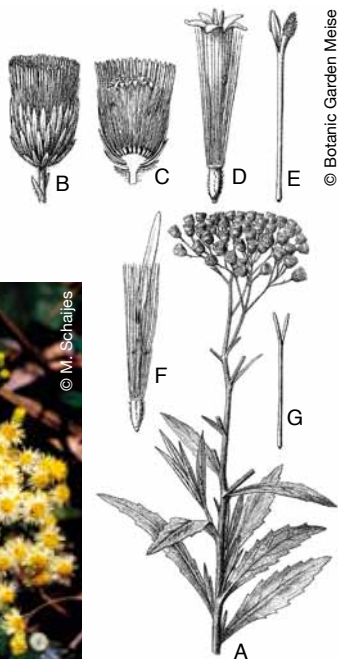
Rehabilitation: No evident interest.

References:

LISOWSKI [1991].
BEENTJE [2002].



Kolwezi-Musokatanda road



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A. Habit (x 0.3) – B. Capitula (x 2.2) – C. Capitula longitudinal section (x 2.2) – D. Tubular flower (x 5.3) – E. Tubular flower style (x 6.6) – F. Ligulate flower (x 5.3) – G. Ligulate flower style (x 8).

[DE WILDEMAN, 1910]

Dicoma anomala Sond.

[Asteraceae]

Holotype: Zeyher 1028.
Copper specimens: Mf 9233, 12718;
Mf-Gj 35; MKM 11, 123, 138; MKS 29.

Habit: Decumbent spreading perennial herb. Aerial stems, borne apically on aromatic turbinate semi-woody tubers. Stems annual, few to many, radiating-procumbent, 5-60 cm long, wiry and flexuous or more stiffy robust, simple or branched, uniformly leafy, closely densely araneose. Leaves discolorous, sessile or with the midrib petiole-like in the lower c. 10 mm; mostly 25-70 x 2-6 mm, linear-elliptic, acute at the apex, broadly cuneate at the base, sharply callose-tipped serrulate, densely greyish araneose-lanate beneath. Capitula from 1-30 per stem, solitary and terminal on stem and branches, in a rosette of 2-many subtending leaves. Phyllaries 90-200. Florets 20-90, corollas purplish-mauve or white.

Ecology: Miombo woodlands, wooded grasslands, rocky hillsides,

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | X | (X) | |
| medium | X | | | |
| wet | | | | |

→ mesocuproresistant

steppe-savannas on high plateaus and copper soils.

General distribution: From Rwanda and Uganda to Namibia and R.S.A.

Distribution on Katangan copper sites (9 sites): Kakavilondo (31), Kabwelunono (34), Shimbidi (35), Kwatebala (45), Mambilima (50), Fungurume (51), Luita (58), Shinkolobwe (67), Etoile (97).

Rehabilitation: Pleasant habit.

References:

LAWALRÉE, MVUKIYUMWANI [1982].
POPE [1992].



Kwatebala



Kwatebala



Kakavilondo

Gutenbergia pubescens (S.Moore) C.Jeffrey [Asteraceae]

Holotype: Rogers 10963.

Copper specimens: Bi 15; Dp 2806 C1; Hh 15935; Lj 4628; Nn 1185; Rw 1775; SDS 26; Sm 1414; Tr 60.

Syn.: *G. cuprophila* P.A.Duvign.,
Ethulia pubescens S.Moore

Habit: Annual herb, often gregarious, erect, much branched, 5-20 cm tall; stems weak, cylindrical, striate, araneose-tomentose, leafy. Leaves opposite, becoming alternate on upper stem, sessile, narrowly oblong to oblong-lanceolate, acute to rounded at base; lamina 3-15 x 1.5-5 mm, denticulate, discoloured, brownish-green above, greyish-white and araneose-felted below. Capitula numerous, 10-15-flowered, campanulate, pedunculate; phyllaries 3-seriate, oval-elliptic, 4-5 x 1.5-2 mm, mauve in upper part. Corolla mauve, funnel-shaped, 4.5-5.0 mm long; 5-lobed, 2.0-2.2 mm long, lanceolate, acute at apex. Achenes turbinate, non-ribbed, 15 mm long, truncate above.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-----|
| | normal | 200 | 800 |
| dry | <X< | <X< | > |
| medium | 800 | 5,000 | |
| wet | XX | XX | |

→ polycuprophyte

Ecology: Copper steppe savannas.

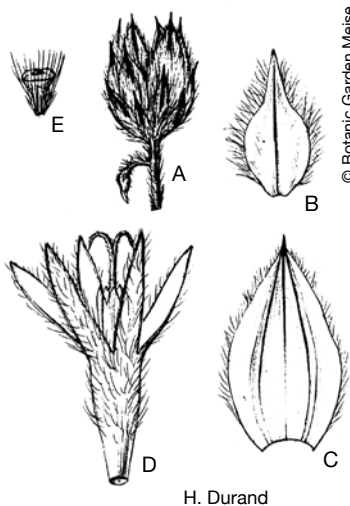
General distribution: Restricted to two copper mines in Upper Katanga.

Distribution on Katangan copper sites (2 sites): Ruashi (96), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 82-5095, Co = 156-2309 µg/g D.M. Copper and cobalt hyper-accumulator. Values need confirmation.

Rehabilitation: Pioneer for rocky soils with high copper content.

Reference: LISOWSKI [1989].



A. Capitula (x 3) – B. External phyllary (x 6) – C. Internal phyllary (x 6) – D. Flower (x 6) – E. Achene (x 6).
[Original plate]



Etoile

Helichrysum keilii Moeser

[Asteraceae]

Holotype: Keil 164.

Copper specimens: Dp 2226 H, 3023 H, 3117 He, 3219; Mf 9878; MKM 70; MKS 385; Sm 4696; Tr 215.
Syn.: *H. gillettii* De Wild.

Habit: Perennial herb, erect annual shoots 1-2, from a woody rootstock, 30-50 cm high. Leaves basal and cauline, linear, subcoriaceous, discolor, dark brown above, whitish-argenteous below, obtuse at top; base attenuate; basal leaves 20-25 x 0.3-1.1 cm; 3-7 parallel nerves. Capitula 2.5-3 mm long, many together in dense subglobose clusters. Phyllaries yellow, 3-seriate, linear to lanceolate, 2-3 mm long, acute. Florets yellow, 3-5, tube 1.9-2.3 mm long, lobes 0.2-0.3 mm long, glandular. Achenes cylindric, 0.6-1 mm long, glabrous; pappus 2-2.5 mm long, flattened and subplumose distally.

Ecology: Herbaceous savannas, also on copper steppe savannas.

General distribution: Angola, D.R.

| Hydration | Copper content of soil (in µg per g of soil) | | |
|-----------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

Congo, Rwanda, Burundi, Tanzania, Zambia.

Distribution on Katangan copper sites (8 sites): Dikuluwe (2), Shabara (24), Kasompi (27), Tenke (32), Kabwelunono (34), Kavifwafwaulu (42), Kwatebala (45), Mindigi (60).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 12-16, Co = 46-206 µg/g D.M.

Rehabilitation: No evident interest.

References:

LISOWSKI [1989].
BEENTJE [2002].



Kavifwafwaulu



Habit (x 0.22) – B. Outer involucre bract (x 6) – C. Achene (x 5).

[Drawn after J. Adamska in LISOWSKI, 1989]

Helichrysum kirkii Oliv. & Hiern var. *kirkii*

[Asteraceae]

Holotype: Grant s.n.
Copper specimens: Dp 321, 2250 H;
Tr 277.

Habit: Perennial suffrutex, 0.3-1.2 m high; one to several stems from a woody rhizome, simple or sparsely branched, pubescent to tomentose, densely leafy. Leaves green above, green or whitish beneath, sessile, linear, 1-5 x 0.1-0.4 cm, soft-hairy above, base rounded, margins revolute, apex acute and mucronate. Capitula 9-16 mm long, terminal, solitary or in few-headed cymes; stalks of individual capitula 1-3 mm long; phyllaries multiseriate, shiny golden yellow, ovate to lanceolate, 2-13 mm long. Florets yellow or orange-yellow; outer florets few, in one or two rows; inner florets many, with tube cylindric, 3.1-4 mm long. Achenes cylindric, 0.6-1.1 mm long, glabrous; pappus yellowish, 3.5-4.5 mm long, caduceus.

Ecology: Savannas, open forests, also on copper steppe savannas.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant

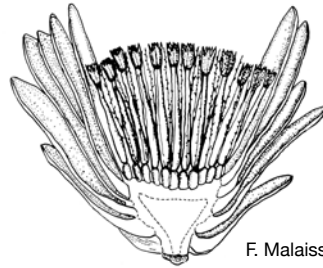
General distribution: D.R. Congo, Tanzania, Kenya, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (3 sites): Kasompi (27), Fungurume (51), Shinkolobwe (67).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 29, Co = 4 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: BEENTJE [2000, 2002].



Capitulum, cross section (x 3.5).
[Drawn after L. Gurr in BEENTJE, 2002]



Shinkolobwe



Helichrysum lejolyanum Lisowski

[Asteraceae]

Holotype: Lukuesa 239.
Copper specimens: Dp 3099, 3117, 3401, 3485, 3506, 4618; Dp-Tj 2217 H, 2220 H; Mf-Kk 113, Wr 873.

Habit: Geofrutex with a robust rootstock; stems erect, very short, 3-9 cm long, at least three times shorter than the basal leaves, densely tomentose-grey. Basal leaves oblanceolate, petiole 2-5 cm long, lamina 15-20 x 3 cm, attenuate to the base on a great length, acute at the apex, nerves well developed on both faces; stem leaves sessile, lanceolate, amplexicaule at the base. Capitula terminal, globose, dense, 2.5-3 cm in diam.; phyllaries 3-4-seriate, yellow-brownish, lanceolate, acute to acuminate at apex. Florets yellow, tube 6.1 mm long, lobes reflected and glandular. Achenes 1.2-1.4 x 0.5-0.6 mm, ellipsoid, angular, brown; pappus 4.5-5 mm long.

Ecology: Steppe savannas, mainly developed on copper soils, very rarely on Kalahari sands.

General distribution: Restricted to Upper Katanga.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | (X) | XX | | |
| medium | | | | |
| wet | | | | |

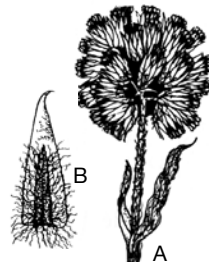
→ oligocuprophyte

Distribution on Katangan copper sites (6 sites): Dikuluwe (2), Mupine (4), Shabara (24), Mindigi (60), Tantara (63), Kalongwe (81).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 31-69, Co = 6-60 µg/g D.M.

Rehabilitation:
No evident interest.

References:
LISOWSKI [1986; 1989].



J. Adamska

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A. Inflorescence (x 5.6) – B. Median involucre bract (x 3.3). [LISOWSKI, 1989]



Dikuluwe

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Helichrysum mechowianum Klatt var. **ceres** (S.Moore)

Beentje

[Asteraceae]

Holotype: Scott Elliot 8170.
 Copper specimens: Dp 3483, 4091;
 He 1012; MKS 757; Rf 10331.
 Syn.: *H. ceres* S.Moore.

Habit: Geofrutex with a robust rootstock; stems erect, up to 50 cm long, cottonous-tomentose, whitish. Basal leaves petiolate, up to 30 x 5 cm, oblanceolate to elliptic; petiole 3-10 cm long; lamina cuneate at the base, acute and frequently apiculate at the apex, greyish on both faces; stem leaves sessile, lanceolate, 1.5-2 cm long. Inflorescences terminal, several-headed; capitula 5-6 mm long, 8-12 flowered; phyllaries 4-seriate, brown and cottony at base, gold yellow and scarious above; outers ovate, 2 mm long; inners lanceolate, 4.5 mm long. Florets yellow, tube 4.5-5 mm long, lobes erect, glandular outside. Achenes 1 mm long, pubescent-angular; pappus as long as corolla.

Ecology: Grass savannas, steppe savannas on Kalahari sands and copper soils.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | XX | X |
| wet | | | |

→ mesocuproresistant

General distribution: Tanzania, Rwanda, Burundi, D.R. Congo, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (4 sites): Shabara (24), Goma (33), Kwatebala (45), Kamoya (72).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 24-37, Co = 72-124 µg/g D.M.

Rehabilitation: Pleasant habit, nice aptitude for low to medium copper rich soils.

References:

LISOWSKI [1986; 1989].



Kwatebala

Helichrysum nitens Oliv. & Hiern subsp. **robynsii** (De Wild.)

Lisowski

[Asteraceae]

Holotype: Robyns W. 2163, 2391.
 Copper specimens: Dp 4747 He;
 MKS 385; Tr 256.
 Syn.: *H. robynii* De Wild.

Habit: Perennial suffrutex, with woody rootstock; rosette of large leaves and a solitary stem 0.2-0.8 m with smaller sessile leaves. Leaves grey or whitish, sessile; rosette leaves ovate to lanceolate, 4-15 x 0.7-3.5 cm, base broad and clasping, apex acute and mucronate, densely tomentose on both surfaces; cauline leaves smaller and narrower, widely spaces on the stem. Capitula 15-23 mm long, in lax terminal cymes. Phyllaries shiny yellow or tinged bronze or brown, 5-seriate, ovate to lanceolate, 5-17 mm long. Florets yellow, outer florets few; inner florets

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-----|-------|
| normal | 200 | 800 | > |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |

| | | |
|--------|----|-----|
| dry | | |
| medium | XX | (X) |
| wet | | |

→ oligocuproresistant

many. Achenes cylindric, 1-1.2 mm long, glabrous; pappus pale yellow, 4.1-4.7 mm long.

Ecology: Steppe savannas, rocky slopes, rarely on copper steppe savannas.

General distribution: Angola, D.R. Congo, Rwanda, Burundi, Zambia, Malawi.

Distribution on Katangan copper sites (2 sites): Shabara (24), Kabwelunono (34).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 18-45, Co = 136-158 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: LISOWSKI [1989].



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Shabara



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Kabwelunono

Inula shirens Oliv.

Holotype: Buchanan 458.
Copper specimens: Mf 7754; MKS 472.

Habit: Perennial herb, with a rosette of basal leaves and an erect flowering stem 0.3-1.5 m high. Blade elliptic, 15-45 x 7-26 cm. Capitula 2-2.4 cm long. Florets yellow; ray florets bright yellow.

Ecology: Miombo and grasslands.

General distribution: From D.R. Congo and Tanzania to Mozambique.

Distribution on Katangan copper sites (5 sites): Notably Kwatebala (G7).



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Mamfwe road



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Kavifwafwaulu

Launaea nana (Baker)

Chiov. [Asteraceae]

Holotype: Rowland s.n.
Copper specimen: Wr 582.

Habit: Acaulescent perennial herb; rootstock vertical and fleshy. Leaves in rosette, obovate to spatulate, 3-19 x 1.5-5 cm, margins denticulate, apex rounded to acute, glabrous. Inflorescence domed, of several short flowering shoots, densely branched, less than 15 cm long; involucre 11-16 mm long; phyllaries 1-20 mm long, with a minute hair-tuft at apex. Corolla yellow, fading purple, tube 5-6 mm long, ligule 4-6 mm x 1.2-1.4 mm. Achenes red-brown, 3.5-5.5 mm long, 5-angular, glabrous, pappus of setae 9-14 mm long.

Ecology: Grasslands and wooded grasslands subject to burning.

General distribution: From Sierra Leone to Sudan and southwards to Angola and R.S.A.

Distribution on Katangan copper sites (1 site): Kamatanda (73).

Reference (for both species): JEFFREY, BEENTJE [2000].



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Kasenga road



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Mamfwe road

Lopholaena deltombei P.A.Duvign.

[Asteraceae]

Holotype: Duvigneaud 3435 D1.
 Copper specimens: Dp 3023 D, 3435 D1; KSM 24; Mf 9783, 10870; MKS 122, 349; Sm 4695, 4712; Rw 676; Tr 247.

Habit: Perennial grass, 40-90 cm high, much branched in upper part, tomentose, rarely glabrescent. Leaves alternate, simple, entire, amplexicaul, palmatinerve, 8-12 x 3-4 cm; base asymmetric, cuneate; apex acute; densely tomentose with olivaceous hairs or glaucous green and glabrous. Capitulum homogamous, 11-13-flowered, campanulate, 15-17 x 6-8 mm, aggregate at apex of branches, surrounded by leaves and leafy bracts; involucre bracts 4-6, uniseriate, coriaceous, oval. Corolla white.

Ecology: Copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (13 sites): Tilwezembe (20), Shabara (24), Kakavilondo (31),

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | X | (X) | |
| medium | | X | | |
| wet | | | | |

→ eurycuprophyte

Goma (33), Kabwelunono (34), Kavifwafwaulu (42), Kwatebala (45), Fungurume (51), Kamoya (72), Kamatanda (73), Luishia (77), Kalongwe (81), Kasonta (91).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 41-50, Co = 377-976 µg/g D.M. Co accumulator.

Rehabilitation: Imposing habit.

References:

DUVIGNEAUD, TIMPERMAN [1959].
 LISOWSKI [1991].



Shabara



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Pasaccardoa procumbens (Lisowski) G.V. Pope

[Asteraceae]

Holotype: Duvigneaud 5503.

Copper specimens: Dp 5503; Mf 9230; Mf-Gj 111; Tr 216.

Syn.: *P. jeffreyi* Wild. subsp. *procumbens* Lisowski.

Habit: Decumbent suffrutex from a woody rootstock. Stems annual, 1-several, up to 50 cm long, trailing. Leaves subsessile or petiole 2-5 mm long; lamina 3-8 x 0.5-1.2 cm, narrowly elliptic, acute to rounded at the apex, arrowly cuneate below, margin serrulate, lower surface araneose-lanate, both surfaces densely gland-dotted. Capitula solitary and terminal, subtended by leaf-like bracts. Phyllaries numerous lanceolate-subulate (outer) to linear-lanceolate (inner). Corollas of ray- and disk-florets creamy-white to yellowish. Ray-florets up to 14 mm long. Achenes 5 mm long, subcylindric, 10-ribbed with numerous stiff white hairs appressed in the grooves.

Ecology: Wooded savannas, steppe savannas on Kalahari sands and on copper outcrops.

General distribution: Restricted to Upper Katanga and North-Western Province of Zambia.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (4 sites): Shabara (24), Kalukundi (16), Kwatebala (45), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 14-50, Co = 51-462 µg/g D.M.

Rehabilitation: No evident interest.

References:
LISOWSKI [1991].
POPE [1992].



Kwatebala



Fungurume



Manika plateau

Pleiotaxis bampsiana Lisowski

[Asteraceae]

Holotype: Lisowski 341.
Copper specimens: Dp 3316, 3502, 5505, 5176; Mf 16178; Mf-Re 2383.

Habit: Erect perennial herb, with woody tuberous rootstock, 12-60 cm tall. Stem annual, 1, simple or branching, striate, tomentose-whitish. Stem leaves very reduced, lanceolate, 0.6-2 cm long; basal leaves in rosette, sessile, broadly elliptic, 3.5-11 x 0.7-2 cm, base cuneate, apex acute, lamina bullate, discolorous, dark green above and lanose when young, grey-tomentose below, margin irregularly dentate; nervation pinnate, 9-12 lateral nerves, minor impressed venation above, reticulation strong below. Capitula terminal, solitary or with 1-2 lateral capitula; involucre obconic, 2.5 cm long; phyllaries ± 5-seriate. Florets with red corolla, 19-24 mm long. Achenes 8 mm long, strongly 5-ribbed, hairy; pappus stramineous, 12-14 mm long.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | X | |
| medium | (X) | XX | |
| wet | | | |

→ oligocuproresistant

Ecology: Rocky outcrops, including copper rocky steppe savannas, woodlands.

General distribution: Restricted to Upper Katanga, mainly in the surroundings of Kolwezi.

Distribution on Katangan copper sites (5 sites): Dikuluwe (2), Mupine (4), Kananga East (7), Kalukundi (16), Menda (28).

Rehabilitation: Pleasant habit.

Reference: LISOWSKI [1991].



Manika plateau



Kananga East

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Pleiotaxis lejolyana

Lisowski [Asteraceae]

Holotype: Lisowski 347.
Copper specimens: Mf 16131, 16164.

Habit: Perennial herb from a woody rootstock. Leaves sessile, blade ovate, auriculate, tomentous-tawny on both faces, upper face of old leaves becoming green-grey, margin crenulate-denticulate. Flowers all hermaphrodite, 9-12 per capitula; capitula 16-20 x 7-9 mm; corolla red, 13 mm long.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (1 site): Kananga East (A5).

Ecology: Open forests, rocky slopes, dembos, rare on copper rocky slopes.



Nzilo-Kyamasumba road



Kananga East

Pleiotaxis rogersii S.Moore

[Asteraceae]

Holotype: Rogers 26231.
Copper specimens: Mf 10785, 16266; Tr 185.

Habit: Perennial herb from a woody rootstock. Leaves subsessile to 15 mm long petiole; blade discolorous, subcoriaceous, linear to narrowly lanceolate, margin serrulate.

General distribution: Restricted to Upper Katanga and Zambia.

Distribution on Katangan copper sites (16 sites): From Mashamba (5) to Etoile (97).

Ecology: Miombo, mainly copper steppe savannas.

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 29, Co= 124 µg/g D.M.



Manika plateau



Shadirandzoro

Pleiotaxis pulcherrima Steetz

[Asteraceae]

Holotype: Peters s.n.
 Copper specimens: Dp 3432, 3483,
 4134, 4140, 4658; Mf-Re 2359;
 MHK 201; Sm 4920.

Habit: Perennial herb, 1-several stemmed, from a woody rootstock. Stems ascending, white-tomentose, 20-60 cm tall. Leaves sessile; blade ovate to lanceolate, 10-18 x 1-6 cm, rounded or cuneate, minutely serrate, obtuse to acute, bright green and glabrous above, silvery-white or grey tomentose beneath, pinnately veined. Capitula solitary, terminal, involucre narrowly ovoid to obconic, 27-35 mm long, glabrous. Phyllaris ± 70, ± 8-seriate, rather rigid, outer ovate, oblong, innermost narrowly elliptic. Florets ± 40; corolla dark crimson to red, 22-24 mm long, lobes oblong-lanceolate.

Ecology: Open forests and grasslands, rarely also in copper steppe savannas.

General distribution: Angola, D.R. Congo, Burundi, Tanzania, Malawi, Mozambique.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Shabara (24), Mambilima (50), Niamumenda (93).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 24, Co = 74 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: JEFFREY, BEENTJE [2000].



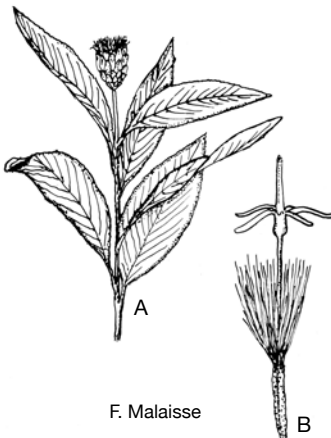
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Kipopo



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Shabara



F. Malaisse

A. Habit, part of stem (x 0.2) – B. Floret (x 1.2). [Drawn after E. Catherine in POPE, 1992]

***Pseudognaphalium luteo-album* (L.) Hilliard & Burt**

[Asteraceae]

Lectotype: van Royen 900.286-294.
Copper specimens: LMM 232, 265;
MKS 947.
Syn.: *Gnaphalium luteo-album* L.

Habit: Annual or short-lived perennial herb, 30-60 cm high, simple or branched. Stems decumbent first, then erect, covered by long white or silvery hairs. Leaves discolorous, with the upper surface paler, sessile, oblanceolate to narrowly obovate, 1-10 x 0.3-1.8 cm, base narrowing and sometimes slightly auriculate, margins entire, apex obtuse or acute, lanate on both surfaces. Capitula straw-coloured to golden, 2.5-5 mm long, many together in dense glomerules 1-2 cm across, glomerules solitary and terminal or several together in terminal corymbs; phyllaries in 3 series, chaffy, pale golden-brown or straw-coloured, lanceolate, 3-4 mm long, acute. Outer florets white or yellow, ± 100; inner florets 5-15, 1.3-2 mm long. Achene ellipsoid, 0.5-0.6 mm long; pappus of barbellate bristles.

Ecology: A weed of arable land, locally on copper outcrops.

General distribution: Southern Europe, but widespread as a (sub) tropical weed.

Distribution on Katangan copper sites (3 sites): Notably Kov (9).

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|----|-----|
| dry | | |
| medium | XX | (X) |
| wet | | |

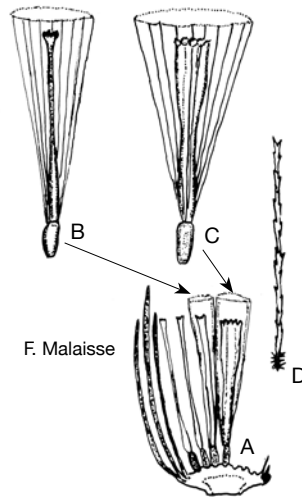
→ oligocuproresistant

Distribution on Zambian copper sites (1 site): Bwana Mkubwa (145).

Rehabilitation: No evident interest.

Reference: POPE [1992].

Note: This plant has been noted on several copper mines of Zimbabwe (Alaska, Mhangura and Muriel mines).



F. Malaisse



Kov mine Kwatebala

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A. Capitulum section (x 7) – B. Outer floret (x 14) – C. Inner floret (x 14) – D. Pappus bristle (x 11). [Drawn after P. Halliday in SCOTT, 1993]

Schistostephium artemisiifolium Baker subsp.

artemisiifolium

[Asteraceae]

Holotype: Whyte 225.
Copper specimens: Mf 10254, 10919;
MKM 52; Tr 290.

Habit: Perennial herb with sparsely branched or unbranched shoots from a rootstock 3-4 mm in diam. Shoots several, subwoody or herbaceous, up to 90 cm high. Stems terete, to 3 mm in diam., sparsely to densely appressed pubescent. Leaves grey-green, pinnatifid, 1-5 x 0.2-3 cm, sessile, deeply lobed with up to 5 lobes on each side plus a terminal lobe; lobes lanceolate up to 2 x 0.4 cm, with acute apex, thinly to densely pubescent. Capitula 4-6 mm long, in terminal corymbs, composed of axillary branches ending in terminal capitula, with up to 6 capitula per branch, individual capitula 3-8 mm in diam. Florets yellow; outer florets few; inner florets many (> 50), lobes 4, 0.2-0.5 mm long.

Ecology: Miombo open forests, savannas, copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-----|-------|
| normal | 200 | 800 | > |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |
| dry | (X) | | |
| medium | XXX | X | |
| wet | | | |

→ oligocuproresistant

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (3 sites): Kwatebala (45), Fungurume (51), Mirungwe (61).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 14, Co = 22 µg/g D.M.

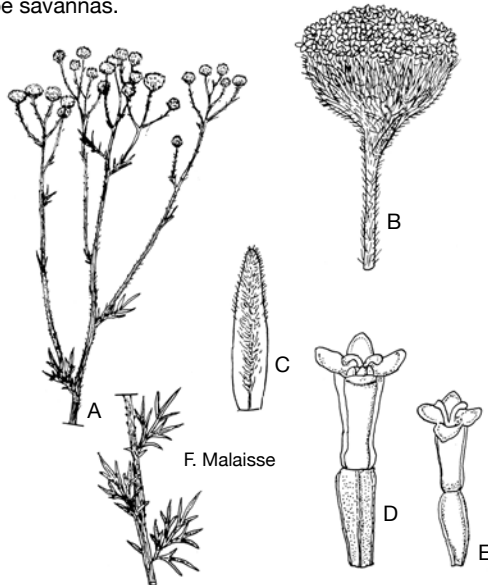
Rehabilitation: No evident interest.

References:

- LISOWSKI [1991].
- BEENTJE [2002].



Fungurume



A. Habit (x 0.5) – B. Capitulum (x 0.7) – C. Phyllary (x 7) – D. Outer floret (x 9.5) – E. Inner floret (x 9.5).

[Drawn after M. Tebbs in BEENTJE, 2002]

Holotype: Descamps 33.
Copper specimen: Mf 16163.
Syn.: *Eremanthus descampsii* Klatt ex De Wild. & T.Durand

Habit: Harsh perennial herb, up to 1 m high, from a large woody rootstock. Stems annual, 1-several, becoming woody below, usually dark-purple, simple and densely leafy, scattered whitish patent-pilose, with short purple T-shaped hairs. Leaves numerous, overlapping, thinly harshly coriaceous, subsessile, up to 11 x 5 cm, obovate to broadly lanceolate, apex subacute, base rounded to broadly cunate, margins coarsely serrate-dentate to subentire, lamina ± scabrous; venation prominent beneath. Capitula numerous, sessile, congested in a very dense terminal, subglobose spike. Involucre up to 15 mm long, obconic or narrowly campanulate. Phyllaries numerous, imbricate, ± cartilaginous, glabrous with large dark gland-pits outside towards

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | X | (X) | |
| wet | | | |

→ oligocuproresistant
the apex, the apices pungent. Corolla purple, 13 mm long. Achenes 2-3 mm long, densely strigose.

Ecology: Mainly Kalahari sandy steppe savannas, rarely miombo and edges of copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga), Zambia.

Distribution on Katangan copper sites (1 site): Kananga East (7).

Rehabilitation: Ornamental value for soils with low copper content.

Reference: POPE [1992].



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Kasipa road



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Kananga



Nzilo-Kyamasumba road

Vernonia melleri Oliv. & Hiern var. *melleri*

[Asteraceae]

Holotype: Meller s.n.

Copper specimen: MSH 377.

Habit: Perennial herb, 20-75 cm tall. Stems erect, one or several, arising from a woody rootstock, often purplish. Leaves oblanceolate, 8-23.5 x 2.2-4.5 cm, cuneate to attenuate into petioloid base, serrate, apex obtuse to shortly acuminate, hispid especially beneath, glabrescent above, mostly on lower part of stem. Capitula 2-13 in lax corymbiform cymes, globose; stalks of individual capitula sometimes

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuproresistant

with numerous narrow bracteoles below the capitulum; involucre 15-22 mm long; phyllaries 4-seriate, lanceolate, 6-23 mm long, acute or attenuate, pale green with dark green or sometimes reddish purple apices. Corolla vivid blue-green, turquoise or pale blue, 15-18.5 long, lobes 5.5-6 mm long, with a few stiff apical hairs. Achenes 7-7.7 mm long, 10-ribbed, pubescent.

Ecology: Woodlands or grasslands, also copper steppe savannas with low copper content.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Mozambique, Zimbabwe, Botswana.

Distribution on Katangan copper sites (1 site): Goma (33).

Rehabilitation: Pleasant habit.

Reference: POPE [1992].



F. Malaisse



Goma



M. Schajtes

Mamfwe road

Vernonia filipendula Hiern

Vernonia perrottetii Walp.

[Asteraceae]

Holotype: Gossweiler 1940.
Copper specimens: Mf 7922, 12833;
Mf-Kk 224; MKS 1008.

Holotype: Perrottet s.n.
Copper specimen: St 662.

Distribution on Katangan copper sites (2 sites): Zikule (30), Etoile (97).

Distribution on Katangan copper sites (2 sites): Luishia (77), Lupoto (92).

See upper pictures

See lower pictures



Manika plateau



Biano plateau

© M. Schaljes



Nzilo-Kyamasumba road



© M. Schaljes

Vernonia stenocephala

[Asteraceae]

Holotype: Thomson s.n.
 Copper specimens: Mf 16559;
 Mf-Gp 1122; Qp 5301; Tr 19.
 Syn.: *V. luteoalbida* De Wild.

Habit: Erect leafy perennial herb, up to 1.3 m high, from a woody rootstock. Stems 1-several, soon becoming leafless below, usually much-branched above, subterete or ribbed, tomentellous-pubescent. Leaves ascending, subsessile, variable; cauline leaves up to 7 x 0.6 cm and linear-elliptic, or up to 7 x 2.2 cm and lanceolate, apices acute to rounded mucronate, margins revolute entire; lamina upper surface puberulous, lower surface finely pubescent; branch leaves mostly ericaceous, 1-3 x 0.1-0.3 cm, linear. Capitula very numerous ± densely paniculate. Involucre up to 12 mm long, ellipsoid-campanulate; phyllaries numerous, appressed-imbriate. Corollas white or creamy-white, up to 9 mm long, tubular below, widening above.

Ecology: Miombo, also copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X | <X | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

General distribution: Nigeria, Angola, D.R. Congo, Burundi, Tanzania, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (3 sites): Lukuni (86), Luiswishi (87), Mabaya (103).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 58-122, Co = 3-61 µg/g D.M.

Rehabilitation: No evident interest.

Reference: POPE [1992].



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Luiswishi



F. Malaisse

A. Habit, basal part (x 0.5) – B. Upper part (x 0.7).

[Drawn after J. Adamska in KALANDA & LISOWSKI, 1995]

Vernonia suprafastigiata

Klatt

Holotype: Descamps 29.
 Copper specimens: Mf 956; Mf-Re 2122; Qp 5235; Sm 4841; St 183.

Distribution on Katangan copper sites (9 sites): Notably Shabara (24), Kambove (71), Kamwali (89).

See upper pictures



Etoile



Kalukundi

Vernonia turbinella S.Moore

[Asteraceae]

Holotype: Kassner 2687.
 Copper specimens: Mf 10337, 10888; Tr 120.

Distribution on Katangan copper sites (3 sites): Shabara (24), Kalukundi (18), Fungurume (51).

See lower pictures



Shabara



Fungurume

Begonia princeae Gilg var. *princeae*

[Begoniaceae]

Holotype: Stolz 166 A.

Copper specimens: Lb-Mf 208;
Mf 9189; Mf-Gr 17; Sa 14030; 168.

Habit: Perennial herb, 5-33 cm tall. Stems erect, simple or sparsely branched; tuber ellipsoid, pinkish. Leaves glabrous; laminae 2-7 cm long, \pm suborbicular, slightly cordate at the base; margins irregularly crenulated; petioles 0.4-3.5 cm long; stipules 5-22 mm long, brownish. Flowers in terminal and axillary dichasial cymes; peduncles 0.3-4.5 cm long. Bracts 1-2 mm long. Male flowers: tepals 2 + 2, pink; outer pair 9-14 x 8-12 mm, suborbicular; inner pair 5-7 x 3-4 mm, obovate. Female flowers: tepals 5, the outer 6-12 x 4-6 mm, elliptic, the innermost smaller; ovary 4-8 x 4-7 mm, ovoid; styles 2-3.5 mm long. Fruits 6-10 x 5-8 mm globose; wings very unequal: largest 7-15 mm wide, triangular; second and third wings much smaller.

Ecology: On termitaria in miombo, also rarely on copper siliceous rocks.

General distribution: Tanzania, D.R. Congo, Zambia, Mozambique.

Distribution on Katangan copper sites (3 sites): Notably Mambilima (50).

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 32-78, Co = 317-432 $\mu\text{g/g}$ D.M. Copper accumulator.

Rehabilitation: Pleasant habit.

Reference: KUPICHA [1978].



Goma



Lulua river



Kundelungu N.P.

***Chamaecrista comosa* E.Mey. var. *capricornia* Steyaert**
 [Caesalpinaceae]

Holotype: F.A. Rogers 10184.
 Copper specimen: Mf-Kk 596.
 Syn.: *Cassia comosa* (E.Mey) Vogel.

Habit: Perennial herb with, erect, simplified or not much branched stems 15-60 cm high arising from a woody rootstock. Stems ± pubescent. Leaves oblong to linear-oblong, 4-13 x 1-3.5 cm; gland at or below top of petiole, sessile, elliptic, cushion-like, depressed in the middle, 1.5-4 x 1-1.5 mm, usually sunk in the petiole; rachis eglandular, channeled. Leaflets sessile, in 10-41 pairs, asymmetrically oblong, 6-22 x 1.25-7 mm, acute and mucronate or apiculate, glabrous, often ± ciliate; midrib somewhat excentric, numerous prominent lateral nerves towards both margins. Inflorescences mostly strongly supra-axillary, 1-3-flowered; pedicels 0.8-2 cm long, pubescent. Petals yellow, 8-18 x 4-13 mm. Pods 4-6.5 x 0.5 cm. Seeds brown, elliptic, 3.5-4 x 2.5-2.75 mm, not areolate.

Ecology: Miombo open forests, clearings, also copper steppe savannas.

General distribution: Tanzania, D.R. Congo, R.S.A.

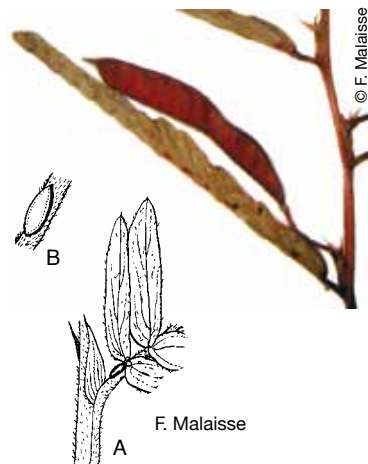
| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|-----|
| | normal | 200 | 800 |
| dry | <X< | <X< | |
| medium | XX | (X) | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (1 site): Mwadikomba (47).

Rehabilitation: Pleasant habit.

Reference: BRENAN [1967].



A. Lower part of leaf (x 2) – B. Petiolar gland (x 4). [Drawn after BRENAN, 1967]



Mwadikomba



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Chamaecrista mimosoides (L.) Green [Caesalpinaceae]

Holotype: Herman 78.

Copper specimens: DKM 1174; MKS 77, 39, 830; Mf 7570; Mf-SI 1; Q 5304.
Syn.: *Cassia mimosoides* L.

Habit: Variable herb, usually annual, erect, 0.3-0.7 m high. Leaves linear to linear-oblong, 0.6-10 x 0.4-1.5 cm; gland near top of petiole, orbicular, dish-shaped when dry, 0.4-1.0 mm in diam.; leaflets sessile, 16-76 pairs, obliquely oblong to oblong-elliptic, 2.5-8 x 0.5-1.3 mm, acute or subacute and shortly mucronate, glabrous, midrib somewhat excentric; lateral nerves obscure. Inflorescences supra-axillary, 1-3 flowered; pedicels 0.3-2.5 cm long. Petals yellow, obovate, 4-13 x 2-9 mm. Pods linear to linear-oblong, 3.5-8 x 3-5 mm, usually appressed-hairy. Seeds brown, \pm rhombic, 2-3 x 1-2 mm, without areoles.

Ecology: Miombo, clearings, also copper steppe savannas.

General distribution: Widespread in Old World tropics.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-----|-------|
| normal | 200 | 800 | > |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

Distribution on Katangan copper sites (10 sites): Pumpi (29), Kakavilondo (31), Goma (33), Kabwelunono (34), Kavifwafwaulu (42), Kwatebala (45), Mwadikombu (47), Lukuni (86), Luiswishi (87), Kasonta (91).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 14-57, Co = 4-7 $\mu\text{g/g}$ D.M.

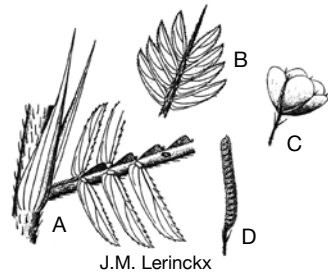
Rehabilitation: No evident interest.

Reference: BRENNAN [1967].



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Luiswishi



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J.M. Lerinckx

- A. Stipule and base of rachis (x 4) –
B. End of leaf (x 4) – C. Flower (x 4.5) –
D. Pod (x 1.3). [STEYAERT, 1952]



© M. Schajies

Biano plateau

Holotype: Kirk s.n.

Copper specimens: LLM 21; LMM 166;

Mf 222, 9320, 9877, 10869;

Mf-Gp 9320; MKM 33; Qp 4903.

Syn.: *C. dasycladum* Harms

Habit: Suffrutex with a thickened woody rhizomatous rootstock; tufted erect annual stems, each 4-40 cm high, simple and with a single terminal inflorescence. Leaves with rachis 3-14 cm long; leaflets 3-16 pairs, \pm asymmetrically oblong-lanceolate, oblong-elliptic or oblong, 0.6-8 x 0.2-2.7 cm rounded to subacute at apex, asymmetric at base, usually glabrous or subglabrous, sometimes \pm pubescent. Racemes terminal, single, 2-12 cm long, glabrous to \pm pubescent. Bracteoles elliptic, 5-15 x 2.5-8 mm. Sepals 1-6, small or very small. Petal 1, 7-9 mm long, sometimes in addition with 1-2 smaller ones 3.5-5 x 1-1.5 mm wide. Stamens usually 3, rarely with up to 2 smaller fertile ones also. Pods mostly 1-2 seeded, 2.5-5 x 1.5-2.7 cm. Seeds 1.2-1.3 cm long, 0.7-1.0 cm wide.

Ecology: Edge of wetter miombo, mainly in steppe savannas, also in surroundings of copper sites, ecotones with low copper mineralization.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Mozambique, Zimbabwe.

Distribution on Katangan copper sites (30 sites): Dikuluwe (2), Mupine (4), Mashamba (5), Kananga (7), Tilwezembe (20), Shabara (24), Pumpi (29), Kakavilondo (31), Tenke (32), Goma (33), Kabwelunono (34), Shimbidi (35), Kavifwafwaulu (45), Mwinansefu (43), Kwatebala (45), Mwadikomba (47), Shadiranzoro (48), Mambilima (50), Kazinyanga (49), Fungurume (51), Mindigi (60), Shinkolobwe (67), Luishia (77), Kasongwe (76), Luiswishi (87),

| Hydra-tation | Copper content of soil (in μg per g of soil) | | |
|--------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

dry

medium **XXX** **XX**

wet

→ oligocuproresistant

Kasonta (91), Lupoto (92), Ruashi (96), Etoile (97), Kimpe (102).

Distribution on Zambian copper sites (3 sites): Kansanshi (100), Chambishi (133), Muliashi (173).



A. Habit (x 0.4) – B. C. Abaxial faces of leaflet (x 0.4) – D. Bud (x 2) – E. Flower (x 2) – F. Flower, longitudinal section (x 2) – G. Pod (x 0.4) – H. Seed (x 0.8).

[LÉONARD, 1952]

Continuation of page 153.

Phytogeochemistry: Cu-Co content of leaves (15 samples) Cu = 22-259, Co = 3-24 $\mu\text{g/g}$ D.M.

Rehabilitation: Great interest for low mineralised copper soils. Great facilitator aptitude. Slow growth.

References:

DUVIGNEAUD, BRENNAN [1966].
BRENNAN [1967].



Nzilo-Kyamasumba road



Luiswishi



Mutuba hill, near Kolwezi

Cyphia erecta De Wild. var. *erecta*

[Campanulaceae]

Holotype: Verdick 345.

Copper specimens: Dp 4102, 4412, 4413, 4423; Mf 11513, 12147; Mf-Gj 22, 34; Tr 241.

Habit: Erect or rarely somewhat twining herb, 8-80 cm tall, from a globose tuber 2 cm in diam.; stem not or sparsely branched. Leaves sessile or shortly petiolate, up to 30-110 x 3-25 mm, linear to broadly elliptic. Raceme dense or lax, up to 25 cm long, pedicels 1-6 mm long; bracts leaf-like. Hypanthium broadly obconical, 10-nerved. Calyx-lobes ± narrowly triangular, 1.5-4.5 mm long, with 1-3 pairs of teeth. Corolla 9-16 mm long, pale blue to mauve or purple, ± saccate at the base, split to the base into 2 lips, the upper 3-lobed, the lower divided into 2 free petals; all petals linear, glabrous, white pubescent inside. Stamens 4-7 mm long, filament dilated and connate at the base; anthers elliptic-oblong, 1.6-3.2 mm long. Ovary semi-superior. Capsule ovoid, with 10 nerves. Seeds broadly elliptic, 1-1.5 mm long, coarsely reticulate, brown.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-----|---------|
| normal | 200 | 800 | > 5,000 |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |

| | | | |
|--------|----|---|--|
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

Ecology: Grasslands, woodlands, also on copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia, Malawi.

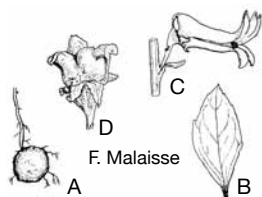
Distribution on Katangan copper sites (6 sites): Tilwezembe (20), Kasompi (27), Fungurume (51), Luita (58), Mindigi (60), Kamoya (72).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 15-82, Co = 27-156 µg/g D.M.

Rehabilitation: Pleasant habit.

References:

THULIN [1983; 1984; 1985].



A. Tuber (x 0.4) – B. Leaves (x 0.4) – C. Flower – D. Capsule (x 1.6). [Drawn after THULIN, 1984]



Kalukundi



Potopoto valley



Fungurume

Cyphia gamopetala P.A.Duvign. & Denaeyer

[Campanulaceae]

Holotype: Duvigneaud 4806C (†).
 Neotype: Malaisse & Robbrecht 2391.
 Copper specimens: Dp 4668, 5413, 5475; Mf 10075; Mf-Re 2391.

Habit: Erect herb, 15-40 cm high. Leaves sessile or with a petiole up to 10 mm long, crowded towards the base of the stem, elliptic, obtuse to subacute at the apex, attenuate to cuneate at the base, 20-50 x 10-25 mm, margin serrate-crenate. Raceme lax, 3-20 cm long, 5-20 flowers; bracts 1.5-5 mm long. Pedicel 1-2 mm long. Hypanthium broadly obconical, 10-nerved; calyx-lobes narrowly triangular, 2.5-5 mm long; corolla mauve, 11-15 mm long, tubular, with 5 subequal lobes; petals linear. Stamens c. 5 mm long; ovary semi-inferior. Capsule subglobose, 10-nerved. Seeds flat, broadly winged, 2.8 x 2.5 mm, brown.

Ecology: Grasslands, copper steppes and siliceous cellular rocks.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XX | XX | | |

→ oligocuproresistant

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (7 sites): Dikuluwe (2), Kalukundi (16), Menda (28), Kavifwafwaulu (42), Luita (58), Swambo (62), Kamoya (72).

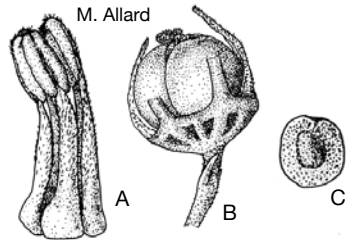
Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 214, Co = 88 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: THULIN [1985].



Kavifwafwaulu



A. Androecium (x 4) – B. Fruit (x 2) – C Seed (x 2). [THULIN, 1985]

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Lobelia erinus L.

[Campanulaceae]

Neotype: Burmester s.n.
Copper specimens: Dp 4130 Lo;
Mf 16136, 16141; Mf-Kk 4.
Syn.: *L. senegalensis* A.DC.

Habit: Annual or sometimes perennial, decumbent to erect herb, 5–70 cm long or tall; stem terete to ± triangular or ribbed, glabrous to pubescent. Leaves 15–75 x 4–20 mm, sparsely serrulate to dentate, crenate or almost pinnatifid, the upper linear to narrowly elliptic, the lower ± rosulate, oblanceolate to spatulate, acute to obtuse at the apex, narrowing below into a petiole up to 15 mm long. Flowers in lax racemes, pedicels up to 5–45 mm long. Hypanthium narrowly obconical to obovoid, 8–10-nerved, glabrous; calyx-lobes narrowly triangular to subulate, erect, 1.2–5 mm long, entire; corolla 7–13 mm long, blue or rarely mauve or white, split to 0.6–2.8 mm from the base at the back; stamens 4–7 mm long, filaments linear, attached to the corolla-tube; anther-tube 1.5–2 mm long. Ovary subinferior. Capsule 8–10-nerved and with 2 valves ± 1 mm long. Seeds elliptic, 0.3–0.4 mm long, very finely striate, brown.

Ecology: Marshy herbaceous vegetation units, river banks, also on disturbed wet copper soils.



Luilu river



KOV mine

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | | | | |
| wet | XX | X | | |

→ oligocuproresistant

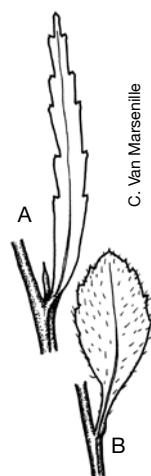
General distribution: Tropical Africa and southern Africa.

Distribution on Katangan copper sites (3 sites): Dikuluwe (2), Kamoto (6), Kingamyambo (8). Also on banks and disturbed soils with copper pollution (KOV mine, Musonoie river, Luilu river).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 113, Co = 22 µg/g D.M.

Rehabilitation: A good pioneer for wet copper polluted sites.

References: THULIN [1983; 1985].



C. Van Marsenille

A. Upper leaf (x 0.9) – B. Lower leaf (x 1.3).

[Original plate]

Lobelia trullifolia Hemsl. subsp. *rhodesica* Thulin

[Campanulaceae]

Holotype: R.E. Fries 449.

Copper specimens: Dp 4194L, 4199L;

Mf 11869.

Syn.: *L. rhodesica* R.E.Fr.

Habit: Annual or short-lived perennial, erect to decumbent herb; 5-20 cm tall, ± densely puberulous with hairs up to 0.3 mm long. Leaves up to 5-12 x 5-12 mm, broadly ovate to subcircular or subreniform, obtuse to subacute at the apex, lower leaves truncate to subcordate at the base, ± incised-crenate; petiole up to 13-22 mm long. Flowers in lax leafy racemes. Corolla blue or pale blue, 4-6.5 mm long, split to 0.6 mm from the base on the back, sparsely puberulous inside, short pubescent on the lobes outside. Filaments linear. Anther-tube 0.6-1.2 mm long, short pubescent on the back. Ovary subsuperior to semisuperior. Capsule ± obovoid, with prominent valves 1.5-3.2 mm long. Seeds elliptic to broadly elliptic in outline, ± compressed, 0.3-0.4 mm long, very finely striate, brown.

Ecology: Rock crevices including copper rocky sites.

General distribution: Upper-Katanga and Zambia.

Distribution on Katangan copper sites (1 site): Mindigi (60).

Distribution on Zambian copper sites (1 site): Bwana Mkubwa (145).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 113-263, Co = 22-51 µg/g D.M.

Rehabilitation: No evident interest, but decorative on rock crevices.

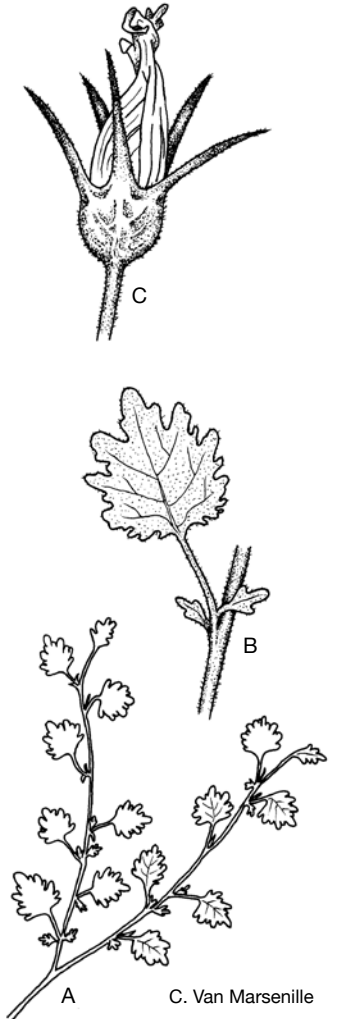
References:

DUVIGNEAUD, DENAEYER-DE SMET [1963].

THULIN [1983].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XX | X | X | |
| medium | | | | |
| wet | | | | |

→ mesocuproresistant



A. Twig (x 0.7) – B. Leaf (x 2.4) – C. Young fruit (x 5). [Original plate]

Wahlenbergia capitata (Baker) Thulin [Campanulaceae]

Holotype: Whyte s.n.

Copper specimens: Dp. 2061, 2829; Mf 7749, 16173; Mf-Kk 118; Tr 54, 257, 279.

Habit: Annual or usually perennial, although probably often short-lived, ± erect herb, up to 1 m tall, from a taproot. Stem with long branches from near the base, hirsute. Leaves sessile, linear to lanceolate or elliptic, up to 15-60 x 1.5-10 mm, acute, with truncate to cunate base, ± hirsute; margin cartilaginous, dentate, often ± undulate. Inflorescence leafy, head-like, sometimes only a terminal head present, but usually a number of smaller lateral heads. Hypanthium obconical, ± 10-nerved. Calyx lobes 2.4-4 mm long, ciliate-pubescent; margins cartilaginous. Corolla 5-6.5 mm long, blue, white or mauve, split almost to the base into linear lobes. Stamens with filament-bases broadly dilated, ciliate-pubescent; anthers 1.2-2.4 mm long. Ovary 3-locular, semi-inferior; style as long as the corolla. Capsule 3-locular, ± 10-nerved, valves 3, 1.5-2.5 mm long. Seeds elliptic-oblong, compressed, 0.5-0.8 mm long; testa almost smooth.

Ecology: Miombo open forests, old cultivations, Kalahari sand and copper steppe savannas, also on Mn steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | XX | | |
| wet | | | | |

→ oligocuproresistant

General distribution: From Rwanda and Burundi to Mozambique.

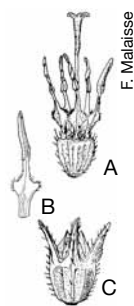
Distribution on Katangan copper sites (18 sites): Notably Ruashi (96).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 11-20, Co = 32-838 µg/g D.M. Cobalt accumulator.

Need confirmation.

Rehabilitation: No evident interest.

References: THULIN [1975; 1976; 1977].



A. Flower (x 4)
– B. Stamen (x 3)
– C. Capsule (x 2.5).

[Drawn after V. Goaman in THULIN, 1976]



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Kipopo



© F. Malaisse

Fungurume



© B. Leclercq

Fungurume

Wahlenbergia collomioides (A.DC.) Thulin

[Campanulaceae]

Holotype: Welwitsch 1163.
 Copper specimens: Dp 3301 L, 3491;
 Mf 10788; Mf-Gj 784, 1185.
 Syn.: *Lightfootia collomioides* A.DC.

Habit: Annual or short-lived perennial herb, up to 1 m tall. Stems erect, rarely unbranched, ± hirsute or glabrescent. Leaves alternate, sessile to subpetiolate, very narrowly elliptic to elliptic, 30-60 x 3-12 mm, acute with cuneate base; margin cartilaginous, undulate-dentate; upper leaves of the same size as the lower ones, forming a sort of involucre. Inflorescences terminal, dense, head-like, round or somewhat elongate; flowers subsessile. Hypanthium obconical or hemispherical, glabrous, 5-nerved. Calyx-lobes 2-4 mm long, glabrous or ciliate. Corolla 5-7 mm long, white or blue, split almost to the base into lanceolate lobes, glabrous outside, puberulous inside near the base; tube 0.1-0.4 mm long. Stamens 4-6 mm long, filament-bases dilated, very shortly and densely ciliate; anthers 1.5-3 mm long. Ovary 3-locular, semi-inferior. Style longer than the corolla, thickened in the upper part, eglandular; lobes 3, 0.6-0.8 mm long. Capsule 3-locular, 5-nerved, valves ± 1 mm long. Seeds elliptic in outline with acute ends, 0.5-0.7 mm long; testa almost smooth.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

Ecology: Grasslands, woodlands, also on copper steppe savannas.

General distribution: Central Africa R., Angola, D.R. Congo, Tanzania, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (6 sites): Shabara (24), Kwatebala (45), Fungurume (51), Swambo (62), Kamatanda (73), Kipushi (90).

Rehabilitation: No evident interest.

References: THULIN [1975; 1977].



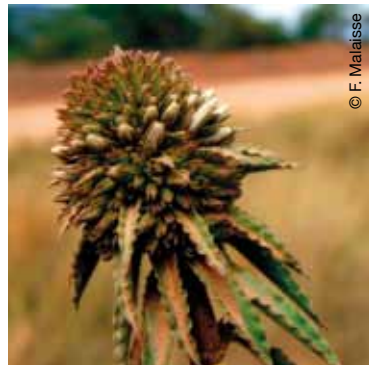
Fungurume

© F. Malaisse



Mamfwe road

© M. Schallies



Kwatebala

© F. Malaisse

Wahlenbergia malaissei Thulin

[Campanulaceae]

Holotype: Malaisse 10549.
Copper specimens: Mf 10549;
Mf-Gp 897.

Habit: Annual erect herb, 20-35 cm tall. Stems ± sparsely branched, angular, hirsute. Leaves alternate, sessile, narrowly elliptic to linear, 13-20 x 1.5-5 mm, acute at the apex, attenuate at the base, margin denticulate. Inflorescence frondose with subsessile flowers in small, axillary and terminal few-flowered clusters. Hypanthium campanulate to hemispherical, 10-nerved, hirsute. Calyx-lobes 1.2-2 mm long, narrowly triangular, acute. Corolla white, split practically to the base, 2.5 mm long, lobes linear, hirsute outside. Stamens 1.5 mm long. Ovary 2-locular, semi-inferior.

Ecology: Copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (2 sites): Kela (52), Kambove (71).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 77, Co = 16 µg/g D.M.

Rehabilitation: No evident interest.

Reference: THULIN [1987].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | X | | | |
| medium | | | | |
| wet | | | | |

→ oligocuprophyte



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F. Malaisse

Habit (x 0.55).
[Drawn after THULIN, 1987]



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Kambove

Wahlenbergia verbascoides Thulin

[Campanulaceae]

Holotype: Gossweiler 12434.

Copper specimens: DKM 1906; MHK 20.

Syn. nov.: *W. polyphylla* Thulin.

Habit: Perennial erect herb or subshrub, 40-80 cm tall. Stems not branched. Leaves erect, numerous, covering the stem except towards the base, lanceolate to narrowly ovate, up to 18 x 7 mm, acute, hirsute, margin cartilaginous, slightly revolute, denticulate. Inflorescence frondose, very dense, spike-like, 5-17 x 1 cm; flowers sessile. Hypanthium 10-nerved, glabrous. Calyx-lobes narrowly triangular 2.4-3.2 mm long. Corolla pale violet, ± 5 mm long, deeply split into linear lobes, stamens 4 mm long, anthers 1.6 mm long. Ovary 3-locular, semi-inferior. Capsule 3-locular, 10-nerved.

Ecology: Grasslands on rocky grounds, also on rocky copper steppe savannas.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | (X) | (X) | |
| medium | | | |
| wet | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo (Upper Katanga).

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 4, Co = 5 µg/g D.M.

Rehabilitation: No evident interest.

References: THULIN [1975; 1987].

Note: The species is known from one site in Angola and six sites in Katanga.



© F. Malaisse

Kwatebala

Holotype: Verdick 577.
Copper specimens: Mf 11705;
MKS 262; Qp 5339; Tr 275.
Syn.: *C. attenuata* var. *longifolia* De Wild.

Habit: Perennial herb, erect, with a basal tuft of leaves; inflorescence up to 2 m high. Stem herbaceous, 6-sided. Radical leaves elliptic to linear-lanceolate and acute above, linear-lanceolate and acute above, cuneate below, margins entire or serrate in the upper part only, lower stem leaves lanceolate. Inflorescence 3-several dense globose capitula, 2-2.5 cm diam. Involucre a series of broadly ovate bracts 4-5 mm long; receptacle bracts elliptic-lanceolate, 5-6 mm long; involucre cupular, 3-4 mm long, including the 4 subulate 1.5-2 mm long teeth, densely pubescent, becoming 4-sided, 8-furrowed and up to 8 mm long in fruit. Calyx small and densely villous. Corolla creamy white, campanulate, 4-lobed, up to 12 mm long. Stamens 4, inserted in the upper part of the tube and

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |

| | | | | |
|--------|----|---|--|--|
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant
alternating with the corolla lobes.
Ovary unilocular, one ovule.

Ecology: Open forests, wooded savannas and copper steppe savannas.

General distribution: Angola, D.R. Congo (Upper Katanga), Tanzania, Zambia.

Distribution on Katangan copper sites (4 sites): Goma (33), Kahumbwe (57), Shinkolobwe (67), Lukuni (86).

Rehabilitation: Pleasant habit.

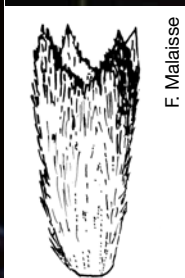
Reference: NAPPER [1968].



Goma



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F. Malaisse

Involucre (x 5).
[Drawn after M. Tebbs in NAPPER, 1968]



© J. Lebrun

Mwadikomba

Silene burchellii Otth ex
DC. var. ***angustifolia*** Sond.

Holotype: Burchell 271.
Copper specimen: Mf 10073.

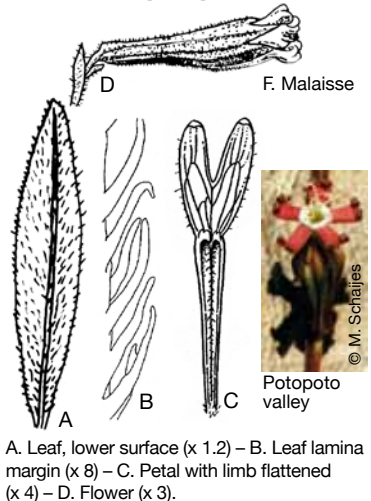
Habit (both species): Perennial herb, numerous fasciculate stems from a woody taproot. Stems dichotomous, 30-40 cm high. Nodes swollen, internodes 8-40 mm long. Leaves numerous, opposite, appearing verticillate, sessile; limb linear, 1.5-3 x 1 mm. Inflorescence with unilateral cyme few-flowered. Flowers 2-7. Calyx tubular-clavate, 10 main veins, densely covered with appressed hooked hairs. Capsule with septa.

Habit (*S. burchellii*): Leaf 200-260 μ m thick, margin hairy. Calyx 15 mm long. Petal with limb flattened, bifid to half length.

Ecology: Grasslands, rocky and stony places, high plateau steppe savannas.

General distribution: From Sudan to Arabia, and southwards to Angola and R.S.A.

References (for both species):
BAKER et al. [1983].
MALAISSE et al. [1983].



A. Leaf, lower surface (x 1.2) – B. Leaf lamina margin (x 8) – C. Petal with limb flattened (x 4) – D. Flower (x 3).

[Drawn after D.R.Thompson
in TURRILL, 1956; MALAISSE et al., 1983]

Silene cobalticola
P.A.Duvign. & Plancke
[Caryophyllaceae]

Holotype: Duvigneaud & Timperman
2190 S.
Copper specimens: Dp-Tj 2192 S, 2224
S; Mf 10799, 11746, 11870; Tr 297.

Habit (*S. cobalticola*): Leaf succulent (450 μ m thick), margin glabrous. Calyx 11 mm long. Petal invaginate.

Ecology: Copper steppe savannas.

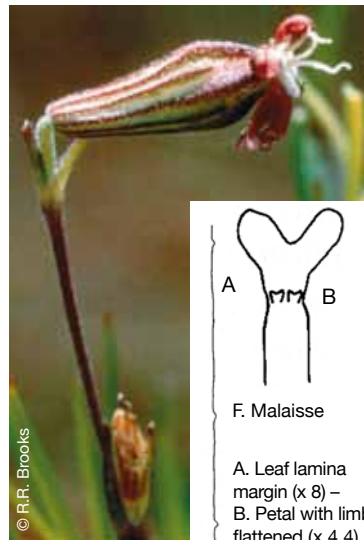
| Hydratation | Copper content of soil (in μ g per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | | |
|--------|-----|--------|-----|---|
| dry | | | | |
| medium | bbb | (b, c) | ccc | c |
| wet | | | | |

→ b (*burchellii*) = mesocuproresistant,
c (*cobalticola*) = polycuprophyte.

General distribution and on Katangan copper site: Restricted to Mindigi (60).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 23-64, Co = 40-46 μ g/g D.M.



Mindigi mine

Combretum platypetalum Welw. ex M.A.Lawson subsp.
oatesii (Rolfe) Exell [Combretaceae]

Holotype: Welwitsch 4356.
 Copper specimens: DKM 1908;
 KSM 65, 154; Sa 5450.

Habit: Shrublet 15-30 cm high, with a thick woody rhizome, often leafless when flowering. Leaves opposite, subopposite or alternate; lamina from 1 x 1.4 to 10 x 5 cm, subcircular to very narrowly elliptic, glabrous to densely tomentose. Inflorescences terminal or axillary panicles; flowers red, 4(5)-merous. Lower receptacle up to 4 mm long, densely fulvous-pubescent; upper receptacle 4-5 x 2-3 mm, campanulate, rufous-pubescent. Petals red, circa 2.5 x 2.5 mm, subcircular to ovate. Stamen-filaments 7-8 mm long, usually red; anthers 0.9 mm long, red or purplish. Fruit 4(5)-winged, 2-2.5 x 1.5-2 cm, elliptic in outline, sparsely pubescent on the body, with a distinct apical peg, wings up to 9 mm broad, thin, stipe 2-6 mm long.

Ecology: Steppe savannas, also on copper steppe savannas.

General distribution: From Angola to Mozambique, Namibia and Botswana.

Distribution on Katangan copper sites (8 sites): Notably Lupoto (92).

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-----|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 154, Co = 32 µg/g D.M.

Rehabilitation: No evident interest, but colourful during blossoming and fruiting.

Reference: EXELL [1978].



Kolwezi-Musokatanda road



Mamfwe road

***Ipomoea cairica* (L.) Sweet
var. *cairica***

Holotype: From Egypte (illustration).
Copper specimens: Bi 11; Qp 4907.

Habit: Perennial herb. Stems twining or prostrate, up to 1.8 m long. Leaf-blade ovate to orbicular in outline, palmately divided to the base into 5-7 lobes, 3-10 cm long and wide. Corolla broadly funnel-shaped, purple, red or white with purple centre 4.5-6 cm long.

Ecology: Forest clearings and cultivated grounds, very rare in disturbed places of copper mines.

General distribution: Throughout tropical Africa; also from eastern Mediterranean region through Asia to Formosa.

Distribution on Katangan copper sites (1 site): Etoile (97).



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Kolwezi-Kapata road

***Ipomoea linosepala* Hall. f.
subsp. *alpina* (Rendle) Lejoly
& Lisowski [Convolvulaceae]**

Holotype: Kassner 2909.
Copper specimens: Mf 11435, Mf-Gp 108.

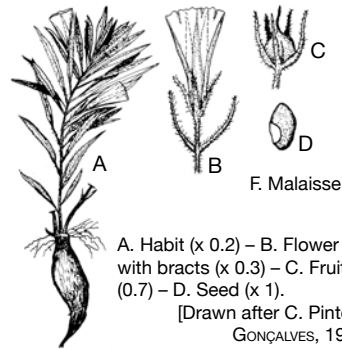
General distribution: Nigeria, Burundi, Tanzania, Angola, D.R. Congo, Zambia and Malawi.

Distribution on Katangan copper sites (17 sites): Notably Shabara (C4).



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Kolwezi-Musokatanda road



F. Malaisse

A. Habit (x 0.2) – B. Flower with bracts (x 0.3) – C. Fruit (0.7) – D. Seed (x 1).

[Drawn after C. Pinto in GONÇALVES, 1987]



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Mamfwe road

Ipomoea linosepala Hall.f.
subsp. *linosepala*

Holotype: Welwitsch 6191.
Copper specimens: Mf 11512, Mf-Gp 59.

Habit: Perennial robust herb. Leaves narrowly oblong or lanceolate, up to 7 x 1.5 cm, concolorous. Flowers numerous on dense inflorescences. Sepals up to 17 mm long, bearing 2-3 mm long yellow-ferruginous hairs.

Ecology: Miombo open forests, copper steppe savannas on slopes.

General distribution: Angola, D.R. Congo, Zambia and Malawi.

Distribution on Katangan copper sites (7 sites): Notably Tilwezembe (20).



Busanga

Ipomoea recta De Wild.
[Convolvulaceae]

Holotype: Verdick 306.
Copper specimens: Dp 47271; Mf 10252.

Habit: Perennial, erect or prostrate herb, unbranched, up to 45 cm high. Leaves hairy, petiole 1.5-3 mm long. Lamina ovate or lanceolate, 12-33 x 2-10 mm, base cuneate or rounded, apex apiculate. Flowers axillary, solitary, erect; pedicels 5-6 mm long; sepals subequal, ovate-lanceolate. Corolla narrowly funnel-shaped, white or pink outside, up to 4.5 cm long. Capsule globose, 7-8 mm in diam., glabrous, Seeds globose, velutinous tomentose.

Ecology: Steppe savannas on Kalahari sands, rocky slopes and copper soils.

General distribution: Tanzania, D.R. Congo, Zambia.

Distribution on Katangan copper sites (8 sites): Notably Goma (33).

References: GONÇALVES [1987]. LEJOLY, LISOWSKI [1992].



Fungurume



Mamfwe road

Crassula vaginata* Eckl. & Zeyh. subsp. *vaginata

[Crassulaceae]

Holotype: Ecklon & Zeyher 1903.

Copper specimens: Ba-Mf 8233;

Bh 239; Mf 7688, 9207, 10290, 10359, 10871; Mf-Gj 47; MKM 45; Mf-Re 2171, 2800; Pl 5358; Tr 141.

Syn.: *C. alba* Auct. non Forssk.

Habit: Succulent perennial, 8-90 cm high, forming clumps. Rootstock a fleshy to woody swollen tuber. Stems annual, dying back after flowering, erect, straight, terete, pale-green below, bright red to crimson above. Leaves sessile, oblong to linear, 2.5-17.5 x 0.2-2.1 cm, the basal ones the longest, rosulate, bases of opposite leaves united to form a sheath around the stem. Inflorescence a terminal repeatedly dichotomous, sub-hemispherical, corymbose cyme, with foliaceous bracts; pedicels 2-6 mm long. Flowers 5-merous. Calyxlobes narrowly triangular to ovate-lanceolate. Petals cream or white, 3-4 x 1-1.3 mm. Carpels oblong, up to 2.7 mm long. Seeds 2-6 per carpel, broadly oblong.

Ecology: On high plateau sands, also in cellular siliceous copper rocks.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | XX | |
| medium | | | |
| wet | | | |

→ oligocuproresistant

General distribution: From Nigeria to Sudan, southwards to South Africa and Angola.

Distribution on Katangan copper sites (3 sites): Shabara (24), Kwatebala (45), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 25-28, Co = 1625-1905 $\mu\text{g/g}$ D.M. Cobalt hyperaccumulator.

Rehabilitation: Pleasant habit.

Reference: TÖLKEN [1985].



Biano plateau



Fungurume

Coccinia adoensis (A.Rich.)

Cogn.

Syntypes: Dillon & Petit s.n., Schimper 166.
Copper specimen: Mal 278.

Habit: Climber or trailer to 3 m; rootstock perennial. Leaves variable; blade triangular, ovate to ovate-cordate, entire to sharply dentate, unlobed to palmately 3-5-lobed. Tendrils simple. Male flowers 2-22 in solitary and unbranched racemes on 5-75 mm long peduncles; corolla campalulate, golden-orange to pale apricot or salmon-coloured. Female flowers solitary, corolla funnel-shaped.

General distribution: Nigeria to Ethiopia, and southwards to R.S.A.

Ecology (for both species): Deciduous woodlands to grasslands, rare on copper steppe savannas with low copper content.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).



Shinkusu



Kalukundi

Mukia maderaspatana (L.)

M.J. Roem. [Cucurbitaceae]

Holotype: Illustration of *Cucumis maderaspatensis* fructo minimo in Pluk.
Copper specimen: LMM 200.

Habit: Climber or trailer to 2.5 m; perennial woody rootstock. Leaf-blade sagittate, hastate, triangular, ovate to cordate, sinuate-toothed to dentate-lobulate, scabrid-hairy, 12-113 x 14-110 mm, unlobed or 3(-5)-lobed. Male flowers on 1-3 mm long pedicels; petals yellow. Female flowers 5-10 in separate clusters on 1 mm long pedicels, petals 1 mm long and broad. Fruits subglobose, bright scarlet, smooth. Seeds ovate in outline, bordered, scrobiculate.

General distribution: Tropical Africa, Asia and Australasia.

Distribution on Katangan copper sites (4 sites): Notably Shinkusu (G5).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

References (for both species):

JEFFREY [1967].

KERAUDREN-AYMONIN [1975].



F. Malaisse

A. Male flower, opened to show stamens (x 2.5) – B. Female flower, opened to show disk (x 3.3) – C. Seed, side and face views (x 2.8). [Drawn after JEFFREY, 1967]



Shinkusu

Trochomeria macrocarpa (Sond.) Hook.

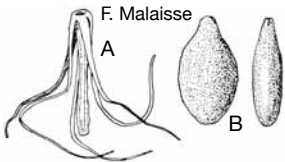
Syntypes: Burke 290, Zeyher 579.
Copper specimen: Mf 11132.

Habit: Perennial climbing or trailing herb to 2.5 m long. Leaf-blade ovate-acuminate to broadly ovate-cordate, 18-95 x 24-98 mm, unlobed to palmately 3-5-lobed. Stipuliform bracts absent or suborbicular, ciliate-toothed. Male flowers with petals linear-lanceolate, green or greenish-yellow.

Ecology: Deciduous woodlands to grasslands, rare on copper steppe savannas with low copper content.

General distribution: From Senegal to Sudan and southwards to R.S.A.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).



A. Male flower (x 0.8) –
B. Seed, face and side views bract (x 0.8)
– C. Fruit (x 0.4) – D. Stipule (x 0.4).
[Drawn after JEFFREY, 1967]



Mamfwe road



Kazinyanga

Zehneria minutiflora (Cogn.) C. Jeffrey [Cucurbitaceae]

Isotypes: Stolz 566, 1139.
Copper specimen: Mal 280.

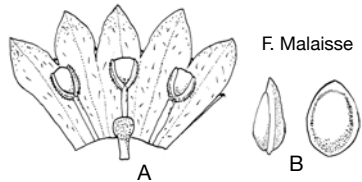
Habit: Climber to 4.5 m long. Stems glabrous. Leaf-blade ovate-cordate to pentagonal, hastate or sagittate, subentire to sinuate-toothed. Dioecious. Male flowers 2-21 in subumbelliform clusters; petals white, becoming cream then yellow when old. Female flowers solitary. Fruit on a 22-27 mm long stalk, fusiform, bright red, 11-24 x 5-8 mm. Seeds ovate, biconvex, compressed, bordered.

Ecology: Grasslands, moist places, rare on ecotone of copper *Uapaca* belts.

General distribution: From Cameroon to Ethiopia, and southwards to Zambia.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Reference (for both species):
JEFFREY [1967].



A. Male flower, opened (x 6) – B. Seed, side and front views (x 2).

[Drawn after KERAUDREN-AYMONIN, 1975]

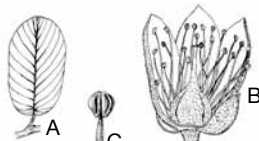


Kazinyanga

Monotes katangensis (De Wild.) De Wild. [Dipterocarpaceae]

Holotype: Verdick 486 & 548.
Copper specimen: Qp 4897.

Habit: Tree 5-14 m tall. Leaf-blades oblong to elliptic, 6-9 x 3.5-6 cm, obtuse or slightly emarginated at apex, rounded or slightly cordate at the base; petiole 1-2 cm long. Inflorescences of subsessile condensed many-flowered clusters up to 15 cm long, yellow-brown or red-brown tomentose; pedicels 1-3 mm long. Sepals ovate, 3-4 x 2.5-3 mm, densely silky tomentose. Petals linear-oblong, 0.6-1 x 0.2 cm, densely silky tomentose. Connectives of anthers not produced at the apex. Fruit 7-9 mm in diam., tomentose; wings pinkish, red or reddish purple, obovate-oblong to spatulate, 2.5-4 x 0.7-1.5 cm.



F. Malaisse

A. Leaf (x 0.2) – B. Vertical section of flower (x 1.5) – C. Anther and part of filament (x 6).

[Drawn after W.A. in DUVIGNEAUD, 1949; 1961]

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuprophyte

Ecology: Miombo open forests.

General distribution: D.R. Congo (Katanga), Tanzania, Zambia, Mozambique.

Distribution on Katangan copper sites (5 sites): Notably Fungurume (51).

Reference: DUVIGNEAUD [1961].



© M. Schaljes

Lubumbashi-Likasi road



Biano plateau



Mwera road

Monotes magnificus Gilg

[Dipterocarpaceae]

Holotype: Goetze 680.

Copper specimens: Mal 145, 478.

Habit: Shrub to small tree up to 8 m high; branchlets pubescent, becoming glabrous. Leaf-lamina very large, 13-23 x 11-17 cm, suborbicular, emarginate at the apex, cordate at the base; upper surface finely reticulate; lower surface discolorous, greyish- or brownish-floccose-tomentose, minute stellate hairs; purple extra leaf-glands in the axils of lateral nerves; lateral nerves in 10-11 pairs; veins prominent and conspicuous; petiole 2-3.5 cm long. Inflorescence axillary, few-flowered, subsessile, densely rufous-tomentose; pedicels 3-6 mm long. Sepals 7 mm long, rufous-sericeous-tomentose. Petals 11-12 mm long, rufous-sericeous-tomentose. Stamens with anthers produced into a short triangular apiculum. Fruit 15-23 mm in diam.,

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium | XX | | |
| wet | | | |

→ oligocuprophyte

brownish. Wings 6-7 x 2.5 cm, yellow or reddish, broadly oblanceolate.

Ecology: Woodlands, also rocky copper steppe savannas.**General distribution:** D.R. Congo (Katanga), Tanzania, Zambia and Malawi.**Distribution on Katangan copper sites** (3 sites): Kinshasa (14), Katuto (41), Shadirandzoro (48).**Reference:** VERDCOURT [1989].

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Kawambwa (Zambia)



Katuto



© F. Malaisse

Erica benguelensis (Welw. ex Engl.) E.G.H. Oliver var.***benguelensis***

[Ericaceae]

Holotype: Welwitsch 2560.

Copper specimens: Mf-Kk 431;

Pi-Kk 4633.

Habit: Much branched shrub or small tree up to 6 m tall, evergreen; bark dark brown and peeling off in strips. Leaves in whorls of 4, pale green, fleshy, flat above, convex and sulcate beneath, narrowly elliptic, 0.8-4.5 x 0.4-0.9 mm; petioles 0.5-0.7 mm long. Inflorescence with nodding flowers in clusters of 4-12 at the tip of branchlets; pedicel reddish, 1-2.2 mm long, puberulous with minute simple or glandular hairs. Calyx bowl-shaped, shortly pubescent, margin glandular or fimbriate; 3 equal lobes broadly triangular, 0.9-1.2 mm long, 4th lobe somewhat longer. Corolla 4(-5)-partite, dark pink to red, fading brown, bowl-shaped, 1.1-1.8 x 1.5-2.5 mm, pubescent outside. Stamens 8, rarely 5-9, anthers remaining fused after dehiscence. Ovary 4-locular, puberulous, to 0.8 mm long; style 0.1-0.3 mm long, stigma peltate, 0.6-1.5 mm in diam. Fruit splitting in 4 at maturity, with a ridged central axis topped by the capitate stigma.

Ecology: High plateau on Kalahari sands, rocky submontane escarpment, very rare on rocky copper shrub steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 800 | |
| | | | 5,000 | |
| dry | X | (X) | | |
| medium | XX | | | |
| wet | | | | |

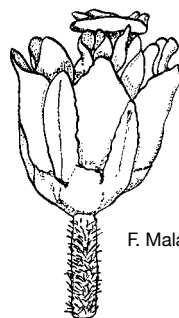
→ oligocuproresistant

General distribution: Angola, D.R. Congo, Uganda, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (2 sites): Pumpi (29), Mindigi (60).

Rehabilitation: No evident interest.

Reference: BEENTJE [2006].



F. Malaisse

Flower (x 15).

[Drawn after J. Williamson
in BEENTJE, 2006]

Manika plateau



© M. Schallies

Acalypha cupricola W.Robyns ex G.A. Levin

[Euphorbiaceae]

Holotype: Robyns 1711.

Copper specimens: Ls 11829; Mf 7928; MKM 81; Rw 1711; Tr 197; Wr 598.

Habit: Perennial herb, from a woody rootstock. Stems numerous, simple, erect, 30-60(90) cm tall, light green when young, becoming greyish green. Stipules caduceous, linear, 1-2 x 0.5 mm; petioles 0.5-4 mm long. Lamina very narrowly ovate to narrowly obovate, (2.5)4-6(8) x (0.3)0.8-1.2(1.5) mm, apex acute, base acute to obtuse, margins entire except serrate in the distal quarter; lamina 3-nerved from the base. Plant dioecious, inflorescences axillary. Staminate inflorescence 10-20 mm long, 0.5-0.7 mm in diam.; staminate flowers puberulent, stamens 8, anthers cream-coloured. Pistillate flowers, sessile, sepals 3, ovate; pistil with 3 carpels; ovary densely puberulent; styles 2-3 mm long. Seeds 2.3-2.8 x 1.8-2 mm.

Ecology: Copper steppe savannas.

General distribution: Upper Katanga copper orebodies.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | XXX | X |
| wet | | | |

→ eurycuprophyte

Distribution on Katangan copper sites (25 sites): Notably Likasi (75).

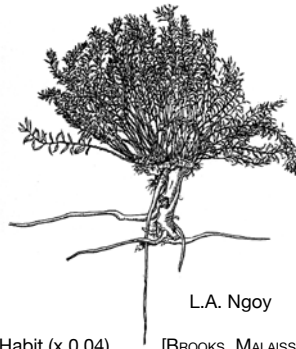
Phytogeochemistry: Cu-Co content of leaves (9 samples): Cu = 35-559, Co = 5-430 $\mu\text{g/g}$ D.M. Copper accumulator, cobalt accumulator.

Rehabilitation: Large amplitude regarding Cu/Co content of soil.

References:

ROBYNS [1932].

LEVIN et al. [2007].



L.A. Ngoy

Habit (x 0.04).

[BROOKS, MALAISSE, 1985]



Mamfiwe road



© F. Malaisse

Acalypha dikuluwensis P.A.Duvign. & Dewit

[Euphorbiaceae]

Holotype: Duvigneaud 4485 Ac.
Copper specimen: Dp 4485 Ac.
Syn.: *A. clutioides* Radcl.-Sm. syn. nov.

Habit: Perennial densely caespitose suffrutex, 20-40(50) cm high, stout woody rootstock. Stems many, simple, densely leafy, pilose or pubescent. Leaves sessile, or petiole 0.5-2 mm long. Leaves blade elliptic-ovate to ovate lanceolate, 0.5-3 x 0.4-1.2 cm, acuminate, entire, rounded to shallowly cordate at the base, sparingly pilose above, pubescent along the midrib and main nerves beneath, chartaceous, 5-nerved from the base, with tertiary nerves parallel and fairly prominent beneath; lateral nerves in 1-3 pairs, slightly prominent above, fairly prominent beneath. Lower leaf blades more broadly ovate to almost suborbicular. Stipules 1-1.5 mm long, linear, reddish-brown. Plant dioecious. Male racemes up to 5 cm long, axillary, solitary, densely flowered, on peduncles up to 2 cm long; bracts 1.5 mm long, linear-spathulate. Male flowers: pedicels 1 mm long; buds subglobose, sparingly pubescent, greenish-brown; anthers minute, cream-coloured. Female flowers axillary, solitary; peduncles 2 mm long; bracts 5 x 8 mm, palmatipartite to palmatifid with lobes linear-lanceolate and acuminate, pubescent, glabrous within; flower sessile within the bract; sepals 3, 2 mm long, ovate-lanceolate, acute ciliate; ovary 2 mm in diam., 3-lobed, pubescent, hirsute and tuberculate at the apex; styles 4 mm long, free fimbriate, red. Fruits 3 x 3 mm, 3-lobed, pubescent-pilose, yellowish. Seeds 2 x 1.5 mm, ovoid, dark brown.

Ecology: Steppe savannas on Kalahari sands, copper soils, sandy dembos and *Uapaca* woodlands.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ mesocuproresistant

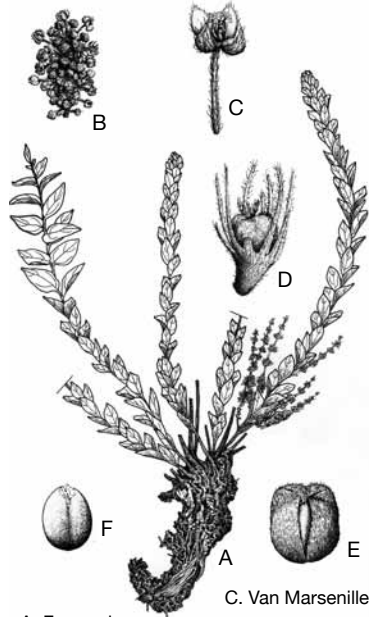
General distribution: Zambia (Western Province) and D.R. Congo (Upper Katanga).

Distribution on Katangan copper sites (1 site): Dikuluwe (2).

Rehabilitation: No evident interest.

References:

DUVIGNEAUD, DENAEYER-DE SMET [1963].
RADCLIFFE-SMITH [1996].



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A. Fernandez

A. Habit (x 0.2) – B. Male inflorescence (x 1.5) – C. Male flowers (x 6) – D. Female flowers (x 2.3) – E. Fruit (x 3) – F. Seed (x 3).

[A. Original plate, B-F. BAMPs MALAISSE, 1996]

Euphorbia cupricola (Malaisse & Lecron) Bruyns

[Euphorbiaceae]

Holotype: Malaisse 10356.

Copper specimens: Mf 9124, 9228, 12704, 16243; Pi 5352; Tr 127, 245.

Syn.: *Monadenium cupricola* Malaisse & Lecron

Habit: Perennial herb, erect, glabrous, succulent. Tuberous root, cylindrical, 2-4 cm high. Stems solitary or two, unbranched, up to 30 cm high. Leaves 5-10, alternate, spirally disposed, linear, sessile or subsessile, with an entire margin, 11 x 0.8 cm, green, midrib prominent below. Cymes solitary, axillary, in the upper half of the stem, 0.5 mm pedunculate; bract-cup glabrous, green, bicarinate, 2-lobed, at 1/3 to 2/3 divided; involucre cup-shaped, truncate at top, shortly longer than bract-cup; style divided up to the base. Capsule pedicellate, exserted on a reflexed pedicel, trilobate, 3.5 x 3.4 mm. Seed tetragone, truncate at base and summit, pale brown, 2.6 x 1 mm; caruncle white, short pedicellate, 0.7 mm in diameter.

Ecology: In rock crevices with low copper content (notably siliceous

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| medium | X | X | | |
| wet | | XX | | |

→ mesocuprophyte

cellular rocks) and in steppe-savannas with medium copper content.

General distribution: Restricted to the Katangan Copper Arc.

Distribution on Katangan copper sites (2 sites): Tilwezembe (20), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 20-52, Co = 76-1,234 $\mu\text{g/g}$ D.M. Cobalt accumulator. Values need confirmation.

Rehabilitation: Medium interest for rocky sites.

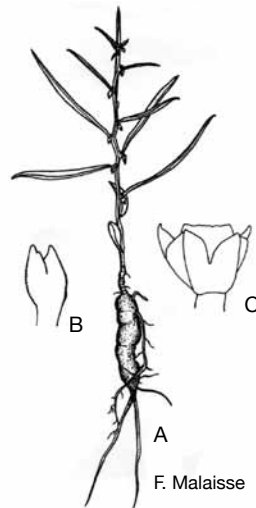
References:

MALAISSE, LECRON [1990].

MALAISSE et al. [1995].



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A. Habit (x 0.2) – B. Bracteal head bud (x 5)
– C. Bracteal head, dorsal view (x 2.3).

[MALAISSE, LECRON, 1990]

Fungurume



© M. Schajles

Tilwezembe



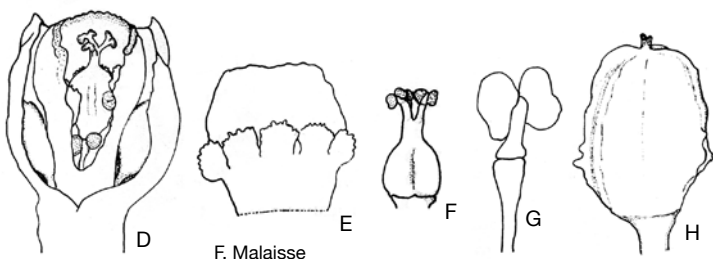
© J. Lebrun

Fungurume



© J.M. Lecron

Seed



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D. Bracteal head, front view (x 4.3) – E. Involucre cup (x 3.7) – F. Ovary (x 9) – G. Stamen (x 9) – H. Capsule (x 6).
[MALAISSE, LECRON, 1990]

Euphorbia discoidea (P.R.O.Bally) Bruyns [Euphorbiaceae]

Holotype: A.W. Cruse 435.

Copper specimens: Mf 11530, 12408.

Syn.: *Monadenium discoideum*

P.R.O.Bally

Habit: Perennial herb, erect, setuligerous, succulent. Tuberous root, cylindrical, 2-5 cm high. Stems solitary, unbranched, up to 20 cm high. Leaves sessile, scale-like at the base of the stem, getting shortly petiolate, elliptic, cuneate, acute, to 4.2 x 1.4 cm towards the tip of the stem; margin entire setuligerous at both sides. Cymes solitary, in the leaf axils, once forked, scattered along the stem. Bract-cup nodding, transversally ovate, almost circular, 9-11 x 11-18 mm, much exceeding the involucre. Involucre barrel-shaped, 4-4.5 x 3.5-4 mm in diam., truncate at the top.

Ecology: Miombo, also steppe savannas with low copper content.

General distribution: Restricted to the D.R. Congo (Upper Katanga) and Zambia (Copperbelt).

Distribution on Katangan copper sites (3 sites): Tilwezembe (20), Shabara (24), Kavifwafwaulu (42).



Near Lubumbashi

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| medium | <X< | <X< | 5,000 |
| wet | 800 | 5,000 | |

| | | |
|--------|----|---|
| dry | | |
| medium | XX | X |
| wet | | |

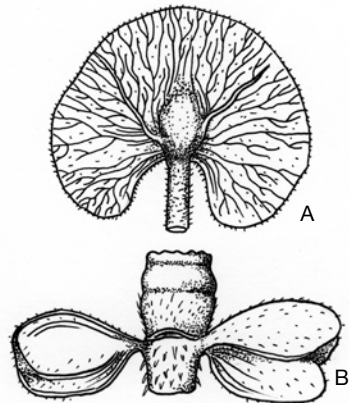
→ oligocuproresistant

Rehabilitation: No evident interest.

References:

BALLY [1961].

MALAISSÉ et al. [1995].



C. Van Marsenille

A. Bract-cup (x 0.7) – B. Cyme (x 0.7).

[Original plate]



© L. Lemaire

Euphorbia fanshawei L.C. Leach.

[Euphorbiaceae]

Holotype: Williamson & Drummond 1985 A.

Copper specimens: Mf 9193; Tr 180.

Habit: Spiny succulent dwarf perennial, with a much-reduced underground stem merging into a depressed subspherical tuberous root to 8 cm in diam. Branches numerous radiating from stem apex, erect and spreading, simple, to 15 cm long and 4-7 mm in diam., 5-6 angled. Spine shields borne on the upper oblique edge of the tubercles, 3 x 3 mm, subquadrate, dark reddish-brown. Leaves to 2.5 mm long, fleshy, deciduous. Cymes solitary, simple. Cyathia 2 x 5 mm, cup-shaped involucre; gland 2 x 1 mm, yellow. Male flowers, ± 20. Female flower, perianth 3-lobed.

Ecology: Lithophyte on cellular siliceous rocks in soil pockets with low copper content (Katanga) or shallow quartzitic soils (Zambia).

General distribution: Fungurume and Kawambwa (Zambia).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | X | X | | |
| medium | | | | |
| wet | | | | |

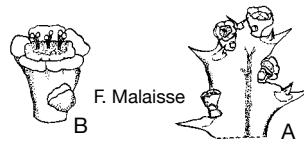
→ oligocuproresistant

Distribution on Katangan copper sites (1 site): Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 7-21, Co = 73-182 µg/g D.M.

Rehabilitation: Scenic succulent habit.

Reference: CARTER, LEACH [2001].



A. Apical portion of flowering branch (x 1.2) – B. Cyathium (x 3.6). [Drawn after CARTER & LEACH, 2001]



Fungurume

Euphorbia lorifolia (P.R.O.Bally) Malaisse comb. nov.

[Euphorbiaceae]

Holotype: Richards 5399.

Copper specimens: MKS 486, 809, 940.

Syn.: *M. pseudoracemosum* P.R.O.Ballyvar. *lorifolium* P.R.O.Bally syn. nov.

Habit: Geophyte; rootstock tuberous, 8-10 cm long, up to 7 cm in diam., napiform, producing a woody stem up to 6 cm long below ground. Annual aerial stems to 10 cm high. Leaves sessile up to 11 x 2 cm, linear-oblongate, margin minutely crisped, lower surface often tinged red; stipule minute, glandular. Cymes on peduncles to 2.5 cm long, simple or reduced to solitary cyathia, with cymes branches to 1.5 cm long; bracts joined in a bract-cup 6 x 10 mm, ± equal to the involucre, notched to halfway between acute apices, green with dark veining. Capsule exserted on a pedicel to 6 mm long, 5 x 6 mm, obtusely 3-lobed, with a fleshy ridge along each angle. Seeds 2.8 x 2.5 mm, subglobose, black with shallow

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| dry | <X | <X | 5,000 |
| medium | 800 | 5,000 | |
| wet | X | X | |

→ oligocuproresistant

yellowish tubercles, caruncle sessile, 1 mm in diameter.

Ecology: Slopes, on dry rocky soils.**General distribution:** Upper Katanga and Northern Zambia.**Distribution on Katangan copper sites** (2 sites): Kalukundi (16), Kazinyanga (49).**Rehabilitation:** No evident interest.**References:**

BALLY [1961].

CARTER, LEACH [2001].



Kazinyanga



© F. Malaisse

Euphorbia zambesiana* Benth. var. *zambesiana

[Euphorbiaceae]

Holotype: Buchanan 10.
Copper specimen: Mf-Gp 1047.

Habit: Perennial herb with a woody root. Branching diffusely at ground level; branches densely rebranching, leafy and prostrate,

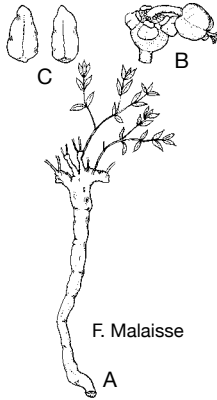
Phenology: One of the first species to appear after burning, producing short, erect, very floriferous shoots.

Ecology: Pyrophyte of open miombo, wooded grasslands, dambos and high plateau grasslands; also on mine workings in copper steppe savannas.

General distribution: From South Ethiopia to Angola, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (10 sites): Notably Kimpe (102).

Reference: CARTER, LEACH [2001].



A. Habit (x 0.5) – B. Cyathium (x 3.3) – C. Seeds (x 7.4). [Drawn after CARTER & LEACH, 2001]



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Mamfwe road

Adenodolichos rhomboideus (O.Hoffm.) Harms

[Fabaceae]

Holotype: Welwitsch 4092.

Copper specimens: Dp 5411;

Dp-Tj 2056; Mf 9778, 13079; Pj 35/542;

Qp 4901; Rw 1719.

Syn.: *Dolichos rhomboideus* O.Hoffm.

Habit: Trailing perennial subshrub, from a woody rootstock; stems ridged; flowering shoots erect or prostrate; leafy shoots erect, 16–80 cm long; leaves and flowers appearing at the same time but often on different shoots. Leaflets 3, 4–13 x 1.9–8 cm, rhombic-ovate to ovate; petiole 7.5–13 cm long; rhachis 3–3.5 cm long; petiolules 3–9 mm long; stipules 3–6 x 1.5–2.5 mm. Inflorescences terminal and axillary, pseudoracemose or paniculate, 9–55 cm long; peduncle 5–13 cm long. Calyx pubescent, glandular, tube 4–5 mm long, lobes 6–8 mm long. Standard purple or crimson outside, pink inside, 12–14 x 10 mm, with 2 triangular appendages. Pods 4–5 x 0.8–1.5 cm, oblanceolate-falcate. Seeds black, 7–8 x 5 x 2 mm, oblong-discoid; hilum narrow.



Etoile mine

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | XX | X |
| wet | | | |

→ mesocuproresistant

Ecology: Miombo, copper steppe savannas.

General distribution: Angola, D.R. Congo (Upper Katanga), Zambia, Mozambique.

Distribution on Katangan copper sites (38 sites): Notably Kalukundi (16), Tilwezembe (20), Shabara (24), Kasompi (27), Goma (33), Mwadikomba (47), Mambilima (50), Fungurume (51), Disele (55), Mindigi (60), Kamoya (72), Luishia (77), Kalongwe (81), Luiswishi (87), Lupoto (92), Etoile (97), Kimpe (102).

Distribution on Zambian copper sites (5 sites): Notably Mufulira (150).

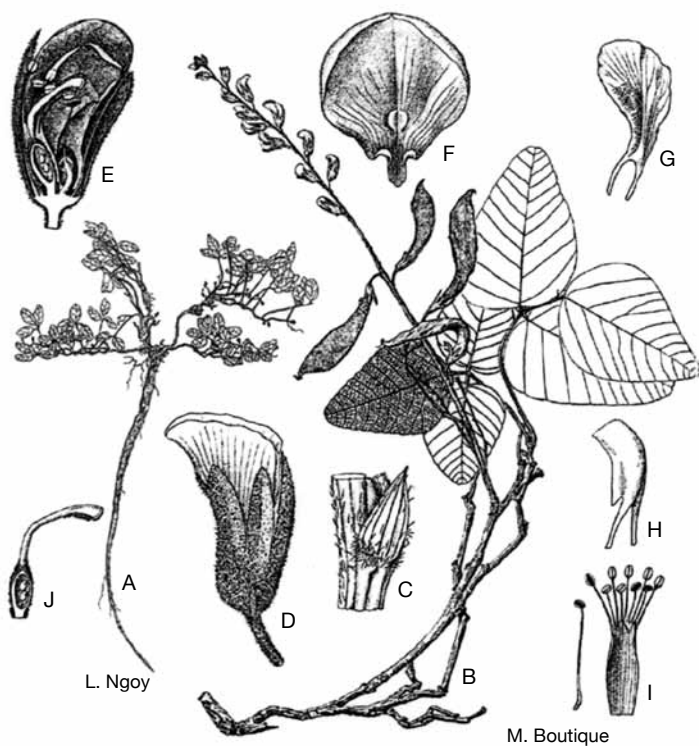
Phytogeochemistry: Cu-Co content of leaves (8 samples): Cu = 19–360, Co = 3–27 µg/g D.M.

Rehabilitation: Facilitator.

Reference: VERDCOURT [2001].



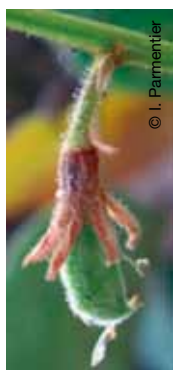
Pumpi



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A. Habit (x 0.03) – B. Flowering branch (x 0.3) – C. Stipule and part of twig (x 2.6) – D. Flower (x 2) – E. Flower, longitudinal section (x 2) – F. Standard (x 2) – G. Wing (x 2) – H. Carina (x 2) – I. Spreaded androecium (x 2) – J. Gynoeceum (x 2).

[WILCZEK, 1954; MALAISSE, GRÉGOIRE, 1978]



© I. Parmentier

Pumpi



Biano plateau



© M. Schajles

Shabara

Aeschynomene pararubrofarinacea J.Léonard

[Fabaceae]

Holotype: Duvigneaud 1273 G.
Copper specimens: Mf-Kk 315, 479;
MKS 593, 610.

Habit: Shrub or small tree, 1.5-4.5 m tall. Leaves (12)18-26-foliolate; leaflets 6-23 x 2-10 mm, oblong, lanceolate, rounded to truncate and mucronulate at the apex, obliquely rounded at the base, glabrous, midrib \pm central with 3 basal nerves below it; petiole and rachis 5.5-10 cm long; stipules 5-13 x 2.5-4.5 mm, ovate, deciduous. Inflorescences axillary, zigzag, several-flowered, 2.5-10 cm long. Bracts green, leaf-like, overlapping but not hiding the flowers, persistent, 4-10 x 3-12 cm, deeply bilobed. Calyx 2-lipped; lips 7-9 x 4-6 mm, ovate to oblong-elliptic, one 2-toothed, the other shortly 3-lobed. Standard shaped, rounded at the apex, wings yellow; keel petals yellow, not lacinate. Fruit of 1-2 articles joined by a narrow neck, each article semicircular, 5-7 x 4-5.5 mm, compressed, glabrous, smooth, veined. Seeds reddish-brown, 5 x 4 x 2 mm, reniform.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | (X) | (X) | | |
| medium | X | | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Open forests, often in rocky places, shrub steppe savannas, including copper ecotones.

General distribution: Restricted to Upper Katanga and Western Province of Zambia.

Distribution on Katangan copper sites (11 sites): Notably Myunga (18), Shimbidi (35), Kavifwafwaulu (42), Kwatebala (45), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 14, Co = 9 $\mu\text{g/g}$ D.M.

Rehabilitation: Fine habit for copper shrubby steppe savanna ecotones.

References:

LÉONARD [1954].
VERDCOURT [2000].



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Shimbidi

Aeschynomene pygmaea* Welw. ex Baker var. *hebecarpa
J.Léonard [Fabaceae]

Holotype: Young 123.

Copper specimens: KSM 20; LLM 141; MKS 57, 249, 384, 787, 842; Mf 14249.

Syn.: *A. hockii* De Wild., *A. homblei* De Wild.

Habit: Subshrub with several caespitose stems from a tough woody rhizome-like rootstock. Stems 0.05-1.5 m tall, in burnt areas mostly unbranched and often leafless when flowering but in the absence of fire forming branched leafy shrub. Leaves alternate or subfasciculate, 14-38-foliolate; leaflets 1.5-7 x 0.3-1.8 mm, linear-oblong or linear, often falcate, acute or rounded and mucronulate at the apex, obliquely rounded at base, somewhat coriaceous, glabrous or ciliate; petiole and rachis together 4-35 mm long; petiolules 0.3 mm long; stipules 2.5-13 x 0.5-3 mm, linear-lanceolate to ovate-lanceolate, ciliolate, scarious, sometimes subpersistent. Racemes or panicles terminal or axillary, 2-16 cm long; peduncles 0.3-4 cm long; pedicels 1.5-6 mm long; bracts entire or 2-3-fid, 1.5-5 x 0.5-1.5 mm, ovate or ovate-lanceolate. Calyx flushed crimson, 2-lipped; lips 3-6 x 2-3.5 mm, elliptic, one entire or narrowly emarginated, the other slightly 3-fid. Standard orange-yellow, \pm rectangular, 4-11.5 x 2.5-4.5 mm, somewhat constricted in the middle,

| Hydra-tation | Copper content of soil (in μg per g of soil) | | |
|--------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | XX | (X) |
| wet | | | |

→ mesocuproresistant

emarginated at the apex, truncate or subauriculate at the base; wings and keel orange-yellow, the petals of the latter not laciniate. Fruit of 1-2 articles joined by a narrow neck, each article semicircular, 5-8 x 4.5-6 mm, with fine tubercular-based hairs, reticulate. Seeds dark reddish-brown, 3.5 x 2.5 x 1 mm, rounded-reniform.

Ecology: Miombo open forests, steppe savannas, often also on copper steppe savannas.

General distribution: Restricted to Upper Katanga and Zambia.

Distribution on Katangan copper sites (11 sites): Notably Goma (33).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 72, Co = 57 $\mu\text{g/g}$ D.M.

Rehabilitation: Good facilitator aptitude.

References:

LÉONARD [1954].

VERDCOURT [2000].



Shabara



Kwatebala

Crotalaria cobalticola P.A.Duvign. & Plancke [Fabaceae]

Holotype: Duvigneaud & Timperman 2227 C.

Copper specimens: Dp 3498 CR; Dp-Tj 2227 C; Mf 9853.

Habit: Erect much-branched annual herb, 30-60 cm tall; stem slender. Leaves mostly 3-foliolate, upper ones sometimes 1-foliolate; leaflets mostly linear-oblongate, acute, 4-20 x 0.5-7 mm; petiole 0-15 mm long. Racemes 1-8 cm long, laxly 4-16 flowered; bracts linear-subulate. Calyx 3-4 mm long. Standard elliptic, pointed, yellow, lined and flushed reddish with age; wings much shorter than the keel; keel angular, with a straight twisted beak, 7-9 mm long. Legume sessile, oblong-ellipsoid, 6-9 x 3.5-4 mm. Seeds rounded-cordiform, 1.2-1.5 mm long.

Ecology: Copper-cobalt rocky steppe savannas.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium (X) | XX | | |
| wet | | | |

→ oligocuproresistant

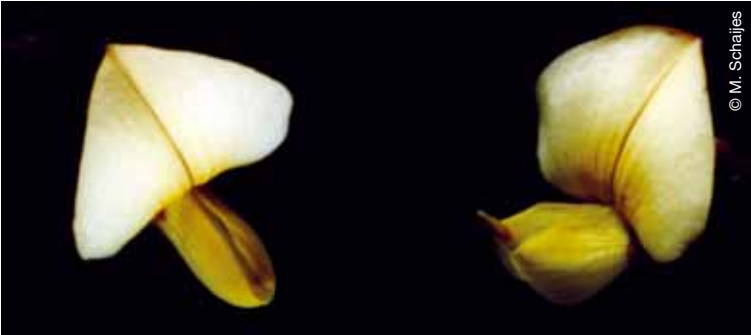
General distribution: Katanga.

Distribution on Katangan copper sites (13 sites): Notably Mupine (4).

Phytogeochemistry: Cu-Co content of leaves (7 samples) Cu = 27-340, Co = 31-2923 $\mu\text{g/g}$ D.M. Cobalt hyperaccumulator. Values need confirmation.

Rehabilitation: Medium interest for rocky sites.

Reference: POLHILL [1982].



Chabara



Tilwezembe



Chabara

Holotype: Cornet s.n.

Copper specimens: He 1011; LLM 106; Mf 7931; Mf-Gj 58; MKM 49; MKS 285; Sm 2999; Tr 24; Rw 1749.

Habit: Suffrutex with woody rootstock and numerous spreading or ascending stems up to 75 cm tall, glabrous overall except for minute puberulence on the youngest parts. Leaves subsessile, simple; blade ovate-elliptic or elliptic-oblong, bluntly pointed to rounded at the apex, shortly cordate at the base, mostly 2.5-5.5 x 1.2-3.5 cm, chartaceous, ± glaucous, prominently venose. Stipules absent. Calyx 1.2-1.6 cm long, drying blackish; standard mauve to purpish with darker lines. Pods subsessile, oblong-clavate to sub-cylindrical, 3-3.5 cm long, with ± 10 seeds.

Ecology: Plateau wet miombo open forests and wooded savannas, frequently on metalliferous soils.

General distribution: Restricted to Katanga and Northern and Copperbelt provinces of Zambia.

Distribution on Katangan copper sites (10 sites): Kananga East (7), Kavifwafwaulu (42), Kwatebala (45), Fungurume (51), Kamatanda (73), Likasi (75), Luiswishi (87), Kasonta (91), Lupoto (92), Etoile (97).

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | (X) | |
| medium | X | XX | |
| wet | | | |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (38 samples): Cu = 1-114, Co = 1-336 µg/g D.M. Cobalt accumulator. Values need confirmation.

Rehabilitation: Great interest for rocky sites.

References:

DUVIGNEAUD, TIMPERMAN [1959].
BROOKS et al. [1977].
POLHILL [1982; 2003].



Nzilo-Kyamasumba

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Luiswishi

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Crotalaria glauca Willd.

[Fabaceae]

Holotype: Isert in Herb. Willdenow
13242.

Copper specimens: MKS 153; Tr 89,
167.

Habit: Erect annual or short-lived perennial, laxly branched above, up to 0.5-1.2 m tall; stem slender, glabrous. Leaves estipulate, subsessile, simple; blade 2-8.5 x 0.2-1 cm, linear to oblong-lanceolate, glabrous, ± glaucous, sometimes drying blackish. Racemes laxly 3-12-flowered; bracts 1-9 mm long, linear to narrowly elliptic. Calyx 4-7 mm long, glabrous or sparsely puberulous; lobes narrow, longer than the tube. Standard subcircular, pale yellow, veined brownish, glabrous outside; wings exceeding the keel, bright yellow; keel 6-8 mm long, semicircular, crested behind the small beak. Pod, with the (3)4-7 mm long stipe, (1.8)2.4-3.6 long, cylindrical, glabrous, 24-32-seeded. Seeds 2-3 mm long, obliquely oblong-cordiform, smooth, shiny, bottle-green to brown.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | (X) | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Catholic opportunist, but frequently in disturbed places in moderately dry areas; also in disturbed copper steppe savannas.

General distribution: Widespread in tropical Africa (from Senegal to Zimbabwe and Mozambique).

Distribution on Katangan copper sites (3 sites): Kavifwafwaulu (42), Fungurume (51), Kamoya (72).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 74, Co = 5 µg/g D.M.

Rehabilitation: No evident interest.

References: POLHILL [1982; 2003].



Kolwezi-Musokatanda road



Mamfwe road

Crotalaria peschiana P.A.Duvign. & Timperman [Fabaceae]

Holotype: Duvigneaud 3433 C.
Copper specimens: Dp 2821 Cr,
2824 C, 2830 C, 3433 C.

Habit: Numerous stems, ascending from a horizontal rhizomatous rootstock. Stems 10-40 cm long, ribbed, covered with short appressed and subappressed hairs. Leaves 3-foliate; leaflets linear-oblancoelate to oblanceolate, 8-25 x 2-8 mm; petiole 1-3 mm long. Stipules linear-subulate, 0.5-2 mm long. Racemes 2-9 cm long, laxly 3-8-flowered; buds ascending; bracts linear-lanceolate, 1-3 mm long; bracteoles on the pedicel, setaceous, 1-2 mm long. Calyx 4.5-6 mm long, lobes narrowly triangular, 1.5-2 times as long as the tube. Standard elliptic, yellow, reddish lined; wings nearly as long as the keel; keel angular, with a narrow twisted beak, 7-9 mm long. Pod sessile, oblong-obovoid, slightly compressed laterally, 8-9 x 5-6 mm, minutely puberulous, maturing 6-8 seeds. Seeds oblique-cordiform, 2.5 mm long, smooth, brown.

Ecology: Copper steppe savannas.

General distribution: South-eastern part of the Katangan copper arc.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | | X | X | |
| wet | | | | |

→ mesocuprophyte

Distribution on Katangan copper sites (3 sites): Kasonta (91), Niamumenda (93), Etoile (97).

Rehabilitation: Pleasant habit, medium interest for copper steppe savannas.

Reference:
POLHILL [1982].



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Kinsevere



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Etoile



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Nyamumenda

Crotalaria quangensis

Taub. var. *malangensis*

(Baker f) Polhill

Holotype: Pogge 155.

Copper specimen: Dp 3507 Cr.

Syn.: *C. francoisiana* P.A.Duvign. & Timperman

Habit: Perennial suffrutex, stems erect from a napiform or rhizomatous rootstock, 10-70 cm tall. Leaves almost all 3-foliolate; leaflets 8-45 x 2-17 mm, oblanceolate; petiole 0.2-2.5 cm long. Racemes (sub)sessile, 1-17 cm long, 15-40 flowered. Calyx 3-5 mm long; lobes 1.2-1.5 as long as the tube. Standard elliptic to subcircular, yellow, sometimes lined or flushed reddish; wings ± as long as the keel. Pod sessile, 5-7 x 4-5.5 mm, ovoid-globular.

Ecology: Dambos on Kalahari sands, miombo woodlands, also in copper steppe savannas.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|----|-----|
| dry | | |
| medium | XX | (X) |
| wet | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo (Upper Katanga), Zambia.

Distribution on Katangan copper sites (1 site): Mupine (4).



Kolwezi-Musokatanda road

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Crotalaria variegata Welw.

ex Baker

[Fabaceae]

Holotype: Welwitsch 1968.

Copper specimens: Ls 13436, 13438; Mf 9088.

Habit: Training perennial herb, flexuous stems up to 1 m long. Leaves 3-foliolate; leaflets 1.5-6.5 x 0.8-3.2 cm, obovate, chartaceous, silvery tomentose beneath. Calyx 5-9 mm long, lobes narrow, 2-4 times as long as the tube. Standard subcircular, pink inside; wings yellow. Pod subsessile, 1.2-1.6 cm long, 4-6-seeded.

Ecology: Miombo woodlands, also in copper steppe savannas.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

General distribution: From Angola, to Tanzania, and southwards to Mozambique.

Distribution on Katangan copper sites (1 site): Etoile (97).

References (for both species): POLHILL [1982; 2003].



Etoile mine

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Dolichos gululu De Wild.

[Fabaceae]

Holotype: Verdick 236.
Copper specimen: Mf-Kk 391.
Syn.: *Dolichos praecox* R.E.Fries

Habit: Erect perennial geofrutex 8-30 cm tall, arising from a woody rootstock. Stems annual, unbranched or slightly branched at the base. Leaves 1-foliate, leaflet 12-60 x 8-35 cm, elliptic, apex acute, base attenuated or rounded, glabrous to densely pubescent; petiole 2-5 mm long; stipules 1-1.8 cm long, ovate to narrowly-lanceolate, leafy; stipels 2-3 mm long, filiform. Usually flowering before the leaves appear. Flowers axillary, in 6-14-flowered fascicles, pedicels 8-31 mm long, slender. Calyx glabrous or hirsute, tube 3-5 mm long, lower lobes 2-5 mm long, upper pair fused for almost all of their length. Standard cream, bluish-pink or mauve, sometimes purple inside, 13-25 x 10-20 mm, rounded-ovate or elliptic; wings white. Pods 4.8-6.8 x 0.8-1.4, linear-oblong, held erect, glabrous on surfaces, but sparsely ciliate along the somewhat thickened margins, 2-7 seeded. Seeds black, 5-6 x 5-6 x 2-5 mm, globose or compressed; aril minute.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Miombo open forests, wooded savannas and grasslands on sandy soils, copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia.

Distribution on Katangan copper sites (1 site): Shadiranzoro (48).

Reference: MACKINDER [2001].



Kolwezi-Nzilo road



Kolwezi-Nzilo road



Mwadikomba



Mwadikomba

Dolichos trinervatus Baker

[Fabaceae]

Holotype: Buchanan 406.

Copper specimens: Mf 16394, 16479;
Mf-MKS 161, 201.

Habit: Erect perennial herb, 40-80 cm tall, from a stout woody rootstock. Stems several, annual, not or sparsely branched. Leaflets 3, paler beneath, narrowly long-elliptic, 4-13 x 0.2-1.6 cm, acute at the apex, cuneate at the base, very conspicuously 3-nerved from the base to the apex, glabrescent to silvery-pubescent; petiole 3-7 mm long, broad and channelled. Flowers axillary, in pairs or 3-6-flowered fascicles. Standard white or pale green tinged purple outside, purple inside; wings pale mauve, keel purple at the tip. Pods linear-oblong, 3-4 x 0.6 cm, finely pubescent on faces and hairy along the margins. Seeds pinkish-grey to chestnut, densely mottled with black.

Ecology: Miombo, *Uapaca* woodlands, copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (2 sites): Kavifwafwaulu (42), Shadiranzoro (48).

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

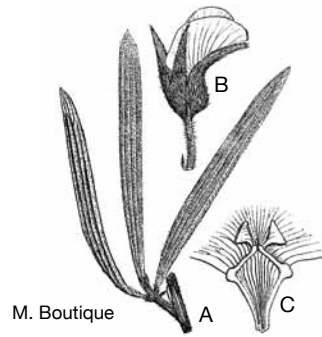
| | | | |
|--------|---|---|--|
| dry | | | |
| medium | X | | |
| wet | X | X | |

→ oligocuproresistant

Rehabilitation: Good pioneer for seasonal wet humiferous copper soils.

Reference:

GILLETT et al. [1971].



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A. Leaf with stipules (x 0.5) – B. Flower (x 0.9) – C. Standard base (x 1.8).

[WILCZEK, 1954]



Kavifwafwaulu

Droogmansia munamensis De Wild.

[Fabaceae]

Holotype: Carson 94, 117.
 Copper specimens: DKM 186, 375;
 LLM 79; Mf 11701, 11072; MKM 102,
 127; MMK 33; Sa 2021; Sm 3231; Tr 157.
 Syn.: *D. pteropus* (Baker) De Wild. var.
pteropus.

Habit: Subshrub, 0.3-2.5 m tall, with several shoots from a woody rootstock. Stems glaucous, glabrous. Leaves dark green concolorous. Winged petiole elliptic, oblong, 0.7-3 x 0.3-2.4 cm, leaflets 2-6.5 x 0.5-3.2 cm; stipules linear 4-10 x 0.6-1.5 mm. Flowers in terminal, lax, unbranched, elongate and narrow inflorescences. Pedicels 2-22 mm long; calyx pubescent or hairy; standard, yellow outside and mauve inside, veins dark purple or crimson. Fruit densely yellowish-brown hairy, stipitate; articles 1-5, strongly compressed.

Ecology: Woodlands steppe savannas on Kalahari sands and copper soils.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (13 sites): Notably Kabwelunono (34), Shimbidi (35), Kavifwafwaulu (42), Mwinansefu (43), Kwatebala (45), Fungurume (51), Kahumbwe (57), Shinkolobwe (67), Likasi (75), Sokoroshe (83), Etoile (97).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | XX | | |
| wet | | | | |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 14-112, Co = 25-65 µg/g D.M.

Rehabilitation: Good aptitude, fine habit.

Reference: VERDCOURT [2000].



Sokoroshe II



Kolwezi-Musokatanda road



Fungurume

Droogmansia quarrei De Wild.

[Fabaceae]

Holotype: Quarré 3003.

Copper specimens: Mf-Sh 79; MKM 89; MKS 283, 386, 438, 543, 759.

Syn.: *D. pteropus* (Baker) De Wild. var. *quarrei* (De Wild.) Verdc.

Habit: Perennial subshrub, 0.5-3 m tall, with one shoot from a robust woody rootstock. Leaves glaucous. Stipules brown, linear-lanceolate, 7-12 x 1.5-2 mm. Winged petiole oblong or elliptic-oblong, 5.5-6 x 3.5-4.5 cm; leaflets 6-14 x 2-7 cm, oblong or elliptic. Flowers in terminal lax, almost glabrous inflorescences, pedicels 15-17 mm long. Standard glabrous outside, stipe of fruit 6-8 cm long, pedicels 2 cm long.

Ecology: Open forests, steppe savannas on high plateaus and on copper soils.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (9 sites): Goma (33), Kabwelunono (34), Shimbidi (35), Kavifwafwaulu (42), Shinkusu (44), Kwatebala (45), Mwadikomba (47), Shadirandzoro (48), Fungurume (51).



Kavifwafwaulu

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | |
|--------|---|------|--|
| dry | | | |
| medium | X | X(X) | |
| wet | | | |

→ oligocuproresistant

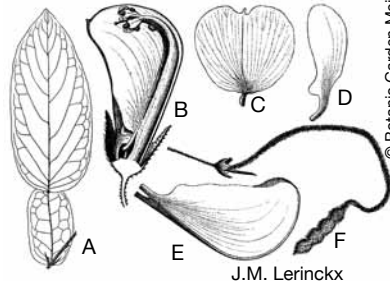
Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 12, Co = 19 $\mu\text{g/g}$ D.M.

Rehabilitation: Decorative habit.

References:

SCHUBERT [1954].

VERDCOURT [2000].



J.M. Lerinckx

A. Leaf (x 0.2) – B. Flower, longitudinal section (x 1.6) – C. Standard, internal face (x 1.1) – D. Wing (x 1.7) – E. Keel (x 1.3) – F. Fruit (x 0.4). [SCHUBERT, 1954]

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Holotype: Engler 3023.

Copper specimens: LMM 168;

Mf-Kk 611, 746; MKS 403; MSK 207.

Syn.: *E. hockii* De Wild.

Habit: Perennial suffrutex, from a woody rootstock up to 2.5 cm wide, with red juice; producing at first leafless flowering branches, 15–22 cm tall, and later developing leafy branches 0.6–2 m tall; stems with dense whitish velvety tomentum. Leaves (1)3-foliolate; leaflets 3.5–14 x 1.5–10 cm, elliptic to oblong-ovate, rounded but mucronate at the apex, subcordate or broadly cuneate at the base, often whitish or silvery beneath; stipules 5–8 x 4–5 mm, silky; petiole 0–1.2 cm long. Inflorescences dense, either arising from the rootstock or later axillary on the leafy shoots, 6.5–20 cm long. Standard orange or golden-yellow, reddish-brown striate outside, 12–18 x 7–8 mm; wings yellow and keel greenish-yellow flushed purple-brown at the tip. Pods 2 x 1 cm, oblong-elliptic, mucronate. Seeds dark purple, with yellow rim aril.

Ecology: Miombo, grasslands, also in copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | | |
|--------|----|---|--|
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

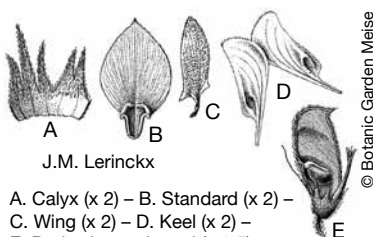
General distribution: D.R. Congo, Zambia, Malawi, Mozambique, Zimbabwe.

Distribution on Katangan copper sites (13 sites): Notably Zikule (30), Kakavilondo (31), Kabwelunono (34).

Distribution on Zambian copper sites (1 site): Kansanshi (T1).

Rehabilitation: Stout stabilisator.

Reference: VERDCOURT [2001].



J.M. Lerinckx

A. Calyx (x 2) – B. Standard (x 2) –
C. Wing (x 2) – D. Keel (x 2) –
E. Pod valve and seed (x 1.5).

[HAUMAN, 1954]

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Potopoto valley



Kakavilondo

Eriosema shireense Baker f.

[Fabaceae]

Holotypes: Whyte s.n., Buchanan 31, 1350.

Copper specimens: LLM 27, 85; Mf 11357, 12134; Mf-Kk 231; MMK 10; Qp 5335.

Habit: Perennial herb, with 1-few erect unbranched or sparsely branched stems, 8-35 cm tall; rootstock a globose or ovoid tuber, 1.5-4 x 1-2.5 cm, sometimes 2, one beneath the other. Stems slender, when young covered with long hairs up to 4 mm long. Leaflets 1-3, 2.5-14 x 0.5-2.4 cm, elliptic to lanceolate, acute at the apex, rounded or narrowed at the base; petiole 1-10 mm long. Racemes axillary or pseudo-terminal. Calyx with long white spreading hairs and yellow glands, 4.5-6 mm long. Standard cream with reddish nerves outside; cream or yellow within, wings yellow, keel greenish. Pods oblong-elliptic, 1-1.3 x 0.6-1.1 cm, covered with long ferruginous hairs. Seeds oblong, reddish-brown, rim aril cream.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | | 800 | 5,000 | |
| dry | X | | | |
| medium | XX | X | (X) | |
| wet | X | | | |

→ oligocuproresistant

Ecology: Miombo, grasslands, also in copper steppe savannas.

General distribution: Cameroon, Ethiopia southwards to Angola, Zimbabwe and Mozambique.

Distribution on Katangan copper sites (6 sites): Kwatebala (45), Fungurume (51), Kambove (71), Lukuni (86), Luiswishi (87), Dikulushi (99).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 58-66, Co = 88-105 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: VERDCOURT [2001].



Luiswishi



Kolwezi-Musokatanda road

Humularia kapiriensis (De Wild.) P.A.Duvign. var. ***nummularia*** P.A.Duvign. [Fabaceae]

Holotype: Duvigneaud 1336G.
 Copper specimens: MKM 16; MKS 253.
 Syn.: *Geissaspis welwitschii* Baker. f.
 var. *kapiriensis* De Wild.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

Habit: Erect perennial subshrub, 0.6-2.1 m tall. Stem glabrous to glandular-pubescent. Leaves 2-4(6)-foliolate; 5-35 x 6-23 mm, elliptic to obovate, obtuse or emarginated at the apex, often mucronulate, obliquely rounded at the base, glabrous, entire, the main nerve oblique, dividing the lamina into unequal parts; stipules clearly more developed than the leaflets, cordate at the base. Inflorescences mostly borne on shoots with leaves reduced to stipules, 4 cm long; peduncle 5-12 mm long; bracts yellow-green, 14-18 x 2-24 mm, rounded, divided shortly or up to one-third their length into 2 lobes. Calyx lobes 10-11 x 3-4 mm, oblong-lanceolate. Standard yellow, 1-16 x 5-10 mm, panduriform or rectangular. Fruit of 1-2 articles three-quarters elliptic, the upper margin straight, the lower strongly curved. Seeds very dark red-brown.

| | | |
|--------|----|-----|
| dry | | |
| medium | XX | (X) |
| wet | | |

→ oligocuproresistant

References:
 DUVIGNEAUD [1954].
 VERDCOURT [2000].

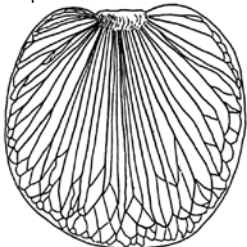
Ecology: Mostly steppe savannas on Kalahari sands, also in miombo woodlands, rarely in shrubby copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (15 sites): Notably Goma (33).

Rehabilitation: Pleasant habit.

M. Boutique



Stipule (x 1.7). [DUVIGNEAUD, 1954]

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Goma

Indigofera peltata Gillett

Holotype: Richards 11572.
Copper specimen: Mf-Kk 412.

Habit: Perennial subshrub, 25–45 cm high, woody rootstock. Leaves 1-foliolate; stipules triangular, up to 7 mm long; petiole up to 12 cm long; petiolule blackish, 4–5 mm long; leaflet peltate, ovate, up to 14 x 10 cm. Racemes 2–3 on each shoot, in the axil of vestigial leaves, many-flowered. Corolla golden-brown; stamens 11–12 mm long.

Ecology: *Brachystegia* woodlands, steppe savannas on Kalahari sands, rarely on copper soils.

General distribution: D.R. Congo (Katanga), Tanzania, Malawi.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Kavifwafwaulu

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Indigofera podocarpa

Baker f. & Martin [Fabaceae]

Holotype: Homblé 1207.
Copper specimen: Pi-Kk 4550.

Habit: Woody shrub, up to 2 m tall. Stipules setaceous; rachis brownish, up to 8 cm long; leaflets 5–11, oblong-elliptic, apiculate, 2.5(5) x 1.8(3.5) cm; reticulate venation. Racemes many-flowered; up to 16 cm long. Calyx brown. Corolla brown, standard pointed, keel rostrate. Pod cylindrical, 50 x 2.8 mm. Seeds 8, well separated.

Ecology: *Brachystegia* woodlands, also copper steppe savannas.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | (X) | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuproresistant

General distribution: C.A. Republic, D.R. Congo, Angola, Burundi, Tanzania, Zambia.

Distribution on Katangan copper sites (3 sites): Tilwezembe (20), Shadiranzoro (48), Luiswishi (87).

Reference (for both species): GILLETT et al. [1971].



Kwatebala

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Indigofera sutherlandioides Welw. ex Baker [Fabaceae]

Holotype: Welwitsch 2012.
Copper specimens: Hs-Tc 433;
Mf 7993, 9875, 12160; Mf-Kk 262;
MKM 17; Qp 4384; Tr 40.

Habit: Perennial woody subshrub, up to 1.5 m tall. Stem often slightly zigzag, pubescent at first, then glabrescent. Stipules filiform, pubescent, up to 18 mm long; rachis pubescent, up to 13 mm long, including a petiole of ± 10 mm. Leaflets 7-15, becoming rather rigid, paler beneath than above, elliptic-lanceolate, pointed at the base, up to 25 x 11 mm, sparsely silky pubescent on upper surface, silky pubescent on lower surface. Racemes densely many-flowered, pubescent, up to 11 cm long. Corolla dark red.

Ecology: Miombo open forests, woodlands and steppe savannas on Kalahari sands, also copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia and Tanzania.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|---------|
| normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | (X) | | |
| medium | X | XX | (X) |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (17 sites): Notably Tilwezembe (20), Kabwelunono (34), Shadirandzoro (48), Mambilima (50), Mindigi (60), Shinkolobwe (67), Lukuni (86), Luiswishi (87), Lupoto (92), Ruashi (96), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 20-344, Co = 21-109 µg/g D.M.

Rehabilitation: Very elegant habit.

Reference: GILLETT et al. [1958].



Kabwelunono



Tilwezembe



Shimbidi

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Pericopsis angolensis (Baker) van Meeuwen [Fabaceae]

Holotype: Welwitsch 615.
Copper specimen: Mf s.n.

Habit: Tree up to 17 m tall; bark smooth, pale. Leaves with 5-11 leaflets, widely spaced, arranged alternately or rarely in opposite pairs; leaflets ovate to elliptic; stipels filiform. Inflorescence in terminal panicle, rusty-brown or rarely greyish tomentose. Calyx 7-10 mm long. Petals white, greenish-white or violet, with dark purple veins; standard 13-15 mm long; wings slightly longer. Pod flat, oblong to linear-oblong, \pm winged along upper margin; the larger pods often constricted about the middle, 7-24 x 2.5-3.5 cm. Seeds flat, oblong to suborbicular, reddish; hilum small.

Ecology: Miombo open forests and *Terminalia* woodlands; rare in shrub steppe savannas with low copper content.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe and Mozambique.

Distribution on Katangan copper sites (3 sites): Notably Luiswishi (87).

Reference: GILLETT et al. [1971].

| Hydration | Copper content of soil (in μg per g of soil) | | | |
|-----------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuprophyte



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Mamfwe road



© F. Malaisse

Kawifwafwaulu

Sphenostylis erecta (Baker f.) Hutch.

[Fabaceae]

Holotype: Whyte s.n.
Copper specimen: Mf-Kk 617.

Habit: Perennial erect subshrub, 30-70 cm tall, from a woody rootstock, producing a red exsudate. Occasionally flowering when entirely leafless. Leaves pinnately 3-foliolate. Leaflets oblong to ovate-lanceolate, obtusely acuminate to rounded at the apex, cuneate at the base, glabrous; 2.5-8 x 0.7-4 cm. Inflorescence few-flowered, dense, subcapitate; peduncle 5-30 cm long; pedicelle 3-12 mm long. Standard yellow inside, flushed brownish, 0.6-2.3 x 0.6-2.6 cm, obovate; wings yellow; keel pale yellow. Pods 7-12 x 0.5-0.8 cm, margined, glabrous. Seeds brown, 5-7 x 4.5-6 x 2.5-3.5 mm, oblong-ovoid or discoid, covered with a scurfy scaly indumentum, keeled around the longest circumference.

Ecology: Miombo open forests and wooded savannas, rarely on copper soils.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo (Katanga), Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (2 sites): Mwadikombwa (47), Fungurume (51).

Rehabilitation: Robust stabilizer for low copper soils.

References:

- WILCZEK [1954].
- VERDCOURT, DØYGAARD [2001].



Manika plateau



Mwadikombwa



Manika plateau

Vigna antunesii Harms

[Fabaceae]

Holotype: Bryce s.n.
 Copper specimen: Mf-Kk 595.
 Syn.: *V. nuda* N.E.Br.

Habit: Perennial herb from a thick, often extensively branched, woody rootstock, nearly always flowering before the leaves appear. Stem at first erect, later prostrate, less often climbing, 6 cm tall to 1.8 m long. Leaflets 3, 3.5–9.5 x 0.4–6.5 cm, ovate-oblong, lanceolate or subrhombic-oblong, obtuse at apex, cuneate, rounded or minutely subcordate at the base, mostly rather leathery; venation raised and closely reticulate on both surfaces; petiole 3–13 cm long. Flower 13–25 mm long; pedicel 1–3 mm long; true bract 1–3 x 1–1.5 mm, oblong. Calyx tube 4 mm long, lobes 2–9 mm long. Standard asymmetrical, with 2 parallel widely spaced appendages; keel twisted towards the right and incurved, bearing a pocket on the left-hand petal. Pods 7–11 x 0.4–0.7 cm, linear-cylindrical.

Ecology: Grasslands, copper steppe savannas with low copper content.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | > | 5,000 |
| medium | 800 | 5,000 | | |
| wet | XXX | X | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Mozambique, Zimbabwe.

Distribution on Katangan copper sites (5 sites): Notably Mwadikomba (47).

Rehabilitation: No evident interest.

Reference: PASQUET [2001].



Mwadikomba



Mamfwe road



Holotype: R.R.P.P. Salésiens 1129.
 Copper specimens: Hh 15939;
 Kk-My 65; Mf 7706, 7896; Nn 1085;
 Qp 8484; Sj 10138; Sm 1412; Tr 61.

Habit: Perennial prostrate herb, tomentous to pubescent, with greyish spreaded hairs. Leaf 3-foliolate; stipule subcordate, dressed, ovate-lanceolate, longly acuminate, 4-7 x 2 mm; rachis 4-10 mm long; leaflets petiolule 0.4-0.7 mm long; limb elliptic, 1.5-3.5 x 0.9-2.5 cm, hairy. Racemes axillary, dense, subcapituliform; peduncle 1.5-5.5 cm long. Calyx pubescent tawny, upper lip bilobed on half of its length, lobes longer than the tube. Flower mauve, 1-1.4 cm long, subsessile; standard glabrous, with 4 inner parallel appendices. Carene dressed, lightly beaked. Style ended by a short beak; stigmathe subterminal. Pods horizontal, brown-blackish, seeds 6-7.

Ecology: Copper steppe savannas.

General distribution: Restricted to one mine: Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 3,000, Co = 600 µg/g D.M.; of seedling leaves up to Cu = 171, Co = 498 µg/g D.M. Copper hyperaccumulator

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | XX | XXX | |
| wet | | | | |

→ polycuprophyte

(value need confirmation), cobalt accumulator.

Rehabilitation: Good interest both as cover plant and facilitator.

References:

WILCZEK [1954].

LETEINTURIER [2002].



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Etoile mine



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***Vigna vexillata* (L.) A.Rich. var. *angustifolia* (Shumach. & Thonn.) Baker** [Fabaceae]

Holotype: Thonning s.n.

Copper specimens: MKS 74, 150, 275, 400.

Habit: Perennial climbing or trailing herb, 0.3-6 m long, from a narrow woody rootstock. Stems covered with pale to brown hairs. Leaflets 3, very narrow, 4-8 x 0.4-1.5 cm, venation \pm raised and reticulate on both surfaces; stipules lanceolate, 0.5-1.3 cm long. Inflorescence axillary, 2-6-flowered, subumbellate. Calyx with long whitish bristly and also short white hairs; tube 5-7 mm long, calyx-lobes mostly short, 2-8 mm long. Standard pink, with yellow marks at the base; wings purple; keel pale lilac, falcate. Pods linear-cylindrical 8-14 cm long, covered with long brown bristly hairs, apex with a straight beak.

Ecology: Grasslands, including copper steppe savannas.

General distribution: Tropical Africa, India, Malesia, Australia.

Distribution on Katagan copper sites (8 sites): Notably Kalukundi (14), Kakavilondo (31), Kavifwafwaulu (42), Kazinyanga (49).

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XXX | X | | |

→ oligocuproresistant

Rehabilitation: No evident interest.

Reference:

GILLETT et al. [1971].



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Kazinyanga



Kavifwafwaulu

Chironia katangensis De Wild.

[Gentianaceae]

Holotype: Bequaert 319.
Copper specimens: MKS 433, 484, 532.
Syn.: *Chironia verdickii* De Wild.

Habit: Erect herb, 35-55 cm high, spindly. Stem unbranched or not much branched. Leaves linear to oval-lanceolate, 10-30 mm long, 1-7 mm wide, acute at top. Cymes 1-2 flowered, solitary or grouped in few-flowered panicles; bracts linear-filiform, 5-10 mm long. Flowers with pedicel 5-20 mm long; calyx tube 1.5-2 mm long, lobes linear-subulate, 7-10 mm long; corolla red, pink to mauve, more rarely yellow, with tube 4-6 mm long; lobes oval-lanceolate, 13-19 mm long, stamens with filament 1.5-2 mm long; anthers 5-7 mm long, straight; ovary oblong; style filiform, 9-10 mm long, stigma subglobulous.

Ecology: Open woodlands and grasslands, also in copper shrub savannas, namely *Uapaca robynsii* belts.

General distribution: Restricted to Upper Katanga.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

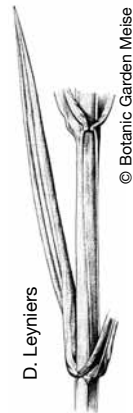
→ oligocuproresistant

Distribution on Katangan copper sites (2 sites): Kazinyanga (49), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 23, Co = 12 µg/g D.M.

Rehabilitation: No evident interest, but ornamental aptitudes.

Reference: BOUTIQUE [1972].



D. Leyniers

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Part of stem (x 2).
[BOUTIQUE, 1972]



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Kiniama road

Faroa acaulis R.E.Fr.

[Gentianaceae]

Holotype: Fries 501a.
Copper specimens: Dp 2998;
Mf-Gp 1042; MKS 333.

Habit: Acaulescent annual herb. Leaves clustered into basal rosette, appressed to the ground, petiole \pm 2.5 mm long; lamina ovate, 4.5-5.6 x 3-4.5 mm, obtuse. Inflorescences dense fascicles of numerous flowers, sessile in the centre of a leaf rosette; bracts subtending flowers ovate, 8-21 mm long, 4-13 mm wide, obtuse, not inflated at the base, much longer than inflorescences. Flowers violet, blue, rose to whitish. Calyx almost divided to the base; tube \pm 1 mm long; segments spatulate, 2-2.5 mm long, 0.5-1 mm wide, obtuse. Corolla tube 1.5-3 mm long, scabrid-denticulate on both sides; lobes ovate-lanceolate, 1-1.5 mm long, 0.3-0.5 mm wide at base, \pm obtuse. Filaments 0.6-0.8 mm long; anthers 0.3 mm long. Ovary ellipsoid, 0.6 mm long, 0.4-0.5 mm in diam.; style 1.4 mm long, stigma minute, bilobed. Capsule ellipsoid, 1.3-2.1 mm long, 1-1.1 mm in diam., bivalved. Seeds 0.3-0.5 mm, surface reticulate.

Ecology: Shallow soils over rocks, also in copper steppe savannas.

General distribution: Angola, D.R. Congo, Rwanda, Burundi, Tanzania, Zambia, Malawi.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | X | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Kabwelunono (34), Swambo (62), Kimpe (102).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 181, Co = 29 $\mu\text{g/g}$ D.M.

Rehabilitation: No evident interest.

References:

BOUTIQUE [1972].
NEMOMISSA [2002].



Manika plateau

© M. Schallies

Holotype: J. Léonard 4620.

Copper specimens: Bh 4812; Ec 6711; Kk-My 67; Lj 4620; Mf 8859, 9286, 9286bis, 14250; Nn 1082.

Habit: Annual herb, 1.5–6 cm high. Stem erect, simple or branched in the upper part, up to 0.6 mm thick, tetraedric. Leaves elliptic acute, summit obtuse or subacute, basis cuneate, lower leaves up to 8 mm long, upper leaves not exceeding the subtended fascicles of flowers. Inflorescence congested, subcapitate. Flowers axil, 12–15 fasciculate, in dense terminal cylindrical or ovoid capitulum, pink to mauve; pedicels 1–3 mm long, finely papillose; calyx campanulate, about 2 mm long, lobes oblong-ovovate; tube of corolla cylindrical, papillose, about 1.7 mm long, corolla lobes oval acute c. 1.7 mm long; anthers circa 0.5 mm long. Capsule obovoid, circa 1.5 mm long; seed few (about 5), globose, circa 0.5 mm in diam., finely scrobiculate.

Ecology: Copper steppe savannas.

General distribution: Restricted to the south-eastern part of the Katangan Copper Bow.

Distribution on Katangan copper sites (3 sites): Luiswishi (87), Ruashi (96), Etoile (97).

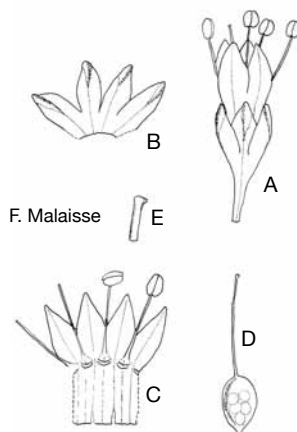
| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|---------|
| | normal | 200 | 800 |
| dry | <X< | <X< | > 5,000 |
| medium | | (X) | XX |
| wet | | | |

→ polycuprophyte

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 84, Co = 55 µg/g D.M.

Rehabilitation: No evident interest.

References: TAYLOR [1971; 1973].



A. Flower (x 12) – B. Calyx opened (x 12) – C. Corolla opened (x 12) – D. Capsule with style and stigma (x 12) – E. Stigma (x 48).

[Drawn after TAYLOR, 1973]



Etoile mine



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Faroe malaissei Bamps

[Gentianaceae]

Holotype: Malaisse 7684.

Copper specimens: Dp 3018 F;
LMS 13039 bis; Mf 13817; Mf-Gp 518;
Tr 136.

Habit: Annual herb, stem simple or few branched, 5-18 cm high. Leaves subsessile, elliptic, attenuate to the base and to the summit, 10-25 x 3-10 mm, lower leaves smaller and petiolate. Flowers in fascicule, inflorescences subspheric and capituliforme, 5-15 in diam. Flowers with pedicelle 1.5-2 mm long; calyx 3 mm long; corolla lilac to blue, tube 2 mm long, lobes 2-2.5 mm long. Capsules ellipsoidal, 1.5 mm long.

Ecology: Only recorded from rocky outcrops sites (siliceous cellular rocks) on slopes.

General distribution: Restricted to the central part of the Katangan

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | XX | X | |
| medium | | | |
| wet | | | |

→ mesocuprophyte

Copper Bow, mostly but not exclusively on copper sites.

Distribution on Katangan copper sites (4 sites): Mwinansefu (43), Kwatebala (45), Fungurume (51), Luita (58).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 29, Co = 22 $\mu\text{g/g}$ D.M.

Rehabilitation: Pleasant habit.

Reference: BAMPs [1982].



Fungurume



Kwatebala



Mwinansefu

Sebaea bojeri Griseb.

Holotype: Bojer s.n.

Copper specimen: MHK 87.

Habit: Annual erect herb, 8-30 cm tall. Stem slender, unbranched or branched at inflorescence, sometimes glandular at the base. Leaves sessile, the lower ones reduced and scale-like, in 2-3 distant pairs; 3-4 x 1 mm, linear-lanceolate, acute. Flowers yellow, solitary or in few-flowered cymes. Calyx with a very short tube, winged on the keel, with hyaline margins. Stamens inserted in the corolla-sinuses; anthers with or without a small apical, sessile gland.

Ecology: Grasslands, also steppe savannas with low copper content.

General distribution: From Uganda and Tanzania southwards to R.S.A. and Madagascar.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).



Kazinyanga

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Sebaea microphylla (Edgew.)

Knobl. [Gentianaceae]

Holotype: Edgeworth s.n.

Copper specimens: Dp 2930; MKS 540.

Syn.: *S. welwitschii* Schinz.

Habit: Annual saprophytic herb, 3-40 cm high. Stem slender, unbranched or branched at inflorescence. Leaves sessile, in 6-9 distant pairs, reduced, scale-like, triangular, lanceolate or linear-lanceolate, 2-4 mm long, 0.5-1 mm wide, acute to acuminate. Flowers terminal solitary or few-flowered inflorescences, lax, dichasially branched cymes. Pedicels 13-20 mm long, slender. Flowers 5-merous, rarely white, pale yellow, yellow or golden yellow. Calyx lobes free to the base, 5.5-7 mm long, 1-2 mm wide, linear-lanceolate to lanceolate-oval, acute, crenate, wing narrow. Corolla tube cylindrical, 4-7.4 mm long, narrowed into the ovary, enlarged at point of filament insertion; lobes elliptic, 5-8.5 mm long, 2.5-4 mm wide, subobtuse. Stamens inserted in the sinuses of corolla lobe. Capsule oblong, 3-5 mm long. Seed \pm 0.2 mm in diam., surface reticulate-pitted.

Ecology: In shallow soil over rock, rarely in copper steppe savannas.

General distribution: Throughout tropical Africa (from Ethiopia, to Malawi and Angola), tropical Asia (to China, Thailand).

Distribution on Katangan copper sites (3 sites): Shandizandzoro (48), Fungurume (51), Mindigi (60).

References:

PAIVA, NOGUEIRA [1990].

NEMOMISSA [2002].

***Sebaea* sp.**

Copper specimen: Mf K101.



Kwatebala

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Kwatebala

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***Streptocarpus* aff.
*michelmorei*** B.L.Burt

Copper specimens: MHK 140, 265.

Habit: Unifoliate leaf prostrate, elliptic-oblong. Corolla 7-10 mm long, tube dull violet, lobes violet.

Ecology (for both species): In shelter of rock outcrops on mountain slopes, also between rocks in copper steppes.

Distribution on Katangan copper sites (2 sites): Katuto (41), Kamakonka (39).

Rehabilitation (for both species): Pleasant habit for copper rocky sites.



Katuto

***Streptocarpus*
*rhodesianus*** S.Moore
[Gesneriaceae]

Holotype: Kassner 2162.

Copper specimens: Dp 5126 S; Mf 13819.

Habit: Several rosulate leaves, both surfaces densely pilose, almost lanate, upper surface grey-green. Corolla 8-12 mm long, tube dull wine red, lobes white, floor of tube white blotched wine red.

Distribution on Katangan copper sites (2 sites): Notably Luita (58).

References:

HILLIARD, BURTT [1971].

DARBYSHIRE [2006].



Kasumbalesa



Chibuli Hill (Zambia)



Dikuluwe

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Aeollanthus homblei

De Wild.

Holotype: Homblé 832.

Copper specimens: MKS 261; Mf-Re 2193.

Habit: Herb with one globose root. Stems 1-4, up to 10-35 cm high. Basal leaves, 2-4, opposite, elliptic, obtuse at the apex, cuneiform at the base, 4-12 x 3.5-9 cm, green, concolorous margin crenate. Panicle lax frequently reduced to a single spike 5-20 cm long. Corolla white, bilabiate, upper lip 4-lobed with the midlobes markedly larger. Disc ovate in fruiting stage. Nutlets brownish.

Ecology: Kalahari sands, rocks and copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga) and Zambia.

Distribution on Katangan copper sites (6 sites): Notably Shabara (24).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 6-890, Co = 328-846 µg/g D.M. Accumulator of Cu and Co. Values need confirmation.



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Kazinyanga



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Shabara



Kazinyanga



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Aeollanthus rosulifolius

P.A.Duvign. & Denaeyer

[Lamiaceae]

Holotype: Duvigneaud 5141 L.

Copper specimens: Dp 4089, 4412, 4657, Ba-Mf 8229.

Syn.: *A. homblei* auct. non *A. homblei* De Wild.

Habit: Herb with one globose root, rarely tuberous roots. Stems 1-(2), up to 10-20 cm high. World of 4-6 leaves at the base of the stem; leaves elliptic, obtuse at the apex, cuneiform at the base, 1-2 x 0.5-1 cm, green above, purple or violaceous beneath, margin entire or crenate. Panicle lax reduced to a single spike 8-12 cm long. Calyx 1-1.2 mm long, bilabiate; corolla white or pink, bilabiate, upper lip 4-lobed with the midlobes markedly larger. Disc ovate in fruiting stage. Nutlets brownish.

Ecology: Grasslands often also on copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (3 sites): Dikuluwe (2), Kansunki (22), Shabara (24).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 78, Co = 65 µg/g D.M.

Reference: RYDING [1986].



© P. Bamps

Shabara

Aeollanthus saxatilis P.A.Duvign. & Denaeyer-DeSmet

[Lamiaceae]

Holotype: Duvigneaud 4647 L.
Copper specimens: Dp 4647 L, 4670;
Mf 7694, 9184; Mf-Gj 37, 91;
Mf-Re 2155; Tr 232.

Habit: Perennial herb. Roots with tuberulous and/or woody thickened parts. Stems many, ascending, decumbent or erect, up to 10-25 cm long. Leaves opposite, subsessile and obovate or shortly petiolate and elliptic, 10-20 x 4-7 mm, obtuse or acute at the apex, attenuate at the base. Panicles lax and only slightly branched; the spike of the main axis often one-sided with 2 flowers at each node. Corolla violet.

Ecology: Copper rich rocks.

General distribution: Restricted to the West-central part of the Katangan Copper Bow.

Distribution on Katangan copper sites (4 sites): Mupine (3), Chabara (12), Kalukundi (18), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu =6-53, Co = 86-1343 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | <X< | 5,000 |
| dry | 800 | 5,000 | | |
| medium | XX | X | | |
| wet | | | | |

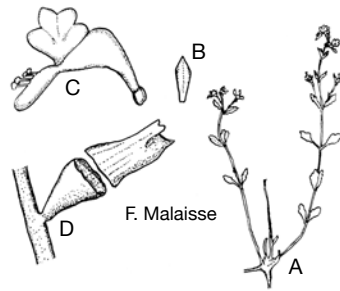
→ mesocuprophyte

Cobalt hyperaccumulator

Rehabilitation: No evident interest.

References:

DUVIGNEAUD, DENAEYER-DE SMET [1963].
RYDING [1986].



A. Habit (x 0.15) – B. Fertile bract (abaxial side) (x 1) – C. Flower (x 1.5) – D. Fruiting calyx (x 2.5). [Drawn after RYDING, 1986]



Fungurume



Aeollanthus subacaulis (Baker) Hua & Briq. [Lamiaceae]

Syn.: *Icomum biformifolium* De Wild.

Habit: Herb, root tuberous, globose, 5-70 mm in diam. Corolla white; tube broadened towards the throat, 5-10 mm long; upper lip 4-lobed, lower lip boat-shaped, 3-5 mm long. Disc circular to square. Nutlets smooth, black or dark brown.

Ecology: Rocks in shallow soil or on hill-slope steppes, often also in copper steppe savannas.

var. ***ericoides*** (De Wild.) Ryding

Left picture, drawings A and B.

Copper specimens: Mf 10491, 11677.

Habit: Stem 1, erect. Cauline leaves up to 35 x 3 mm.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (3 sites): Notably Luiswishi (P5).

var. ***linearis*** (Burk.) Ryding

Middle and right pictures, drawing C.

Copper specimens: Bp 824, Lj 5242, Mf 9236, Mf-Re 2062, Tr 298, Rw 1748.

Habit: Stem several, with 12-200 vegetative leaves. Leaves irregularly scattered, sub-opposite, usually rosulate at the base of the plant. Basal leaves up to 6-45 x 1-7 mm; cauline leaves up to 6-25 x 0.5-3. mm.

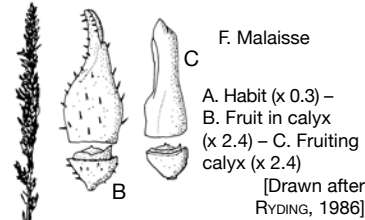
General distribution: From Angola to Tanzania and Mozambique.

Distribution on Katangan copper sites (19 sites): Notably Etoile (97).

Phytochemochemistry: Copper and cobalt hyperaccumulator; but needs confirmation.

References:

MALAISSÉ et al. [1978].
RYDING [1986].



Luiswishi



Manika plateau



Etoile mine



Kolwezi-Musokatanda

Haumaniastrum katangense (S.Moore) P.A.Duvign. & Plancke [Lamiaceae]

Holotype: Rogers 10904.

Copper specimens: Ls 231, Mf 9284, 9317.

Syn.: *Acrocephalus katangensis*

S. Moore

Habit: Annual herb, 5-65 cm tall. Stem erect, quadrangular, branching, arising from a fibrous root system. Leaves slightly deflexed to ascending, sessile or shortly petiolate; blades linear or narrowly obovate, 15-70 x 2-11 mm, entire or serrate, apex acute, base cuneate. Upper leaves subtending heads caudate or apiculate, purple, pink or white, membranous, lacinate, fimbriate. Heads 4-12 x 3-15 mm, solitary or in panicle. Flowering calyx 1.5 mm long, villous with adpressed hairs. Fruiting calyx 3.5-5 mm long, pubescent distally.

Ecology: Mainly on copper/cobalt and even uranium rich soils in Katanga, on rocky copper polluted grounds.

General distribution: Angola, D.R. Congo, Tanzania, Zambia.

Distribution on Katangan copper sites (16 sites): Dikuluwe (2), Tantara (63), Shinkolobwe (67), Kamoya (72), Kamatanda (73), Luishia (77), Lukuni (86), Luiswishi (87), Kipushi

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| dry | | | | |
|--------|---|---|----|---|
| medium | X | X | XX | X |
| wet | | | | |

→ eurycuproresistant, local cuprophyte

(90), Kasonta (91), Lupoto (92), Niamumenda (93), Kasombo (94), Ruashi (96), Etoile (97).

Distribution on Zambian Copper sites (2 sites): Kansanshi (100), Roan Antelope (147).

Phytogeochemistry: Cu-Co content of leaves (15 samples) Hyper-accumulator of copper and of cobalt. Needs confirmation.

Rehabilitation: Good pioneer of skeletal soils.

Reference: PATON [1997].



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Near Lubumbashi



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Karavia

Sokoroshe

Haumaniastrum polyneurum (S.Moore) P.A.Duvign. & Plancke [Lamiaceae]

Holotype: Kässner 2766.
 Copper specimens: Dp 2998, 3008, 3088, 5171; Mf 9858, 10790; Tr 278.
 Syn.: *Acrocephalus polyneurus* S.Moore.

Habit: Perennial suffrutex with one or few stems arising from a rosette of leaves on a woody rootstock, 0.2-0.5 m tall. Stems erect, rounded-quadrangular, leafy, sparsely branched, pubescent to lanate. Leaves ternately arranged on stem, sometimes opposite, and in a basal rosette around stem base; leaves sessile, apex sometimes reflexed. Blades chartaceous, ovate elliptic or lanceolate 15-50 x 3-13 mm, apex acute, base rounded or cuneate. Upper leaves subtending heads ovate, white or pinkish at base, flat or directed slightly upwards, apex apiculate, rarely caudate, green, 10 mm long. Heads 10-20 mm long, 10-18 mm in diam., solitary or arranged in a panicle or very dense corymb. Corolla mauve or bluish, 5.5-7 mm long; tube 4-5.5 mm long; posterior lip 4-lobed with median lobes small. Nutlets dark brown, ovate, 2 mm long.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | X | XX | X |
| wet | | | |

→ eurycuproresistant

Ecology: Steppe savannas on Kalahari sands and on copper/cobalt rich soils, also open woodlands, edge of dambos.

General distribution: Restricted to the D.R. Congo (Upper Katanga).

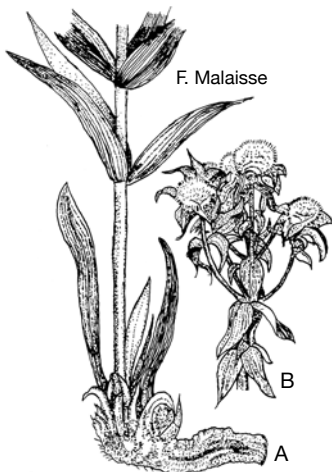
Distribution on Katangan copper sites (5 sites): Notably Mitonte (68).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 4-97, Co = 7-67 µg/g D.M.

Rehabilitation: No evident interest.

References:

DUVIGNEAUD, PLANCKE [1959].
 PATON [1997].



A. Habit of base (x 0.4) – B. Inflorescence (x 0.6) [Drawn after PATON, 1997]



Manika plateau



Mindigi

Haumaniastrum prealtum (Briq.) P.A.Duvign. & Plancke var.
homblei (De Wild.) A.J. Paton [Lamiaceae]

Holotype: Homblé 121.

Copper specimens: Dp 2046; Mf-Re 2101.

Syn.: *Acrocephalus homblei* De Wild.

Habit: Perennial suffrutex arising on a woody rootstock, 0.1-1.2 m tall. Stems branching above, glabrous to densely villous. Leaves arranged mostly in a basal rosette, grey-green, elliptic to obovate; blades crenate or serrate, apex rounded, obtuse to acute, base, attenuate, sparsely pubescent to almost sericeous and glandular-punctate; petioles 0-100 mm. Upper leaves subtending heads similar to leaves but smaller, 10-20 mm long and coloured at base. Heads 5-25 mm long, 5-15 mm in diam., solitary or arranged in a dense corymb or lax panicle; bracts ovate, rarely apiculate; verticals 6-flowered. Fruiting calyx 4-6 mm long, apex of posterior lip rounded to truncate, anterior lip \pm equal to posterior, apex rounded,

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | | |
|--------|---|----|---|
| dry | | | |
| medium | X | XX | X |
| wet | | | |

→ eurycuproresistant

truncate. Corolla white or pale pink, 4-8 mm long; tube 3-5 mm long; posterior lip 4-lobed with median lobes bifid. Nutlets pale brown, 1.5-2 mm.

Ecology: Open woodlands, steppe savannas on rocky slopes, and often on copper and cobalt rich soils.

General distribution: Angola, D.R. Congo, Zambia (Western Province).

Distribution on Katangan copper sites (19 sites): Notably Lukuni (86).

Phytogeochemistry: Cu-Co content of leaves (9 samples): Cu = 18-513, Co = 6-2,633 $\mu\text{g/g}$ D.M. Values need confirmation.

Rehabilitation: No particular interest.

Reference: PATON [1997].



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Kolwezi-Mamfwe road

Haumaniastrum robertii (Robyns) P.A.Duvign. & Plancke
[Lamiaceae]

Holotype: Rogers 10904.
Copper specimens: Dp 3098; Mf 9284.

Habit: Annual branched herb, 5–65 cm tall. Leaves linear or narrowly obovate, 15–70 x 2–11 mm, entire or serrate. Upper leaves subtending heads purple, pink or white, membranous, laciniate, fimbriate.

Ecology: Rock slopes and man-made rocky heaps on cobalt-copper rich soils.

General distribution: Restricted to Upper Katanga (western and central part of Katangan Copper Arc).

Distribution on Katangan copper sites (18 sites): Notably Mutoshi (10).

Phytogeochemistry: Cu-Co content of leaves (12 samples). Hyperaccumulator of copper and of cobalt.

Rehabilitation: Good pioneer of skeletal rich cobalt soils.



Fungurume



Near Mutoshi mine

Haumaniastrum rosulatum (De Wild.) P.A.Duvign. & Plancke [Lamiaceae]

Holotype: Corbisier in Homblé 626.
Copper specimens: Dp 2046 A1; Dp-Tj 2056A1; Mf 7682; Mf-Gj 60; Tr 90.
Syn.: *Acrocephalus rosulatus* De Wild.

Habit: Perennial herb with 1(2) stems arising from a flat 4-6 leaved rosette on a woody rootstock, often tuber-like, 0.15-0.5 m tall. Stems erect, quadrangular, usually leafless except for leaves subtending heads, mostly unbranched, with numerous white or rarely bluish hairs. Leaves petiolate or sessile; blades bullate, rotund or obovate, 20-120 x 15-70 mm, crenate, apex obtuse, base rounded, pubescent. Heads 5-15 mm long, 5-15 mm in diameter, solitary or arranged in a very dense corymb. Flowering calyx 1.5-2 mm long, villous with adpressed hairs. Fruiting calyx 4.5-5.5 mm long. Corolla pinkish-white or pale-blue 5-7 mm long, tube 4-5 mm long. Nutlets pale brown, 2 mm long.

Ecology: Grasslands and woodlands, also on copper-cobalt rich soils.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | XX | X |
| wet | | | |

→ mesocuproresistant

General distribution: Upper Katanga.

Distribution on Katangan copper sites (18 sites): Notably Dikuluwe (2), Tilwezembe (20), Kasompi (27), Menda (28), Tenke (32), Mindigi (60), Shinkolobwe (65), Mitonte (68), Kamoya (72), Kamatanda (73), Likasi (75), Luishia (77), Sokoroshe (83).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 21-1,089, Co = 4-195 µg/g D.M. Copper accumulator.

Rehabilitation: No evident interest.

Reference: PATON [1997].



Fungurume

Haumaniastrum timpermanii (P.A.Duvign. & Plancke)

P.A.Duvign. & Plancke

[Lamiaceae]

Holotype: Duvigneaud & Timperman 2626 A.

Copper specimens: Mf 10777, 11771, 11790; Mf-Gp 857; Tr 99, 25.

Syn.: *Acrocephalus timpermanii*.

Habit: Perennial arborescent herb, 1-2 m tall, with annual stems arising from a woody trunk 20 cm tall and 2 cm in diameter, corky with horizontal fissures. Unthickened stems arising from a rosette of leaves on top of trunk, erect, quadrangular, branching above. Rosette leaves petiolate or sessile; broadly elliptic, ovate to obovate, 12-200 x 10-50 mm, crenate, apex acute to rounded, base attenuate, densely pubescent with sessile glands; petiole 0-10 mm long. Stem leaves, similar in form to rosette ones. Upper leaves subtending heads similar coloured white or violet, apex cuspidate, 15 mm long. Heads 10-30 mm long, 10-20 mm in diam., oppositely, ternately or quadrately arranged in a panicle; verticals 6-9 flowered. Flowering calyx 4 mm long, distally pubescent. Fruiting calyx 7-10 mm long, distally villous; apex of posterior lip 3-toothed, anterior

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |

| | | | | |
|--------|------|----|--|--|
| dry | | | | |
| medium | X(X) | XX | | |
| wet | | | | |

→ oligocuproresistant

lip with 2 deltoid teeth. Corolla whitish, 8-10 mm long, tube 6.5-8 mm long, posterior lip almost 3-lobed, median lobe emarginated.

Ecology: Open *Uapaca* woodlands, steppe savannas on sandy or copper-rich soils.

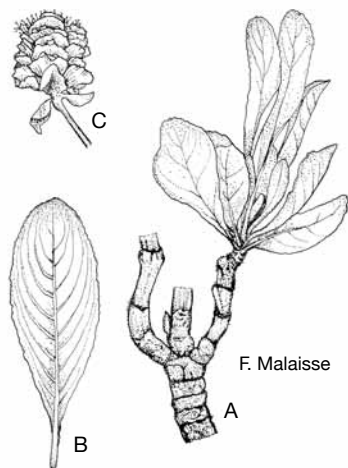
General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (6 sites): Notably Goma (33).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 8-44, Co = 3-48 $\mu\text{g/g}$ D.M.

Rehabilitation: No evident interest.

Reference: PATON [1997].



A. Habit of base (x 0.3) – B. Leaf showing venation patterns (x 0.2) – C. Inflorescence (x 0.5). [Drawn after PATON, 1997]



Kabwelunono

Ocimum centraliafricanum

R.E.Fries

Syntypes: R.E. Fries 1166, 1282.

Copper specimen: Pj 31/486.

Syn.: *Ocimum homblei* De Wild.

Habit: Aromatic perennial suffrutex; thick woody rootstock. Stems erect, with simply antrorse hairs. Leaves elliptic to obovate, entire or distally serrate. Inflorescence condensed with 6-flowered verticils. Calyx 4.5-6 mm long at anthesis; fruiting calyx 8-10 mm long; lateral lobe of the lower calyx-lip distally tomentose. Corolla white, pink, purple or bluish, 6-11 mm long.

Ecology: Copper steppe savannas, open *Brachystegia* woodlands, dambos.

General distribution: D.R. Congo, Tanzania, Zambia, Zimbabwe.

Distribution on Katangan copper sites (18 sites): Notably Luiswishi (87).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 5-6, Co = 5-12 µg/g D.M.

Rehabilitation: Pleasant habit.

Ocimum vanderystii (De

Wild.) A.J. Paton [Lamiaceae]

Holotype: Vanderyst 3273.

Copper specimens: Dp 4062 B;

Dp-Tj 2615 B.

Syn.: *Becium aureoviride* P.A.Duvign.

Habit: Perennial suffrutex; 30-45 cm tall; stems arising from a woody rootstock; with yellowish dendroid hairs. Leaves elliptic or oblong, with yellowish dendroid hairs. Calyx 5-6 mm long at anthesis; fruiting calyx 9-10 mm long. Corolla white or white marked pink, 8-12 mm long.

Ecology: Open *Brachystegia* woodlands, often on copper steppe savannas.

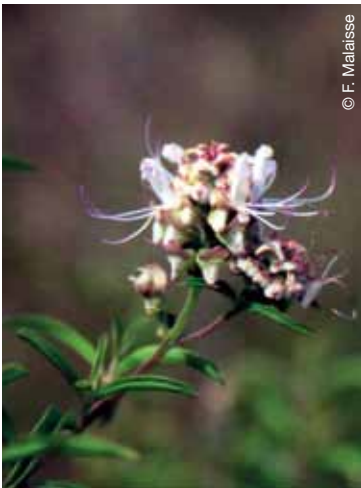
General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (16 sites): Notably Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 143, Co = 78 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference (for both species): PATON [1995].



Karavia



Plectranthastrum rosmarinifolium (Welw.) B.Mathew

[Lamiaceae]

Holotype: Welwitsch 1636.
 Copper specimens: Mf 10806; Rw 1718.
 Syn.: *Alvesia rosmarinifolia* Welw.

Habit: Perennial suffrutex, several stems arising from a woody rootstock, 0.9-1.5 m high. Stems with short hairs, tomentous, leaves dense, twigs opposite. Leaves opposite, lanceolate to oblong-lanceolate, shortly acute, green above, tomentose below, 25-35 x 4-8 mm. Flowers 6 per verticil, bracts oval, shorter than pedicels, deciduous, in dense ovoid racemes, pyramid-shaped. Calyx 4-6 mm long before anthesis, becoming 30-40 x 15-25 mm when fruiting, green-violaceous, ciliate; corolla 18-22 mm long, tomentous. Nucules mostly solitary, oboval, sessile, glandulous.

Ecology: Grasslands and woodlands, also in shrub savannas surrounding copper sites.

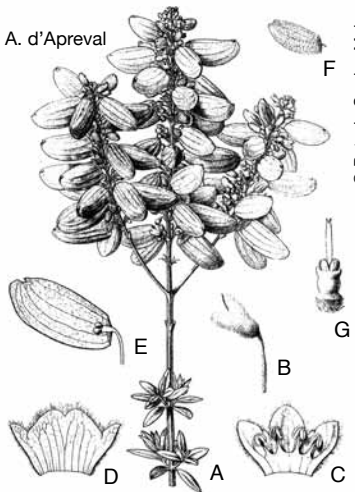
General distribution: Angola, Congo-Brazzaville, D.R. Congo, Zambia.

Distribution on Katangan copper sites (2 sites): Mindigi (60), Kambove (71).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu =22-32, Co = 2-7 µg/g D.M.

Rehabilitation: Ornamental aptitude for ecotone of copper steppe savanna.

Reference:
 DE WILDEMAN, DURAND [1899].



A. Branch (x 1.4) – B. Flower without corolla (x 3.2) – C. Young corolla, flattened cross-section (x 3.7) – D. Calyx, flatened cross-section (x 3.7) – E. Fructiferous calyx, longitudinal section (x 0.5) – F. Fructiferous calyx (x 0.3) – G. Gynoecium in a bud (x 4.9).

[DE WILDEMAN, DURAND, 1899]



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Kasipa road



© M. Schajles

Biano plateau

Plectranthus esculentus N.E.Br.

[Lamiaceae]

Holotype: Medley Wood 3633.

Copper specimens: DKM 1900; Mf 7736;

MKM 134; MKS 353, 468; Tr 224.

Syn.: *Coleus esculentus* (N.E.Br.) G.Taylor

Habit: Erect or decumbent, perennial, aromatic herb or suffrutex from a tuberous-rooted base, 60-120 cm tall. Stems 1-several, 4-angled, leafless at flowering. Leaves subsessile; blade oblong-elliptic, 5-8 x 1.3-2.5 cm broad, dotted with brown gland-dots below; apex obtuse to rounded, base obtuse to cuneate, margin obscurely denticulate. Inflorescences occupying the apical 20-60 cm of the stem; racemes 3-5 cm long. Calyx campanulate, 4-5 mm long at flowering time. Corolla yellow, 14-16 mm long, puberulous, tube 6-8 mm long; upper lip erect, 2 mm long, emarginated and with 2 small ear-like lateral lobes; lower lip deeply boat-shaped, 7-8 mm long.

Ecology: Open forests, spread by cultivation, rarely also in copper steppe savannas.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | 800 | 5,000 | |
| wet | | | |

→ oligocuproresistant

General distribution: From tropical Africa southwards to Angola, R.S.A., Swaziland.

Distribution on Katangan copper sites (5 sites): Shabara (24), Kabwelunono (34), Shimbidi (35), Kwatebala (45), Fungurume (51).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 35-50, Co = 92-679 $\mu\text{g/g}$ D.M.

Rehabilitation: No evident interest.

Reference: CODD [1975].



Shabara



Kwatebala

***Tinnea coerulea* Gürke var. *obovata* (Robyns & Lebrun) Vollesen**
[Lamiaceae]

Holotype: W. Robyns 1708.

Copper specimens: Mf 7735; Sm 7738.

Syn.: *T. obovata* Robyns & Lebrun

Habit: Suffrutex, 0.3-1.5 m high. Leaves in whorls of three, opposite or alternate; petiole 1.5-4 mm long; lamina obovate-orbicular, 10-15 x 8-9 mm, apex truncate-retuse. Inflorescence 15-30 cm long, raceme or thyse with 3 flowers in the axils of the lower bracts; upper bracts ovate-roundish, violet but often only at the margins. Calyx 7-13 x 4-10 mm, purple all over or the basal part yellowish, densely villous-pubescent, hairs yellow-golden. Corolla 13-23 mm long; lower lip blue-red-purple; tube white-cream, 7-13 mm long; stamens 7-10 and 9-12 mm long, inserted 2.5-6 mm above the base of the tube and adnate to this for 2-3.5 mm. Nutlets 5-8 mm long, pubescent, wing 7-9 mm in diam.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | (X) | |
| wet | | | |

→ oligocuprophyte

Ecology: Copper steppe savannas.

General distribution: Restricted to several copper-cobalt mines in Upper Katanga.

Distribution on Katangan copper sites (36 sites): Notably Likasi (75).

Rehabilitation: Pleasant habit.

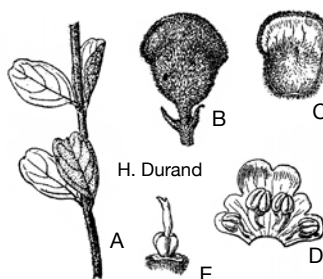
References:

ROBYNS, LEBRUN [1930].

VOLLESEN [1975].



Shagulowe



A. Part of stem (x 0.5) – B. Bud (x 1.7) – C. Calyx (x 1.7) – D. Corolla, flattened cross-section (x 1.7) – E. Gynoecium (x 1.5).
[Original plate]



Shabara



Kabwelunono

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Crepidorhopalon bifolius (Skan) Eb.Fisch. [Linderniaceae]

Holotype: W.H. Nutt s.n.

Copper specimens: Mf 16580, 16608.

Syn.: *Lindernia bifolia* Skan

Habit: Annual herb, 2-24 cm high; stem erect, slender stem, glabrous, quadrangular, simple or few branching. Leaves opposite, sessile, simple or branched from base, basal in one or two pairs, thin, limb oblanceolate to obovate, summit acuminate, 8-23 x 5-14 mm, obtusely dentate, nervation palmate. Inflorescence lax, mostly in terminal racemes, each node bearing one leaf and one bracteal leaf at the opposite site. Bracts 0.6-1.2(2.5) mm long, subulate to linear-lanceolate. Flower yellow with an orange spot on lower lip, calyx 3.5 mm long with 3 mm long lobes, corolla tube 4 mm long, upper lip entire, 3 mm long, lower lip tripartite, 4 mm long; filament of abaxial stamen 2.5 mm long, geniculate, with clavate appendages covered with glandular hairs and papillose; filament of adaxial stamen straight, 1.2 mm long. Capsule 3-3.5 x 1.5-2.5 mm, broadly ellipsoid to ellipsoid-globose, apiculate, septicidal-septifragal.

Ecology: Savannas, miombo open forests on rocky slopes, rare in copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-----|---|
| | normal | 200 | 800 | > |
| dry | X | (X) | > | |
| medium | X | | > | |
| wet | | | > | |

→ oligocuproresistant

Distribution on Katangan copper sites (1 site): Tilwezembe (20).

Rehabilitation: No evident interest.

References:

PHILCOX [1990].

FISCHER [1992; 1999].



Tilwezembe



Crepidorhopalon perennis (P.A.Duvign.) Eb.Fisch.
[Linderniaceae]

Holotype: Duvigneaud-Damblon 2870 T2.
Copper specimens: Bi 13; Bp 803;
Hh 15938; Kk-My 68; Lj 4261;
Mu-Fm 7; Qp 4896; Sj 4834; Sa 5177.
Syn.: *Lindernia perennis* P.A.Duvign.

Habit: Perennial herb, suffruticose, 7-19 cm high; stem erect, glabrous, quadrangular, much branching. Leaves opposite, sessile, limb oblanceolate, spatulate, summit acuminate, 9-20 x 1-2 mm, obtusely dentate, nervation palmate. Inflorescence lax; flower blue-violeaceous with a yellow spot on lower lip, calyx 5 mm long, corolla tube 5 mm long, upper lip 5 mm long, bipartite, with glandular hairs, lower lip tripartite, 5-6 mm long; filament of abaxial stamen 4-5 mm long, geniculate, with clavate appendages covered with glandular hairs and papillose; filament of adaxial stamen straight, 1 mm long. Capsule 4-5 mm long, septicidal-septifragal.

Ecology: Copper steppe savannas.

General distribution: Restricted to the Etoile and Ruashi mines (Upper Katanga).

Distribution on Katangan copper sites (2 sites): Ruashi (96), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 25-9,322,

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | | XX | XXX |
| wet | | | |

→ eurycuprophyte

Co = 41-404 µg/g D.M. Copper hyper-accumulator, cobalt accumulator.

Rehabilitation: Great aptitude as stabilizer for heavy copper soils.

References:

- DUVIGNEAUD, DENAEYER-DE SMET [1963].
FISCHER [1989; 1992; 1999].
LETEINTURIER et al. [1999].
FAUCON et al. [2009a; 2009b].



E. Fischer

Habit (x 0.4).

[FISCHER, 1999]



Etoile mine



© M. Schallies



© M.P. Faucon

Crepidorhopalon tenuis (S.Moore) Eb.Fisch.

[Linderniaceae]

Holotype: F.A. Rogers 10886.

Copper specimens: Ba 384; Dg 1308; Fm-Su 7; Kk-My 69; Mf 7710; LMM 178; Mf-Gp 313; Sa 824; Tr 114; Rw 1275.
Syn.: *Lindernia damblonii* P.A.Duvign.

Habit: Annual herb, 6-16 cm high; stem erect, glabrous, quadrangular, much branching. Leaves opposite, sessile, limb lanceolate, summit acuminate, 5-15 x 1.5-4 mm, narrowly dentate, nervation palmate. Inflorescence lax. Flower blue-violeaceous with a yellow spot on lower lip, pedicel 1 mm long, calyx 4 mm long, corolla tube 4-6 mm long; filament of abaxial stamen 2.5-3 mm long, geniculate, with clavate appendages; filament of adaxial stamen straight. Capsule 3-4 mm long, septicidal-septifragal.

Ecology: Steppe savannas on copper outcrops, copper polluted soils, rarely steppe savannas on Kalahari sands, dambos.

General distribution: Upper Katanga, Northern Zambia and Tanzania.

Distribution on Katangan copper sites (9 sites): Tantara (63), Kalabi (69), Kambove (71), Kamoya (72), Kasonta (91), Lupoto (92), Ruashi (96), Etoile (97), Kimpe (102).

Distribution on Zambian copper sites (2 sites): Kansanshi (100), Bwana Mkubwa (145). Also on copper

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | XX | XX | |
| wet | | XX | X | |

→ eurycuproresistant local cuprophyte

polluted soils along roads in Upper Katanga (Lubumbashi, Karavia).

Phytogeochemistry: Cu-Co content of leaves (7 samples): Cu = 97-927, Co = 17-1,113 µg/g D.M. Cobalt hyperaccumulator, copper accumulator.

Rehabilitation: Medium interest for copper polluted soils, according to the fact that it is a therophyte (annual plant species).

References:

FAUCON et al. [2009a; 2009b].
FISCHER [1989; 1992; 1999].



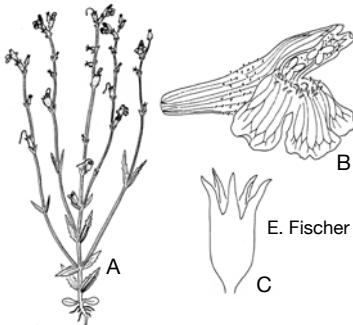
© F. Malaisse

Etoile



© B. Lachenrue

Kansanshi



A. Habit (x 0.3) – B. Corolla (x 3.0) –
C. Calyx (x 3.6). [FISCHER, 1999]

Hartiella cupricola Eb.Fisch.

[Linderniaceae]

Holotype: Malaise 11707.
Copper specimen: M 11707.

Habit: Perennial herb, suffrutex, 14-20 cm high, with a woody base; stem erect, glabrous, quadrangular, simple or few branched. Leaves opposite, sessile, coriaceous, lanceolate, apex acuminate, 35-42 x 7-9.5 mm, nerves palmate. Inflorescence in form of capitulum. Flowers blue-violet; pedicel 1 mm long, calyx 14 mm long, corolla tube 6 mm long; upper lip entire, 5-6 mm long, with glandular hairs; lower lip tripartite, 5-6 mm long; stamens 4, filament of abaxial stamen 3.5-4 mm long, with clavate geniculate appendages covered with glandular hairs and papillose; filament of adaxial stamen straight, 3.5 mm long. Ovary ovoid, 2 mm long, glabrous; style 8 mm long.

Ecology: Cupriferous steppe savannas.

General distribution: Only recorded from holotype site.

Hartiella suffruticosa (Lisowski & Mielcarek) Eb.Fisch.

[Linderniaceae]

Holotype: Duvigneaud & Timperman 2570 Sc.
Copper specimen: Pj 100/1324.
Syn.: *Lindernia suffruticosa* Lisowski & Mielcarek

Habit: Perennial herb, 6-11 cm high stem erect, woody base. Leaves opposite, at least 4 pairs 15-25 x 12-16 mm. Flowers blue-violet.

Ecology: Mainly *Cryptosepalum* steppe savannas on cupriferous soils.

General distribution: Restricted to Upper-Katanga.

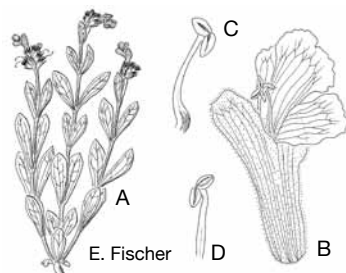
Distribution on Katangan copper sites (6 sites): Notably Mupine (4).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | | X | | |
| wet | | | | |

→ oligocuprophyte

Distribution on Katangan copper sites (1 site): Kahumbwe (57).

References: FISCHER [1992; 1999].



A. Habit (0.25) – B. Corolla (x 2.2) – C. Abaxial stamen (x 3) – D. Adaxial stamen (x 3). [FISCHER, 1999]

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 21, Co = 2 µg/g D.M.

References: LISOWSKI, MIELCAREK [1984]
FISCHER [1992; 1999].



Nzilo-Kyamasumba road

Phragmanthera cornetii (Dewèvre) Polhill & Wiens

[Loranthaceae]

Holotype: Cornet in Descamps s.n.
 Copper specimens: LMM 169;
 Mf-Gj 93; MKM 28; PI 60/847; Tr 283.
 Syn.: *Loranthus cornetii* Dewèvre,
P. rufescens (DC.) Balle var. *cornetii*
 (Dewèvre) Balle.

Habit: Branches 1-2 m; branchlets tomentose with red-brown dendritic hairs 0.5-1.5 mm long. Petiole 0.5-2 cm; lamina coriaceous, ovate to elliptic, obtuse to shortly rounded at apex, cuneate to shortly cordate at base, 8-20 x 3.5-9 cm. Umbels confluent around older nodes, 2-4 flowered. Receptacle 2-3.5 mm, red-brown tomentose; calyx 1-1.5 mm, tomentose. Corolla 3.5-5 cm, coloured by red-brown tomentum outside, reddish on head of bud, pink to orange-red inside, red along filament-lines and darkening red overall; apical swelling of bud 3.5-5 x 3-3.5 mm, lobes erect, 8-12 mm; filaments dark red. Berry ellipsoid, reddish tomentellous.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant

Ecology: In *Brachystegia* woodlands, generally parasitic on *Uapaca* spp.

General distribution: Angola, Katanga, Zambia, Malawi, Southern Tanzania.

Distribution on Katangan copper sites (4 sites): Notably Kambove (71).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 30-41, Co = 667-765 µg/g D.M. Cobalt accumulator.

Reference: POLHILL, WIENS [1998].



Fungurume



© I. Parmeter



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Kazinyanga



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Mambilima

Hibiscus rhodanthus Gürke

[Malvaceae]

Holotype: Pogge 13.
Copper specimens: LLM 218; Mf 7717, 9232; Mf-Re 2120.

Habit: Perennial herb, 5-100 cm tall, producing annual shoots from a woody rootstock; stems stellate-setose or stellate-setulose. Leaf-lamina 2-13 x 0.8-3 cm, oblong or oblong-elliptic to very narrowly oblong, sparsely to fairly densely stellate-setose, apex acute or rounded, margin rather distantly serrate, base cuneate to rounded, usually 3-nerved; petiole 1-14 mm long; stipules 2-4 mm, acicular. Flowers 2.5-4 cm in diam., red, solitary, axillary and often forming terminal racemes or panicles by reduction of the upper leaves; peduncle up to 5 cm long, stellate-hispid, rather inconspicuously articulated usually near the middle. Epicalyx of 6-7 bracts, 1-4 mm long, linear to subulate. Calyx up to 8 mm long, stellate-hispide outside, glabrous inside; lobes 3-6 x 1.5-3 mm, lanceolate to triangular, slightly connate or jointed nearly to half-way. Staminal tube 6-8 mm long; free parts of filaments 1.5-4 mm long. Style projecting up to 10 mm beyond the staminal tube, branches 3.5-4.5 mm long. Capsule 8-10 x 10-

| Hydratation | Copper content of soil | | |
|-------------|------------------------|-------|-----|
| | normal | 200 | 800 |
| | <X< | <X< | |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | XX | |
| wet | | | |

→ oligocuproresistant

12 mm, subglobose, usually densely pubescent. Seeds with a white silky floss.

Ecology: Open woodlands, frequent on copper steppe savannas.

General distribution: Zambezi distribution.

Distribution on Katangan copper sites (12 sites): Kwatebala (45), Fungurume (51), Luita (58), Kamatanda (73), Luishia (77), Lukuni (86), Luiswishi (87), Kamwali (89), Kasonta (91), Lupoto (92), Ruashi (96), Etoile (97).

Distribution on Zambian copper sites (2 sites): Kansanshi (100), Roan Antelope (147).

Phytogeochemistry: Cu-Co content of leaves (9 samples): Cu = 19-435, Co = 14-1,527 µg/g D.M. Hyperaccumulator of cobalt. Values need confirmation.



Mamfwe road

Continuation of page 229.

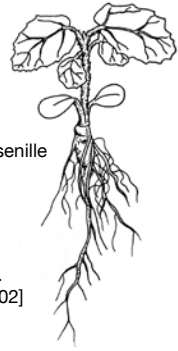
Hibiscus rhodanthus Gürke

Rehabilitation: Pioneer for low copper content soils.

References:

EXELL [1961]

MALAISSÉ, GRÉGOIRE [1978].



C. Van Marsenille

Seedling (x 0.4).
[LETEINTURIER, 2002]



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Kipushi-Kansanshi road

Antherotoma naudinii Hook.f.

[Melastomataceae]

Holotype: Schimper 1237.
Copper specimens: Dp 2220, 2829,
3005 M, 3018, 3089; Mf 10332, 10654;
Mf-Gr 49; MHK 123, 186, 207.
Syn.: *Dissotis kundelungensis* De Wild.

Habit: Delicate annual herb; up to 38 cm high, stem unbranched or with long ascending branches, laxly leafy. Leaf-lamina 0.5-4.5 x 0.1-0.8 cm, ovate to oblong, acute at the apex, contracted at the base, entire or crenulated, yellowish-green or pale green. Flowers 4-merous in terminal capitate cymes, surrounded at the base by 2-4 leaves. Receptacle 2 mm high, pale green, with sparse, brownish red or purplish bristles. Sepals 1.5 mm long, triangular-subulate. Petals 5 x 3.5 mm, obovate, pale mauve to pink. Stamens 8, equal, straight, yellow; anthers obovate-oblong, 0.75-1.75 mm long; pedoconnective 0.5-2 mm long; filaments 2 mm long. Ovary with a ring of bristles surrounding the base of the style. Fructiferous receptacle 3 x 2.75 mm.

Ecology: Open forests, woodlands, grasslands, dambos, rocky sites.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | X | | |
| wet | X | | | |

→ oligocuproresistant

General distribution: Tropical Africa (notably D.R. Congo, Zambia, Malawi) and Madagascar.

Distribution on Katangan copper sites (18 sites): Notably Dikuluwe (2), Pumpi XI (29), Kakavilondo (36), Katuto (41), Kwatebala (45).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 163, Co = 5 µg/g D.M.

Reference: FERNANDES, FERNANDES [1978].

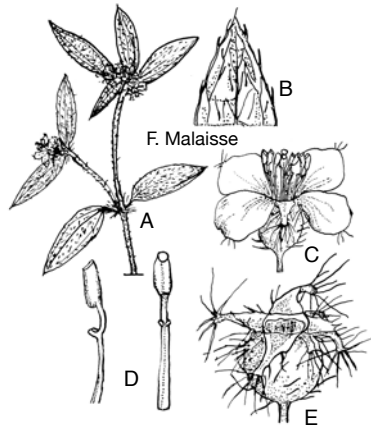
Note: Also on old copper furnace sites (Mwanamumba), as well as on soils rich in manganese.



Kiniama road



Kiniama road



A. Flowering branch (x 0.5) – B. Part of leaf, inferior surface (x 3) – C. Flower (x 3) – D. Stamen in lateral and frontal view respectively (x 6) – E. Fruiting calyx (x 4).

[Drawn after M.E. Church in WICKENS, 1975]

Dichaetanthera schuilingiana P.A.Duvign. & Plancke
[Melastomataceae]

Holotype: Duvigneaud 3494 D.
Copper specimens: Mf 10635, 11485,
11787.

Habit: Perennial small tree up to 6 m high, flowering before the leaves; bark corky, branches rounded, nodes long-setose, swollen. Petiole up to 4 cm long, leaf-lamina broadly ovate, 20 x 15-20 cm, base round to subcordate, 7-nerved, dense pilose, hairs fulvous. Inflorescence a lax terminal panicle, ± 30-flowered, calyx cupular, 6-7 mm long, 4 mm in diam. Petals pink to mauve, elliptic, 6 x 4 mm.

Ecology: Rocky outcrops, mainly siliceous cellular rocks, dry shrubby steppes.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (2 sites): Dikuluwe (2), Mashamba (5).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 107, Co = 32 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XX | (X) | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: Weak interest, slow growing decorative small tree.

Reference: DUVIGNEAUD [1958].



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Potopoto valley



© F. Malaisse

Kasobantu hill



© C. D'Outraigne

Nzilo-Kyamasumba road



© M. Schajles

Potopoto valley



© C. D'Outreligne

Nzilo-Kyamasumba road

Dissotis derriksiana

P.A. Du vign.

Holotype: Du vigneaud & Dambon 3088 D.
Copper specimens: Mf 16371; Mf-Gj 43;
MKS 119; PKS 4433.

Habit: Perennial erect herb, 20-90 cm tall. Leaves 3-nate, cordate, 7-nerved. Calyx campanulate, sepals 7 x 4 mm.

Ecology: Copper steppe savannas with low copper content.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (5 sites): Notably Goma (33).



Kakalalwe

© F. Matalaise

Dissotis gilgiana De Wild. var. *gilgiana* [Melastomataceae]

Holotype: Verdick s.n.
Copper specimens: Dp 2076 M, 2620 D.

Habit: Perennial erect herb, 30-45 cm tall, stem terete. Petiole 1-2 cm long; lamina ovate - lanceolate. Flowers in 3-flowered cymes, 5-merous.

Ecology: Kalahari sands and copper steppe savannas, miombo woodlands.

General distribution: Restricted to Upper Katanga and Western Zambia.

Distribution on Katangan copper sites (4 sites): Kasompi (27), Menda (28), Fungurume (51), Mindigi (60).



Lufunfu

© M. Schaljes



Upemba National Park

© G. De Witte

Stephania abyssinica* (Dill. & A.Rich.) Walp var. *abyssinica
[Menispermaceae]

Holotype: Quantin Dillon & Petit s.n.
Copper specimen: Mf-Kk 220.

Habit: Twining liane, woody at the base; stem covered with a thin bark, branchlets glabrous. Leaves simple, peltate, lamina 5-20 x 4-13 cm, ovate, top broadly ovate, rarely suborbicular, rounded at the base, obtuse or subacute at the apex, membranous or papery, slightly discolorous, basal nerves 8-10, palmate, petiole 4-12 cm long. Male inflorescences of false compound umbels, axillary, solitary or clustered 2-4 together; peduncle 4-10 cm long with 3-6 rays ending in umbel-like cymes; involucre of 3-5 glabrous bracts. Male flowers with 6-8 obovate sepals, purplish, their base often violet; petals 3-4, 0.8-1.2 mm long, broadly ovate; synandrium 6-8-locular. Female inflorescences similar to the male, carpels glabrous. Drupe subspherical-flattened, 5-8 mm in diam.

Ecology: (Wooded) grasslands, termite hills, rarely in copper savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | X | | | |

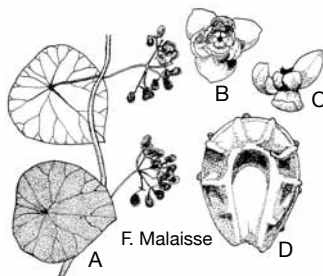
→ oligocuproresistant

General distribution: From Guinea East to Ethiopia, and southwards to Botswana and Natal.

Distribution on Katangan copper sites (1 site): Etoile (97).

Rehabilitation: No evident interest.

References: TROUPIN [1951; 1960].



A. Portion of stem with infructescence (x 1.5) – B. Male flower (x 4.5) – C. Female flower (x 4.5) – D. Fruit endocarp (x 2.5).
[Drawn after BENVENUTO, 1974]



Kwatebala



Etoile mine

Dichrostachys cinerea* (L.) Wight & Arn. subsp. *nyassana
(Taub.) Brenan [Mimosaceae]

Holotype: Buchanan 195.

Copper specimen: Mf-Kk 229.

Syn.: *Dichrostachys nyassana* Taub.

Habit: Shrub 1-5 m high, armed with spines terminating short lateral spreading twigs. Leaves with 5-19 pairs of pinnae. Inflorescences yellow in apical hermaphrodite part, mauve or pink in lower neuter part, 2-5 cm long, pendent on peduncles 1-9 cm long. Pods clustered, coriaceous, usually irregularly contorted or spiral.

Ecology: Woodlands, rarely on copper steppe savannas ecotones.

General distribution: Widespread in Africa and Asia, reaching Australia.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (2 sites): Luiswishi (87), Etoile (97).

Rehabilitation: Robust pioneer on low copper polluted soils.

Reference: BRENNAN, BRUMMITT [1970].



Sabi Sabi P.G.R. (R.S.A.)

© M. Schallies

Dorstenia barnimiana* Schweinf. var. *barnimiana

[Moraceae]

Holotype: Hartmann s.n.

Copper specimens: MKS 555, 592, 795, 1007.

Habit: Herb up to 20 cm tall, tuber subglobose, up to 3 cm in diam. Stem up to 2.5 cm long and 4 mm thick. Lamina basally attached, subcircular to cordate; young leaves shortly petiolate and prostrate. Inflorescences solitary; peduncle 4-16 cm long, 1-3 mm thick. Receptacle in a vertical position, naviculate, 1.2-2.7 x 0.2-1.0 cm; flowering face linear to elliptic, margin up to 1.5 mm, appendages 2, in one row; upper filiform up to 4 cm long, shortly pubescent; lower linear up to 2 cm.

Ecology: Wooded and open grasslands, often on shallow soils overlying rocks, also in copper steppe savannas.

General distribution: Cameroon to Somalia and Yemen, Uganda, Kenya, Tanzania, Burundi, D.R. Congo, Zambia.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | XX | X | |
| wet | | | |

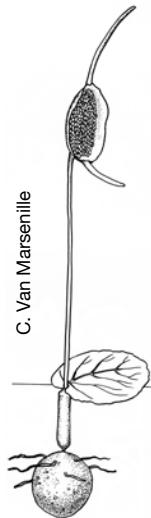
→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Kavifwafwaulu (42), Shadirandzoro (48), Kazinyanga (49).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 17, Co = 26 µg/g D.M.

Rehabilitation: Pleasant habit, but dwarf plant.

Reference: BERG, HIJMAN [1999].



Habit (x 0.7).

[Original plate] Kavifwafwaulu



© F. Malaisse

Dorstenia benguellensis Welw.

[Moraceae]

Holotype: Welwitsch 1566.

Copper specimens: LLM 144; Mf 16501; MKS 194.

Syn.: *D. verdickii* De Wild. & T.Durand, *D. homblei* De Wild.

Habit: Herb up to 50 cm tall, tuberous; tuber discoid to subglobose, 1-12 cm in diam.; stems annual, unbranched or branched, 1.5-8 mm thick, puberulous to hirtellous. Leaves spirally arranged, on the lower part of the stem scale-like; petiole 0-2 mm long, lamina of normal leaves oblong to subovate or linear, 1-15 x 0.2-4.5 cm, apex acute, base obtuse to rounded; margin finely to coarsely dentate; both surfaces puberulous to hirtellous. Receptacle discoid to broadly turbinate to shallowly cup-shaped, subcircular to elliptic, 0.5-2 cm in diam.; margin very narrow; appendages in 2 rows; inner (marginal) row with numerous triangular to subulate, or ovate appendages, 1 mm long, forming a subdentate ring, or appendages triangular to ovate, up to 7 mm long forming a subcrenate rim, or appendages indistinct and the rim subentire; outer (submarginal) row usually with c. 10-20 appendages, less commonly 2 or 1, ligulate to filiform or subspathulate to oblong, 2-20 mm long. Staminate flowers crowded, perianth 2-lobed, with 2 stamens; pistillate flowers numerous, perianth shortly tubular, with (1)-2 stigmas. Endocarp body tetrahedral, c. 2 mm in diam., tuberculate.

Ecology: Miombo, rocky slopes, not rare on copper steppe savannas.

General distribution: Cameroon, Sudan, Uganda, Kenya, Tanzania, Angola D.R. Congo, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (5 sites): Notably Kakavilondo (31), Kavifwafwaulu (42), Fungurume (51).

| Hydration | Copper content of soil (in µg per g of soil) | | | |
|-----------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | X | X | | |
| medium | XXX | X | | |
| wet | | (X) | | |

→ oligocuproresistant

Rehabilitation: No evident interest.

References:

HAUMAN [1948]

BERG, HIJMAN [1999].

Note: The present knowledge and treatment of the *Dorstenia* spp. of Katanga and Zambia is unsatisfactory. At least 5 taxa seem to be merged into the *D. benguellensis* complex. Four of them have been collected on copper outcrops. They have been observed in contrasted ecological conditions, notably dry rocks (Kavifwafwaulu South-West) versus humic soils (Kavifwafwaulu North). Moreover they develop and flower at completely different seasons, respectively November and April. Further collections as well as field studies are needed to fill this gap in our knowledge. Photographs on page 240 present this diversity.

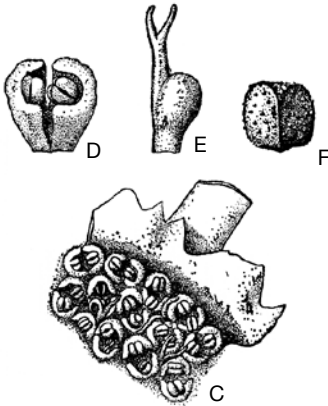


Kavifwafwaulu

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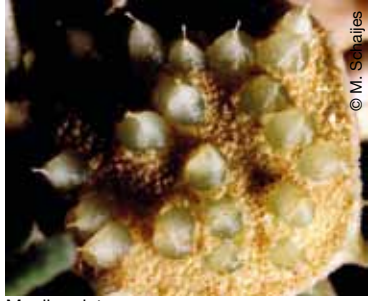
Katuto

A. Flowering plant (x 0.25) – B. Plant with inflorescences, fruits and leaves (x 0.25) –
 C. Fragment of inflorescence with male and female flowers (x 8) – D. Male flower (x 16) –
 E. Female flower (x 15) – F. Fruit (x 8). [HAUMAN, 1948]



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Fungurume



© M. Schafers

Manika plateau



© L. Lemaire

Lubumbashi-Kasenga road



© F. Malaisse

Kumanua



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Kavifwafwaulu

Ochna leptoclada Oliv.

[Ochnaceae]

Holotype: Kirk s.n.
Copper specimen: Mf 16703.

Habit: Rhizomatous shrublet up to 1 m high, with brown bark. Shoots erect, ± branched, often caespitose, terete or angular, greyish-white, not lenticellate. Leaves petiolate, glaucous, rarely bluish-green. Lamina 6.5-12 x 2-4.5 cm, obovate to oblong-elliptic, rounded at the apex, attenuate and recurved at the base, with margin entire, chartaceous; petiole 2.5-4 mm long, rather stout. Flowers 1-3, pseudo-umbellate; pedicels 0.9-2 cm long in fruit, articulated at base. Sepals 3-5 mm in flower, becoming crimson, 9-11 mm in fruit. Petals bright yellow, 6-8 x 4.5 mm, obovate to elliptic. Stamens with anthers 1-2 mm long, dehiscing by longitudinal slits. Carpels 5, with styles completely united; stigma globose. Drupelets 5-8

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | X | |
| wet | | | |

→ oligocuproresistant

x 5-6 mm, subglobose, inserted at the base.

Ecology: Open forests on sandy soil; also copper steppe savannas with low copper content.

General distribution: From Sudan to Zimbabwe and Mozambique.

Distribution on Katangan copper sites (3 sites): Notably Kinshasa (14).

Rehabilitation: Pleasant habit.

Reference: ROBSON [1963].



Shadiranzoro



© M. Schajjes

Nzilo-Kyamasumba road



© I. Parmentier

Olax obtusifolia De Wild.

[Olacaceae]

Holotype: Verdick 156.

Copper specimens: LLM 32; Mf 9315, 12885; Mf-Gj 45.

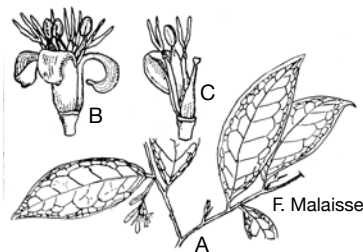
Habit: Shrub up to 6 m tall. Young shoots rust colour, rugulose. Leaves lamina 4-8 x 2-4 cm, ovate-lanceolate, blunt or subacute at the apex, rounded or obtuse at the base, dull, light green, chartaceous; lateral nerves 6-10 pairs, petiole up to 1 mm long. Flowers in solitary or fasciculate racemes 1-3 cm long; pedicels 1-2 mm long, sometimes foliaceous, caduceus. Calyx short, cupuliform, accrescent. Petals 3, 7-10 mm long, spatulate, apiculate, yellowish or greenish-white. Stamens 3; anthers 1.5-2.5 mm long, yellow; staminodes 5-6; anther-thecae 2-3 mm long, undulate, white. Fruit up to 2.5 cm in diam., globose, drupaceous, yellow-orange, with a very large stone.

Ecology: Grasslands often also on copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia, Malawi, Zimbabwe, Mozambique.



Mwadikomba



A. Flowering branch (x 0.2) – B. Flower (x 2.4) – C. Petal, stamen, staminodes and pistil (x 2.5).

[Drawn after D.E. in LUCAS, 1968]

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | XX | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (17 sites): Notably Kimpe (102).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 20-234, Co = 18-180 $\mu\text{g/g}$ D.M.

Rehabilitation: No evident interest.

References:

GARCIA [1963].

LUCAS [1968].

Note: *Olax obtusifolia* has been observed on sites of copper mines in Zimbabwe (Copper King South mine, Norah mine).

Ximenia caffra Sond.

[Olacaceae]

Holotype: From South Africa.

Copper specimen: Mal 253.

Habit: Shrub, armed with spines. Leaf elliptic. Drupe 2.5 x 1.8 cm, ellipsoid, bright scarlet when ripe, edible.

General distribution: From Angola to Tanzania and southwards to R.S.A.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Kavifwafwaulu

Alectra sessiliflora (Vahl) Kuntze

[Orobanchaceae]

Holotype: Bülow s.n.
Copper specimens: Dp 2851, 3023 Al;
Mf 7007, 10033, 16548; Mf-Gj 12;
Rw 1713.

Habit: Erect annual herb, 15-40(60) cm tall, stems simple or branched. Leaves sessile, subsessile to shortly petiolate, opposite, alternate within inflorescence, linear-ovate to broadly lanceolate, subentire or crenate to coarsely toothed, acute, cuneate, rounded to cordate at base. Inflorescence a dense raceme, bracts leaf-like. Corolla yellow to dark orange, with reddish-purple venation, 13-14 mm long.

Ecology: Marshes, swamps, wet grasslands, also in copper and manganese steppe savannas.

General distribution: From West to South Africa, Madagascar, India, S-E Asia and China.

Distribution on Katangan copper sites (9 sites): Notably Karavia (95),

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-----|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | | 800 |
| | | | | 5,000 |

| | | | | |
|--------|----|----|--|--|
| dry | | | | |
| medium | X | XX | | |
| wet | XX | X | | |

→ oligocuproresistant

Kimpe (102). Also copper polluted soils in Katanga (Mwanamumba).

Distribution on Zambian copper sites (1 site): Kansanshi (65). Also Alaska copper mine (Zimbabwe).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 126-782, Co = 85-2,782 µg/g D.M. Cobalt hyperaccumulator, copper accumulator. Needs confirmation.

Rehabilitation: No evident interest.

References:

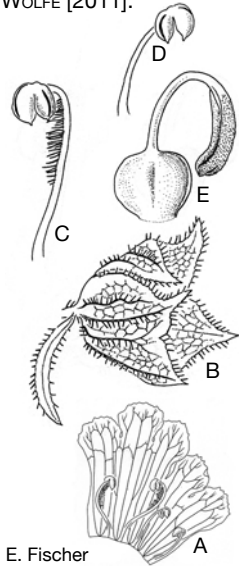
- MIELCAREK [1996].
- MORAWETZ, WOLFE [2011].



Fungurume



Kansanshi



E. Fischer
 A. Dissected corolla (x 1) –
 B. Calyx with bracteole (x 2) –
 C. Abaxial stamen (x 4) –
 D. Adaxial stamen (x 4) –
 E. Ovary (x 4). [FISCHER, 1996]

Buchnera cryptocephala (Baker) Philcox [Orobanchaceae]

Holotype: Carson s.n.

Copper specimen: Dp 4717.

Habit: Erect annual herb, 25-100 cm tall; stem simple or branched. Leaves opposite in lower part, alternate in upper part, entire, sessile, elliptic to lanceolate, 0.5-6.5 x 0.1-1.5 cm. Flowers violet or blue, in compact terminal spikes. Bracts 0.4-1.0 x 0.3-0.5 cm, apex setaceous. Bracteoles 2, spatulate, 8-9 mm long. Calyx 2.5-4 mm long, 5-toothed, teeth equal.

Ecology: Wooded savannas, grasslands, steppe savannas on Kalahari sands and copper soils.

General distribution: Burundi, Uganda, Tanzania, D.R. Congo, Zambia, Malawi.

Distribution on Katangan copper sites (4 sites): Dikulushi (1), Shabara (24), Fungurume (51), Kambove (71).

Reference (for both species): MIELCARECK [1996].



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Kipopo

Buchnera henriquesii Engl.

Holotype: Welwitsch 5833.

Copper specimens: Mf 11747, 11874; Pj 1230.

Habit: Short perennial sub-shrub, 4.5-18 cm high. Leaves opposite, linear to lanceolate, 10-30 x 1-5 mm; apex acute, base cuneate. Flowers in dense terminal spikes, violet, blue, pink or white.

Ecology: Miombo, copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (5 sites): Notably Shabara (24).



Etoile mine



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Kanzenze-Kyamasumba road

Buchnera hispida Buch.-Ham. in D. Don [Orobanchaceae]

Holotype: Buchanan-Hamilton s.n.
Copper specimens: Dp 3006; MHK 216.

Habit: Erect annual herb, 15-75 cm tall, hispidous; stem cylindrical, branched. Leaves opposite in lower part, alternate in upper part; leaves below inflorescence linear, 3 x 0.3 cm. Flowers sessile, in terminal spikes, not dense, 15-45 cm long; bracts not imbricate. Calyx persistent, 4-7 mm long, 5-toothed, 10-nerves; teeth equal, deltoid or triangular. Corolla pale blue.

General distribution: From Senegal, Gambia and Guinea-Bissau to Sudan and Ethiopia and southwards to South Africa, Madagascar, also Oman, Yemen, India and Nepal.

Ecology: Woodlands, wooded savannas, steppe savannas on Kalahari sands and copper soils.

Distribution on Katangan copper sites (2 sites): Kamakonka (39), Mitonte (68).

Reference (for both species): MIELCARECK [1996].



Fungurume

Buchnera inflata (De Wild.) Skan

Holotype: Briart s.n.
Copper specimens: Mf 10545, 10905.

Habit: Erect perennial herb, 35-48 cm high. Leaves opposite, lanceolate, 25-40 x 2-3 mm; apex acute. Flowers in terminal spikes, spikes 7-21 cm long, very dense; bracts imbricate, elliptic, 6-7 x 2.5 mm, acuminate. Calyx cylindrical, 8-10 x 1 mm, 4 teeth, 1.5-2 mm long, ciliate. Corolla tube cylindrical, yellow to yellow-green, 2.5 mm long. Capsule 6 x 1.5 mm, oblong, apex apiculate. Seeds 0.5 x 0.3 mm, ellipsoid.

Ecology: Mainly copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (5 sites): Notably Kwatebala (45).



Kwatebala

Buchnera keilii Mildbr. & Pilg.

[Orobanchaceae]

Holotype: From Uganda.
Copper specimens: Mf-Gp 514, 541;
Qp 346.

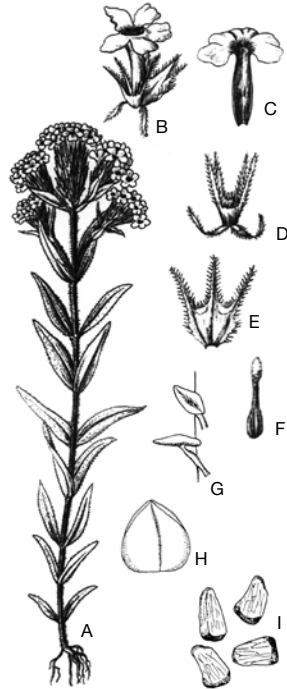
Habit: Annual herb, erect stem, 15-40 cm high, 1-3 mm in diam.; internodes 1.5-6.0 cm long. Leaves sessile, opposite, rarely ± alternate, lamina narrowly elliptic or lanceolate, 0.7-4.0 x 0.2-0.7 cm, cuneiform, acute at apex; 1-nerved. Flowers in terminal spikes, cylindric, 12-30 x 7-15 mm; bracts obovate or lanceolate, 5-15 x 2-5 mm, cuneiform; oboval bracts with several teeth at apex. Calyx campanulate, 5 mm long, 4-toothed; teeth subulate, 4 x 0.5 mm, ciliate. Corolla mauve or violet, 5-6 mm in diam. at apex; tube cylindric, curved in the middle, 7-8 mm long; corolla lobes obovate.

Ecology: Open forests, riparian forests, copper steppe savannas.

General distribution: Rwanda, Burundi, Uganda, D.R. Congo, R.S.A.

Distribution on Katangan copper sites (3 sites): Shabara (24), Fungurume (51), Etoile (97).

References (for both species):
MIELCAREK [1996].
LETEINTURIER et al. [1999].



A. Habit (x 0.5) – B. Flower (x 1.2) – C. Corolla, longitudinal section (x 1.3) – D. Sepals (x 1.5) – E. Bract (x 1.5) – F. Gynoecium (x 3) – G. Anther (x 8.5) – H. Capsule (x 3.5) – I. Seeds (x 10).
[A-F MILDREAD, PILGER, 1911; G-I Drawn by F. Malaisse after MIELCAREK, 1996]

Buchnera quadrifaria Baker

[Orobanchaceae]

Lectotype: Carson s.n.
Copper specimen: MHK 327.

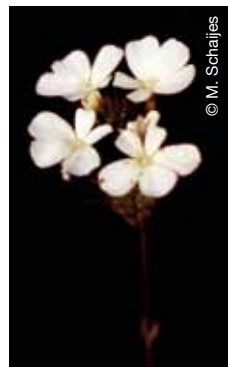
Habit: Annual erect herb, 25-50 cm tall. Leaves linear, 1-8 mm long. Inflorescence, a terminal dense spike. Corolla white.

Ecology: Open forests, Kalahari and copper steppe savannas.

Distribution on Katangan copper sites (6 sites): Notably Menda (28), Mindigi (60), Swambo (62), Tantara (63), Kambove (71).



Kamakonka



Mwera road

Buchnera robynsii Mielcarek

[Orobanchaceae]

Holotype: Lisowski 85692.
Copper specimens: Mf 10795;
MKS 152, 345, 396.

Habit: Erect suffrutex, rigid, 70-100 cm high, drying green, base ligneous, stem unbranched or branched in upper part; internodes 1.5-2.5 cm long. Leaves opposite, sessile, oblong to elliptic, 2.2-5.5 x 0.3-1.4 cm, base cuneiform, apex acute. Flowers violet, in dense terminal spikes, 10-15 x 10-40 mm, until 3.5 cm long in fruiting stage, bracts oval-lanceolate, 5 x 2 mm; calyx 5-lobes, 5 mm long, lobes oval, 3 x 3.5 mm; corolla tube 6-7 mm long. Capsule



Kavifwafwaulu

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | X | | |
| wet | | | | |

→ oligocuproresistant

glabrous, green, acute, 4.5-5 mm long; seeds numerous, 0.3 x 0.1 mm.

Ecology: Steppe savannas on Kalahari sands, also on copper and manganiferous soils.

General distribution: D.R. Congo (Upper Katanga).

Distribution on Katangan copper sites (5 sites): Kakavilondo (31), Goma (33), Kabwelunono (34), Kavifwafwaulu (42), Mindigi (60).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 27-788, Co = 25-823 µg/g D.M. Copper and cobalt accumulator.

Rehabilitation: No evident interest.

References (for both species):
MIELCAREK [1996].
LETEINTURIER et al. [1999].

Buchnera symoensiana Mielcarek

[Orobanchaceae]

Holotype: Duvigneaud 2052.
Copper specimens: Dp 3103; MHK 332.

Habit: Erect annual herb, 14-23 cm tall. Leaves lanceolate, 10-20 x 1-3 mm. Inflorescence, a short terminal spike. Corolla white.

Ecology: Savannas, mainly steppe savannas on copper soils.

Distribution on Katangan copper sites (3 sites): Kakalalwe (38), Kamakonka (39), Kalongwe (81).



Kakalalwe

Buchnera trilobata Skan

[Orobanchaceae]

Holotype: Mc Counie 55.

Copper specimens: Mf 10914, 11836; MKS 123, 218, 250, 326, 361, 394, 425; Sm 1911.

Habit: Annual herb, 50-80 cm high, stem yellow, simple. Leaves opposite (or subopposite for the two upper pairs), 17-25 x 3-5 mm, cuneiform, acute. Flowers red, in dense terminal spike, 15-40 x 5-9 mm, bracts obovate-cuneate, trilobed, 3-4 x 2.5 mm; calyx with 4 lobes, 5 mm long; corolla 6 mm in diameter. Capsule ovoid, 3 mm long; seeds black, 0.5 mm long.

Ecology: Copper and Kalahari sandy steppe-savannas, miombo, rocky outcrops.

General distribution: D.R. Congo (Upper Katanga), Zambia and Malawi.

Distribution on Katangan copper sites (13 sites): Zikule (30), Kakavilondo (31), Tenke (32), Goma (33), Kabwelunono (34), Mwinansefu (43), Kwatebala (45), Mwadi kombamba (47), Fungurume (51), Mupapala (53), Luita (58), Shangolowe (70), Kambove (71).

Phytochemochemistry: Cu-Co content of leaves (3 samples): Cu = 18-35, Co = 15-248 µg/g D.M.

Rehabilitation: Pleasant habit.

| Hydration | Copper content of soil (in µg per g of soil) | | |
|-----------|---|-----|-------|
| normal | 200 | 800 | > |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |

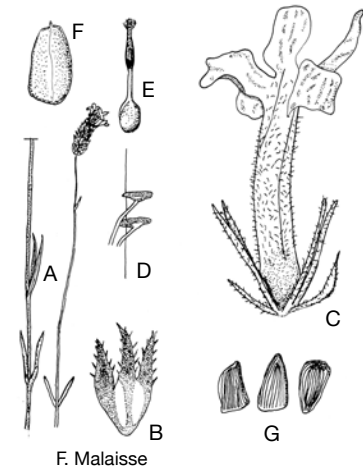
| | | | |
|--------|---|----|--|
| dry | | | |
| medium | X | XX | |
| wet | | | |

→ oligocuproresistant

References:

MIELCAREK [1996].

LETEINTURIER et al. [1999].



A. Habit (x 0.5) – B. Bract (x 5) – C. Flower (x 2) – D. Stamens (x 5 4/5) – E. Pistil (x) – F. Capsule (x 5) – G. Seed (x 24).

[Drawn after MIELCAREK, 1996]



Shangulowe



Shadirandzoro

Sopubia eminii Engl.

Holotype: Whyte s.n.
Copper specimens: Mf-Kk 380; Mf-SI 54.
Syn.: *S. parviflora* Engl. subsp. *eminii*
(Engl.) Mielcarek

Habit: Annual herb, 20-50 cm high.
Lower leaves trifold and pennatisect.
Loose terminal racemes; pedicels
0.6-1.2 cm long, very slender; corolla
yellow.



Mambilima

Sopubia lanata Engl. var.
densiflora (Skan) O.J.Hansen

Holotype: White s.n.
Copper specimen:
Ry s.n.

Habit: Perennial
herb, robust
stem, densely
woolly. Leaves
linear to
lanceolate.
Dense terminal
spikes;
corolla pink,
campanulate.



Kalukundi

Sopubia metallorum

P.A.Duvign. [Orobanchaceae]

Holotype: Duvigneaud 2932 S.
Copper specimens: Mf-Kk 380; Mf-SI 54.
Syn.: *S. mannii* Skan var. *metallorum*
(Duvign.) Mielcarek

Habit: Perennial herb, 50-90 cm high;
stems branched in the upper part.
Leaves entire, filiform to filiform-linear.
Flowers numerous, 3-verticillate, in
terminal racemes up to 10 cm long,
pedicels 10-24 mm long.

Ecology: Rocky copper steppe
savannas, rarely on rocky outcrops.

**Distribution on Katangan copper
sites** (7 sites): Notably Shabara (24),
Kwatebala (45), Mindigi (60).

Reference (for 3 species):
MILECAREK [1996].



Fungurume



Manika plateau

Sopubia neptunii P.A.Duvign. & Van Bockstal

[Orobanchaceae]

Holotype: Ledocte s.n.
Copper specimens: LMM 163;
Mf 7722, 10238.

Habit: Perennial herb, 3-6 cm high, woody rootstock, stems simple or branched in the upper part. Leaves very dense, subverticillate, sessile, most trifid at 2/3 of length, 1.5-2.5 cm long. Flowers in terminal, cylindrical spikes, bracts trifid or lanceolate. Corolla pink.

Ecology: Copper and rarely Kalahari sandy (Marungu) steppe-savannas.

General distribution: Restricted to Upper Katanga and Northern Zambia.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | <X< | <X< | | |
| medium | (X) | XX | XX | |
| wet | | | | |

→ mesocuproresistant

Distribution on Katangan copper sites (12 sites): Notably Lupoto (92).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

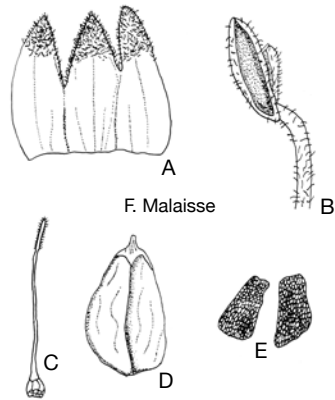
Reference:

DUVIGNEAUD, DENAEYER-DE SMET [1963].



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Shabara



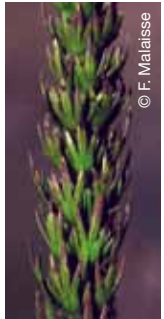
F. Malaisse

A. Calyx lobes (x 3.5) – B. Stamen (x 5) – C. Pistil (x 3) – D. Capsule (x 3.5) – E. Seed (x 18). [Drawn after MIELCAREK, 1996]



© J. Lebrun

Kavifwafwaulu



© F. Malaisse

Kabwelunono



© M. Schajles

Kolwezi-Kyamasumba road

***Striga asiatica* (L.) Kuntze**

Holotype: Torreen s.n.
Copper specimens: Mf-Kk 2; Tr 239.

Habit: Annual delicate herb, remaining green when drying. Stem 10-15 cm high, 0.5-1 mm thick, quadrangular. Leaves narrowly linear, 5-12 x 1 mm. Calyx 10-nerved, bristled with straight hairs. Inflorescence terminal, lax spike. Flowers solitary on axil bracts. Corolla limb scarlet, tube yellow.

Ecology: Grasslands, fields, steppe savannas.

General distribution: Paleotropical.

Distribution on Katangan copper sites (8 sites): Notably Kazinyanga (49).

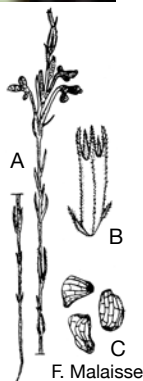


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Manika plateau



Biano plateau



A. Habit (x 0.2) – B. Calyx with bracteoles (x 3.5) – C. Seeds (x 18).

[Drawn after MUSSELMAN & HEPPER, 1986; MIELCAREK, 1996]

***Striga hermonthica* (Del.) Benth.** [Orobanchaceae]

Holotype: Dellie s.n.
Copper specimen: Malaisse s.n.

Habit: Erect annual herb, many-flowered, becoming blackish when drying. Stems 35-60 cm high. Leaves linear-lanceolate to lanceolate, 3-10 x 0.3-1.5 cm. Calyx 5-nerved, hispid on ribs.

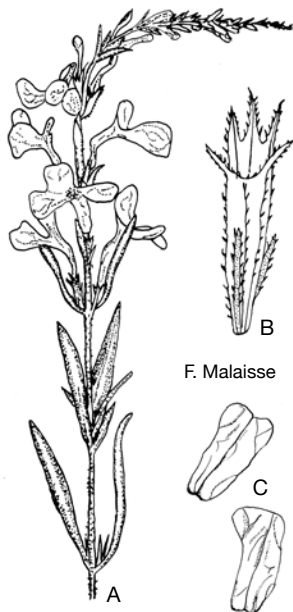
Ecology: Grasslands, fields, steppe savannas.

General distribution: Paleotropical.

Distribution on Katangan copper sites (2 sites): Notably Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 583-1,105, Co = 333-484 µg/g D.M. Values need to confirm.

References (for both species):
MIELCAREK [1996].
HEPPER [2008].



A. Habit (x 0.4) – B. Calyx with bracteoles (x 5.5) – C. Seeds (x 45).

[Drawn after MUSSELMAN & HEPPER, 1986; MIELCAREK, 1996]

Biophytum petersianum Klotzsch

[Oxalidaceae]

Holotype: Peters s.n.

Copper specimens: Mf-Gj 106, Tr 177.

Habit: Annual herb, 1-40 cm tall. Stems simple, erect, appressed-pilose or appressed-pubescent or tomentose, with a simple rosette of leaves at the apex. Leaves up to 5 cm long; leaflets 3-10-jugate, the terminal pair usually 3/2 times as long as the next pair and the rest decreasing gradually in size, up to 10 x 6.5 mm, chartaceous, opaque, obliquely elliptic or oblong-elliptic to subcircular, margin sparsely ciliate, otherwise glabrous, with up to 6 pair of rather thick prominent lateral nerves at right angles to the midrib; petiolule 0.5 mm long. Flowers yellow or orange, with the pedicels up to 2 mm long, in 2-5-flowered congested pseudo-umbels; peduncle up to 9 cm long, sometimes very short. Sepals up to 6 x 1.5 mm, lanceolate to linear-lanceolate, 3-7-nerved, longer than the capsule. Petals 5-6 x 1 mm long, ± coherent. Stamens with 5 longer ones 2 mm long, 5 shorter ones 1 mm long. Capsule 4 x 3.5 mm, obovoid-ellipsoid. Seeds 0.4 mm long, flattened-ellipsoid, minutely cuspidate, brownish.

Ecology: *Brachystegia* woodlands.



Kipushi-Kansanshi road

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-----|-------|
| normal | 200 | 800 | > |
| <X< | <X< | <X< | 5,000 |
| 800 | 5,000 | | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuproresistant

General distribution: Widespread in Tropical Africa, Madagascar and tropical Asia.

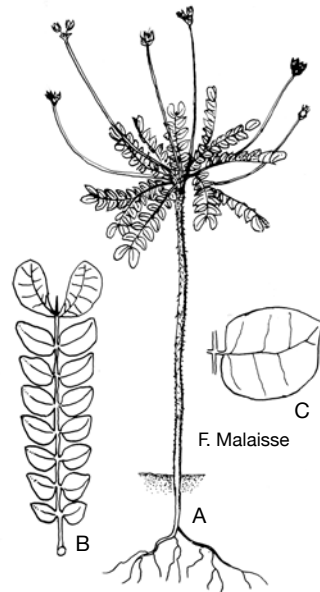
Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: No evident interest.

References:

EXELL [1963].

KABUYE [1971].



A. Habit (x 0.3) – B. Leaf (x 0.7) – C. Leaflet (x 1.2). [Drawn after G.W.D. in EXELL, 1963]

Syntypes: Schimper 1643, Petit s.n.
Copper specimens: LLM 164; Mf-Gj 26;
Mf-Kk 318; Mf-Re 2185; MMK 58.

Habit: Acaulescent perennial bulbous herb, vertical rhizome 1-10 cm long. Bulb solitary, ovoid-ellipsoid. Leaves 3-foliolate, in a rosette at the soil-surface; leaflets sessile, broadly obovate. Flowers solitary on erect peduncles longer than petiole. Sepals oblong-lanceolate, tinged purple. Petals pink or purple, sometimes with a yellow base. Capsule globose, shorter than the sepals.

Ecology: Stony soils, grasslands and *Brachystegia* woodlands, also on copper rocky sites.

General distribution: From Ethiopia to R.S.A, Angola, D.R. Congo.

Distribution on Katangan copper sites (7 sites): Pumpi (29), Kavifwafwaulu (42), Mwinansefu (43), Kwatebala (45), Shadirandzoro (48), Fungurume (51), Luiswishi (87).

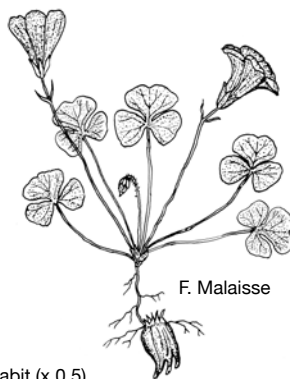
Distribution on Zambian copper site (1 site): Kansanshi (100).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | X | X | | |
| medium | XXX | | | |
| wet | X | | | |

→ oligocuproresistant

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 74-139, Co = 56-268 µg/g D.M.

Reference: KABUYE [1971].



Habit (x 0,5).

[Drawn after DE FLORIANI in
ROTI MICHELOZZI, 1978]



Luiswishi

© F. Malaisse

Oxalis semiloba Sond.
subsp. *angustifolia* (R.E.Fries)
Bamps & Malaisse comb. nov.

Holotypes: R.E.Fries 1298, 1389.
Copper specimens: Mf-Kk 361; MKS 957;
Mal 393.

Habit: Perennial herb, vertical rhizome,
ovoid bulb. Leaves 2-5, digitately
3-foliolate; leaflets deeply 2-lobed;
lobes oblong-lanceolate making a
narrow angle between them.

**Distribution on Katangan copper
sites** (1 site): Notably Shadiranzoro
(48).



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Shadiranzoro

Oxalis semiloba Sond.
subsp. *semiloba*
[Oxalidaceae]

Holotypes: Burke 440 & Zeyher 271.
Copper specimens: Mf 12827, 16458;
Mf-SI 5.
Syn.: *O. katangensis* De Wild. & Th.Dur.

**Distribution on Katangan copper
sites** (11 sites): Notably Pumpi (29).



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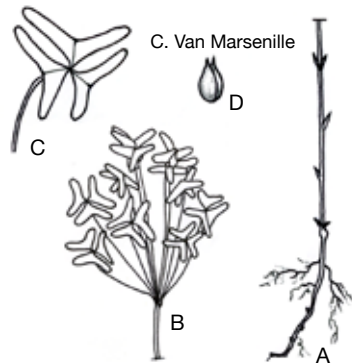
Kwatebala

Oxalis semiloba Sond.
subsp. *uhehensis* (Engl.) Exell

Holotype: Goetze 499.
Copper specimens: Mf-Kk 500, 541.

**Distribution on Katangan copper
sites** (8 sites): Notably Zikule (30).

Reference: KABUYE [1971].



A. Habit, lower part (x 0.3) – B. Habit, upper
part (x 0.4) – C. Leaf (x 1) – D. Bulb (x 0.6).
[Original plate]

Adenia erecta W.J.de Wilde

[Passifloraceae]

Holotype: Richards 16959.
Copper specimen: SHS 4931.

Habit: Perennial erect unbranched herb, up to 40 cm tall; elongate rootstock. Leaf-lamina 8–20 × 0.2–0.4 cm, linear, margin entire, ± coriaceous, ± glaucous-green. Glands of the lamina-base 2, 1–1.5 mm in diam., on 2 inconspicuous auricles; lamina-glands 10–20, 0.5–1 mm in diam., in a single row on either side of the midrib. Tendrils absent. Male cymes 1–3-flowered; male flower 40–52 × 3–5 mm, narrowly tubular-infundibuliform; hypanthium and calyx-tube 20–23 mm long. Petals 4 × 0.7 mm, lanceolate, 1-nerved, laciniate-fimbriate near the apex; corona consisting of hairs 0.5–1 mm long; stamen-filaments 7–9 mm long, connate at the base, inserted on an

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | | 5,000 |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

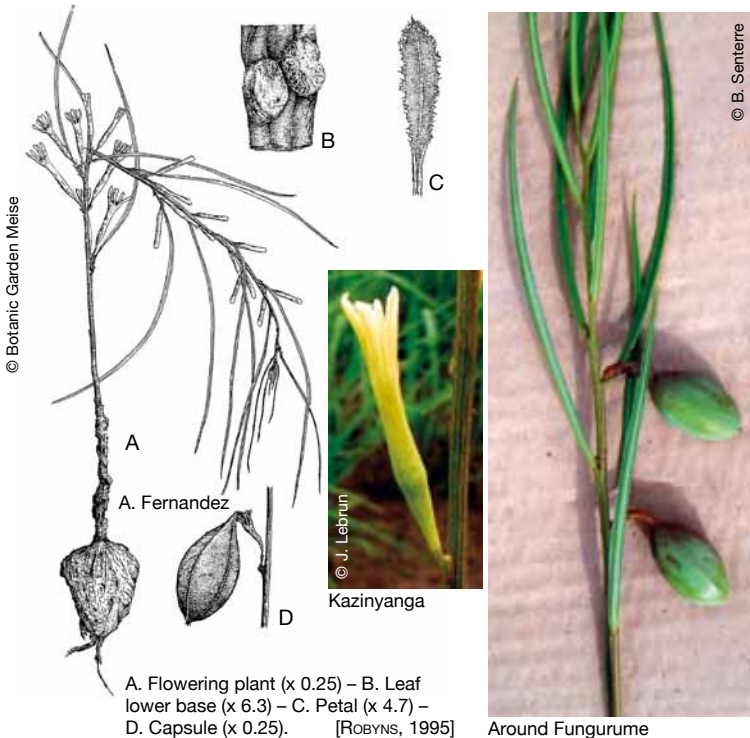
androgynophore 1.5–2 mm long; disk-glands 2–3 mm long. Female flower not known. Capsule ellipsoid, 4 × 2 cm.

Ecology: Miombo open forest, rare on copper steppe savannas.

General distribution: D.R. Congo (Katanga), Zambia.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Reference: DE WILDE [1971].



A. Flowering plant (x 0.25) – B. Leaf lower base (x 6.3) – C. Petal (x 4.7) – D. Capsule (x 0.25). [ROBYNS, 1995]

Around Fungurume

Basananthe cupricola A.Robyns

[Passifloraceae]

Holotype: Malaise 10287.
Copper specimen: Mf 10287.

Habit: Perennial herb, with a woody rootstock; stems \pm flexuous, branched, longitudinally striate, up to 40 cm long, glabrous; tendrils absents. Leaves subsessile or with a petiole 1-2 mm long, simple, glabrous, with subulate stipules, 1.5-2 mm long; limb linear, attenuate at base, acute to mucronate at the apex, 3-9 cm long, 2.5-7 mm wide, 2-4 glandular teeth near the base. Inflorescences axile, 2-flowered, peduncle 1.5-2.5 mm long, glabrous. Flowers glabrous, pedicel 1.5-2 mm long, with 3 subulate bracts at the apex, 0.5-1 mm long; stipe 2-4 mm long, hypanthium patelliform, 1.5-2 mm wide; sepals 5, ovate, obtuse at the apex, 4.5-5.5 mm long and 2 mm wide; petals 5, oblong, obtuse at the apex, 3.5-4 mm long and 0.8-1 mm wide, membranous; extern corolla tubulate, tube 1.3 mm high; disc fleshy, 0.15 mm high; inner corona infundibuliform, 1 mm high; stamens 5, filet 1.8-2 mm long, anthers \pm sagittate, 1.5 mm long; ovary shortly stipitate, ovoid, 1.2 x 0.6 mm; styles 3, 3 mm long, free; stigmatae capitate.

Ecology: Cupriferous steppe savanna.

General distribution: Only one specimen known from holotype site.

Distribution on Katangan copper site (1 site): Etoile (97).

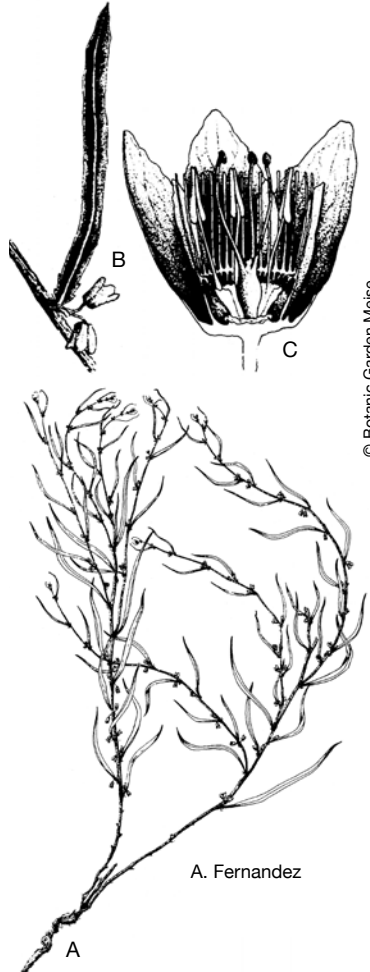
Rehabilitation: No interest.

References:

ROBYNS [1989; 1995].
LETEINTURIER [2002].

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | | X | | |
| wet | | | | |

→ oligocuprophyte



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A. Habit (x 0.2) – B. Leaf, lower face and inflorescence (x 1) – C. Flower, longitudinal section (x 5).

[ROBYNS, 1989]

Basananthe kisimbae Malaisse & Bamps [Passifloraceae]

Holotype: Dikumbwa, Kisimba & Muzinga 487.

Copper specimens: DKM 466, 487; Mf 16481, 16500; MMK 70.

Habit: Perennial suffrutex, annual stems 5-11 cm long, arising from a woody rootstock. Leaves sessile, linear to narrowly elliptic, 3-8 x 0.2-0.9 cm, apex shortly mucronate; upper lamina face pubescent, with short glandular hairs; lower face entirely and densely white papillose, stipules narrowly triangular to filiform, 3 mm length. Inflorescence axillar, cymose, 2-flowered; floral buds dark brown, 3 x 1.5 mm, glabrous. Flower with 5 sepals, 7 mm long; petals 5, membranous, 5 x 0.7, glabrous; inside corona tubulate, 1.2 mm high; stamens 5, anthers sagittate; ovary ellipsoidal, 5 mm long, 3 mm in diam. Capsule ellipsoidal, 15 x 8 mm, orange-brown.

Ecology: Copper steppe savannas and on the edge of surrounding miombo.

General distribution: Central part of the Katangan Copper Bow.

Distribution on Katangan copper sites (7 sites): Kakavilondo (31),

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----------|------------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | | XX | (X) | |
| wet | | | | |

→ oligocuprophyte

Goma (33), Kabwelunono (34), Shimbidi (35), Kavifwafwaulu (42), Kwatebala (45), Kazinyanga (49).

Rehabilitation: Valuable for rocky copper sites.

Reference: MALAISSE, BAMPS [2005].



Kabwelunono



Kwatebala

***Phyllanthus* sp.**

Copper specimens: Mf 7685, 7742.

Habit: Monoecious erect perennial herb, 25-45 cm tall. Shoots up to 8 cm long. Leaves distichous; lamina 3-11 x 1-4 mm, elliptic-lanceolate, green above, glaucous beneath, margin often reddish-tinged. Male flowers in small cymules. Female flowers: pedicels 5 mm long, 2 cm in fruit.

Ecology: Notably on rocky copper steppes.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Kavifwafwaulu

***Phyllanthus taylorianus* J.F.**

Brunel ex Radcl.-Sm.

[Phyllanthaceae]

Holotype: Milne-Redhead & Taylor 8716.

Copper specimen: MKS 1039.

Syn.: *P. niruroides* Auct. non Müll.Arg.

Habit: Monoecious erect annual herb, 10-25 cm tall, with terete stems. Lateral shoots up to 8 cm long. Leaves distichous; petioles 0.3 mm long; stipules 1 mm long; linear-setaceous; lamina 3-11 x 1-4 mm, elliptic-lanceolate, green above, glaucous beneath, margin often reddish-tinged. Male flowers in small cymules. Female flowers: pedicels 0.5-1 mm long, 2 mm in fruit.

General distribution: From Cameroon to Ethiopia and southwards to Zimbabwe.

Distribution on Katangan copper sites (5 sites): Notably Katuto (41).

Reference: RADCLIFFE-SMITH [1996].



Mwinansefu



Shinkusu

Holotype: Welwitsch 328.
Copper specimens: KSM 4b; MKS 987.

Habit: Dioecious suffrutex or tufted perennial herb, glabrous; stems several, erect from a woody rootstock, shoots mostly leafy. Flowering branches slender, spreading, up to 30 cm long, subterete. Leaves spirally disposed or subdistichous, stipules up to 2 mm long, petiole 0.2 mm long, leaf-blade 5-15 x 2-7 mm, coriaceous, lanceolate to ovate-lanceolate, with sharply spinescent apices and hyaline cartilaginous margins. Male flowers axillary, solitary, shortly pedicellate; sepals 6, in two series, elliptic; disk-glands 6, thin, smooth. Female flowers solitary, sepals 6, in two series, ovate to ovate-oblong, very thick and coriaceous; ovary subglobose, styles erect, free to the base, entire; stigma subcapitate. Capsule subglobose, smooth.

Ecology: Miombo and steppe savannas on Kalahari sands, also in rocky copper steppes and copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (16 sites): Notably Shadiranzoro (48), Fungurume (51).

Rehabilitation: No evident interest.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

References:

- HUTCHINSON [1912].
- RADCLIFFE-SMITH [1996].



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Kazinyanga

Uapaca robynii De Wild.

[Phyllanthaceae]

Holotype: Robyns 1701.

Copper specimens: Ls 771; Mf 9446, MKS 80; Mf-Re 2413; Rw 1701.

Habit: Small tree up to 5 m high; crown spreading, rounded; bark thick, very rough, deeply fissured, brownish-black. Leaves crowded at ends of very stout branchlets, at least 1.8 cm thick; obovate to broadly elliptic, 11 x 8 – 25 x 15 cm, chartaceous, persistently fulvous-lanate beneath; petiole 5-9 cm long. Fruit ellipsoid or subglobose, about 3.5 cm in diam.

Ecology: Edges of dambos, of steppe savannas on Kalahari sands and edges of copper deposits.

General distribution: Restricted to D.R. Congo (Upper Katanga), Zambia and Malawi.

Distribution on Katangan copper sites (11 sites): Notably Likasi (75).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 15-38, Co = 136-153 µg/g D.M.

| Hydration | Copper content of soil (in µg per g of soil) | | |
|-----------|---|-----|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | X | X | |
| wet | | | |

→ mesocuproresistant

Rehabilitation: No evident interest. Slow growth, but habit aesthetically pleasing.

Reference: WHITE [1962].



© I. Parmentier
Shadirandzoro



Shinkolobwe



© H. Schat



Kazinyanga



Shinkolobwe



Fungurume

Polygala albida Schinz. var. ***stanleyana*** (Chodat) Paiva
[Polygalaceae]

Syntypes: Pogge 28, Welwitsch 1015, 1017.
Copper specimen: Mf 11693.
Syn.: *P. stanleyana* Chodat

Habit: Annual herb 5–40 cm tall. Leaves alternate, linear to narrowly elliptic, apex subacute to rounded, base cuneate. Flowers white, greenish white, pale pink to pale purple, in laxe racemes.

Ecology: Woodlands, cultivated grounds, also copper steppe savannas.

General distribution: From Ethiopia to Namibia and R.S.A.

Distribution on Katangan copper sites (4 sites): Notably Luita (58).

Reference (both species):
PAIVA [2007].



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Shadiranzoro

Polygala myrtillopis Welw. ex. Oliv.

Holotype: Welwitsch 1029.
Copper specimens: FMMM 39; LLM 6.
Syn.: *P. katangensis* Exell

Habit: Perennial erect herb up to 6–20 cm tall; stems several from a vertical woody rootstock at least 10 cm long and 0.5–1.1 cm in diam. Leaves numerous, petiole 1 mm long, lamina elliptic to oblong-lanceolate, acute to acuminate at the apex, acute at the base, 1–3 x 0.7–1.4 cm.

Ecology: Kalahari sands and mostly copper steppe savannas.

General distribution: Angola (1 site): D.R. Congo (Katanga).

Distribution on Katangan copper sites (10 sites): Notably Kasongwe (76), Etoile (97), Kinsevere (98).



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Kasongwe

C. Van
MarsenilleHabit
(x 0.2)

[Original Plate]



© J. Piquera

Kinsevere

Polygala petitiana* A.Rich. subsp. *petitiana* var. *petitiana
 [Polygalaceae]

Holotype: Schimper 1188.
 Copper specimens: Mf 7712, 9209;
 Mf-Gj 2; Mf-Re 1789, Nn 1095, 1156.

Habit: Annual herb up to 100 cm tall, with stem erect, slender, simple or few-branched in the upper part. Leaves 20–40 x 0.5–4 mm, linear to very narrowly elliptic, with needle-like tips, glabrous. Flowers blue or white, in elongated terminal racemes up to 15 cm long, with caduceous bracts. Capsule 3–4 x 2–2.5 mm, oblong elliptic, very narrowly winged. Seeds ellipsoid, with long, white, silky hairs; caruncle 0.8 mm long, appendage absent.

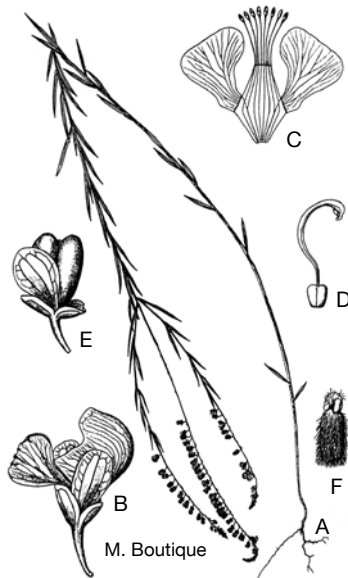
Ecology: Miombo open forests, wetlands, Kalahari sands and copper steppe savannas.

General distribution: From Ethiopia, Kenya, Uganda, Angola, D.R. Congo (Katanga), Tanzania, Zambia, Malawi, Mozambique, to Zimbabwe.

Distribution on Katangan copper sites (11 sites): Notably Disele (55).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 13–196, Co = 8–251 µg/g D.M.

Reference: PAIVA [2007].



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A. Habit (x 0.2) – B. Leaf, lower face and inflorescence (x 1) – C. Flower, longitudinal section (x 5) – D. Gynoecium (x 5) – E. Sepals and capsule (x 2.2) – F. Seed (x 3).

[PETIT, 1958]



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Fungurume

***Securidaca longepedunculata* Fresen var. *parvifolia* Oliv.**

[Polygalaceae]

Lectotype: Welwitsch 1006.

Copper specimens: DKM 442, 662.

Habit: Thorny shrub or small tree up to about 6 m, sometimes spiny. Bark grey, minutely flaking, slash on mature trees pale yellow or orange. Leaves petiolate, linear-oblong, petiole up to 5 mm, lamina 1-5 x 0.5-1.8 cm, mid-green, leathery, apex rounded or obtuse. Inflorescence a simple terminal or lateral raceme, often borne on short shoots which become spiny; flowers rose to magenta or violet, sweet-scented; pedicels up to 4 mm long; posterior sepal up to 5 x 4 mm ovate-acuminate, with ciliate margins; wing sepals 5-11 x 4-9 mm, suborbicular; anterior sepals up to 5 x 4.5 mm, broadly ovate; upper petals up to 7.5 x 3.5 mm, narrowly elliptic; carina up to 10 mm long with a small lobed appendage about 1 mm long near the apex. Fruit 3-5 x 0.8-2 cm, with an oblong or elliptic somewhat obliquely curved wing. Nut containing the seeds 8-10 mm in diam., rugulose or smooth.

Ecology: Mainly open woodlands, also rocky sites (siliceous cellular rocks) with low copper content.

General distribution: From Senegal to Sudan, southwards to Mozambique, Zimbabwe and Angola.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | <X< | 5,000 |
| | 800 | 5,000 | | |
| dry | X | X | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (22 sites): Notably Kamoto (6).

Rehabilitation: Pioneer for stabilisation on low copper content soils.



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Likasi-Kolwezi road



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Kanzenze-Kyamasumba road



Luiswishi

Protea lemairei De Wild. subsp. ***trichophylla*** (Engl. & Gilg)

Beard

[Proteaceae]

Holotype: Baum 918.

Copper specimen: Mf 16157.

Habit: Suffrutex with numerous annual simple slender stems, 30-40 cm long and 3-4 mm thick, arising from a woody rootstock. Leaves sessile, linear or linear-oblong, 8-12 x 0.6-1.5 cm, apex acute to rounded, narrowed gradually at the base; blade with long adpressed grey silky hairs at first, later glabrescent, midrib red prominent. Heads solitary, terminal, 6 cm long and 5 cm in diam., globose, pedunculate with a small stipe or subsessile. Bracts few, orange-red or red, oblong-lanceolate, rounded at the apex, up to 4 x 1 cm. Perianth pink, 4 cm long of which 1.5 cm for the base and tube each tapering one into the other, 1 cm for the limb, long and densely grey-silky, teeth 1 mm long. Style red, 5 cm long, compressed.

Ecology: Open grassy places in miombo, rarely in shrubby copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia.

Distribution on Katangan copper sites (1 site): Kananga East (7).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 274, Co = 13 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuprophyte

Rehabilitation: No evident interest.

References:

BEARD [1992].

BRUMMITT, MARNER [1993].



Manika plateau



Kananga East



Potopoto valley

Protea welwitschii Engl.

[Proteaceae]

Lectotype: Welwitsch 1600.
 Copper specimens: Mf 10246;
 Mf-Kk 276; Rw 1746; Qp 5310;
 Sp 1158; Tr 36.

Habit: Small bushy tree, 1-3 m high. Young branches brown, tomentose, glabrescent later, bark grey. Leaves sessile, elliptic to narrowly oblanceolate, 8-14 x 1.8-4.5 cm, rounded at the base, apex rounded to emarginated; blade leathery. Heads terminal or lateral, 3-6 cm long, 5-8 cm in diam., sometimes aggregated into clusters. Middle bracts 1.2-2 x 0.8-1.7 cm, rounded to obtuse, the hairs grey to rusty-brown, often sericeous. Flowers 3-4.5 cm, white but usually with a brown, orange or pink tinge at tip. Perianth-base glabrous in the lower part, brown-villous in the upper part; limb 12-15 mm, brown-villous on 3 fused segments but glabrous on the fourth.

Ecology: Montane grasslands, Kalahari sands steppe savannas, also in shrubby copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | |
|--------|-----|---|
| dry | | |
| medium | XXX | X |
| wet | | |

→ oligocuprophyte

General distribution: Rwanda, Burundi, D.R. Congo, Angola, Zambia, Malawi, Mozambique, Zimbabwe, R.S.A.

Distribution on Katangan copper sites (5 sites): Kwatebala (45), Sokoroshe (83), Lukuni (86), Luiswishi (87), Lupoto (92).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 167, Co = 156 µg/g D.M.

Rehabilitation: No evident interest.

References:

BEARD [1992].
 BRUMMITT, MARNER [1993].



Sokoroshe



Sokoroshe



Fungurume

© F. Malaisse

Clematis villosa DC. subsp. **villosa**

[Ranunculaceae]

Holotype: Anonymous from Angola.
Copper specimens: Mf 11214; Tr 191.
Syn.: *Clematopsis scabiosifolia* (DC.) Hutch.

Habit: Perennial herb, with erect stems, 0.7-1.5 m tall, longitudinally ribbed and furrowed, indumentum very variable from silky-tomentose to nearly glabrous. Leaves pinnate, bipinnate or pinnate-trifoliolate. Flowers 3.5-7 cm in diam., usually several at the ends of the stems or main branches. Sepals white, pink, mauve or lilac. Anthers up to 5 mm long. Achenes in heads up to 10 cm in diam.

Ecology: Miombo open forests and upland steppe savannas, rarely copper steppe savannas.

General distribution: Nigeria, Sudan, Uganda, Kenya, Angola, D.R. Congo, Tanzania, Zambia, Malawi, Mozambique, Zimbabwe, R.S.A.

Distribution on Katangan copper sites (3 sites): Fungurume (51), Kahumbwe (57), Luita (58).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 3, Co = 6 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: No evident interest.

References:

- STANER, LEONARD [1959].
- EXELL, MILNE-REDHEAD [1960].
- BRUMMITT [2000].



Lualaba river

© M. Schajles



Kasobantu



Kipopo

© M. Schajles

Clematis welwitschii

(Hiern ex) O.Ktze

Holotype: Welwitsch 1217.
Copper specimen: MHK 72.

Habit: Woody or climbing plant. Leaves (bi-)pinnate; leaflets trilobed.

Ecology: Upland grasslands, miombo.

Distribution on Katangan copper sites (1 site): Fungurume (51).

See upper pictures



Mamfwe road



Nzilo-Kyamasumba road

© M. Schaljes

Delphinium dasycaudon

Fresen [Ranunculaceae]

Holotype: Rüppell s.n.
Copper specimens: Mf 11699; Mf-Gp 865.

Habit: Erect herb. Flowers zygomorphic; sepals 5, petaloid, deep blue.

Ecology: Upland grasslands.

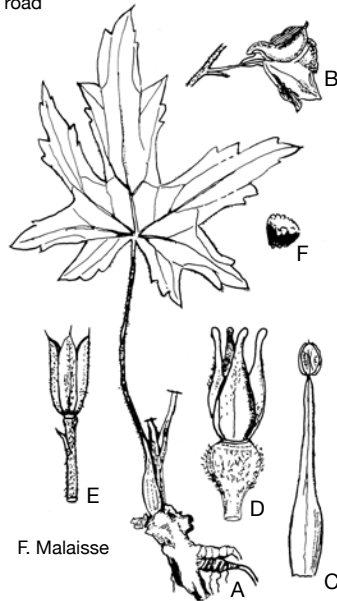
Distribution on Katangan copper sites (4 sites): Notably Luita (58).

See lower pictures



Etoile mine

© F. Malaisse



A. Rootstock, basal leaves (x 0.4) – B. Flower (x 0.5) – C. Stamen (x 4) – D. Carpels (x 2.5) – E. Fruit (x 0.5) – F. Seed (x 5). [Drawn after M.C.S. in EXELL & MILNE-REDHEAD, 1960]

Batopedina pulvinellata Robbrecht

[Rubiaceae]

Holotypes: Malaisse 9672, 11476.
Copper specimens: Bh 2396; Dp 3018
R2, 3077 R2; Ls 59135; Mf 7695,
11476; MKS 96.

Habit: Perennial, 5 cm high, numerous procumbent stems arising from a woody rootstock. Leaves small, petiole 12 mm long, hairy; limb 2-4 x 4-7 mm, acute at apex, 2-3 lateral nerves. Inflorescence 1-flowered, Flowers sessile, 5-merous, corolla white, hypocrateriforme, white, heterostylous. Capsule obconic, seeds numerous.

Ecology: True chasmophyte restricted to (siliceous cellular) rocky outcrops, mainly in copper steppes.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (13 sites): Notably Mupine (4).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 22-88, Co = 395-601 µg/g D.M.

Rehabilitation: Good facilitator on copper rocky outcrops.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|-----|
| | normal | 200 | 800 |
| dry | (X) | XX | X |
| medium | | | |
| wet | | | |

→ mesocuproresistant

Note: Two subspecies have been observed on copper rocky outcrops, namely subsp. *pulvinellata* and subsp. *glabrifolia* Robbrecht.

References:
ROBBRECHT [1981; 1986].



Tilwezembe

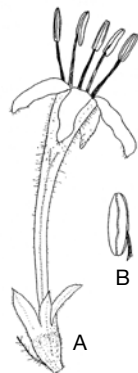
© R. R. Brooks



Tilwezembe

Longistylous flower

© M. Schajles



© Botanic Garden Meise

A. Brevistylous flower & included style (x 2.6) – B. Included anther from longistylous flower (x 5.5).

[ROBBRECHT, 1981]

Fadogia cienkowski

Schweinf.

Holotype: Cienkowski 159.
 Copper specimen: Sm 4768.
 Syn.: *F. katangensis* De Wild.

Habit: Suffrutex, 0.3-1.2 m tall. Leaves 3-4-whorled, discolorous, narrowly elliptic; mixture of coarse hairs and an understorey of papillae on underside of leaves. Inflorescence 2-6-flowered or solitary. Calyx lobes triangular-subulate, 1-2.5 mm long. Corolla apiculate, yellow or cream-coloured; tube cylindrical, 2.5-3.5 mm long; lobes narrowly lanceolate, 3.5-5 long. Fruit subglobose, dark green becoming black and shining, crowned with the calyx lobes.

Distribution on Katangan copper sites (5 sites): Notably Shabara (24).



© M. Schajjes



Shabara

Fadogia fuchsioides Welw.

ex Oliv. [Rubiaceae]

Holotypes: Welwitsch 2567, Grant s.n.
 Copper specimen: Sm 4534.
 Syn.: *Temnocalyx fuchsioides* (Welw. ex Oliv.) Robyns.

Habit: Suffrutex 0.3-1.5 m tall; stem reddish or purplish. Leaves in whorl of 3-4; elliptic to obovate, rather thicker. Inflorescence 1-3-flowered. Calyx red. Corolla acuminate in bud; tube deep red; lobes 6-9, cream, buff or yellow within. Fruit black, fleshy, 12-15 mm in diam., globose, 6-9 pyrenes.

General distribution: From Angola to S-W Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (3 sites): Notably Shinkusu (44).

Reference: (for both species) BRIDSON [1998].



© M. Schajjes



Sokele road

Fadogia triphylla Baker

[Rubiaceae]

Holotype: Carson 43.

Copper specimens: Sm 3115; Tr 292.

Habit: Suffrutex 20-50 cm tall. Stems several, erect, yellowish. Leaves in whorls of 3-4 or opposite above; elliptic or ovate, cuneate at the base, paler beneath. Inflorescence 3-7-flowered. Corolla apiculate, white to greenish-yellow outside, creamy-green inside; tube 5-6 mm long; lobes 4.5-7 x 1.5-2.5, oblong-triangular.

Distribution on Katangan copper sites (2 sites): Notably Mindigi (60).



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Nzilo-Kyamasumba road

Fadogia verdickii De Wild & T. Durand

Holotype: Verdick 60.

Copper specimens: Not collected.



© J. Piquery

Kinsevere

Habit: Suffrutex 30-90 cm tall, from a woody rootstock. Leaves in whorls of 3 or 4; blades oblong to oblanceolate. Flowers scented, solitary or apparently in 3-flowered inflorescences. Corolla clavate, tube green or white; lobes cream or white.

Distribution on Katangan copper sites (1 site): Kinsevere (84).

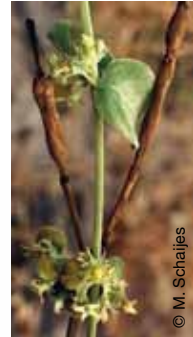
Fadogiella stigmatoloba (K. Schum.) Robyns

Holotype: Goetze 1428.

Copper specimen: Mf 14239.

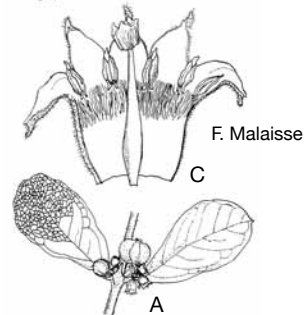
Habit: Suffrutex up to 50 cm tall. Stems several, erect, 3-4-gone. Lamina 6-6.5 x 2.5-4 cm, discolorous. Flowers yellowish.

Distribution on Katangan copper sites (2 sites): Notably Kwatebala (45).



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Kolwezi-Musokatanda road



A. Fruiting branch (x 0.25) – B. Calyx (x 2.6) – C. Corolla open out, with style and pollen presenter (x 2.6) – D. Pyrene (x 2).

[Drawn after M.E. Church in BRIDSON, 1998]

Geophila obvallata

(Schumach.) F.Didir.

Holotype: Iserst s.n.
Copper specimen: Mf s.n.

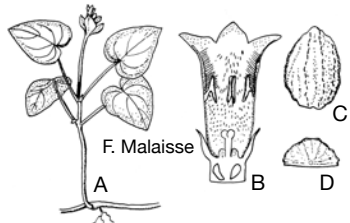
Habit: Creeping herb often forming carpets. Leaf blades ovate-reniform, up to 6 x 4 cm. Corolla white. Berries black, crowned with the persistent calyx.

Ecology: Miombo open forest.

General distribution: From Guinea-Bissau to Angola, South-central Africa.

Distribution on Katangan copper sites (1 site): Kela (52).

Note: To which subsp. the taxon belongs remains to be studied.



A. Habit (x 0.1) – B. Flower, longitudinal section (x 8) – C.-D. Pyrene, dorsal and lateral views (x 5). [Drawn after D. Bridson in VERDCOURT, 1976]



Musokatanda Sokele road



Nzilo-Kyamasumba road

Hymenodictyon

floribundum (Hochst. & Steud.) B.L.Rob. [Rubiaceae]

Holotype: Schimper 277.
Copper specimens: Mf 12323, 16709; Sm 1231.

Habit: Irregularly-shaped shrub, up to 6 m high and 20 cm in diam.; bark rough. Young leaves reddish, leaves clustered at ends of branchlets, obovate or obovate-elliptic, shortly acuminate at apex, base cuneate. Flowers yellow-green or red-purple. Capsule dark brown, verrucose, narrowly ellipsoidal, 1 x 0.4 cm, loculicidal.

Ecology: Rocky hills, also on cellular siliceous rocks.

General distribution: Tropical Africa, from Guinea to Sudan, and southwards to Angola, Zambia, Malawi and Mozambique.

Distribution on Katangan copper sites (2 sites): Kamoto (6), Kinshasa (14).

Reference: WHITE [1962].



Kolwezi, hill D

Lelya prostrata (Good)W.H.Lewis var. ***prostrata***

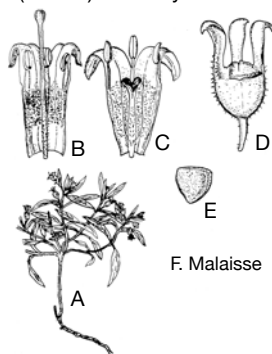
Holotype: Gossweiler 7385.

Copper specimens: Mf 14227; Mf-Kk 257.

Habit: Prostrate perennial herb, with many stems 2.5-10 cm long radiating from a woody rootstock; often forming small mats. Leaf-blades elliptic to almost linear, 0.5-1.5 x 0.1-1 cm.

General distribution: Nigeria, from Angola to Tanzania and Malawi.

Distribution on Katangan copper sites (4 sites): Notably Shabara (24).



A. Habit (x 0.3) – B. Longitudinal section of long-styled flower (x 2.8) – C. Longitudinal section of short-styled flower (x 2.9) – D. Capsule, one calyx-lobe removed (x 2.8) – E. Seed (x 6). [Drawn after D. Bridson in VERDCOURT, 1976]



Kolwezi

Leptactina benguelensis

(Welw. ex Benth. & Hook.f.)

R.D.Good [Rubiaceae]

Holotype: Gossweiler 3251.

Copper specimen: MKS 573.

Habit: Perennial subshrub, 0.3-0.7 m high, much branched, from a woody rootstock. Leaf-blade oblong-elliptic, slightly coriaceous, ± shiny above. Flowers fragrant, solitary or 3-several together, sessile; bracts closely appressed to calyx and stipules, toothed. Corolla white; tube 2.5-6.5 cm long; lobes 4-5, 1.2-3.8 x 1.1-1.5 cm, elliptic. Fruit orange-yellow, 1-2 x 0.8-1.2 cm, subglobose to ellipsoid, fleshy. Seed dark brown, irregularly rhomboid.

Ecology: Miombo open forest, Kalahari and copper steppe savanna.

General distribution: D.R. Congo, Burundi, Tanzania, Zambia.

Distribution on Katangan copper sites (3 sites): Notably Zikule (30).

References:

ROBBRECHT, DE BLOCK [1999].

NEUBA et al. [2006].



Lufupa north falls road



Kanzenze-Kyamasumba road

Manostachya staelioides (K.Schum.) Bremek.

[Rubiaceae]

Holotype: Welwitsch 5328.

Copper specimens: DKM 385, 540;
Dp-Tj 2213 M; LLM 71, 86; Mf 7991,
12433, 12826, 13031; Mj-Gj 81.

Habit: Woody-based *Thesium*-like herb with several erect glabrous branched stems, 20–45 cm tall, the stems below the lateral branches essentially leafless. Leaves 2–6 x 0.5 mm, linear-subulate, glabrous or with margins ciliolate towards the base. Stipular sheath very short. Flowers distinctly bracteolate, solitary or few in axils, sessile or pedicels about 0.5 mm; the nodes well separated and forming spike-like inflorescences 10–20 cm long. Calyx tube glabrous; lobes 0.5–1.5 mm long. Corolla white, tube 1.5–2.5 mm, shortly cylindrical; lobes ovate 1–2 x 0.9–1.2 mm, densely pilose inside. Style 2–2.5 mm long in long-styled flowers, 0.5 mm long in short-styled flowers; stigmatic lobes ovoid, 0.3 mm long. Capsule subglobose, 2 mm long.

Ecology: Grasslands, dambo margins, copper steppe savannas.

General distribution: Angola, Upper Katanga, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (7 sites): Kasompi (27), Kabwelunono (34), Kwatebala (45), Fungurume (51), Luiswishi (87), Kasonta (91), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 41, Co = 8 µg/g D.M.

Rehabilitation: No evident interest.

Reference: VERDCOURT [1980].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant



Etoile mine

© F. Kalambayi

Holotype: Mendes 2662.

Paratypes: Mendes 2143, 2446.

Copper specimens: DKM 1682;

Mf 11671, 11752, 11803, 13065;

Mf-Re 2063, 2411; MKS 146, 337, 406;

MSH 26; Tr 102.

Habit: Strictly erect perennial herb, 40–90 cm tall with 1–several stems, woody at the base, 3–4-angled, glabrescent. Leaves in whorls of 3–4 or opposite, but appearing densely verticillate due to abbreviated axillary shoots, 5–25 x 0.4–1 mm, subulate, rigid. Inflorescences 1–7-flowered contracted cymes, densely bracteate, axillary in the top 7–30 spaces nodes, the whole spike-like, up to 30 cm long. Corolla white, tube 1–1.3 x 0.8 mm, cylindrical-funnel-shaped, lobes triangular-ovate. Short-styled and long-styled flowers; style 0.5 or 1.8 mm long. Capsule 1.7 x 1.3 mm, ellipsoid. Seeds 1–2 per loculus, brown, oblong, testa reticulate.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

Ecology: High plateaus and copper steppe savannas, miombo woodlands.

General distribution: Congo Rep., Angola, D.R. Congo, Tanzania, Zambia.

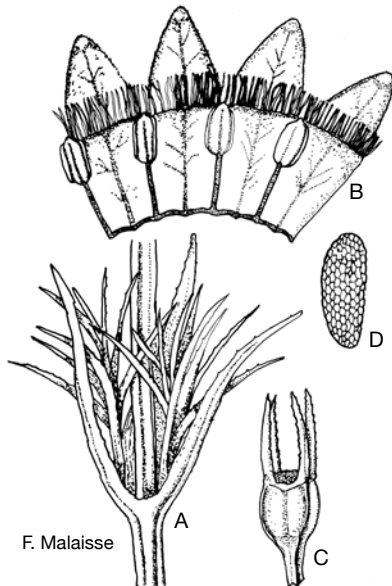
Distribution on Katangan copper sites (11 sites): Notably Goma (33), Kavifwafwaulu (42), Mindigi (60), Shinkolobwe (67), Shangolowe (70), Kamoya (72).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 10, Co = 64 µg/g D.M.

References:

MARTINS [1982].

VERDCOURT [1989].



A. Node showing axillary brachyblasts (x 2.8) –
B. Corolla of long-styled flower (x 7.5) –
C. Fruit (x 8.5) – D. Seed (x 18).

[Drawn after C. Pinto in VERDCOURT, 1989].



Kakavilondo



Bianco

Mitrasacmopsis quadrivalvis Jovet

[Rubiaceae]

Syntypes: Perrier de la Bâthie 3802, 12544.

Copper specimens: Mal 844; MKS 1020, 1030, 1034.

Habit: Herb 8-40 cm tall, with sparsely hairy square stems. Leaf-blades 0.8-3.2 x 0.1-1.1 cm, acute but mucronulate at the apex; petiole obsolete. Pedicels obsolete or up to 3 mm long in fruiting stage. Calyx puberulous; tube shallow, 0.5 x 1 mm; lobes 0.5-0.8 x 0.3 mm. Corolla white, pink or pale mauve. Capsule 2 mm wide, beak 1 mm long and wide. Seeds brown, \pm 20 per capsule.

Ecology: Miombo open forests, also shallow soils on rocky sites.

General distribution: Angola, D.R. Congo, Burundi, Tanzania, Zambia, Madagascar.

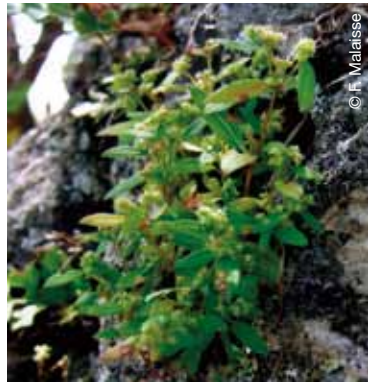
Distribution on Katangan copper sites (5 sites): Notably Katuto (41).

Rehabilitation: Pioneer rocky sites.

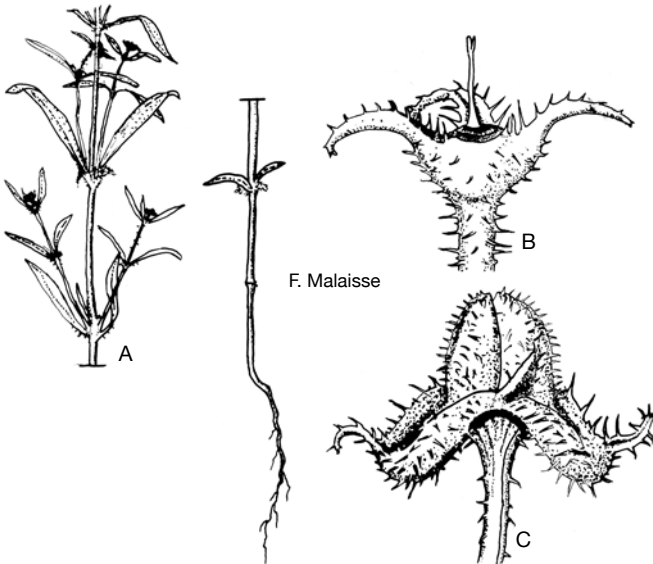
| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-----|-----|---|
| | normal | 200 | 800 | > |
| dry | X | X | | |
| medium | X | | | |
| wet | | | | |

→ oligocuprophyte

Reference: VERDCOURT [1976].



Kwatebala



A. Habit (x 0.7) – B. Calyx, with one lobe removed, and style (x 20) – C. Capsule (x 14).

[Drawn after D. Bridson in VERDCOURT, 1976]

Otiophora caerulea (Hiern)
Bullock

Holotype: Welwitsch 5314.
Copper specimens: Dp 2046; Mf 10241.

Habit: Perennial herb, 10-30 cm tall. Blades linear or elliptic-lanceolate, 1.7-5 x 0.2-1.1 cm, acute at the apex, cuneate at the base, glabrous, sessile. Flowers in compact heads. Corolla blue to mauve or mauve-pink; tube narrowly filiform; lobes lanceolate, 5-6 x 0.75-1 mm.

Ecology: Open forests, Kalahari sands and copper steppe savannas.

General distribution: D.R. Congo, Burundi, Tanzania, Angola, Zambia, Malawi.

Distribution on Katangan copper sites (5 sites): Notably Kela (52).



Nzilo-Kyamasumba road



Manika plateau

Otiophora villicaulis Mildbr.
[Rubiaceae]

Holotype: Zerny 378.
Copper specimen: Mf 12669.

Habit: Small perennial herb, 3.5-15 cm tall, with up to 15-20 procumbent, stems spreading from a ± woody rootstock. Blades ovate, 1-2 x 0.6-1.5 cm. Flowers in dense terminal heads 0.8-1.5 cm wide. Corolla lilac or bluish lilac; corolla-tube filiform, 5-6 x 0.25 mm; lobes 4-5, ovate-lanceolate, 2-3 x 1 mm. Stamens 4-5, exserted ± 2 mm. Style filiform, stigma bilobed. Fruit pale brown, ovoid to subglobose, 2 x 1.5 mm. Seeds dark reddish brown, depressed, ovoid or subglobose, 1-1.3 x 0.8-1 mm.

Ecology: Bare patches in grasslands, rare in copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (2 sites): Notably Shabara (24).

Rehabilitation: No evident interest.

Reference (for both species):
VERDCOURT [1976].



Biano plateau



Kolwezi-Musokatanda road, Lulua river

Pentania schweinfurthii Hiern.

[Rubiaceae]

Holotype: Schweinfurth 8.

Copper specimens: Dp 4062; LLM 65; Mf 7970, 9576, 11024; Sj 346; Wr 876.

Habit: Perennial pyrophytic suffrutex, 4-24 cm tall, from a woody rootstock; stems up to 25 from each root. Leaf-blade very variable, the lower rounded, elliptic, or elliptic-obovate, the upper linear to round, 0.3-5.5 x 0.2-1.8 cm; petiole up to 2 mm long; stipules with 2-4 deltoid lobes or 1 trifid lobe, 1-4.5 mm long. Inflorescences capitate, 1-2.5 cm long, 0.3-1.3 wide or branched and spike-like; peduncle up to 7.4 cm long. Calyx tube squarish, 0.6-1 mm long, 0.5-1 mm wide, glabrous; lobes unequal. Corolla bright blue, white, pale lilac or purple; tube 0.6-1.3 cm long, 1.2-2 cm wide, at the apex, glabrous, throat densely hairy. Style exerted 2-4 mm in long-styled flowers; stamens linear, 0.5-1.5 mm long. Fruiting inflorescence spicate, up to 4 cm long; fruit ovoid, broadest at the middle, 1.5-2.5 x 1.5-2 mm.

Ecology: Grasslands, woodlands, area subject to burning, also on copper steppe savannas.

General distribution: From Nigeria to Sudan, and southwards to Zimbabwe.

Distribution on Katangan copper sites (35 sites): Notably Tantara (63).

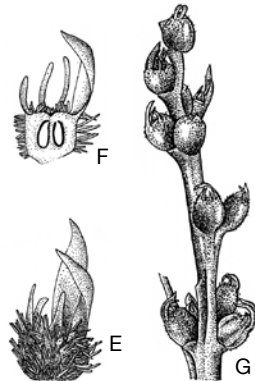
| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | 5,000 | |
| medium | 800 | 5,000 | | |
| wet | XXX | X | | |

→ oligocuproresistant

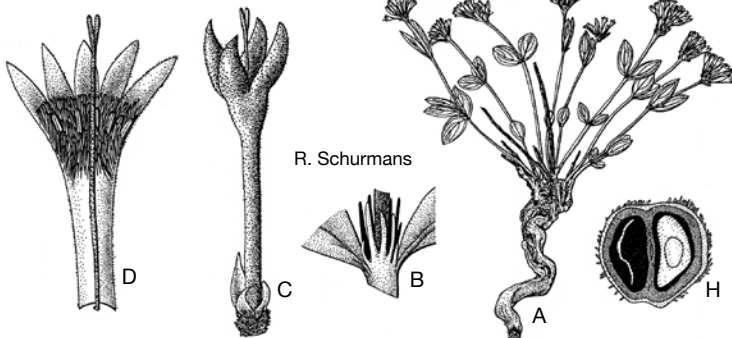
Distribution on Zambian copper sites (1 site): Muliashi (173).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 24-234, Co = 6-92 $\mu\text{g/g}$ D.M.

Reference: VERDCOURT [1976].



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A. Habit (x 0.1) – B. Node showing stipule (x 3) – C. Flower (x 3.5) – D. Longitudinal section of upper part of corolla (x 7) – E. Calyx (x 18) – F. Longitudinal section of ovary and calyx (x 12) – G. Inflorescence (x 1.2) – H. Longitudinal section of ovary (x 5).

[Original plate]



© M. Schalljes

Shabara



© J. Parmentier

Fungurume



© M. Schalljes

Kipopo

Mamfwe road

Pentas purpurea Oliv.

Holotype: Grant 140.
Copper specimens: Mf 11339;
Mf-Re 2161.

Habit: Perennial herb, 30–45 cm tall. Woody rootstock, 12 cm long, 0.8 cm wide. Stems 1–4, mostly unbranched. Stipule with 1–7 setae, 1–9 mm long from a short base. Leaves elliptic-lanceolate, bluntly acute apically, rounded or cuneate at base; lamina 4.5–11 x 1–3.2 cm; lateral nerves 7–15. Inflorescence a small dense head, 1.3–2.5 cm in diam., scarcely enlarging in fruit, sessile or peduncle 2–20 cm long. Fruit 4 x 3 mm, beak papillate, enveloped in the persistent calyx lobes.

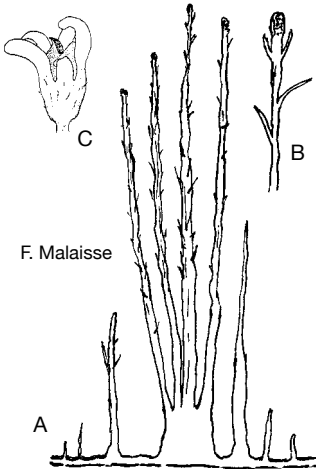
Ecology: Grasslands.

General distribution: From Nigeria to Tanzania and southwards to Zimbabwe and Mozambique.

Distribution on Katangan copper sites (2 sites): Fungurume (51), Dikulushi (99).

Rehabilitation: No evident interest.

Reference: VERDCOURT [1952].



A. Interpetiolar stipule (x 7) – B. Stipule apex (x 20) – C. Flower (x 2.5).

[Drawn after VERDCOURT, 1952]

Psychotria tenuissima

E.M.A.Petit [Rubiaceae]

Holotype: Schmitz 7487.
Copper specimens: Mf 10620; Mf-Gj 80.

Habit: Suffrutex 0.1–0.4 m tall. Leaves sessile or petiole 1–2 mm long; blade linear or narrowly elliptic, glabrous, 1.5–5 x 0.1–0.8 cm, papery. Stipules oval-triangular, 1–3 mm long. Inflorescence few-branched, dense, 0.8–1.5 cm long. Flower 5-merous, pedicel glabrous, 1 mm long; calyx cupula-shaped, glabrous, tube 0.5 mm long, lobes 0.25 mm long. Corolla white, tube 4 mm long, lobes 0.5 mm long. Drupes globose, red, 4 mm in diam.

Ecology: Open forests, shrubby savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (2 sites): Notably Katuto (41).

Reference: PETIT [1966].



Katuto

Piste Allard



Katuto

Spermacoce dibrachiata Oliv.

[Rubiaceae]

Holotype: Grant 439.
Copper specimens: Mf 10240; MKM 104.
Syn.: *Borreria dibrachiata* (Oliv.) K.Schum.

Habit: Annual or biennial herb, 6-75 cm tall. Leaf-blades lanceolate, 4.5-12 x 0.4-1.5 cm, acute at the apex, narrowed at the base into the stipule-sheath. Flowers in very dense mostly many-flowered apical heads, closely subtended by 2-4 leafy bracts. Corolla blue or violet-blue, with a white eye. Filaments exerted 2-4 mm. Style exerted 2-4.5 mm.

Ecology: Miombo woodlands clearings, also on copper steppe savannas.

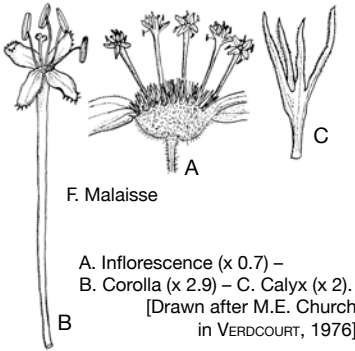
| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

General distribution: From Angola to Tanzania and southwards to Zimbabwe and Mozambique

Distribution on Katangan copper sites (6 sites): Notably Kwatebala (45).

Reference: STEVENS [2006].



Kipopo

Spermacoce pusilla Wall.

Holotype: Gardner s.n.

Copper specimens: Dp 2247Sp; Tr 307.

Habit: Erect or rarely prostrate annual herb, 7.5-60 cm tall. Leaf-blades linear-lanceolate, 1-5.3 cm x 2-5.5 mm, acute at the apex. Flowers in dense very compact spherical clusters at most nodes. Corolla white or pink; tube narrowly funnel-shaped, 1.3 mm long; lobes 0.8-1.1 x 0.4 mm. Filaments exerted 1 mm. Style exerted 0.5 mm. Capsule ellipsoid, 1.5 mm long. Seeds chestnut-brown, shiny.

Ecology: Grasslands, woodlands, rocky sites, also weed of cultivations.

Distribution on Katangan copper sites (3 sites): Notably Mitonte (68).

Reference: STEVENS [2006].



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Solwezi



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Likasi-Lubumbashi road

Vangueria cinerascens
(Welw. ex Hiern) Lantz var.
inaequale (Robyns) Lantz
[Rubiaceae]

Holotype: Grant 439.

Copper specimens: Mf 9447, 10240.

Habit: Suffrutex with 1-several shoots from a woody rootstock. Leaf blades 3.5-9.5 x 1-2.7 cm, narrowly oblong to linear-lanceolate, very discolorous, glabrescent to densely pubescent above. Calyx lobes 3-10 mm long, very narrow. Fruits yellow or orange-brown when ripe, 8-9 mm in diam., subglobose, crowned with the persistent calyx; pyrenes 1-5.

Ecology: Open forests, steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (2 sites): Notably Fungurume (51).

Reference: BRIDSON [1998].



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Kundelungu plateau

Thesium lynesii Robyns &
Lawalrée

Holotype: Lynes 231.

Copper specimens: KSM 581; Mf 16218;
MKS 997.

Habit: Perennial herb from a woody rootstock, 20-25 high, yellow-green, even dried. Leaves linear-subulate, cylindrical, curved, 1-3 cm long. Flowers terminal, sessile, 5-merous, 2.25-2.5 mm long; surrounded by 4-5 bracteoles subulate, 1.3-1.5 mm long. Tepals oblong-lanceolate, obtuse, cu-cullate, 0.8 mm long, margin recurved and papillose. Achenes ovoid, 2 x 1.5 mm, with 10 longitudinal ribs, 5 of which stronger, reticulate between ribs, glabrous.

Ecology: Dry savannas, mainly on copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (4 sites): Notably Kazinyanga (49), Fungurume (51).

Rehabilitation: No evident interest.

Reference:

ROBYNS, LAWALRÉE [1948].



Potopoto valley-Mpala road

Thesium pawlowskianum
Lawalrée [Santalaceae]

Holotype: Robyns W. 3930.

Copper specimens: Mf 9579, 11875;
Sa 5445.

Habit: Perennial erect herb, 10-35 cm tall. Woody rootstock, up to 3 cm thick. Stems numerous, spread to erect, up to 25-30 cm long, 2.5 mm thick at base; base woody, ± ribbed. Inflorescences numerous, axillary. Stem leaves scattered, ascending, linear-subulate, apex acute, 10 x 1 mm, cataphylls similar to leaves but shorter and wider. Inflorescence 1-3-flowered, peduncle 5-9 mm long. Flower sessile, 5-merous, perianth persistent, 1.75-2 mm long. Nut ellipsoid, 2.5-2.75 x 2.25-2.5 mm, conspicuously reticulated-nerved, 10-ribbed.

Ecology: Rarely Kalahari sandy steppe savannas, mainly copper steppe savannas with low to medium copper content.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (11 sites): Notably Mwinansefu (43), Luiswishi (87), Lupoto (92).

Reference: LAWALRÉE [1970b].



Fungurume

Thesium quarrei Robyns & Lawalrée

[Santalaceae]

Holotype: Quarré 42.

Copper specimens: Lb-Mf 229; Mf 16218; Mf-Gr 1.

Habit: Perennial herb from a woody rootstock, 20-40 high, drying black. Leaves lanceolate, subulate, up to 4 x 0.75 mm, ciliolate. Flowers terminal, sessile, 5-merous, 2.8-4 mm long; surrounded by 4-6 bracteoles lanceolate-subulate, 1-1.5 mm long. Tepals ovate-lanceolate, obtuse, cucullate, 1.2-1.7 mm long. Achenes globular, \pm 2 mm in diam., with 10 longitudinal ribs, 5 of which stronger, reticulate between ribs, glabrous.

Ecology: Dry savannas, mainly copper steppe savannas.

General distribution: Restricted to Upper Katanga.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-----|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | X | XX | |
| wet | | | |

→ oligocuproresistant

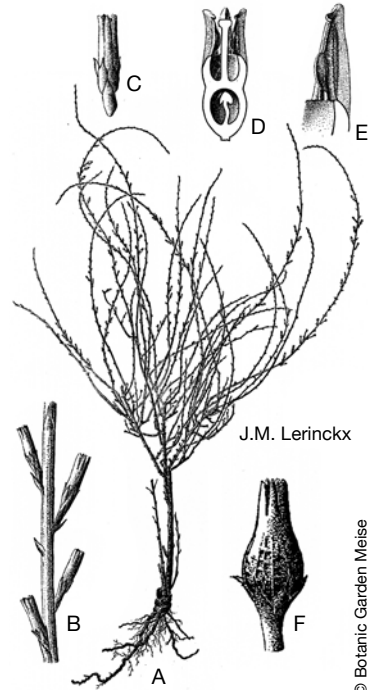
Distribution on Katangan copper sites (13 sites): Notably Tilwezembe (20), Kazinyanga (49), Fungurume (51), Luiswishi (87).

Rehabilitation: No evident interest.

Reference: ROBYNS, LAVALRÉE [1948].



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J.M. Lerinckx

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A. Habit (x 0.2) – B. Part of inflorescence (x 2) – C. Flower (x 3.4) – D. Flower, longitudinal section (x 6.5) – E. Part of receptacle with one tepal and one stamen (x 12.2) – F. Fruit (x 6.1).

[ROBYNS, LAVALRÉE, 1948]

Luiswishi

Holotype: Volkens 1712.
Copper specimens: MKS 73, 449.

Habit: Annual herb, erect; stem up to 50 cm high, ± flattened, narrowly winged, branched above the middle. Cotyledons, 2, opposite, flattened linear, 15-30 x 1-1.5 mm, located in the lower part of the stem; above the stem, scale-like leaves, 1 mm long, lanceolate, acute. Inflorescence, a lax spike, bracts and bracteoles scale-like, subulate, much shorter than the flowers. Flowers greenish-yellow, perianth infundibuliform, 5-merous, 1.5 mm long; lobes triangular-oblong, obtuse, glabrous. Nut ± spherical to ovoid, pale, yellowish-green, 2.5 x 2.5 mm, conspicuously reticulated-nerved, 10-ribbed, persistent perianth circa 1/3 as long as nut.

Ecology: Upland grasslands, rare on copper steppe savannas.

General distribution: From Ethiopia to Malawi.

Distribution on Katangan copper sites (2 sites): Kavifwafwaulu (42), Kazinyanga (49).

Rehabilitation: No evident interest.

Reference: LAWALRÉE [1969a].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X | | |
| wet | | | | |

→ oligocuproresistant

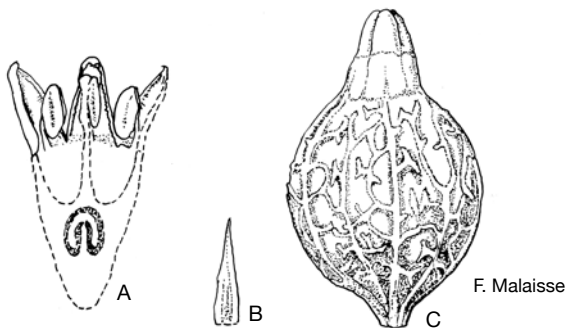
F. Malaisse



Habit, lower part with two cotyledons (x 0.6).
[Original plate]



Kazinyanga



A. Longitudinal section – B. Bract – C. Fruit (x 0.6).

[Drawn after M. Bates in POLHILL, 2005]

Gnidia hockii De Wild.

[Thymelaeaceae]

Holotype: Hock s.n.
 Copper specimens: Kk-Mf 459; LLM 63;
 Mf 11021, 16373; Mf-Kk 674; MSK 226,
 295, 324.

Habit: Perennial herb or undershrub, with a woody rhizome, 8-25 cm high. Stems and branches glabrous, green to reddish. Leaves on all the length of the stem, sessile of shortly petiolate; petiole up to 1 mm; lamina rigid, papery, glabrous. Upper leaves sessile, narrowly ovate, apex acute, 7-17 x 1.7-3.2 mm. Inflorescence terminal, sessile, 20-36-flowered. Involucral bracts 2-6, persistent,

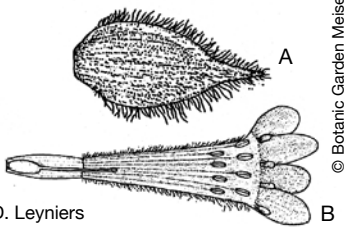
side entire, ciliolate. Flowers yellow, sometimes reddish, 4-merous. Petals 0.5-0.8 mm long. Ovary glabrous.

Ecology: Steppe savannas on high plateaux Kalahari sands and on copper outcrops, also in dambos.

General distribution: D.R. Congo (Upper Katanga), Burundi.

Distribution on Katangan copper sites (8 sites): Notably Goma (33), Kabwelunono (34), Kwatebala (45), Fungurume (51), Luiswishi (87), Etoile (97).

Reference: ROBYNS [1975].



D. Leyniers

A. Involucral bract (x 6.1) – B. Flattened flower, internal face (x 3.6). [ROBYNS, 1975]

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Luiswishi



Kwatebala south

***Gnidia involucrata* A.Rich.**

Holotypes: Schimper 770, Quartin Dillon & Petit s.n.
 Copper specimen: Wr 585.
 Synonym: *G. macrorrhiza* Gilg

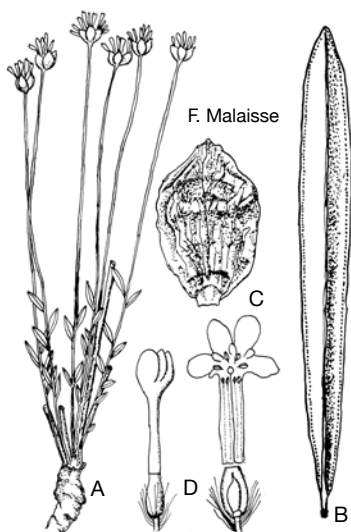
Habit: Perennial herb or undershrub, 10 cm to 1 m high, with a woody rhizome. Stems and branches glabrous, green to reddish, often brownish. Leaves sessile or shortly petiolate; leaf-blade linear to elliptic, obtuse to acute, 12-20 x 2-6 mm. Inflorescence a terminal or axillary, 15-25-flowered head. Bracts 5-6. Flowers orange-yellow or pink to red, 4-merous. Petals obovate to spatulate, 0.7-1.5 x 0.3-1.2 mm, often ± emarginated.

Ecology: Open and wooded grasslands, (copper) stony hills.

General distribution: From Nigeria to Ethiopia and southwards to Mozambique, Zimbabwe and Angola.

Distribution on Katangan copper sites (2 sites): Notably Kamatanda (73).

Reference: PETERSON [1978].



A. Flowering plant habit (x 0.4) – B. Leaf (x 3.9) – C. Bract (x 2.3) – D. Flower (x 2.6).

[Drawn after AYMONIN, 1966; BEAUMONT et al., 2001]

***Gnidia kasaiensis* S.Moore**

[Thymelaeaceae]

Holotype: Kassner 3322.
 Copper specimens: LLM 36; Mf-Kk 287.

Habit: Undershrub, up to 45 cm high, woody rootstock. Stems numerous, with leaves all the length. Leaves sessile, longer as internodes, 10-40 x 2-12 mm, linear-oval, rigid and papery. Inflorescence in corymbs of heads. Central head with more numerous flowers as external heads; bracts 2-6, persistent, oval, apex acute. Flowers 4-numerous, sepals orange to red, elliptic to oboval; petals 4, linear, 0.5-0.7 x 0.1 mm, floral tube 18 mm long. Stamens included, all similar, sessile, about 0.8 mm long.

Ecology: Wooded savannas, dambos, wooded valleys, rare on copper steppe savannas.

General distribution: D.R. Congo (Kasai and Upper Katanga).

Distribution on Katangan copper sites (1 site): Sokoroshe (83).

Reference: ROBYNS [1975].



Sokoroshe

Gnidia kraussiana Meissner var. **kraussiana**

[Thymelaeaceae]

Holotype: F. Krauss 455
Copper specimens: Mf 9573; Mf-Kk 111.

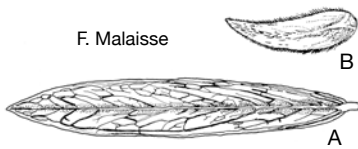
Habit: Perennial unbranched or branched herb from a thick woody base. Leaves with petiole 1-2 mm long; leaf-blade narrowly lanceolate or lanceolate to ovate, acute to obtuse, base tapering to rounded, larger leaves strongly nerved, glabrous to pubescent. Inflorescence

capitate, terminal, 18-45-flowered; peduncle 1-12 cm long. Bracts 5-10 lanceolate to ovate. Flowers yellow or orange, 5-merous; pedicel 1-3 mm long. Calyx-tube 7-12 mm long, lobes densely pubescent on the outside, shining golden yellow inside. Stamens subsessile, upper row usually exerted. Disc minute, ring-shaped.

Ecology: Grasslands, *Brachystegia* and *Uapaca* woodlands.

General distribution: From Guinea to Sudan and southwards to Angola and R.S.A.

Distribution on Katangan copper sites (5 sites): Notably Etoile (97).



A. Leaf (x 1.1) – B. Bract (x 4.4).
[Drawn after BEAUMONT et al., 2001]



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Zibwe valley road



© M. Schajjes

Kipushi-Kansanshi road

Gnidia kraussiana
Meissner var. **mollissima**
(E.A.Bruce) A.Robyns

Holotype: Burt 6115.
Copper specimen: Mf 11755.

Habit: Stems densely hirsute, leaves greyish; capitule sessile.

Distribution on Katangan copper sites (1 site): Mindigi (60).

Reference (for both varieties):
ROBYNS [1975].



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Mindigi

Holotype: Carson 1
Copper vouchers: LLM 4, 179, 189;
Mf 7969, 10393, 12173; Mf-Kk 236; Tr 1.

Habit: Woody erect low shrub 0.6-1.2 m tall, sometimes with the branches trailing, branches densely ferruginously stellate-hairy when young. Leaves deeply 5-7-partite or -digitate; segments or leaflets oblanceolate, with appressed-stellate hairs of two kinds, margin serrate, 1.7-7 cm long, 0.5-1.3 cm wide. Petals yellow, spatulate, 9-10 mm long. Fruit up to 3.5 cm in diameter, indehiscent, globose, completely covered by more than 100 weak aculei, + 1.5 mm long; each aculeus densely plumose, covered by reddish hairs in the lower part, with a single fine terminal seta.

Ecology: Steppe savannas on high Kalahari sandy plateaus and copper outcrops.

General distribution: Angola, D.R. Congo (Upper Katanga), Rwanda, Burundi, Tanzania, Zambia.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | XX | X | |
| wet | | | | |

→ eurycuproresistant

Distribution on Katangan copper sites (11 sites): Notably Lukuni (86).

Distribution on Zambian copper sites (1 site): Kansanshi (100).

Phytogeochemistry: Cu-Co content of leaves (6 samples): Cu = 10-725, Co = 0.6-126 µg/g D.M. Copper accumulator.

Rehabilitation: No precise interest.

Reference:
BRUMMITT, SEYANI [1978].



Luiswishi



Luanshya

© B. Letinturier

Triumfetta likasiensis De Wild.

[Tiliaceae]

Holotype: Robyns 1710.

Copper specimens: Mf 9872, 10883, 12140; Mf -Re 2071; Pj 95/226; Tr 95; Rw 1710.

Habit: Woody perennial procumbent sub-shrub; branches trailing, woody at base, densely stellate-hairy, annual shoots up to 75 cm long. Lower leaves trilobate, with sharp lobes, 5-7 basal nerves; upper leaves oval-elliptic, entire, rounded at apex. Flowers yellow, oboval, 3-6 mm long, Capsules globose, 1-2 cm in diam., indehiscent; aculei rigid, 0.8-1.2 mm long, with 1-(2) rigid seta.

Ecology: Medium copper rich steppe savannas, only one specimen from high plateaux Kalahari sands.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (29 sites): Notably Dikuluwe (2),

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| | | | |
|--------|-----|----|----|
| dry | | | |
| medium | (X) | XX | XX |
| wet | | | |

→ eurycuprophyte

Tilwezembe (20), Kasunki (22), Menda (28), Mindigi (60), Swambo (62), Kamoya (72), Kamatanda (73), Shituru (74), Likasi (75).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 40-152, Co = 71-120 $\mu\text{g/g}$ D.M.

Rehabilitation: Excellent facilitator according to the close carpets of procumbent stems that cover the soil surface.

Reference: WILCZEK [1963].



Chabara

Triumfetta rogersii N.E.Br.

[Tiliaceae]

Holotype: Rogers 26263.
Copper specimens: Mf 10867, 11439.
Syn.: *T. welwitschii* Mast. var. *rogersii* (N.E.Br.) Brummitt & Seyani.

Habit: Perennial herb; stems up to 40 cm, shortly stellate-pubescent throughout from a woody rootstock. Leaves up to 2.5 x 0.3 cm, linear, sparsely and shortly stellate-pubescent, sometimes glabrescent in age, crowded on stems. Stipules at base of stem up to 5 x 2.5mm. Fruiting heads 1-2 cm in diam., the aculei purplish and covered with stellate hairs which are very much shorter to slightly longer than the thickness of the aculeus, the base of the aculei usually clearly visible.

Ecology: Steppe savannas on medium copper rich soils, very rarely on high plateaus Kalahari sands.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |

| | | | | |
|--------|-----|----|----|--|
| dry | | | | |
| medium | (X) | XX | XX | |
| wet | | | | |

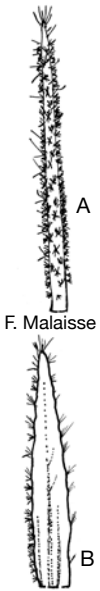
→ eurycuproresistant

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (15 sites): Notably Kalukundi (16), Tilwezembe (20), Kasunki (22), Shabara (24), Kasompi (27), Etoile (97).

Rehabilitation: No special interest.

Reference: BRUMMITT, SEYANI [1978].



A. Hair from fruit (x 6) – B. Stipule, inside view (x 6).
[Drawn after BRUMMITT & SEYANI, 1978]



Shabara



Shabara

Cyphostemma junceum (Webb) Wild & Drummond
subsp. **jatrophioides** (Baker) Verdc. [Vitaceae]

Holotype: Welwitsch 1474.
Copper specimen: MSK 49.
Syn.: *Cissus jatrophoides* (Baker)
Planch.

Habit: Erect herb, 0.9-1.8 m tall, often wine-coloured to glaucous when young. Orange ± ovoid rootstock. Stem often crimson, swollen at the nodes; plant glabrous, except for ciliate stipules; tendrils absent. Leaves very variable, the upper pair often opposite, often red or edged with red, digitately 3(-5)-foliolate; leaflets sessile, linear to oblong-elliptic, 2-30 x 4-10 cm, acuminate, apiculate at the apex, cuneate at the base, often folded, serrate or serrate-crenate; petiole 0-10 cm long; stipules lanceolate, 2.5-4 x 0.8-1 cm, ciliate. Cyme lax, terminal, usually with 3 main branches each again branched, up to 30 cm wide; peduncle to 25 cm long. Buds oblong-cylindric, ± 3 mm long, constricted just above the middle. Petals greenish red, greenish yellow or whitish. Ovary glabrous, disk crimson. Fruits reddish purple turning blue-black, or violet; 9-12 x 4-7 mm. Seed ellipsoid, 7 x 4 mm; dorsal ridges well marked, with few transverse ridges.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| medium | <X< | <X< | 5,000 | |
| wet | 800 | 5,000 | | |

dry
medium **XXX (X)**
wet

→ oligocuproresistant

Ecology: *Brachystegia* woodlands and copper steppe savannas ecotone.

General distribution: Guinea to Nigeria, and Angola to Tanzania and Mozambique.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: Pleasant habit.

Reference: VERDCOURT [1993].



Shadirandzoro



Fungurume

© F. Malaisse

Cyphostemma sessilifolium (Dewit) Desc.

[Vitaceae]

Holotype: Quarré 5329.

Copper specimens: Mf 16573;

Mf-Re 217; Qp 5329; Tr 175.

Syn.: *Cissus sessilifolia* Dewit

Habit: Prostrate herb from a tuberous rootstock; stems striate, pubescent. Leaves 3-foliolate, sessile; stipules triangular, 8 x 5 mm, glabrous, ciliate, caducous. Leaflets pubescent, ovate, cuneiform at the base, the median 10-16 x 4-9 cm, petiolule 2-10 mm long. Cymes compound, peduncle 5-9 mm long, bracts and bracteoles triangular, 1 x 0.25 mm, ciliate. Buds cylindrical, constricted at 1/3 superior, 3 x 1 mm; calyx 0.5 mm long, entire. Fruits reddish.

Ecology: Copper steppe savannas.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (5 sites): Kwatebala (45), Fungurume (51), Lukuni (86), Luiswishi (87), Etoile (97).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | | XX | X | |
| wet | | | | |

→ mesocuprophyte

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 17-59, Co = 66-313 µg/g D.M.

Rehabilitation: Facilitator.

Reference: DEWIT [1960].



Fungurume



Kwatebala

Exotic invaders of Cu-Co mining sites

Tithonia diversifolia (Hemsl.) A.Gray

[Asteraceae]

Copper specimen: Mf 16159 bis.

Habit: Tall perennial herb, woody stems, up to 3-(4) m high. Leaves alternate, petiolate, biauriculate, deeply 3-lobed. Capitula solitary on end of side-branches. Ray florets yellow or orange-yellow, ligule up to 6 cm long.

Distribution on Katangan copper sites (3 sites): Notably Fungurume (51).



Kolwezi

Tecoma stans (L.) Juss. ex Kunth

[Bignoniaceae]

Copper specimens: Mf 7713; Sm 1419; SDBS 27.

Habit: Much branched shrub, twigs reddish tan. Leaves opposite, pinnately compound, leaflets 3-7, ovate-lanceolate, apex acuminate, base acute. Flowers rather few; corolla bright yellow, narrowly campanulate. Capsule linear, compressed, 10-20 x 7-8 mm; seeds flat, with membranous transparent wing on each end.

Distribution on Katangan copper sites (2 sites): Luishia (77), Etoile (97).



Etoile

Bocconia arborea Watsons

[Papaveraceae]

Copper specimen: Mf 16144 bis.

Habit: Small tree, up to 7 m high, 25 cm in diam., bark thick, pale brown, corky, deeply fissured. Leaves up to 20 cm long, deeply pinatifid, base longly cuneate; mid-green above, grey-green beneath. Flowers in large, terminal, laxly branched panicles. Fruit 7 mm long, stipitate, with long persistent style.

Distribution on Katangan copper sites (3 sites): On mine embankments KOV, Musonoi.



Kov Mine



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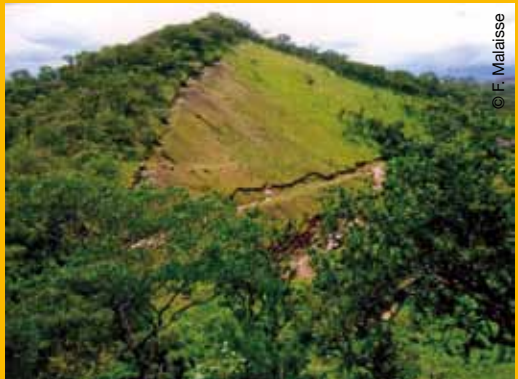
Shabara



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Katuto

Liliopsida
by Claire D'OUTRELIGNE,
Michel SCHAJES and
François MALAISSE



© F. Malaisse

Mwadikomba

Boophone disticha (L.f.) Herb.

[Amaryllidaceae]

Holotype: Thunberg s.n.
Copper specimen: Mf 10012.

Habit: Perennial herb, bulb up to 25 cm in diameter, the upper part with dry loose tunics of old leaf-bases, often emergent from the ground. Leaves grey-green or glaucous, up to 60 cm long, 1.5-4 cm broad, glabrous. Scape 5-30 cm long, with a globose inflorescence of 50 to more than 100 flowers. Flowers pink to dark purple; tube narrowly funnel-shaped, 0.5-2 cm long. Filaments 3-4.5 cm long; anthers yellow, 2.5-3.5 mm long. Style 5 cm long. Capsule triquetrous, up to 3 cm long, with irregular dehiscence.

Ecology: Steppe savannas on Kalahari sands, miombo, rarely copper steppe savannas.

General distribution: Rwanda, Burundi, Uganda, Kenya, Tanzania,

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuproresistant

Angola, D.R. Congo, Zambia, Malawi, Mozambique, Zimbabwe, Namibia, Botswana, R.S.A.

Distribution on Katangan copper sites (2 sites): Kabwelunono (34), Kasonta (91).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 28; Co = 6 µg/g D.M.

Rehabilitation: Pleasant habit.

References:

GEERINCK [1973].
NORDAL [1982].



Kolwezi-Mushima road



Mamfwe road



Biano plateau



Manika plateau

© M. Schafjies

© M. Schafjies

Crinum papillosum Nordal

Holotype: Bjørnstad 1108.

Copper specimens: Mf-Kk 820; Mal 127.

Habit: Bulb subglobose, 7-12 cm wide. Leaves green, distinctly ciliate, ± spreading on the ground, up to 40 x 6 cm, most leaves necrotic apically. Scapes 1-2, suberect, lateral, 3-17 cm long. Inflorescence 3-7-flowered. Perianth tube 11-12 cm long, segments connivent into a funnel, whitish with faint pink keel. Fruit subglobose, turning dull yellow.

Ecology: Steppe savannas on rocky slopes.

General distribution: Tanzania, D.R. Congo, Zambia.

Distribution on Katangan copper sites (3 sites): Notably Zikule (30).

Rehabilitation: Pleasant habit.

Reference: NORDAL [2008].



Kyamasumba muhulu



Kolwezi-Musokatanda road



Shadirandzoro

Scadoxus multiflorus

(Marty) Raf. subsp. ***multiflorus***
[Amaryllidaceae]

Holotype: From Sierra Leone (lost).

Copper specimen: Mf & al. 722.

Habit: Bulbous herb; pseudostem 5-20 cm long. Leaf blade ovate-lanceolate. Scape up to 50 cm long. Inflorescence globose, 14-200-flowered. Perianth tube 0.4-1.4 cm long; segments linear scarlet. Berries red.

Ecology: Dry forests, woodlands, termitaria; rare on copper steppe savannas with low copper content.

General distribution: Sudano-Zambeian region.

Distribution on Katangan copper sites (1 site): Fungurume (51).

Rehabilitation: Pleasant habit.

Reference: NORDAL [2008].



Kolwezi-Musokatanda road



Luvilombo river

***Albuca abyssinica* Jacq.**

[Asparagaceae]

Lectotype: t. 64 in Jacq. (1783).
Copper specimens: Mf 16240, 16553.

Habit: Perennial herb, 10-90 cm high. Bulbs up to 8 cm in diam. Scales with or without fibrous apex. Leaves lanceolate, up to 80 x 5 cm, ± ciliate to pubescent. Inflorescence a relatively lax raceme with 5-110 flowers; bracts lanceolate, up to 6 x 1 cm; pedicels 0.2-2 cm. Flowers nodding; perianth-segments 8-35 mm long, cream to yellow with a green midrib. Filament clasping the ovary. Ovary 3-7 mm long; style slender, 1.5-3 times as long as the ovary. Capsule 1-2 cm long. Seeds 3-7 mm across.

Ecology: Grasslands, also on copper steppe savannas.

General distribution: Widely distributed in Tropical Africa and extending to Arabia.

Distribution on Katangan copper sites (3 sites): Tilwezembe (20), Luiswishi (87), Etoile (97).

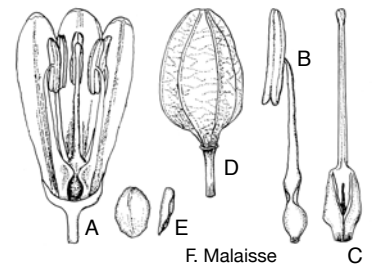
| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | | |
|--------|-----|---|--|--|
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

Rehabilitation: No evident interest, but very elegant habit.

Reference: STEDJE [1996].



A. Longitudinal section of flower (x 1.1) – B. Stamen (x 1.6) – C. Gynoecium (x 1.6) – D. Capsule (x 1.5) – E. Seed (x 1.1).

[Drawn after M. Tebbs in STEDJE, 1996].



Etoile mine



Kanzenze-Kyamasumba road



Mamfwe road

***Albuca* sp.**

[Asparagaceae]

Copper specimens: Mf-Hg 357, 365; MHK 869.

Habit: Perennial slender herb, mostly pending, flowering with the leaves. Bulb unknown. Leaves filiform, glabrous, 20-30 cm long, 1 mm wide. Inflorescence, a relative lax raceme with 6-18 flowers. Flowers white with a greenish midrib. Ovary 3-locular. Capsule ovoid, 3-lobed, 4-6 mm long. Seeds black.

Ecology: Cellular siliceous rocks, mostly on vertical walls, with locally some copper.

General distribution: Up to now restricted to 3 sites.

Distribution on Katangan copper sites (3 sites): Kakalalwe (38), Kamakonka (39), Katuto (41).



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Kakalalwe



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Katuto

Asparagus africanus Lam. var. *africanus* [Asparagaceae]

Holotype: Sonnerat s.n.
 Copper specimen: Mf-Kk 234.
 Syn. : *A. abyssinicus* Auct. non Hochst.
 ex A.Rich.

Habit: Erect or scandent subshrub, 0.5-3 m high, glabrous to puberulous, smooth, green. Spines straight or reflexed, sharp, 5-10 mm long. Cladodes 3-12 per fascicle, filiform, slightly curved, apiculate, unequally long, 5-15 mm long. Flowers 2-8 in each cladode fascicle; pedicels 5-10 mm long, articulated in lower half. Tepals narrowly obovate, 2.5-4 mm long, whitish. Stamens with small yellow anthers. Ovary with 4 ovules per locule. Berry 5-6 mm in diam., orange to red.

Ecology: Savannas, bushes, rarely in copper steppe savannas.

General distribution: From Eritrea and Ethiopia to D.R. Congo, Zambia, Botswana, Zimbabwe, Malawi, Mozambique, Namibia, Lesotho, Swaziland and R.S.A.

Distribution on Katangan copper sites (5 sites): Notably Fungurume (51), Luiswishi (87).

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| medium | <X< | <X< | 5,000 |
| wet | 800 | 5,000 | |

dry
 medium **XXX (X)**
 wet

→ oligocuproresistant

Rehabilitation: No evident interest.

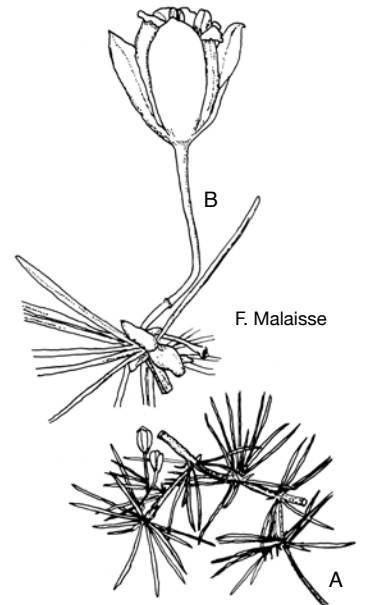
Reference: DEMISSEW [2006].



Fungurume



Fungurume Luiswishi mine



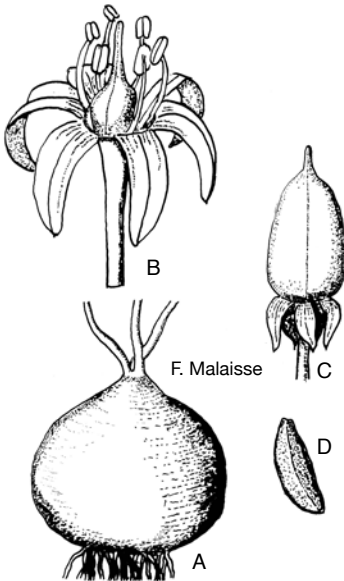
A. Branch with cladodes (x 0.8) –
 B. Pedicel with flower (x 2.3).

[Drawn after J. Williamson in DEMISSEW, 2006]

Bowiea volubilis Hook.f. subsp. **volubilis** [Asparagaceae]

Holotype: Cooper 3263.
Copper specimen: MSK 103.

Habit: Perennial geophyte. Leaves 1-2, linear, perishing early. Inflorescence glabrous, much branched, twining and climbing, up to several meters long; bracts narrowly triangular with a short spur. Flowers pedicellate, greenish; pedicels 2-5 cm long.



A. Bulb (x 0.4) – B. Flower (x 3) –
C. Capsule (x 1.2) – D. Seed (x 2).
[Drawn after M. Tebbs in STEDJE, 1996]



Mambilima

| Hydra- tation | Copper content of soil (in μg per g of soil) | | | |
|------------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Perianth-segments free, triangular with a rounded apex, \pm reflexed, 4-8 mm long. Filaments free; anthers oblong. Capsule ellipsoid, 9-25 mm, with a pointed apex. Seeds black and shiny, flattened, up to 10 mm long.

Ecology: Wooded grasslands, steppe savannas with low copper content.

General distribution: From Uganda southwards to R.S.A. and Angola.

Distribution on Katangan copper sites (1 site): Mambilima (50).

Rehabilitation: Pleasant habit.

Reference: STEDJE [1996].



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***Chlorophytum andongense* Baker**

[Asparagaceae]

Holotype: Welwitsch 3770.
Copper specimen: MSH 553.

Habit: Robust plant, 65-200 cm high. Rhizome short, thick, moniliform; roots spongy, fusiform, without tubers. Leaves rosulate, sheathing at the base, oblong-lanceolate, petiolate, glabrous, 25-80 x 3-8 cm. Peduncle terete, 5-7 mm in diam., with deciduous leaves all along. Inflorescence a lax panicle, much exserted above the leaves, up to 80 cm long. Pedicels articulated above the middle, up to 30 mm long in fruit. Flowers \pm pendulous, often congested; perianth greenish to whitish, urceolate; tepals 12-20 x 2-3 mm, with ligulate

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | X | | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

rims above the constriction to the cup, 3-veined. Capsule obovoid, nearly rounded in cross-section, 10-12 mm long. Seed disc-shaped, 3 mm in diam.

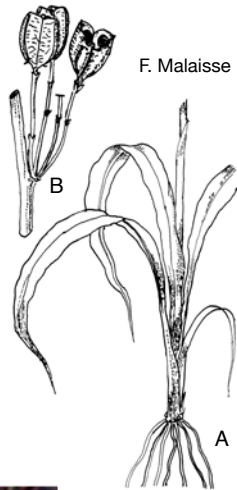
Ecology: Open woodlands, often on termite mounds, also *Uapaca* belts on copper hills.

General distribution: From Guinea and Sierra Leone to Sudan, and southwards to Angola, Zimbabwe and Mozambique.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Rehabilitation: Pleasant habit.

Reference: NORDAL et al. [2000].



A. Habit (x 0.1) –
B. Fruiting node (x 0.6).
[Drawn after NORDAL et al., 2000]

Kazinyanga

Chlorophytum bleparophyllum* Baker var. *amplexicaule
(Baker) Meerts [Asparagaceae]

Holotype: Cameron s.n.
Copper specimen: Mf-Hg 214.

Habit: Plant 15-35 cm high, drying blackish. Rhizome short; roots ± spongy, apparently without tubers. Leaves 4-7 to a plant, rosulate, broadly lanceolate, strongly clasping the peduncle, superposed, chartaceous, lower ones cordate-ovate, upper ones oblong, purplish-green below, dull green above, acute; margins thinly membranous, often with a red-purplish tinge, lamina glabrous, 4-25 x 4-15 cm. Peduncle covered by leaves for almost its entire length, terete, glabrous. Inflorescences exserted, with up to 4 racemes, each with a single lanceolate bract at the base, narrowed above to a soft awn point, up to 15 mm long, brown, later turning blackish. Pedicels short, articulated above the middle, lower ones 2-5-nate, ca 5 mm in fruit. Perianth brownish-white, 7 mm long; segments 5-nerved. Stamens as long as the perianth; anthers 2 mm long, shorter than the filliform filaments.

Ecology: In woodlands, also in copper steppe savannas with low copper content.

General distribution: D.R. Congo, Tanzania, Zambia.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XX | X | |
| wet | | | |

→ oligocuprophyte

Distribution on Katangan copper sites (1 site): Kabwelunono (34).

Reference: KATIVU et al. [2008].



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Kabwelunono



Kabwelunono



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Shadirandzoro



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Kabwelunono

***Chlorophytum calyptrocarpum* (Baker) Kativu**

[Asparagaceae]

Holotype: Welwitsch 3796.
 Copper specimen: Mf 10959.
 Syn.: *Anthericum calyptrocarpum* Baker

Habit: Plant small, grass-like, clumped, 15-35(85) cm high. Rhizome short, moniliform. Roots spongy, cylindrical, often reduced to elongate sessile tubers, white, filiform. Leaves fascicled, up to ten to a plant, more or less terete, dull green. Peduncle bracteate, glandular spotted. Inflorescence a deltoid panicle. Tepals white, with greenish-brown median line outside; filaments and style white, anthers orange, ovary green. Flowers open one at a time on each inflorescence.

Ecology: Exposed rocks in open miombo woodlands, also in copper steppe savannas.

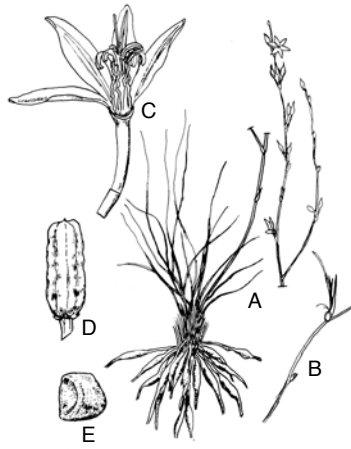
General distribution: From Angola to Tanzania and southwards to R.S.A.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-----|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | X | | |
| wet | X | X | | |

→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Notably Etoile (97).

Reference: KATIVU et al. [2008].



F. Malaisse

A. Habit (x 0.4) – B. Portion of inflorescence with plantlet (x 0.6) – C. Flower with 2 petals removed (x 3.2) – D. Capsule uncovered (x 3.8) – E. Seed (x 10). [Drawn after E. Catherine in NORDAL et al., 1997]



Etoile mine



Etoile mine (February, 1987)

***Chlorophytum colubrinum* (Baker) Engl. [Asparagaceae]**

Holotype: Welwitsch 3784.

Copper specimens: DKM 1875; MMK 56.

Syn.: *Dasystachys verdickii* De Wild.

Habit: Plants often in clumps, 20-150 cm high. Rhizome thick, moniliform, horizontal. Leaves subdistichous, sheathing at the base, linear to linear-lanceolate, firm, 12-75 x 0.5-2.5 cm. Peduncle terete, glabrous, 20-95 cm long, with bract-like leaves along its entire length. Inflorescence a narrow subspicate raceme, often dense, exerted above the leaves, 10-30 cm long; rachis angled, winged. Pedicels articulated at the apex. Perianth white, ± bell-shaped; tepals connate, cucullate, 6-10 x 1.5-3 mm, 1-veined. Capsule obovoid, triquetrous; seed disc-shaped.

Ecology: Open miombo woodlands, wooded grasslands, often on stony,

| Hydra-tation | Copper content of soil (in µg per g of soil) | | |
|--------------|---|-------|---------|
| normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | X | X | |
| wet | X | X | |

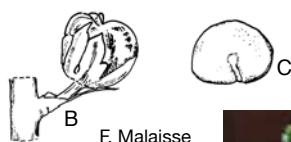
→ oligocuproresistant

gravely, light soils, also in copper steppe savannas.

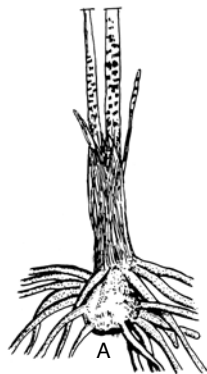
General distribution: Angola, D.R. Congo, Rwanda, Burundi, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (9 sites): Notably Kavifwafwaulu (42), Kwatebala (45), Fungurume (51), Luiswishi (87).

Reference: KATIVU et al. [2008].



F. Malaisse



A. Base of plant (x 0.2) –
B. Fruiting node (x 1.9) –
C. Seed (x 3.5).

[Drawn after
E. Catherine in NORDAL
et al., 1997]



Kabwelunono



Luiswishi



Fungurume



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Chlorophytum cordifolium De Wild.

[Asparagaceae]

Holotype: Homblé 788.
 Copper specimens: Mf 16646, 16713;
 Mal 232, 270, 447; MKS 562, 598.
 Syn.: *C. unifolium* Malaisse & Bamps

Habit: Perennial erect herb up to 20 cm high. Rhizome thick, roots fusiform, 5-6 cm long, spreading ± horizontally, and bearing radicles. Cataphylles 3, sheath-formed, flared above. Leaf 1, lamina oval, apex acuminate, mucronate, base cordate, 5-8 x 4-6.5 cm, margin chartaceous and crenulate; nerves numerous, parallel and curve. Floral scape 12-21 cm long, lower part ± completely locked in petiole. Raceme 3-7 cm long. Flowers mostly 3-clustered, pedicels articulated in upper part at 2/3; tepals 3 + 3, greenish with white margin, 4-5 x 1.5 mm, glabrous. Capsules triquetrous, 5.5 x 5 mm. Seeds ± flat, reniform, 2.5 mm in diam., black, finely and densely hillocky.

Ecology: Ecotone copper steppe savannas with low copper content and surrounding wooded savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | | |
|--------|---|---|--|--|
| dry | | | | |
| medium | X | X | | |
| wet | | | | |

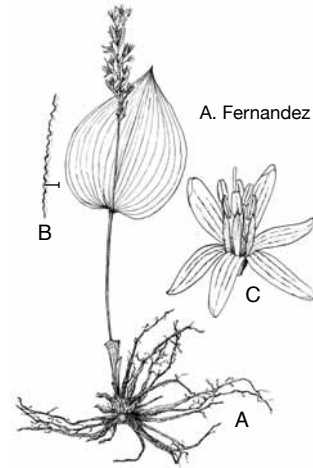
→ oligocuproresistant

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Rehabilitation: No evident interest.

Reference: MALAISSE, BAMPS [2009].



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A. Habit (x 0.3) – B. Lamina margin (x 2) – C. Flower (x 0.3). [MALAISSE, BAMPS, 2009]



Kavifwafwaulu



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Chlorophytum macrophyllum (A.Rich.) Aschers

[Asparagaceae]

Holotype: Quartin-Dillon s.n.
Copper specimens: Mf 16585; MSH 556.

Habit: Plant 20-80 cm high, drying yellowish brown to olive-green. Rhizome short, compact; roots medium thick, expanding to spindle-shaped tubers up to 3 cm long. Leaves rosulate, not petiolate, broadly lanceolate, 10-70 x 3-10 cm, with undulate or crisped margins, glabrous. Peduncle terete, leafless, stout, erect, up to 50 cm long, glabrous. Inflorescence up to 30 cm, usually unbranched; rachis glabrous; floral bracts 2.5-3 cm long. Pedicels articulated in the upper half, whitish, 10-14 mm long. Perianth whitish, turning brownish after anthesis, tepals semi-patent, 8-15 x 2-4 mm, usually 5-veined. Stamens equal to the tepals. Style declinate. Capsule deltate, emarginated, 6-11 mm long, blackish when dehiscent. Seeds saucer-shaped, 2-2.5 mm in diam.

Ecology: Dry evergreen forests and open woodlands, also rarely

| Hydra-tation | Copper content of soil (in μg per g of soil) | | | |
|--------------|--|-----|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | | <X< | <X< | |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | X | | | |

→ oligocuproresistant

on termite mound in copper steppe savannas.

General distribution: From Senegal to Ethiopia, and southwards to Mozambique and Zimbabwe.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Rehabilitation: Pleasant habit.

Reference:

NORDAL et al. [1997].



Kazinyanga

Chlorophytum pusillum Baker

[Asparagaceae]

Holotype: Schweinfurth 2043.
Copper specimen: Mf 13067.

Habit: Plant small, often in patches, up to 3.5 cm high. Rhizome not distinct; roots short, ± spongy, with elongated tubers. Leaves rosulate, ± prostrate, 1-4 to a plant, rarely more, oblanceolate, thinly membranaceous, glabrous, 5-15 x 3-10 cm; margins crisped. Peduncle up to 1 cm long. Inflorescence unbranched, dense, 2-5 cm long, several at each node. Pedicels without articulation, 1-5 mm long. Perianth white; tepals 4-5 x 1 mm, 3-veined. Stamens as long as perianth; filaments fusiform and papillate, 2.5-5 mm long, longer than the anthers. Ovary sessile, with ± 5 ovules per locule; style straight, as long as the stamens. Capsule shallowly deltoid, smooth, 4 x 3 mm.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | X | | |
| wet | | | | |

→ oligocuproresistant

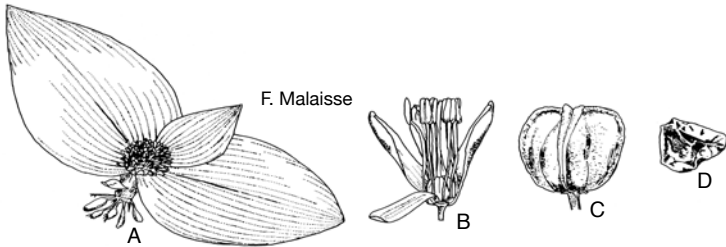
Seeds slightly folded, saucer-shaped, 1.5 mm in diam.

Ecology: Woodlands, often in rock crevices, also on termite hills and in copper steppe savannas.

General distribution: From Senegal to Sudan, and southwards to Zimbabwe.

Distribution on Katangan copper sites (3 sites): Notably Kwatebala (45).

Reference: NORDAL et al. [1997].



A. Habit (x 0.3) – B. Flower with 2 tepals removed (x 3) – C. Capsule (x 3) – D. Seed (x 6).

[Drawn after E. Catherine in NORDAL et al., 1997]



Near Fungurume



Kinsevere

Chlorophytum rubribracteatum (De Wild.) Kativu
[Asparagaceae]

Holotype: Hock s.n.
Copper specimens: LLM 1; MSK 213.
Syn.: *Anthericum rubribracteatum*
De Wild.

Habit: Plant tufted 10-40 cm high. Rhizome short, horizontal, moniliform, covered with fibrous remains of old leaf-bases; roots many, fibrous, slender, bearing tubers at the tips. Leaves distichous, grass-like, linear, ciliate, rarely minutely pubescent, often with a purplish-pink tinge, up to 30 x 0.2-0.4 cm; margins minutely scabrid to ciliate near the base; cataphylls with purple coloration, shortly ciliate on margins and veins, occasionally glabrous. Peduncle terete, often purplish, glabrous, up to 20 cm long. Inflorescence unbranched. Pedicels articulate below the middle, often pinkish, up to 9 mm long in fruit, 2-nate at the lower nodes. Perianth open, star-shaped; tepals 10-13 x 3-5 mm, 5-7-veined, outer ones pinkish-red, inner ones white with the keel pinkish. Stamens with radial symmetry, shorter than the perianth; filaments terete, 2-3 mm long, equal to shorter than the anthers. Style

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | X | | | |
| medium | XX | X | | |
| wet | X | | | |

→ oligocuproresistant

declinate, exserted; stigma pinkish. Capsule reddish, shallowly 3-lobed in cross-section, transversely ridged, emarginated, 6-8.5 mm long. Seeds irregularly folded, ± 1 mm in diam.

Ecology: Miombo open forests, grasslands margins, rocky outcrops, also copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Burundi, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (5 sites): Mwadikomba (47), Shadirandzoro (48), Fungurume (51), Kazinyanga (49), Luiswishi (87).

Rehabilitation: Pleasant habit.

Reference: NORDAL et al. [1997].



Luiswishi



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Chlorophytum stolzii (K.Krause) Kativu [Asparagaceae]

Holotype: Stolz 339.
 Copper specimens: DKM 3592;
 Mf 10354, 10959, 12888; Mf-Gp 44.
 Syn.: *Albuca stolzii* K. Krause.

Habit: Plant robust, 80-250 cm high. Rhizome moniliform, with corm-like elements; roots many, thin to slightly spongy, bearing long tubers at the tips. Leaves distichous or nearly so, firm, broadly linear, up to 80 cm long, 2-3.5 cm wide; cataphylls papery. Peduncle terete, with bract-like leaves, glabrous, up to 2 m long. Inflorescence unbranched, up to 70 cm long. Perianth white with green keel, sometimes slightly pinkish; tepals 12-20 x 3-7 mm, 3(-5)-veined. Stamens 3 + 3 or 2 + 4. Capsule obovoid, shallowly transversely ridged, 10-12 mm long.

Ecology: Open miombo woodlands, wet places, also in copper steppe savannas.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |

| dry | | |
|--------|---|---|
| medium | X | X |
| wet | | |
| | X | X |

→ oligocuproresistant

General distribution: Angola, D.R. Congo, Burundi, Tanzania, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (5 sites): Notably Fungurume (51), Luiswishi (87).

Rehabilitation: Pleasant habit.

References:

DUVIGNEAUD, DENAEYER-DE SMET [1963].
 NORDAL et al. [1997].



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Kazinyanga



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Fungurume



© M. Schajjes

Likasi-Kolwezi road



© M. Schajjes

Likasi-Kolwezi road

Chlorophytum subpetiolatum* (Baker) Kativu var. *subpetiolatum

[Asparagaceae]

Holotype: Kirk s.n.

Copper specimens: LLM 43; Mf 16443; MKS 546, 732.

Habit: Plant variable, clumped or simple, 10-40 cm high. Rhizome thick, occasionally tuberous, bearing fibrous remains of old leaf-bases; roots spongy, swollen at the base. Leaves linear-lanceolate to lanceolate, 5-30 x 0.5-5 cm. Inflorescence, a lax raceme; pedicels articulate below the middle. Perianth star-shaped, white; stamens shorter than tepals. Capsule shallowly 3-lobed, 5-9 x 6-8 mm. Seeds irregularly folded.

Ecology: All kinds of woodland, grasslands, rocky soils, also copper steppe savannas.

General distribution: Widespread from Nigeria to Ethiopia and south to Angola, Zimbabwe, Mozambique.

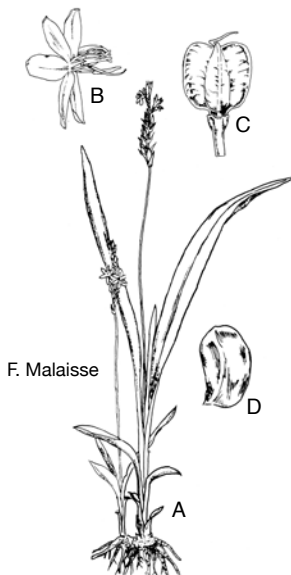
Distribution on Katangan copper sites (5 sites): Notably Kabwelunono (34), Shimbidi (35), Kwatebala (45).

Rehabilitation: Pleasant habit.

Reference: NORDAL et al. [1997].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | X | X | (X) | |
| medium | X | | | |
| wet | XXX | | | |

→ oligocuproresistant



A. Habit (x 0.17) – B. Flower (x 0.9) – C. Capsule (x 1.8) – D. Seed (x 5.5). [Drawn after E. Catherine in NORDAL et al., 1997]



Kwatebala



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Dipcadi sp. 1

Copper specimens: LLM 37, 55; MSK 140, 176, 203.

Habit: Perennial geophyte, 15-40 cm high. Bulb 1-3 cm in diam. Leaves 1-4 per shoot, 6-25 cm long, 3-7 mm broad, shiny, flaccid, somewhat succulent. Raceme central, ± few flowered. Flowering early rainy season (November). Flower yellow-brown, with unequal perianth-segment; outer usually recurved from the middle, lanceolate, with a short appendage, 5-10 mm long; inner forming a connivent tube, lanceolate, acute, with the tips curved outwards. Capsule subspherical, trigonous, 5-10 x 6-12 mm.

Ecology (for both species): Grasslands, wooded grasslands, copper steppe savannas.

Distribution on Katangan copper sites (12 sites): Tenke (32), Kabwelunono (34), Kakavilondo (36), Katuto (41), Kavifwafwalu (42), Mwinansefu (43), Shinkusu (44), Mwadikomba (47), Mambilima (50), Kakalalwe (38), Fungurume (51), Etoile (87).



Isi



Shinkusu

Dipcadi sp. 2 [Asparagaceae]

Copper specimens: Mal 875, 971.

Habit: Perennial geophyte, 25-50 cm high. Bulb 1-3 cm in diam. Leaves 3-6 per shoot, 10-35 cm long, 3-7 mm broad. Raceme central, many flowered. Flowering late rainy season (March). Flower yellow-green to green, with unequal perianth-segment; outer usually erect, linear, with a long, filiform appendage, 10-20 mm long; inner forming a connivent tube, acute, with the tips erect. Capsule oblong to cylindrical, 10-25 x 5-8 mm.



Mwinansefu



Fungurume

Eriospermum flagelliforme (Baker) J.C.Manning
 [Asparagaceae]

Holotype: Schweinfurth 26.
 Copper specimens: Dp 2227 Er, 2893 E, 4063 E, 4073 E, 4101 E, 4435 Eri, 4586 E, 4626 E, 4650 E; LLM 7, 37, 55; Mf 9570; Mf-Gp 316; PI 41/615; Sa 333, 12201; Sm 6044.
 Syn.: *E. abyssinicum* Baker

Habit: Perennial herb with hysteranthous leaves, solitary, inflorescence 3-40 cm high. Tuber depresso-globose, up to 42x 40 mm; skin dark brown. Leaf solitary, erect; lamina narrowly lanceolate to falcate, cuneate, acuminate, mucronate up to 1 x 1.7 cm, glaucous green, coriaceous. Flowers campanulate; tepals lemon to yellow with a green midnerve overlaid with red streaking. Fruit turbinate 8 x 6 mm. Seeds 6 x 2 mm, hairs dense.

Ecology: Most frequently on sandy or well drained soils among rocks, including copper rocky steppes.

General distribution: From Senegal to Ethiopia and southwards to R.S.A.

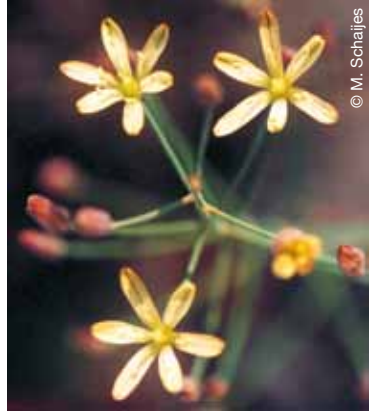
Distribution on Katangan copper sites (21 sites): Notably Kela (52).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 54-75; Co = 9-13 µg/g D.M.

References: PERRY [1994; 2010].

| Hydratation | Copper content of soil | | | |
|-------------|------------------------|-----|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | XXX | XX | X | |
| medium | | | | |
| wet | | | | |

→ mesocuproresistant



© M. Schallies

Manika plateau



© F. Malaisse

Dikuluwe



© M. Schallies

Biano plateau



© I. Parmentier

Mambilima

Ledebouria revoluta (L.f.) Jess.

[Asparagaceae]

Holotype: Thunberg s.n.

Copper specimens: Mf 7924, 12435; Mf-Kk 638, 775; MKS 554; MSK 91.

Habit: Small to relatively robust perennial herb; 9-45 cm high. Bulb ovoid, 25-75 mm long and in diam. Leaves 4-8, developing variously before flowering, up to 150 x 30 mm, linear-lanceolate in early stage, later ovate to lanceolate, often narrowing to the base. Inflorescence 1-(2), erect or suberect, lax to dense, usually with fewer than 100 flowers; pedicels 2-9 mm. Perianth segments greenish to pink or purple. Filaments filiform. Ovary ± 1 mm long; style 2-5 mm long. Capsule subglobose or sometimes schizocarpous. Seeds 3 per capsule, 3-4 mm long.

Ecology: Grasslands, rocky places, often also on copper steppe savannas.

General distribution: Widespread in tropical and southern Africa.

Distribution on Katangan copper sites (6 sites): Zikule (30), Goma (33), Kwatebala (45), Kazinyanga (49), Luiswishi (87), Etoile (97).

Rehabilitation: Pleasant habit.

References:

JESSOP [1970].
STEDJE [1996].

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | XX | X | | |
| medium | XX | | | |
| wet | | | | |

→ oligocuproresistant

Note: Recognizable as a genus, but extremely difficult to identify at species level. Entirely different specimens are found. We show images of various specimens encountered. *L. revoluta* is the most probable, but in need of further studies.



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Near Fungurume



© F. Malaisse

Kwatebala



© L. Lemaire

Etoile



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Potopoto valley

Littonia lindenii Baker

[Colchicaceae]

Holotype: Linden s.n.
Copper specimens: MKS 782, 824, 852, 1010.

Habit: Erect or scrambling herb, arising from a tuber; stem leafy. Leaves oblong to lanceolate, acute, sessile, subcoriaceous, glabrous, sometimes obscurely uncinuate at the tip. Flowers pendulous on rather long stalks; perianth bellshaped, 2.5-3 cm long, with 6 pointed lobes, deep orange; stamens less than half as long as the perianth; anthers linear, 3 mm long; style trifid to the base. Fruit, a fleshy capsule.

Ecology: Upland grasslands, open forests (miombo), also in copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia, Malawi.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | (X) | | |
| medium | X | X | | |
| wet | X | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (5 sites): Zikule (30), Kwatebala (45), Mwadikomba (47), Kazinyanga (49), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 23, Co = 31 µg/g D.M.

Rehabilitation: Pleasant habit.

Reference: BURROWS, WILLIS [2005].



Tenke-Kando road

© M. Schaeffers



F. Malaisse
Stamens and ovary (x 4). [Original plate]



Mwadikomba

© F. Malaisse



Shadirandzoro

© F. Malaisse

Aneilema sp.

[Commelinaceae]

Copper specimens: Mf 7924, 12435; Mf-Kk 638, 775; MKS 554; MSK 91.

Habit: Perennial geophyte, fusiform tubers, 8-12 cm long; shoots erect to ascending, 15-40 cm tall. Leaves spirally arranged; lamina cordate to mostly lanceolate, apex acute, 5-15 cm long. Inflorescence terminal, solitary thyse, ovoid to cylindrical, 2-4 x 2-3 cm. Paired petals white; lower petal light green. Stamens with white filaments and yellow anthers.

Ecology: Steppe savannas with low copper content.

Distribution on Katangan copper sites (3 sites): Notably Kakavilondo (36).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | XX | X | | |
| medium | XX | | | |
| wet | | | | |

→ oligocupproresistant

Reference: FADEN [2012].

Note: R. Faden (in litt.) points out concerning this taxon, its affinity with *Aneilema welwitschii* C.B. Clarke. The very variable morphology of this last species is well known; the paired petals are yellow. We need to have more than flower color to separate this taxon from *A. welwitschii*; seeds are notably wanted.



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Kakavilondo

Commelina transversifolia De Wild.

[Commelinaceae]

Holotype: Homblé 731.
Copper specimen: Mf 16402.

Habit: Perennial herb.

Ecology: High plateau wooded and copper steppe savannas.

General distribution: Known from 2 sites in Katanga.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



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Kavifwafwaulu

Commelina velutina Mildbr.

Holotype: Mildbraed 9604.
Copper specimens: Tr 252, 264.

Ecology: Grasslands, often also in copper steppe savannas.

Distribution on Katangan copper sites (1 site): Notably Tilwezembe (20).



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Tilwezembe



© J. Lebrun

Mambilima



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Kinsevere

Commelina zigzag

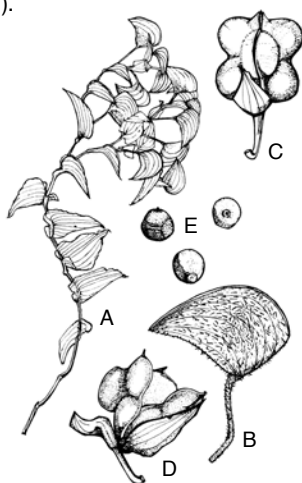
P.A.Duvign. & Dewit

Holotype: Duvigneaud 5025 C.
Copper specimens: Dp 5025 C; Tr 263.

Ecology: Mainly rocky copper steppe savannas.

General distribution: Katanga.

Distribution on Katangan copper sites (4 sites): Notably Fungurume (51).



A. Habit (x 3.5) – B. Spathe (x 1.2) – C. Closed capsule (x 3) – D. Open capsule (x 3) – E. Seeds (x 3).

[DUVIGNEAUD, DENAYER-DE SMET, 1963]

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Cyanotis caespitosa

Kotschy & Peyr.

Holotype: Tinne 6.

Copper vouchers: Mf 16381; MKS 667.

Syn.: *C. cupricola* P.A.Duvign.

Habit: Perennial herb, with a stout hairy base. Leaves in a radical rosette. Purple flowering stems, 3-30 cm high. Outer bract of each cincinnus not exceeding. Flowers blue, lilac, purple or white, with blue staminal hairs and yellow anthers.

Ecology: Grasslands, woodlands, rocky copper steppes, mainly on rock heaps workings from mine trenches.

General distribution: Ivory Coast to Sudan and Ethiopia, southwards to Angola, D.R. Congo and Zambia.

Distribution on Katangan copper sites (4 sites): Notably Kavifwafwaulu (42).



Kavifwafwaulu



Fungurume



Kavifwafwaulu

Cyanotis longifolia Benth.

[Commelinaceae]

Holotype: Speke & Grant s.n.

Copper vouchers: Mf 14230, 10131, 10488.

Habit: Perennial herb, more or less erect, up to 40 cm tall, growing from a dense spreading cluster of fleshy, swollen roots. Leaves mostly basal, linear, up to 30 cm long, covered with spreading hairs, particularly near the base. Flowers in terminal or pseudo-axillary clusters held in 2 fleshy leaf-like bracts exceeding the cincinni; tepals blue or mauve; stamens embedded in dense blue hairs.

Ecology: Woodlands and copper steppe savannas.

General distribution: Tropical Africa.

Distribution on Katangan copper sites (19 sites): Notably Fungurume (51), Kalabi (69).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 157-448; Co = 7-226 µg/g D.M.



Kwatebala



Fungurume

Costus spectabilis (Fenzl) K.Schum.

[Costaceae]

Holotype: Boriani s.n.
Copper specimen: Ra-Kk-It 99.

Habit: Perennial herb. Leafy stem borne laterally on the rhizome, erect, bearing several reduced leaves and (3)-4 broadly spatulate leaves, imbricate, arranged like a cross, lying flat on the ground. Lamina of normal leaves 4-17 cm broad and long, obtuse to retuse at apex, cuneate at base, glabrous above, green or yellowish-green with a pink, or brownish or reddish margin. Inflorescence terminal, arising at centre of leaf-rosette, 6-12-flowered, usually only one flower open at any time. Calyx tubular 2.5-4.5 cm long; petals 3, yellow, rarely bright orange. Fertile stamen 4.5-6 cm long, petaloid, narrowed above anther; anther-thecae 5-7 mm long.

Ecology: Grasslands, deciduous woodlands, often around termitaria, ecotone of copper steppe savannas.

General distribution: From Sierra Leone to Ethiopia, and southwards to Zimbabwe and Angola.

Distribution on Katangan copper sites (2 sites): Mwadikomba (47), Kazinyanga (49).

Reference: LOCK [1985].



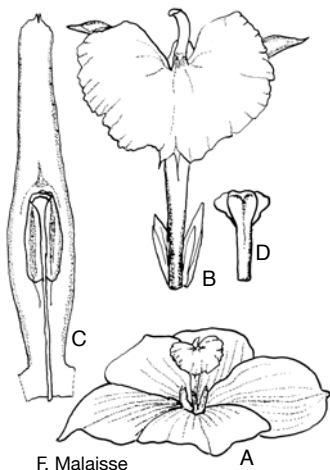
Shadirandzoro



Shadirandzoro



Lufupa north falls road



F. Malaisse

A. Habit (x 0.15) – B. Flower (x 0.4) – C. Stamen and style (x 1.2) – D. Stigma, rear view (x 3.5).
[Drawn after C. Grey-Wilson in Lock, 1985]

Ascolepis metallorum P.A.Duvign. & G.Léonard

[Cyperaceae]

Holotype: Duvigneaud 3061.
Copper specimens: Ba 375; Bp 805;
Mf 9903.

Habit: Perennial erect herb, up to 25 cm high. Base bulbous, globosel, greyish. Stems canaliculate, 0.5-0.7 in diam. Leaves cylindrical, recurvate, glabrous, linear, 10 cm x 0.3-0.5 mm. Inflorescence hemispherical, white, 3-5 bracts threadlike, 2-3 cm long.

Ecology: Mainly wet copper steppe savannas; also zinc lawns.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (17 sites): Notably Lukuni (86).

Phytochemistry: Cu-Co content of leaves (3 samples): Cu = 12-134, Co = 64-129 µg/g D.M.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | | X | | |
| wet | (X) | XX | X | |

→ mesometallophyte

Rehabilitation: Good aptitude for covering and stabilisation of wet sites with medium to high copper content.

Reference: DUVIGNEAUD [1958].



Etoile Mine

© J. Piqueray



Fungurume

© F. Matasse



Etoile Mine

© J. Piqueray

***Ascolepis protea* Welw. var. *anthemiflora* (Welw.) Goetgh.**
[Cyperaceae]

Holotype: Welwitsch 1669.

Copper specimens: Mf-Kk 9; Tr 195.

Habit: Tufted perennial herb, single- or few-stemmed, stem 10-60 cm tall, obscurely 3-angled, 0.5-2 mm across, bases swollen and with dense bundles of fibrous leaf-bases; rhizome short, creeping or erect. Leaves 7-23 x 0.1-0.2 cm, bases dark brown. Involucral bracts pale green, 1.5-10 cm long. Inflorescence ± flattened, 15-25 mm in diam.; glumes bright or golden yellow, 3-10 mm long, the marginal ones elongated and 5-10 mm long, their tips dorsiventrally flattened, apex broadly rounded, central glumes hardly elongated and 3-5 mm long. Nutlets metallic grey, obovoid, 0.6-1.2 x 0.3-0.6 mm, tuberculate.

Ecology: Grasslands, also on copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | | X | | |
| wet | X | X | X | |

→ mesocuproresistant

Distribution on Katangan copper sites (6 sites): Notably Shituru (74). Also around Kolwezi on copper polluted sandy wet deposits (Musonoi).

Reference: HOENSELLAR et al. [2010].



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Near Musonoi river

Bulbostylis cinnamomea (Boeck.) C.B.Clarke [Cyperaceae]

Holotype: Buchanan 29.

Copper specimens: Mf-Kk 2; Tr 239.

Habit: Cespitose perennial herb. Stems glabrous; stem base mostly covered by pale brownish living leaf sheaths. Leaves 0.5-1 mm wide. Inflorescence head-like, involucre bracts without long white hairs; glumes (4)5-6(7) mm long, rounded-emarginated to bifid, often fimbriate, mid-nerve not reaching the tip, typically cinnamon-coloured, but sometimes darker. Wall of fruit transversely rugose, base of style persistent.

Ecology: Riverine swamps, dembos, also wet copper polluted soils.

General distribution: East Tropical Africa, D.R. Congo (Upper Katanga), Zambia, Zimbabwe, Madagascar, Mauritius.

Distribution on Katangan copper sites (2 sites): Kingamyambo (8), Mutoshi (10). Also around Kolwezi on copper polluted sandy deposits (Musonoi).

Reference:

GOETGHEBEUR, COUDIJZER [1985].

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| dry | <X< | <X< | > | 5,000 |
| medium | | 800 | 5,000 | |
| wet | XXX | (X) | | |

→ oligocupproresistant



Kingamyambo mine



Near Musonoi river

Bulbostylis cupricola Goetgh.

[Cyperaceae]

Holotype: Lisowski 5248.
Copper specimens: Mf 9225, 9771,
11523, 11658; Mf-Gj 52; Rw 1698.

Habit: Rather slender annual, stem
5-15 cm high, solitary or fasciculate,
erect. Stem and inflorescence
branches shortly hairy, involucrel
bract glabrous. Fruit 0.7 x 0.4 mm,
with silica deposits on the tangential
walls of the epidermal cells.

Ecology: Copper steppe savannas,
mainly on rocky sites, also on copper
polluted soils as well as on sites of
washing of extracted rocks.

General distribution: Distribution
restricted to Upper Katanga on copper
orebodies, as well as on one mining
site of the Zambian Copperbelt.

**Distribution on Katangan copper
sites** (23 sites): Notably Tantara (63).

**Distribution on Zambian copper
sites** (1 site): Roan Antelope (147).

**Also on copper polluted soils in
Katanga** (Kinganyambo, Tilwezembe).

Phytogeochemistry: Cu-Co content
of leaves (5 samples): Cu = 20-

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-----|
| | normal | 200 | 800 |
| | <X< | <X< | |
| | 800 | 5,000 | |
| dry | X | | |
| medium | XX | | |
| wet | X | | |

→ oligocuprophyte
948 µg/g; Co = 85-771 µg/g D.M.
Values need confirmation.

Rehabilitation: Great interest, even if
it is an annual plant. Able to develop
into a closed lawn.

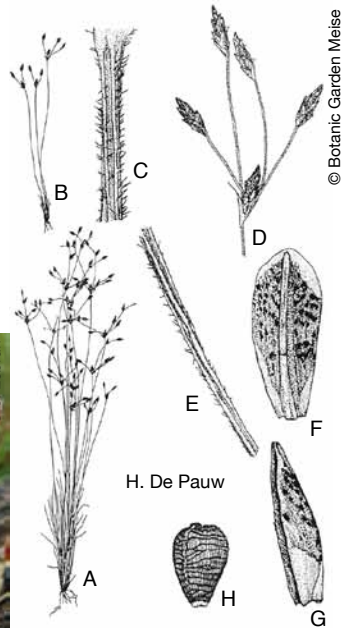
Reference: GOETGHEBEUR [1984].



Roan Antelope



Shadirandzoro



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A-B. Habit (x 0.3) – C. Tip of stem
(x 12) – D. Inflorescence (x 1.9) –
E. Inflorescence branch (x 28) –
F-G. Glume, dorsal and inner views
(x 12) - H. Fruit (x 15).

[GOETGHEBEUR, 1984]

Bulbostylis filamentosa

(Vahl) C.B. Clarke

Holotype: Thonning s.n.

Copper specimens: Mf-Kk 293;

MKS 109, 110.

Habit: Cespitose perennial herb. Culms 20-70 long, 0.6-1.0 mm thick. Leaves 10-15 cm x 0.3-0.5 mm. Inflorescence a dense head 5-15 mm in diam., consisting of numerous crowded spikelets. Spikelets 5-8 mm long; glumes (4)5-6(7) mm long, rounded-emarginated to bifid, often fimbriate, midnerve not reaching the tip, typically cinnamon-coloured. Nutlets 0.8 x 0.6 mm, obovate, triangular, greyish, surface minutely papillose.

Ecology: Shallow soil overlaying outcropping rocks; copper rocky sites.

General distribution: Tropical and subtropical Africa, from Senegal to Sudan, southwards to South Africa.

Distribution on Katangan copper sites (8 sites): Notably Kwatebala (45).



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Kwatebala

Bulbostylis fusiformis

Goetgh. [Cyperaceae]

Holotype: Malaisse & Robbrecht 2111.

Copper specimen: Mf-Re 2111.

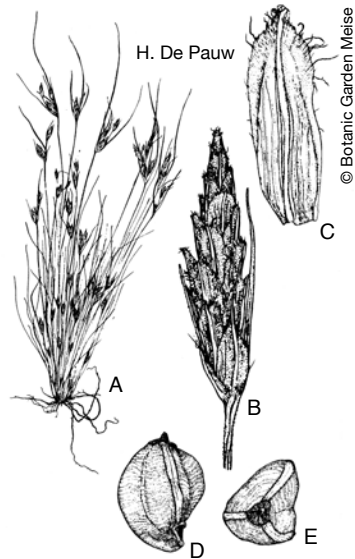
Habit: Annual herb, rather slender, 5-20 cm high. Inflorescence anhelate or reduced to a single spikelet; involucre bracts, 1 or more, 1-9 cm long, slender, scabrous. Spikelets 9-14 x 2-3 mm, acute, narrowly spindle-shaped, remarkably long; glumes 4 x 1.5 mm, slightly mu-cronate, fimbriate, 3-nerved. Fruit 1.2 x 0.7 mm, obovate, transversely rugose; stylopode persistent and discolorous.

Ecology: Copper steppe savannas and swards.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (1 site): Luiswishi (87).

Reference (for both species): GOETGHEBEUR, COUDIJZER [1985].



A. Habit (x 0.3) – B. Inflorescence (x 3) – C. Glume (x 7.5) – D-E. Basal fruit, lateral and upper view (x 6).

[GOETGHEBEUR, COUDIJZER, 1985]

Bulbostylis pseudoperennis Goetgh.

[Cyperaceae]

Holotype: Malaisse 7743.

Copper specimens: Bp 819; Be 16; Dp 3080 B; Mf 7687, 10232; Mf-Gp 1189.

Syn. : *Bulbostylis mucronata* auct. non C.B. Clarke.

Habit: Cespitose annual, with fasciculate, erect, scabrous or subglabrous stems, 3-10 cm high. Leaves numerous, 20-80 x 0.2 mm. Inflorescence clearly anthelate to completely condensed, glumes pale brownish-cinnamon to dark brown or even blackish. Fruit 0.6 x 0.5 mm, obovate, slightly transversely rugose.

Ecology: steppe savannas on copper outcrops, copper polluted soils.

General distribution: Distribution restricted to Upper Katanga, Northern Zambia and one site in Zimbabwe.

Distribution on Katangan copper sites (16 sites): Dikuluwe (2), Tilwezembe (20), Shabara (24), Kwatebala (45), Fungurume (51), Shinkolobwe (67), Kambove (71), Likasi (75), Luishia (77), Luiswishi (87), Kipushi (90), Kasonta (91), Lupoto (92), Karavia (95), Ruashi (96), Etoile (97), Kimpe (102).

Distribution on Zambian copper sites (1 site): Bwana Mkubwa (X2).

Also Alaska copper mine (Zimbabwe), and copper polluted soils in Katanga (Kinganyambo, Kisanga [= Keyberg], Mwanamumba).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | XX | X | | |
| wet | XXX | XX | X | |

→ eurycuprophyte

Phytogeochemistry: Cu-Co content of leaves (8 samples): Cu = 169-7,783 µg/g; Co = 7-1,373 µg/g D.M. Copper hyperaccumulator, cobalt hyperaccumulator. Need confirmation.

Rehabilitation: Very great interest. Open and more rarely closed swards on seasonal wet, even sometimes briefly waterlogged copper polluted soils.

References:

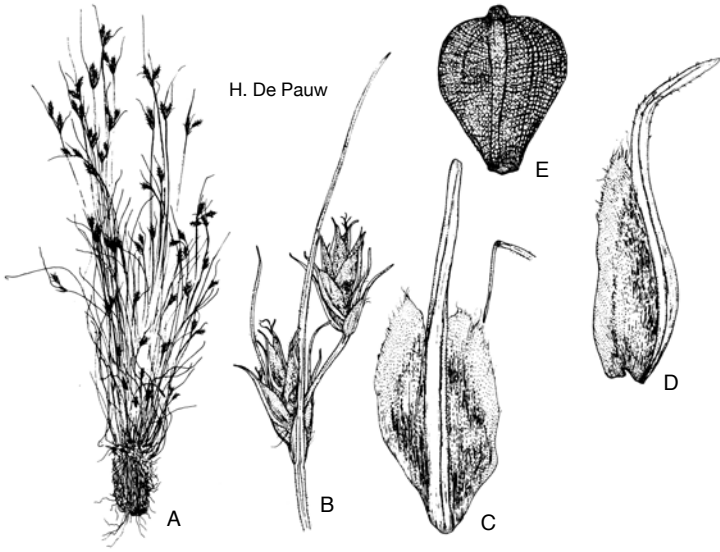
- DUVIGNEAUD, DENAEYER-DE SMET [1963].
- GOETGHEBEUR, COUDIJZER [1985].
- BROOKS, MALAISSE [1985].
- BROOKS et al. [1987].
- LETEINTURIER et al. [1999].



Etoile mine



Near KOV mine



H. De Pauw

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A. Habit (x 0.5) – B. Inflorescence (x 4.3) – C-D. Glumes (x 18) – E. Fruit (x 35).
 [GOETGHEBEUR, COUDIJZER, 1985]



Karavia

© N. Moulart



Karavia

© N. Moulart



Musonoi river

© F. Malabise

Holotype: Duvigneaud 4389 C.
Copper specimens: LLM 41; Mf 12889;
Mf-Kk 327; Sa 1257.

Habit: Perennial bulbiferous herb, 10-35 cm high. Bulbous blackish, non shining, 1-2 cm long and wide, laterally repeated. Leaves linear, 5-15 x 0.5 mm, cylindric, rolled inwards, glaucous. Scape trigonous, slender, ± 0.5 mm broad, smooth. Inflorescences subcapitate; 7-13-flowered; bracts 2, thread-like, short, 0.5-2 cm long; spicules 2-4, at maturity 7-15 x 5 mm, flattened, deep yellow or orange; lower glume sterile, always bilobate, bicarinate, submembranous; fertiles glumes ± 4 x 2-3 mm, heavily marked with numerous deep cracks longitudinally disposed.

Ecology: Open forest, grasslands, copper steppe savannas, on superficial rocky, lateritic or clayey compact soils.

General distribution: D.R. Congo, Zambia, Zimbabwe.

Distribution on Katangan copper sites (8 sites): Notably Sokoroshe I (83), Kinsevere (84), Luiswishi (87),

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | | <X< | <X< | > |
| medium | XX | XX | XX | (X) |
| wet | | 800 | 5,000 | |

→ eurycuproresistant

Etoile (97).

Distribution on Zambian copper sites (2 sites): Notably Roan Antelope (147).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 13; Co = 106 µg/g D.M.

Rehabilitation: Great interest on rocky sites with high copper content.

Reference:

DUVIGNEAUD, DENAEYER-DE SMET [1963].



Kinsevere

Cyperus margaritaceus Vahl

[Cyperaceae]

Holotype: Thonning s.n.

Copper specimens: Kk-Mf 405, 420;

Mf 13072; Mf-Re 2168.

Habit: Robust perennial erect herb, 12–60 cm tall, rather slender, thickened at the base and bulb-like, clustered on a very short woody rhizome, covered by hardened reddish brown or blackish leaf sheaths. Leaves $\frac{1}{2}$ as long as the stem, 2–3 mm broad. Inflorescence a solitary congested head of 2–8 spikelets. Bracts 3, lowest up to 6–9 cm long, similar to the leaves. Spikelets 8–25 mm long, compressed, shining straw coloured, 10–20-flowered; glumes boat-shaped, ovate, obtuse, strongly 11–15-nerved, closely packed and inflated; margins not incurved. Nut large, $\frac{1}{3}$ – $\frac{2}{5}$ the length of the glume, ellipsoid, acute at the top, strongly triquetrous with concave faces, dull black.

Ecology: Open woodlands, grasslands, often on sandy soils, also copper steppe savannas with low copper content.

General distribution: Tropical and southern Africa.

Distribution on Katangan copper sites (12 sites): Notably Goma (33), Shinkolobwe Milestone XIII (67).

Rehabilitation: Robust pioneer, stabilizer.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | X | | |
| wet | XX | | | |

→ oligocuproresistant

Reference: HOENSELAAR et al. [2010].

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Goma



Scleria bulbifera Hochst. ex A. Rich.

[Cyperaceae]

Holotype: Schimper 327.
Copper specimens: MKS 612, 744;
St 656.
Syn.: *S. buchananii* Boeck

Habit: Stoloniferous perennial herb. Horizontal rhizome bearing a series of few brown scaly bulbs up to 1 cm diam., these being the bases of previous shoots. Bulb tapering upwards and prolonged into an aerial shoot. A few clasping basal sheaths, one or two prolonged to a leaf ca 10 cm long, 1-3 foliage leaves up to 15-30 cm x 2-5 mm. Culms 30-70 cm x 0.7-1.5 mm, triangular, glabrous. Inflorescence 5-20 cm, usually simply spicate, consisting of 6-20 sessile clusters of bisexual spikelets. Spikelets 4-6.5 mm. Glumes 3-4 mm, reddish-brown. Nutlet 1.6-2 x 1.2-1.5 mm, obovoid to subspherical, mostly white, also grey or pale brown, smooth to tuberculate.

Ecology: Grasslands, inselbergs, also copper steppe savannas with low copper content.

General distribution: From Ethiopia southwards to R.S.A., also Angola, Botswana, Madagascar.

Distribution on Katangan copper sites (5 sites): Shimbidi (35), Kavifwafwaulu (42), Fungurume (51), Luishia (77), Kinsevere (84).

Reference: PIÉART [1953].

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | (X) | | |
| medium | X | X | | |
| wet | X | X | (X) | |

→ mesocuproresistant



© M. Schajles

Dipidi (Upemba Nat. Park)



© E. Ilunga

Kinsevere



© M. Saleck

Fungurume



© J. Lebrun

Fungurume



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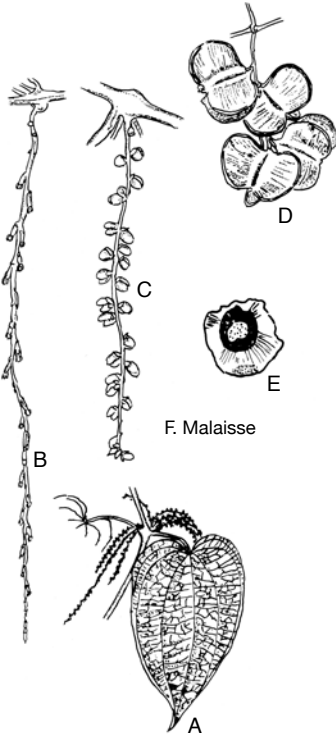
Kisanga

Dioscorea praeheasilis

Benth.

Lectotype: Vogel 21.

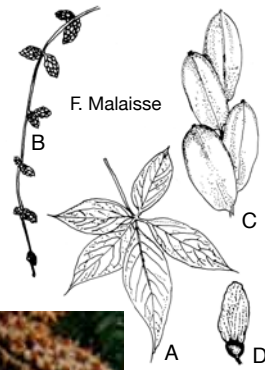
Copper specimen: Mal 733.

Distribution on Katangan copper sites (3 sites): Notably Kazinyanga (49).**Ecology of the three taxa:** Miombo open forests, *Uapaca robynsii* copper belts.**Reference** (for the three species): WILKIN [2001].

A. Habit of male plant (x 0.3) –
 B. Female inflorescence (x 0.4) – C. Male
 inflorescence (x 1.5) – D. Capsules (x 0.25)
 – E. Seed (x 0.7). [Drawn after L. Gurr
 in WILKIN, 2001]

Dioscorea quartiniana

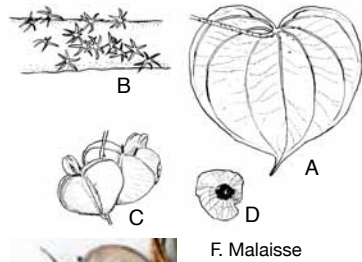
A.Rich. [Dioscoreaceae]

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

A. 5 foliolate leaf (x 0.3) – B. Compound
 male inflorescence (x 0.4) – C. Capsules
 (x 0.1) – D. Seed (x 0.8). [Drawn after
 D. Lambkin in WILKIN, 2001]

Dioscorea schimperiana

Hochst. ex Kunth

Distribution on Katangan copper sites (4 sites): Notably Kazinyanga (49), Fungurume (51).

A. Leaf (x 0.4) – B. Dense stellate
 pubescence (x 9.4) – C. Capsules (x 0.4) –
 D. Seed (x 0.4). [Drawn after J.A. Lows
 in WILKIN, 2001]

Holotype: J. Amman (1736).

Copper specimens: Mf-Gj 39;

Mf-Kk 219, 233.

Syn.: *T. pinnatifida* J.R. & G. Forst.,

T. involucrata Thonn.

Habit: Stout perennial herb, up to 1.5 m tall. Tuber up to 10 cm in diam., roots fibrous. Leaves 1-3, petiole ridged longitudinally, leaf-blade trisected, each segment 1-3-pinnatisect. Flowering stem 1, ridged longitudinally; outer bracts 2, spreading, ovate-lanceolate, with 2-3-fid tips, 4 x 2.5 cm; inner bracts 3-4, erect, ovate; both types green, tinged with purple; filiform bracts many, purplish, with whitish tips, stiff and pendulous, up to 20 cm long; flowers 20-40, but only a few of these produce fruits. Perianth-segments erect, green tinged with purple. Fruit subglobose, 6-ridged, up to 3 x 2.5 cm. Seeds ovate, longitudinally ridged, 5 x 3 mm, red-brown.

Ecology: Woodlands, including termite hills, rarely on copper steppe savannas.

| Hydra-tation | Copper content of soil | | | |
|--------------|------------------------|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XXX | (X) | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Tropical Africa (from Senegal to Ethiopia and southwards to Zimbabwe), Madagascar and the Mascarene islands, from India and China to the Pacific islands.

Distribution on Katangan copper sites (3 sites): Fungurume (51), Luiswishi (87), Etoile (97).

Rehabilitation: No evident interest.

References:

LISOWSKI et al. [1976].

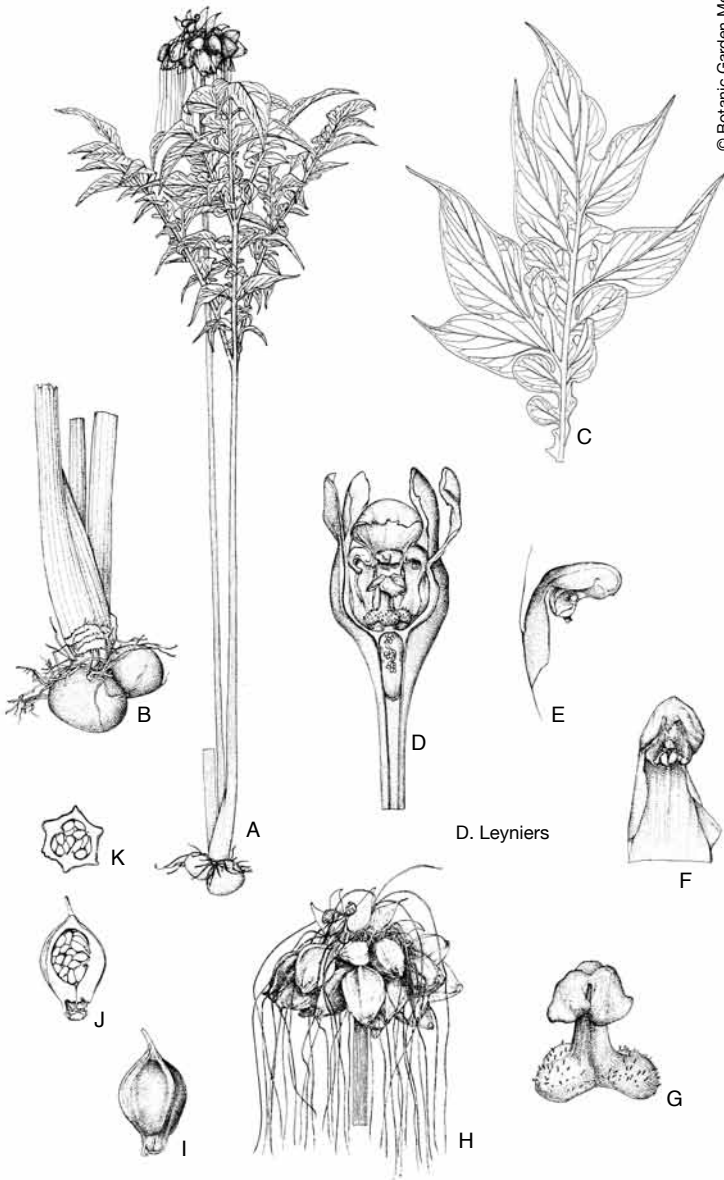
CARTER [1999].



Kipopo



Near Kwatebala



A. Habit (x 0.08) – B. Tubers (x 0.16) – C. Leaf, upper part (x 0.15) – D. Flower, longitudinal section (x 2) – E.F. Stamen (x 5) – G. Gynecium, apex (x 5) – H. Infrutescence (x 0.16) – I. Fruit (x 0.3) – J. Fruit, longitudinal section (x 0.3) – K. Fruit, transversal section (x 0.3).

[LISOWSKI et al., 1976]

Hypoxis filiformis Baker

[Hypoxidaceae]

Holotype: Sutherland s.n.
Copper specimen: Mal 274.
Syn.: *H. malosana* Baker

Habit: Slender perennial herb, 20-50 cm tall. Corm vertical, cylindrical to subglobose, whitish or yellow inside, crowned by stiff, black old leaf remnants. Leaves forming a pseudostem up to 5 cm long, grass-like, linear 5-61 cm x 1-3 mm, finely pilose-pubescent with 2-branched, 3 mm long, red-brown to golden hairs; leaves strongly ribbed with 5-11 veins. Inflorescences 1-10. Flowers 1-5 in corymbose cymes, first appearing before the leaves; pedicels very different in length, lower ones 1-3 mm, upper to 20 mm long; bracts linear-subulate, 2-9 x 1 mm; tepals narrowly elliptic to ovate, up to 0.5-12 x 2-4 mm, acute, inner somewhat broader than outer; stamens unequal, outer 2.5-5 mm long with filaments 2-3.5 mm long, inner 1.5-3 mm long with filiform filaments 0.5-1.5 mm long, anthers 1.2-2.5 mm long, emarginated at the apex; ovary obconical, 2-3.5 x 1.5-2.5 mm, style 0-0.5 mm long; stigma 1-2 mm long, composed of 3 lobes, entirely fused or emarginate. Capsule obovoid to turbinate, 2-5 x 2-3 mm, opening by a transverse slit. Seeds black and glossy, (sub)globose, 0.6-

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | (X) | | | |
| medium | X | (X) | | |
| wet | XX | (X) | | |

→ oligocuproresistant

1 mm in diam., testa papillose, the papillae dome-shaped with a smooth shiny cuticle.

Ecology: Grasslands, rare in copper steppe savannas.

General distribution: Angola, D.R. Congo (Katanga), Burundi, Uganda, Tanzania, Zambia, Malawi, Mozambique, Swaziland, Lesotho and R.S.A.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

References:

NORDAL, ZIMUDZI [1987].
WILAND-SZYMANSKA, NORDAL [2006].



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Manika plateau

Hypoxis polystachya Baker

[Hypoxidaceae]

Holotype: Welwitsch 4060.

Copper specimens: MKS 577, 776.

Syn.: *H. subspicata* Pax

Habit: Robust perennial herb, up to 60 cm tall, with indistinct pseudostem. Corms subglobose to elongated, 5-9 x 4-5.5 cm, white or yellow inside. Leaves lanceolate to broadly linear, 40 x 4-7 cm, lamina whitish pilose abaxially, margins and abaxial midrib densely white-lanate, hairs silvery-white, up to 3 mm long, tufted. Inflorescences 1-7, scape up to 18 cm long. Flowers 8-20 in a dense cylindrical raceme; tepals ovate-lanceolate, dark yellow. Seeds brownish, 1.6-1.8 mm in diam.; testa papillose.

Ecology: Miombo woodlands, also rare in copper steppe savannas.

General distribution: Angola, D.R. Congo (Katanga), Tanzania, Malawi.

Distribution on Katangan copper sites (2 sites): Kavifwafwaulu (42), Kwatebala (45).

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|----|
| | normal | 200 | 800 | > |
| dry | <X | <X | <X | <X |
| medium | 800 | 5,000 | | |
| wet | XX | (X) | | |

→ oligocuproresistant

References:

NORDAL, ZIMUDIZI [1987].

WILAND-SZYMANSKA, NORDAL [2006].



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Kazinyanga



Kavifwafwaulu



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Nzilo trail

***Aristea* aff. *abyssinica* Pax**

Copper specimen: Lj et al. 79.

Habit: Evergreen perennial herb, 25-90 cm high, stem 2-6-branched, 2-angled but not winged. Leaves several, mostly basal and about half as long as the stem, 2.5-7 mm wide, linear to narrowly lanceolate. Flower clusters 4-14, terminal and axillary, 4-6-flowered. Flower blue, \pm sessile. Tepals 12 x 4-5 mm, obovate. Filaments 4 mm long, anthers 1.5 mm long; style 6-7 mm long, exceeding the anthers, apex 3-lobed. Capsules ovoid-obovoid, 5-7 mm long, subsessile or on pedicels up to 4 mm long.

Ecology: Dembo, wet sites, rare on copper steppe savannas.

General distribution: From Nigeria to Ethiopia and southwards to R.S.A. and Angola.

Distribution on Katangan copper sites (5 sites): Notably Shinkusu (44), Kansalawile (51).

References:

GOLDBLATT [1993].

GEERINCK, SCHAJES [2005].



Kansalawile

Gladiolus actinomorphantus

P.A.Duvign. & Van Bockstal

[Iridaceae]

Holotype: Duvigneaud 5141 G1.

Copper specimens: Mf-Re 2381; Sm 4691.

Habit: Spike 5-15-flowered. Flowers pale yellow, perianth tube curved.

Ecology: Tree rocky savannas, steppe savannas, mainly on copper sites.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (4 sites): Notably Mupine (4).



Mamfwe road

Gladiolus atropurpureus

Baker

Lectotype and syntype: Kirk s.n.; Meller s.n.

Copper specimens: Dp 4727; Mf 11216, 12473.

Habit: Perennial herb, 30-60 cm tall. Flowers, either pale-flowered with purple nectar guides or dark purple.**Ecology:** Woodlands, rocky outcrops, also copper-cobalt steppe savannas.**General distribution:** From Angola to Tanzania and Mozambique.**Distribution on Katangan copper sites** (10 sites): Notably Mupine (4).

Kipopo



Potopoto valley

Gladiolus dalenii van Geelvar. *dalenii* [Iridaceae]

Holotype: South Africa, collector unknown.

Copper specimens: Mf 12623; SDBF 16.

Habit: Perennial herb, 70-120 cm tall. Flowers, either red or yellow with brown streaks on upper tepals.**Distribution on Katangan copper sites** (4 sites): Notably Goma (33).

Kolwezi-Musokatanda road



Zibwe valley

Gladiolus erectiflorus

Baker

Holotype: Carson 1/1894.

Copper specimen: Mf-Gp 783.

Ecology: Rocky sites in miombo hills (Xerobrachystegion), rare on edges of copper steppe savannas.

Distribution on Katangan copper sites (1 site): Fungurume (51).



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Nzilo-Kyamasumba road

Gladiolus gregarius Welw.

ex Baker

[Iridaceae]

Holotype: Welwitsch 1528.

Copper specimens: Mf 9183, 10248; Mf-Gj 36.

Habit: Perennial herb, 25-120 cm high. Leaves 4-7, cauline, imbricate, linear to elliptic, up to 60 cm long, 9-20 mm wide. Spike erect, 8-20-flowered. Flower zygomorphic, bilabiate, light purple, the lower petals white, with sublosangic dark purple mark.

Ecology: Woodlands, rocky habitats, also in copper steppe savannas.

General distribution: From Senegal to Angola and across to Uganda, Tanzania and Mozambique.

Distribution on Katangan copper sites (7 sites): Notably Dikuluwe (2).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 4-12; Co = 14-49 $\mu\text{g/g}$ D.M.

References (for both species):

GOLDBLATT [1996].

GEERINCK [2005].



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Biano plateau

Gladiolus ledoctei

P.A.Duvign. & Van Bockstal

Holotype: Le Docte s.n.

Copper specimens: Dp 2247 G1;
Lb-Mf 242; Ld sn; Mf 7697; Mf-Gj 6;
Sm 1908; Tr 109.Syn.: *G. fungurumeensis* P.A.Duvign. &
Van Bockstal**Habit:** Slender perennial herb, 35–45 cm high. Cataphylls sometimes purplish. Leaves 5–7, subcylindric, 20–40 cm long, 1–3 mm in diam., the lower two basal longest and reaching at least the base of the spike. Spike 3–8-flowered, inclined or suberect; flowers pink, pale lilac or cream to yellow; lower 3 tepals with a dark blue, purple or dark yellow diamond-shaped mark.**Ecology:** Miombo woodlands, steppe savannas, mainly on copper sites.**General distribution:** Restricted to Upper Katanga.**Distribution on Katangan copper sites** (8 sites): Notably Tenke (32), Mupapala (53), Shinkolobwe (65).**References** (for both species):

GOLDBLATT [1996].

GEERINCK [2005].



Kamfundwa

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Gladiolus robiliartianus

P.A.Duvign. [Iridaceae]

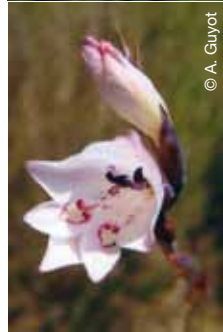
Holotype: Derricks 6.

Copper specimens: Bp-Mf 8228; De 6, 9;
Mf-Re 2188; Tr 274.Syn.: *G. duvigeaudii* Van Bockstal**Habit:** Tepals blue to lilac or pink, the two lateral lower with a blue to purple angular smudge.

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Fungurume

Gladiolus tshombeanus P.A.Duvign. & Van Bockstal

[Iridaceae]

Holotype: Duvigneaud 4371G.
Copper specimens: Dp 3014G, 4030G, 4055G, 4067G, 4588G; Mf 7966, 12822; Sa 6032.
Syn.: *G. peschianus* P.A.Duvign. & Van Bockstal

Habit: Perennial slender herb, 15-30 cm tall, growing in clumps. Corm 9-12 in diam.; stem erect, unbranched. Cataphylls brownish. Leaves, 2, 2-6 cm long, terete, the lower one basal, the upper one inserted in the upper half of the stem, reaching the middle of the spike. Spike 4-7-flowered, inclined 45°. Flowers pale blue, dark purple, to light purple; perianth tube 8-10 mm long, curved outwards and emerging between the bracts; tepals unequal, the dorsal largest and hooded over the stamens, 12-14 x 7-9 mm; the upper laterals directed forward, the lower three held close together. Capsules nearly globose, 5 mm long.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|--|-------|---------|
| | 200 | 800 | > 5,000 |
| normal | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium (X) | XX | X | |
| wet | X | | |

→ mesocuproresistant

Ecology: Mostly on copper-cobalt steppe savannas, rare in miombo.

General distribution: Restricted to Upper Katanga.

Distribution on Katangan copper sites (8 sites): Tilwezembe (20), Fungurume (51), Luiswishi (87), Kasonta (91), Lupoto (92), Niamumenda (93), Karavia (95), Etoile (97).

References:

DUVIGNEAUD, DENAEYER-DE SMET [1963].
GOLDBLATT [1996].
GEERINCK [2005].



Etoile mine



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Kinsevere hill

Gladiolus unguiculatus Baker

[Iridaceae]

Holotype: Morson s.n.

Copper specimens: Dp 4125 G, 4134, 4405 G2; Mf 12856.

Habit: Perennial herb, 30-60 cm high, corm 15-25 mm in diam. Cataphylls up to 15 cm long. Basal leaves, 2-3, linear to narrowly elliptic, up to 45 x 1 cm. Leaves of flowering stem, 2-3, 6-9 cm long, 4 mm wide. Spike erect, 10-18-flowered; bracts green, 10-15 mm long. Flowers cream to light purple, the upper tepals flushed light to deep purple, the lower three each with deep purple spear-shaped marking in the upper third; the upper dorsal tepal 18-22 x 10-12 mm; the lower 3 tepals 10-12 mm long. Capsule ellipsoid-ovoid, 12-16 mm long; seeds elliptic, 7 x 4 mm.

Ecology: Open forests, savannas, also in copper steppe savannas.

General distribution: Tropical Africa (from Senegal and Gambia to Sudan;

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | X | |
| wet | X | | |

→ oligocuproresistant

southwards to Gabon and Angola, and eastwards to Mozambique and R.S.A.).

Distribution on Katangan copper sites (6 sites): Dikuluwe (2), Kansuki (22), Shabara (24), Swambo (62), Kamwali (89), Etoile (97).

Rehabilitation: Pleasant habit.

References:

GOLDBLATT [1996].

GEERINCK [2005].



Manika plateau



Potopoto valley

Holotype: Verdick 612.

Copper specimen: MKS 478.

Syn.: *G. erectiflorus* Baker var. *verdickii* (De Wild. & T.Durand) Geerinck

Habit: Perennial herb, 70-110 cm high, corm 2-3.5 cm in diam., tunics of papery to matted fibrous layers. Cataphylls membranous, brown, becoming greenish above the ground. Leaves 5-7, subcylindric, 20-40 cm long, 1-3 mm in diam., the lower 3-4 basal and largest and reaching at least the base of the spike, narrowly lanceolate to linear, 10-15 mm wide, the midrib and margins hyaline, upper leaves cauline. Stem unbranched or with one short branch. Spike 4-8-flowered, flexed outward at the base; bracts narrowly lanceolate, attenuate, green below. Flowers white to yellow, sometimes veined dark red to pink; tepals unequal, the dorsal largest, 4.5-5 cm long, the upper laterals spreading at right angles to the tube, the lower lateral smallest, 3.8-4 cm long. Filaments arcuate, 30 mm long; anthers 7-8 mm long. Ovary ellipsoid, 5.5-6.5 mm long; style arching over stamens, branches 3.5 mm long, spreading beyond the anthers. Capsule obovoid - ellipsoid,

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|--|
| normal | 200 | 800 | > | |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | | |
|--------|----|-----|--|--|
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

10-16 mm long. Seeds broadly elliptic, 5 x 4 mm.

Ecology: Miombo woodlands, rare in shrub steppe savannas on copper sites.

General distribution: Restricted to Upper Katanga and NW. Zambia (one collection).

Distribution on Katangan copper sites (2 sites): Kwatebala (45), Fungurume (51).

Rehabilitation: Very pleasant habit.

References:

GOLDBLATT [1996].

GEERINCK [2001; 2005].



Shangulowe-Kamfundwa road



Kwatebala

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Lapeirousia erythrantha (Klotzsch ex Klatt) Baker [Iridaceae]

Holotype: Peters s.n.

Copper specimens: Dp 5172 L; Mf 13067.

Habit: Perennial herb, 20–45 cm high. Corm 8–16 mm in diam.; tunics blackish. Foliage leaves, 3–4, the basal 2–3 leaves one-to-two-thirds as long as the stem, 4–8 mm wide, linear to lanceolate, sometimes falcate. Stem compressed and 2-angled below, 3-angle above, branched repeatedly. Inflorescence a several-to many-branched panicle, ultimate branches with 3–6 flowers. Flowers zygomorphic, either blue-violet and the lower tepals each with a hastate white mark outlined in dark-blue to purple, or tepals crimson, or rarely white. Stamens unilateral. Capsule 3–4 mm long.

Ecology: On rocks, granite outcrops, often also on copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Botswana, Zambia, Malawi, Zimbabwe, Mozambique.

| Hydratation | Copper content of soil (in μg per g of soil) | | |
|-------------|--|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | X | | |
| medium | XX | X | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (10 sites): Dikuluwe (2), Kalukundi (16), Shabara (24), Kasompi (27), Fungurume (51), Mindigi (60), Swambo (62), Luiswishi (87), Kasonta (91), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (3 samples): Cu = 3–12, Co = 97–143 $\mu\text{g/g}$ D.M.

Rehabilitation: Of interest on rocky copper sites, scenic aspect.

References:

GEERINCK et al. [1972].

GOLDBLATT [1990].



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Kolwezi-Musokatanda road



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Kavifwafwaulu

Moraea bella Harms

[Iridaceae]

Holotype: Goetze 698.
Copper specimens: SIIW 114.

Habit: Perennial herb, 40-70 cm high. Corm 15 mm in diam.; tunic of pale medium to coarse fibres. Cataphylls light-brown, irregularly broken. Foliage leaf solitary, much exceeding the stem, 2.5-6 mm wide, linear, channelled; sheathing leaves 2-4, green, 6-7 mm long. Stem erect, simple. Rhipidium single, terminal; spathes green with a dry brown apex, the inner 6-10 cm long, the outer two-thirds as long as the inner. Flowers pale-yellow, the outer tepals with deeper yellow nectar guides and the limbs conspicuously darkly veined and spotted in the lower half; outer tepals 45-55 mm long, lanceolate, the limb 25-40 mm long, often slightly exceeding the claw; inner tepals 35-50 mm long, lanceolate, erect. Filaments 9-14 mm long, free in the upper third, anthers

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | | | | |
| wet | X | (X) | | |

→ oligocuproresistant

8-10 mm long. Ovary 15-20 mm long, usually exserted; styles branches 13-16 mm long, crests 8-15 mm long. Capsules 20-30 mm long, oblong.

Ecology: Dambos, high plateau steppe savannas, also copper steppe savannas.

General distribution: Tanzania (South West), D.R. Congo (Katanga), Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (2 sites): Kabwelunono (34), Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.

Reference: GOLDBLATT [1993].



Kabwelunono



Kavifwafwaulu



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Moraea carsonii Baker

[Iridaceae]

Holotype: Carson s.n.
Copper specimen: Mf 9204.

Habit: Perennial herb, 20-40 cm high. Corm 10-15 mm in diam.; tunics of fine to medium dark-brown fibres. Cataphylls pale, often broken or fibrous above. Foliage leaf 2(3), longer than the stem, but often trailing, 2-5 mm wide, linear, channelled; the lowermost basal or inserted near to well above the ground, the upper 1-2 leaves shorter than the basal leaf; sheathing leaves 2.5-6 cm long, green with dry brown attenuate apices. Stem erect, with 1-2(several) ascending branches. Rhipidia few to several, one per branch; spathes green and sometimes flushed with red, becoming dry and brown apically, the inner 3-4(5) cm long, outer ca 1 cm shorter than the inner. Flowers blue-violet with white to yellow nectar guides on the outer tepals; outer

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-----|-------|
| | normal | 200 | 800 |
| dry | <X< | <X< | 5,000 |
| medium | X | (X) | |
| wet | | | |

→ oligocuproresistant

tepals 18-30 mm long, lanceolate, the limb slightly longer than the claw, spreading at 30° below horizontal; inner tepals 17-28 mm long, narrowly lanceolate to nearly linear, the limb also spreading. Filaments 7.5 mm long, free in the upper third, anthers 4.5-5.5 mm long. Ovary 3.5-7 mm long. Capsules 7-9 mm long, globose.

Ecology: Grasslands, high plateau steppe savannas, also copper steppe savannas, often among rocks.

General distribution: D.R. Congo (Katanga), Tanzania (SW), Botswana, Namibia, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (5 sites): Notably Tilwizembe (20).

Reference: GOLDBLATT [1993].



Fungurume



Zibwe valley



© M. Schajjes

Holotype: Sanderson 253, Sutherland s.n.
Copper specimen: Mf 12150.

Habit: Perennial herb, 15-45 cm high. Corm 10-15 mm in diam.; tunic of dark-brown to blackish fibres. Cataphylls membranous, usually unbroken. Foliage leaf solitary, inserted on the upper third of the stem, 5-20 cm long, shorter than or more often shortly exceeding the stem at anthesis, narrowly channelled, sometimes terete above; sheathing leaves seldom exceeding 2.5 cm in length, green at least below, dry and brown above. Stem erect or inclined, usually with crowded branches, the lowermost internode very long, the internodes above the foliage leaf short. Rhipidia (1)3-several, crowded apically; spathes green, becoming dry above, apices attenuate, the inner 2.5-3.5 cm long, the outer 1 cm shorter than the inner, sometimes apically lacerate. Flowers grey-blue to violet with yellow nectar guides edged with dark-violet on the outer tepals; narrowly lanceolate, the limb 4-6 mm wide, also spreading. Filaments

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | X | XX | | |
| wet | X | | | |

→ oligocuproresistant

4-5 mm long, free in the upper half, anthers 4-5 mm long. Ovary 4 mm long, exerted; styles branches 10-12 mm long including crests. Capsules 4.5-10 x 4-5 mm broadly ovoid.

Ecology: Copper steppe savannas, also high plateau steppe savannas, dambos.

General distribution: D.R. Congo (Katanga), Zambia, Malawi, Zimbabwe, Mozambique, R.S.A. (Transvaal, Natal).

Distribution on Katangan copper sites (8 sites): Notably Luita (58).

Rehabilitation: Pleasant habit.

Reference: GOLDBLATT [1993].



Kolwezi-Kansanshi road

Moraea ventricosa Baker

[Iridaceae]

Holotype: Carson 37.
Copper specimen: Mf-Kk 403.

Habit: Perennial herb, 30-55 cm high. Corm 15 mm in diam.; tunics of fine to medium pale straw-coloured fibres. Cataphylls pale to dark-brown, broken and becoming fibrous. Foliage leaf solitary, exceeding the stem, 3-7 mm wide, linear, channelled; sheathing leaves 3-6, imbricate, green, 5-8 cm long. Stem erect, unbranched. Rhipidium single, terminal; spathes green, with dry apices, the inner 8-12 cm long, the outer two-thirds as long as the inner. Flowers usually blue-purple (or white to pale-yellow) with white to yellow nectar guides on the outer tepals; outer tepals 40-55 mm long, lanceolate, claw usually slightly longer than the limb; inner tepals 37-44 mm long, strongly spatulate, erect. Filaments 12-15 mm long, united in the lower two-thirds, anthers 8-10 mm long. Ovary 20 mm long, crests 10 mm long. Capsules ca 3 cm long, narrowly ovoid.

Ecology: Miombo open forests, also copper steppe savannas, dambos margins.

| Hydratation | Copper content of soil (in μg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

General distribution: D.R. Congo (Katanga), Tanzania, Burundi, Zambia.

Distribution on Katangan copper sites (2 sites): Notably Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.

Reference: GOLDBLATT [1993].



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Mamfwe road



Kavifwafwaulu



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Mamfwe road

Moraea verdickii De Wild.

[Iridaceae]

Holotype: Verdick 281.
Copper specimen: Mf 16627.

Habit: Perennial herb, 45-75 cm high. Corm 20 mm in diam.; tunics of coarse pale or dark-brown fibres. Cataphylls pale to dark-brown, dry, broken and becoming fibrous above. Foliage leaf solitary, shortly exceeding the stem, 8-12 mm wide, linear, channelled or flat; sheathing leaves 2-3(4) usually widely spaced, green with a dry brown apex, 9-11 cm long. Stem erect, simple. Rhipidium single, terminal; spathes green, with a dry brown apex, the inner 9-15 cm long, the outer two-thirds as long as the inner. Flowers yellow with deeper yellow nectar guides on the outer tepals; outer tepals 60-75(100) mm long, lanceolate, the limb 30-50 mm long; inner tepals 45-70 mm long, lanceolate, erect. Filaments 11-16 mm long, free in the upper third, anthers 10-14 mm long. Ovary 15-25 mm long, crests 10-17 mm long. Capsules unknown.

Ecology: Miombo woodlands, rocky grasslands, also copper steppe savannas.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Angola (East), D.R. Congo (Katanga), Tanzania (SW), Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (2 sites): Notably Kwatebala (45).

Rehabilitation: Pleasant habit.

Reference: GOLDBLATT [1993].



Kwatebala



Manika plateau

Brachycorythis pleistophylla Rchb.f. subsp. *pleistophylla*

Holotype: Kirk s.n.
Copper specimens: Mf 12118;
SDI 5785, 6033.

Habit: Terrestrial herb, 35-90 cm tall, with fleshy, woolly, cylindrical roots. Leaves numerous, overlapping, up to 10 x 1.5 cm, lanceolate, acuminate. Inflorescence 12-25 x 2.5-4.5 cm, densely many-flowered. Flowers mauve-purple to purple, drying dark blackish-brown. Sepals ovate or elliptic; dorsal sepal 5.5-8.3 x 2-4.6 mm; lateral sepals 6-9 x 3.5-5.5 mm, rather oblique. Petals 6-8.4 x 3.7-8 mm, semi-orbicular. Lip 11-15 mm long; hypochile boat-shaped, 2-3 mm long; epichile 8-13 x 6.6-14.4 mm, longer than broad, or as long as broad, horizontal, 3-lobed with the mid-lobe very small and tooth-like.

Ecology: Steppe savannas, dembo, open woodlands.

General distribution: Tropical Africa.

Distribution on Katangan copper sites (2 sites): Kasonta (91), Lupoto (92).

Rehabilitation: Pleasant habit.

References (for both species):

GEERINCK [1984].
LA CROIX, CRIBB [1995].



Manika plateau

Brachycorythis tenuior Rchb.f. [Orchidaceae]

Holotype: Gueinzus s.n.
Copper specimen: SDI 371.

Habit: Terrestrial herb, 35-55 cm tall, with ellipsoid to conical-fusiform tubers. Leaves numerous, lanceolate, acute, up to 5.5 cm long and 1.5 cm broad. Flowers purple or violet, often with darker spots or whitish portions. Dorsal sepal elliptic, 5-9 mm long; laterals obliquely ovate or oblong. Petals oblong, somewhat S-shaped, about as long as the dorsal sepal. Lip-hypochile forming a long slightly curved cylindrical spur 5.5-10.5 mm long; epichile with a fleshy raised median portion and thin wing-like lateral portions which may be shorter than or nearly as long as the central portion, 5-10.5 mm long, 3.5-7 mm broad. Column rather slender, 4-6 mm long.

Ecology: Steppe savannas, open woodlands.

General distribution: Tropical Africa.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.



Biano plateau

Cyrtorchis arcuata (Lindl.)Schltr. subsp. *arcuata*

Holotype: Drège s.a.
Copper specimen: Mal 177.

Habit: Epiphytic or lithophytic herb. Roots stout, ca 5 mm in diam. Leaves coriaceous, 7-20 x 1-3.8 cm, linear, ligulate, oblong or elliptic. Inflorescences spreading, 8-18 cm long, up to 10-flowered. Pedicel and ovary 15-50 mm long; bracts large, 10-30 x 10-16 mm. Flowers stellate, sweetly scented, white, turning apricot-coloured with age. Sepals and petals subsimilar, lanceolate, acuminate, recurved at apex; sepals 10-53 x 4.5-7 mm; petals 8-38 x 4-6 mm. Lip 8-42 x 3.5-6 mm, lanceolate, acuminate; spur 3-10 cm long.

Ecology: Miombo open forests, wooded grasslands, very rarely lithophytic in copper shrubby steppe savannas.

General distribution: Widespread in tropical and southern Africa.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Reference:

LA CROIX, CRIBB [1998].



Mamfwe road



Manika plateau

Disa engleriana Kraenzl.

[Orchidaceae]

Holotype: Polhill & Paulo 1787.
Copper specimen: Mf 16128.

Habit: Terrestrial herb, 30-55 cm high; tubers ellipsoid. Inflorescence 6-21 cm long, rather loosely 5-27-flowered. Flowers pink to purple or magenta, often darker spotted. Dorsal sepal somewhat reflexed to the middle, orbicular or transversely elliptical with a distinct narrow lower part, the spur pendent, cylindrical, 5-7 mm long. Petals 2-lobed at the middle, altogether 1-1.8 cm long. Lip pendent, linear, 15-18 mm long, 0.5-2 mm broad.

Ecology: Steppe savannas.

General distribution: Tanganyika, D.R. Congo, Zambia and Malawi.

Distribution on Katangan copper sites (1 site): Kananga East (7).



Manika plateau

Disa hircicornis Rchb.f.

Holotype: Kirk 2.

Copper specimen: MSH 538.

Habit: Terrestrial herb 30-85 cm high. Flowering stems erect, terete, leafy throughout their length; leaves 6-15, the largest lanceolate or linear-lanceolate, acute, 7-31 cm long and 1-3.5 cm broad. Inflorescence cylindrical, 6-25 cm long, 2-3 cm in diam., densely 16-to many-flowered. Bracts green or coloured. Flowers pale pink to brownish-red, purple or very deep purple.

Ecology: Wet grasslands, rarely on copper steppe savannas.

General distribution: Nigeria, Cameroun, Sudan, Angola, D.R. Congo, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Kakalalwe (38).



Manika plateau

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Disa katangensis De Wild.

[Orchidaceae]

Holotype: Verdick 418.

Copper specimens: Mf 16154, 11648.

Syn.: *D. erubescens* Rendle var.*katangensis* (De Wild.) Geerinck

Habit: Terrestrial herb with fertile and sterile shoots. Inflorescence lax, 8-16 cm long, 2-8-flowered. Flowers red, pink or scarlet, the galea with darker spots. Spur pendent from a ridge below the middle of the dorsal sepal, 13-16 mm long, filiform. Lateral sepals 21-36 mm long. Petals 2-lobed. Lip pendent, 14-22 mm long, linear.

Ecology: Grasslands and miombo woodlands on sandy soils, also rarely on copper steppe savannas.

General distribution: Angola, D.R. Congo (Upper Katanga), Zambia.

Distribution on Katangan copper sites (2 sites): Kabwelunono (34), Kwatebala (45).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 17; Co = 61 µg/g D.M.

Reference (for both species):

LA CROIX, CRIBB [1995].



Near Kasobantu hill

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Eulophia brenanii P.J.Cribb
& la Croix

Holotype: Brenan R.A.F. 24.
Copper specimen: ISI 195.

Habit: Slender terrestrial herb, 20-30 cm tall. Leaves 3-4, vestigial at flowering time. Inflorescence rather laxly 3-7-flowered. Flowers purplish, the sepals dusted with rusty-brown, the tepals paler; lip mid-lobe white or pale lilac, side lobes with purple veins. Sepals erect, 9-13.5 x 0.7-1 mm, lanceolate, acute. Petals 8-9 x 2-2.5 mm, lanceolate, acute, projecting over the column. Lip 14-15 x 4 mm, 3-lobed in apical half; side lobes erect; mid-lobe 5-7 x 2-2.5 mm, diamond-shaped with a few papillae. Spur 8-10 mm long, slender, cylindrical, straight. Column 6 mm long.

Ecology: Miombo, in bare rocky places, rare on copper rocky sites.

General distribution: D.R. Congo (Upper Katanga), Zambia.

Distribution on Katangan copper sites (1 site): Shadiranzoro (48).



Kafubu



Nzilo-Kyamasumba road

Eulophia carsonii Rolfe
[Orchidaceae]

Holotype: Carson s.n.
Copper specimen: Not collected.

Habit: Slender terrestrial herb, 20-30 cm tall. Leaves 1-3, erect, 15-31 x 0.1-0.6 cm, linear, acuminate, plicate, grass-like. Inflorescence 2-10-flowered. Flowers rather bell-shaped, primrose-yellow or pale lemon-yellow.

Ecology: Miombo, woodlands on Kalahari sands, escarpments.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Reference (for both species):
LA CROIX, CRIBB [1998].



Kolwezi-Kansanshi road

Eulophia chilangensis Summerh.

[Orchidaceae]

Holotype: Rogers 8522.

Copper specimens: Mf-Kk 662, 736, 785, 792; MSK 84, 101, 182, 196.

Habit: Terrestrial herb. Inflorescences 1-2, laxly 10-20-flowered. Flowers straw-coloured to brown, the lip violet or purple-tinged, with no papillae; the 3 main veins of the lip thickened at the base, usually running almost to the apex; spur 2-3 mm long, slender, downcurved.

Ecology: Miombo, on rocky outcrops, also on copper rocky sites.

General distribution: D.R. Congo, Zambia.

Distribution on Katangan copper sites (7 sites): Pumpi XI (29), Zikule (30), Kakavilondo (31), Kabwelunono (34), Mwinansefu (43), Kazinyanga (49), Mambilima (50).



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Tenke-Kando road



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Mamfwe road

Eulophia cucullata (Afz. ex Sw.) Steud.

[Orchidaceae]

Holotype: Afzelius s.n.

Copper specimens: Mf 11149; MKS 551.

Habit: Herb 40-130 cm tall. Leaves 3-4, plicate erect, linear. Inflorescence laxly 3-8-flowered. Flowers: petals rose-purple; lip rose-purple.

Ecology: Miombo, wooded grasslands, dambos and copper steppe savannas.

General distribution: From Senegal to R.S.A., Madagascar.

Distribution on Katangan copper sites (9 sites): Notably Shabara (24).



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Near Kolwezi



Manika plateau



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Eulophia gonychila Schltr.

Holotype: Baum 261.
Copper specimen: ISI 275.

Habit: Terrestrial herb, 15–40 cm tall. Leaves 3–4, 8–15 x 3–5.5 cm, ovate, obtuse, plicate. Inflorescence fairly densely up to about 30-flowered. Flowers pink or pinkish-brown, the petals veined with red on the inner surface, the lip red-veined on the side lobes and the mid-lobe. Lip 15 mm long, obscurely 3-lobed, with a lacerate membrane in the throat.

Ecology: Miombo, steppe savannas.

General distribution: Angola, D.R. Congo, Burundi, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Fungurume (51).



Fungurume

Eulophia holubii Rolfe
[Orchidaceae]

Holotype: Holub s.n.
Copper specimen: Mf 12119.

Habit: Slender terrestrial herb, 17–46 cm tall. Inflorescence laxly 2–10-flowered. Leaves 3, 12–33 x 0.1–0.25 cm, linear, acuminate, grass-like. Flowers pale to deep pink, or mauve flushed with purple; the lip darker with white fimbriae.

Ecology: Steppe savannas on Kalahari sands, rarely on fringe of copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia, Zimbabwe, Namibia, Botswana.

Distribution on Katangan copper sites (1 site): Kasonta (91).



Manika plateau

Eulophia katangensis

(De Wild.) De Wild.

Holotype: Verdick s.n.

Copper specimen: Not collected.

Habit: Terrestrial herb, 10-60 cm tall. Leaves linear, grass-like, 20-30 cm x 3 mm. Inflorescences laxly 2-8 flowered. Flowers cream or pale pink with a mauve lip or brownish with a purple-(green) lip. Lip 3-lobed about halfway; side lobes erect, mid-lobe suborbicular.

Ecology: Miombo, wooded savannas, rocky outcrops.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Mambilima (50).

Eulophia longisepala Rendle

[Orchidaceae]

Holotype: Whyte s.n.

Copper specimens: ISI 114, 237.

Habit: Terrestrial, semi-saprophytic herb, 10-75 cm tall. Leaves vestigial, linear purplish, 2-4 cm long. Inflorescences 1-3. Flowers greenish-brown, purple or scarlet, lip white with purple veins and margins. Sepals erect, linear-spathulate, acute. Petals narrowly elliptic, acute, lying over the column. Lip 10-16 mm long, 6-11 mm wide.

Ecology: Miombo, rocky outcrops.

General distribution: From Burundi and Tanzania to R.S.A. and Angola.

Distribution on Katangan copper sites (1 site): Fungurume (51).



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Kasipa road



Lufupa North falls road



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Mamfwe road

Eulophia monotropis Schltr.

Holotype: R.E. Fries 631a.
Copper specimen: ISI 140.

Habit: Slender terrestrial herb, 30-43 cm tall. Perennating organs pseudobulbs, forming a chain. Leaves 7-8, erect, 5-20 cm x 1-1.5 mm, linear, acuminate, the basal 3 sheathing. Inflorescence laxly 3-10-flowered. Flowers spreading, becoming pendent as the capsule starts to develop; sepals greenish-brown, petals pale pinkish-white, lip lilac or pinkish with red veins and white papillae, spur greenish-brown. Spur 4-7 mm long, conical, incurved, not swollen at the tip.

Ecology: Miombo on sandy soil, also on copper rocky sites.

General distribution: D.R. Congo, Tanzania, Zambia, Zimbabwe.

Distribution on Katangan copper sites (1 site): Fungurume (51).



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Mamfwe road

Eulophia mumbwaensis

Summerh. [Orchidaceae]

Holotype: Macaulay 859.
Copper specimens: ISI 139, 182.

Habit: Terrestrial herb, 25-80 cm tall. Perennating organs pseudobulbous. Leaves 4-8, erect, 9 cm x 3 mm, linear, grass-like, absent or poorly developed at flowering time. Inflorescence laxly 5-9-flowered. Flowers spreading or subnuttant; sepals purple-brown, petals cream or yellow with brownish veins, lip yellow, the side lobes purple-veined; spur reddish.

Ecology: Miombo and Kalahari sands woodlands on sandy soil, escarpment woodlands, dry dambos, also on copper rocky sites.

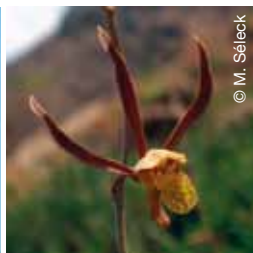
General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (2 sites): Shadirandzoro (48), Fungurume (51).

Reference (for both species):
LA CROIX, CRIBB [1998].



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Mamfwe road

Eulophia nyasae Rendle

Holotype: Whyte s.n.
Copper specimen: Not collected.

Habit: Terrestrial herb, 25-40 cm tall. Leaves 2-4, vestigial. Inflorescences 1-2, many-flowered. Sepals green, red-brown or brown; petals green lined with brown; lip white with red veins.

Ecology: Miombo woodlands.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Kinsevere (84).



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Lubumbashi-Kasumbalesa road

Eulophia odontoglossa

Rchb.f. [Orchidaceae]

Holotype: Gueinzus s.n.
Copper specimen: SHS 4687.

Habit: Terrestrial herb 50-100 cm tall. Leaves 5-6, oblanceolate, grass-like. Flowers bright yellow with yellow, orange or red papillae on lip.

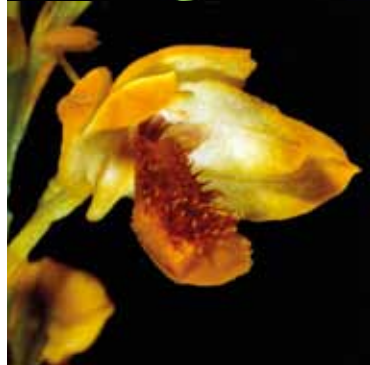
Ecology: Open montane grassland, dambos and seasonally wet areas in plateau, sandy soils and rocky areas.

General distribution: Throughout tropical Africa, from Guinea and Sierra Leone to Ethiopia and southwards to South Africa.

Distribution on Katangan copper sites (1 site): Kwatebala (45).



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Biano plateau

Eulophia* aff. *parvula
(Rendle) Summerh.

Holotype: Scott Elliot 7081.
Copper specimen: ISI 194.

Habit: Terrestrial herb 30-60 cm tall.

Ecology: Copper steppe savannas, rocky miombo woodlands, Kalahari and copper steppe savannas.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



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Tenke-Kando road

Eulophia rhodesiaca Schltr.
[Orchidaceae]

Holotype: R.E. Fries 585a.
Copper specimen: Dp-Tj 2213.

Habit: Terrestrial herb 20-30 cm tall. Leaves 2-4, 10-30 cm x 1.5-4.5 mm, linear, grass-like. Inflorescence laxly 1-5-flowered. Flowers light brown outside, purple brown inside; petals cream or yellow-green with brownish veins; lip white or mauve-pink with yellow lamellae.

Ecology: Rocky sites.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Zimbabwe.

Distribution on Katangan copper sites (1 site): Kasompi (27).



A. Fernandez

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Labellum, front view (x 3).

[GEERINCK, 1992]



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Mamfwe road

Eulophia rolfeana Kraenzl.

Holotype: Baum 369.
Copper specimen: PI 70/999.

Habit: Slender terrestrial herb, 20–30 cm tall. Leaves 3–5, 17–18 x 0.1–0.6 cm, linear, grass-like; scape with 1 ovate bract, 10–11 mm long. Pedicel and ovary arched. Lip 12–16 mm x 8 mm, recurved, covered with white or yellow-green papillae.

General distribution: Angola, D.R. Congo, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Fungurume (51).



Nzilo-Kyamasumba road



Mamfwe road

Eulophia schajjesii Geerinck
[Orchidaceae]

Holotype: Schajjes 2106.
Copper specimens: Mf 11301; Mf-Gj 130.

Habit: Slender terrestrial herb, up to 50 cm tall. Leaves up to 3, attenuate in petiole, 10–20 x 0.1–0.7 cm, linear to oblong. Inflorescence laxly 5–8-flowered. Flowers leaning, perianth orange. Median sepal oblong, acute, 13 x 3 mm; lateral sepals narrow, triangular, 15 x 2.5 mm. Petals oblong, 10–12 x 2.5 mm. Lip 10–12 x 4 mm, deeply 3-lobed, no spur, with a double crest at basis and several thread-like papilla to the summit; lateral lobes oblong, parallel; mid-lobe spatulate, half the length of the lip. Ovary 4 mm long.

Ecology: Seasonally wet steppe savannas, including copper clearings.

General distribution: Restricted to the surroundings of Kolwezi in Upper Katanga.

Distribution on Katangan copper sites (1 site): Dikulushi (1).

Reference: GEERINCK [1992].



Munanga

Eulophia schweinfurthii

Kraenzl.

Holotype: Schweinfurth 2671.

Copper specimen: ISI 97.

Syn.: *Eulophia orthoplectra* (Reichb. f.)Summerh. var. *schweinfurthii* (Kraenzl.)

Geerinck

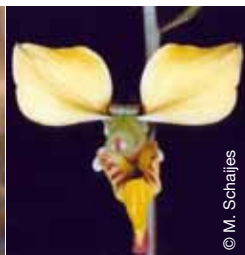
Habit: Terrestrial herb. Perennating organs subterranean, tuberous. Leaves 4-7, forming a fan, 17-38 cm x 2.5-18 mm, linear, acuminate, absent or not fully developed at flowering time. Inflorescence up to 1 m tall. Flowers rather fleshy, sepals purple-red, petals yellow, heavily veined with red inside, lip yellow, the side lobes purplish, the mid-lobe edged with purple. Sepals 6.7-10.6 x 3.5-4 mm, oblong, apiculate. Petals 8.5-13 x 9-13 mm, suborbicular or broadly ovate, acute or obtuse. Lip 12-14 mm long, 3-lobed, spur 5.5-8 mm long, conical, upcurved. Column 3-5 mm long.

Ecology: Open forests (miombo), steppe savannas, also with low copper content.

General distribution: Sudan and Ethiopia southwards to R.S.A.



Mamfwe road



Kolwezi-Wasela road



Near Sokoroshe

Eulophia seleensis (De Wild.)

Butzin

[Orchidaceae]

Holotype: Butaye in Gillet 1449.

Copper specimens: Kk-Mf 304, 349.

Habit: Slender terrestrial herb, 30-50 cm tall. Leaves 5-9, forming a fan, 12-20 x 0.3-1.0 cm, linear or linear-lanceolate, starting to develop at flowering time. Inflorescences 1-2, laxly few- to several-flowered. Sepals green-brown or yellow-green; petals whitish; lip white or greenish-white with a pale purple edged, purple-veined side lobes and lilac and white papillae on mid-lobe, spur 3-4 mm.

Ecology: Kalahari sandy woodlands and dry miombo, also on rocky hillsides.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Mamfwe road



Manika plateau

***Eulophia* sp.**

Copper specimens: Pi 4567; RSHI 64.

Habit: Terrestrial herb. Sepals brownish red; labellum white, mauve-veined.

Ecology: Copper steppe savannas.

Distribution on Katangan copper sites (20 sites): Notably Katuto (41), Fungurume (51).

Note: This taxon resembles to *E. seleensis*, but differs by the globulose end of the spur as well as by the crest of the labellum.



Tenke-Kando road

***Eulophia tuberculata* Bolus**
[Orchidaceae]

Holotype: Syntypes from South Africa.
Copper specimen: MKS 142.

Habit: Terrestrial herb. Leaves up to 20 x 0.6 cm, linear, coriaceous, silvery-green. Inflorescence 15-60 cm tall, few- to several-flowered; scape reddish. Sepals brownish, petals yellow on outside, red-brown inside; lip yellowish with heavy red veining and yellow crests, side lobe cream. Lip 8-11 mm long, 3-lobed, difficult to flatten, side lobes erect; mid-lobe elliptic with 3 rugulose crests; spur very short.

Ecology: Open forests, grasslands, Kalahari and copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique, R.S.A.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).

Reference:

LA CROIX, CRIBB [1998].



Manika plateau

Holotype: Waller s.n.
Copper specimens: Bp-Mf 8227;
Mf 11234, 11443, 12854, 16478.

Habit: Slender terrestrial herb up to 0.7 m tall. Perennating organs subterranean, tuberous, 2.5-4 cm long, 1.5-2 cm in diam., irregularly shaped, forming chains, roots 1 mm in diam. Leaves 2-3, 30-55 x 0.4-2 cm, linear, acuminate. Inflorescence rather densely 8-20-flowered. Pedicel and ovary 6-10 mm long; bracts up to 7.5 cm long, setose. Flowers drooping, bright orange to vermilion-red, the lip paler at the base, with cream or yellow side lobes veined with purple; callus yellow. Sepals and petals linear, acute or acuminate. Dorsal sepal 30-45 x 2-5 mm; laterals similar but up to 55 mm long. Petals 26-40 x 3 mm. Lip 20-27 mm long, 3-lobed near the base; side lobes to 4 mm long, narrowly triangular, acute; mid-lobe 16-18 x 2 mm, spatulate-elliptic; callus of 2 basal ridges; spur absent. Capsule 15-20 mm long, pendent.

Ecology: Open grasslands on Kalahari sands, dambos, miombo woodlands on sandy soils, also on copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi, Mozambique, Namibia, Botswana, Zimbabwe.

| Hydratation | Copper content of soil | | | |
|-------------|------------------------|-----|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| dry | | <X< | <X< | |
| medium | XX | X | | |
| wet | X | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (3 sites): Shabara (24), Kavifwafwaulu (42), Etoile (97).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 65; Co = 9 µg/g D.M.

Rehabilitation: No evident interest.

References:

- GEERINCK [1992].
- LA CROIX, CRIEBB [1998].



Mamfwe road



© M. Schatjies

Habenaria cataphysema

Rchb.f.

Holotype: Welwitsch 722.

Copper specimen: Not collected.

Habit: Slender terrestrial herb, 30-80 cm tall. Tubers 1-1.5 x 1 cm, globose to ovoid. Stem leafy; leaves 7-9, the lowermost 1-2 sheath-like, the uppermost 3-4 bract-like, the rest 5.5-13.5 x 0.4-0.8 cm, linear.

Ecology: Dambos, damp marshy places, sandy and rarely wet copper steppe savannas.

General distribution: Angola, D.R. Congo, Zambia.

Distribution on Katangan copper sites (1 site): Dikuluwe (2).



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Manika plateau

Habenaria cirrhata (Lindl.)

Rchb.f. [Orchidaceae]

Holotype: Lyall s.n.

Copper specimen: MSH 413.

Habit: Robust terrestrial herb, 50-130 cm tall. Leaves 9-13, the mid-stem leaves 7-22 x 3.5-9 cm, lanceolate, ovate or orbicular. Inflorescence laxly 2-12-flowered. Flowers green or greenish-white.

Ecology: Miombo open forests, *Uapaca robynsii* copper belts.

General distribution: Tropical Africa and Madagascar.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).



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Kazinyanga



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Mamfwe road

Habenaria disparilis

Summerh.

Holotype: Robson 1345.
Copper specimen: Mal 192.

Habit: Robust herb, 50-80 cm high. Leaves 7-13, the largest linear-lanceolate. Inflorescence 10-30 x 3-4 cm, densely many-flowered. Flowers green, white in centre. Sepals all reflexed. Petals 2-lobed almost to base, upper lobe 6-9 mm long, less than 1 mm wide; lower lobes, 10-13 x 2.5-3 mm, lanceolate. Lip deflexed, 3-lobed; mid-lobe 10.5-16 mm long, side lobes usually, slightly shorter, all lobes ca 1 mm wide. Spur 20-30 mm long, curving forwards, inflated in apical third. Stigmatic arms diverging from each other at an angle of ca 60°.

Ecology: Miombo woodlands, grasslands, dambos.

General distribution: D.R. Congo (Upper Katanga), Zambia, Malawi, Zimbabwe.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Potopoto valley



Kipopo

Habenaria falciloba

Summerh. [Orchidaceae]

Holotype: De Witte 195.
Copper specimens: Mal 925; Mf-SI 87.

Habit: Robust herb, up to 75 cm high. Stem leafy. Leaves 17 x 5 cm, broadly lanceolate. Inflorescence 15 x 6.5 cm densely many-flowered. Flowers semi-erect, greenish. Petals 25 x 7 mm, falcate-lanceolate from a narrow base, entire. Lip 3-lobed with a claw 5-8 x 5 mm. Spur 20 mm long, swollen to a width of 3.5 mm near apex.

Ecology: Wet *Uapaca* woodlands, also on wet copper steppe savannas.

General distribution: D.R. Congo (Upper Katanga), Zambia (West).

Distribution on Katangan copper sites (1 site): Shadiranzoro (48).



Shadiranzoro



Mamfwe road

Habenaria malacophyllaRchb.f. var. *shabaensis*

Geerinck

Holotype: Hutton 45.

Copper specimen: Dp 5155 Or.

Habit: Terrestrial herb 30-60 cm tall. Stem erect, leafy nearly to the base. Inflorescence 12-20 cm long, densely many-flowered. Flowers green, yellowish-green or greenish-white.

Ecology: Rocky outcrops, also on copper orebodies.

General distribution: From Sierra Leone to Ethiopia and southwards to R.S.A.

Distribution on Katangan copper sites (1 site): Dikuluwe (2).



Manika plateau

Habenaria perpulchra

Kraenzl.

[Orchidaceae]

Holotype: Kassner 2372.

Copper specimens: LSDIH 5; Mf 11646, 16404, 16524.

Habit: Terrestrial herb 15-35 cm tall. Stem erect, with 1 basal leaf appressed to ground, up to 4.5 cm long and broad, ovate, orbicular or reniform and 2-7 loosely sheathing stem leaves. Inflorescences up to 7 cm long, fairly densely 1-5-flowered. Flowers white. Petals 2-lobed almost to base.

Ecology: Upland grasslands, also on copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (3 sites): Kabwelunono (34), Kavifwafwaulu (42), Luiswishi (87).



Kavifwafwaulu

Habenaria retinervis

Summerh.

Holotype: Milne-Redhead 3805.
Copper specimen: SDI 124.

Habit: Herb up to 80 cm tall. Leaves 7-11, the largest 5-16 x 1-3 cm, lanceolate. Inflorescence laxly 8-30-flowered. Flowers pale green, curved outwards. Petals 2-lobed, upper lobe recurved, lower lobes 9-11 x 1-2.5 mm, lanceolate, acute. Side lobes of lip 7.5-11 x 1.5 mm, lanceolate, ± parallel to petal lower lobes.

Ecology: Open forests, also on copper steppe savannas.

General distribution: D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



Kipopo

Habenaria robbrechtiana

Geerinck & Schajjes

[Orchidaceae]

Holotype: Schajjes 2832 B.
Copper specimen: MSH 412.

Habit: Herb 10-15 cm tall, nearly totally hairy. Basal leaf appressed to the ground, cordate. Inflorescence laxly 1-3-flowered. Flowers white.

Ecology: Open forests, also on dry rocky copper steppe savannas.

General distribution: Upper Katanga, restricted to five sites.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Reference: GEERINCK [1992].



Nzilo-Kyamasumba road

Habenaria tetraceras

Summerh.

Holotype: Milne-Redhead & Taylor 8567.
Copper specimens: SDI 115, 321.

Habit: Terrestrial herb 20-60 cm tall. Flower green, petals bipartite to base, lobes filiform, curving up.

Ecology: Boggy grasslands, swamps, also in a wet copper steppe savanna.

General distribution: D.R. Congo (Upper Katanga), Tanzania, Zambia.

Distribution on Katangan copper sites (1 site): Kachimilumbwe (xx).



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Near Kolwezi

Habenaria weberiana Schltr.

[Orchidaceae]

Holotype: Stolz 762.
Copper specimen: Mf 16418.
Syn.: *H. huillensis* Rchb.f. var. *weberiana* (Schltr.) Geerinck

Habit: Terrestrial herb 30-60 cm tall. Leaves 6-13. Flower green, white in centre, lip 3-lobed, all lobes linear.

Ecology: Dambos, wet grasslands, also in a wet copper steppe savanna.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (1 site): Kavifwafwaulu (42).



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Potopoto valley



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Kavifwafwaulu

Liparis mulindana Schltr.

[Orchidaceae]

Holotype: Stolz 1933.
Copper specimen: MSK 86.

Habit: Dwarf terrestrial herb; short, fleshy rhizome. Leaf 1, appressed to the ground, up to 6 x 5 cm, ovate or ± orbicular, cordate at the base, with 8-9 deeply impressed veins, dark olive-green with a reddish tinge above, deep purple beneath. Inflorescence to 15 cm long, 4-8-flowered; peduncle 8-12 cm long, reddish-green, with 2-3 narrow, acuminate, reddish bracts ca 5 mm long. Flowers dull reddish, green towards the centre. Pedicel and ovary 5-8 mm long, winged; bracts 4-5 mm long, narrowly triangular, acuminate, purple. Dorsal sepal erect, 6-10 x 1-1.5 mm, linear, fleshy; lateral sepals 6-7 x 3-4 mm, obovate, falcate, joined at first but later separating, projecting forwards, the tips curled down, lying below the lip. Petals 6-11 mm long, less than 1 mm wide, linear, fleshy, deflexed or spreading. Lip 8 x 4.5 mm, geniculate, constricted after a broadly auriculate base then ± heart-shaped, concave with a fleshy disk in the centre; slightly emarginated at the apex. Column 4-6 mm long, geniculate, winged towards the apex.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|---|-------|-----|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | <X< | 5,000 |
| | 800 | 5,000 | | |
| dry | X | X | (X) | |
| medium | X | | | |
| wet | | | | |

→ mesocuproresistant

Ecology: *Brachystegia* woodlands, stony hill sides, also stony copper steppe savannas.

General distribution: Tanzania, Burundi, D.R. Congo, Zambia, Zimbabwe, Malawi.

Distribution on Katangan copper sites (2 sites): Kwatebala (45), Mwadikombamba (47).

Rehabilitation: No evident interest.

Reference:

LA CROIX, CRIEBB [1995].



Nzilo-Kyamasumba road



© M. Schajles



Liparis nervosa (Thunb.) Lindl.

[Orchidaceae]

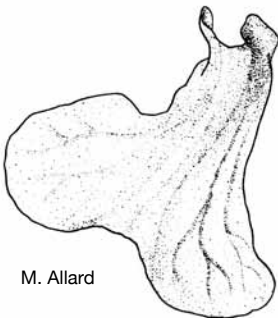
Holotype: Thunberg s.n.

Copper specimens: Kp-Kk 61; MMK 51; MSH 40, 474.

Habit: Terrestrial herb to 60 cm tall. Pseudobulbs up to 4 x 2.5 cm, ovoid, covered with leaf sheaths, partly underground. Leaves 2-3, petiolate with a sheathing base, the lamina to 35 x 9 cm, lanceolate to ovate, acute, ribbed, light green. Peduncle 5-angled with several sheaths; inflorescence densely many-flowered, rhachis up to 15 cm long. Flowers small, ca 6 mm in diameter, green or yellow-green, the lip deep purple or green-purple. Pedicel and ovary 10-12 mm long, erect; bracts to 7 mm long. Dorsal sepal 5.3-6.3 x 1-2 mm, linear, fleshy, erect or reflexed; lateral sepals 3-5 x 2-3 mm, oblong, falcate, often rolled up, lying below lip. Petals 4.5-6 mm long, narrowly linear, reflexed. Lip 2.5-4 x 2.5-4.5 mm, ± orbicular, auriculate at the base. Column arched, 2.5-4 mm long with lateral wings towards the apex and an apical wing around the anther.

Ecology: *Brachystegia* woodlands, rarely on copper shrubby steppes.

General distribution: Pantropical, from Costa Rica and Columbia to Japan and Philippines.



M. Allard

Labellum, front view (x 12.5). [GEERINCK, 1984]

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| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| normal | 200 | 800 | > |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | (X) | | |
| medium | XX | | |
| wet | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (4 sites): Kwatebala (45), Mwadikomba (47), Kazinyanga (49), Fungurumba (51).

Phytogeochemistry: Cu-Co content of leaves (1 sample): Cu = 31, Co = 50 µg/g D.M.

Rehabilitation: No evident interest.

References:

GEERINCK [1984].

LA CROIX, CRIBB [1995].



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Manika plateau

Malaxis katangensis Summerh. var. *katangensis*

[Orchidaceae]

Holotype: von Hirschberg 152.
Copper specimen: MSH 2.

Habit: Dwarf terrestrial herb, 3-15 cm tall. Rhizome creeping, but cigar-shaped and tuberlike below the flowering stems. Leaves 2-3 at base of stem, the lowermost sheath-like, the others subopposite, to 6 x 4 cm, ovate or elliptic, light green, plicate. Inflorescence 2-14 cm long, narrowly cylindrical, densely many-flowered; flowers very small, yellow-green, turning buff-orange with age. Pedicel and ovary 2 mm long; bracts 2-3.5 mm long. Dorsal sepal erect, 2-2.5 x 1 mm, lanceolate; lateral sepals 1.5-2.2 x 1-1.5 mm, obliquely ovate. Petals 1.8-2.3 x 0.3-0.6 mm, linear-lanceolate, the margins glandular. Lip 1.3-1.8 x 1.5-1.8 mm, obovate, auriculate at the base, with a central pad of hairs; margins smooth. Column 0.7 mm long.

Ecology: Miombo open forests, rarely copper steppe savannas with low copper content.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|---------|
| normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | | | |
| medium | XXX | (X) | |
| wet | | | |

→ oligocuproresistant

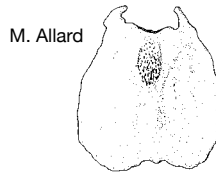
General distribution: Sierra Leone, Nigeria, D.R. Congo, Burundi, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (3 sites): Notably Shadirandzoro (48).

Rehabilitation: No evident interest.

References:

- GEERINCK [1984].
- LA CROIX, CRIBB [1995].



M. Allard

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Labellum, front view (x 5). [GEERINCK, 1984]



Manika plateau



Kipopo

© M. Schallies

Nervilia adolphi Schltr.

[Orchidaceae]

Holotype: Stolz 1870.
Copper specimen: Lj-Cs-Hg 148.

Habit: Erect herb, 5-8 cm high. Scape 1-flowered at apex. Sepals and petals brownish green; lip white to faint pink, spotted purple-violet; lateral lobes short, erect, obtuse.



Mamfwe road



Tenke-Kando road

Ecology: Woodlands, grasslands.

General distribution: Togo, Nigeria, D.R. Congo to Uganda and southwards to R.S.A.

Distribution on Katangan copper sites (1 site): Kabwelunono (34).



Kabwelunono



© J. Lebrun

Nervilia kotschy (Reich.f.) Schltr.

[Orchidaceae]

Holotype: Cienkowski s.n.
Copper specimen: MKS 1014.

Habit: Terrestrial erect herb up to 28 cm tall. Tuber ovoid to ellipsoid, 1-2 cm in diam. Leaf solitary, broadly cordate, acute to apiculate, 3-7 x 4-13 cm, dark green above, purple beneath. Inflorescences erect, 2-(7)-flowered. Flowers suberect to pendent, pale to olive-green with a white lip lined on veins with purple.

Sepals and petals linear-lanceolate, acute, 1.4-1.9 x 0.3 cm. Lip porrect, obscurely 3-lobed in apical half, elliptic in outline, 1.4-1.8 x 0.9-1.2 cm; side lobes shortly triangular, acute.

Ecology: Shady places in woodlands, rarely in copper steppe savannas.

General distribution: West Africa across to Sudan and Ethiopia and southwards to R.S.A. (Transvaal).



Mamfwe road



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Nervilia kotschy (Reich.f.) Schltr.

[Orchidaceae]

Continuation of page 370.

Distribution on Katangan copper sites (1 site): Zikule (30).

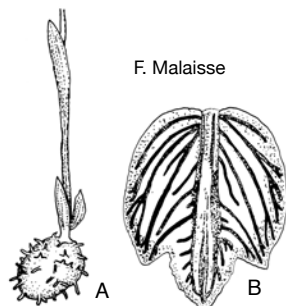
References:

CRIBB [1984].
GEERINCK [1984].



Zikule

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A. Bulb and stem (x 0.7) – B. Lip (x 3.2).
[Drawn after PETERSSON, 1991]

Nervilia petraea (Afz. ex Sw.) Summerh.

[Orchidaceae]

Holotype: Afzelius s.n.
Copper specimen: MSK 98.

Habit: Erect terrestrial herb, 2-8.5 cm tall, glabrous except for lip and subterranean parts. Tuber subspherical or ovoid, 3-8 mm in diam., 3-noded.

Ecology: Woodlands, grasslands, dambos, copper steppe savannas.

General distribution: Tropical Africa (from Sierra Leone to Mozambique), Madagascar and Mauritius.

Distribution on Katangan copper sites (1 site): Mwadikomba (47).

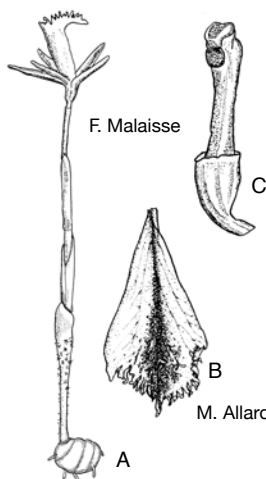
Rehabilitation: No evident interest.

Reference: PETERSSON [1991].



Mwadikomba

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A. Flowering plant (x 0.7) – B. Lip (x 2.5) – C. Column (x 1.7).

[GEERINCK, 1984; Drawn after PETERSSON, 1991]

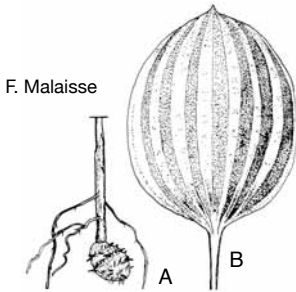
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Nervilia shirensis (Rolfe) Schltr.

[Orchidaceae]

Holotype: Buchanan 317.
Copper specimen: Mf-Kk-SI 1014.

Habit: Erect herb to 35 cm high. Flowers 2-(3), becoming pendent. Sepals and petals greenish-yellow with red veins; lip cream with red or purple venation. Dorsal sepal porrect, linear-lanceolate, acute. Petals porrect, shorter than sepals.



A. Tuber (x 0.25) – B. Lamina (x 0.25).
[Original plate]

Ecology: Miombo open forest.

General distribution: Zambezan.

Distribution on Katangan copper sites (1 site): Zikule (30).



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Mwashya

Nervilia stolziana Schltr.

[Orchidaceae]

Holotype: Stolz 201.
Copper specimen: Note collected.

Habit: Erect herb to 8 cm high, 1-flowered at apex. Sepals and petals reddish green; lip spurred,

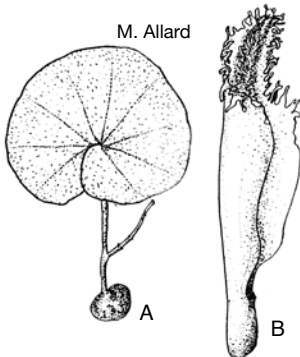
lilac, mauve or red. Sepals linear-lanceolate. Petals similar but shorter.

Ecology: Woodlands, grasslands.

General distribution: Zambezan.

Distribution on Katangan copper sites (1 site): Mwadikomba (47).

Reference (for both species):
PETERSSON [1991].



A. Habit, leafy plant (x 0.5) – B. Labellum (x 3).
[GEERINCK, 1984]

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Kipopo road



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Tshilongo

Polystachya dendrobiiflora Rchb.f.

[Orchidaceae]

Holotype: Meller s.n.
Copper specimens: Pi-Kp 4700, 4742;
MSH 169.
Syn.: *P. tayloriana* Rendle

Habit: Erect epiphytic, lithophytic or terrestrial herb, with pseudobulbs clustered. Pseudobulbs 1.5-5 x 0.6-1 cm, conical, 2-4-noded, 5-10-leaved. Leaves distichous, grass-like, linear, conduplicate, deciduous. Flowers borne on old pseudobulbs when plants are leafless; inflorescence to 80 cm long, with one to several short branches, each several-flowered. Pedicel and ovary slender, 8-13 mm long. Flowers showy, opening wide, shell-pink to mauve-pink, sometimes almost white, sometimes with red or lilac spots on the lip. Dorsal sepal 5.7-12 x 1.7-4 mm, oblong, subacute or obtuse; lateral sepals 7-11.5 x 3.5-6.5 mm, obliquely oblong-lanceolate, forming a curved, conical mentum 3-5 mm high. Petals 5.8-11.6 x 1.5-4.5 mm, oblong to obovate, rounded. Lip entire, 7-11 x 3-6.8 mm ovate-oblong, rounded or emarginated at the apex, with a yellow, slightly pubescent, longitudinal callus in the basal third. Column 2.5-4 mm long. Capsule cylindrical, 4-4.5 x 3-4 cm.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | XX | X | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

Ecology: Rocky outcrops, epiphytic on *Xerophyta* spp., including copper steppe savannas.

General distribution: Angola, D.R. Congo, Burundi, Kenya, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique.

Distribution on Katangan copper sites (3 sites): Kwatebala (45), Shadirandzoro (48), Mambilima (50).

Rehabilitation: Pleasant habit.

Reference:
LA CROIX, CRIEB [1998].



Nzilo-Kyamasumba road



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Polystachya modesta Rchb.f.

[Orchidaceae]

Holotype: Welwitsch 874.

Copper specimen: Mf-Kk 1031.

Habit: Epiphytic, rarely lithophytic herb. Pseudobulbs clustered, 0.6-10 x 0.3-1.5 cm, conical, purple or yellow, 3-4-leaved. Leaves 4-12.5 x 1-2.2 cm, elliptic or lanceolate, dark green, often edged with purple. Inflorescence (floral axis) 5-18 cm tall, simple or with a few short, pubescent branches, fairly densely several- to many-flowered. Peduncle covered with flattened sheaths. Flowers glabrous, fleshy, variously described as lemon-yellow, dull red and yellow, green and yellow, and bright purple, often not opening properly but apparently self-fertile. Pedicel and ovary 3-4 mm long; bracts 2-3 mm long, ovate, acuminate. Dorsal sepal 2.5-3.2 x 1.5-2.3 mm, ovate, acute; lateral sepals 3.5-5 x 2.5-3 mm, obliquely triangular, acute; mentum conical, rounded, 2.5-3 mm high. Petals 2-3 x 0.6-1 mm, oblanceolate. Lip 3.25-4.75 x 2.3-3.5 mm, clawed, 3-lobed at about the middle. Mid-lobe 1-2 x 1.6-2.3 mm, ± orbicular, recurved, bullate, emarginated; side lobes erect, ca 1 mm long, acute; disk with a cushion of whitish hairs. Column ca 1.5 mm long.

Ecology: Woodlands, epiphytic on trees, occasionally on *Xerophyta* spp., also on rocks.

General distribution: Widespread in tropical Africa.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Rehabilitation: No evident interest.

Reference:

LA CROIX, CRIBB [1998].

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | X | (X) | | |
| medium | X | | | |
| wet | X | | | |

→ oligocupproresistant



Kwatebala

© M. Séléck



Nzilo-Kyamasumba road

© M. Schajles



Near Kolwezi

© M. Schajles

Rangaëris muscicola (Rchb.f.) Summerh.

[Orchidaceae]

Holotype: Welwitsch 699.
Copper specimen: Mf 16622.

Habit: Epiphytic or lithopytic herb; stem short, 1-6 cm long. Roots arising at the base of the plant, 3-5 mm in diam. Leaves 5-11, forming a fan; lamina 6.5-20 x 0.6-1.8 cm, linear, conduplicate, unequally and obtusely 2-lobed at the apex, slightly recurved, coriaceous, dark green. Inflorescences 1-2, arising from lower leaf axils, to 20 cm long, 5-12-flowered. Pedicel and ovary slender, 25 mm long, bracts sheathing, black, 3-9 mm long. Flowers waxy white, turning apricot-coloured with age, very sweetly scented. Dorsal sepal 7-9 x 2.5-4 mm, ovate, erect; lateral sepals 7.3-9.4 x 2.3-4 mm, obliquely lanceolate, acute, deflexed. Petals 6.5-8 x 1.5-3 mm, obliquely elliptic, slightly reflexed.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-----|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

Lip entire, 6.7-9 x 4-7 mm, broadly ovate, acute; spur 5.5-8.5 cm long, filiform, pendent, ± straight or slightly S-shaped. Column 3-4.5 mm long.

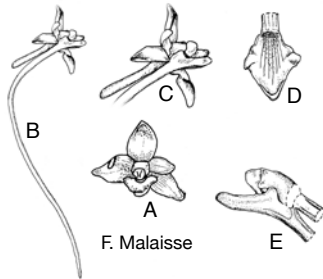
Ecology: Miombo open forests, often on rocks, rarely on copper siliceous cellular rocks.

General distribution: Widespread in tropical Africa and in South Africa.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Rehabilitation: No evident interest.

Reference: LA CROIX, CRIBB [1998].



A. Flower, front view (x 1) – B. Flower, side view (x 0.5) – C. Flower, side view detail (x 0.8) – D. Lip (x 1.5) – E. Column & lip, side view (x 1.3). [Drawn after J. Stone in LA CROIX & CRIBB, 1998]



© M. Schaffies

Near Kolwezi



Nzilo-Kyamasumba road



Satyrium kitiboense Kraenzl.

[Orchidaceae]

Holotype: Kassner 2290.
Copper specimen: Sb 4914.

Habit: Terrestrial herb, 35-75 cm tall. Tuber 2.5-4 x 1-2.5 cm, ovoid or globose. Basal leaves 2, appressed to the ground, broadly ovate to reniform, glabrous. Stem with 3-6 sheathing leaves, up to 7 cm long. Inflorescence 3-12-flowered, 10 x 7 cm. Flowers white, the spurs green at the tips. Sepals and petals projecting or decurved, joined at the base to each other and to the lip. Median sepal 18-23 x 5-10 mm, oblanceolate; lateral sepals 17-25 x 6.5-12 mm, obliquely oblong-lanceolate, obtuse. Petals similar to median sepal. Lip 16-23 mm long, very convex and wide-mouthed, the apex reflexed; spurs 2, 24-35 mm long, less than 2 mm wide at base, tapering to an acute apex.

Ecology: Open forests, woodlands, steppe savannas, dambos.

General distribution: D.R. Congo, Burundi, Tanzania, and from Angola to Mozambique.

| Hydratation | Copper content of soil (in µg per g of soil) | | |
|-------------|---|-------|-------|
| | normal | 200 | 800 |
| medium | <X | <X | 5,000 |
| wet | 800 | 5,000 | |

→ oligocuproresistant

Distribution on Katangan copper sites (1 site): Mukandjila (171).

Rehabilitation: Pleasant habit.

Reference:

LA CROIX, CRIBB [1995].



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Nzilo-Kyamasumba road



Manika plateau



Mamfwe road

Holotype: Volkens 270.

Copper specimen: SDI 199.

Habit: Terrestrial herb 45-85 cm tall; tubers to 5 cm long, ellipsoid, woolly. Sterile shoots 3-4 leaved; lowermost 1-2 leaves sheathing; upper leaves up to 18 x 5 cm, lanceolate or elliptic. Flowering stem with 7-13 sheathing leaves up to 10 cm long. Flowers green or yellow-green, sometimes tinged with brown; scented. Ovary 6-10 mm long, glabrous or slightly papillate; bracts up to 35 mm long at base of inflorescence, reflexed. Sepals and petals curled under, joined on each other and lip in lower half or third. Median sepal 3.5-5 x 0.7 mm, oblanceolate, rounded at apex; lateral sepals slightly longer and about twice as wide, oblique. Petal similar to median sepal. Lip 4.5-5.5 mm long, ellipsoid, hooded, the apex reflexed, fleshy with a narrow mouth. Spurs 14-22 mm long, slender, pendent, sometimes with 2 extra rudimentary spurs less than 1 mm long below them. Column 3-5 mm long, curved; stigma 1-2 x 1-2 mm; rostellum mid-lobe spoon-shaped from a narrow base, much longer than side lobes.

Ecology: *Brachystegia* and mixed woodlands, grasslands



Kipopo

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | (X) | | |
| wet | (X) | | | |

→ oligocuproresistant

with scattered bushes, montane grasslands and dambos margins, also copper steppe savannas with low copper content.

General distribution: Nigeria, Cameroon, Kenya, D.R. Congo, Tanzania, Zambia, Zimbabwe, Malawi.

Distribution on Katangan copper sites (1 site): Kachimilumbwe (XX).

Rehabilitation: No evident interest.

Reference:

LA CROIX, CRIBB [1995].



Tridactyle bicaudata (Lindl.) Schltr.

[Orchidaceae]

Holotype: Drège s.n.

Copper specimen: Mf s.n.

Habit: Robust epiphytic herb. Stems erect or pendent, woody, 20-80 cm long, seldom branched, covered with old leaves bases. Roots 2-8 mm in diam., smooth or very slightly verrucose. Leaves distichous, very variable in size or texture, depending largely on degree of exposure to light, 6-15 x 0.6-1.8 cm, linear or ligulate, unequally 2-lobed at the apex, thin-textured and flat, or fleshy and conduplicate. Inflorescences arising along the stem, 3.5-13 cm long, densely up to ca 25-flowered, the flowers in 2 rows, all facing the same way. Pedicel and ovary 3-6 mm long; bracts sheathing, 1-2 mm long. Flowers yellowish, yellow-green or dingy-cream. Sepals 4-6 x 1.5-4 mm, ovate, acute, the lateral sepals oblique and slightly longer and wider than the dorsal sepal. Petals 4-6 x 1-2 mm, narrowly oblong. Lip auricled at the base, 4-6 mm long, 3-lobed at about

| Hydra- tation | Copper content of soil (in µg per g of soil) | | |
|------------------|---|-------|-------|
| | normal | 200 | 800 |
| | <X< | <X< | 5,000 |
| | 800 | 5,000 | |
| dry | (X) | | |
| medium | XX | | |
| wet | | | |

→ oligocuproresistant

halfway; mid-lobe 2-3 mm long, triangular; side lobes spreading, 3-5.5 mm long, linear, laciniate at the apex; spur 10-20 mm long, straight. Column 1-1.7 mm long.

Ecology: Miombo open forests, usually riverine evergreen forests, also rarely in copper steppe savannas with low copper content; sometimes lithophytic.

General distribution: Widespread in tropical and southern Africa.

Distribution on Katangan copper sites (1 site): Luishia (77).

Rehabilitation: No evident interest.

Reference:

LA CROIX, CRIBB [1998].



Luishia

© F. Malaisse



Kipushi-Kansanshi road

© M. Schatler

Holotype: Welwitsch 699.
Copper specimen: Mf 16621.

Habit: Erect or pending epiphytic or rarely lithophytic herb. Stem stout, up to 50 cm long, 4-5 mm in diam., rather sparsely branched. Roots 2-4 mm in diam., smooth. Leaves borne on apical end of the stem, 7-15 x 0.15-0.4 cm, terete, olive-green. Inflorescences borne along the stem, below the leaves and in leaf axils, 1.5-3 cm long, densely 4-8-flowered. Pedicels and ovary 2.5-5 mm long, lepidote; bracts 1 mm long. Flowers straw-yellow or apricot-coloured. Sepals 3-6 x 2.5-3.5 mm, ovate, acute, the lateral sepals oblique. Petals 3-6 x 1-2 mm, lanceolate, acute, falcate. Lip auriculate at the base, 3-6.5 x 3.5-4 mm, 3-lobed towards the apex; mid-lobe 1.7-2.5 mm long, triangular, acute; side lobes slender, acute; spur 6-18 mm long, straight, very slightly dilated in the apical half. Column 1-2 mm long.

Ecology: Miombo open forests, rarely on copper siliceous cellular rocks.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---------|
| | normal | 200 | 800 | > 5,000 |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | XX | (X) | | |
| wet | | | | |

→ oligocuproresistant

General distribution: D.R. Congo, Uganda, Tanzania, Zambia, Malawi, Zimbabwe, Mozambique, South Africa.

Distribution on Katangan copper sites (1 site): Kwatebala (45).

Rehabilitation: No evident interest.

Reference: LA CROIX, CRIBB [1998].



Lip and spur (x 2.5).
[GEERING, 1992]



Mamfwe road



Near Kolwezi



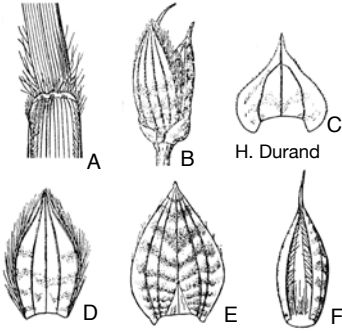
Lualaba river

Allopteropsis semialata

(R.Br.) Hitchc.

Holotype: Brown 6101.

Copper specimen: MKS 572.

Ecology: Dembo, sandy high plateau and copper steppe savannas, miombo.**General distribution:** Paleotropical.**Distribution on Katangan copper sites** (7 sites): Notably Lupoto (92).**Distribution on Zambian copper sites** (1 site): Bwana Mukubwa (145).

A. Ligule (x 1) – B. Spike (x 2.5) – C. Lower glume (x 3.5) – D. Upper glume (x 3.7) – E. Lemma, flower ♂ (x 3.7) – F. Lemma, flower ♀ (x 3.7). [ROBYNS, 1934]

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Andropogon schirensis

A.Rich.

[Poaceae]

Holotype: Schimper 1807.

Copper specimens: Dp 2999 An;

Mf-Re 2107.

Syn.: *A. dummeri* Stapf; *A. congoensis* Franch.**Habit:** Tufted perennial, culms 40-120 cm high, erect. Leaf-blades flat, 9-70 x 0.2-1.2 cm; sheath-auricles absent, the ligule up to 2 mm long. Inflorescences of paired (rarely 3) racemes, terminal.**Ecology:** Wooded grasslands and Kalahari as well as copper steppe savannas.**Distribution on Katangan copper sites** (18 sites): Notably Swambo (62).**Distribution on Zambian copper sites** (2 sites): Chambishi (133), Muliashi (173).**Reference** (for both species):

CLAYTON, RENVOIZE [1982].



Kwatebala

Kavifwafwaulu

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Shimbidi

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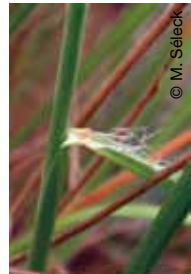


Kananga East



Luiswishi

© F. Malaisse



Fungurume

© M. Séleck

Antephora elongata De Wild.

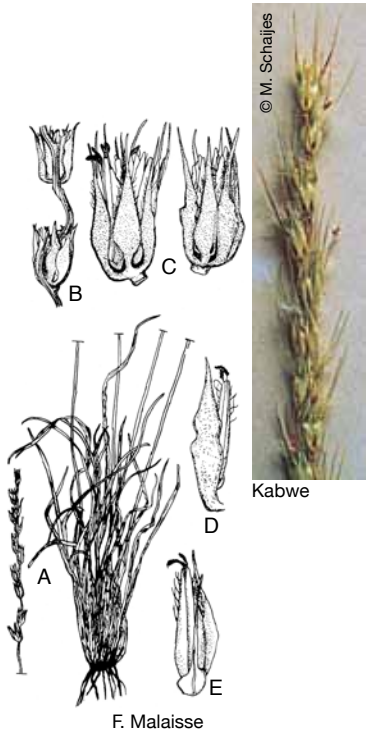
Holotype: Verdick 413.
Copper specimen: Qp 5259.

Habit: Tufted perennial; culms 50-100 cm. Leafblades flat 10-40 x 0.2-0.7 cm, ligule membranous. Inflorescence spike-like, its wavy rachis bearing deciduous sessile clusters of 3-11 spikelets.

Ecology: Wooded grasslands, also in copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (4 sites): Notably Luiswishi (92).



A. Habit (x 0.33) – B. Portion of spike (x 1.5) – C. Spikelet clusters (x 2.5) – D. Spikelet broken from cluster, showing lower glume (x 2.5) – E. Same, seen from within to show upper glume (x 2.5). [Drawn after A. Davies in CLAYTON, RENVOIZE, 1982]

Aristida junciformis Trin. & Rupr. [Poaceae]

Holotype: Buchanan 238.
Copper specimens: Sa 2790; Tr 240.

Habit: Densely caespitose perennial. Culms 20-70 cm high. Internodes of the culms very unequal the lower short, the uppermost long-exserted. Leaf-laminae usually spreading at more or less right angles from the culm, those of the uppermost leaves often approximate in pairs. Auricles of the leaves especially of the lower ones, long-barbate. Panicle 5-20 x 1-8 cm, narrow; branches up to 5 cm long. Inferior glume 2.5-5 mm long; the superior one 4.5-7 mm long. Lemma 5.5 mm long, with a short beak, usually up to 1 mm long; awns unequal, the central usually 9-11 mm long, the lateral ones 6.5-8 mm long.

Ecology: Mainly moist grasslands, also on copper steppe savannas.

General distribution: Angola, D.R. Congo, Tanzania, and southwards to R.S.A.

Distribution on Katangan copper sites (2 sites): Mutoshi (10), Etoile (97).

Reference:
COPE [2002].



Etoile mine

Arthraxon micans (Nees) Hochst.

[Poaceae]

Holotype: Royle s.n.

Copper specimens: LMM 197, 225, 407;

Mf 9775; Sa 7231; St 660; Tr 73.

Syn.: *A. quartinianus* (A.Rich.) Nash

Habit: Annual herb; culms slender, 7-60 cm long. Leaf-blades lanceolate to narrowly ovate, 1-8 cm x 3-20 mm. Inflorescence of 2-30 fasciculate racemes, each 2-4 cm long; internodes ciliate, the hairs seldom over 0.5 mm long. Sessile spikelet narrowly lanceolate, 2.5-4.5 mm long; lower glume chartaceous, strongly convex on the back, scaberulous to scabrid; upper glume acute to mucronate; awn 4-8 mm long; 2 anthers 0.3-0.8 mm long. Pedicel reduced to a subulate point 0.1-0.6 mm long, glabrous.

Ecology: Wooded grasslands, rocks, also on copper steppe savannas.

General distribution: Tropical Africa, extending through India and Sri Lanka to Thailand.

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-----|-----|---|
| | normal | 200 | 800 | > |
| dry | X | X | | |
| medium | X | (X) | | |
| wet | X | | | |

→ oligocuproresistant

Distribution on Katangan copper sites (6 sites): Pumpi XI (29), Kambove (71), Luishia (77), Kasonta (91), Lupoto (92), Etoile (97). Also on copper polluted sites such as the place of old copper furnaces (Mwanamumba) and copper tailings (Kambove).

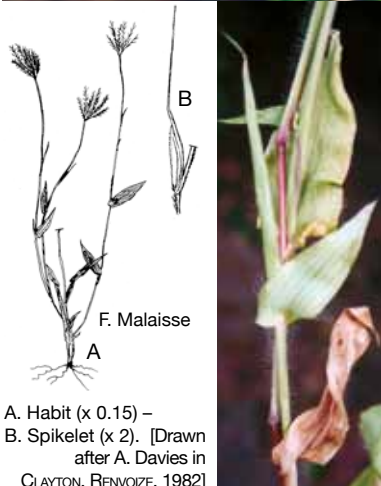
Distribution on Zambian copper sites (3 sites): Kansanshi (100), Bwana Mkubwa (145), Roan Antelope (147).

Phytogeochemistry: Cu-Co content of leaves (5 samples): Cu = 59-115, Co = 2-90 µg/g D.M.

Rehabilitation: No evident interest.

Reference:

CLAYTON, RENVOIZE [1982].



A. Habit (x 0.15) –

B. Spikelet (x 2). [Drawn after A. Davies in

CLAYTON, RENVOIZE, 1982]



Pumpi

Ctenium concinnum Nees

Holotype: Drège s.n.
Copper specimens: MKS 41, 251; Tr 228.

Habit: Tufted wiry perennial, the basal sheaths broad, becoming chestnut brown and chaffy like wood shavings; culms up to 1 m high. Leaf-blades 10-30 cm long, tightly involute. Spikes solitary, mostly 6-10 cm long, curved in an arc, bearded at the summit of the peduncle. Upper glume 5-6 mm long, hispidulous; lowest lemma oblong-elliptic, 3-3.5 mm long, ciliate on keel and marginal nerves, awned from below the tip; second lemma lanceolate, 3-3.5 mm long, ciliate on keel and marginal nerves, densely pubescent to pilose between; fertile lemma ovate 4-4.5 mm long, awned from just below the tip with awn 4.5-5.5 mm long.

Ecology: Mainly steppe savannas, often also on copper steppe savannas.

General distribution: Angola, D.R. Congo, Uganda, Kenya, southwards to R.S.A.

Distribution on Katangan copper sites (5 sites): Notably Goma (33).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 6-14, Co = 16-20 µg/g D.M.

Rehabilitation: Stabilizer.

Reference: CLAYTON et al. [1974].



Kwatebala

Cymbopogon densiflorus (Steud.) Stapf [Poaceae]

Holotype: Jardin s.n.
Copper specimens: Ls 619; Tr 75.

Habit: Tufted perennial; culms stout, 1-2 m high. Leaf-blades aromatic, broadly linear to narrowly lanceolate, 25-45 x 0.8-3 cm. False panicle globose to obovate, 6-20 cm long, very dense. Upper lemma entire.

Ecology: Open places along roads, in wooded grasslands, on disturbed copper polluted soils.

General distribution: Cameroon, Gabon, Angola, D.R. Congo, Tanzania, Zambia, Zimbabwe.

Distribution on Katangan copper sites (4 sites): Notably Ruashi (96). Also on disturbed copper polluted soils (KOV, Musonoi).

Distribution on Zambian copper sites (1 site): Bwana Mkubwa (145).

Phytogeochemistry: Cu-Co content of leaves (2 samples): Cu = 12-27, Co = 1-6 µg/g D.M.

Rehabilitation: Pioneer for rocky disturbed sites with low copper content.

Reference: CLAYTON, RENVOIZE [1982].



Musonoi

Diheteropogon filifolius

(Nees) Clayton

Holotype: Gossweiler 9497.

Copper specimens: Mf 10885; Mf-Gj 4.

Syn.: *D. emarginatus* (De Wild.) Robyns,
D. grandiflorus (Hack.) Stapf

Habit: Caespitose perennial, culms often glaucous, 60-160 cm high. Leaf sheaths glabrous; ligule a minutely fringed rim 1-1.5 mm long; lamina 8-26 cm x 2.5-4 mm, inrolled, tapering to a very fine point at the apex. Racemes in pairs, 7.5-9 cm long, robust, clearly exerted from the spatheoles, internodes and pedicels with silvery-white hairs. Sessile spikelet 6.5-9 mm long; inferior glume with a deep median groove; lemma with an awn 7.5-11 cm long. Pedicelled spikelet male, 14-20 mm long; inferior glume winged on the keels, purplish-green, coriaceous, acuminate at the apex and with a mucro 1-2 mm long.

Ecology: Grasslands, Kalahari and copper steppe savannas.

General distribution: From Nigeria to Angola, D.R. Congo, Tanzania and southwards to R.S.A.

Distribution on Katangan copper sites (15 sites): Notably Shabara (24).



Kwatebala

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Eragrostis racemosa

(Thunb.) Steud. [Poaceae]

Holotype: Thunberg s.n.

Copper specimens: Ec 7065; Fm 64;
PI 5359.Syn.: *E. boehmii* Hack.

Habit: Tufted perennial, the basal sheaths glabrous or thinly silky hairy, sometimes becoming fibrous with age; culms 9-80 cm high. Leaf-blades mostly basal, flat or sometimes involute, 6-10 cm long, 2-5 mm wide.

Ecology: On poor sandy or shallow stony soils, not rare in copper steppe savannas.

General distribution: Sudan, Uganda, Kenya, Tanzania, D.R. Congo to R.S.A. and Madagascar.

Distribution on Katangan copper sites (15 sites): Notably Menda (28).

Reference: CLAYTON et al. [1974].



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Loudetia kagerensis

(K.Schum.) Hutch.

Holotype: Stuhlmann 1961.
Copper specimens: MKS 41, 251; Tr 228.

Habit: Tufted perennial herb; culms 25-90 cm high, wiry, ascending or erect, blackened at the nodes.

Ecology: Rocky hillsides, Kalahari sandy and copper steppe savannas.

General distribution: Guinea to Uganda, and southwards to Zimbabwe and Angola.

Distribution on Katangan copper sites (5 sites): Notably Fungurume (51).



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Kavifwafwaulu



© M. Séleck

Fungurume

Loudetia simplex (Nees)

C.E.Hubb. [Poaceae]

Holotype: Drège s.n.
Copper specimens: Mf 9192, 9288, 10244.

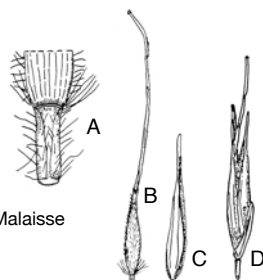
Habit: Tufted perennial herb; culms 30-150 cm high, erect, the nodes yellowish to black.

Ecology: Rocky hillsides, Kalahari sandy and copper steppe savannas.

General distribution: Tropical and South Africa, Madagascar.

Distribution on Katangan copper sites (13 sites): Notably Etoile (97).

Distribution on Zambian copper sites (3 sites): Notably Frontier (141).



F. Malaisse

A. Ligule (x 6) – B. Upper glume (x 1.2) –
C. Lower lemma (x 1.2) – D. Spikelet (x 1.2).
[Drawn after P. Halliday in CLAYTON et al. 1974]



© F. Malaisse

Luiswishi

Microchloa altera (Rendle) Stapf

[Poaceae]

Holotype: Royle s.n.

Copper specimens: LMM 197, 225, 407;

Mf 9775; Sa 7231; St 660; Tr 73.

Syn.: *Rendlia altera* (Rendle) Chiov.

Habit: Small, densely caespitose perennial, the base often clad in the fibrous remains of old leaf-sheaths. Culms up to 30-70 cm high, slender, erect, wiry, glabrous to woolly tomentose. Leaf-blades very narrow, often filiform, 3-25 cm long, 1.5 mm wide, folded, erect, often curved. Spike 2-7 cm long, erect, straight or curved. Spikelets 4-5.5 mm long; glumes subequal, 3.8-5.5 mm long, glabrous; lower lemma 2.9-4 mm long, pubescent to ciliate on the keel, densely ciliate on the margins, obtusely bilobed or entire; upper floret banana-shaped.

Ecology: On shallow, sometimes waterlogged, soils; frequently on metalliferous soils.

General distribution: D.R. Congo, Tanzania, southwards to South Africa.

Distribution on Katangan copper sites (18 sites): Notably Dikulushi (1)

| Hydratation | Copper content of soil (in µg per g of soil) | | | |
|-------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |

| | | | |
|--------|----|---|--|
| dry | | | |
| medium | X | X | |
| wet | XX | X | |

→ oligocuproresistant

Fungurume (51), Likasi (75), Luishia (77), Lukuni (86), Luiswishi (87), Kamwali (89), Kasonta (91), Lupoto (92), Ruashi (96), Etoile (97).

Seasonal wet heavy metal polluted sites (Buluo river, surroundings of Etoile mine, hill II at Fungurume).

Phytogeochemistry: Cu-Co content of leaves (4 samples): Cu = 220-394, Co = 11-13 µg/g D.M.

Rehabilitation: Very great interest for heavy metal polluted sites, in particular seasonally wet or even sometimes waterlogged areas.

References:

BROOKS, MALAISSE [1985].

BROOKS et al. [1987].

LETEINTURIER et al. [1999].



Baluo

© B. Leteinturier

Microchloa altera (Rendle)

Stapf

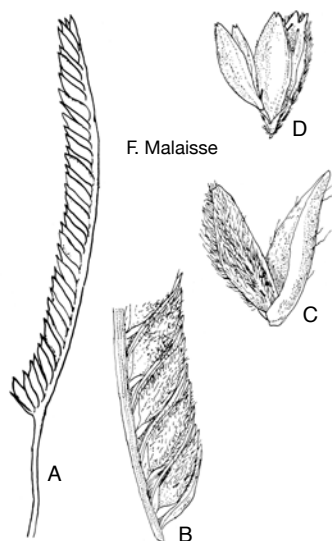
Continuation of page 386.



Luiswishi



Fungurume



A. Spike (x 1) – B. Part of spike (x 2) –
C. Glume (x 9) – D. Spikelet, with glumes
removed (x 9).

[Drawn after D. Erasmus in CLAYTON et al. 1974]

Microchloa kunthii Desv.

[Poaceae]

Holotype: Desveaux s.n.

Copper specimens: MKS 378; Tr 88.

Habit: Densely caespitose perennial growing in compact mats; culms 10–60 cm high, 1–4 noded. Leaf-blades filiform, 1–8 cm long, tapering to a fine point. Spikes 2–25 cm long, the rachis 0.8–1.2 mm wide. Spikelets 2.5–4 mm long; anthers 0.5–1.2 mm long. Caryopsis 1.5 mm long.

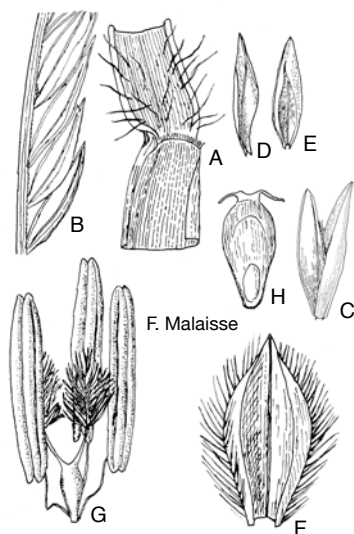
Ecology: Open places, also on rocky copper siliceous cellular rocks.

General distribution: Palearctic.

Distribution on Katangan copper sites (7 sites): Notably Kamoya II (72).

Reference:

CLAYTON et al. [1974].



A. Ligule (x 6) – B. Part of inflorescence (x 3) –
C. Spikelet (x 6) – D. Lower glume (x 6) –
E. Upper glume (x 6) – F. Lemma (x 13) –
G. Flower (x 30) – H. Caryopsis (x 15).

[Drawn after J.C. Webb in CLAYTON et al. 1974]

Monocymbium *ceresiiforme* (Nees) Stapf

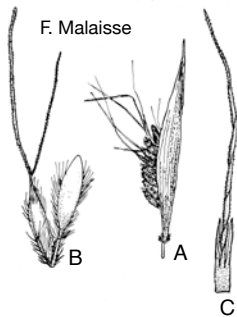
Holotype: Drège s.n.
Copper specimens: Lb-Mf 216;
Mf 9290; Mf-Re 2123; Mn 1088; Tr 5.

Habit: Tufted perennial herb; culms 25-90 cm high, wiry, ascending or erect, blackened at the nodes. Spatheoles narrowly lanceolate, 2-4 cm long, reddish brown. Sessile spikelet elliptic, 3-4 mm long, upper lemma with an awn 6-20 mm long.

Ecology: Rocky hillsides, Kalahari sandy and copper steppe savannas.

General distribution: Guinea to Uganda, and southwards to Zimbabwe and Angola.

Distribution on Katangan copper sites (5 sites): Notably Fungurume (51).



A. Spatheole and raceme (x 1.1) – B. Spikelet pair (x 2.5) – C. Upper glume lemma (x 3.5).
[Drawn after A. Davies in CLAYTON & RENOIZE, 1982]

Kavifwafwaulu

Rytachne rottboellioides Desv. [Poaceae]

Holotype: West Indies.
Copper specimens: Dp 1373 R; Mf 11026.

Habit: Perennial herb, forming dense tussocks. Culms 20-100 cm high. Leaf-blades setaceous, 5-25 cm long; ligule membranous. Inflorescence a single terminal raceme, cylindrical, 2-20 cm long. Spikelets sessile, 2-5 mm long; callus truncate, with prominent central peg; lower glume 2-5 mm long, crustaceous, 5-9 nerved, rugose or muricate at least on the keels.

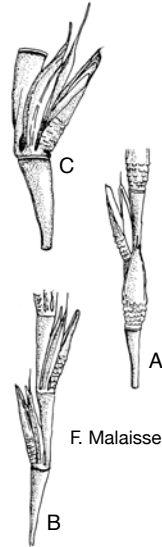
Ecology: Seasonally wet grasslands, also on copper steppe savannas.

General distribution: Tropical Africa, R.S.A., Madagascar, also in the West Indies and Brazil.

Distribution on Katangan copper sites (4 sites): Notably Kasonta (91).



Kavifwafwaulu



A. Racemes (x 7) – B. The same, from the rear (x 3) – C. Spikelet-pairs (x 13). [Drawn after A. Davies in CLAYTON & RENOIZE, 1982]

Sporobolus congoensis

Franch.

Holotype: Brazza & Thollon 594.
Copper specimens: Mf-Gj 74; Tr 196.
Syn.: *S. stelliger* P.Duvign. & Kiwak

Habit: Caespitose perennial; culm 60 cm high. Leaf-blades broadly linear, flat, 6-22 cm long, 3-10 mm wide. Panicle pyramidal; primary branches in 7-9 whorls, 10-20 cm long; spikelets 3-4.5 mm long, glabrous, darkgreen.

Ecology: Grasslands, also on copper steppe savannas.

General distribution: From D.R. Congo to Kenya, and southwards to R.S.A.

Distribution on Katangan copper sites (8 sites): Notably Kwatebala (45), Shinkolobwe (65), Shituru (74).

Note: The material observed on Katangan copper outcrops deals with a short form with a basal rosette of leaves.



Kabwelunono



Shinkolobwe



Kakavilondo

Themeda triandra Forssk.

[Poaceae]

Holotype: Forsskål s.n.
Copper specimens: Mal 572; MSH 246.

Habit: Tufted perennial, 0.3-2 m tall. Leaf-blades flat, up to 30 cm long, 1-8 mm wide. False panicle, up to about 30 cm long, composed of wedge-shaped clusters of 2-8 racemes enfolded by spatheoles and spathes; spatheole 1.5-3.5 cm long, russet coloured, glabrous to tuberculate-pilose; raceme containing 1 fertile spikelet. Sessile spikelet 6-11 mm long, including a pungent rufously bearded callus 2-4 mm long; lower glume brown; awn 2.5-7 cm long, puberulous. Pedicelled spikelet 6-14 mm long, glabrous or tuberculate-pilose; callus 2-3 mm long.

Ecology: Open deciduous bushlands, savannas, copper steppe savannas.

General distribution: Tropical regions of the Old World.

Distribution on Katangan copper sites (4 sites): Notably Kavifwafwaulu (42).

Reference:

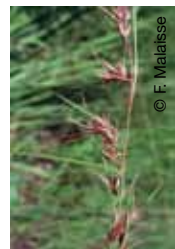
CLAYTON, RENVOIZE [1981].



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Kavifwafwaulu



Kazinyanga

Tristachya bequaertii De Wild.

[Poaceae]

Holotype: Bequaert 318.
Copper specimen: Sb-Kk 4490.

Habit: Densely tufted perennial herb, culms 60-150 cm high, basal sheaths woolly tomentose. Panicle 8-25 cm long, narrowly ovate, 5-30 triads. Spikelets 16-30 mm long, straw coloured to brownish; lower glume ciliate from black tubercles near the margin; upper lemma 6-8 mm long, bilobed, lobes drawn out into bristles 7-15 mm long; central awn 3.5-5 cm long, deciduous.



Mambilima

Ecology: Deciduous woodlands, grasslands, rare in copper steppe savannas.

General distribution: Tanzania, D.R. Congo, Zambia, Malawi.

Distribution on Katangan copper sites (8 sites): Notably Shituru (74).



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Tristachya superba (De Not.) Schweinf. & Asch.

Holotype: Figari s.n.
Copper specimens: Dp 5133 T;
Mf-Re 2149; Mf-Sb 52.
Syn.: *Loudetia superba* De Not.

Habit: Tufted perennial grass; culms 1.2-2.4 m high, base bulbous. Panicle 20-40 cm long, linear, contracted, occasionally the branches villous, the spikelets in group of (2)-3 on short pedicels. Spikelets 25-35 mm long, light brown, glabrous. Inferior glume 1/3-1/2 length of spikelet. Inferior lemma 5(7)-nerved. Superior lemma sparsely pubescent, the lobes acuminate to a setiform apex, with a central awn 4-12 cm long.



Kananga East

Ecology: Deciduous woodlands, grasslands, rare in copper steppe savannas.

General distribution: From Benin to Uganda, and southwards to Zimbabwe and Namibia.

Distribution on Katangan copper sites (3 sites): Kananga East (7), Fungurume (51), Kamwali (89).

Reference (for both species): CLAYTON et al. [1974].



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Zonotriche decora (Stapf) Phipps

[Poaceae]

Holotype: Carson 36.
Copper specimens: Mf 10249, 10555,
11695, 11808; MKS 59; Pi-Kk 4628;
Tr 262.

General distribution: D.R. Congo,
Tanzania, Zambia.

**Distribution on Katangan copper
sites** (9 sites): Notably Kwatebala
(45), Kela (52), Sokoroshe I (83).

Ecology: Miombo, also on Kalahari
sands and copper steppe savannas.



Kwatebala

Nzilo-Kyamasumba road

Shadiranzoro

Zonotriche inamoena (K. Schum.) Clayton

Holotype: Buchanan 49.
Copper specimens: Mf 16558; Mf-Kk
237; Nn 1121; PKS 4389, 4555; Qp 5311.

General distribution: D.R. Congo,
Tanzania to Zimbabwe.

Habit: Tufted perennial. Triad clad
in golden brown hairs; upper lemma
glabrous, but without tufts of hair.

**Distribution on Katangan copper
sites** (5 sites): Notably Lukuni (86),
Luiswishi (87).

Ecology: Open forests, wooded
savannas, copper steppe savannas.

Reference (for both species):
CLAYTON et al. [1974].



Luiswishi

***Smilax anceps* Willd.**

[Smilacaceae]

Type: W. Heyne 18393.

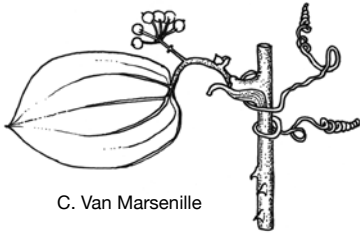
Copper specimens: Mf 13392; Nn 1142.

Syn.: *S. kraussiana* Meisn. ex Krause

Habit: Climbing shrub or behaving as a suffrutex. Stem usually prickly. Leaves alternate, elliptic to ovate-elliptic, apex usually cuspidate; 5-11 x 2-5 cm; with 3 prominent nerves from the base; stipules often modified to form tendrils; tendrils, 2, spiral. Flowers 5-6 mm long, pale green or pale yellowish-green, dioecious, in shortly pedunculate, many-flowered, axillary umbels, 2-3 cm in diam.; each peduncle with a pair of bracts, usually about half-way up. Fruit a subglobose, purple or black berry, 1 cm in diam.

Ecology: Evergreen forests, chipya vegetation, woodlands, rare in copper steppe savannas.

General distribution: Tropical Africa, Southern Africa.



C. Van Marsenille

Leaf and infructescence (x 2/3).

[Original plate]



Near Kwatebala

| Hydra- tation | Copper content of soil (in μg per g of soil) | | | |
|------------------|--|-------|-------|---|
| | normal | 200 | 800 | > |
| medium | <X< | <X< | 5,000 | |
| wet | 800 | 5,000 | | |

→ oligocuproresistant

Distribution on Katangan copper sites (4 sites): Notably Ruashi (96). Also on copper polluted soils (Musonoi).

Rehabilitation: Good aptitude as stabilizer on little wet sandy soils with low heavy metal content; but may become invador in such sites.

Reference: COWLEY [1989].



Fungurume



Musonoi river

Walleria mackenziei Kirk

[Tecophilaeaceae]

Syntypes: H. Waller s.n. from Malawi and painting by Kirk.
Copper specimen: MKS 672.

Habit: Perennial erect slender herb 18-80 cm tall. Tubers 1-5, at the base of a long underground stem. Stem simple. Leaves all cauline, alternate, ovate to linear-lanceolate, sessile, green. Flowers axillary, solitary; pedicels 1.3-6 cm long, bracteoles at about the middle of the pedicels. Perianth bright blue, or mauve, perianth-segments ± free to the base; lobes 14-19 x 4-6 mm. Anthers linear, deep blue with yellow base and tips, free, 6-12 mm long; pore terminal; filaments whitish, 1-2.7 mm long. Ovary semi-superior, style colourless. Capsule globose to oblong, 3-lobed, up to 2 cm in diam.; seeds ovoid, dark red-brown, skinny, with protuberances.

Ecology: Miombo on red sandy loam soils, termitaria, often rocky outcrops, also rarely on rocky blocks in copper steppe savannas.

| Hydra-tation | Copper content of soil (in µg per g of soil) | | | |
|--------------|--|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | X | (X) | | |
| wet | | | | |

→ oligocuproresistant

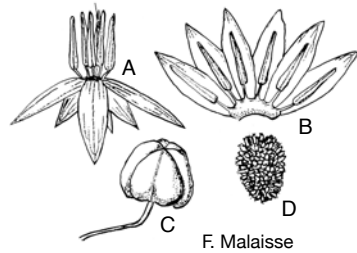
General distribution: Angola, D.R. Congo (Katanga), Tanzania, Zambia, Malawi, Mozambique.

Distribution on Katangan copper sites (1 site): Mwinansefu (43).

Rehabilitation: No evident interest.

References:

- CARTER [1966].
- COWLEY, BRUMMITT [2001].



A. Flower (x 0.7) – B. Perianth opened out & stamens (x 0.8) – C. Fruit (x 0.6) – D. Seed (x 1.4). [Drawn after O. Milne-Redhead in CARTER, 1966]



Mwinansefu



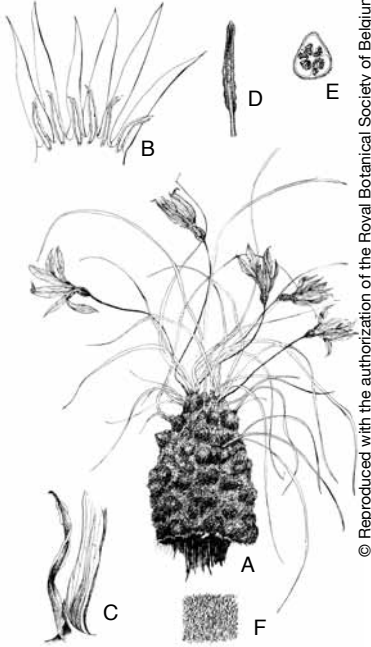
Tenke-Kando road

Xerophyta barbaraeP.A.Duvign. & Dewit subsp.
barbaraeHolotype: Duvigneaud 4118.
Copper specimen: Dp 4118.

Habit: Undershrub, 30-50 cm high, irregularly branched, stem-like structure 3-5 cm thick. Leaves tufted at end of dilated articles; blade linear, 20-35 x 0.3-0.5 cm; young leaves subsericeous, adult leaves longly attenuate at apex and base. Peduncle of flowers 4-10 cm long, softly-hairy; Perianth violet, tepals coalescent at base, 2.5-3.5 x 0.5-0.8 cm, apex acute; anthers 8 mm long.

General distribution: Only known from one site, a steppe on a copper rocky slope at Dikuluwe (2).

Reference: DUVIGNEAUD, DENAEYER-DESMET 119631.



A. Habit (x 0.2) – B. Perianth, spreaded (x 0.6) – C. Stamen, in profile (x 14.1) – D. Style and stigma (x 1.3) – E. Ovary, transversal section (x 1.2) – F. Ovary, hair-covering (x 1.2).

[DUVIGNEAUD, DENAEYER-DE SMET, 1963]

Xerophyta barbarae

P.A.Duvign. & Dewit subsp.

cuprophila P.A.Duvign. & Dewit
[Velloziaceae]

Copper specimens: Mf 16355, 16688.

General distribution: Only known from few sites in Upper Katanga.

Ecology: Steppes on rocky copper slope.

Distribution on Katangan copper sites (4 sites): Notably Kii (15).



© C. D'Outreligne

Nzilo-Kyamasumba road

Xerophyta equisetoides Baker var. ***equisetoides***

[Velloziaceae]

Holotype: Meller s.n.
 Copper specimens: LLM 13; Mf-Re 2399.
 Syn.: *X. demeesmaeckeriana* P.A.Duvign.
 & Dewit

Habit: Undershrub, with a mass of densely packed adventitious roots forming a stem-like structure, 5-50 cm long, 2.5-3.6 cm thick. Leaves 3-7, tufted at end of very short, stout branches; blade stiff-leathery, 4-67 x 0.1-0.9 cm, glabrous or sub-glabrous; leaf-sheath bases 4-5 cm long. Flowers 1-5 at end of branches. Perianth white, pink or pale mauve.

Ecology: Rocky slopes in miombo and copper steppe savannas.

General distribution: From Angola to Tanzania and southwards to Zimbabwe.

Distribution on Katangan copper sites (17 sites): Notably Goma (33).



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Luiswishi



© M. Schatjies

Dikuluwe

Xerophyta equisetoides Baker var. ***trichophylla*** (Baker) Smith & Ayensu

Holotype: Buchanan 854.
 Copper specimen: Mf 12129.

Habit: Leaf blades soft-hairy on both surfaces.

Distribution on Katangan copper sites (4 sites): Notably Kambove (71).



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Shinkolobwe

Aloe nuttii Baker

[Xanthorrhoeaceae]

Holotypes: Carson 29 & Nutt s.n.
Copper specimen: Mal 326.

Habit: Herb, with 1-12 tufted stems. Leaves erect, linear, grass-like, to 40 cm long, 1.5-4 cm wide at base; white-spotted below on lower surface, occasionally spinescent. Inflorescence erect, 60-80 cm high, unbranched. Perianth coral-pink to orange-red with green tips to the segments.

Ecology: Montane grasslands, also on copper steppe savannas.

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | | <X< | <X< | 5,000 |
| | | 800 | 5,000 | |
| dry | XXX | XX | | |
| medium | | | | |
| wet | | | | |

→ oligocuproresistant

General distribution: Angola, D.R. Congo, Tanzania, Zambia, Malawi.

Distribution on Katangan copper sites (2 sites): Tenke (32), Kavifwafwaulu (42).

Rehabilitation: Pleasant habit.

References: REYNOLDS [1966].
CARTER [1994; 2001].



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Kavifwafwaulu IV



Tenke



Tenke



Mamfweroad

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© M. Schajtes

Bulbine abyssinica A. Rich.

[Xanthorrhoeaceae]

Holotype: Quartin Dillon & Petit 177.
Copper specimens: Dp 4131; L2, 4493;
L3, 4640 L1, 5330 B, Sa 6012.
Syn. : *B. asphodeloides* sensu auct. div.

Habit: Succulent perennial herb with a short vertical rhizome, up to 1.5 cm long, 0.7-1.5 cm in diam.; roots fleshy, fibrous, ± 2 mm in diam., yellow-brown. Leaves fleshy, terete, up to 54 cm long, 1-4 mm wide, expanding at the base into tubular sheaths 1.8-5.5 cm long, 1.5-3.5 mm wide; raceme 3-18 cm long, 1.5-5 cm in diam. and broadening to 7.5 cm in fruit; bracts cuspidate, 5-20 mm long, 1-3 mm wide at the base, attenuate into a filiform apex; pedicels 7-20 mm long at anthesis, to 35 mm long in fruit. Inflorescence many-flowered raceme; flowers yellow; 6 tepals, 5-7 mm long, 1.5-2.5 mm wide; stamens 3-4 mm long; ovary 1 mm long; style 2-3 mm long. Capsule globose to obovoid, 4-5 mm long, 4-5 mm in diam., sometimes constricted at the base, topped by the persistent style at the apex, brown black. Seeds pyramidal, sharply 3-angled, + 2.5 mm across.

Ecology: Grasslands, often on shallow soil over rocks, also on copper steppe savannas.

General distribution: Ethiopia, Somalia, Eritrea, Sudan, Congo, Angola, D.R. Congo, Rwanda, Burundi,

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | X | X | | |
| wet | X | | | |

→ oligocuproresistant

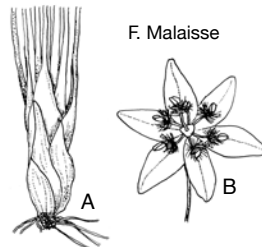
Uganda, Kenya, Tanzania, Zambia, Malawi, Zimbabwe, Botswana, R.S.A.

Distribution on Katangan copper sites (3 sites): Dikuluwe (2), Mupine (3), Lupoto (57).

Distribution on Zambian copper sites (1 site): Chambishi (78).

Rehabilitation: No evident interest.

Reference: WHITEHOUSE [2002].



F. Malaisse

A. Basal part (x 0.5) – B. Flower (x 2).
[Drawn after MAQUET, 1988]



Manika plateau



Biano plateau

© M. Schajjes

Kniphofia benguellensis Baker

[Xanthorrhoeaceae]

Holotype: Welwitsch 3736.

Copper specimens: Mal 236, 276, 972.

Habit: Robust perennial herb up to 2.5-3 m high. Rhizome short, thick, moniliform, horizontal, up to 15 cm long; numerous horizontal roots up to 60 cm long, without tubers. Leaves rosulate, sheathing at the base, 4-stychous, linear, 175-225 x 4-5.5 cm, 34-40-nerved. Floral scape robust, 2 cm in diam. Inflorescence spiciform, 60-75 cm long.

Ecology: Savannas, copper steppe savannas with low copper content.

General distribution: From Angola to Tanzania.

Distribution on Katangan copper sites (1 site): Kazinyanga (49).

Reference: KATIVU [1996].

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-------|-------|---|
| | normal | 200 | 800 | > |
| | <X< | <X< | 5,000 | |
| | 800 | 5,000 | | |
| dry | | | | |
| medium | X | X | | |
| wet | X | | | |

→ oligocupproresistant



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Kazinyanga



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Fungurume



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Mamfwe road



© M. Schajles

Malawi, Viphya plateau



© M. Schajles

Malawi, Viphya plateau



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Near Fungurume



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Near Fungurume

Xyris dissimilis Malme

[Xyridaceae]

Holotype: Corbisier in Homblé 636.
Copper specimens: Dp 2991, 3204;
Mf 13071; Mf-Re 2069; Mf-SI 15.

Habit: Perennial herb, caespitose; shoot bases bulbous, covered with persistent sheaths. Leaves to 24 cm long; sheaths red-brown, shiny when young, smooth; ligule absent; lamina flattened, 24 cm long, 1-1.5 mm wide, glabrous, smooth, margins strongly papillose to very short spreading-hairy, apex solid, curved to one side. Peduncle 40-50 cm long, 0.5-0.7 mm in diam., terete, smooth or weakly furrowed. Sterile bracts 3.5 x 2 mm, coriaceous, shiny below and cell-patterned above, 5-nerved when viewed from inside; fertile bracts similar but thinner and narrower. Lateral sepals narrowly obovate, 4 x 1 mm, strongly keeled, keel densely recurved, spinose-hairy except at extreme tip. Corolla yellow, lobes obovate, 3-4 mm long, dentate at tips. Stamens 3-4 mm long; staminodes as long as stamens, bifid, with branches ending in tuft of yellow hairs. Ovary 1-2 mm long; style trifid. Capsule ellipsoid, 3.5 x 2 mm. Seeds subspherical, 0.4 x 0.35 mm, dark brown with paler apices, with more than 20 longitudinal ridges.



Pumpi

| Hydra- tation | Copper content of soil (in µg per g of soil) | | | |
|------------------|---|-----|-------|-------|
| | normal | 200 | 800 | > |
| | <X< | <X< | > | 5,000 |
| | | 800 | 5,000 | |
| dry | | | | |
| medium | X | X | | |
| wet | X | | | |

→ oligocuproresistant

Ecology: Seasonally wet sites in miombo, also in copper steppe savannas.

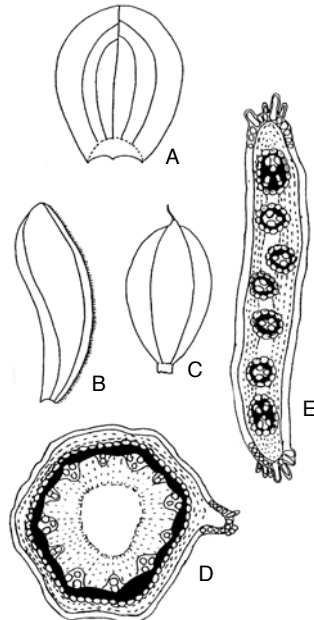
General distribution: D.R. Congo, Zambia (1 site, single specimen).

Distribution on Katangan copper sites (9 sites): Notably Kasompi (27), Pumpi (29), Shinkolobwe (67).

References:

LISOWSKI et al. [2001].

LOCK [2010].



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A. Internal involucral bract (x 3) -
B. Lateral sepal (x 3.5) - C. Fruit (x 5) -
D. Transversal section of floral peduncle
(x 35) - E. Leaf limb transversal section
(x 35). [LISOWSKI et al., 2001]

Siphonochilus aethiopicus (Schweinf.) B.L.Burt.

[Zingiberaceae]

Holotype: Cienkowski s.n. & Steudner s.n.
Copper specimen: Mal 474.

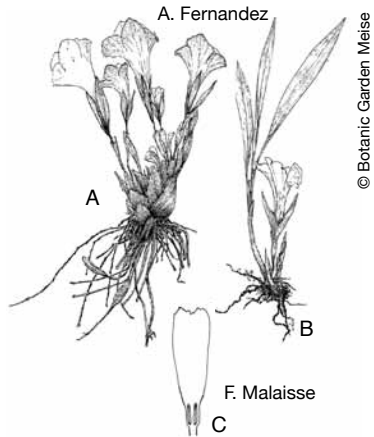
Habit: Perennial herb from a short ovoid rhizome, 3-5 cm long. Roots with fusiform tubers 3-10 cm long. Leaves developing at anthesis; lamina narrowly elliptic, 17-36 x 2-4.5 cm, apex acuminate, base narrowly cuneate. Pseudostem to 70 cm tall. Inflorescence arising at the base of the leafy shoot, 4-12 flowered. Calyx tubular, shortly 3-lobed at apex; corolla tube 2.5-5.5 cm long; petals elliptic, whitish and translucent. Labellum mauve to purple, 3-lobed, 5-11 cm long; central lobe with a central deep yellow ark at the base. Fruit ± subterranean, subglobose, weakly 3-lobed, 1.5 cm wide; seeds 6 x 2 mm, pale brown, shiny.

Ecology: Deciduous woodlands, wooded grassland, rarely on copper steppe savannas.

General distribution: From Senegal to Ethiopia, southwards to South Africa.

Distribution on Katangan copper sites (1 site): Katuto (41).

Reference: Lock [1985].



A. B. Habit (x 0.15) - C. Stamen (x 0.5).
[Drawn after C. Grey-Wilson in LISOWSKI, 2009; Lock, 1985]



Kipopo



Manika plateau



Kinsevere

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INDEX (synonyms in italics)

A

| | |
|--|----------|
| <i>Acalypha clutioides</i> | 175 |
| <i>Acalypha cupricola</i> | 174 |
| <i>Acalypha dikuluwensis</i> | 175 |
| <i>Acrocephalus homblei</i> | 216 |
| <i>Acrocephalus katangensis</i> | 214 |
| <i>Acrocephalus polyneurus</i> | 215 |
| <i>Acrocephalus rosulatus</i> | 218 |
| <i>Acrocephalus timpermanii</i> | 219 |
| <i>Actiniopteris kornasii</i> | 69 |
| <i>Actiniopteris pauciloba</i> | 70 |
| <i>Adenia erecta</i> | 255 |
| <i>Adenodolichos rhomboideus</i> | 182 |
| <i>Adiantum lunulatum</i> | 71 |
| <i>Adiantum philippense</i> | 71 |
| <i>Aeollanthus homblei</i> | 211 |
| <i>Aeollanthus rosulifolius</i> | 211 |
| <i>Aeollanthus saxatilis</i> | 212 |
| <i>Aeollanthus subacaulis</i> | 213 |
| <i>Aeschynomene hockii</i> | 185 |
| <i>Aeschynomene homblei</i> | 185, 211 |
| <i>Aeschynomene pararubrofarinacea</i> | 184 |
| <i>Aeschynomene pygmaea</i> | 185 |
| <i>Aitonia eximia</i> | 54 |
| <i>Albua abyssinica</i> | 298 |
| <i>Albua</i> sp. | 299 |
| <i>Albua stolzii</i> | 310 |
| <i>Alectra sessiliflora</i> | 243 |
| <i>Allopteroopsis semialata</i> | 380 |
| <i>Aloe nuttii</i> | 396 |
| <i>Alvesia rosmarinifolia</i> | 221 |
| <i>Andropogon congoensis</i> | 380 |
| <i>Andropogon dummeri</i> | 380 |
| <i>Andropogon schirensis</i> | 380 |
| <i>Aneilema</i> sp. | 316 |
| <i>Aneilema welwitschii</i> | 316 |
| <i>Anemia angolensis</i> | 66 |
| <i>Anisopappus chinensis</i> | 125 |
| <i>Anisopappus davyi</i> | 126 |
| <i>Anisopappus hoffmannianus</i> | 125 |
| <i>Annona stenophylla</i> | 109 |
| <i>Antephora elongata</i> | 381 |
| <i>Anthericum calyptrocarpum</i> | 304 |
| <i>Anthericum rubibracteatum</i> | 309 |
| <i>Antherotoma naudinii</i> | 231 |
| <i>Anthoceros caucasicus</i> | 53 |
| <i>Anthoceros mandonii</i> | 53 |
| <i>Aristea</i> aff. <i>abyssinica</i> | 335 |
| <i>Aristida junciformis</i> | 381 |

| | |
|-------------------------------------|-----|
| <i>Aristolochia heppii</i> | 124 |
| <i>Arthraxon micans</i> | 382 |
| <i>Arthraxon quartinianus</i> | 382 |
| <i>Arthropteris anniana</i> | 79 |
| <i>Arthropteris monocarpa</i> | 79 |
| <i>Ascolepis metallorum</i> | 320 |
| <i>Ascolepis protea</i> | 321 |
| <i>Asparagus abyssinicus</i> | 300 |
| <i>Asparagus africanus</i> | 300 |
| <i>Aspilia mossambicensis</i> | 127 |
| <i>Aspilia natalensis</i> | 127 |
| <i>Asplenium buettneri</i> | 75 |
| <i>Asplenium formosum</i> | 76 |

B

| | |
|---|-----|
| <i>Barleria descampsii</i> | 90 |
| <i>Barleria lobelioides</i> | 91 |
| <i>Barleria variabilis</i> | 90 |
| <i>Barleria velutina</i> | 92 |
| <i>Basananthe cupricola</i> | 256 |
| <i>Basananthe kisimbuae</i> | 257 |
| <i>Batopedina pulvinellata</i> | 269 |
| <i>Becium aureoviride</i> | 220 |
| <i>Begonia princeae</i> | 150 |
| <i>Bidens oligoflora</i> | 127 |
| <i>Biophytum petersianum</i> | 252 |
| <i>Blepharis buchneri</i> | 93 |
| <i>Blepharis cuanzensis</i> | 94 |
| <i>Blepharis glumacea</i> | 95 |
| <i>Blepharis homblei</i> | 94 |
| <i>Blepharis kassneri</i> | 95 |
| <i>Bocconia arborea</i> | 294 |
| <i>Boophone disticha</i> | 296 |
| <i>Borreria dibrachiata</i> | 281 |
| <i>Bowiea volubilis</i> | 301 |
| <i>Brachycorythis pleistophylla</i> | 348 |
| <i>Brachycorythis tenuior</i> | 348 |
| <i>Brachymenium acuminatum</i> | 58 |
| <i>Brachystelma</i> sp. | 116 |
| <i>Bryum arachnoideum</i> | 59 |
| <i>Buchnera cryptocephala</i> | 244 |
| <i>Buchnera henriquesii</i> | 244 |
| <i>Buchnera hispida</i> | 245 |
| <i>Buchnera inflata</i> | 245 |
| <i>Buchnera keilii</i> | 246 |
| <i>Buchnera quadrifaria</i> | 246 |
| <i>Buchnera robynsii</i> | 247 |
| <i>Buchnera symoensiana</i> | 247 |
| <i>Buchnera trilobata</i> | 248 |

| | |
|------------------------------------|-----|
| Bulbine abyssinica | 397 |
| <i>Bulbine asphodeloides</i> | 397 |
| Bulbostylis cinnamomea | 322 |
| Bulbostylis cupricola | 323 |
| Bulbostylis filamentosa | 324 |
| Bulbostylis fusiformis | 324 |
| <i>Bulbostylis mucronata</i> | 325 |
| Bulbostylis pseudoperennis | 325 |

C

| | |
|--|------------|
| Caloplaca cinnabarina | 52 |
| <i>Cassia comosa</i> | 151 |
| <i>Cassia mimosoides</i> | 152 |
| Centaurea praecox | 128 |
| <i>Cephalaria attenuata</i> | 163 |
| <i>Cephalaria katangensis</i> | 163 |
| Ceropegia achtenii | 117 |
| Ceropegia umbraticola | 117 |
| Chamaecrista comosa | 151 |
| Chamaecrista mimosoides | 152 |
| Cheilanthes angustifrons | 83 |
| Cheilanthes inaequalis | 84 |
| Cheilanthes perlanata | 85, 86, 87 |
| Cheilanthes similis | 88 |
| Chironia katangensis | 205 |
| <i>Chironia verdickii</i> | 205 |
| Chlorophytum andongense | 302 |
| Chlorophytum bleparophyllum ... | 303 |
| Chlorophytum calyptrocarpum ... | 304 |
| Chlorophytum colubrinum | 305 |
| Chlorophytum cordifolium | 306 |
| Chlorophytum macrophyllum | 307 |
| Chlorophytum pusillum | 308 |
| Chlorophytum rubibracteatum .. | 309 |
| Chlorophytum stolzii | 310 |
| Chlorophytum subpetiolatum | 311 |
| <i>Chlorophytum unifolium</i> | 306 |
| <i>Cissus jatrophoides</i> | 292 |
| <i>Cissus sessilifolia</i> | 293 |
| Clematis villosa | 267 |
| Clematis welwitschii | 268 |
| <i>Clematopsis scabiosifolia</i> | 267 |
| Coccinia adoensis | 169 |
| <i>Coleus esculentus</i> | 222 |
| Combretum platypetalum | 165 |
| Commelina transversifolia | 317 |
| Commelina velutina | 317 |
| Commelina zigzag | 317 |
| Conyza pyrhopappa | 129 |
| Costus spectabilis | 319 |
| Crabbea kaessneri | 96 |
| <i>Crassula alba</i> | 168 |

| | |
|---------------------------------------|-----|
| <i>Crassula vaginata</i> | 168 |
| Crepidorhopalon bifolius | 224 |
| Crepidorhopalon perennis | 225 |
| Crepidorhopalon tenuis | 226 |
| Crinum papillosum | 297 |
| Crotalaria cobalticola | 186 |
| Crotalaria cornetii | 187 |
| <i>Crotalaria francoisiana</i> | 190 |
| Crotalaria glauca | 188 |
| Crotalaria peschiana | 189 |
| Crotalaria quangensis | 190 |
| Crotalaria variegata | 190 |
| Cryptolepis oblongifolia | 118 |
| <i>Cryptosepalum dasycladum</i> | 153 |
| Cryptosepalum maraviense | 153 |
| Ctenium concinnum | 383 |
| Cussonia arborea | 123 |
| Cussonia corbisieri | 123 |
| Cyanotis caespitosa | 318 |
| <i>Cyanotis cupricola</i> | 318 |
| Cyanotis longifolia | 318 |
| Cyathea dregei | 68 |
| Cyathodium africanum | 55 |
| Cyathodium aureonitens | 55 |
| <i>Cyathodium caverarum</i> | 55 |
| Cymbopogon densiflorus | 383 |
| Cynanchum praecox | 118 |
| Cynanchum viminale | 119 |
| Cyperus kibweanus | 327 |
| Cyperus margaritaceus | 328 |
| Cyphia erecta | 155 |
| Cyphia gamopetala | 156 |
| Cyphostemma junceum | 292 |
| Cyphostemma sessilifolium | 293 |
| Cyrtorchis arcuata | 349 |

D

| | |
|---|-----|
| <i>Dasystachys verdickii</i> | 305 |
| Delphinium dasycadon | 268 |
| Dichaetanthera schuilingiana | 232 |
| Dichrostachys cinerea | 236 |
| <i>Dichrostachys nyassana</i> | 236 |
| Dicliptera capitata | 97 |
| Dicliptera carvalhoi | 97 |
| Dicoma anomala | 130 |
| <i>Diheteropogon emarginatus</i> | 384 |
| Diheteropogon filifolius | 384 |
| <i>Diheteropogon grandiflorus</i> | 384 |
| Dioscorea praeheensis | 330 |
| Dioscorea quartiniiana | 330 |
| Dioscorea schimperiana | 330 |
| Dipcadi sp. | 312 |

| | |
|--------------------------------------|----------|
| Diplolophium marthozianum | 110 |
| Diplolophium zambesianum | 111 |
| Disa engleriana | 349 |
| <i>Disa erubescens</i> | 350 |
| <i>Disa hircicornis</i> | 350 |
| <i>Disa katangensis</i> | 350 |
| Dissotis derriksiana | 234 |
| Dissotis gilgiana | 234 |
| <i>Dissotis kundelungensis</i> | 231 |
| Dolichos gululu | 191 |
| <i>Dolichos praecox</i> | 191 |
| <i>Dolichos rhomboideus</i> | 182 |
| Dolichos trinervatus | 192 |
| Dorstenia barnimiana | 237 |
| Dorstenia benguelensis | 238, 239 |
| <i>Dorstenia homblei</i> | 238 |
| <i>Dorstenia verdickii</i> | 238 |
| Droogmansia munamensis | 193 |
| <i>Droogmansia pteropus</i> | 193, 194 |
| <i>Droogmansia quarrei</i> | 194 |
| <i>Dyschoriste linifolia</i> | 101 |

E

| | |
|--------------------------------------|-----|
| Equisetum ramosissimum | 65 |
| <i>Eragrostis boehmii</i> | 384 |
| <i>Eragrostis racemosa</i> | 384 |
| <i>Eremanthus descampsii</i> | 145 |
| Erica benguelensis | 173 |
| Eriosema englerianum | 195 |
| <i>Eriosema hockii</i> | 195 |
| Eriosema shirensis | 196 |
| <i>Eriospermum abyssinicum</i> | 313 |
| Eriospermum flagelliforme | 313 |
| <i>Ethulia pubescens</i> | 131 |
| Eulophia brenanii | 351 |
| Eulophia carsonii | 351 |
| Eulophia chilangensis | 352 |
| Eulophia cucullata | 352 |
| Eulophia gonychila | 353 |
| Eulophia holubii | 353 |
| Eulophia katangensis | 354 |
| Eulophia longisepala | 354 |
| Eulophia monotropis | 355 |
| Eulophia mumbwaensis | 355 |
| Eulophia nyasae | 356 |
| Eulophia odontoglossa | 356 |
| Eulophia orthoplectra | 359 |
| Eulophia aff. parvula | 357 |
| Eulophia rhodesiaca | 357 |
| Eulophia rolfeana | 358 |
| Eulophia schaijesii | 358 |
| Eulophia schweinfurthii | 359 |

| | |
|----------------------------|-----|
| Eulophia seleensis | 359 |
| Eulophia sp. | 360 |
| Eulophia tuberculata | 360 |
| Eulophia walleri | 361 |
| Euphorbia cupricola | 176 |
| Euphorbia discoidea | 178 |
| Euphorbia fanshawei | 179 |
| Euphorbia lorifolia | 180 |
| Euphorbia zambesiana | 181 |

F

| | |
|----------------------------------|-----|
| Fadogia cienkowski | 270 |
| Fadogia fuchsioides | 270 |
| <i>Fadogia katangensis</i> | 270 |
| Fadogia triphylla | 271 |
| Fadogia verdickii | 271 |
| Fadogiella stigmatoloba | 271 |
| Faroa acaulis | 206 |
| Faroa chalcophila | 207 |
| Faroa malaissei | 208 |

G

| | |
|---------------------------------------|-----|
| <i>Geissaspis welwitschii</i> | 197 |
| Geophila obvallata | 272 |
| Gladiolus actinomorphantus | 335 |
| Gladiolus atropurpureus | 336 |
| Gladiolus dalenii | 336 |
| <i>Gladiolus duvigeaudii</i> | 338 |
| Gladiolus erectiflorus | 337 |
| <i>Gladiolus erectiflorus</i> | 341 |
| <i>Gladiolus fungurumeensis</i> | 338 |
| Gladiolus gregarius | 337 |
| Gladiolus ledoctei | 338 |
| <i>Gladiolus peschianus</i> | 339 |
| Gladiolus robiliartianus | 338 |
| Gladiolus tshombeanus | 339 |
| Gladiolus unguiculatus | 340 |
| Gladiolus verdickii | 341 |
| <i>Gnaphalium luteo-album</i> | 143 |
| Gnidia hockii | 286 |
| Gnidia involucrata | 287 |
| Gnidia kasaiensis | 287 |
| Gnidia kraussiana | 288 |
| <i>Gnidia macrorrhiza</i> | 287 |
| <i>Gutenbergia cuprophila</i> | 131 |
| <i>Gutenbergia pubescens</i> | 131 |

H

| | |
|-----------------------------|-----|
| Habenaria cataphysema | 362 |
| Habenaria cirrhata | 362 |
| Habenaria disparilis | 363 |

| | |
|--|----------|
| <i>Habenaria falculoba</i> | 363 |
| <i>Habenaria huillensis</i> | 366 |
| <i>Habenaria malacophylla</i> | 364 |
| <i>Habenaria perpulchra</i> | 364 |
| <i>Habenaria retinervis</i> | 365 |
| <i>Habenaria robbrechtiana</i> | 365 |
| <i>Habenaria tetraceras</i> | 366 |
| <i>Habenaria weberiana</i> | 366 |
| <i>Hartiella cupricola</i> | 227 |
| <i>Hartiella suffruticosa</i> | 227 |
| <i>Haumaniastrum katangense</i> | 214 |
| <i>Haumaniastrum polyneurum</i> | 215 |
| <i>Haumaniastrum prealtum</i> | 216 |
| <i>Haumaniastrum robertii</i> | 217 |
| <i>Haumaniastrum rosulatum</i> | 218 |
| <i>Haumaniastrum timpermanii</i> | 219 |
| <i>Heeria reticulata</i> | 108 |
| <i>Helichrysum ceres</i> | 135 |
| <i>Helichrysum gillettii</i> | 132 |
| <i>Helichrysum keilii</i> | 132 |
| <i>Helichrysum kirkii</i> | 133 |
| <i>Helichrysum lejolyanum</i> | 134 |
| <i>Helichrysum mechowianum</i> | 135 |
| <i>Helichrysum nitens</i> | 136 |
| <i>Helichrysum robynsii</i> | 136 |
| <i>Heterodermia hypoleuca</i> | 51 |
| <i>Hibiscus rhodanthus</i> | 229, 230 |
| <i>Humularia kapiiriensis</i> | 197 |
| <i>Hymenodictyon floribundum</i> | 272 |
| <i>Hypoxis filiformis</i> | 333 |
| <i>Hypoxis malosana</i> | 333 |
| <i>Hypoxis polystachya</i> | 334 |
| <i>Hypoxis subspicata</i> | 334 |

I

| | |
|--|----------|
| <i>Icomum biformifolium</i> | 213 |
| <i>Indigofera peltata</i> | 198 |
| <i>Indigofera podocarpa</i> | 198 |
| <i>Indigofera sutherlandioides</i> | 199 |
| <i>Inula shirensis</i> | 137 |
| <i>Ipomoea cairica</i> | 166 |
| <i>Ipomoea linosepala</i> | 166, 167 |
| <i>Ipomoea recta</i> | 167 |

J

| | |
|----------------------------------|-----|
| <i>Justicia bequaertii</i> | 98 |
| <i>Justicia betonica</i> | 98 |
| <i>Justicia cupricola</i> | 99 |
| <i>Justicia elegantula</i> | 99 |
| <i>Justicia metallorum</i> | 100 |

K

| | |
|--------------------------------------|----------|
| <i>Kniphofia benguellensis</i> | 398, 399 |
|--------------------------------------|----------|

L

| | |
|---------------------------------------|-----|
| <i>Lannea edulis</i> | 107 |
| <i>Lapeirousia erythrantha</i> | 342 |
| <i>Launaea nana</i> | 137 |
| <i>Ledebouria revoluta</i> | 314 |
| <i>Lefebvrea abyssinica</i> | 112 |
| <i>Lefebvrea stuhlmannii</i> | 112 |
| <i>Lelya prostrata</i> | 273 |
| <i>Lepisorus excavatus</i> | 81 |
| <i>Leptactina benguelensis</i> | 273 |
| <i>Leucobryum boryanum</i> | 60 |
| <i>Leucobryum madagassum</i> | 60 |
| <i>Lichenized Fungi</i> | 46 |
| <i>Lightfootia collomioides</i> | 160 |
| <i>Lindernia bifolia</i> | 224 |
| <i>Lindernia damblonii</i> | 226 |
| <i>Lindernia perennis</i> | 225 |
| <i>Lindernia suffruticosa</i> | 227 |
| <i>Liparis mulindana</i> | 367 |
| <i>Liparis nervosa</i> | 368 |
| <i>Littonia lindenii</i> | 315 |
| <i>Lobelia erinus</i> | 157 |
| <i>Lobelia rhodesica</i> | 158 |
| <i>Lobelia senegalensis</i> | 157 |
| <i>Lobelia trullifolia</i> | 158 |
| <i>Lopholaena deltombei</i> | 138 |
| <i>Loranthus cornetii</i> | 228 |
| <i>Loudetia kagerensis</i> | 385 |
| <i>Loudetia simplex</i> | 385 |
| <i>Loudetia superba</i> | 390 |

M

| | |
|--|----------|
| <i>Malaxis katangensis</i> | 369 |
| <i>Manostachya staelioides</i> | 274 |
| <i>Manostachya ternifolia</i> | 275 |
| <i>Mechowia grandiflora</i> | 105 |
| <i>Microchloa altera</i> | 386, 387 |
| <i>Microchloa kunthii</i> | 387 |
| <i>Microglossa angolensis</i> | 129 |
| <i>Mitrasacmopsis quadrivalvis</i> | 276 |
| <i>Mohria lepigera</i> | 67 |
| <i>Monadenium cupricola</i> | 176 |
| <i>Monadenium discoideum</i> | 178 |
| <i>Monadenium pseudoracemosum</i> | 180 |
| <i>Monocymbium cerasiiforme</i> | 388 |
| <i>Monotes katangensis</i> | 171 |
| <i>Monotes magnificus</i> | 172 |

| | |
|---------------------------|-----|
| Moraea bella | 343 |
| Moraea carsonii | 344 |
| Moraea natalensis | 345 |
| Moraea ventricosa | 346 |
| Moraea verdickii | 347 |
| Mukia maderaspatana | 169 |

N

| | |
|-------------------------------------|----------|
| <i>Nephrolepis cordifolia</i> | 80 |
| <i>Nephrolepis undulata</i> | 80 |
| <i>Nervilia adolphi</i> | 370 |
| <i>Nervilia kotschyi</i> | 370, 371 |
| <i>Nervilia petraea</i> | 371 |
| <i>Nervilia shirensis</i> | 372 |
| <i>Nervilia stolziana</i> | 372 |
| <i>Notholaena lepigera</i> | 67 |
| <i>Notholaena perlanata</i> | 87 |

O

| | |
|--|-----|
| <i>Ochna leptoclada</i> | 241 |
| <i>Ocimum centraliafricanum</i> | 220 |
| <i>Ocimum homblei</i> | 220 |
| <i>Ocimum vanderystii</i> | 220 |
| <i>Olax obtusifolia</i> | 242 |
| <i>Oleandra distenta</i> | 77 |
| <i>Ophioglossum lancifolium</i> | 63 |
| <i>Ophioglossum lusoaffricanum</i> | 63 |
| <i>Ophioglossum reticulatum</i> | 64 |
| <i>Ophioglossum thomasii</i> | 63 |
| <i>Otiophora caerulea</i> | 277 |
| <i>Otiophora villicaulis</i> | 277 |
| <i>Oxalis katangensis</i> | 253 |
| <i>Oxalis obliquifolia</i> | 253 |
| <i>Oxalis semiloba</i> | 254 |
| <i>Ozoroa reticulata</i> | 108 |

P

| | |
|-------------------------------------|----------|
| <i>Pandiaka carsonii</i> | 106 |
| <i>Pandiaka carsonii</i> | 106 |
| <i>Parmotrema tinctorum</i> | 48 |
| <i>Parmotrema zollingeri</i> | 49 |
| <i>Pasaccardoa jeffreyi</i> | 139 |
| <i>Pasaccardoa procumbens</i> | 139 |
| <i>Pellaea goudotii</i> | 73 |
| <i>Pellaea longipilosa</i> | 72 |
| <i>Pellaea pectiniformis</i> | 73 |
| <i>Pentania schweinfurthii</i> | 278, 279 |
| <i>Pentas purpurea</i> | 280 |
| <i>Pericopsis angolensis</i> | 200 |
| <i>Peucedanum heracloides</i> | 113 |
| <i>Phaulopsis johnstonii</i> | 101 |

| | |
|--|-----|
| <i>Phragmanthera cornetii</i> | 228 |
| <i>Phragmanthera rufescens</i> | 228 |
| <i>Phyllanthus niruroides</i> | 258 |
| <i>Phyllanthus</i> sp. | 258 |
| <i>Phyllanthus taylorianus</i> | 258 |
| <i>Phyllanthus virgulatus</i> | 259 |
| <i>Physotrichia muriculata</i> | 113 |
| <i>Physotrichia kassneri</i> | 114 |
| <i>Pimpinella acutidentata</i> | 113 |
| <i>Pimpinella kassneri</i> | 114 |
| <i>Pityrogramma calomelanos</i> | 74 |
| <i>Plagiochasma eximium</i> | 54 |
| <i>Plectranthastrum rosmarinifolium</i> .. | 221 |
| <i>Plectranthus esculentus</i> | 222 |
| <i>Pleiotaxis bampsiana</i> | 140 |
| <i>Pleiotaxis lejolyana</i> | 141 |
| <i>Pleiotaxis pulcherrima</i> | 142 |
| <i>Pleiotaxis rogersii</i> | 141 |
| <i>Pleopeltis excavata</i> | 81 |
| <i>Polygala albida</i> | 262 |
| <i>Polygala katangensis</i> | 262 |
| <i>Polygala myrtilloopsis</i> | 262 |
| <i>Polygala petitiana</i> | 263 |
| <i>Polygala stanleyana</i> | 262 |
| <i>Polystachya dendrobiiflora</i> | 373 |
| <i>Polystachya modesta</i> | 374 |
| <i>Polystachya tayloriana</i> | 373 |
| <i>Porphyrosiphon notarisii</i> | 44 |
| <i>Protea lemairei</i> | 265 |
| <i>Protea welwitschii</i> | 266 |
| <i>Pseudognaphalium luteo-album</i> .. | 143 |
| <i>Psychotria tenuissima</i> | 280 |
| <i>Pteridium aquilinum</i> | 78 |
| <i>Pteris vittata</i> | 82 |

R

| | |
|---------------------------------------|-----|
| <i>Rangaëris muscicola</i> | 375 |
| <i>Raphionacme angolensis</i> | 120 |
| <i>Raphionacme globosa</i> | 120 |
| <i>Rendlia altera</i> | 386 |
| <i>Rytachne rottboellioides</i> | 388 |

S

| | |
|--|-----|
| <i>Sarcostemma viminale</i> | 119 |
| <i>Satyrium kitiboense</i> | 376 |
| <i>Satyrium volkensii</i> | 377 |
| <i>Scadoxus multiflorus</i> | 297 |
| <i>Schistostephium artemisiifolium</i> ... | 144 |
| <i>Scleria buchananii</i> | 329 |
| <i>Scleria bulbifera</i> | 329 |
| <i>Sebaea bojeri</i> | 209 |
| <i>Sebaea microphylla</i> | 209 |

| | | | |
|-------------------------------------|----------|--------------------------------------|----------|
| Sebaea sp. | 209 | Tristachya superba | 390 |
| <i>Sebaea welwitschii</i> | 209 | Triumfetta digitata | 289 |
| Securidaca longepedunculata | 264 | Triumfetta likasiensis | 290 |
| Selaginella goudotiana | 62 | Triumfetta rogersii | 291 |
| Silene burchellii | 164 | <i>Triumfetta welwitschii</i> | 291 |
| Silene cobalticola | 164 | Trochomeria macrocarpa | 170 |
| Siphonochilus aethiopicus | 401 | | |
| <i>Smilax anceps</i> | 392 | U | |
| <i>Smilax kraussiana</i> | 392 | Uapaca robynsii | 260, 261 |
| Sopubia eminii | 249 | Usnea sp. | 50 |
| Sopubia lanata | 249 | | |
| <i>Sopubia mannii</i> | 249 | V | |
| Sopubia metallorum | 249 | Vangueria cinerascens | 282 |
| Sopubia neptunii | 250 | Vernonia adenocephala | 145 |
| <i>Sopubia parviflora</i> | 250 | Vernonia filipendula | 147 |
| Spermacoce dibrachiata | 281 | <i>Vernonia luteoalbida</i> | 148 |
| Spermacoce pusilla | 282 | Vernonia melleri | 146 |
| Sphenostylis erecta | 201 | Vernonia perrottetii | 147 |
| Sporobolus congoensis | 389 | Vernonia stenocephala | 148 |
| <i>Sporobolus stelliger</i> | 389 | Vernonia suprafastigiata | 149 |
| Steganotaenia araliacea | 115 | Vernonia turbinella | 149 |
| Stephania abyssinica | 235 | Vigna antunesii | 202 |
| Streptocarpus michelmorrei | 210 | Vigna dolomitica | 203 |
| Streptocarpus rhodesianus | 210 | <i>Vigna nuda</i> | 202 |
| Striga asiatica | 251 | Vigna vexillata | 204 |
| Striga hermonthica | 251 | | |
| Strobilianthopsis linifolia | 101 | W | |
| <i>Strophanthus verdickii</i> | 121 | Wahlenbergia capitata | 159 |
| Strophanthus welwitschii | 121 | Wahlenbergia collomioides | 160 |
| | | Wahlenbergia malaisei | 161 |
| T | | <i>Wahlenbergia polyphylla</i> | 162 |
| <i>Tacca involucrata</i> | 331 | Wahlenbergia verbascooides | 162 |
| <i>Tacca leontopetaloides</i> | 331, 332 | Walleria mackenziei | 393 |
| <i>Tacca pinnatifida</i> | 331 | | |
| Targionia hypophylla | 57 | X | |
| Tecoma stans | 294 | Xerophyta barbarae | 394 |
| <i>Temnocalyx fuchsoides</i> | 270 | <i>Xerophyta demeesmaeckeriana</i> . | 395 |
| Themeda triandra | 389 | Xerophyta equisetoides | 395 |
| Thesium lynesii | 283 | Ximenia caffra | 242 |
| Thesium pawlowskianum | 283 | Xyris dissimilis | 400 |
| Thesium quarrei | 284 | | |
| Thesium subaphyllum | 285 | Z | |
| Thunbergia graminifolia | 102 | Zehneria minutiflora | 170 |
| Thunbergia kirkiana | 103 | Zonotriche decora | 391 |
| Thunbergia rogersii | 104 | Zonotriche inamoena | 391 |
| Tinnea coerulea | 223 | | |
| <i>Tinnea obovata</i> | 223 | | |
| Tithonia diversifolia | 294 | | |
| Trachycalymma foliosum | 122 | | |
| Tridactyle bicaudata | 378 | | |
| Tridactyle tridentata | 379 | | |
| Tristachya bequaertii | 390 | | |



The copper-cobalt outcrops of Upper Katanga and north-western Zambia host a particular flora which comprises an estimated 750 species of which more than 400 are treated in this Copper-Cobalt Field Guide.

The aim of this book, resulting from several years of intensive field work and study, is to bring together the basic knowledges permitting an easy approach to the identification of a great number of the species to be encountered. More than 400 species are illustrated with color photographs and/or drawings together with comments concerning synonyms, habit, description, ecology and distribution.

Plant species are listed and color-coded according to classification: Cyanoprocaryota, lichenized Fungi, Anthocerophyta, Marchantiophyta and Bryophyta (red edge), Lycophyta and Monilophyta (green edge), Magnoliopsida (blue edge) and Liliopsida (yellow edge). An index allows easy location either according to genus and species.

An account of the research on copper-cobalt ecosystems carried out during the last ten years in southeastern D.R. Congo is also presented.

The editors have spent more than twenty years in the area concerned and have collected more than 8,500 voucher specimens, including eleven species new to science (holotypes).

