An Interactive Computerized Botanical Key for Identification of Tree and Shrub Species of Abu Gieli Forest, Sennar State, Sudan

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ABSTRACT

This study is devoted to the trees and shrubs of Abu Gieli forest that located on East bank of Blue Nile, Sennar State, Sudan, to which ten field trips were carried out for sample collection and photography. Using herbaria manuals and internet facilities, fifty nine tree and shrub species were investigated and identified. For speedy and reliable identification, two keys were developed; the first is for all species described when they are leafy, flowery or fruity; while the other is for trees when deciduous, this is based entirely on characters which can be seen the whole year round i.e. those of buds, leaf- scars, twigs and bark. The process of recognizing plants passes through the families, genera and then the species in a form of a key that constructed and developed in a way liable to computerization. First, all tree species, classified to families, and arranged in an overall structure, then a flowchart has been constructed. The flowchart shows the overall program and the choice the user makes to go through the program. Flowchart is used to create the program using one of the object oriented programming visual basic language. The keys were computerized by using Microsoft Visual Basic version 6 program. The interactive nature of the key enables the user to interact with the program by responding to prompt order depending on the choice he or she takes. The program will guide the user according to his or her choice step by step until the right species is given. The present program makes provision for (26) families, (46) genera and (59) species, in addition to these groups which can be made according to the choice. In addition, Illustrations are given, the photograph folder can be resident in C drive and the program can be put in the desktop.

Key words: Interactive; computerized; key, tree; Abu Gieli Forest; Sudan
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INTRODUCTION

The total number of tree species in the Sudan was estimated at about 533 of which 25 are exotic, while shrub species were estimated at 184 of which 33 are exotic (Mukhtar, 2003). However, the forest wealth has not been well documented; in addition, many trees species are under pressure and endangered as a consequence of drought and over cutting. Moreover many others are expected to be endangered in the near future.

Trees play a pivotal role as a component of natural resources and useful to man, so developing methods to recognize them is needed to know what features to look for and which

ones are reliable. These are identification tags. Many different types of keys have been devised for plant identification, two of which are especially important. The indented key is used mostly in manuals for the identification of spermatophytes, and the bracket or parallel key (two or more contrasting characters are described in consecutive lines of the page so that they are easily compared) (Swingle, 1946). Many such systems have been developed for the classification of flowering plants, computerized key for identification tree and shrubs as cited by Elkhalifa (1986) had been chosen as the best artificial system.

The need for identification trees at various seasons of the year depend upon organs which are then present, thus to know all the features which are typical of a particular kind of tree is necessary. Many botanical works have been carried out and others have published their works based on the ecological classification of vegetation of the Sudan of Harrison and Jackson (1958).

An interactive program is one in which the user may interact with the program by responding to prompt order depending on the choice the user had made. The program will guide you according to your choice step by step until you reach the right species, combined with its photograph. The program, then gives you two choices to exit the program or identify another species.

The change of climate and human intervention has occurred. Several ecological changes necessitate investigation of the ecological effect on the flora of the country. Abu Gieli forest was considered as one of the forests which are used as trails, many exotic and native diversity species have been introduced. The aim of this study was to develop interactive computerized keys to identify tree species of the study area at different seasons.

MATERIALS AND METHODS

Site description:

The study area is confined to Abu Gieli forest which is situated opposite to Sennar town on the eastern bank of the Blue Nile river, at a distance of about 6 km north Sennar Dam, at latitude 13˚ 34´ N, longitude 32˚ 34´ E (Bushara 1974) at elevation of 420m above sea level. The total area of the forest is about 807 fedans (1fedan =0.42 ha) of which 362 Gerif land, 378 low land (Mayaa) and 67 upland (Karab site) (Fig 1). The area is situated in low rainfall savanna wood land. Metrological data obtained from Sennar station shown in figures 2, 3 and 4 describe the climate of the study area.

The vegetation cover of Abu Gieli forest is *Acacia nilotica* in pure stand on the flood basin in the northern part, other species mainly *Eucalyptus* spp. and *Khaya senegalensis* are raised at the southern part of the forest. This part also contains small species trials of *Sclerocarya birrea, Albizzia lebbek, Dalbergia melanoxylon, Moringa oleifera* and *Cordia africana*. These species are found within the *Eucalyptus* plots. A small nursery and a small garden of mango trees are also found, and a few bamboo clumps are found at the river bank, many other species in the Gerif land are present including, for example, *Faidherbia albida, Calotropis procera, Maytenus senegalensis, Boscia senegalensis* and *Cordia rothii*. On the Karab site, outside the basin, *Capparis decidua* and *Acacia seyal* are found.

Methods of data collection:

Ten field trips for data collection were carried to Abu Gieli Forest during different seasons of the year 2007. Specimens from a total number of 59 species belong to 46 genera and 26 families were collected. Botanical data were collected to be used for identification. The morphological characters of the tree examined are shown in table 1.

Species were identified by using keys referring to Andrews (1950, 1952 and 1956), El amin, (1989 and 1990) and Thirakul (1984) in addition to matching all specimens with already identified plants of Abdelnour (2005), Hilary and Malte (1990) and Noda *et al.* (1984). Updating of tree and shrub names was taken into account according to recent literature such

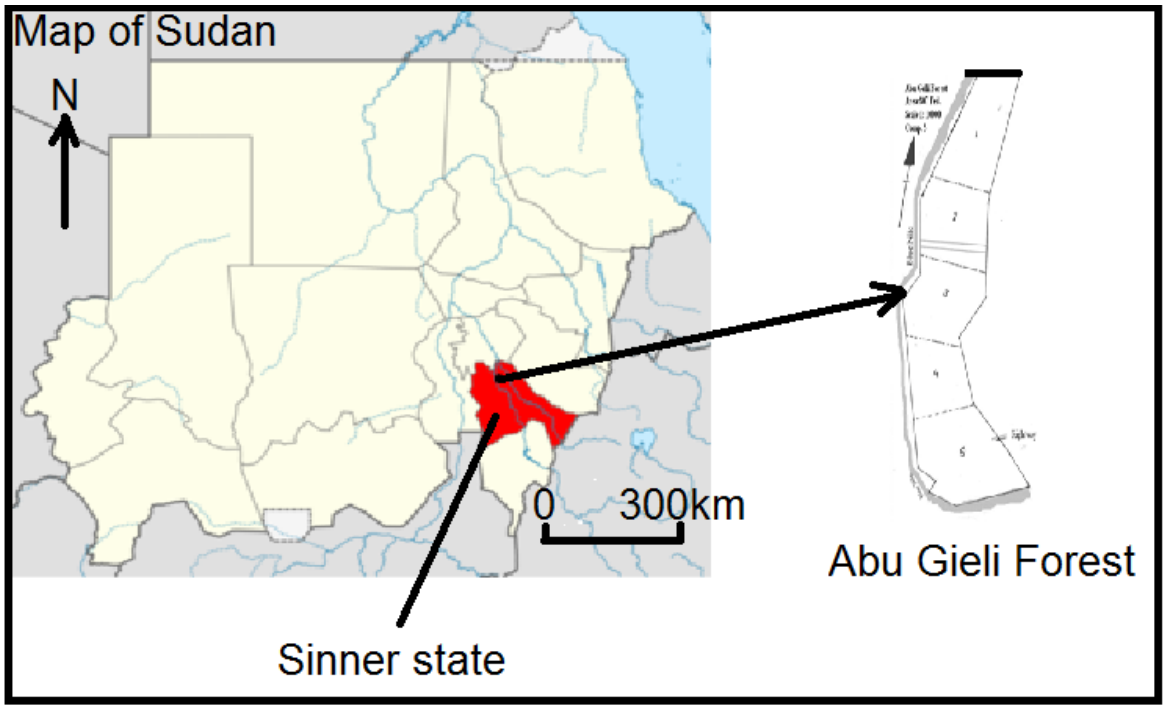


Fig. 1. Location of the Study Area , Source: Sinnar Metrological Station (2007)

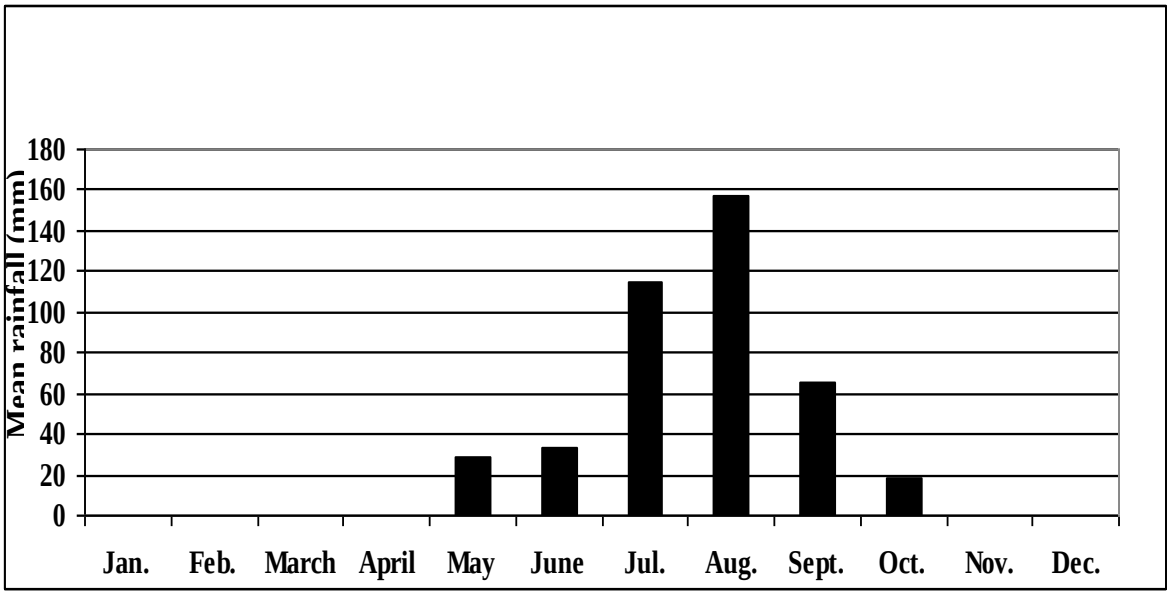


Fig. 2. Mean annual rainfall in Sinnar during 1992-2007

Source: Sinnar Metrological Station (2007)

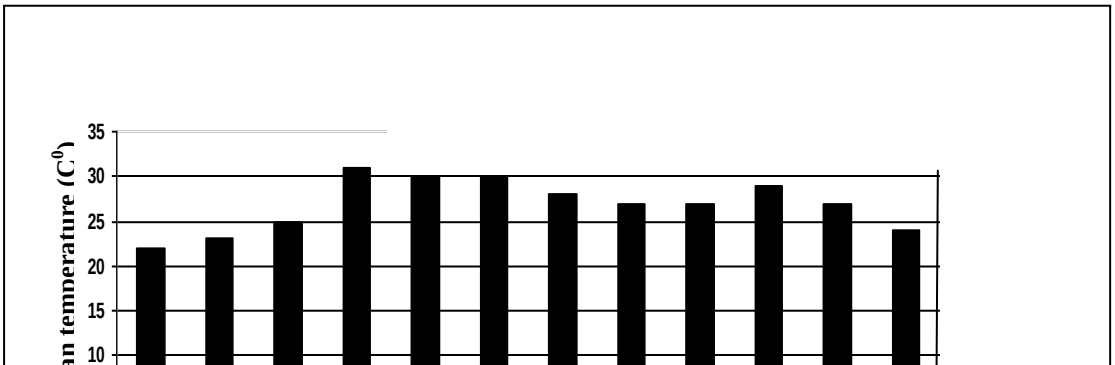


Fig. 3. Mean monthly temperature (1992-2007)
Source: Sinnar Metrological Station 2007

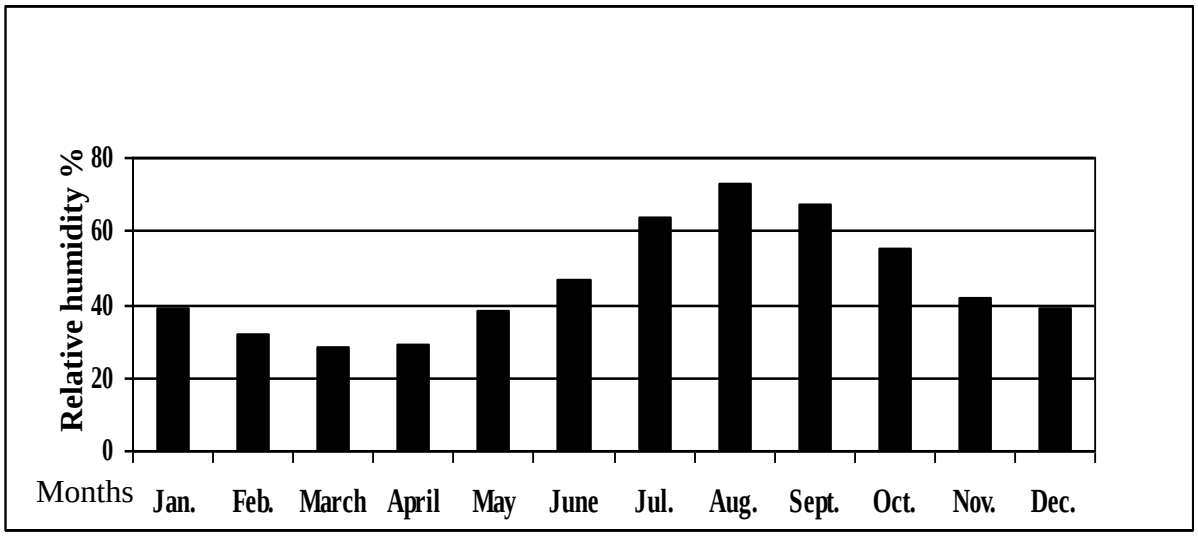


Fig. 4. Mean monthly relative humidity in Sinnar
Source: Sinnar Metrological Station 2007

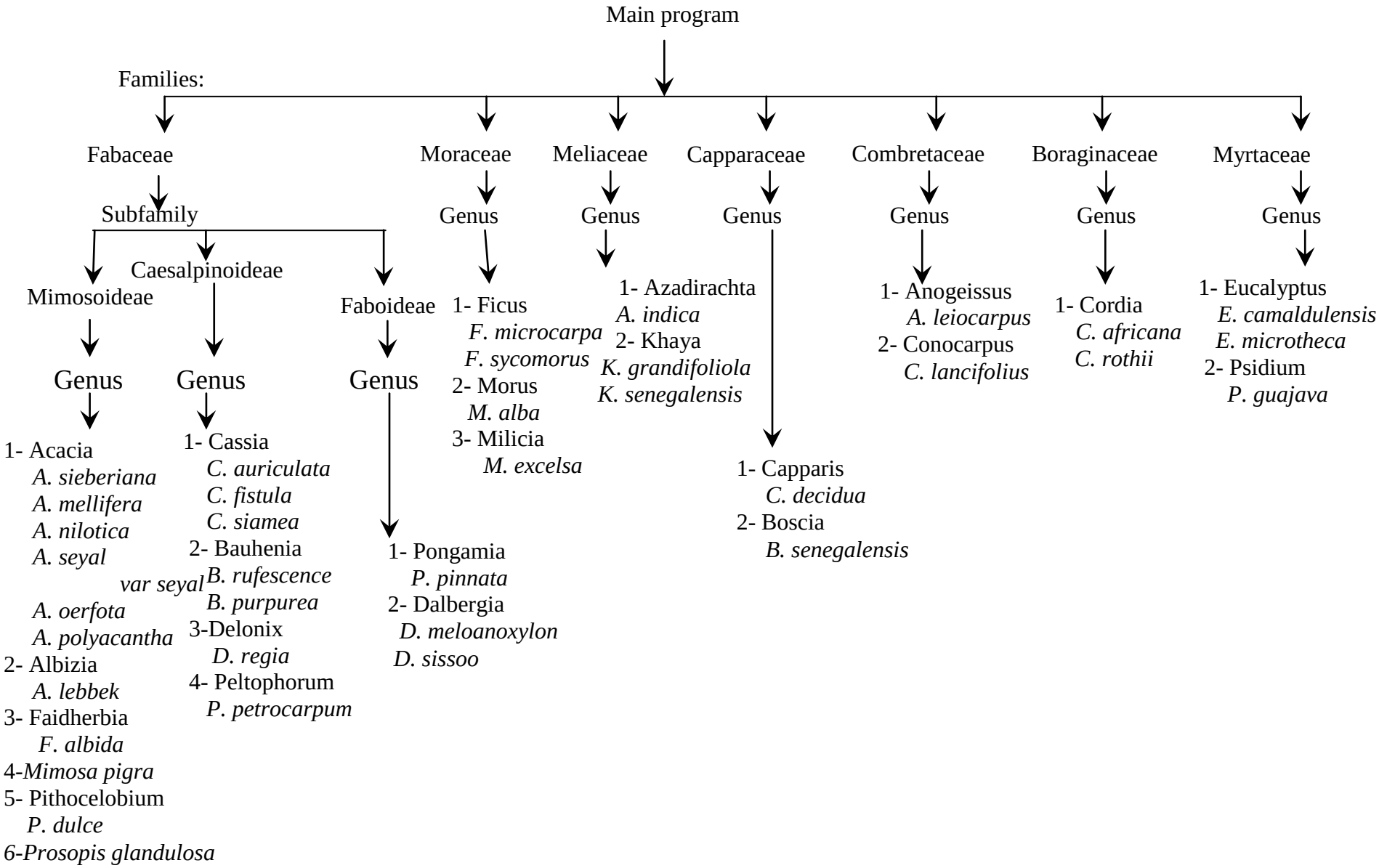
Table 1. Botanical characters examined for identification

Parts of plant	Qualitative data	Quantitative (measurable data)
Leaves	Type	Leaf (length, width)
	Arrangement	Petiole (length)
	Margin	Number of pinnae
	Venation	Pinnae length
	Apex and bases	Number of leaflet
	Texture	Leaflet (length-width)
	Stipules	----------
Stem branches twigs	Shape	Spine(length)
	Color	Buds (length, width)
	Texture	Leaf scars (diameter length)
	- -------	Lenticels
Flower	Aestivation	Inflorescence (length)
	Color	Stamens (number, length)
	-----	Sepals and petals (length, width)
Fruit	Type	Length
	Shapes	Width
	Color	Diameter
	Texture	------
General form	Tree form	Height (m)
	Crown	Diameter (cm)
	Branching	---------

as catalogue of Friis and Velloson (1998 and 2005), internet and Ismail (2007). Families, genera and species were arranged in an alphabetical order. The previous names were included as synonyms. First, all tree species, were classified to families and arranged in an overall structure (Fig. 5). Second, a flowchart, which shows the overall program and choices the user makes to go through, was constructed (Fig.6).

In families, keys are prepared by using prominent characters, in the existing literature a set of characters used by Hutchinson and Dalziel (1963) adopted by Andrews (1952-1956), El amin (1990), Jaques (1976), Mbuya (1994) and Storrs (1979) and combining characteristic features using photographs. Key to the genera within families had been done and those with more than two species representation. The key to the species was produced solely from photographs. Fresh specimens were also examined, the distinguishing characteristic for each species were recorded and put into a brief description statement.

The keys were computerized by using Microsoft Visual Basic version 6 program. The first step in making the program was to create flowchart which shows the overall program and the choices that the user make to go through the program. Flowchart was used to create the program using one of the object oriented programming visual basic language. This key was transformed into a simple dichotomous one, each point consisted of two contrasting characters could be put on one question, obtained from the characters. If the positive identification is absent the answer “NO” lead automatically to a next question of the same format.


Main program
Families:
Fabaceae
Moraceae
Meliaceae
Capparaceae
Combretaceae
Boraginaceae
Myrtaceae
Subfamily
Genus
Genus
Genus
Genus
Genus
Genus
Mimosoideae
Caesalpinoideae
Faboideae
Genus
Genus
Genus
1- Acacia
A. sieberiana
A. mellifera
A. nilotica
A. seyal
var seyal
A. oerfota
A. polyacantha
2- Albizia
A. lebbek
3- Faidherbia
F. albida
4-Mimosa pigra
5- Pithocelobium
P. dulce
6-Prosopis glandulosa
1- Cassia
C. auriculata
C. fistula
C. siamea
2- Bauhenia
B. rufescence
B. purpurea
3-Delonix
D. regia
4- Peltophorum
P. petrocarpum
1- Pongamia
P. pinnata
2- Dalbergia
D. meloanoxylon
D. sissoo
1- Ficus
F. microcarpa
F. sycomorus
2- Morus
M. alba
3- Milicia
M. excelsa
1- Azadirachta
A. indica
2- Khaya
K. grandifoliola
K. senegalensis
1- Capparis
C. decidua
2- Boscia
B. senegalensis
1- Anogeissus
A. leiocarpus
2- Conocarpus
C. lancifolius
1- Cordia
C. africana
C. rothii
1- Eucalyptus
E. camaldulensis
E. microtheca
2- Psidium
P. guajava

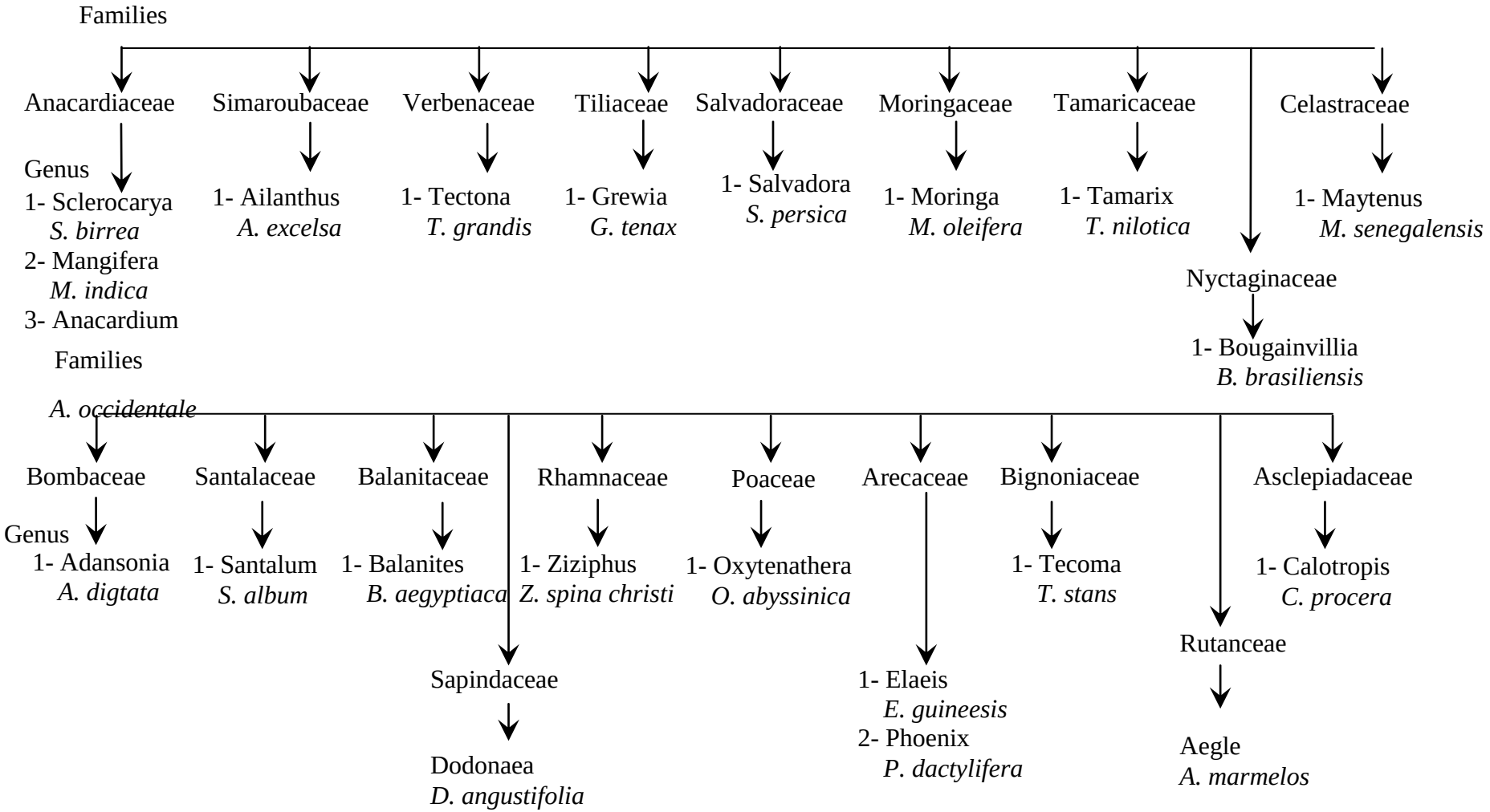


Fig. 3. Overall Structure of the Program.

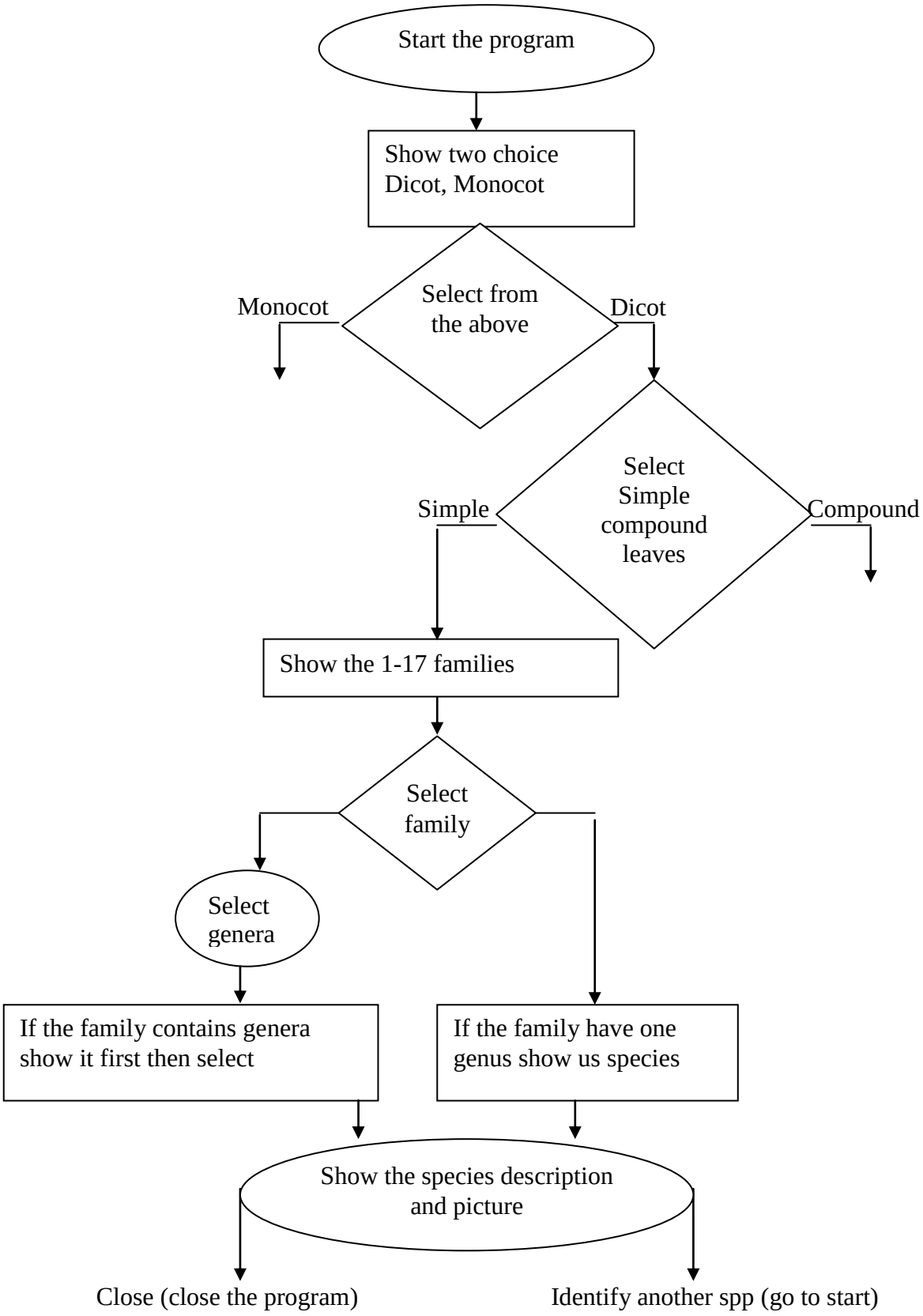

Start the program
Show two choice
Dicot, Monocot
Select from
the above
Monocot
Dicot
Select
Simple
compound
leaves
Simple
Compound
Show the 1-17 families
Select
family
Select
genera
If the family contains genera
show it first then select
If the family have one
genus show us species
Show the species description
and picture
Close (close the program)
Identify another spp (go to start)

Fig 6. General flowchart for the overall program

RESULTS

Two keys were developed. The first main is used for all species described when they are green; while the other, which is based entirely on characters which can be seen the whole year round i.e. those of buds, leaf- scars, twigs and bark, is used for trees when deciduous.

~~Main key:~~

A distinguishing feature of the first key is the inclusion of many combos (groups) in the overall program structure. The present program makes provision for 26 families, 46 genera and 59 species, in addition to these groups which can be made according to the choice.

Key for deciduous trees

There is a great need for identification of trees when deciduous. There are few characters when the leaves are absent such as, size of twigs, buds, thorns, bark characters, leaf-scars and lenticels. The key developed for trees when leafless was a simple dichotomous key based on summer twigs characteristics. It is not structured along botanical lines but it gives the botanical names of the species. This key, however, facilitates the identification of species of trees and shrubs, from a few summer twigs characters.

In the first key the characters were transformed into the following form:

Tree deciduous 2

Tree evergreen – please see the main key

2. Tree deciduous.

Key for trees when deciduous (summer key)

1. Is the tree deciduous?

YES 2 NO Please see the main key

2. Are twigs with thorns?

YES 3 NO 13

3. Is the tree with spines?

YES 4 NO 10

4. Are spines in pairs straight white 7-12cm long and bark smooth yellowish brown.

YES *Acacia sieberiana* NO 5

5. Is the bark reddish, spines 4-10 cm straight, branches oblique?

YES *Acacia seyal* NO 6

6. Is the shrubs multi-stemmed, twigs giving bad smell when crushed?

YES *Acacia oerfata* NO 7

7. Are twigs pale grey or whitish, slightly zigzag, spine straight, and short with brown tips, about 0.9 to 2.3 cm-long?

YES *Faidherbia albida* NO 8

8. Are branches spreading and drooping bark grey smooth, flaking off in thin irregular patches spines whitish grey often bearing leaves and flowers?

YES *Dalbergia melanoxylon* NO 9

9. Are tree small with a corky stem, bark grey whitish, branches ascending with strong spines?

YES *Aegle marmelos* NO 10

10. Is the tree with prickles?

YES 11 NO 13

11. Are shrubs much branched, bark with white horizontal lenticels, prickles in pairs below each node, falcate 2 to 6mm. Long brown to black?

YES *Acacia mellifera* NO 12

12. Is the shrub much-branched with green twigs. Prickles up to 0.5 cm. Long, bark smooth green turning whitish grey when old?

YES *Capparis deciduas* NO 13

13. Is the bole, compressed forming angular section, branches spreading, twig angular at nodes, lenticelate , and bark grey lenticelate?

YES *Delonix regia* NO 14

14. Are branches blackish grey, buds and leaf-scars prominent? Bark dark brown cracked narrowed longitudinally fissured?

YES *Morus alba* NO 15

15. Are branches cylinderical drooping, twigs slightly zigzag, bark grey white, scales typically recurved, dark grey on old tree?

YES *Anogeissus leiocarpus* NO 16

16. Are branches ascending, twigs stout rounded dark brown, Leaf-scars closely prominent, bark grey to dark, slightly fissured flacking off in small elongated scales?

YES *Sclerocarya birrea* NO 17

17. Are branches in whorled arrangement, bark fissured, grey, Leaf-scars prominent(2 – 3) cm across, twigs rounded, very stout ?

YES *Ailanthus excels* NO 18

18. Are branches ascending, short and thick, bole tapered to the top and extremely broad at base, bark very smooth, shining whitish grey coloured?

YES *Adansonia digitata* NO 19

19. Are branches spreading, bark smooth or sometime slightly rough fissured, lenticels numerous spot yellowish grey coloured?

YES *Moringa oleifera*

DISCUSSION

As in most other countries there are many botanical works available for the identification of tree species in the Sudan e.g. Andrews (1950, 1952 and 1956) and El amin (1990) which are of extensive nature. Sahni (1968), however, carries out some regional works. Most of these works depend on comparisons with illustrations, line drawing, photographs or color plates in manuals, or with herbarium specimens. In this study two keys are developed; the main key is based on vegetative characters and reproductive structures or organs. Using photographs and specimens of the present work all species were identified and interactive computerized keys were developed to facilitate the speedy and easy identification of tree species at various seasons of the year. A second separate summer key for 15 deciduous tree species was constructed based on vegetative characters only that include leaf-scars, spines, lenticels, buds, twigs and branches. The construction of dichotomous key is difficult if the number of trees is big.

These keys are constructed depending on extract characters from tree species, which are observable during various seasons of the year, which make them permanent and can be used in different seasons. Photographs, however, were made for comparisons. The keys are built-up to code using Microsoft visual basic version 6, this high level machine independent computer language is standardized at intervals by the American standards National Institute. The keys were briefly put in the format and were subsequently transformed into standard form. Conversion should allow the program to be transferred from the main frame system to the discs of any computer equipped with visual basic compiler.

The key was constructed in a way that makes it liable for expansion to incorporate additional families, genera and species and may include regional or more extensive flora. This expansion facility is needed, due to the large number of tree species in the Sudan.

The largest family in the study area was found to be fabaceae which is divided into three subfamilies, Mimosoideae, Caesalpinoideae and Faboidae. Mimosoideae includes 9 species, *Acacia nilotica, Acacia sieberiana, Acacia mellifera, Acacia seyal, Acacia oerfota, Albizia lebbek, Faidherbia albida, Pithocelobium dulce* and *Mimosa pigra.* The subfamily Caesalpinoidae includes 6 species, *Cassia fistula, Cassia siamia, Bauhenia rufescence, Bauhenia purpurea, Delonix regia and Peltophram petrocarpum.* Faboidae includes 3 species, *Pongamia pinnata, Dalbergia melanoxylon and Dalbergia sissoo*. There is one exotic tree *Aegle marmelos,* which was not recorded in the flora of the Sudan, is recognized by comparison with international flora. Therefore there is great need to survey and up-date the flora of the Sudan, urgently.

The botanical names appearing in the text and index are up-dated as: Families, Capparidaceae to Capparaceae, Leguminosae to Fabaceae, Palmae to Arecaceae and Gramineae to Poaceae. Subfamilies, Papilionaceae to Faboideae, Caesalpinaceae to Caesalpinoideae, Mimosaceae to Mimosoideae. Species, *Acacia albida* Del.to *Faidherbia*

albida (del.) Achew, *Ficus nitida* Thunb to *Ficus microcarpa* L. *Chlorophlora excels (Welw.) Benth. and H. to Milicia excels* (Welw) C.C.Berg, *Acacia nubica* Benth.to *Acacic oerfota (*Forssk.) schweinf., *Cordia rothii* Roem and Schult to *Cordia sinensis* Lam and *Poinciana regia* (Hook.) Raf. to *Delonix regia* (Boj.ex Hook.) Raf**.**

CONCLUSIONS AND RECOMMENDATIONS

The surveys show that in Abu Gieli forest there are 59 tree species belonging to 46 genera and 26 families. Keys are developed for speedy and reliable identification of both deciduous and green tree species. They are computerized into interactive programs using Microsoft visual basic version 6. They might work as template for identification of species of different regions in the country. The study updated the over storey of the area and one species is described for the first time using international flora and some of the scientific names for both species and families are updated.

The study recommends conservation of the present stand area as it is very rich in plant diversity including indigenous and exotic valuable tree species. Developed keys are elastic and can accept the inclusion of many tree species introduced to the area, hence recommended to be used for plant identification.

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