R7275. African acacias - monographs and manuals
Final Technical Report

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Abbreviations

BRAHMS - Botanical Research And Herbarium Management System
DFID - Department for International Development
FAO – Food and Agriculture Organisation
OFI - Oxford Forestry Institute
TFP - Tropical Forest Papers

Executive Summary

The purpose of this project was to assemble the large amount of published and unpublished material on the African acacias in forms that make it accessible to the scientist, the extension worker and, ultimately, the farmer.

Library- and herbarium-based research resulted in the publication of three books.

Two of the books are species monographs and annotated bibliographies of *Faidherbia albida* and *Acacia senegal*. The third book is an *Acacia* Handbook that is focussed on growing and managing acacias in south central Africa.

The fourth proposed output from this project, a Conspectus of African acacias, has yet to be completed. However, lines drawings of all of the African *Acacia* species made as part of this project have been made available via the Web using the Virtual Field Herbarium website (http://herbaria.plants.ox.ac.uk/vfh/image/). Dynamic maps of *Acacia* herbarium data collected as part of this project have been made available through BRAHMS Online (http://herbaria.plants.ox.ac.uk/bol/?Oxford).

This project has made available high-quality information about African acacias to a broad community of users. The users range from the academic researcher, the extension worker and ultimately the farmer. The outputs have been made available in hard-copy but it is envisaged that the Tropical Forestry Papers will be made available for free over the Web. It is envisaged that information gathered as part of this project and made available free over the Web will result in a reliable resource for information about African acacias.

Background

Population pressure and drought are causing deforestation and land degradation throughout the semi-arid parts of the African continent. Trees are needed in agricultural systems to provide fuelwood, fodder and shelter, to rehabilitate degraded land and particularly to increase the productivity of non-arable land (FAO, 1980). Once the traditionally preferred trees in the climax plant communities have disappeared, they cannot be re-established under the harsh conditions. Exotic species have rarely proved to be successful in this situation and the solution is increasingly being sought among the natural pioneers, particularly the acacias. There is a need for the farmer, and the scientist and extension workers who work on their problems, to be provided with information on the acacias in a form that will help them in their efforts to exploit the trees' potential.

The potential of the African acacias to resolve the developmental problems being addressed by this project was recognized in the early 1980s (FAO, 1980; Palmberg, 1981). The Rockefeller Foundation (1987) background paper to the Bellagio strategy meeting on tropical forests stressed the need for information and understanding in the relationships between forestry, agriculture and economics and between people and trees based on thorough and expert research. A prime research topic was to identify and evaluate potential tree crops for adaptability to various local conditions, rapid growth, minimum management requirements, and generous yields of multiple products. The only species mentioned specifically in the whole paper were the African acacias and the need to explore their natural ranges, collect samples for taxonomy and collect seed for international testing and germplasm conservation was stressed. The success of afforestation in semi-arid lands lies in incorporating trees into farming systems rather than in establishing plantations (El-Lakany, 1995). The acacias have an inherent advantage in this respect in that they are armed against livestock and do not need expensive protection, they compete minimally with, and often benefit crop and grass yields and they provide a wide range of products with cash value (Barnes and Fagg, 1995; Barnes *et al*., 1996; Barnes *et al*., 1997), for example pods (Bongkoungou, 1995) and gum (Coppen, 1995).

In a study in the Mutambara Communal Area in Zimbabwe, it was found in a wild food and tree-based resource valuation exercise that only *Acacia* species showed an increase in productivity over time; few other products even remained stable (Campbell *et al*., 1994). Communal farmers themselves in parts of Zimbabwe are beginning to recognize the value of acacias in their agricultural systems (Clarke, 1994) and requests for research and materials from farmers and farmers' organizations have recently increased.

This project was intended to be the culmination of six Department for International Development (DFID)-funded projects conducted by the Oxford Forestry Institute (OFI), and directed by the late Dr Richard Barnes, since 1987:-

R4348: African acacias: study and acquisition of the genetic resources; R4526: *Acacia karroo*: Evaluation and acquisition of genetic resources;

R4583: African acacias: study and assembly of genetic resources;
R5655: African acacias: study and assembly of genetic resources (extension);
R5653: Genetic evaluation of African *Acacia* species: phase 1
R6550: Genetic evaluation of African *Acacia* species: phase 2

No formal analysis or specific market studies were undertaken before this project was started. However, the experience of Dr. Barnes and his collaborators and the demand for previous publications from the African acacia projects showed that a good market for such information was available. During the lifetime of the project, the Internet became more widely available and was used as a means of information delivery; something that was not envisaged at the start of the project.

The ultimate beneficiary of this research is the farmer, both small- and large-scale, and the range manager in Africa. The knowledge that is being disseminated through the project will contribute to exploiting the potential of the acacias to sustain and increase productivity of both non-arable and arable land through livestock production and cash crops. Information in the manuals will be of direct and immediate use to the farmer and his/her advisers but the scientific works will assist scientists in research institutions in both developing and developed countries to target and conduct their work more effectively. The rural poor, and particularly women, will benefit from an increase in the products of acacias for cash crops and the well-being and even survival of their livestock. The rural community in Zimbabwe has had, and will have, a substantial input to defining their needs through the participatory rural appraisals that have been conducted in the acacia trials projects (R5653 and R6550) and through the knowledge and contacts that the selected local collaborators for this project will have on the contents of the manual. The manual will have practical relevance to a large natural region that extends beyond the borders of Zimbabwe and can be described as the unimodal upland plateau of southern Africa. Further, the publication will provide a model and information for similar manuals that could be more specific to other parts of Africa.

Barnes, R.D., and Fagg, C.F. (1995) The potential of the African acacias in agricultural systems in the dryland tropics. Invited paper, IUFRO XX World Congress. 6-12 August, 1995, Tampere, Finland. 12 pp.

Barnes, R.D., Fagg, C.W. and Milton, S.J. (1997). *Acacia erioloba*: monograph and annotated bibliography. Tropical Forestry Papers No 35. Oxford Forestry Institute, Department of Plant Sciences, University of Oxford.

Barnes, R.D., Filer, D.L., and Milton, S.J. (1996) *Acacia karroo*: Monograph and annotated bibliography. Tropical Forestry Papers No. 32. Oxford Forestry Institute.

Bongkoungou, E.G. (1995). Trees in land management strategies in the Sahel: the role of agroforestry. Invited paper, IUFRO XX World Congress. 6-12 August, 1995, Tampere, Finland. 18 pp.

Campbell *et al*. (1994) Local level economic evaluation of savanna woodland resources: village cases for Zimbabwe. CIDA, Zimbabwe Forestry Commission and University of Zimbabwe. 118pp.

Clarke, J. (1994) Building on indigenous natural resource management. Zimbabwe Forestry Commission. 55 pp.

Coppen, J.J.W. (1995). Gums, resins and latexes of plant origin. Non-wood forest products 6, FAO, Rome. 25 pp.

El-Lakany, M.H. (1995) Afforestation techniques for desert development. Invited paper, IUFRO XX World Congress. 6-12 August, 1995, Tampere, Finland. 10 pp.

Fagg, C.W., and Barnes, R.D. (1995) African acacias: study and assembly of genetic resources. Final report, Project 5655, Oxford Forestry Institute.

FAO (1980) Genetic resources of tree species in arid and semi-arid areas. FAO/IBPGR.

Palmberg, C. (1981) A vital fuelwood gene pool is in danger. Unasylva 33 (133) 22.30

Rockefeller Foundation (1987). Research: needs and opportunities for improved management of tropical forests. Background paper for the strategy meeting on tropical forests, Bellagio, Italy, July 1-2, 1987.

Project Purpose

The use of trees within farming systems, including community and farm woodlots, optimized. The purpose of this project was to assemble the large amount of published and unpublished material on the African acacias in forms that make it accessible to the scientist, the

extension worker and the farmer to use this in achieving the programme purpose. To this end, four publications were envisaged:

1. A monograph on *Faidherbia albida*, to include an annotated bibliography and a synthesis of all available published and unpublished information on the species.
2. A monograph on *Acacia senegal* that will include a history and analysis of the acacia gum trade and an assessment of the prospects for commercial production from *A.. senegal* and other *Acacia* species.
3. A manual on the identity, ecology, site requirements, seed sources, silviculture management and uses of the six most important *Acacia* species in Africa *viz. Acacia erioloba, A. karroo, A.. nilotica, A. tortilis, A. senegal* and *Faidherbia albida* plus six others important species from Zimbabwe and the surrounding territories. The information for this manual would be drawn from the monographs, annotated bibliographies, results from previous projects and the personal experiences of Dr Barnes and his collaborators in Africa.
4. A Conspectus on all the African acacias; to include details of nomenclature, distribution, botanical description, botanical drawings and notes on the ecology and uses of each species.

Research Activities

Most of the project was based in either the library or herbarium and involved the synthesis of existing information or experience, particularly that of the Principal Investigator, the late Dr Richard Barnes, and his African colleagues.

The literature-based parts of the projects involved the summarising and abstracting and referencing of all information available (including the 'grey' literature) on African *Acacia* species in the Oxford Forestry Library, together with information available through on-line agricultural (CABI Abstracts), forestry (TREE-CD) and biological (Biological Abstracts). These literature searches were focussed on two species, *Acacia senegal* and *Faidherbia albida*, because of the potential economic importance of *A. senegal* gum (gum arabic) and the agroforestry value of *F. albida* in the Sahelian regions of Africa. Literature searches on the other African *Acacia* species were directed towards taxonomic and ecological works. In addition to the libraries in Oxford, searches were also made in the library at the Royal Botanic Garden Kew for *Acacia* literature.

Given the numbers of African *Acacia* species (129 species; 165 taxa), and the complexities of the infraspecific variation in some, e.g. *A. nilotica*, the investigation of herbarium material was essential. Therefore, *Acacia* material from all of the major African herbaria and European and North American herbaria, with significant African holdings were either visited or their material was sent on loan to Oxford. This material was seen by either Dr Barnes or Dr Christopher Fagg and annotated with currently accepted names. Each specimen was entered into the herbarium specimen management programme BRAHMS (Botanical Research And Herbarium Management System) and the geographic position determined so that they could be mapped. This process has yielded a database of more than 10,000 herbarium records. In addition, all known African *Acacia* type specimens were studied and all African *Acacia* names on the International Plant Names Index (http://www.ipni.org/index.html) were investigated.

The BRAHMS database formed the core of the project and was used for entering species data (e.g. leaf and flower measurements) from either specimens or literature, so that descriptions could be built-up. BRAHMS was also used for managing the nomenclatural data associated with species names, e.g., authors, places of publications and type details, together with synonymy relationships.

Pen and ink drawings of all *Acacia* species were made by Rosemary Wise. Ideally, each plate comprised a flowering or fruiting branch, together with details of fruits, flower and leaf, and an indication of plant habit. All of the plates were drawn from herbarium specimens, or photographs associated with herbarium specimens, and therefore each plate has at least one voucher. There are gaps on some plates since flowers and fruits have not been collected, despite extensive searches in herbaria. Thus there are some species of African *Acacia* that are incompletely known morphologically; especially rare, narrowly distributed species from northern Tanzania.

In recent years there has been a resurgence of interest in African *Acacia* taxonomy, especially in Kenya and South Africa. This has resulted in the publication of a number of new names. However, it is unclear whether these represent new taxa. Since type material was unavailable to the project these new names were not considered to the same depth as other names. The other major event in *Acacia* taxonomy has been the realisation that Acacia is not a

single evolutionary group but at least five separate groups. One of the consequences of this is the need to make name changes at the generic level. Two Australian taxonomists proposed that the name *Acacia* should be associated with Australian *Acacia* species (Orchard & Maslin, 2003.). Despite vigorous arguments (Luckow *et al*., 2005) against this radical change, the change was recommended by the Committee for Spermatophyta (Brummitt, 1999) and adopted at the International Botanical Congress in Vienna in 2005. This will necessitate the split of the African acacias into the genera *Vachellia* and *Senegalia*; there will no longer be any native species of *Acacia* in Africa. Since this will necessitate a very large number of name changes, most of which have not been made, the genus name *Acacia* was used throughout this project.

The planned inputs of Dr Richard Barnes were curtailed by his illness and subsequent death in 2004. This had a major impact on the project, particularly the Conspectus, which was still at a relatively early stage when he died. Dr Stephen Harris took over the formal management of the project in late-2004. Dr Christopher Fagg provided the needed taxonomic expertise and knowledge of Dr Barnes' working methods. Unfortunately, since Dr Fagg had commitments in Brazil, his time was limited and this has delayed considerable the completion of the Conspectus.

Brummitt, R. K. (1999) Report of the Committee for Spermatophyta: 48. *Taxon* 48: 367-368.

Luckow, M., Hughes, C., Schrire, B., Winter, P., Fagg, C., Fortunato, R., Hurter, J., Rico, L., Breteler, F.J., Bruneau, A., Caccavari, M., Craven, L., Crisp, M., Delgado, A.S., Demissew, S., Doyle, J.J., Grether, R., Harris, S., Herendeen, P.S., Hernández, H.M., Hirsch, A.M., Jobson, R., Klitgaard, B.B., Labat, J.-N., Lock, M., MacKinder, B., Pfeil, B., Simpson, B.B., Smith, G.F., Sousa, M.S., Timberlake, J., van der Maesen, J.G., Van Wyk, A.E., Vorster, P., Willis, C.K., Wieringa, J.J. & Wojciechowski, M.F. (2005) *Acacia*: the case against moving the type to Australia. Taxon 54, 513-519.

Orchard, A. E. & Maslin, B. R. (2003) Proposal to conserve the name *Acacia* with a conserved type. *Taxon* 52: 362-363.

Outputs

Three major outputs have been produced to date; two Tropical Forest Papers (TFP) on *Faidherbia albida* (Annex 1) and *Acacia senegal* (Annex 2), and an *Acacia* Handbook (Annex 3). These outputs have been sent to the organisations and individuals listed in Annex 4; multiple copies of outputs have been sent to larger organisations. The fourth output, a Conspectus of the acacias of Africa, has yet to be published.

TFP41 and TFP42 are species monographs on *Faidherbia albida* and *Acacia senegal,* respectively. These two volumes complement earlier TFP publications by Barnes and colleagues on *A. erioloba* (Barnes *et al*., 1997) and *A. karroo* (Barnes *et al*., 1996). TFP41 and TFP42 follow the familiar style of these publications. Detailed discussions of taxonomy, genetic variation, life history, ecology, reproductive biology, pests and diseases, wood properties and plant uses and management are included. In both cases, all of the available literature was reviewed (including 'grey' literature). TFP41 and TFP42 include alphabetically arranged, annotated bibliographies of 757 and 838 publications, respectively. TFP42 also includes detailed analyses of the history of gum arabic trade in Africa, together with an economic analysis of current world trade patterns and likely demand.

The *Acacia* Handbook is focussed on growing and managing acacias in south central Africa. In contrast to the TFP publications, this publication is aimed firmly at agricultural and forestry extension workers and forestry and conservation teachers in southern Africa. Chapters are focussed on identifying the species for planting and planting site, together with important chapters on the raising, establishment and management of *Acacia* species. A final chapter provides advice on the use of the Handbook in the activities of extension workers and teachers. An appendix describes and illustrates the main characteristics of the nine *Acacia* species considered in the Handbook, together with *Faidherbia albida* and *Dicrostachys cinerea*.

The final output, a Conspectus of all African *Acacia* species, has not been completed. 90% of the text has been written, all of the drawings have been produced, together with all of the map information. Final editing of the text is now needed so that it can be printed. An example of the final text for three *Acacia* species is given in Annex 5.

The reason that this output could not be achieved in the necessary time scale was through the death of the Principal Investigator, Dr Barnes, in 2004. Dr Barnes' death was preceded by a period of debilitating illness. The death of Dr Barnes was a major blow to this project, since the project was going to be the culmination of all of his work on African *Acacia* species. The majority of

the writing was therefore left to the consultant, Dr Fagg, University of Brasilia, since he was the most appropriate person to complete this work as he had worked with Dr Barnes for many years and is a well-known expert on African *Acacia* species. Dr Fagg, however, had commitments in Brazil and could only undertake work on the Conspectus periodically. However, all of the *Acacia* plates drawn by Rosemary Wise for this part of the project, together with short summaries of distributions, are available through the Virtual Field Herbarium (http://herbaria.plants.ox.ac.uk/vfh/image/). In addition, the *Acacia* specimen database, constructed by Dr Fagg in BRAHMS, forms the basis of the *Acacia* mapping facility available at http://herbaria.plants.ox.ac.uk/bol/?Oxford.

Barnes, R.D., Filer, D.L. and Milton, S.J. (1996) *Acacia karroo*. Monograph and annotated bibliography. Tropical Forestry Paper 32. Oxford Forestry Institute, Oxford.

Barnes, R.D., Fagg, C.W. and Milton, S.J. (1997) *Acacia erioloba*. Monograph and annotated bibliography. Tropical Forestry Paper 35. Oxford Forestry Institute, Oxford.

Contribution of Outputs

This project has been about providing information about African *Acacia* species to a broad community of users. The users range from the academic researcher, the extension worker and ultimately the farmer. The focus of the project has been on two of the most widely used *Acacia* species, *Acacia senegal* and *Faidherbia albida*, and much of the information from other *Acacia* species has been directed to those in use in southern Africa. The over-riding aim of the project has been to provide reliable, well-referenced information about these species. Whilst the outputs have been made available in hard-copy, it is envisaged that the TFPs will be made available for free over the Web. Once the editing of the Conspectus has been completed, this will result in a high-quality publication that will become the standard reference for information on African acacias, replacing Ross' very difficult to find account of the genus.

Whilst much information is available over the Web, the quality of that information may be doubtful. With the *Acacia* TFPs, and ultimately the *Acacia* Conspectus, available over the Web it is envisaged that these will be reliable resourced for information about African acacias. The power of this approach has been demonstrated using with the African *Acacia* images that are currently available and the mapping facilities that already exist within BRAHMS online. The web delivery of this information forms part of the current remit of Oxford University Herbaria, where the actively data are maintained.

The publications from this project are:

Barnes, R.D. and Fagg, C.W. (2003) *Faidherbia albida*. Monograph and annotated bibliography. Tropical Forestry Paper 41. Oxford Forestry Institute, Oxford.

Fagg, C. W. and Allison, G. E. (2004) *Acacia senegal* and the gum Arabic trade. Tropical Forestry Paper 42. Oxford Forestry Institute, Oxford.

Spicer, N., Barnes, R. and Timberlake, J. (2005) Acacia Handbook. Growing and managing acacias in south central Africa. CBC, Harare, Zimbabwe.

Acknowledgement

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Report Annexes

Annex 1. Barnes, R.D. and Fagg, C.W. (2003) Faidherbia albida. Monograph and annotated bibliography. Tropical Forestry Paper 41. Oxford Forestry Institute, Oxford. [Included in box file]
Annex 2. Fagg, C. W. and Allison, G. E. (2004) *Acacia senegal* and the gum Arabic trade. Tropical Forestry Paper 42. Oxford Forestry Institute, Oxford. [Included in box file]
Annex 3. Spicer, N., Barnes, R. and Timberlake, J. (2005) Acacia Handbook. Growing and managing acacias in south central Africa. CBC, Harare, Zimbabwe. [Included in box file]
Annex 4. Addresses of organisations and individuals to which outputs sent.
Annex 5. Example of three species for the *Acacia* Conspectus.

Annex 4. Addresses of organisations and individuals to which outputs sent.

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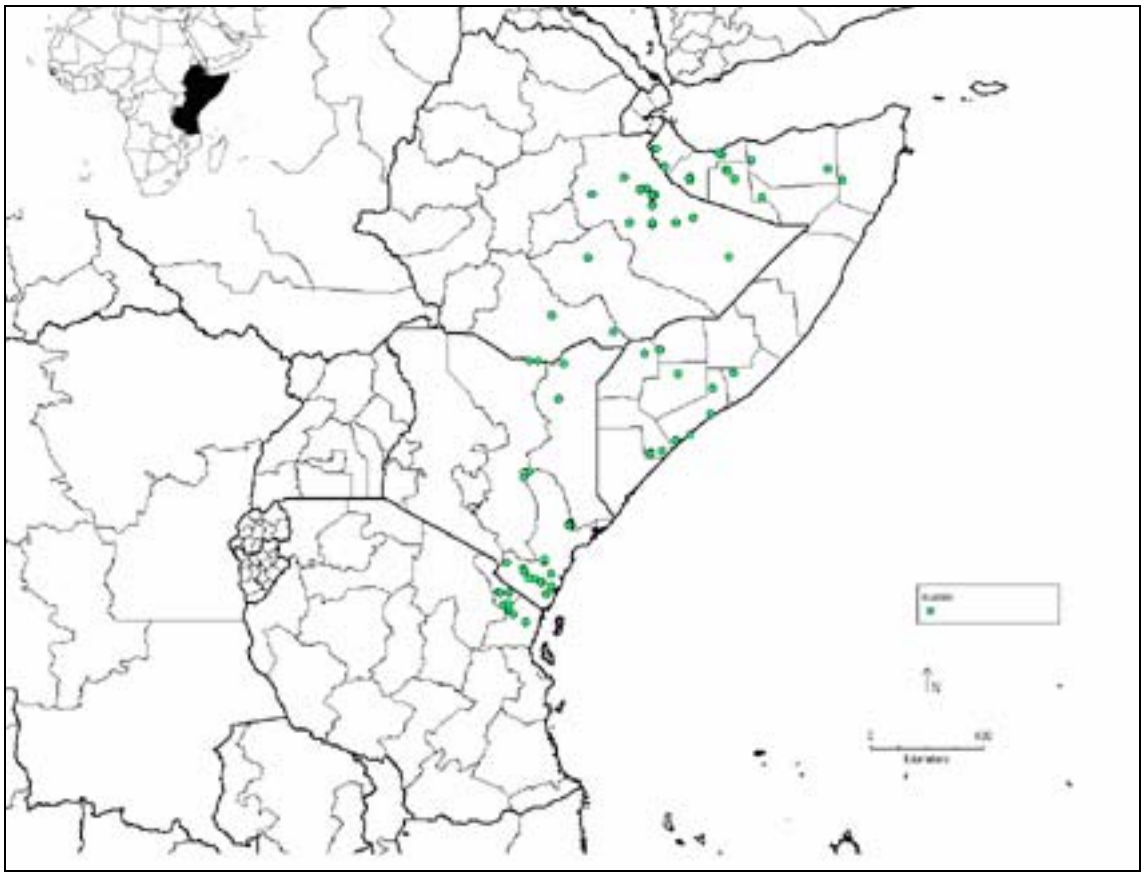
Annex 5 Example of three species for the *Acacia* Conspectus.

***Acacia bussei* Harms ex Sjostedt, Schwed. Zool. Exped., Kilmandjaro, viii. 117-118 (1908)**

Synonyms: *A. benadirensis sensu* Chiov.
Description: Tree single-stemmed to 3-10 m tall with a flattened crown, occasionally shrub with obconical crown, bark brownish-black or grey, fissured, young twigs grey-brown to purplish, glabrous or pubescent. Thorns straight (stipules spinescent), paired, up to 9 cm long, some swollen basally but constricted where are attached to stem. *Leaves*: petiole 0.4-1.8 cm long, usually with a conspicuous gland; rhachis 0.7-2.5 cm long, eglandular; pinnae 2-8 pairs; rhachillae 0.4-1.8 cm long; leaflets (7)-10-19 pairs, 1.5-5 x 0.5-1.6 mm, pubescent. *Flowers* creamy-white, sessile, grouped into spikes 1.5-6 cm long on peduncles 0.4-1.5 cm, calyx 0.7 mm long, corolla 2.5-3.5 mm long, glabrous. *Pods* straight, narrowly oblong, dehiscent, brown, 2-8 x 0.8-1.5 cm, puberulous. *Seeds* flattened, 5 x 4.5 mm, areole 2 x 1.5 mm.
Ecology: Widespread in the Somalia-Masai *Acacia*/*Commiphora* bushland of lower altitudes this species can dominate large woodlands often in association with *A. mellifera*, *A. nilotica* and *A. tortilis*. The species grows in woodland and bushland on a wide range of soils from red sands to black cotton (clay), as well as on limestone outcrops. Found on calcareous soils of low to medium salinity in Ethiopia, with pH values up to 8.5. Common in sandy soils, noted to stabilise them. Also found in *Acacia*/*Combretum* woodland.
Occurrence: Ethiopia, Kenya, Somalia, Tanzania.
Uses: This species is the main source of charcoal in Somalia, particularly the Bay region. The nomadic Somali use the species for hut construction: stem for central poles; roots for hoops; bark for covering mats; chewed inner bark for thread. Branches are used for axe and hoe handles (Bird & Shepherd 1992). Roots are used for covering wells because of resistance to rot and termites; also used for wattle and daub walls. Root fibres used to make wide-mesh baskets to protect water or milk vessels. Both in Ethiopia and Somalia, the species is widely browsed by cattle, sheep and goats. The flowers appear before the leaves and are an important part of camels' diet. The bark contains 17-21% tannin, and is used for tanning skins used for carrying water (Wickens *et al*. 1995). In Somalia, bark and root bark fibre is used for making rope, roots for making sorghum storage sacks and string hanging doors, and young thorns are even eaten as food.
Related species: *A. bussei* is related to *A. horrida* ssp. *benadirensis* and *A. lahai*.
Etymology: Named after the German collector Walter Busse who collected one specimen at Mazinde (Lushoto District, Tanzania).
Altitude range: 30 – 1800 m.



Distribution of *Acacia bussei* Harms ex Sjostedt.

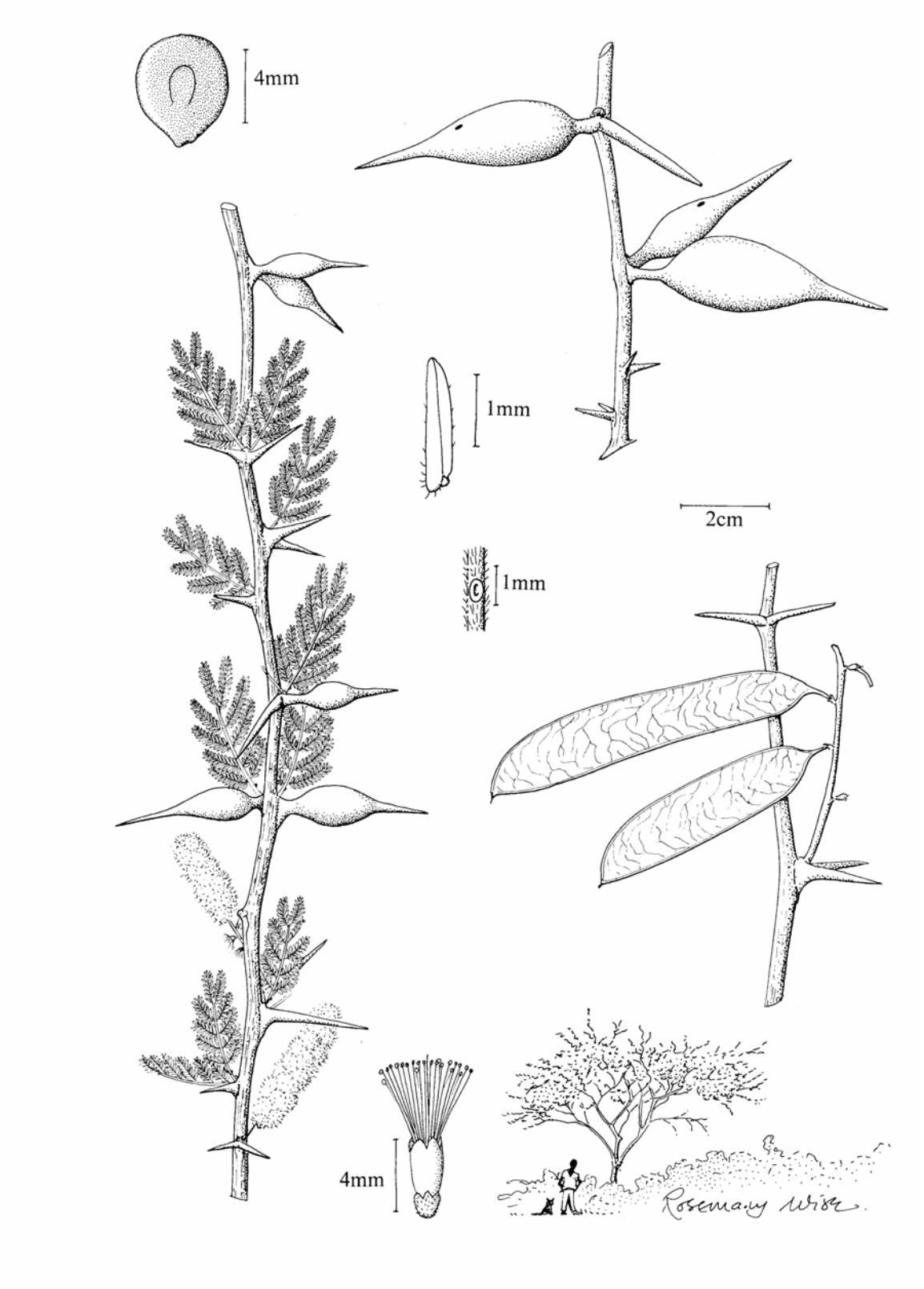


Plate of *Acacia bussei* Harms ex Sjostedt.

***Acacia nilotica* (L.) Willd. ex Del., Deutsche Fl. 722 (1880-83) (1813)**

Description: Tree single-stemmed, deciduous or evergreen, usually 2.5-15 m tall, but reaching 25 m or more in riverine subspecies. Trunk straight, girth up to 2-3 m; bark rough and longitudinally fissured, 1-1.5 cm thick, grey to brownish-black, younger stems grey-brown and smooth; crown upright and flattened, rounded and spreading. Twigs usually bearing paired stipular spines at the leaf axils or nodes, 1-5 cm long, usually characteristically deflexed. *Leaves* alternate, bipinnately compound, glabrous to subtomentose; petiole 0.4-2.5 cm long, adaxial gland (sometimes 2) often present; rhachis 1.2-10 cm long, with a gland at the junction of each pinna pair or top few pairs only; pinnae 2-14 pairs, with 7-36 pairs of leaflets per pinna; leaflet subsessile, elliptic or narrowly oblong, 1.5-7 mm × 0.5-2 mm, rounded and oblique at base, margin entire, apex obtuse, glabrous to pubescent, lateral veins not visible beneath. *Flowers* golden-yellow and sweetly scented, grouped into round heads, borne on a short peduncle, with an involucel (small pair of bracts) occurring from near the base to over halfway up the peduncle, and sometimes having a few sterile flowers developing from it; flowers about 50 per head; calyx 4-6-lobed, 1-2 mm long, glabrous or pubescent; corolla 4-6-lobed, 2.5-3.5 mm long, glabrous or pubescent; stamens numerous, up to 6 mm long, filaments free, glandular. *Fruit* a beaded or in outline oblong, flattened pod, 4-22 cm × 0.9-2.2 cm, very variable depending on the subspecies, straight or curved, margins entire or deeply constricted between the seeds, the position of each seed clearly marked by a distinct raised bump in the pod valves, indehiscent with varying thickness, dark brown to grey, glabrous or velvety. *Seeds* 6-17 per pod, flattened, elliptic to subcircular in outline, 6.5-9 mm × 5-8 mm, dark brown to brownish-black, areole horseshoe or closed circle in shape, 5-7 mm × 4-7 mm.

Ecology: *Acacia nilotica* in Africa exhibits two very distinct ecological preferences. Subspecies *subalata*, *leiocarpa* and *adstringens* occur in wooded grassland, savanna and dry scrub forests on deep sandy loamy soils, and also on lateritic and calcareous sites, whilst ssp. *kraussiana* is also found in dry grasslands and savannas, especially on compacted sandy loam, shallow granite or clay soils along drainage lines and rivers, but away from flooding. On the other hand, sspp. *nilotica* and *tomentosa* are restricted to riverine habitats and seasonally flooded areas on clay alluvial soils. In the Indian subcontinent, ssp. *indica* forms low altitude dry forests, usually on alluvium soils subject to flooding or black cotton soils. Root system deep and extensive in dry sites, the taproot developing first and then the laterals, which become compact and massive, but in flooded sites the root system is largely lateral. Now widely planted on farms throughout the plains, ssp. *indica* will also grow on saline, alkaline, and on soils with calcareous pans.

Occurrence: Angola, Burkina Faso, Cape Verde, Central African Republic, Chad, Ethiopia, French Guiana, Ghana, Kenya, Mali, Mauritania, Mozambique, Nigeria, Oman, Senegal, Somalia, South Africa, Sudan, Tanzania, Yemen Republic.

Uses: An important source of firewood and good quality charcoal in the Sahelian regions and Tanzania, its calorific value is 4950 kcal kg^{-1} for heartwood and 4800 kcal kg^{-1} for sapwood. Its bark is preferred by the Mbeere tribe (Kenya) for firing pottery, and its thorny branches for livestock pens. Its heartwood is very hard and heavy (1170 kg m^{-3}), red-brown and sometimes with dark striations, it dries and works well but its high silica content blunts tools. The species has many timber uses, e.g., hut construction, boat building, oil, sugar and cane presses, railway sleepers, poles for granaries and digging sticks (Wickens et al. 1995). The species produces a gum with a positive optical rotation, and usually with high tannin contents. It is an important source of tannin for producing high quality leather in parts of Africa; the bark contains over 20% tannin, and green pods 30% tannin, although only half this when mature (the seeds must be removed first). Bark fibre is used in Somalia for making rope, and is a preferred fibre source in Tanzania. The bark is also used to produce a red or black dye, and the pods produce a black, red or yellow dye and an ink. Tender young pods are eaten as a vegetable, and roasted seeds served as a spice or are fermented to make an alcoholic beverage. Boiled bark produces a coffee-like beverage in Tanzania. The Mbeere use the tree sap and shreds of bark to deter bed bugs, and the sap also produces a black anti-rust coating on iron. The sharp spines are used to remove jiggers from feet and in male circumcision.

Related species: This is a very variable species, which can be easily recognised by its golden yellow flowers in round heads, straight, often deflexed, paired stipular thorns, which are never inflated into "ant-galls", and indehiscent compressed pods. *Acacia nilotica* may be confused with *A. seyal* (similar flowers but powdery white-red-yellow bark and dehiscent pods) or *A. karroo* (similar thorns, usually not deflexed, and dehiscent pods). *Acacia gummifera* is probably the

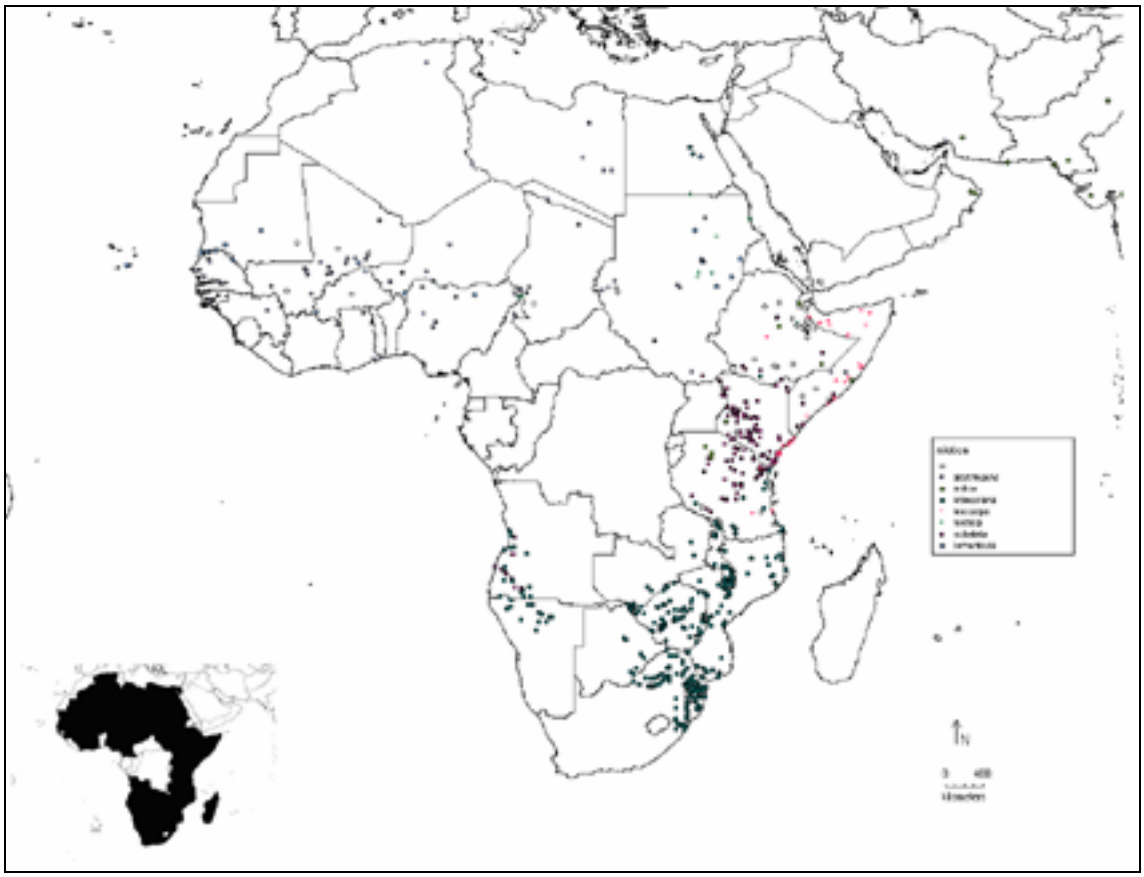
most closely related species, and is endemic to Morocco, where *A. nilotica* does not occur. *Acacia gummifera* differs from *A. nilotica* in having only 1-3 pinnae pairs and eglandular petioles.

Etymology: The specific name is Latin for "of the Nile"; the species was originally described by Linnaeus in 1753 as *Mimosa nilotica* from a specimen collected along the Nile in Egypt. The subspecific names in Africa refer to medicinal adstringent properties (*adstringens*), smooth glabrous (*leio*-) fruits (-*carpa*), tomentose pods (*tomentosa*), almost (*sub*-) winged (-*alata*) pods and Indian origin (*indica*), whilst ssp. *kraussiana* is named after the scientist and traveller Christian Ferdinand Friedrich Krauss, who collected the type specimen in Kwazulu-Natal in the 1830s.

Altitude range: 2 - 1950 m.

Key to subspecies

1.	Pods beaded, narrowly and regularly constricted between the seeds	2
1.	Pods not beaded, margins straight or occasionally constricted between seeds	4
2.	Pods hairless, young twigs hairless or covered with minute hairs	ssp. *nilotica*
2.	Pods densely covered with soft grey to white hairs	3
3.	Young twigs densely clothed with soft grey to white hairs	ssp. *tomentosa*
3.	Young twigs hairless or with a short hairs	ssp. *indica*
4.	Twigs and pods (at least when young) densely covered with short hairs, pods 1-2.2 cm wide	5
4.	Twigs and pods hairless or nearly so, pods 1-1.3 cm wide	ssp. *leiocarpa*
5.	Pods covered with short hairs when young, which later become hairless with a shining raised area over each seed, pods 1-1.6 cm wide	ssp. *kraussiana*
5.	Pods densely clothed with soft grey-white hairs, pods wider (1.3-2.2 cm)	6
6.	Pods hairy and curved with an occasional constriction between the odd seed, restricted to west Africa to Somalia	ssp. *adstringens*
6.	Pods hairy with straight margins, restricted to east Africa	ssp. *subalata*



Distribution of *Acacia nilotica* (L.) Willd. ex Del. *sensu lato*

***Acacia nilotica* ssp. *adstringens* (Schumach. & Thonn.) Roberty**
Synonyms: *Mimosa adstringens* Schumach. & Thonn.; *A. adansonii* Guill. & Perr.; *A. nilotica* var. *adansonii* (Guill. & Perr.) O.Kuntze; *A. arabica* var. *adansonii* Dubard; *A. arabica* var. *adansonii* (Guill. & Perr.) A. Chev.; *A. scorpioides* var. *adstringens* (Schumach & Thonn.) A. Chev.; *A. arabica* var. *adstringens* (Schumach & Thonn.) Baker f.; *A. nilotica* var. *adstringens* (Schumach & Thonn.) Chiov.; *A. nilotica* var. *adansoniana* (Dubard) A.F.Hill; *A. nilotica* ssp. *adstringens* var, *adansonii* (Guill. & Perr.) Roberty; A. *adstringens* (Schumach & Thonn.) Berhaut non. Mart.; A. *nilotica* subsp. *adansonii* (Schumach & Thonn.) Brenan.
Description: Pods not necklace-like, margins straight or crenate and rarely narrowly constricted between the seeds, if constricted then only occasionally along the pod. Branches and pods densely pubescent to tomentose especially when young. Pods often rather wide (1.3-2.2 cm) with distinctly and often irregularly crenate margins.
Occurrence: Algeria, Burkina Faso, Cameroon, Cape Verde, Chad, French Guiana, Gambia, Ghana, Guinea Bissau, India, Iran, Ivory Coast, Libya, Mali, Niger, Nigeria, Oman, Pakistan, Senegal, Somalia, Sudan, Togo.
Uses: Occasionally used for firewood and good quality charcoal in the Sahelian regions, and is a preferred firewood in Tanzania. It has a hard heavy heartwood, with a density of 0.945 and a sapwood with a density of 0.827, it is resistant to water and termites. The subspecies uses include construction work, boat-building, fencing, tool handles and art objects. Foliage and pods are browsed by camels, horses, sheep and goats. The subspecies is a source of gum and tannin, the bark and pods are used for tanning leather (preferred by shoemakers in the Sahelian regions) and as a dye source. The gum is locally used for making ink. The subspecies is commonly planted as a shade tree in the Sahelian regions. In Burkina Faso, the leaves are used against diarrhoea, the grilled and crushed seeds for treatment of haemorrhoids and gingivitis, and the powdered bark as a local aemostatic. A decoction of the pods is used for coughs, and swallowing the juice formed by chewing pods alleviates the rawness of a dry cough. The flowers are a source of pollen and nectar for bees (Wickens et al. 1995).
Altitude range: 15 – 1220 m.

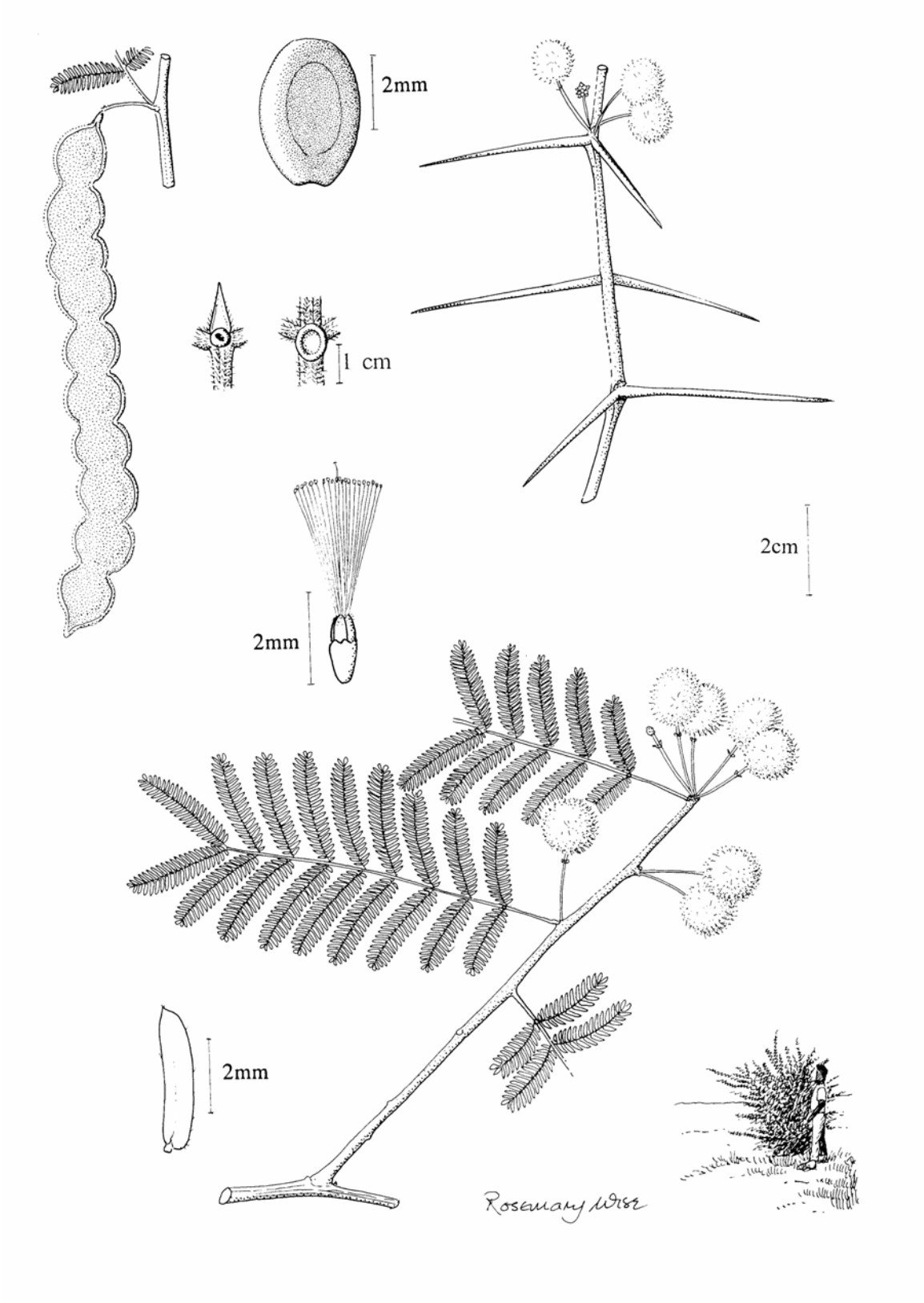


Plate of *Acacia nilotica* ssp. *adstringens* (Schumach. & Thonn.) Roberty

***Acacia nilotica* ssp. *indica* (Benth.) Brenan, Kew Bulletin 12 1957 (1957)**
Synonyms: *A. arabica* var. *indica* Benth.; *A. nilotica* var. *indica* (Benth.) A.F.Hill.
Description: Pods necklace-like, constricted between the seeds. Young twigs glabrous or with a few short hairs, crown rounded and not columnar.

Occurrence: Angola, Djibouti, Ethiopia, India, Iran, Kenya, Oman, Pakistan, Somalia, Tanzania, Yemen, Yemen Republic, Yemen South.
Uses: Foliage is lopped and fed to livestock, the pods are best fed when dry. The subspecies is also used to supplement poultry ration. A dark-coloured gum, containing tannins, is usually produced and is used medicinally and in paints and calico printing. In India, the bark is used as a tannin source, containing between 12-20% tannin, whilst deseeded pods have 18-27% tannin.
Altitude range: 6 - 2200 m.

***Acacia nilotica* (L.) Willd. ex Del. ssp. *kraussiana* (Benth.) Brenan**
Synonyms: *Acacia arabica* var. *kraussiana* Benth.; *A. benthamii* Rochebr. non Meisn.; *A. nilotica* var. *kraussiana* (Benth.) A.F.Hill.
Description: Pods not necklace-like, their margins straight or crenate and rarely narrowly constricted between the seeds, if constricted then only occasionally along the pod. Branches and pods more or less pubescent when young, pods later becoming hairless and shining on the raised part over each seed. Pods rather narrow [1-1.6-(1.9) cm wide] with margins slightly crenate.
Occurrence: Angola, Botswana, Egypt, Ethiopia, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Yemen Republic, Yemen South, Zambia, Zimbabwe.
Uses: A wide layer of light buff to brown sapwood surrounds clear, deep pink-red dense heartwood with variable markings. The very heavy wood (1100-1170 kg m^{-3}) has a coarse to medium, even texture, and is hard and difficult to work. It has a similar hardness to both *A. nigrescens* and *A. erioloba*. The wood seasons well, is very durable, and is resistant to borer and termite attack. Good logs can occasionally be obtained. The wood has been used for mine timber, fence posts, wagons and tool handles, and has also been used for carving, turnery and cabinet-making, although it is difficult to saw and tends to blunt tools. It provides very good firewood. The bark and pods are tannin-rich, yielding up to 38% tannin. Ink is made from the ripe black pods. An edible gum, used in confectionery and as an adhesive, is obtained from the stem, while roasted pods have been used as flavouring. The tree has many medicinal uses in Zimbabwe - the leaves and roots have been used to relieve colds, ophthalmia, haemorrhages and as a stimulant, while the flower is made into an ointment for wounds. The greatest economic value of *A. nilotica* is probably its use for livestock. Both the leaves and pods are high in protein, and the pods are available into the dry season when they are most needed. Both cattle and wildlife will attempt to knock down the unripe pods. In southern Matabeleland, 35 kg of pods were obtained from a single average tree in a good season. There appears to be a chemical in the pods, perhaps tannin, which limits animals' intake. The tree is also a useful source of shade as it loses its leaves later in the season than many other species. *Acacia nilotica* is obviously adapted for animal dispersal, but if concentrations of cattle build-up, creating disturbed, open habitats, the species will become invasive and form thickets, thus reducing available grass. The subspecies is browsed by cattle, sheep, goats and camels in Ethiopia.
Altitude range: 2 – 1829 m.

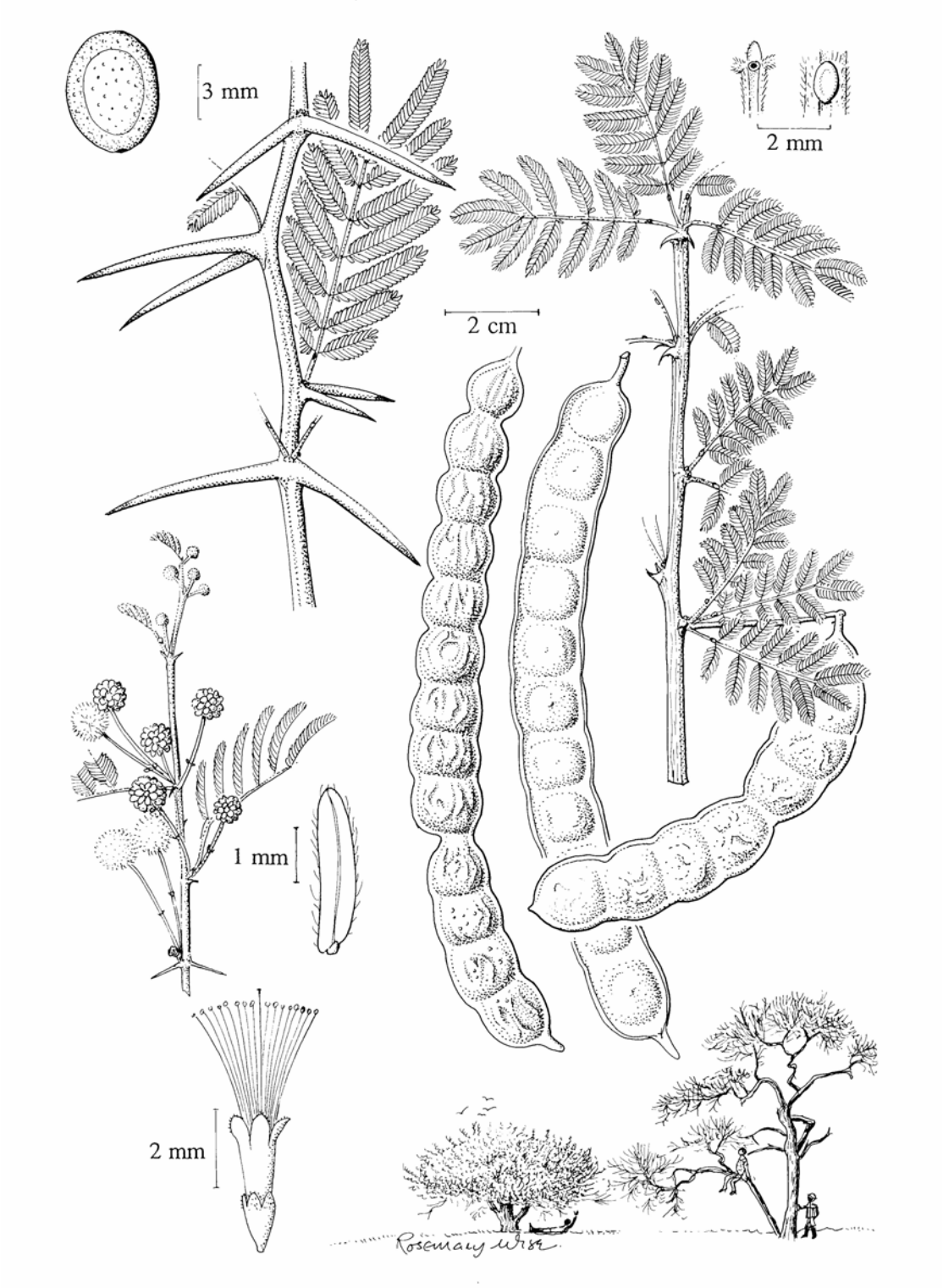


Plate of *Acacia nilotica* (L.) Willd. ex Del. ssp. *kraussiana* (Benth.) Brenan

***Acacia nilotica* ssp. *leiocarpa* Brenan**

Description: Pods not necklace-like, their margins straight or crenate and rarely narrowly constricted between the seeds, and if constricted then only occasionally along the pod. Branches and pods more or less hairless. Pods rather narrow (1-1.3 cm wide) with margins slightly crenate. Tree not hemispherical with distinct stem.

Ecology: Occurs into two different habitats, along the coastal regions of Somalia and Kenya, and also in Ethiopia and Somalia between 1000 and 1800 m.
Occurrence: Ethiopia, Kenya, Mozambique, Oman, Somalia, Tanzania.
Altitude range: 2 – 1658 m.

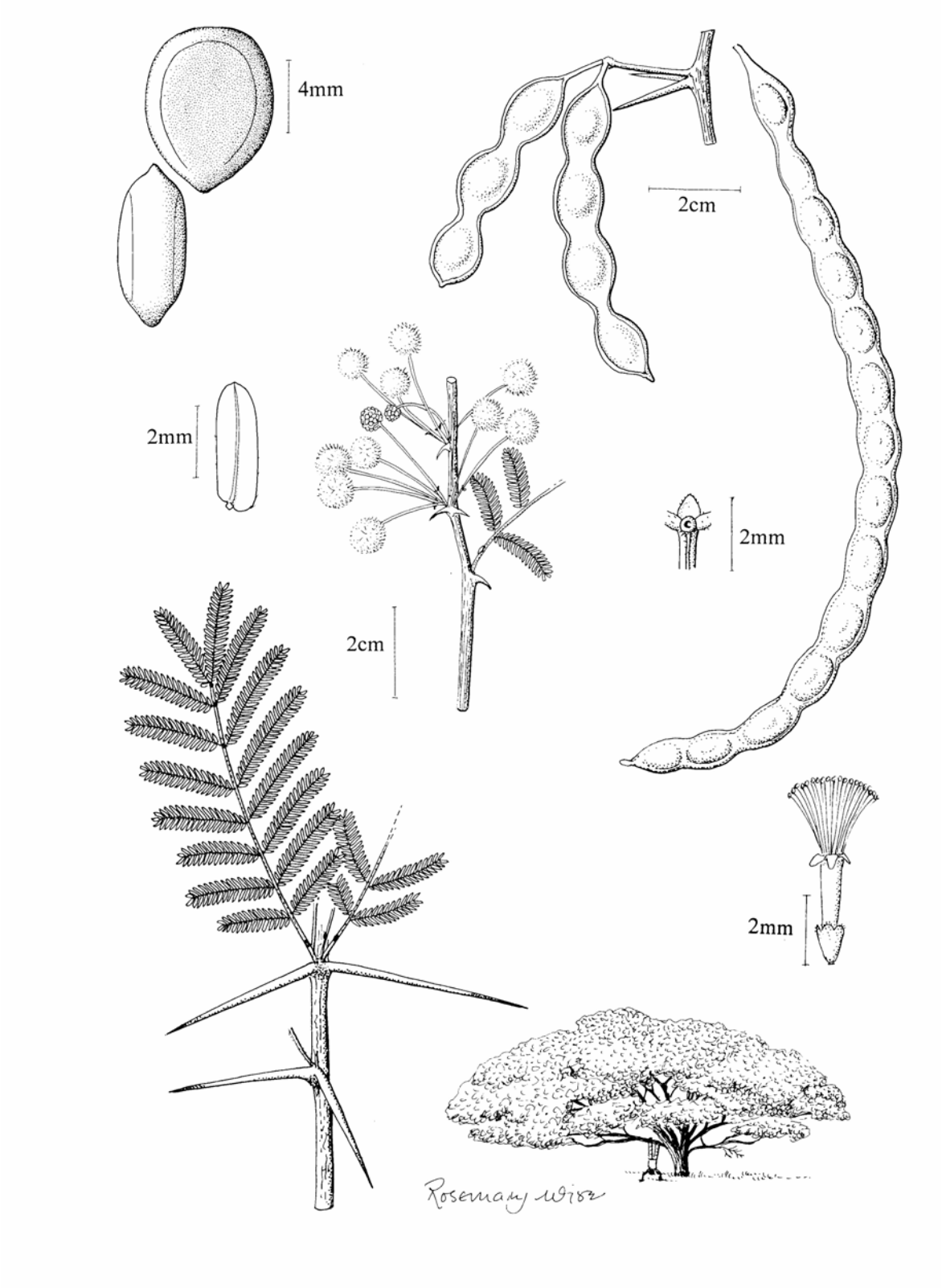


Plate of *Acacia nilotica* ssp. *leiocarpa* Brenan

Acacia nilotica* (L.) Willd. ex Del. ssp. *nilotica
Synonyms: *Mimosa nilotica* L.; *Mimosa scorpioides* L.; *Mimosa arabica* Lam.; *A. arabica* (Lam.) Willd.; *A. vera* Willd. non Garsault.; *A. arabica* var. *nilotica* (L.) Benth.; *A. aegyptiaca* Baill.; *A. nilotica* var. *genuina* O.Kuntze; *A. scorpioides* (L.) W.F.Wright; *A. nilotica* var. *typica* Fiori; *A. scorpioides* var. *nilotica* (L.) A.Chev.; *A. nilotica* ssp. nilotica Roberty var. *vera* Roberty*; A. nilotica* var. *nilotica* Cufodontis
Description: Pods necklace-like, constricted between the seeds. Pods hairless or almost so, young twigs hairless to shortly hairy (puberulous).
Occurrence: Burkina Faso, Cameroon, Chad, Egypt, Ethiopia, Mali, Nigeria, Oman, Sudan, Tanzania, Yemen, Zanzibar.
Uses: An important source of firewood and good quality charcoal in the Sahelian regions. Its sap wood is yellowish-white, and a pinkish-red to reddish-brown heartwood, it is hard and heavy with a density of 0.80. Resistant to water and termites, it is widely used for internal and external utensils and construction, boat-building and pit props. In Sudan, the wood is used for railway sleepers and water wheels. Roots are used for the wide mesh baskets used to protect large water and milk vessels. Source of gum and tannin; pods in Sudan contain 25-33.8% tannin and deseeded pods contain up to 50% tannin. In Cairo, it is planted as a street tree (Wickens et al. 1995).
Altitude range: 5 – 457 m.

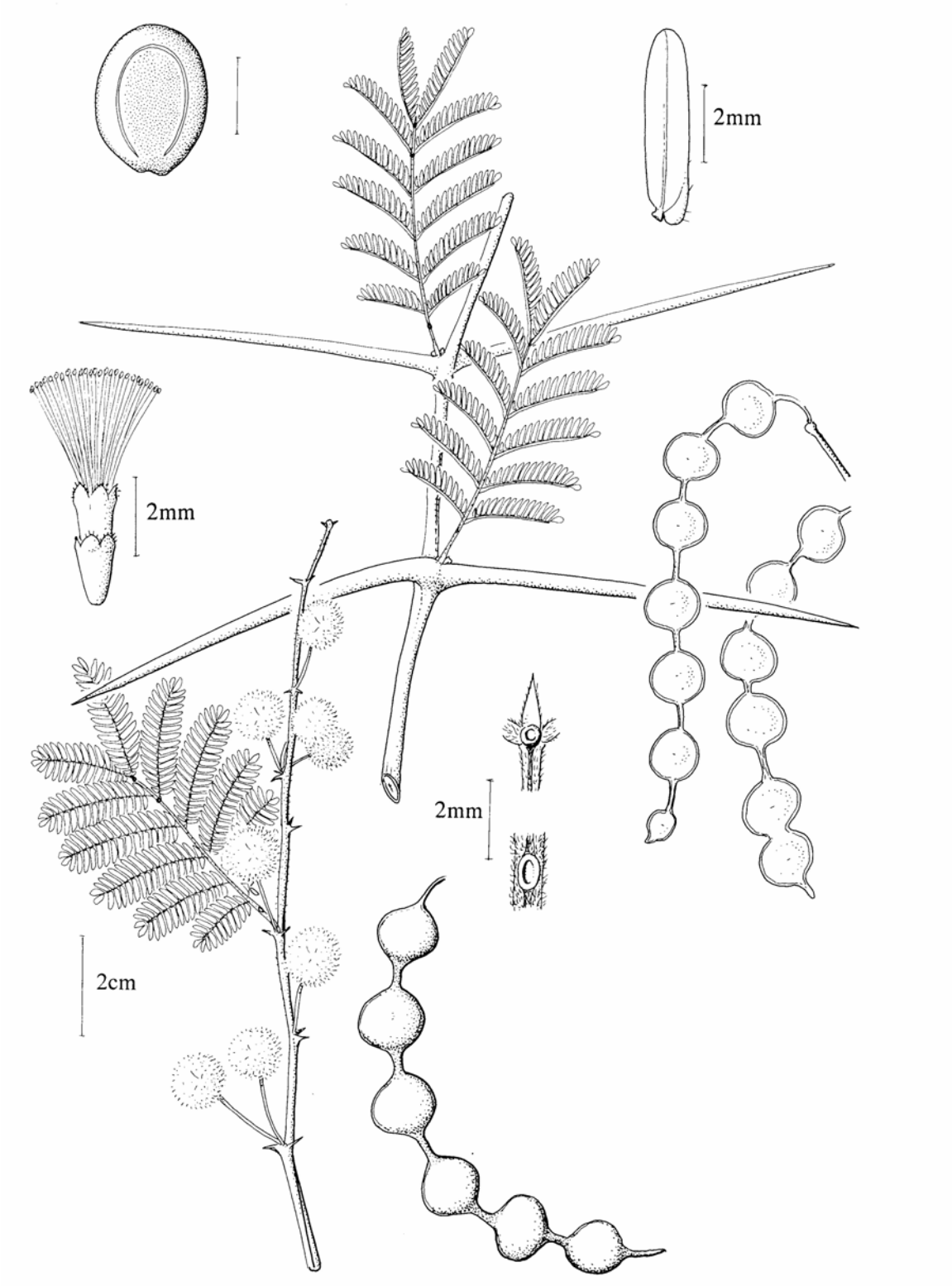


Plate of *Acacia nilotica* (L.) Willd. ex Del. ssp. *nilotica*

***Acacia nilotica* ssp. *subalata* (Vatke) Brenan**
Synonyms: *A. subalata* Vatke; *A. taitensis* Vatke; *A. arabica* var. *vediana* T. Cooke
Description: Pods not necklace-like, their margins straight or crenate and rarely narrowly constricted between the seeds, and if constricted then only occasionally along the pod.

Branches and pods densely pubescent to subtomentose, especially when young. Pods often rather wide (1.3-2.2 cm) with straight to slightly crenate margins.
Occurrence: Angola, Ethiopia, Kenya, Somalia, Sudan, Tanzania, Uganda.
Uses: Similar to the other subspecies, its wood is reddish, hard and durable. It is termite resistant. Recorded uses include turnery, pit props and fence posts. Foliage browsed by cattle, sheep goats and other ruminants and pods eaten by livestock, rhino, baboons, and antelope, especially nyala. (Wickens et al 1995). Pods used for tanning and making ink. Gum is edible, and also used as a glue to attach feathers to arrows. The sap from the inner bark is rubbed on metal to produce rust-preventing, black paint, and with shreds of bark to deter bed bugs. A decoction of root bark is taken for coughs.
Altitude range: 5 – 2300 m.

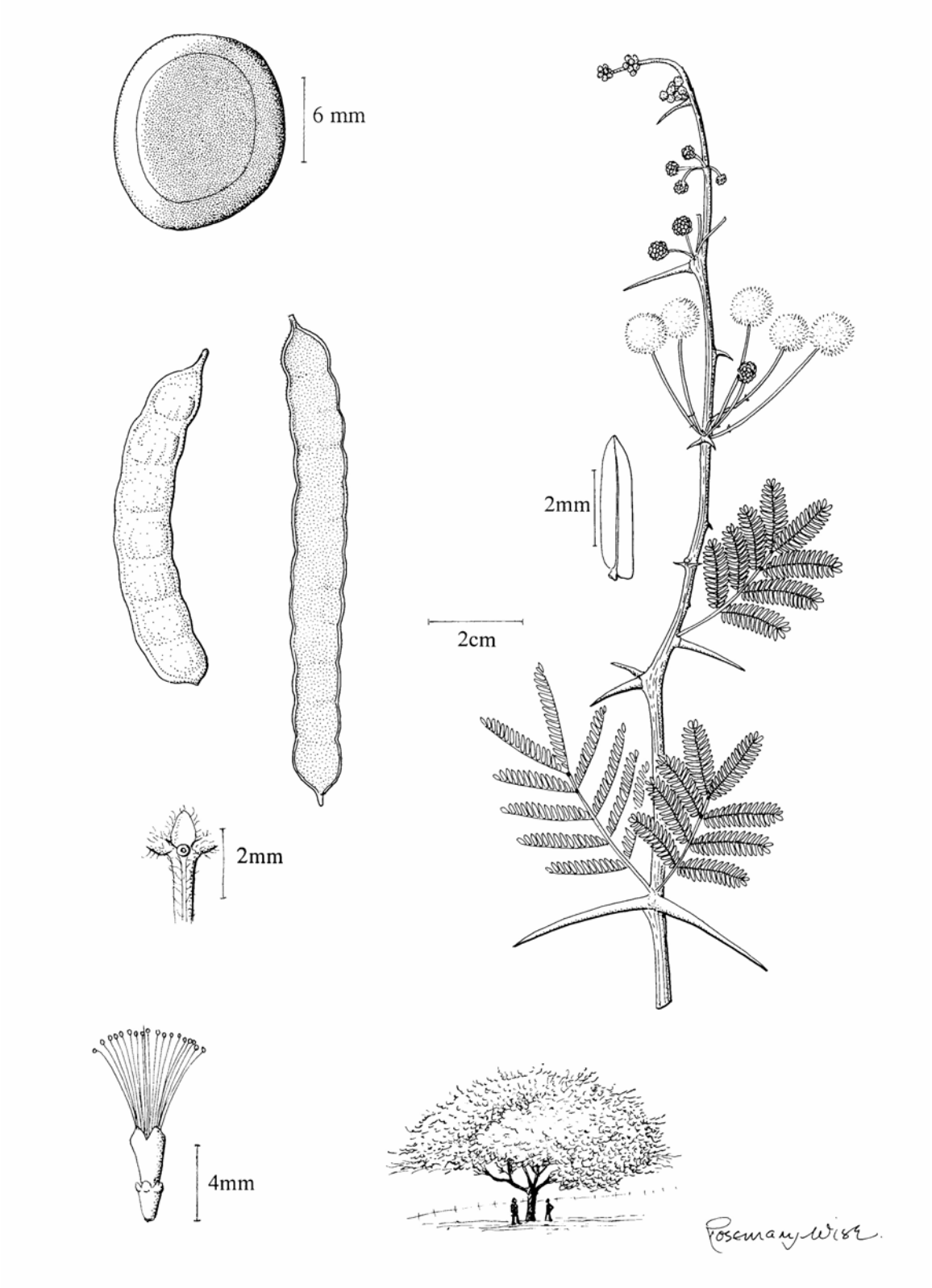


Plate of *Acacia nilotica* ssp. *subalata* (Vatke) Brenan

***Acacia nilotica* ssp. *tomentosa* (Benth.) Brenan**
Synonyms: *Acacia nebneb* Adanson; *A. arabica* var. *tomentosa* Benth.; *A. neboueb* Baill.; *A. scorpioides* var. *pubescens* A. Chev.; *A. nilotica* var. *tomentosa* (Benth.) A.F.Hill.

Description: Pods necklace-like, constricted between the seeds. Pods and young twigs densely grey to white tomentellous.
Occurrence: Burkina Faso, Cape Verde, Egypt, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan.
Uses: An important source of firewood and good quality charcoal in the Sahelian regions. Similar to the other subspecies, its wood is dark red, hard and durable. It is termite and water resistant. Recorded uses include turnery, pit props, sleepers, boat building, wagons and construction timbers to name but a few. Deseeded pods contain up to 50% tannin. The subspecies is occasionally planted as a shade tree in the Sahel. In Burkina Faso, the species has similar uses to those of ssp. *adstringens* (Wickens et al. 1995).
Altitude range: 20 - 760 m.

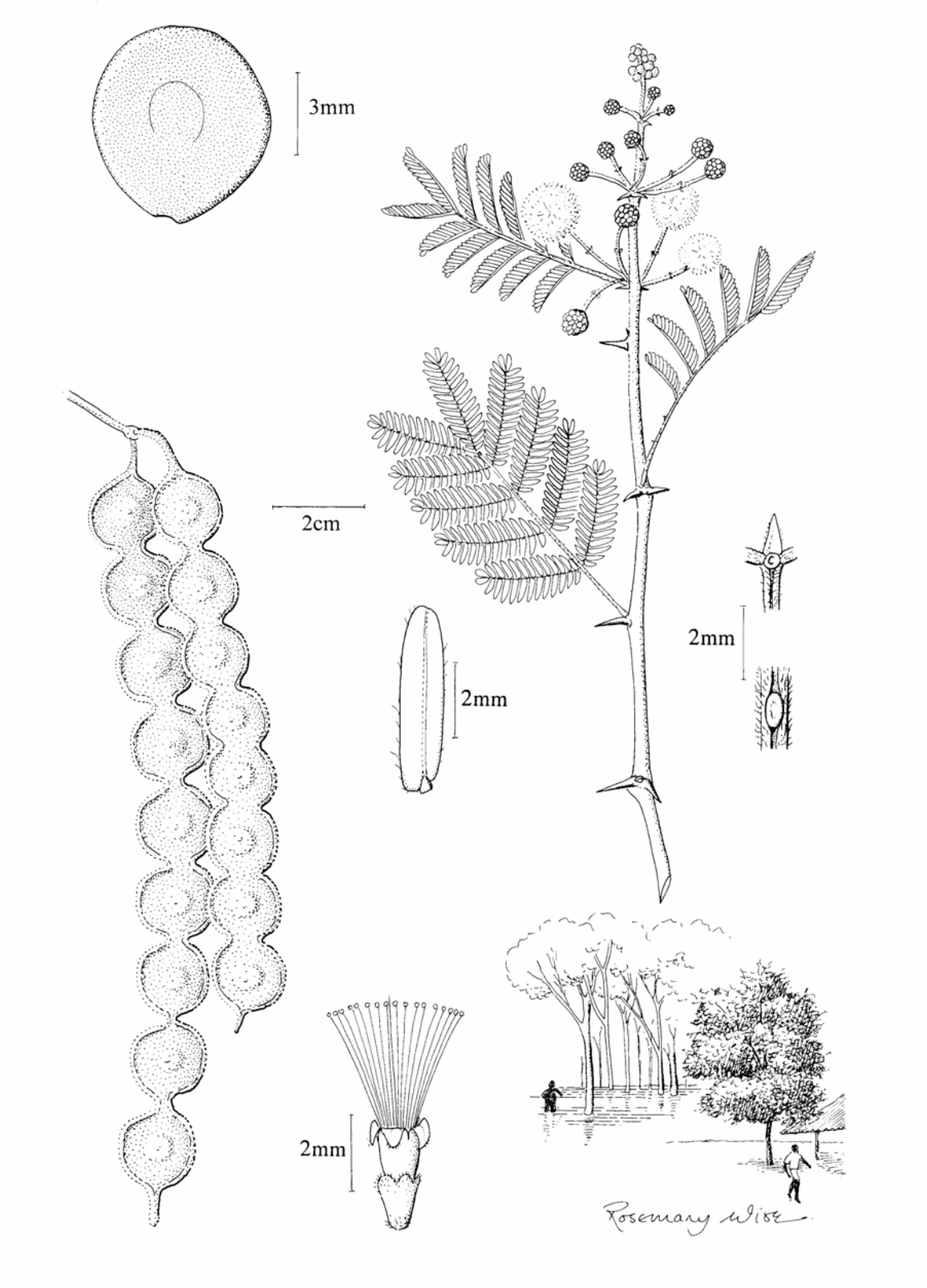
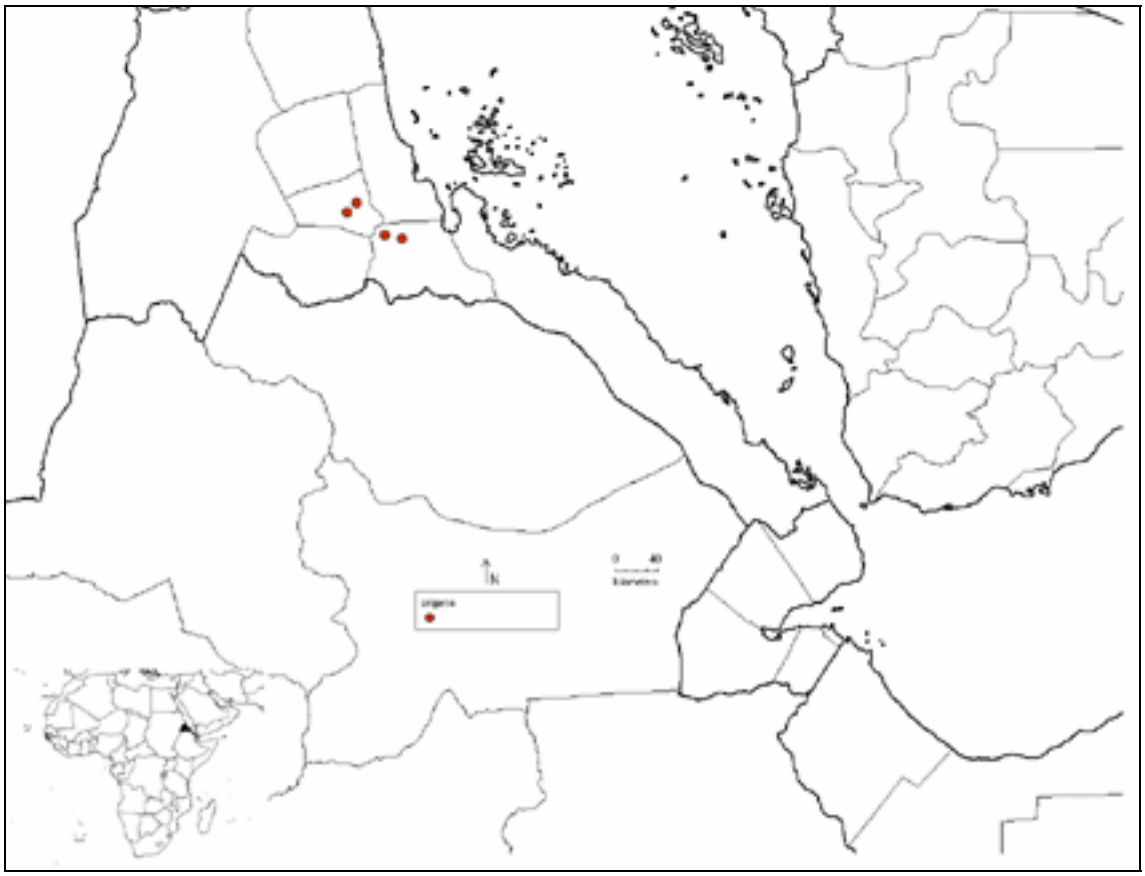


Plate of *Acacia nilotica* ssp. *tomentosa* (Benth.) Brenan

***Acacia origena* Hunde, Nordic J. Bot. 2(4): 337 (1982)**

Description: Tree 5-11 m high. Bark and twigs pale yellowish to greenish-brown, c. lenticellate, ultimately flaking in thin layers, c. puberulous on the younger parts. Thorns straight (stipules spinescent,) paired, (0.5)-3-4-(6) cm long, greyish, ± puberulous especially basally, ± straight, slender, not or scarcely furrowed above. Leaves; petiole and rhachis furrowed above and ± pubescent; petiole 2-8 mm long, with a gland almost at or immediately below the insertion of the lowest pair of pinnae; rhachis 0.6-4.5 cm long with 2-10 pairs of pinnae, normally glandular at the insertion of the top 1-2 pairs, occasionally at insertion of each pair; leaflets 11-30 pairs per pinnae, linear-oblong, 3-7 x 0.75-1.5-(1.8) mm, ciliate along margins, usually dark-green above and paler green beneath, slightly mucronate at apex, c. oblique at base. Flowers creamy-white, in heads 9-12 mm diam. on 1.2-4.8 cm long c. puberulous axillary peduncles; involucel 1.2-3 mm long, pubescent outside, situated from near base to ca. 8 mm up the peduncle. Bracteoles subtending individual flowers ca. 1.7 mm long, with spathulate lamina, ciliate. Calyx ca. 2 mm long, puberulous on the lobes. Corolla ca. 3 mm long, 5-lobed, glabrous outside. Filaments ca. 4.5 mm long. Ovary ± pubescent or glabrous; style terete, ca. 3.5 mm long. Pods straight or almost so, c. puberulous and with numerous small reddish glands with the indumentum denser and more persistent towards the pedicel, or glabrous, linear-oblong, compressed, dehiscent, ca. 6-8.5 (12) x 1.4-2 cm; valves with oblique to longitudinal veins. Seeds commonly number 5-11, ca. 7 x 5 mm, smooth, oval to quadrate, compressed; areole ca. 5 x 2.5 mm.
Ecology: Upland N. Ethiopia (Wello), Eritrea and Yemen, in wooded grassland at 1900-2600 m elevation.
Occurrence: Eritrea, Yemen.
Related species: *Acacia origena* is closely related to *A. abyssinica* and *A. negrii*. It is distinguished from *A. abyssinica* by fewer pinnae pairs (2-10 compared with 15-38) and larger leaflets, and from *A. negrii* in pale yellow to greenish brown bark on twigs, compared with dark purplish brown twigs and hairly and glandular pods compared with hairless pods in *A. negrii*.
Altitude range: 2150 - 2600 m.



Distribution of *Acacia origena* Hunde

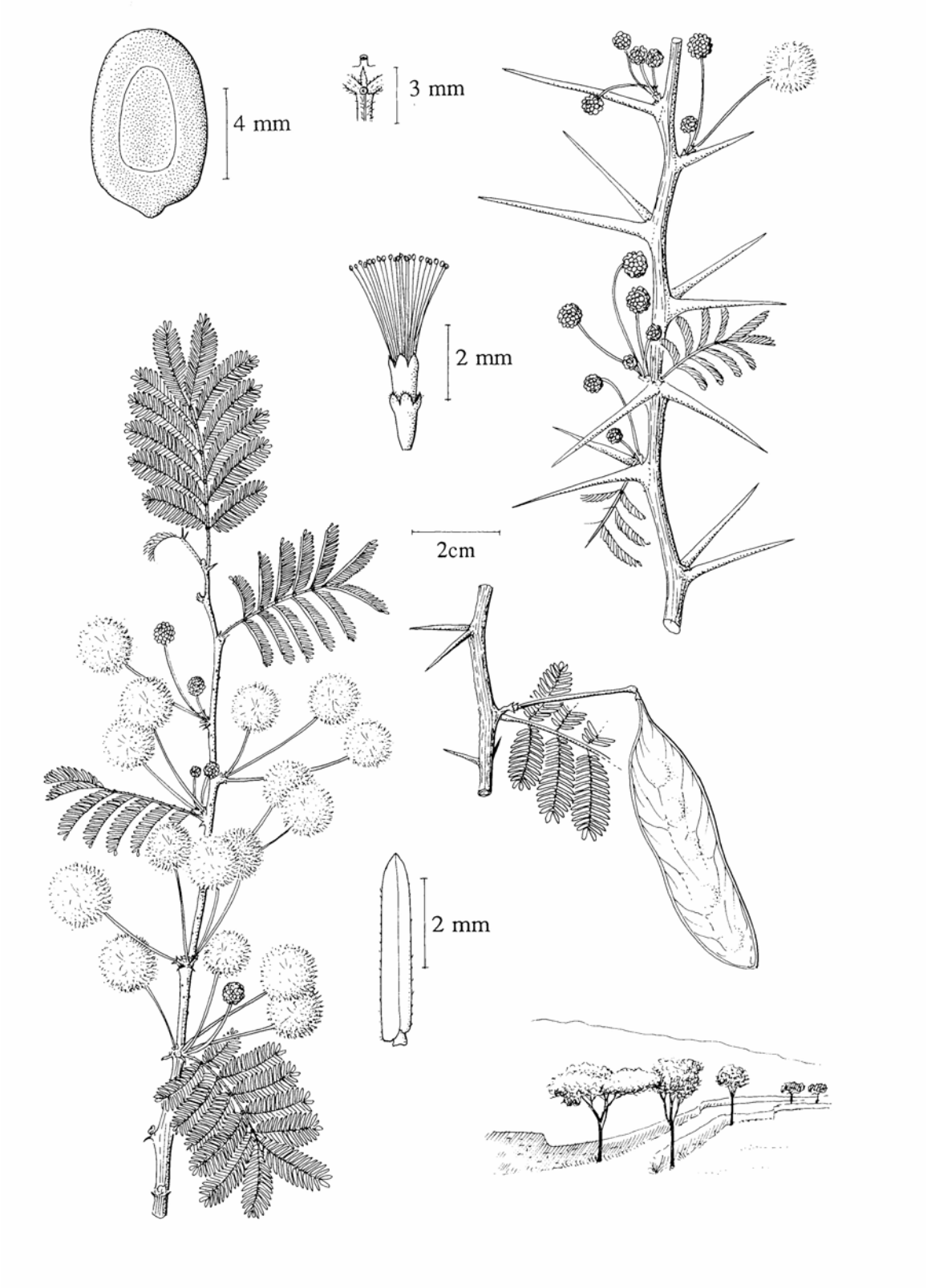


Plate of *Acacia origena* Hunde