

**BIOSYSTEMATIC STUDIES IN THE GENUS *EUPHORBIA* L. IN
NIGERIA**

BY

FABOYEDE, ADEKEMI OMOLAYO

B.Sc. (Hons.), M.Sc. (Botany), University Of Ilorin



UNIVERSITY
OF LAGOS

OCTOBER, 2015

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OF LAGOS**

**A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL
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PHILOSOPHY (BOTANY) UNIVERSITY OF LAGOS**

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SCHOOL OF POSTGRADUATE STUDIES
UNIVERSITY OF LAGOS

CERTIFICATION

This is to certify that the Thesis:

BIOSYSTEMATIC STUDIES IN GENUS *EUPHORBIA* L. IN NIGERIA

Submitted to the
School of Postgraduate Studies
University of Lagos

For the award of the degree of
DOCTOR OF PHILOSOPHY (Ph.D.)
is a record of original research carried out
By:

FABOYEDE, ADEKEMI OMOLAYO
In the Department of Botany

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DEDICATION

This study is dedicated to the Almighty God who made the completion of this research a reality and to the evergreen memory of my late son who never lived to see this day!



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ABSTRACT

Euphorbia L. is a genus of the family Euphorbiaceae. Some of the species are culturally, economically and medicinally valuable. The taxonomy of the genus was re-evaluated using classical and experimental approaches to unravel the complex inter-relationships and problems of identification existing within the genus. Herbarium studies, natural population sampling, ecological observation, experimental cultivation, morphological and anatomical characterization were some of the study approaches. A total of thirty species, four of which are new to literature in Nigeria were circumscribed. Although there were various growth habits observed, species were found as herbs, trees and shrubs. Some species possess distinct leaves while others had ephemeral leaves. Cyathium was found to be a unique feature of the genus. It was also observed that the leaves, inflorescences, fruits and stems of most herbaceous species were covered by dense, woolly, soft-matted tomentose hairs which occur singly as multicellular hairs. The inflorescences occurred either singly, in a group of three or four or as a bunch of flowers (sessile or stalked). Each flower has one or more glands attached to it. The over-all appearances of the stem provided useful taxonomic data. All taxa studied have simple, monad, tri-colporate pollen grains with radial symmetry. The anti-clinal wall patterns of the leaf epidermis were wavy, undulate or straight. Stomata was either epistomatic or hypo-stomatic. Scanning Electron Microscopy revealed surface ornamentations on the abaxial surface of *Euphorbia hirta*. Epicuticular wax was present and granular in all taxa except the abaxial surface of *Euphorbia glomerifera*. The cuticle was either smooth, ridge or striated. Also, trichomes were either present or absent; where present, they were of acicular or fili-form types which were non-glandular (either uni-serrated or multi-serrated). All the species studied have uniform venation patterns that were pinnate with a single primary vein serving as the origin for the higher order venation and craspedodromous with secondary veins terminating at the margin. These were either semi-craspedodromous or mixed-craspedodromous. The cross section of the stems revealed that they were circular in outline. Variable chromosome numbers were recorded. Therefore, based on the results obtained, the Nigerian *Euphorbia* were separated into eight groups i. e: (a) Woody shrubs with spines (b) Succulent shrubs without spines and with deciduous leaves (c) Succulent or cacti form shrub or tree with spines and deciduous leaves (d) poorly understood un-branched geophyte (with tuberous root) (e) Dwarf perennial herbs (f) Erect annual herbs (g) Semi erect herbs or shrubs with stems and leaves that have indumenta and (h) Woody shrubs without spines. Systematics descriptions of all the taxa have been provided while dichotomous key for identifying all species has also been produced. This work has helped to solve some of the problems of misidentifications and synonymy in the genus *Euphorbia*.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Africa's biodiversity is one of the richest in the world but also one of the most threatened by human activities such as population growth, over-exploitation, logging and climatic changes (desertification and global warming). Although, Africa is rich in biodiversity, the taxonomy, distribution, ecology and conservation of majority of plants are poorly known. Geo-referenced information collected on species and their environments are used for analyzing their distribution and threat to diversity (Jalonen, *et al.*, 2012). In order to preserve plants under conservation threat, their correct and proper taxonomy is of paramount importance. *Euphorbia* L. is one of the economic plant groups listed by CITES as threatened.

Euphorbia is one of the largest recognized genera of flowering plants with about 2,000 species. It has a worldwide distribution (Fig. 1) but especially diverse in arid or semi-arid regions of the tropics and subtropics. A number of species occurring in Africa (Fig. 2) have long and succulent cylindrical stems with thorns that are similar in appearance to the Cactus. However, a distinguishing character is the presence of poisonous and caustic white latex that exudes from above ground plant parts when the stems or leaves are broken or damaged. The morphological diversity in this genus includes geophytes, herbs, shrubs, under storey and canopy trees, and an array of succulent and xerophytic forms.

Despite the vast vegetative variation, the entire genus is united by a distinctive morphological synapomorphy, the cyathium – a pseudanthial inflorescence that looks superficially like a typical dicot flower (Horn *et al.*, 2012). This structure is intermediate between a flower and an

inflorescence in developmental terms (Prenner and Rudall, 2007) and is comprised of a cup-like involucre that surrounds multiple male flowers (reduced to single stamens) and a single female flower (reduced to a single pistil). From this basic structure, various elaborations have evolved, including colorful subtending bracts, cyathial nectary glands with petaloid appendages, and fusion or addition of cyathial glands. Some of these cyathial traits represent synapomorphies for particular clades within the genus. Despite the information provided by the cyathium and its variations, relationships among species within *Euphorbia* based on morphological characters have been shown to be equivocal in many cases (Steinmann and Porter, 2002).

Previous phylogenetic work based on DNA sequence data suggests that the evolution of characters in *Euphorbia* including growth form, photosynthetic systems and cyathial form are highly homoplasious and that the genus has a complex bio-geographic history leading to its nearly worldwide distribution (Steinmann and Porter, 2002; Haeevermans *et al.*, 2004; Bruyns *et al.*, 2006; Park and Jansen, 2007; Bruyns *et al.*, 2011; Horn *et al.*, 2012; Yang *et al.*, 2012). These evolutionary and biogeographic patterns make *Euphorbia* an ideal system for the study of complex character evolution and adaptation of plants to different environments.

Over the past decade, molecular phylogenetic studies have made much progress in understanding the broad scale relationships within *Euphorbia* (Steinmann and Porter, 2002; Bruyns *et al.*, 2006; Park and Jansen, 2007; Bruyns *et al.*, 2011; Horn *et al.*, 2012; Yang *et al.*, 2012). Steinmann and Porter (2002) circumscribed *Euphorbia* as the clade that include all species with cyathia and further established the presence of four major clades within the genus. Bruyns *et al.* (2006) formally recognized these four clades as subgenera: *Euphorbia* subg. *Esula* Pers., *Euphorbia* subg. *Athymalus* Neck. (Former *Rhizanthium* (Boiss.) Wheeler, *Euphorbia* subg. *Chamaesyce*

Raf. and *Euphorbia* subg. *Euphorbia*. Horn *et al.* (2012) used markers from all the three plant genomes and with broad sampling across the genus to produce well-supported evidence that *Euphorbia* subgenus *Esula* Pers. is sister to the other three subgenera, with *Euphorbia* subgenus *Athymalus* Neck. ex Rchb. sister in turn to *Euphorbia* subgenus *Euphorbia* and *Euphorbia* subgenus *Chamaesyce* Raf.

Seven hundred and twenty three species of *Euphorbia* are found in Africa (Carter and Eggli, 2003). Thirty four of these were described for West Africa by Hutchinson and Dalziel (1958). Twenty four widely distributed species were deposited in major herbaria in Nigeria. Some of the species are of medicinal, cultural and economic importance, for example as purgatives (Adedapo *et al.*, 2005), diuretic agents (Ogbulie *et al.*, 2007), for bio-fuel production (Maugh, 1979; Calvin, 1980; Mwine *et al.*, 2013), horticulture and sources of natural rubber (Spano *et al.*, 2012) and manufacturing of gun powder and in fireworks (Stephen, 2013). Also, because they accumulate steroids and triterpenoids, they are industrially important chemical sources of insecticides (de Silva *et al.*, 2008), steroids (Baniadam *et al.*, 2013), pesticides (Hirota *et al.*, 1980; Mwine, 2011), antibiotics, expectorants and sedatives (Ogbulie *et al.*, 2007), cyto-toxins (Zhang *et al.*, 2013), remedies for cancers, tumours (Itokawa *et al.*, 1989) and warts (Vasas and Hohmann, 2014).

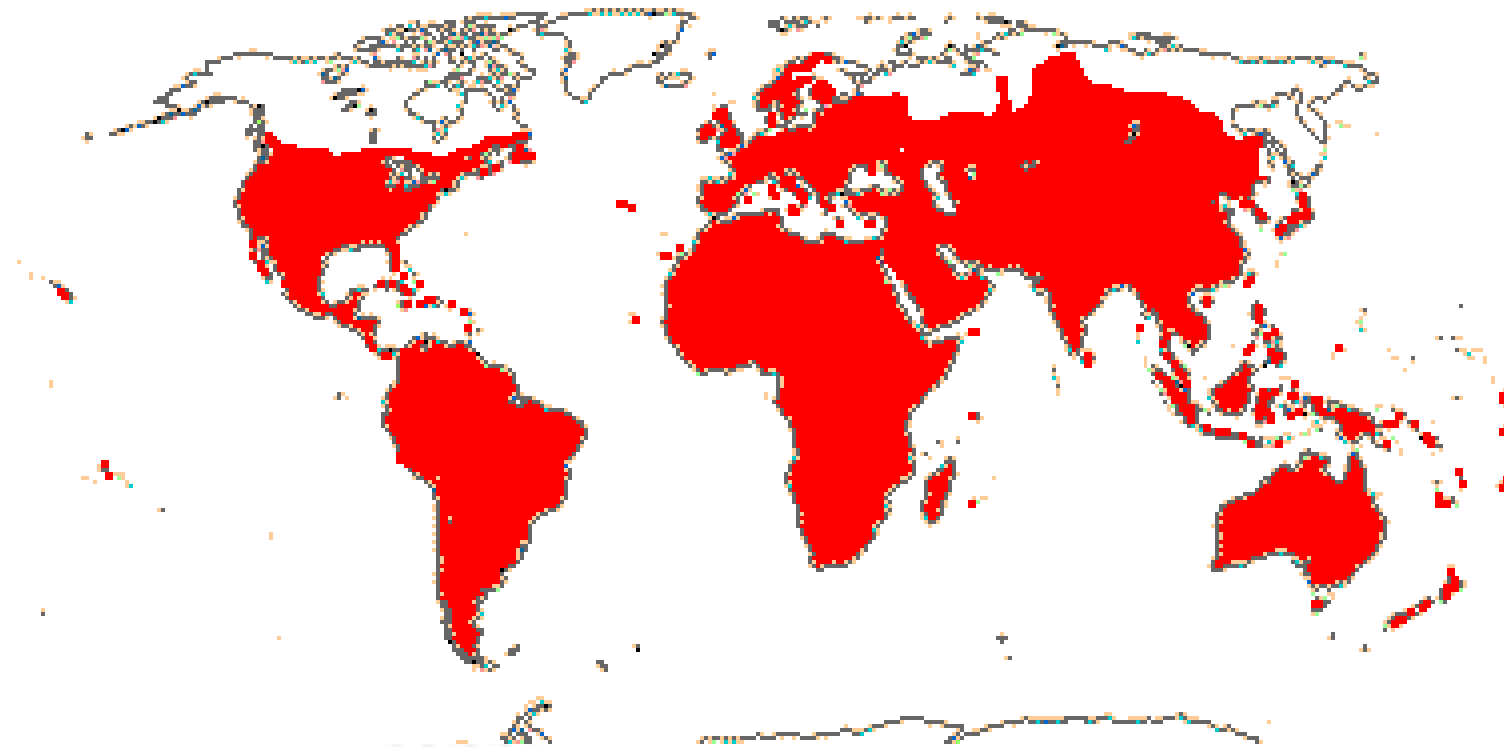


Fig. 1: World wide distribution of *Euphorbia* species

Source: APG 11 (2003)

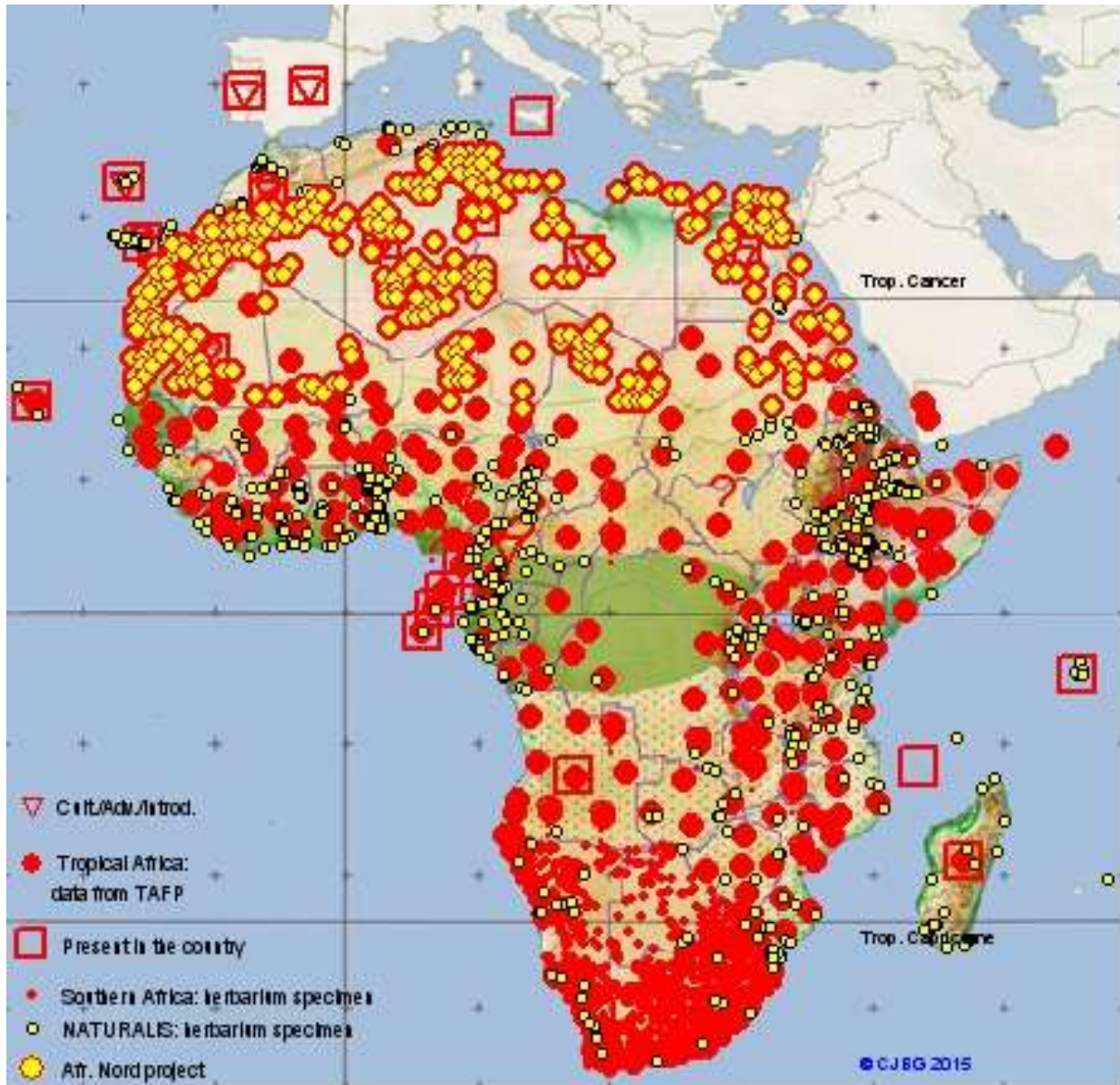


Fig. 2: Geographical distribution of *Euphorbia* in Africa

Source: CJBG (2015)

1.2 Statement of problem

Globally, biodiversity is being lost at an alarming rate. Therefore, there is a need to study every living organisms in order to gain an insight into their distribution and conservation status. Over 850 succulent *Euphorbia* species were listed in Appendix 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Apart from the floristic account of Hutchinson and Dalziel (1958), there is a dearth of information on the taxonomy of *Euphorbia* in Nigeria. Most of the preserved herbarium specimens are wrongly identified and bear insufficient information that could aid their identification. This lack of basic botanical and taxonomic information about many of the species has hampered their optimal utilization in horticulture and traditional medicine.

Euphorbia is generally considered to be taxonomically difficult as a result of the considerable degree of uncertainty that has always existed about the relationships of the species or species-groups within the genus. The sections within *Euphorbia* are described as *nomina nuda* (without precise definitions). The controversy that existed ever since Linnaeus' time on the issue of whether *Euphorbia* should be recognized in its broader sense (as a genus) or be separated into smaller genera (as a group of genera) has not been resolved fully (Steinmann and Porter, 2002). This lack of stable and reliable taxonomic scheme has hindered and to some extent discouraged research work within the genus.

Also, with the relatively sparse taxa sampling in all previous phylogenetic studies, many species in *Euphorbia* have not been placed in their corresponding subgenera, and relationships within the subgenera are still not completely resolved. Therefore, from an evolutionary and taxonomic

standpoint, there is a need to investigate fundamental evolutionary questions about the morphological novelty and diversification of *Euphorbia*.

1.3 Aim and Objectives

The aim of this research was to carry out systematic studies in the genus *Euphorbia* in Nigeria in order to generate a comprehensive taxonomic database that would facilitate easier recognition and identification of all taxa within the genus.

The specific objectives were to:

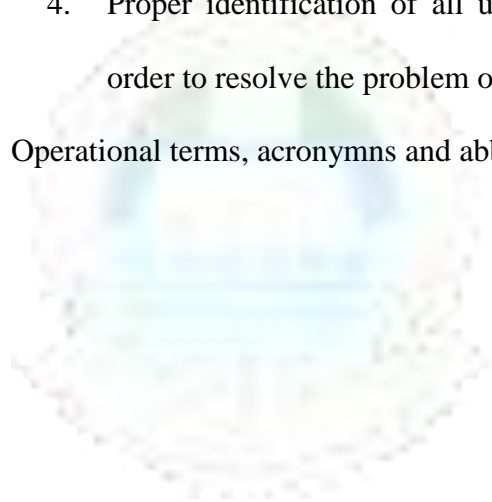
1. Evaluate the patterns of variation displayed by constituent species over their geographical range in order to clarify and define the limits of each taxon and elucidate both intra-specific and interspecific relationships.
2. Investigate limitedly studied sources of characters, such as cytology and leaf microscopic features in order to provide new sources of taxonomic data for the classification and identification of species.
3. Assess and evaluate evolutionary and genomic affinities among species, subspecies and varieties documented in the genus in order to resolve some of the nomenclatural and classification problems.
4. Aggregate critical botanical and taxonomic information to generate dichotomous identification keys which will facilitate species recognition for economic exploitation and effective conservation activities.

1.4 Significance of study

This research is significant in several ways including the following:

1. Determination of the geographical distribution range of common species in order to ascertain the conservation status of the various species in Nigeria.
2. Provision of the actual number of species available in Nigeria thereby resolving some of the threatened conservation status.
3. Provision of a guide to future taxonomic work on *Euphorbia* that will facilitate good phylogenetic understanding of component species.
4. Proper identification of all unidentified herbarium and common species in Nigeria in order to resolve the problem of misidentification and underutilization.

Operational terms, acronymns and abbreviations used in this thesis are defined in Appendix 1.



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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The genus *Euphorbia*

Euphorbia L. belongs to family *Euphorbiaceae* Juss. It was only a few years after Linnaeus (1753) circumscribed the genus *Euphorbia* to include the then tribe *Euphorbieae* (now *Euphorbiinae*) that other botanists began to divide the genus into several smaller genera. 'Euphorbia' can be used in a broad sense (*Euphorbia sensu lato*) or in its strict sense (*Euphorbia sensu stricto*). No one has been able to come to grips with all the available materials of both old World and new World species since Boissier (1862) (who was familiar with only a few species from Africa as at then).

The genus *Euphorbia* has been divided into several genera, subgenera and sections by authors such as: Pax (1924), Croizat (1937), Wheeler (1943), Webster (1994), Carter (1994), Park (1996), Govaerts *et al.* (2000), Steinmann and Porter (2002), Haevermans (2003), Haevermans *et al.* (2004), Park and Jansen (2007), Zimmermann *et al.* (2010), Dorsey (2013), Dorsey *et al.* (2013) and Pierson *et al.* (2013) amongst others. Within *Euphorbia*, the most common primary division employed is the rank of subgenus. Due to widespread convergence in growth forms and cyathial characters, subgeneric classification within *Euphorbia* has been notoriously contentious.

Most systems used to date for *Euphorbia* classification have been artificial in the subdivisions. However, recent authors are employing molecular data for the classification of the genus. Based on molecular phylogenetic studies, it has recently been established that the genus *Euphorbia* (*sensu lato*) is composed of four subgenera (Steinmann and Porter, 2002; Bruyns *et al.*, 2006; Park and Jansen, 2007; Zimmermann *et al.*, 2010; Bruyns *et al.*, 2011; Horn *et al.*, 2012; Yang *et*

al., 2012; Dorsey, 2013; Dorsey *et al.*, 2013; Riina *et al.*, 2013; Peirson *et al.*, 2013). They are formally recognized as *Euphorbia* subg. *Esula* Pers., *Euphorbia* subg. *Athymalus* Neck. ex Rchb. (The former *Euphorbia* subg. *Rhizanthium* (Boiss.) Wheeler), *Euphorbia* subg. *Chamaesyce* Raf. and *Euphorbia* subg. *Euphorbia* L. Of these four subgenera, subgenus *Euphorbia* (*sensu stricto*) is the largest and most morphologically diverse (Dorsey, 2013).

Modern *Euphorbia* taxonomists rely on their DNA sequences although this approach is regarded as controversial (Schnabel, 2013). The many levels of hypothesis testing in taxonomy from characters to species to clades are essential for all evolutionary biology. According to Lipscomb *et al.* (2003), relegating taxonomy that is rich in theory and knowledge, to a high-tech service industry would be a decided step backward for science. Using only molecular data to resolve taxonomic problems will be neglecting any taxa below the basic taxonomic rank of species and relegating them to synonyms under the respective species.

Even though molecular data is the order of the day now, previous authors such as: Oladele (1983); Oladele *et al.* (1985); Oladele (1986); Ayodele and Olowokudejo (1997); Ogunkunle and Oladele (2000); Ayodele (2005); Ayodele and Olowokudejo, (2006) have used both morphological and anatomical features to resolve taxonomic problems. According to Oladele (1983), identification, naming and classification are the chief components of plant taxonomy. Morphological characters are features of external form or appearance of plants that provide the characters used for practical plant identification and some of those used for hypothesizing phylogenetic relationships. They are easily observable and find practical use in keys and descriptions. These features were the only sources of taxonomic evidence in the beginning of Plant Systematics. Basic plant parts useful for morphological studies are either reproductive or

vegetative. The vegetative parts are roots, stems and leaves, while the reproductive parts are inflorescences, flowers, fruits, and seeds. Others include the duration of growth and the habit of the plant.

Therefore, combining molecular data with morphological data will provide enough taxonomic evidence to substantiate and corroborate taxonomic decisions (Schnabel, 2013). In order to bring orderliness to the disorganized *Euphorbia* taxonomy, both the classical and modern approaches were employed in this research.

2.2 Previous Classifications of genus *Euphorbia*

In the genus *Euphorbia* L. *sensu stricto*, the first classification by Boissier (1862) included four cyathium bearing genera. They are: *Anthostema* Juss., *Pedillanthus* L., *Synadenium* Boiss., *Monadenium* Pax and *Euphorbia* L. These are further classified into subgeneric, sectional and subsectional levels by various authors.

Tables 1-2 show the taxonomic treatment of the genus *Euphorbia* from 1943 till date.

Table 1: Classification of genus *Euphorbia* at subgeneric level

| S/N | Authors | Taxa |
|-----|--|--|
| 1. | Wheeler (1943) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Chamaesyce</i> Raf. ii. <i>Euphorbia</i> subg. <i>Agaloma</i> House iii. <i>Euphorbia</i> subg. <i>Poinsettia</i> Grahm. iv. <i>Euphorbia</i> subg. <i>Eremophyton</i> Boiss. v. <i>Euphorbia</i> subg. <i>Lyciopsis</i> Boiss. vi. <i>Euphorbia</i> subg. <i>Tithymalus</i> Pers. vii. <i>Euphorbia</i> subg. <i>Rhizanthium</i> Boiss. viii. <i>Euphorbia</i> subg. <i>Esula</i> Pers. ix. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. |
| 2. | Carter (1987) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Chamaesyce</i> Raf. ii. <i>Euphorbia</i> subg. <i>Esula</i> Pers. iii. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. iv. <i>Euphorbia</i> subg. <i>Lacanthis</i> |
| 3. | Gilbert (1987) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. ii. <i>Euphorbia</i> subg. <i>Chamaesyce</i> Raf. iii. <i>Euphorbia</i> subg. <i>Poinsettia</i> Grahm. iv. <i>Euphorbia</i> subg. <i>Tithymalus</i> Pers. |
| 4. | Steinmann and Porter (2002) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. ii. <i>Euphorbia</i> subg. <i>Lacanthis</i> iii. <i>Euphorbia</i> subg. <i>Elaeophorbia</i> |
| 5. | Bruyns <i>et al.</i> (2006) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Esula</i> Pers. ii. <i>Euphorbia</i> subg. <i>Chamaesyce</i> Raf. iii. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. iv. <i>Euphorbia</i> subg. <i>Rhizanthium</i> Boiss. |
| 6. | Park and Jansen (2007) | <ul style="list-style-type: none"> i. <i>Euphorbia</i> subg. <i>Euphorbia</i> L. ii. <i>Euphorbia</i> subg. <i>Lacanthis</i> iii. <i>Euphorbia</i> subg. <i>monadenium</i>+<i>synadenium</i> |
| 7. | Zimmermann <i>et al.</i> (2010) and Riina and Berry (2012) | <ul style="list-style-type: none"> i. Clade A <i>Euphorbia</i> subg. <i>Rhizanthium</i> ii. Clade B <i>Euphorbia</i> subg. <i>Esula</i> Pers. iii. Clade C <i>Euphorbia</i> subg. <i>Euphorbia</i> L. iv. Clade D <i>Euphorbia</i> subg. <i>Chamaesyce</i> Raf. |

Table 2: Classification of *Euphorbia* at Sectional and Subsectional levels

| S/N | Authors | Taxa |
|-----|------------------------|---|
| 1 | El Hadidi (1973) | <p>ser. 1 Appendiculatae Boiss. sect. 1 <i>Anisophyllum</i> Roep. subsect. <i>Hypericifoliae</i></p> <p>ser. 2 Exappendiculatae Boiss. sect. 2 <i>Poinsettia</i> (Graham) Boiss. sect. 3 <i>Tirucalli</i> Boiss. sect. 4 <i>Lyciopsis</i> Boiss. sect. 5 <i>Pseudocalypha</i> Boiss. sect. 6 <i>Diacanthium</i> Boiss. sect. 7 <i>Tithymalus</i> Boiss. sect. 8 <i>Tithymalopsis</i> subg. <i>Agaloma</i> Boiss. sect. 9 <i>Alectorroctonum</i> Boiss. sect. 10 <i>Zygophyllidium</i> Boiss. sect.11 <i>Cyttarospermum</i> sect. 12 <i>Goniostema</i> sect.13 <i>Lyciopsis</i> Boiss. subsect. <i>Espinosae</i></p> |
| 2 | Radcliff- Smith (1982) | <p>sect. <i>Rhizanthium</i> sect. <i>Tirrucalli</i> sect. <i>Trichardenia</i> sect. <i>Diacanthium</i> subsect. <i>Medusae</i> subsect. <i>Dactylanthes</i> subsect. <i>Trichardenia</i></p> |
| 3 | Park and Jansen (2007) | <p>1. spiny succulents</p> <ol style="list-style-type: none"> i. subg. <i>Euphorbia</i> ii. subg. <i>Lacanthis</i> iii. subg. <i>monadenium</i>+<i>synadenium</i> <p>2. non-spiny succulents</p> <ol style="list-style-type: none"> i. sect. <i>Meleuphorbia</i> ii. sect. <i>Medusae</i> iii. sect. <i>Anthacantha</i> iv. sect. <i>Trichadenia</i> v. sect. <i>Pseudophorbium</i> vi. sect. <i>Treisia</i> vii. sect. <i>Pseudacalypha</i> viii. sect. <i>Esula</i> |

2.3 Recent Classification of genus *Euphorbia*

One solution to the problem in *Euphorbieae* according to Zimmermann *et al.* (2010) and Riina and Berry (2012) is to divide the large genus *Euphorbia* into several monophyletic genera and to keep the generic ranks for previously recognized genera. The authors identified 4 distinct monophyletic groups or clades as:

- i. Clade A *Euphorbia* subg. *Rhizanthium* Boiss.
- ii. Clade B *Euphorbia* subg. *Esula* Pers.
- iii. Clade C *Euphorbia* subg. *Euphorbia* L.
- iv. Clade D *Euphorbia* subg. *Chamaesyce* Raf.

2.3.1 *Euphorbia* subg. *Euphorbia*

This is the largest and most morphologically diverse group (in terms of cyathial variation, growth form, and habitat (Horn *et al.*, 2012). It contains over 650 species. Bruyns *et al.* (2006) proposed a sectional classification for subgenus *Euphorbia* based almost entirely on Old World species. Variation in cyathial morphology in this subgenus is particularly high and had been the basis for previously recognizing five segregate genera. The species of section *Euphorbia* from Africa and Asia are often compared to the cacti of the New World as a classic example of convergent evolution, and they are the prime representatives of stem succulents in subgenus *Euphorbia*. To date, the relationships and phylogenetic position of the New World species in subgenus *Euphorbia* have not been suitably resolved (Steinmann and Porter, 2002; Bruyns *et al.*, 2006).

2.3.2 *Euphorbia* subg. *Chamaesyce* Raf.

This is a well defined group within genus *Euphorbia* (although it has a complicated taxonomic history). It was originally classified as genus *Anisophyllum* by Haworth (1812). Rafinesque

(1817) later recognized it as a genus. Bruyns *et al.* (2006) recognized four sections within the subgenus *Chamaesyce* as: (1) sect. *Chamaesyce* (2) sect. *Frondosae* (3) sect. *Articulofruticosae* and (4) sect. *Espinosaes*. It is best known for its leafy, non-succulent ornamental species such as the Christmas Poinsettia (*E. pulcherrima* Willd. ex Klotzsch). Other widely cultivated members are “snow-on-the-mountain” (*E. marginata* Pursh.) and “Diamond Frost” (a cultivar of *E. graminea* Jacq.). It also includes a large number of cosmopolitan weedy species such as the spotted spurge (*E. maculata* L.).

Euphorbia subg. *Chamaesyce* is the second most species-rich taxon encompassing around 600 species worldwide. It is highly diverse in growth forms, including annual or perennial herbs, shrubs, trees, and pencil-stem succulents (Yang *et al.*, 2012). Notably, it is the only plant lineage at or below the level of genus that has all known photosynthetic types: C3, C4 and CAM, plus a C2 system that represents an early stage of C3 to C4 transition (Sage *et al.*, 2011).

2.3.3 *Euphorbia* subg. *Esula* Pers.

The leafy spurges, *Euphorbia* subg. *Esula*, comprises about 480 species, most of which are annual or perennial herbs, but with a small number of dendroid shrubs and nearly leafless, pencil-stemmed succulents as well (Riina *et al.*, 2013). While the subgenus is most diverse from central Asia to the Mediterranean region, members of the group also occur in Africa, in the Indo-Pacific region, and in the New World. The few available phylogenetic studies yielded contrasting results regarding the monophyly of subg. *Esula* and the phylogenetic relationships among its constituents remain poorly understood (Frajman and Schönswetter, 2011). However, Riina *et al.* (2013) proposed a new classification for *E.* subg. *Esula* that recognizes 21 sections (four of them

newly described and two elevated from sub-sectional rank) and placed over 95% of the accepted species in the *subgenus* into this new classification.

2.3.4 *Euphorbia* subg. *Rhizanthium* (Boiss.) Wheeler

This is a clade of about 200 non-succulent shrubs, small trees, annual herbs, pencil stem succulents, dwarf succulent plants (this is the form that really defines the diversity of the *subgenus*), medusoid succulents, and a few geophytes. The subgenus is defined by ecarunculate seeds (no caruncles) with a teardrop shape and a long peduncle subtending the cyathium. These peduncles are modified to form spines in at least some species which are not homologous with the spines of subg. *Euphorbia*.



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CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Taxonomic concepts

Major Flora and Monographs on genus *Euphorbia* were consulted for a critical review. The taxonomic arrangement of Hutchinson and Dalziel (1958) was adopted for this study. The genus was considered in its broad sense that is *Euphorbia L. sensu lato*. Systematic decisions were based on morphological (vegetative and floral), cytological and anatomical characteristics of all Herbarium specimens studied and those collected in the wild.

3.1.1 Circumscription and delimitation of taxa

One of the primary roles of this study was to clarify and define the limits of the various taxa within the genus by examining and evaluating the patterns of morphological variation displayed by the constituent species over their geographical range. Throughout the study, every effort was made to consider the species in terms of populations exhibiting morphological, ecophenic and genetic variation. Therefore, morphologically coherent units were treated as distinct species based on correlation and discontinuity of characters from available evidences. Geographical races of a species with well marked morphological characters were treated as sub species.

3.2 Sources of materials

Plant materials of all *Euphorbia* species found in Nigeria were investigated in the following herbaria- University of Lagos herbarium, Akoka, Lagos State (LUH), Forestry Herbarium Ibadan, Oyo State (FHI), University of Ibadan Herbarium Ibadan, Oyo State (UIH), Obafemi Awolowo University Herbarium, Ile- Ife, Osun State (IFE), University of Ilorin Herbarium, Ilorin, Kwara State (IUH) and University of Ghana Herbarium, Accra, Ghana (GC). Abbreviations follow Holmgren *et al.* (1981). The number of specimens examined per taxon

varied from two to five depending on the availability of plant materials in the various herbaria. Fresh specimens (from natural populations) were also collected in the wild and voucher specimens deposited in LUH.

3.2.1 Herbarium studies

Card indices (Appendix 2) of both names and specimens were made and all materials available were sorted on the following basis:

- i. Geographically.
- ii. Alphabetically by collectors and numerically for each collector by combining duplicates of the same number.
- iii. Smaller entities which seems to be more or less clearly delimited.
- iv. Herb-scan was used to take photographs of some specimens from University of Ghana herbarium.

Plant materials from these herbaria form the basis of this study.

3.3 Morphological Characterization

Morphological (vegetative and floral) assessments of all available herbarium and fresh specimens (Appendices 3 and 4) were carried out. Descriptive terminologies employed were based on Hutchinson and Dalziel (1958), Steinmann and Porter (2002), Bruyns *et al.* (2006) and Park and Jansen (2007). All measurements were made (where possible) on parts that were similar and at comparable developmental stages either with thread, meter rule, dissecting microscope or magnifying hand lens (X10). Statistical analysis of means, standard deviation, standard error and variance were done using Microsoft Excel. All necessary drawings and photographs were taken using Motic Image Plus version 2.0ML fitted to Olympus XSZ-N 107 binocular microscope in the Botany Research Laboratory, University of Lagos.

3.3.1 Vegetative Characterization

The pattern of variation within and between leaves/leaflets was determined by assessing characters such as; presence or absence, prominence, shape, indumentum, stipule, petiole, type, arrangement, margin, apex and base. Other quantitative features assessed were: leaf length, leaf width, position of maximum width and petiole length.

3.3.2 Reproductive Characterization

Flowers/inflorescences of herbarium specimens were boiled for 5-10 minutes in order to revive and examine them under the dissecting microscope. Variations in floral morphology were assessed. Some of the characters examined include: symmetry, sexuality, plant type (whether monoecious or dioecious), presence or absence of glands and gland appendages, number of glands, number of stamens, presence or absence of sepals and petals, type of inflorescence, shape of seed, presence of caruncle, surface of seed, length and width of the capsule. Longitudinal sections of flowers of representative specimens were cut with sharp razor blades.

3.3.3 Pollen morphology

Pollen grains of eighteen *Euphorbia* species were studied based on availability of sample materials. All materials used were obtained from herbarium specimens and un-mounted dried plants. Acetolysis techniques of Erdtman (1952) and Pereira-Sheteolu (2004) with some modifications were used to prepare the pollen slides: two to four flower buds or complete inflorescence were teased off into mortar containing de-ionized water. Pollens were liberated by crushing the inflorescences with a pestle and sieved through a funnel into already labeled test tubes. Few drops of acetolysis mixture were added and content warmed gently on heating block until boiling. These were cooled under a fuming hood and centrifuged. The filtrates were poured off and glycerine jelly added to the supernatant. Pollen slides were prepared from this, labeled

and examined under the microscope. Appropriate readings and photomicrographs of all slides were taken with Motic Image camera Plus version 2.0ML fitted to Olympus XSZ-N 107 binocular microscope in Botany Research Laboratory, University of Lagos, Akoka, Lagos.

3.4 Anatomical characterization

Foliar epidermal morphology was studied using both fresh and herbarium materials. Methods followed the approaches of Olowokudejo (1993), Olowokudejo and Obi-Osang (1993), Ayodele (2000), Kotresha and Seetharam (2000), Kadiri and Ayodele (2003), Kadiri (2006). Leaf architectural terminologies followed Hickey (1973) and Dilcher (1974). For Scanning Electron Microscopy, the method of Claugher (1990) and Agricultural Research Services (1992) were used with some modifications.

3.4.1 Light Microscopy (LM)

Leaves/leaflets were boiled in soapy water for about ten to twenty minutes. Whole leaves/leaflets or about 0.5 cm² were obtained from standard median portion and soaked in domestic bleach (5% sodium hypochlorite) until suitable for separation into upper and lower epidermises. The two surfaces were cleaned with camel hair brush and labeled accordingly. These were rinsed in distilled water, stained in 1% safranin and dehydrated in 50%, 60%, 70%, 80%, 90% and absolute ethanol. These were mounted in glycerine on slides and examined under the microscope at x160 and x640 magnifications. Thirty randomly selected epidermal cells and stomata were measured using a micrometer eye-piece. Twelve micro characters were examined on each sample. They include: (i) number of epidermal cells (ii) length of epidermal cells (iii) width of epidermal cells (iv) shape of epidermal cells (v) cell wall pattern (vi) thickness of the epidermal cells (vii) type of stomata (viii) number of stomata (ix) length of stomata (x) width of stomata (xi) presence or absence of trichomes (xii) type of trichomes (Appendices 5 and 6).

Statistical analysis of means and variances were carried out using Microsoft Excel. Charts were used to depict the major quantitative features. Photomicrographs of all major characters were taken using Motic Image Plus version 2.0ML fitted to Olympus XSZ-N 107 binocular microscope in Botany Research Laboratory, University of Lagos.

3.4.2 Scanning Electron Microscopy (SEM)

Whole leaf/leaflet or an area of about 6 mm² taken from the mid region of each leaf/leaflet was cut with a knife under an OPTECH microscope and the surfaces were cleansed with a soft brush. This was placed on labelled aluminium stubs covered with sticky tapes with the aid of forceps so that both adaxial and abaxial surfaces faced upward; they were placed in a sputter coater stub holder and coated with gold in an Emscope SC 500 sputter coater for 2-5 mins. The specimens were examined and photographed with JOEL JSM-6380LV Scanning Electron Microscope (SEM) in the Department of Animal Biology and conservation science, University of Ghana, Legon, Ghana.

3.4.3 Venation pattern

Dried leaves/leaflets were either heated in alcohol or distilled water. These were transferred to petri-dishes and soaked in 3.5% Sodium hypochlorite solution. They were rinsed in distilled water and dehydrated in graded alcohol series, stained and mounted in glycerin jelly. They were labeled accordingly and appropriate readings taken.

3.4.4 Petiole Anatomy

Dried plant specimens were boiled in water for tissue revival. Both boiled and fresh specimens were sectioned (at the medial portions) with razor blade directly into water and mounted on the glass slide, stained with one or two drops of Phloroglucinol and Hydrochloric acid. Specimens

were observed at X40, X100 and X400 magnifications. Appropriate readings and relevant interpretations were made.

3.5 Population Studies

Three herbaceous species were studied at three different locations (abandoned farmland inside University of Lagos Biological Garden, Gbagada Express way, Lagos and farmland beside Covenant University Guest house, Ota, Ogun state). The choice of the three locations was as a result of personal observations of the population areas. The three species are: *E. hyssopifolia*, *E. heterophylla* and *E. hirta*. The method of Anderson (1941, 1945) as adopted by Olowokudejo (1985), Ayodele (2000) and Kadiri (2006) was used (with some modifications). For each species, mass collections were made by walking through the populations in straight lines and a plant specimen was collected at every third, fourth or fifth step depending on the size and degree of variability within the population being sampled. Between 10 and 20 matured plants of each population of the three species were collected. Both quantitative and qualitative data were obtained and recorded appropriately. This was done in order to reflect the range of variability displayed by the population as a whole. The following characters among others were assessed: Leaf length, petiole length, leaf width, plant height, leaf shape, leaf margin, leaf base and leaf apex (Appendix 7). All measurements were based on parts at comparable positions on all plants of each population.

3.6 Experimental Cultivation

In order to ascertain the phenotypic plasticity of the characters, the following experimental studies were carried out on three herbaceous and three shrubby species.

3.6.1 Preliminary Studies

Healthy flowering plants (herbaceous species) were transplanted from the wild to ridges made in the experimental ground within the Biological Garden of University of Lagos. Duplicate specimens were raised in the nursery and the glass house in 15.0 cm by 13.5 cm bottom perforated polythene bags. All the shrubby species were raised through stem cuttings on the experimental ground, nursery and in the glass house. Breeding behaviors and phenotypic responses (such as morphology of the leaf, stem, fruit and seed) were examined and recorded (Appendix 8).

3.6.2 Seed Viability Test

A total of 30 seeds in three replicates of ten seeds each for each population were put on wet filter paper in petri-dishes lined with cotton wool for one to ten days in the glass house and in the laboratory. Germination in each petri-dish was scored and percentages were obtained by expressing the number of sprouted seeds for each day as a percentage of total number of seeds used for the test.

3.6.3 Self Compatibility Test

Viable seeds were planted in polythene bags in the glass house/nursery and the growth monitored daily. Five replicates of each growing seedlings were grouped into three and individual buds were marked as they appear. The first group was tagged, left alone as a test for cross pollination and as a control. The second group was caged, tied and bud, protected and then self pollinated to test for self-compatibility. The third group was caged and left alone to test for self pollination and self fertility.

3.7 Cytology and Breeding System

All plants investigated were raised in the University of Lagos glass house and experimental grounds from seeds collected from the Wild and those of known origin. Some data were also from literature.

3.7.1 Chromosome studies

The methods of Peacock and Bradbury (1973) and Olowokudejo (1984) with some modifications were used for this study. Squashes were prepared from actively growing root tips pre-treated in a saturated solution of 8-hydroxyquinoline for 3-4 hours at room temperature. The root tips were then fixed in 3:1 acetic alcohol for 12 hours. They were later hydrolyzed in 1N HCl in a water bath at 60⁰C for 6-8 minutes. After rinsing in water, the root tips were then stained in propionic orcein for 3 minutes before, and two minutes after squashing. Chromosome numbers were counted and determined. Preparations were then photographed.

3.7.2 Self in-compatibility test

Two inflorescence branches containing at least 4 fully formed buds were bagged shortly before anthesis (on two fully grown plants of the same taxon). Pollinations were carried out at anthesis by hand-selfing flowers of the same inflorescence. Seed sets or lack of it was used as a criterion for self compatibility.

3.8 Geographical distribution, Ecology and Conservation status

Data generated during herbarium studies, notes taken during field trips and those obtained from Flora of West Tropical Africa were used to draw-up the geographical distribution maps for each species.

3.9 Data Analysis

Numerical analysis was applied using Cluster method. Each taxon of the genus included in this study (Appendix 9) was used as an Operational Taxonomic Unit (OTU). Some of the results from all parts of the plants (morphology and anatomy) were used as Unit Taxonomic Characters (UTC). Binary and multistate characters were chosen (bearing in mind the characters that are stable and will not change with varying environmental factors). All UTC (41) used and their codes are listed in Appendix 10. Data were selected from sources such as: vegetative morphology (22), floral morphology (8) and leaf epidermal morphology (11).

Data from pollen morphology, leaf venation, chromosome study and petiole anatomy were not included in the study because information about some taxa was incomplete. Statistical package (SPSS) for windows version 19 was used to calculate coefficient of association, coefficient of correlation and measurements of taxonomic distances between OTUs in order to estimate resemblances within the genus. The affinities of the different OTUs were determined. OTUs of similar affinities were grouped together in a cluster. The main features of these were arranged in a dendrogram. The total evidences gathered during this study are incorporated into a synthetic revision of all the recognized taxa. A dichotomous key to all recognized taxa in *Euphorbia* found in Nigeria was also constructed.

CHAPTER FOUR

4.0 RESULTS

4.1 Herbarium Studies

A total of 706 herbarium specimens of *Euphorbia* representing thirty species were investigated (Table 3). Their names are: *Euphorbia aegyptiaca* Boiss, *Euphorbia schimperiana* Schecl. (*Euphorbia ampla* Hook. f.), *Euphorbia бага* A. Chev., *Euphorbia balsamifera* Ait., *Euphorbia leddermaniana* Pax and Hoffm. (*Euphorbia calva* N. E. Br.), *Euphorbia convolvuloides* Hochst. ex. Benth, *Euphorbia deightonii* Croizat., *Euphorbia depauperata* Hochst. et A. Rich., *Euphorbia desmondii* Keay and Milne-Redhead, *Euphorbia glaucophylla* Poir., *Euphorbia glomerifera* Mill., *Euphorbia heterophylla* Linn., *Euphorbia hirta* Linn., *Euphorbia hyssopifolia* Linn., *Euphorbia kamerunica* Pax., *Euphorbia polycnemoides* Hochst ex Boiss. (*Euphorbia kerstingii* Pax), *Euphorbia lateriflora* Schum et. Thonn., *Euphorbia leucophylla*, *Euphorbia macrophylla*, *Euphorbia milii* Des. Moul. (four varieties), *Euphorbia prostrata* Ait., *Euphorbia pulcherrima* Willd, *Euphorbia cotinifolia*, *Euphorbia sudanica* A. Chev., *Euphorbia unispina* N.E.Br., *Euphorbia thymifolia* Linn., *Euphorbia scordifolia* Jacq., *Euphorbia ingens*, *Euphorbia keithii* and *Euphorbia* sp B.

Critical evaluation of herbarium collections (Table 4) revealed that there were problems of misidentification and synonymy. UCI 21642 (Table 4) was misidentified as *Euphorbia sanguinea* instead of *Euphorbia cotinifolia*. *Euphorbia sanguinea* is a synonym of *Euphorbia inequilatera* (a prostrate or decumbent, annual herb, freely branching and forming a loose mat of growth 50cm or more in diameter). *Euphorbia schimperiana* is a synonym of *Euphorbia ampla*. All unmounted herbarium specimens identified as *Euphorbia poissonii* and mounted *Euphorbia*

drupifera were different from the other specimens sighted in their type of fruits (drupes not capsules). The fruits were stony (Plate 15e –f) while the stems were woody as compared to the succulent stems of *Euphorbia poissonii* described in Table 4. Therefore, following the description of Hutchinson and Dalziel (1958), this research treated all the specimens as *Elaeophorbia* and not *Euphorbia*. Also, all mounted herbarium specimens of *Euphorbia poissonii* examined (FHI 83959, FHI 39325, FHI 102315, FHI 21037, FHI 94316, FHI 42154, FHI 47897, IFE 2646A and IFE 2647) were retained in genus *Euphorbia*.

FHI 78815 was identified as *Euphorbia milii* (Plate 6a) as against *Euphorbia monteiri* subsp. *monteiri* on the herbarium file. According to Carter and Leach (2001), *Euphorbia monteiri* subsp. *monteiri* is an evergreen, succulent, perennial plant producing a number of unbranched stems from a woody rhizomatous rootstock. No species was identified as *Euphorbia monteiri* subsp. *monteiri* in all the herbaria following this description. Also, *Euphorbia calva* is a synonym of *Euphorbia leddermaniana*. FHI 20476 was identified as *Euphorbia glomerifera* instead of *Euphorbia glaucophylla*. FHI 76290, FHI 78475 and FHI 83128 were identified as *Euphorbia glaucophylla* instead of *Euphorbia hyssopifolia*.

FHI 39768 was identified as *Euphorbia balsamifera* as against *Euphorbia lateriflora*. FHI 55804 was identified as *E. lateriflora* as against *Euphorbia sudanica*. Also, FHI 37951 was identified as *Euphorbia prostrata* while UIH 21027 was identified as *Euphorbia lateriflora* as against *Euphorbia tirucalli*. This research identified LUH 1582 and LUH 2665 as *Jatropha integrifolia* instead of *Euphorbia integrifolia*. LUH 2733 was identified as *Euphorbia glaucophylla* (instead of *E. sp.* assigned to it). LUH 1015 was identified as *Euphorbia hyssopifolia* (instead of *E. sp.* previously assigned to it).

Table 3: Distribution of specimens of *Euphorbia* species in the herbaria visited.

| S/N | TAXA | LUH | FHI | IUH | UIH | IFE | GC | Total |
|-----|--|-----------|------------|-----------|-----------|-----------|------------|------------|
| 1. | <i>E. aegyptiaca</i> . Boiss. | - | 1 | - | - | - | 6 | 7 |
| 2. | <i>E. бага</i> . A. Chev. | - | 2 | - | - | - | 2 | 4 |
| 3. | <i>E. balsamifera</i> Ait. | - | 3 | - | - | - | 1 | 4 |
| 4. | <i>E. convolvuloides</i> . Hochst. Ex. A. | - | 40 | 1 | - | 7 | 19 | 67 |
| 5. | <i>E. cotinifolia</i> Hort. | - | - | - | 2 | - | - | 2 |
| 6. | <i>E. cyathophora</i> Murr. | - | - | - | - | - | 3 | 3 |
| 7. | <i>E. deightonii</i> Croizat | - | 6 | - | - | - | 2 | 8 |
| 8. | <i>E. depauperata</i> Hochst .ex. A. Rich | - | 5 | - | - | 2 | 3 | 10 |
| 9. | <i>E. desmondi</i> Keay and Milne- Redhead | - | 3 | - | - | 3 | 1 | 7 |
| 10. | <i>E. glaucophylla</i> Poir | - | 16 | - | - | 2 | 23 | 41 |
| 11. | <i>E. glomerifera</i> (Mill sp.) Wheelers. | - | 9 | - | - | 1 | 9 | 19 |
| 12. | <i>E. heterophylla</i> Linn. | 2 | 39 | 1 | 16 | 12 | 14 | 84 |
| 13. | <i>E. hirta</i> Linn. | 3 | 91 | 4 | 24 | 18 | 37 | 177 |
| 14. | <i>E. hyssopifolia</i> Linn. | 2 | 15 | 1 | 9 | 5 | 11 | 43 |
| 15. | <i>E. ingens</i> | - | - | - | - | - | - | - |
| 16. | <i>E. kamerunica</i> Pax. | - | 2 | - | 1 | 3 | - | 6 |
| 17. | <i>E. keithii</i> Pax. | - | - | - | - | - | - | - |
| 18. | <i>E. lateriflora</i> Schum. et Thonn. | - | 10 | - | 1 | 5 | 11 | 27 |
| 19. | <i>E. ledermanniana</i> Pax and Hoffm. | - | 1 | - | - | - | 6 | 7 |
| 20. | <i>E. leucophylla</i> Benth. | - | 1 | - | - | 2 | - | 3 |
| 21. | <i>E. milii</i> | 2 | 2 | - | 1 | 4 | - | 9 |
| 22. | <i>E. poissoni</i> Pax. | - | 5 | - | - | 2 | 5 | 12 |
| 23. | <i>E. polycnemoides</i> . Hochst .ex. Boiss. | - | 14 | - | 2 | 4 | 31 | 51 |
| 24. | <i>E. prostrata</i> Ait | 1 | 23 | - | 3 | 10 | 16 | 53 |
| 25. | <i>E. pulcherrima</i> . Willd. | - | 3 | - | 2 | 4 | - | 9 |
| 26. | <i>E. schimperiana</i> Scheclé. | - | 2 | - | - | - | 1 | 2 |
| 27. | <i>E. scordifolia</i> Jacq. | - | 3 | - | - | - | - | 3 |
| 28. | <i>E. sp</i> (identity unknown) | - | 3 | 3 | 1 | 2 | - | 9 |
| 29. | <i>E. thymifolia</i> Linn. | - | 14 | - | 3 | 7 | 12 | 36 |
| 30. | <i>E. tirucalli</i> Linn. | - | 1 | - | 1 | - | - | 2 |
| | TOTAL | 10 | 314 | 10 | 66 | 93 | 213 | 706 |

Key: LUH: University of Lagos, Herbarium

FHI: Forestry Herbarium Ibadan

IUH: University of Ilorin Herbarium

UIH: University of Ibadan Herbarium

IFE: Obafemi Awolowo University Herbarium

GC: University of Ghana Herbarium, Accra. Ghana.

Table 4: Herbarium collections of all the herbaria visited

| S/N | Herbarium number | Collector/ number | Taxa | Presence | Locality/ Province | Description | Collection Date |
|-----|--------------------|----------------------------|---|----------|--------------------|--|-----------------|
| 1. | FHI 65379 | Gbile, Wit, Daramola, 1150 | <i>E. aegyptiaca</i> | x | Baga | Scrambling herbs. Stem brownish grey, flowers white, leaves grayish | 26/4/72 |
| 2. | GC 3681 | Hall and jenik | <i>E. aegyptiaca</i> | x | Accra (Ghana) | prostrate and pinkish herb | 08/07/67 |
| 3. | GC 1150/ FHI 65379 | Gbile, Wit and Daramola | <i>E. aegyptiaca</i> | x | Baga (Nigeria) | scrambling herb. Stem brownish grey, flowers white. Leaves grayish | 26/04/72 |
| 4. | GC 1407/221 | Plumptie, E.D. | <i>E. ampla</i> | x | cameroon | A much branched leafy spurge growing among long grasses | 19/12/34 |
| 5. | FHI 48079 | King | <i>E. бага</i> | x | Jos | ----- | 1964 |
| 6. | FHI 1458 | Lely, H.O. | <i>E. бага</i> | x | ----- | A perennial herb with red tubular flowers from a flesh root stock with latex. Local on flat topped laterite hill almost base of other vegetation, after fires. | Jan 1929 |
| 7. | GC 498 | Newton, L.E | <i>E. бага</i> | x | Ghana | Geophyte, cyathia appear in dry season, when plants are leafless | 29/5/69 |
| 8. | GC 1408 | Akpabla, G.K. | <i>E. balsamifera</i> | x | yendi, Ghana | small tree 4-5 ft. High, leaves clustered at the end of the branches, | 03/05/50 |
| 9. | FHI 2531 | Lely, O. P190 | <i>E. calva</i> / <i>E. ledermanniana</i> | x | ----- | A perennial herb coming up after fires in dry mashes with greenish flowers 2-3 inches. | March 1929 |
| 10. | GC. A 1159 | Morton, J. K | <i>E. convolvuloides</i> | x | kintampo | Weed | 16/12/54 |
| 11. | FHI 89275 | Ariwaodo | <i>E. convolvuloides</i> | x | Utuwang | Herb with white milky latex. Flowers reddish, fruit dehiscent. | 8/7/78 |

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|-----|-----------|--------------------------------|--------------------------|---|---------|--|-----------|
| 12. | FHI 39772 | Clayton D. DC 1166 | <i>E. convolvuloides</i> | x | Jebba. | Small herb | June 1957 |
| 13. | FHI 67438 | Daramola, B. & Ekwuno, P. | <i>E. convolvuloides</i> | x | Gwadon | Phyllanthus spp to 18" with brown hairs & brown fruits. | 18/7/70 |
| 14. | FHI45594 | Daramola, B.O. & Geerling 3981 | <i>E. convolvuloides</i> | x | Borgu | Savanna woodland, soil dark, rather heavy herb with latex. Stem light green. Leaves dull green, undersurface greenish. Flowers pale red | 13/8/71 |
| 15. | FHI 63369 | Eimujeze & Adebusuyi | <i>E. convolvuloides</i> | x | Igbetti | An herb with reddish stems and leaf stalks leaves simple & paired. Flowers red. | 6/8/70 |
| 16. | FHI 71505 | Eimujeze & Oguntayo | <i>E. convolvuloides</i> | x | Zambufu | Herb with red stem and upper midveins. Fruit red. | 16/10/74 |
| 17. | FHI 71481 | Eimunjeye & Oguntayo | <i>E. convolvuloides</i> | x | Ilorin | Succulent strangling herb with white latex. Fruit Axillarylary & red when ripe. | 13/10/74 |
| 18. | FHI 71531 | Eimunjeye & Oguntayo | <i>E. convolvuloides</i> | x | Lafiagi | Herb about 1ft tall with white latex, fruit reddish. | 17/10/74 |
| 19. | FHI 76978 | Ekwuno, P.O. 39 | <i>E. convolvuloides</i> | x | Gashaka | An erect herb with simple alternate hairy leaves. Latex white, inflorescent Axillarylary. Fruits green. | 13/11/75 |
| 20. | FHI 87525 | Ekwuno, P.O.399 | <i>E. convolvuloides</i> | x | Yankari | A pubescent herb. Leaves simple alternate, hairy. Latex white, fruit green, hairy, 3- celled calyx pink. | 12/6/76 |
| 21. | FHI 93816 | Ekwuno/ Fagbemi EF. 41 | <i>E. convolvuloides</i> | x | Borno | An herb to 1" high. Latex white- fruit brown. | 22/12/80 |
| 22. | FHI 53780 | F.N. Hepper No. 1376 | <i>E. convolvuloides</i> | x | Kirimi | Simple herb with arching habit varying from a few cm to 60cm high. Stems usually purplish towards base & lower leaves beneath upper leaves grey pubescent beneath with latex, cup- like perianth, pure white on top. | 16/11/57 |
| 23. | FHI 20469 | Gbile & Olorunfemi | <i>E. convolvuloides</i> | x | Shaki | Herb of about 9" high with white exudates. Stem brown – green. Leaves succulent. Both petiole and leaf green below while petiole is brown above. | 18/10/68 |
| 24. | FHI 64140 | Gbile, Wit & Daramola ZOG 780 | <i>E. convolvuloides</i> | x | Lokoja | Herb with brown- greenish stem. Fruit grayish green, leaf softly tomentose. | 20/9/71 |
| 25. | IFE 2597 | Gbile, Z.& | <i>E. convolvuloides</i> | x | Shaki | Herb of abt 9" high with whit exudates, stem brown- | 18/10/68 |

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|-----|-------------------------|---|--------------------------|---|-----------|---|----------|
| | | Olorunfemi, J | | | | green. Leaves succulent, both petiole and leaf green below, while petiole brown above | |
| 26. | FHI 26241/ UIH 11241 | J. Lowe- 1445 | <i>E. convolvuloides</i> | x | Gombe | Farm weed | 14/12/68 |
| 27. | FHI3659 | Jones 1945 | <i>E. convolvuloides</i> | x | Okenne | Whole plant reddish pink. Life form - herb. Weed on farm | 3/9/43 |
| 28. | FHI 63480 | Latilo M.G. | <i>E. convolvuloides</i> | x | Yola | Herb up to 2ft high. Fruit green. | 23/20/71 |
| 29. | FHI 28933 | Latilo, M.G. | <i>E. convolvuloides</i> | x | Jamtari | Tall herb up to 2ft high. Fruit green. | 22/12/54 |
| 30. | FHI 054860 | Latilo, M.O. | <i>E. convolvuloides</i> | x | Abuja | Herb to about 10" high. Fruit greyish. | 2/7/74 |
| 31. | FHI 17956 | Magaji, S.O. M.G.152 | <i>E. convolvuloides</i> | x | Runka | More or less succulent herb leaves oblanceolate, toothed & slightly cordate at base, white sticky latex. Flowers mall & red. | 13/9/67 |
| 32. | FHI 94628 | Magbagbeola & others MAOA.37 | <i>E. convolvuloides</i> | x | Abeokuta | Herb with simple, opposite leaves, Axillarylary inflorescence, fruits dehiscent. | 23/4/81 |
| 33. | FHI 100673 | Magbagbeola, Ariwaodo, Babagbemi, M.A.70 | <i>E. convolvuloides</i> | x | Jos | Herb with milky latex, flower red, fruit dehiscence. | 17/10/83 |
| 34. | FHI 83062 | Oguntayo & Adejimi STO. 21 | <i>E. convolvuloides</i> | x | Ilara | Erect herb with opposite leaves. Stem brownish with red fruits. | 1/6/77 |
| 35. | FHI 47814 | Okafor, J.C. | <i>E. convolvuloides</i> | x | Bida | Herb with purple fruits & somewhat narrow leaves | 11/6/63 |
| 36. | FHI 88569 | Olorunfemi, Oguntayo & Ihe | <i>E. convolvuloides</i> | x | Ilorin | Species with red inflorescence | 6/10/78 |
| 37. | FHI 88425 | Olorunfemi, Oguntayo, Ihe 205 | <i>E. convolvuloides</i> | x | Kaaba | Euphorbia spp. prostrating herb with white latex | 2/10/78 |
| 38. | FHI 88569 | Olorunfemi, Oguntayo, Ihe SEI. 439 | <i>E. convolvuloides</i> | x | Maiduguri | A pubescent herb to 6" high. Latex white. Fruit green. | |
| 39. | FHI 64348 | P.Wit .503 | <i>E. convolvuloides</i> | x | Ibuya | Erect herb. Stem yellow-green. Leaves green, white between veins. Undersurface whitish. Flowers white. Fruits with white indumentums. | 29/9/71 |

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| 40. | FHI 25388 | R.W.J. Keay & L.C. Okigbo | <i>E. convolvuloides</i> | x | Olokemeji | Erect herb with drooping tips. Leaves & stems with whitish leaves, petiole red, flower pink. | 12/9/49 |
| 41. | IFE 2596 | Rogers, S. 547 | <i>E. convolvuloides</i> | x | Iwo | Leaves pinkish | Oct. 1996 |
| 42. | IFE 997 | Sijuade, A.A.305 | <i>E. convolvuloides</i> | x | Shagamu | A small strangling herb | 22/9/71 |
| 43. | FHI 44453 | Slihd D.G. | <i>E. convolvuloides</i> | x | Oyo | Herb. 6-12" high, yielding white latex. | 15/11/60 |
| 44. | SL 1729 | J.K. Morton | <i>E. cyathophora</i> | x | Sierra Leone | Bracts red in lower half weed | 21/02/65 |
| 45. | GC 203 | LOT | <i>E. cyathophora</i> | x | Sierra Leone | woody herb growing to 2'. Leaves round greenish yellow. Flowers have scarlet blobs. 4 small leaves immediately below flowers are almost entirely scarlet. | 28/10/38 |
| 46. | FHI 37052 | Keay | <i>E. deightoni</i> | x | Idanre | Cacti form euphorbia of straggling habit, growing on large boulders | 2/6/57 |
| 47. | FHI 41771 | Ntima, O. O. | <i>E. deightoni</i> | x | Ibadan | Cactus like tree of abt 25ft high, stem green, three angled and spiny on the top branches. Flowers slightly yellow, fruits three angled dull pink & green at the furrows | 24/2/58 |
| 48. | FHI 36095X | Onochie, CFA | <i>E. deightoni</i> | x | Akor | Cacti form shrub abt 8ft high with copious white latex. Flanges with bifid sharp prickles. Flowers pale green. | 21/1/57 |
| 49. | FHI 47897 | Onyeachusim & Binuyo | <i>E. deightoni</i> | x | Ibadan | Succulent green shrub without leaves. Thorn paired stem segmented and four-angled. Latex white flower short and five lobed. Stigma forked. Fruit 3-angled & brown in color | 14/10/63 |
| 50. | FHI 36025 | Brenan, JPM, Keay, RWJ- 8703 | <i>E. deightoni</i> | x | Aweba | Succulent candelabrum euphorbia up to 1.5m high branched profusely from near base & branches arcuate ascending forming around the bush. Joints up to c.15m long 7cm wide. 4- Angled or young shoot 3- angled. Surface medium green, slightly glaucous, cyathium and glands pale yellow green. Anther reddish yellow. Seen also to abt 3cm high & 4-8m diameter. The basal branches sprawling widely along the ground and then ascending. Stems with 3-6 angles. No taxonomic value to this character. | 3/1/48 |

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| 51. | GC 1414 | Akpabla, G.K. | <i>E. deightoni</i> | x | Achimota (Ghana) | A shrub with stems, fruits deep red | 12/02/35 |
| 52. | FHI 45117 | Chapman, J.D. - 2676 | <i>E. depauperata</i> | x | Mambilla | Shrubby herb with woody root stalk, the young flowering stem up to C-15" high appearing in abundance with young leafy shoots now that the old stem of up to 3ft high have been burnt together with the grass. Flower green. | 16/2/72 |
| 53. | FHI 63289 | Gbile Z.O. & Daramola B.O. | <i>E. depauperata</i> | x | Mambilla | Herb with brown stem & yellow flowers. | 5/4/70 |
| 54. | FHI 53792 | Herper, F.N. 1560 | <i>E. depauperata</i> | x | Adamawa | Erect perennial herb up to 30 cm high flowering after burning, stout root stock giving rise to numerous shoot, bright red stem at base and partly above, midribs and margins of leaves also tingly red, bracts yellow green, perianth dull yellow on surface, anthers yellow, ovary green at first, tubercles becoming red, styles reddish, pistil nodding at first, later erect, yielding copious white latex. | 10/12/57 |
| 55. | FHI 104324 | Lowe, J. UIH 20457/4572 | <i>E. depauperata</i> | x | Ibadan | Planted shrub, fleshy stem with paired spines and obovate leaves. Flowers present. | 1/11/84 |
| 56. | IFE 2590 | Meddler, J-934 | <i>E. depauperata</i> | x | Mambilla | Inflorescence and some leaf edges tinged with red, flowers green | 26/8/73 |
| 57. | FHI 44781 | S. Horseman | <i>E. depauperata</i> | x | Adamawa | Spurge. Flower green. | 19/4/62 |
| 58. | SL 1853 | Morton, J. K and Glendhill | <i>E. depauperata</i> | x | Sierra leone | found in grass land | 12/04/65 |
| 59. | FHI 27353 | Lowe, J. UIH 12026 | <i>E. desmondi</i> | x | Gombe | Candelabrum type euphorbia 8ft high with leaves & fruits. | 17/11/68 |
| 60. | UIH 1206 | J.Lowe | <i>E. desmondi</i> | x | Tula(Gombe in Nigeria) | Candelabrum type Euphorbia, 8 ft high with leaves and fruits | 17/11/38 |
| 61. | GC 1390 | Johnson, W.H. | <i>E. drupifera</i> | x | Accra | Abundant white latex. Peduncles forked | 27/02/00 |
| 62. | FHI 61569 | Daramola, B.O. | <i>E. glaucophylla</i> | x | Ife | Herb up to 2" high, fruit greenish yellow, flower yellow | Feb. 1969 |
| 63. | FHI 93975 | Ekwuno/ Fagbemi | <i>E. glaucophylla</i> | x | Kauwa | A prostrate herb, latex white, fruit brown | 29/9/80 |

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| | | EF 200 | | | | | |
| 64. | FHI 89405 | Ibh. & Adejimi, G.J. 38 | <i>E. glaucophylla</i> | x | Eruwa | A spreading herb leaves oblanceolate, fruit tiny & lobed. | 14/4/77 |
| 65. | FHI 96343 | Olorunfemi/Binuyo/ Babagbemi OBB41 | <i>E. glaucophylla</i> | x | Abeokuta | Euphorbia spp with white latex, flowers yellows | 16/10/81 |
| 66. | FHI 33485 | Onochie CFA | <i>E. glaucophylla</i> | x | Badagry | Shrub with branches forming a carpet on the sands, but stems not gregarious. Branches dark red and green, flowers pale green | 13/8/54 |
| 67. | GC 1405 | Lucy, O. Todd | <i>E. glaucophylla</i> | x | Liberia | small decumbent herb. Leaves grayish. Whole plant form rosette, growing from strong tap root 6" -8" long. Flowers tiny in leaf Axillarys. Milky juice | 01/04/38 |
| 68. | GC 387 | Amshoff, G.J.H | <i>E. glaucophylla</i> | x | Cote D'ivore | shrub. Stem reddish. Leaves pale glaucous. Sepals white. Plant exuding white latex. | 28/07/67 |
| 69. | GC 30, 056 | R. Rose Innes | <i>E. glaucophylla</i> | x | Accra(Lat. 5 ⁰ 31' E Long. 0 ⁰ 15'W) | prostrate deep rooted herb. A littoral dune colonizer containing latex | 19/09/54 |
| 70. | FHI 95234 | Arasi, G.A. GAA.17 | <i>E. glomerifera</i> | x | Ibadan | A herb abt 2m high with green flower | 7/9/81 |
| 71. | FHI 102637 | Gbile, Z.O. OSU.17 | <i>E. glomerifera</i> | x | Ijebu Igbo | Herb C.40cm high, shoot reddish with white sticky juice, fruit green and 3- lobed | 29/1/87 |
| 72. | FHI 29014 | Gbile, Z.O. ZOG-531 | <i>E. glomerifera</i> | x | Bacita | Procumbent herb, white sap, stem glabrous, flowers yellow | 14/9/71 |
| 73. | FHI 27763 | Wit. PW -97 | <i>E. glomerifera</i> | x | Gambari | Herb, stem greenish brown, leaves pale green with dark ribs. Flowers white | Feb. 1973 |
| 74. | SL 1371 | Morton, J. K. | <i>E. glomerifera</i> | x | Sierra Leone | Weed | 03/07/64 |
| 75. | FHI 20476 | Gbile & Olorunfemi J. | <i>E. glomerifera-Lowe</i> <i>E. glaucophylla-Daramola</i> | - | Shaki. | Herb with milky white exudates. Stem green at base, brownish green at top | 19/10/68 |
| 76. | GC 5046 | Adams, C.D | <i>E. grandifolia</i> | x | Ashanti(Ghana) | Erect small tree with 2 spines at base of leaf | 19/12/54 |
| 77. | FHI 100363 | Aboderin, K – NKA.4 | <i>E. heterophylla</i> | x | Ibadan | Herb up to 30cm tall with clustered seed and whitish latex. | 8/9/81 |
| 78. | IFE 2607 | Akabogu- 34 | <i>E. heterophylla</i> | x | Ife | Erect annual weed, leaves variable in shape & size, | 24/7/73 |

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|-----|------------|---|------------------------|---|---------------------|--|-----------------|
| | | | | | | fruit capsule. | |
| 79. | UCI 22051 | Akanmu, O.O.-01 | <i>E. heterophylla</i> | x | Ibadan | Leaves are alternate in arrangement, latex present, the plant is herbaceous, glands is present, unisexual flowers which are small, perianth is absent, trilocular ovary, annual plant | 13/11/91 |
| 80. | UCI 22047 | Arannilewa, S.T.-2 | <i>E. heterophylla</i> | x | Ibadan | Leaves usually spiral, latex present, herbaceous, glands present, hairy monoecious, has unisexual flowers which are small, perianth is absent, it has trilocular ovary, it is annual, the leaves are variable in size and shape | 13/11/91 |
| 81. | FHI 39909 | Clayton, D. DC.1262 | <i>E. heterophylla</i> | x | Zaria | Annual herb | 10/8/57 |
| 82. | FHI 41794 | Dickson, S.M. 24 | <i>E. heterophylla</i> | x | Ilorin | Herb, flower insignificant, latex in stem. | 23/1/58 |
| 83. | UIH 19954 | Ekpendu, T.O.E-03 | <i>E. heterophylla</i> | x | Ibadan | Locally abundant herb, some individuals around the locality reach 54 cm. Entire plants green, leaves serrated, simple, entire or slightly tri-lobed, leaf may reach 7.1(excluding petiole) ×4.0 cm. Inflorescence a cyathium, green and terminate the shoot axis. Shoot and leaves a copious milky latex on injury | 6/1/76 |
| 84. | FHI 97008 | Ekwuno & Others E & O. 934 | <i>E. heterophylla</i> | x | Okorshie | An herb to 1ft high. Latex white, fruits brown, ovary 3-celled | 19/9/81 |
| 85. | FHI 95638 | Ekwuno & Others E& O 435 | <i>E. heterophylla</i> | x | Benin | Herb up to 1ft high, latex white, fruits green | 11/1/82 |
| 86. | FHI 87644 | Ekwuno/ Fagbemi/ Osanyinlusi PFO.475 | <i>E. heterophylla</i> | x | Edondon | A pubescent herb to 1ft high, latex white | 26/8/28 |
| 87. | FHI 103319 | Emwiogbon/ Oguntayo E.O.519 | <i>E. heterophylla</i> | x | Akpokolo- Ijiani | Fruit green, latex white | 19/6/78 |
| 88. | IFE 2605 | Faremi, I.B. 801 | <i>E. heterophylla</i> | x | Ife | An erect herb up to about 2' high, upper leaves and bracts bases are red | July, 2,1975 |
| 89. | FHI 73623 | Gbile & Daramola | <i>E. heterophylla</i> | x | Zaria | Euphorbiacea up to 45cm with green and brown | 22/11/74 |

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| | | | | | | patches on fruits | |
| 90. | IFE 2606 | Guile, DPM 551 | <i>E. heterophylla</i> | x | Sakpoba | This is the cultivated form of this variable American species. The uppermost leaves are blotched red | May, 1966 |
| 91. | FHI 1773 | Jackson JKJ no. 5168 2l.vi. | <i>E. heterophylla</i> | x | Kaaba | Shrub 2ft high, stem 0.5" thick, semi-woody- Bark brown, leaves subtending the flowers with scarlet blotches. Leaves alternate | 16/10/67 |
| 92. | FHI 54544 | Jackson, JAD. 224 | <i>E. heterophylla</i> | x | Kaduna | Rather slender erect herb 2" high with white latex. Gregarious weed. Stem shortly hairy, flowers terminal, crowded, greenish yellow | 24/5/64 |
| 93. | FHI 6425 | Jones 1392 | <i>E. heterophylla</i> | x | Kafanchan | Erect rather fleshy herb. The leaves have serrate margin and elliptic in shape | 15/4/54 |
| 94. | FHI 28024 | Keay | <i>E. heterophylla</i> | x | Zaria | Annual herb. Flowers yellowish green. | 26/8/50 |
| 95. | FHI 100727 | Magbagbeola, Ariwaodo, Babagbemi, M.A.154 | <i>E. heterophylla</i> | x | Mangu | Herb with green stem, with brown spots, flowers yellow | 22/7/83 |
| 96. | FHI 100463 | Magbagbeola, Ariwaodo, Babagbemi MA.190 | <i>E. heterophylla</i> | x | Bida | Herb with light green stem. flowers pink | 26/7/83 |
| 97. | FHI 102004 | Odewo & Binuyo OB 95 | <i>E. heterophylla</i> | x | Ajobo | Herb to 30cm high, fruits green borne on the head | 30/8/84 |
| 98. | FHI 91092 | Odewo, Ihe & Odebode OIO.736 | <i>E. heterophylla</i> | x | Eruwa | Artemisia to 20cm high, fruits green. | 8/6/78 |
| 99. | FHI 87877 | Odewo, TKO.824 | <i>E. heterophylla</i> | x | Gashaka | Up to 20cm high, white latex present, fruits green. | 30/8/77 |
| 100. | FHI 91086 | Odewo/ Ibh/ Oguntayo OIO. 1198 | <i>E. heterophylla</i> | x | Owena | Herb up to 60cm high with flowers green an unopened indigofera with tiny fruits. | 26/7/79 |
| 101. | FHI 79588 | Ohaeri 933A | <i>E. heterophylla</i> | x | Samaru | Small herb, stem soft. Follicle with three seeds | 21/5/75 |
| 102. | FHI 106419 | Ojelabi, A.W. | <i>E. heterophylla</i> | x | Moniya | Herb abt 45cm high, stem brownish at the nodes in the upper part. Flower leaves are arranged in alternate with white latex | 20/6/02 |
| 103. | FHI 54953 | Olorunfemi | <i>E. heterophylla</i> | x | Naraguta | Herb abt 12"-18" high. Lower part of stem brownish and at the nodes in the upper part. , flowers terminal, | 16/7/64 |

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| | | | | | | fruits 3-lobed, leaf finely serrated, white latex present | |
| 104. | FHI 84614 | Olorunfemi & Oguntayo No. 47 | <i>E. heterophylla</i> | x | Owo | Herb with white latex, fruits clustered and terminal. | Nov. 1977 |
| 105. | FHI 68398 | Opayemi, J. 68 | <i>E. heterophylla</i> | x | Lagos | A weed of waste places | 19/10/72 |
| 106. | FHI 92132 | Oyayomi, Fagbemi, Onijamowo, Oguntayo & Arasi OFOOA.317 | <i>E. heterophylla</i> | x | Naraguta | Herb abt 1m high with unopened flowers | 26/11/76 |
| 107. | FHI 84461 | Soladoye, Ekwuno & Ihe SEI .83 | <i>E. heterophylla</i> | x | Lokoja | Erect herb with simple opposite leaves, latex white. Fruits green. | 19/10/77 |
| 108. | GC A2111 | Morton, J.K | <i>E. heterophylla</i> | x | the West Indies | plant with linear leaves | 22/05/56 |
| 109. | UCI 22058 | Aderibigbe, IA.03 | <i>E. hirta</i> | x | Ibadan | Male & female flower much reduced and enclosed in a common involucre, perianth absent or rim like, plant with milky juice, small herbs, involucre borne on dense rather long pedunculate Axillary bud and terminal leafless glomerules, stem rather coarsely spreading, pilose with yellowish hair over a shorter indumentum, leaves obliquely ovate to lanceolate, rounded on one side, cuneate on the other at the base, acute at the apex | 13/11/91 |
| 110. | UIH 11068 | Alasoadua-162 | <i>E. hirta</i> | x | Ibadan | A small herb with unequal sided leaves white latex, stems covered with hairs | 4/4/58 |
| 111. | FHI 102458 | Ariwaodo/ Adesina AA135 | <i>E. hirta</i> | x | Agbor | Herb with milky latex, inflorescence Axillary umbel | 22/9/81 |
| 112. | FHI 48130 | Bell, G.S. | <i>E. hirta</i> | x | Katsina | Plant 3" high | 10/1/64 |
| 113. | FHI 36380 | Brenan JPM- Brenan 9147 | <i>E. hirta</i> | x | Okomu | Occasional weed in open grass cleared land. Erect herb. Leaves purplish green, venation impressed above. Flowers purplish green. Stamen- filament white. | 26/2/48 |
| 114. | FHI 86183 | Daramola & Ibh. BO238 | <i>E. hirta</i> | x | Ogori – Magogo | Spreading with white latex and brown stem | 2/5/78 |

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| 115. | FHI 55253 | Daramola, B.O. | <i>E. hirta</i> | x | Calabar | Herb to 9" high, flowers yellowish, leaves saw edge, latex white and used for curing stinging of a scorpion | 16/9/64 |
| 116. | FHI 84407 | Daramola, B.O.D.21 | <i>E. hirta</i> | x | Gashaka | Hirta up to 20cm, flower greenish-yellow with white latex on the stem | 12/8/77 |
| 117. | FHI 87391 | Daramola, Emwiogbon/ Ogutayo DEO 466 | <i>E. hirta</i> | x | Otukpo | Brown fruits | 16/6/78 |
| 118. | FHI 103306 | Daramola/Emwio gbon/ Oguntayo DEO 632 | <i>E. hirta</i> | x | Benue | Yellow flower | 1/7/78 |
| 119. | UIH 1875 | Doherty, J | <i>E. hirta</i> | x | Lagos | Leaves opposite, cures discolored face | 30/7/37 |
| 120. | FHI 68180 | Eimunjeze & Ekwuno | <i>E. hirta</i> | x | Ilashe | Herb with distinct nodes and internodes and hairy stems. Inflorescence greenish yellow | 21/11/73 |
| 121. | UIH 19955 | Ekpendu T.D.E-04 | <i>E. hirta</i> | x | Ibadan | A common herb around UI. Erect herb or decumbent, may reach 39cm, as a purple tinge, leaf simple, may reach 3.4×1.2cm, opposite and decussate, finely serrated, inflorescent a cyathium, Axillarylary and color nearing that of the leaves but with a tinge of yellow, fruit a capsule, tri-celled generally, yellowish green and solitary, may reach 1.2 diameter × 1.4mm(height), plant exudes milky latex on wounding | 6/1/76 |
| 122. | FHI 96071 | Ekwuno & Others | <i>E. hirta</i> | x | Sankwala | An herb up to 6" high. Latex white, ovary 3-celled. Flower, cream | 18/9/81 |
| 123. | FHI 95941 | Ekwuno & Others E & O .767 | <i>E. hirta</i> | x | Ikom | A herb to 1 ft high, flowers cream, latex white | 15/9/81 |
| 124. | FHI 95843 | Ekwuno & Others. E & O.670 | <i>E. hirta</i> | x | Iyanmette | A herb to 1ft high, latex white, flower cream | 11/2/82 |
| 125. | FHI 95307 | Ekwuno & Others. E& O.54 | <i>E. hirta</i> | x | Atuagbo | A herb up to 1ft high, latex white, flowers cream | 28/8/81 |
| 126. | FHI 95665 | Ekwuno & | <i>E. hirta</i> | x | Bende | An herb up to 1ft high. Latex white, flower cream. | 31/12/87 |

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| | | Others. E&O.463 | | | | | |
| 127. | FHI 88969 | Ekwuno/Fagbemi/ Osanyinlusi | <i>E. hirta</i> | x | Ekenwa | A herb up to 1ft high, stem and leaves pubescent, latex white, fruit cream | 11/8/78 |
| 128. | FHI 87624 | Ekwuno/Fagbemi/ Osanyinlusi PFO | <i>E. hirta</i> | x | Awi | A pubescent herb to 6" high, latex white, fruit green | 20/8/78 |
| 129. | FHI 103401 | Emwiogbon/ Oguntayo EO.571 | <i>E. hirta</i> | x | Okitipupa | Herb white, leaves opposite | 30/6/78 |
| 130. | IFE 2615 | Faremi, I.B. 521 | <i>E. hirta</i> | x | Igbetti | An erect herb | 2/11/74 |
| 131. | IFE 2627 | Faremi, I.B.1693 | <i>E. hirta</i> | x | Oyo | A herb of abt 35cm high exuding milky latex when cut | 27/10/78 |
| 132. | IFE 2617 | Faremi, I.B-393 | <i>E. hirta</i> | x | Kaduna | A wood herb, white latex when cut | 5/4/74 |
| 133. | FHI 65452 | Gbile, Wit & Daramola 1223 | <i>E. hirta</i> | x | Dadin Kowa | Creeping herb stem brownish green, flower brownish | 2/5/72 |
| 134. | FHI 65480 | Gbile, Wit, Daramola 1251 | <i>E. hirta</i> | x | Hong | Erect herb with brownish green stem, flowers green | 3/5/72 |
| 135. | FHI 101848 | Gbile, Z.O. ZOG.5295 | <i>E. hirta</i> | x | Warri | Procumbent herb, stem brown, flowers green | 27/9/78 |
| 136. | FHI 45714 A | Geerling CG- 3996 | <i>E. hirta</i> | x | Kanji dam | Herb with latex, stem reddish, leaves green, flowers reddish green | 13/8/71 |
| 137. | UIH 1873 | Guba, E.A. | <i>E. hirta</i> | x | Umuahia | A terrible weed on the lawn dries out during dry season, also in villages. It can mixed with a plant called "oso" given to babies for dysentery | 13/9/31 |
| 138. | UIH 1874 | Guba, E.A.1155 | <i>E. hirta</i> | x | Lagos | 4-5ft high, terrible on lawn and difficult to eradicate | 7/8/37 |
| 139. | FHI 91608 | Herbarium wild life staff. KZOG.171 | <i>E. hirta</i> | x | Bacita | Spreading herb latex white | 12/10/79 |
| 140. | FHI 89782 | Ibh & Adejimi G.T.372 | <i>E. hirta</i> | x | Oyo | Creeping herb, leaves opposite, flowers whorled, milky latex exude when the leaves are plucked | 21/2/79 |
| 141. | FHI 96992 | Ibh & Osanyinlusi | <i>E. hirta</i> | x | Okitipupa | An herb. Leaves opposite. | --- |
| 142. | FHI 65205 | Ibh, G | <i>E. hirta</i> | x | Onitsha | A creeping herb, flowers in whorl, leaves green at the surface and light white at the back | 25/5/72 |
| 143. | FHI 77699 | Ibh. G.44 | <i>E. hirta</i> | x | Gashaka | Creeping herb | 13/11/75 |
| 144. | FHI 89421 | Ibhanesebhor & | <i>E. hirta</i> | x | Eruwa | Spreading succulent stem, flowers whorled | 14/4/77 |

| | | Adejimi GT 45 | | | | | |
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| 145. | FHI 65204 | Ibhanesebhor, G. | <i>E. hirta</i> | x | Onitsha | A creeping herb, flower in whorl, leaves green at the surface and light white at the back. | 25/5/72 |
| 146. | FHI 93441 | Ibhanesebhor/ Oguntayo & Ariwaodo IOA.38 | <i>E. hirta</i> | x | Begga | Creeping, fruits whorled | 22/4/80 |
| 147. | FHI 22323 | Jackson, JAD.679 | <i>E. hirta</i> | x | Kaduna | Sub-erect, lactiferous herb 6" high, stems pilose, leaves opposite, flowers green tinged with red inpendunculate Axillarylary cluster | 3/10/69 |
| 148. | FHI 796 | Jones JPD 917 | <i>E. hirta</i> | x | Adugongo | Arable weed, reddish stem & greenish flowers | 11/2/42 |
| 149. | FHI 35362 | Latilo, M.G. | <i>E. hirta</i> | x | Owan | Trailing herb up to 6" high flowers greenish | 20/11/55 |
| 150. | FHI 21779 | Lawlor, D.W. & Hall, JB. 224 | <i>E. hirta</i> | x | Pashanu Pass | Semi- prostrate, hairy herb, stems reddish, flowers very small, whitish in Axillarylary clusters, branched | 10/8/62 |
| 151. | FHI 94597 | Magbagbeola & Others MAOA.3 | <i>E. hirta</i> | x | Ilaro | Herb with hairy stem. Milky latex present, inflorescence umbel | 8/6/81 |
| 152. | FHI 17072 | Obi, F.O. | <i>E. hirta</i> | x | Ikom | Creeping herb, the leaves and stem reddish, flowers are in bunches, minute and greenish, white sap exudes when stem is broken | 18/9/57 |
| 153. | IUH 187 | Obiyomi, D.E.07 | <i>E. hirta</i> | x | Ilorin | Leaves all strictly opposite, stipule present, prostrate herbs, some perennial, involucre born in dense, rather long pedunculate, Axillarylary & terminal leafless glomerules, stem rather coarsely spreading, pilose with yellow hairs over a short indumentum, leaves obliquely ovate to lanceolate, rounded on one side, cuneate on the other at the base acute at apex, up to 5cm long and 2cm broad, serrated | Feb. 1999 |
| 154. | FHI 99934 | Odewo & Adedeji ODA.284 | <i>E. hirta</i> | x | Omo | Herb with milky latex, flower dull white | 14/5/83 |
| 155. | FHI 84341 | Odewo & Daramola TKO. 623 | <i>E. hirta</i> | x | Apomu | Yoruba-saaje | 6/4/78 |
| 156. | FHI 85346 | Odewo & Daramola, TKO | <i>E. hirta</i> | x | Awala | Yoruba- agbaje | 1/2/78 |

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| 157. | FHI 91012 | Odewo, T.K- TKO.786 | <i>E. hirta</i> | x | Mambilla | Herb with red stem. Milky juice present. Flower red. | 26/8/77 |
| 158. | FHI 98620 | Odewo/ Adedeji OA55 | <i>E. hirta</i> | x | Yola | A spreading herb flower green | 14/12/81 |
| 159. | FHI 55841 | Olorunfemi | <i>E. hirta</i> | x | Naraguta | Herb more or less erect leaves unequal sided, yielding white latex when plucked. Flowers creamy yellow | 19/6/65 |
| 160. | FHI 70074 | Olorunfemi & Ibh | <i>E. hirta</i> | x | Dekina | Herb with brown stem, latex white, leaves green above and white below. Flowers greenish yellow | 21/5/73 |
| 161. | FHI 86706 | Olorunfemi & Oguntayo 194 | <i>E. hirta</i> | x | Afonmu | Hairy herb with brownish stem, leaves produce white juice when plucked. Flower yellow. Adendende(Ondo) | Dec.77 |
| 162. | FHI 88487 | Olorunfemi, Oguntayo & Ihe 267 | <i>E. hirta</i> | x | Isanlu | Isanlu—Loloarikuko. Leaves squized and used for dysentery. | 4/10/78 |
| 163. | FHI 76409 | Olorunfemi, Onijamowo & Ariwaodo SE 249 | <i>E. hirta</i> | x | Obubra | Herb 9"-12" high, leaves reddish. Latex white, flowers greenish yellow. | 16/5/75 |
| 164. | FHI 86882 | Olorunfemi/ Oguntayo 488 | <i>E. hirta</i> | x | Ikere-Ise | Prostrating herb with white latex. Flowers brownish green | 24/11/77 |
| 165. | FHI 93664 | Olorunfemi/ Oguntayo/ Adesina OOA 185 | <i>E. hirta</i> | x | Afunremu | Herb with white latex, flowers greenish- yellow. Oye-Ekiti-Biye | 29/7/80 |
| 166. | FHI 94494 | Olorunfemi/Binuy o/Babagbemi OBB 229 | <i>E. hirta</i> | -- | Wusasa | Prostrating herb with white latex, flowers greenish yellow | 17/11/80 |
| 167. | FHI 96325 | Olorunfemi/Binuy o/Babagbemi OBB.23 | <i>E. hirta</i> | x | Igboora- Nenle- Idere | Small herb with white latex. | 15/10/81 |

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| 168. | FHI 88232 | Olorunfemi/Oguntayo/ Ibhanesebhor 12 | <i>E. hirta</i> | x | Owa-ani | Herb with white latex, flowers greenish-yellow | 13/9/78 |
| 169. | FHI 86568 | Olorunfemi/Oguta yo | <i>E. hirta</i> | x | Owo | Herb more or less prostrating flowers brownish green | Nov. 1977 |
| 170. | FHI 58304 | Onyeachusim & Binuyo | <i>E. hirta</i> | x | Borgu | Herb with white juice, fruit green | 5/3/66 |
| 171. | FHI 82983 | Osanyinlusi & Oyayomi SO.197 | <i>E. hirta</i> | x | Ohunbe | Herb up to 20cm high, leaf & stem hairy with inflorescence raceme like | 13/6/77 |
| 172. | FHI 82963 | Oyayomi & Osanyinlusi | <i>E. hirta</i> | x | Imeko | Euphorbia spp abt 10cm high with inflorescence head like | 2/6/77 |
| 173. | FHI 84476 | Oyayomi & Osanyinlusi SO.288 | <i>E. hirta</i> | x | Badagry | Herb up to 40cm high with inflorescence arising at the nodes | 17/6/77 |
| 174. | FHI 83682 | Oyayomi & Osanyinlusi, S.O.314 | <i>E. hirta</i> | x | Owena | Euphorbia spp up to 60cm high with flowers brown | 21/6/77 |
| 175. | FHI 83006 | Oyayomi, Osanyinlusi SO78 | <i>E. hirta</i> | x | Eggua | Shrub abt. 3m high with inflorescent terminal | 6/6/77 |
| 176. | FHI 60469 | P.Wit, Z.O.Gbile, B.O.Daramola | <i>E. hirta</i> | x | Jalingo | Creeping herb, stem yellow- green, purple on upper side, leaves green above, pale green with prominent mid rib beneath. Inflorescence greenish brown | 7/5/72 |
| 177. | UIH 13645 | Williamson, K.R.M. KW-28 | <i>E. hirta</i> | x | Kaiama | Vernacular name Ijaw-obiirima | 14/11/72 |
| 178. | UIH 15468 | Williamson, K.R.M.KW-319 | <i>E. hirta</i> | x | Kolokuma | Vernacular name-Opuruanga(prawn eggs) | 4/11/73 |
| 179. | FHI 64295 | Wit, Gbile and Daramola 401 | <i>E. hirta</i> | x | River Niger | Creeping herb, stem red above, pale green beneath, inflorescences reddish green, all on one side of the stem | 19/9/71 |
| 180. | GC 47751 | Simon Kwaku Attah | <i>E. hirta</i> | x | Ghana | an erect sometimes decumbent herb up to 40cm high, stem slender, cylindrical, reddish white, pubescent, sometime purple tinged; leaves opposite, assymetrical at base, obliquely ovate or lanceolate, | 08/12/2002 |

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| | | | | | | rounded on one base side, cuneate on the other base, apex acute; involucre densely crowded, size 2-5cm long, 0.3-1.5 cm broad, margin minutely dentate or serrate, colour green with purple flush, taste bland, capsule pilose | |
| 181. | FHI 8890 | Ekwuno, Fagbemi, Osanyinlusi | <i>E. hyssopifolia</i> | x | Ekenwa | A herb up to 2ft high, leaves glossy, opposite, latex white, fruit green | 1/8/78 |
| 182. | IFE 2632 | Faremi, I.B.1632 | <i>E. hyssopifolia</i> | x | Kano | A small, slender and well branched herb | 6/ 2 /1976 |
| 183. | UIH 19800 | Freeman, R.A-4C | <i>E. hyssopifolia</i> | x | Port Harcourt | Vern. Name- amakubu iyayan(Olodiama) | 12/7/82 |
| 184. | FHI 988750 | George, E.Pilz.2286 | <i>E. hyssopifolia</i> | x | Ibadan | Sprawling to semi erect herb in ditches | 8/4/79 |
| 185. | FHI 100899 | Ibh/ Osanyinlusi/ Adedeji IOA.37 | <i>E. hyssopifolia</i> | x | Argungu | Indigofera up to 60cm high, stem red, fruits very infinitesimal | 28/10/83 |
| 186. | FHI 96989 | Ibh/Osanyinlusi IO .32 | <i>E. hyssopifolia</i> | x | Okitipupa | A scrambling herb, flowers tiny & white | 15/7/82 |
| 187. | FHI 58580 | Okafor, JC & Macaulay | <i>E. hyssopifolia</i> | x | Apapa | Herb with white latex. Stem reddish, fruits 3-celled. Greenish yellow with persistent styles | 28/4/66 |
| 188. | FHI 70735 | Olorunfemi & Fagbemi | <i>E. hyssopifolia</i> | x | Ise- Ekiti | Herb with small greenish fruits | 8/3/73 |
| 189. | FHI 88382 | Olorunfemi/ Oguntayo/Ihe | <i>E. hyssopifolia</i> | x | Kaaba | Euphorbia with greenish inflorescence | 30/9/78 |
| 190. | 730(WAG) | Amshoff, G.J.H | <i>E. hyssopifolia</i> | x | Iringou (Ghana) | herb exuding white latex. Stem reddish yellow. Leaves medium green above, paler beneath. Flowers pink | 13/08/67 |
| 191. | GC 30097 | R. Rose Innes | <i>E. hyssopifolia</i> | x | Accra Lat. 5 ⁰ 40' N Long.0 ⁰ 06'W | Small herbaceous weed about 8" high containing latex | 25/02/56 |
| 192. | FHI 78475 | E.O.Daramola, Macaulay & Oguntayo C135 | <i>E. hyssopifolia</i> / <i>E. glaucophylla</i> | x | Calabar | Euphorbia to 30 cm with white latex and yellowish green fruits | 9/9/75 |
| 193. | FHI 83128 | Oguntayo & Adejimi | <i>E. hyssopifolia</i> / <i>E. glaucophylla</i> | x | Owena | Herb with pinnate leaves, fruits greenish red | 21/6/77 |

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| 194. | FHI 76290 | Olorunfemi/ Onijamowo/Ariw aodo SEI128 | <i>E. hyssopifolia/ E. glaucophylla</i> | x | Awii | Herb up to 9” – 1ft high with white latex when leaf is cut, flower yellow | 22/4/75 |
| 195. | FHI 16272 | Collies FG | <i>E. kerstingii</i> | x | Igbetti | Small herb | 15/2/46 |
| 196. | FHI 89473 | Ibh & Adejimi- GJ.65 | <i>E. kerstingii</i> | x | Igboora | A scrambling herb, leaves simple, flowers white, with milky latex | 15/4/77 |
| 197. | GC 36729 | Hall and Enti | <i>E. kerstingii</i> | x | Kintampo(Gha na) | low herb with white latex | 29/03/67 |
| 198. | FHI 50568 | Hepper, FN. 1129 | <i>E. lateriflora</i> | x | Jos | Erect, C. 1m.high, branched shrub, all stem fleshy and glaucous green, fertile ones branched several times, those carrying young leaves simple and beginning to rise above others. Young leaves reflexes copious white latex on cutting. Flowers yellow green but only a few fruit in all stages, unripe ones red tinged on top | 23/10/57 |
| 199. | FHI 2139 | Keay, RWJ | <i>E. lateriflora</i> | x | Kano | Hedge plants with acrid white latex. Flowers yellow | 29/10/47 |
| 200. | FHI 93663 | Olorunfemi/Ogunt ayo/ Adesina OOA 184 | <i>E. lateriflora</i> | x | Afunremu | Shrub with white latex very poisonous. Oye Ekiti- Enukopire | 29/7/80 |
| 201. | FHI 47706 | Onochie, CFA | <i>E. lateriflora</i> | x | Zaria | Green succulent plant to24” yielding copious white latex, flowers pale yellow | 29/5/63 |
| 202. | FHI 2949 | Ujo, CFA 1948 | <i>E. lateriflora</i> | x | Maiduguri | Native name; Bideselise. A plant of abt 4ft high, red fruits and yellow flower, milk like juice, green smooth stems | 3/7/48 |
| 203. | FHI 39768 | Clayton, D. 969 | <i>E. lateriflora /E. basalmifera</i> | x | Bichu | Cylindrical succulent stem. No leaves. Hausa- bidaselsi | April, 1957 |
| 204. | FHI 55804 | Olorunfemi 65 | <i>E. lateriflora /E. sudanica</i> | x | Naraguta | Low fleshy shrub up to 4-5” high with white milky latex. Fruit 3-lobed | 11/5/65 |
| 205. | IFE 764 | Daramola, B.O. | <i>E. lateriflora</i> | x | Ilesha | Shrub with milky latex | 26/10/2000 |
| 206. | IFE 2636A | Guile, DPM 2704 | <i>E. lateriflora</i> | x | Ibadan | A succulent herb or small shrub with milky latex- often used for hedging leaves persist only near stem apices | April, 1967 |
| 207. | GC 2584 | Hall, J. B | <i>E. lateriflora</i> | x | cape town | succulent shrub, with yellow green flower | 25/04/64 |

| | | | | | | | |
|------|------------|-----------------------------------|-------------------------|---|------------------|---|-------------|
| 208. | GC 38778 | Enti, A.A. | <i>E. leddermaniana</i> | x | Tamale(Ghana) | herb with tuberous roots | 09/08/68 |
| 209. | IFE 2640 | Guile, D.P.M. 2647 | <i>E. leucophylla</i> | x | Ibadan | A much branched shrub- 4ft high, with white leaves on the apices of the trunks, native of Western N. America | April, 1967 |
| 210. | FHI 55099 | Olorunfemi | <i>E. leucophylla</i> | x | Ibadan | Planted shrub up to 5" high with white milky latex, leaves in whorls, flowers terminal and yellow, fruits green with 3 blunt ridges. Upper leaves white | 9/11/64 |
| 211. | GC 685 | Akpabla, G.K. | <i>E. macrophylla</i> | x | Nalerigu (Ghana) | A herb on sandy soil, leaves in whorls of 3-5 below the umbel of bracteate involucre. Lower leaves alternate. | 22/06/37 |
| 212. | IFE 2642 A | Guile, D.P.M. 558 | <i>E. milii</i> | x | Ibadan | A stout straggling under shrub with numerous thorns and bright red bracts used for small hedges, native of Madagascar | March, 1967 |
| 213. | FHI 64385 | P.Wit.540 | <i>E. milii</i> | x | Ibadan | Woody herb, white latex, stem and spines grey(spines purple when young) leaves green with pink margin, inflorescence red | 3/10/71 |
| 214. | FHI 83959 | Soladoye/ Ekwuno/Ibh. SEI .249 | <i>E. poissonii</i> | x | Pambegwa | A shrub to 4ft high leaves glabrous, stem grey, latex white | 24/10/77 |
| 215. | FHI 39325 | Clayton, DC.573 | <i>E. poissonii</i> | x | Okenne | Tree, 6-10 ft high with soft fleshy branches | 1957 |
| 216. | FHI 102315 | Daramola, B.O. | <i>E. poissonii</i> | x | Bauchi | Tree with very succulent stem, cylindrical and spiny latex white and very copious | Dec., 1986 |
| 217. | IFE 2647 | Faremi, I.B. | <i>E. poissonii</i> | x | Igbetti | A fleshy much branched and juicy shrub of abt. 7" high, flowers whitish green. This plant is very poisonous even to human skin | 3/11/74 |
| 218. | FHI 21037 | Keay, RWJ | <i>E. poissonii</i> | x | Jos | Candelabra euphorbia with large obovate leaves, at the ends of branches. Fruits and fruiting peduncles dull red | 1/11/47 |
| 219. | FHI 94316 | Olorunfemi/Binuyo/Babagbemi OBB51 | <i>E. poissonii</i> | x | Jos | Shrub with white latex stem angled with spines, inflorescence terminal | 3/11/80 |
| 220. | FHI 42154 | Onochie CFA | <i>E. poissonii</i> | x | Jebba | Photo in file | ----- |

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|------|-------------------------|--|---------------------------------------|---|----------------|---|----------|
| 221. | FHI 47897 | Onyeachusim | <i>E. poissonii</i> | x | Ibadan | Planted shrub. C. 3ft high involucre with 5 thick green lobes and slender red flowers on top, individual fl. With three lobes, latex white stem ash white and succulent thorn present | 14/10/63 |
| 222. | IFE 2646 A | Owoseye, Ayo-124 | <i>E. poissonii</i> | x | Kachia | A woody herb like shrub with a lot of scales on the stem, the stem and leaves produce juice, it is rarely seen | 19/6/70 |
| 223. | IFE 2666/ FHI 67330 | Daramola, B. & Ekwuno, P | <i>E. polycnemoides</i> | x | Pendong | Phyllanthus to 2" with light yellow flowers | 15/7/70 |
| 224. | FHI 25943 | Keay RWJ | <i>E. polycnemoides</i> | x | Gidan Mudi | Erect annual herb. Stems crimson, leaves glaucous | 6/7/50 |
| 225. | FHI 12710 | Keay, JM & Keay RWJ | <i>E. polycnemoides</i> | x | Jos | Erect herb, 6" high, stem reddish, leaves glaucous green | 26/8/46 |
| 226. | FHI 25971 | Keay, RWJ | <i>E. polycnemoides</i> | x | Zaria | Annual herb, stems crimson, leaves glaucous | 13/7/50 |
| 227. | UIH 11228 | Lowe, J. -1405 | <i>E. polycnemoides</i> | x | Bauchi | Small herb | 12/11/63 |
| 228. | FHI 68826/ UIH 11419 | Lowe.1628 | <i>E. polycnemoides</i> | x | Gombe | Stem deep red (methane color 12B8-12D8).Involucre green with reddish gland. Ovary & capsule glabrous | 19/2/69 |
| 229. | FHI 56949 | Olorunfemi | <i>E. polycnemoides</i> | x | Jos | Erect slender herb up to 12" high, stem red, produces white latex when leaf is plucked fruits very small. | 30/9/65 |
| 230. | FHI 57061 | Olorunfemi | <i>E. polycnemoides</i> | x | Zaria | Small glabrous herb up to 4-6" high tiny fruits | 21/7/66 |
| 231. | FHI 79529 | Oyayomi/Fagbemi/ Onijamowo/Ogun tayo/Arasi OFOOA.396 | <i>E. polycnemoides</i> | x | Afaka | A herb about 2m high, stem brown and glabrous with fruits green | 5/12/76 |
| 232. | FHI 17979 | S.O Magaji MG-188 | <i>E. polycnemoides</i> | x | Katsina | Herb up to 2ft, flowers red | 21/10/67 |
| 233. | FHI 54827 | Stanfield, D.P | <i>E. polycnemoides</i> | x | Naraguta | Slender herb, white latex | 24/6/64 |
| 234. | GC 694 | Adams, C.D | <i>E. polycnemoides</i> | x | Kampala(Ghana) | low branching herb with reddish stems and pinkish red flower | 22/06/51 |
| 235. | IFE 2635 | Faremi, I.B. | <i>E. polycnemoides/E. kerstingii</i> | x | Borgu | A small succulent herb exudes milky latex when cut | 10/1/77 |
| 236. | FHI 13874 | APD Jones | <i>E. prostrata</i> | x | Ibadan | Plant prostrate, annual, stem reddish brown, peduncle likewise, leaves dark glaucous grey- green | 28/10/45 |

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|------|---------------------|----------------------|-----------------------|---|-----------------|--|----------------|
| | | | | | | above, much paler below, flower pinkish red | |
| 237. | FHI 99529 | Ariwaodo & Others | <i>E. prostrata</i> | x | Hunta-Ibere | Euphorbiacea | Feb, 1982 |
| 238. | FHI 36027 | Brenan J.P.M. | <i>E. prostrata</i> | x | Odode | Herb with prostrata stem radiating from root stalk, stem purple, leaves glaucous above, pale glaucous beneath. Flowers purplish green | 6/1/1948 |
| 239. | FHI 61949 | Daramola & Binuyo | <i>E. prostrata</i> | x | Bida | Herb with red stem, flowers grey and latex | 1/3/68 |
| 240. | IFE 1471 | Daramola, O.B. | <i>E. prostrata</i> | x | Ife | Herb growing by the side of wet walls at the garden, leaf very tiny, flower greenish | 17/10/ 2000 |
| 241. | FHI 95903 | Ekwuno & Others. | <i>E. prostrata</i> | x | Ikom | A prostrate herb, flowers cream, latex white | 11/2/82 |
| 242. | FHI 93940 | Ekwuno/ Fagbemi | <i>E. prostrata</i> | x | Baga | A herb to 6" high, latex white, fruit brown | 26/9/80 |
| 243. | FHI 94073 | Ekwuno/ Fagbemi | <i>E. prostrata</i> | x | Borno | A prostrate herb, latex white, fruit brown | 1/10/80 |
| 244. | UIH 10173 | Gledhill, D. | <i>E. prostrata</i> | x | Ibadan | Weed of damp shaded ground around buildings | 1/5/68 |
| 245. | IFE 2648A | Guile,DPM | <i>E. prostrata</i> | x | Ibadan | A glaucous prostrate herb of pathways | June, 1967 |
| 246. | FHI 37827 | Keay RWJ | <i>E. prostrata</i> | x | Ibadan | Prostrate herb with a bluish tinged to the leaves, stem and petioles dull pinkish | 9/12/60 |
| 247. | FHI 37132 | Keay, RWJ | <i>E. prostrata</i> | x | Ibadan | Prostrate herb, sometimes the stems are slightly ascending rarely. Some stems are wholly erect. Stems and midribs beneath pinkish, leaves bluish-green above, pale beneath | 17/7/57 |
| 248. | UIH 13453/FHI 58426 | Latilo, M.G. | <i>E. prostrata</i> | x | Igbajo | Spreading herb, flowers-petals white hairy-fruits green, hairy | 25/4/66 |
| 249. | FHI 62270 | Latilo, MG | <i>E. prostrata</i> | x | Egbe | Spreading herb, fruits hairy, greenish in color | 14/11/68 |
| 250. | FHI 62763 | Latilo, MG | <i>E. prostrata</i> | x | Amarawa(Sokoto) | Spreading herb, flowers white, fruits green | 3/8/69 |
| 251. | FHI 24746 | Onochie CFA & Latilo | <i>E. prostrata</i> | x | Borno | Prostrate herb, with pink branch lets. Exuding white when broken. | 22/6/58 |
| 252. | FHI 27592 | P.WT-28 | <i>E. prostrata</i> | x | Ibadan | Creeping herb stems dark green above, pale green beneath fruit light green | 17/8/71 |
| 253. | UIH 11069 | Alasoadura,S.A.- | <i>E. pulcherrima</i> | x | Ibadan | Shrub with red colored showy leaves around the | 1/10/55 |

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|------|------------|------------------------------|------------------------|---|-------------|--|------------|
| | | 38 | | | | inflorescence is peculiar in that it stimulates a single flower, where as it is a modified cyme termed a cyathium | |
| 254. | IFE 2663 | Guile, D.P.M. 561 | <i>E. pulcherrima</i> | x | Ife | A shrub with brilliant red bracts- native of Mexico | Oct,1966 |
| 255. | FHI 34364 | Latilo & Daramola | <i>E. pulcherrima</i> | x | Mambilla | Shrub about 3ft high. Flowers yellow | 7/1/55 |
| 256. | FHI 65171 | Oguntayo & Ibh | <i>E. pulcherrima</i> | x | Nsukka | A climber leaves alternate, red at petiole and green on the rest parts. Stem purple green | 27/5/72 |
| 257. | FHI 107236 | Onocha & Usang F. | <i>E. pulcherrima</i> | x | Ibadan | An erect woody shrub or small tree of about 7ft tall pitted stem bark. Simple red leaves or ox-blood used as anti snake. Stem white latex. | 21/6/05 |
| 258. | UCI 21642 | Lowe, J.4941 | <i>E. sanguinea</i> | x | Ibadan | Shrub, young leaves dark red, older leaves with red veins, glands of inflorescence green with a white fringe, stamens purple | 6/6/91 |
| 259. | GC 10792 | A.S. Boughey | <i>E. schimperiana</i> | x | Fernando Po | sunmit wool | 30/12/52 |
| 260. | FHI 37127 | Keay, RWJ | <i>E. scordifolia</i> | x | Markudi | Annual herb, procumbent or weakly ascending, stems and flowers with reddish hairs, leaves green above, greyish beneath | 7/7/57 |
| 261. | FHI 82904 | Oyayomi & Osanyinlusi S.O.68 | <i>E. scordifolia</i> | x | Imeko | A herb up to 30cm. High with red fruits | 2/6/77 |
| 262. | FHI 93864 | Ekwuno & Fagbemi EF.89 | <i>E. sp</i> | X | Zaga, Bornu | A pubescent herb to 1” high, fruit brown | 24/9/80 |
| 263. | IUH 184 | Olawale, J.A. 05 | <i>E. sp.</i> | X | Ilorin | It grows annually, it’s a soft stem, weed with small yellow flowers when fresh, leaf arrangement is alternate and lanceolate in shape | 9/4/84 |
| 264. | FHI 91414 | KZOG.356 | <i>E. sp.</i> | X | | Procumbent herb. Latex white. | 24/10/79 |
| 265. | IFE 2659 | Daramola, | <i>E. thymifolia</i> | X | Ibadan | Herb spreading with red color close to the end of the plant | 28/9/ 2000 |
| 266. | FHI 70356 | Eimujeze/ Ekwuno/ Onijamowo | <i>E. thymifolia</i> | X | Kotonkarifi | Herb with reddish inflorescence | 21/3/73 |
| 267. | FHI 63813 | Ekwuno, P.O | <i>E. thymifolia</i> | X | Bukana | A prostrate herb with white flowers, latex white | 25/1/71 |

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|------|-----------|---------------------------|---|---|-------------------|---|-------------|
| 268. | FHI 93943 | Ekwuno/ Fagbemi EF 168 | <i>E. thymifolia</i> | X | Baga | A herb prostrating, latex white, fruit brown | 26/9/ 80 |
| 269. | IFE 2667A | Faremi, I.B.1608 | <i>E. thymifolia</i> | X | Ife | A well branched shrub of abt 3metres high, leaves dark purple | 19/10/78 |
| 270. | IFE 2658 | Faremi, I.B. | <i>E. thymifolia</i> | X | Ife | A prostrating herb, leaves purple | 17/12/74 |
| 271. | FHI 73611 | Gbile & Daramola | <i>E. thymifolia</i> | X | Zaria | Euphorbia creeping with white latex, brown stem and fruits | 22/11/74 |
| 272. | IFE 2654A | Guile, DPM | <i>E. thymifolia</i> | X | Ibadan | A common lawn weed of pinkish blue | April, 1966 |
| 273. | UIH 14258 | Jackson, G-2 | <i>E. thymifolia</i> | X | Sokoto | Cattle trail experiment crown at Botany dept UI from seed in dung collected at Sokoto | 28/10/70 |
| 274. | FHI 37815 | Keay RWJ | <i>E. thymifolia</i> | X | Maiduguri | Prostrate herb | 22/6/60 |
| 275. | FHI 21185 | Keay, RWJ | <i>E. thymifolia</i> | X | Ijaye | Prostrate herb, branches radiating from central herbs root | 5/3/47 |
| 276. | FHI 37121 | Keay, RWJ | <i>E. thymifolia</i> | X | Kwagiri | Prostrate weed on old road, leaves green, stem pink | 6/7/1957 |
| 277. | FHI 37828 | Keay, RWJ | <i>E. thymifolia</i> | X | Ibadan | Prostrate herb, leaves green above, stem and petioles pink | 9/12/60 |
| 278. | UIH 12017 | Lowe, J. -2047 | <i>E. thymifolia</i> | X | Ibadan | Prostrate herb on lawns | 19/3/70 |
| 279. | FHI 27351 | Lowe, J.2047 | <i>E. thymifolia</i> | X | Ibadan | Prostrate herb on lawns , stems reddish | 20/3/70 |
| 280. | FHI 35857 | Onochie CFA | <i>E. thymifolia</i> | X | Onitsha | Carpet herb. Stem pale green and pink, flowers pale green, exuding white milky sap | 2/6/56 |
| 281. | FHI 58139 | Onyeachusim/ Binuyo | <i>E. thymifolia</i> | X | Kainji | Herb, stem red, stipules hair like, juice white | 5/3/66 |
| 282. | GC 2593 | Hall, J. B | <i>E. thymifolia</i> | X | cape coast(Ghana) | decumbent branched weed with tap root, stems pinkish, leaves bright green | 30/05/64 |
| 283. | FHI 37051 | Keay, RWJ | <i>E. thymifolia</i> / <i>E. aegyptiaca</i> / <i>E. prostrata</i> | X | Owena | Prostrate herb, stems and inflorescences pink | 2/6/57 |
| 284. | UIH 21027 | Sanwo, S.K. | <i>E. tirucalli</i> | X | Ibadan | Tree cylindrical succulent branches | 25/7/85 |
| 285. | FHI 43367 | Oladoyinbo, A | <i>E. unispina</i> | X | Ifon | Succulent plant up to 20ft, green flower yellowish green, fruit brownish red | 30/10/59 |

4. 2 Geographical Distribution, Ecology And Conservation Status

From the result of this study, it was observed that *Euphorbia* species are widely distributed within the country (Figs. 4- 6) where they occupy a wide range of habitats (Table 4). They are clearly separated in to herbs, cacti-forms (succulents) and shrubs (Table 5). Fig. 3 shows the various vegetation zones in Nigeria. Specimens of *E. aegyptiaca* were collected from Jos and Baga in woodland savanna. *E. convolvuloides* were collected from Utuwang, Jebba, Gwandon, Borgu, Igbetti, Zambufu, Ilorin, Ghazaka, Lafiagi, Yankari, Borno, Kiriimi, Abeokuta, Abuja, Runka, Yola, Lokoja, Okenne, Iwo, Olokemeji, Ibuya, Maiduguri, Bida and Kaaba (Rain forest, woodland and short grass savanna zones). Specimens of *E. deightonii* were collected from Akor, Aweba, Ibadan and Idanre hill (rain forest zone). Specimens of *E. depauperata* were collected from Mambilla, Adamawa and Ibadan (Savanna and rain zones).

Two specimens of *E. desmondii* collected are from Tula, Gombe (Short grass savanna). Specimens of *E. glaucophylla* were collected from Ife, Eruwa, Abeokuta, Badagry, Ibadan, Ijebu-Igbo, Bacita, Gambari and Shaki (Mangrove and Rain forest zones). Specimens of *E. heterophylla* were collected from Ibadan, Okorshie, Benin, Edondon, Zaria, Sakpoba, Kaaba, Kaduna, Kafancha, Mangu, Bida, Eruwa, Naraguta, Ajobo, Eruwa, Owo, Samaru, Lagos and Lokoja (all the vegetation zones except montane and marginal savanna zones). *E. hirta* is cosmopolitan in distribution (Fig. 6). Specimens of *Euphorbia hirta* were collected from all the various vegetation zones. *E. hyssopifolia* were collected from Awi, Owenna, Calabar, Ise-Ekiti, Apapa, Okitipupa, Argungu, Port-Harcourt, Ekenwa, Kano, Kolokuma, River Niger, Kaiama, Jalingo, Badagry, Imeko, Borgu and Igbo-ora (Mangrove, Fresh water swamp and Rain forest zones). Specimens of *E. lateriflora* were collected from Afunremu, Jos, Kano, Zaria, Maiduguri,

Bichu, Naraguta, Ilesha and Ibadan (rain forest, short grass savanna and woodland/tall grass savanna zones). Two specimens of *Euphorbia leucophylla* were collected from Ibadan. Also, only two specimens of *E. milii* were collected from Ibadan. Specimens of *E. poissonii* were collected from Kachia, Ibadan, Jebba, Jos, Igbetti, Bauchi and Pambegwa (woodland/tall grass savanna). Specimens of *E. polycnemoides* were collected from Pedong, Gidan Mundi, Jos, Zaria, Bauchi, Afaka, Naraguta, Borgu and Gombe. *E. prostrata* specimens were collected from Egbe, Ibadan, Borno, Sokoto, Baga, Ikom, Ife and Ohunbe. Specimens of *E. pulcherrima* were collected from Ibadan, Mambilla, Nsukka and Ife. Only two specimens of *E. scordifolia* were collected from Imeko and Markudi. Specimens of *E. thymifolia* were collected from Ibadan, Kotonkarifi, Bukana, Baga, Ife, Zaria, Sokoto, Maiduguri, Ijaye, Onitsha and Kainji.



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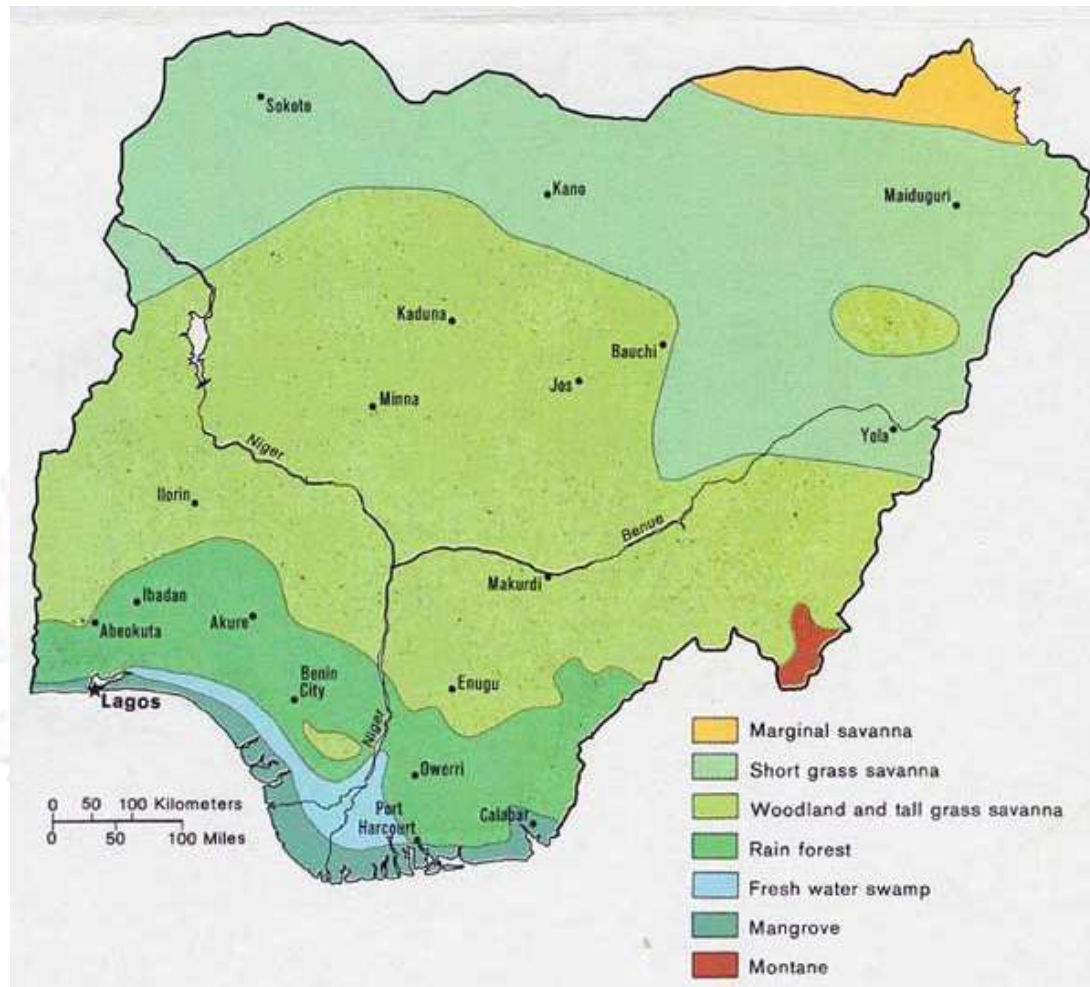


Fig. 3: Map of Nigeria showing the vegetation zones (Iloeje, 2001)

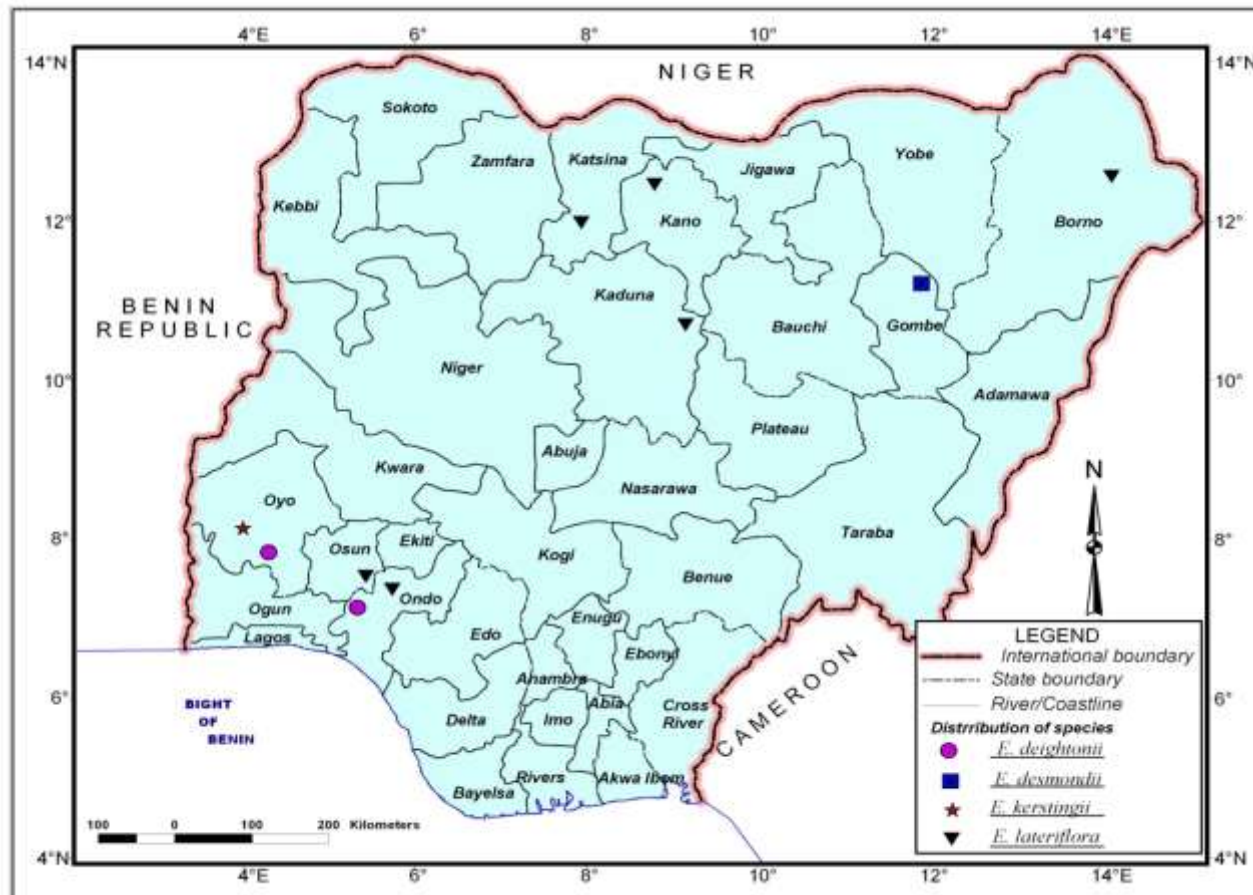


Fig. 4: Distribution map for *E. lateriflora*, *E. deightonii*, *E. desmondii* and *E. kerstingii* in Nigeria



Fig. 5: Distribution map for *E. heterophylla* in Nigeria

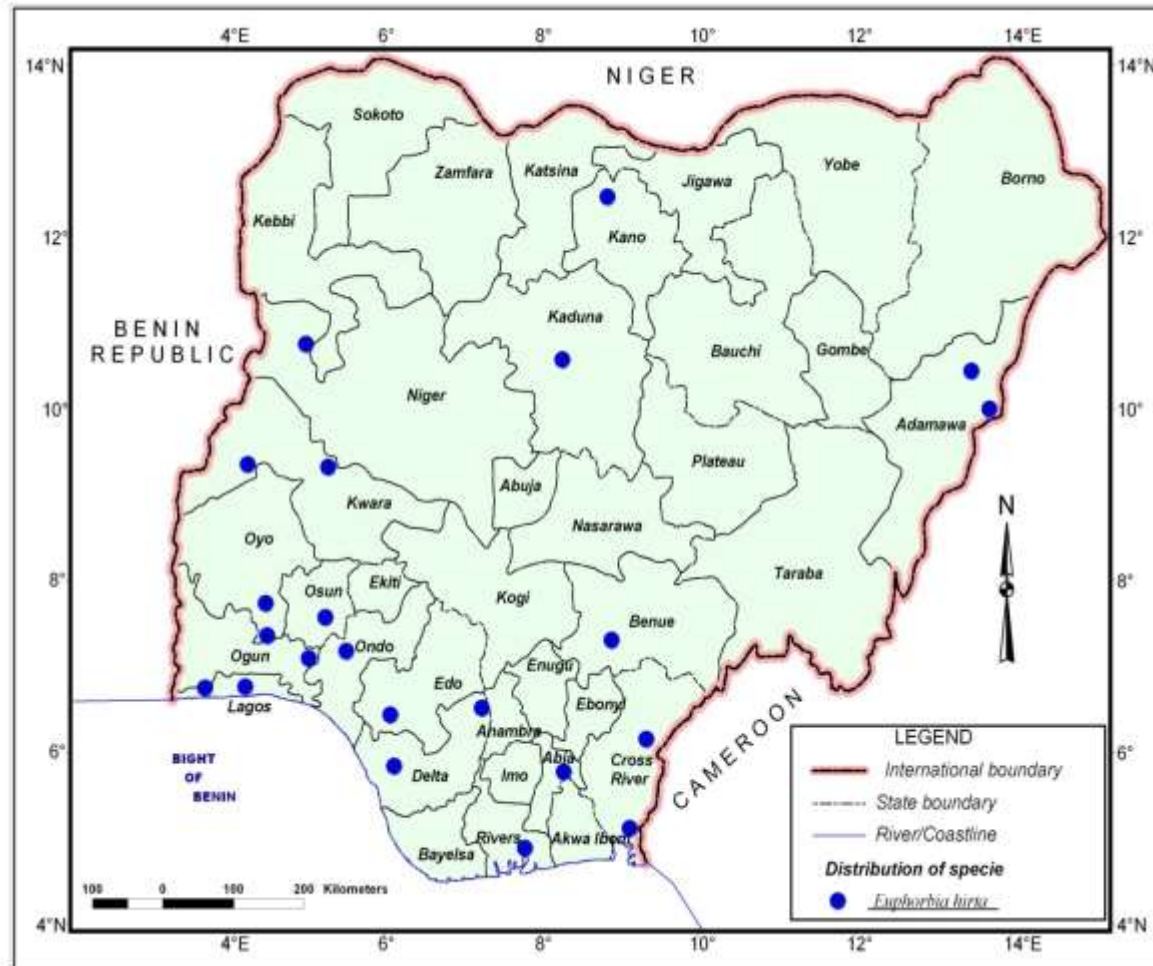


Fig. 6: Distribution map for *E. hirta* in Nigeria

4.3 Morphological characterization

4.3.1 Vegetative morphology

All *Euphorbia* spp. Studied were small, low growing perennial herbs to prostrate annuals (dwarf), leafy shrubs and well-developed trees that were either succulent or cacti like (Table 5, Plates 1-2). Herbaceous species include: *E. aegyptiaca*, *E. thymifolia*, *E. kerstingii*, *E. prostrata*, *E. scordifolia*, *E. ampla*, *E. бага*, *E. calva*, *E. convolvuloides*, *E. depauperata*, *E. glaucophylla*, *E. glomerifera*, *E. heterophylla*, *E. hirta*, *E. hyssopifolia*, *E. macrophylla* and *E. sp. B*. Shrubby species include: *E. cotinifolia*, *E. leucophylla*, *E. milii*, *E. pulcherimma* and *E. sudanica*. While cactiform or succulent species include: *E. deightonii*, *E. desmondii*, *E. ingens*, *E. kamerunica*, *E. keithii*, *E. lateriflora*, *E. lateriflora* and *E. unispina*.

The vegetative morphological features of the genus are summarized in Tables 5- 7 and shown in Plates 1-10. The leaves were either prominently present or drastically reduced and ephemeral. Species with ephemeral leaves include: *E. aegyptiaca*, *E. depauperata*, *E. hyssopifolia*, *E. ingens*, *E. kamerunica*, *E. keithii*, *E. lateriflora* and *E. prostrata* while others were prominent. These were either pinnately compound or simple. The leaf lengths ranged from 0.52 ± 0.12 cm to 10.00 ± 0.82 cm while the leaf widths ranged from 0.10 ± 0.01 cm to 5.43 ± 0.32 cm (Table 5). Leaf arrangement was opposite/deccussate, alternate or whorled; petiole was either petiolated or sessile. The leaf surface was either glossy or pubescent while the shapes were elliptic, ovate, obovate, oblong or lanceolate. The leaf base was acute, obtuse, rounded, cuneate, truncate or chordate; leaf apex was apiculate, acute, sub- acute, mucronate, cuspidate, retuse or emarginate; leaf margin was serrulate, serrate, toothed, crenulate or entire (Tables 6 and 7, Plates 3- 7). In this study, the overall appearance of the stem provided useful taxonomic characters within the genus *Euphorbia*. Spines on stems were single, tufted or bifid (Plate 8). The stem were greenish,

greyish, pinkish or reddish purple. *E. cotinifolia* was reddish purple, *E. milii* and *E. sudanica* were greyish while *E. hirta*, *E. hyssopifolia*, *E. prostrata* and *E. thymifolia* were pinkish. All cactiform species were greenish in colour. Their appearances resembled the cacti. Some of them had well developed segmented stems. Apart from this, spines were either present or absent. Where present, they were solitary, paired or tufted; arranged all over the stem or along the angles. Some of them had spines whose types and arrangements were different. Some were spirally arranged while others were angled. Those without spines were either glabrous or pubescent. There were considerable differences in the heights and appearances of the plants. Both *E. бага* and *E. calva* had tuberous stems (Plate 3C).

Members were characterized by mainly tomentose indumentum (although some of them were pilose). The leaves, inflorescences, fruits and stems were covered by densely wooly soft matted hairs which occur singly as multicellular hairs (Plate 9). Such species include: *E. aegyptiaca*, *E. convolvuloides*, *E. heterophylla*, *E. hirta*, *E. leucophylla*, *E. scordifolia* and *E. thymifolia*. Pilose indumenta were found on *E. thymifolia* and *E. prostrata*. Also, some of the species were glabrous in nature most especially the succulent species (with spines on their stems). Herbaceous species had glabrous and shining leaves, inflorescences, fruits and stems. Examples include: *E. ampla*, *E. balsamifera*, *E. convolvuloides*, *E. cotinifolia*, *E. depauperata*, *E. kerstingi*, *E. glaucophylla*, *E. sudanica*, *E. pulcherimma*, *E. polycnemoides*, *E. poissonii* and *E. calva*. The different types of indumenta found in genus *Euphorbia* are shown in Table 3 and Plate 9. The root system consisted mainly of a tap root system which branched profusely. However, two species (*E. calva* and *E. бага*) were found to be fine or thick and tuberous (Plate 10). The annual/perennial species also branched profusely and most of the roots were long and creeping.

Table 5: Quantitative leaf features and growth habits of *Euphorbia* species in Nigeria

| S/N | Taxa | Nature | Habit | Leaf Length (cm) | Leaf width (cm) | Petiole length (cm) |
|-----|--------------------------|-------------------------|-------------------|------------------|-----------------|---------------------|
| | | | | (Mean ± SE) | (Mean ± SE) | (Mean ± SE) |
| 1 | <i>E. aegyptiaca</i> | Herb (dwarf) | Procumbent | 0.55 ± 0.05 | 0.28 ± 0.03 | 0.05 ± 0.004 |
| 2 | <i>E. ampla</i> | Herb | Erect | 4.40 ± 0.05 | 0.4 ± 0.01 | 0.25 ± 0.01 |
| 3 | <i>E. бага</i> | Herb | Erect | 3.50 ± 0.01 | 0.65 ± 0.01 | 0.6 ± 0.01 |
| 4 | <i>E. balsamifera</i> | Shrub | Erect | 1.60 ± 0.05 | 0.10 ± 0.01 | 0.00 |
| 5 | <i>E. calva</i> | Herb | Erect | 5.20 ± 0.08 | 0.21 ± 0.01 | 0.00 |
| 6 | <i>E. convolvuloides</i> | Herb | Semi- erect | 1.96 ± 0.08 | 0.56 ± 0.03 | 0.17 ± 0.01 |
| 7 | <i>E. cotinifolia</i> | Shrub | Erect | 7.30 ± 1.62 | 4.55 ± 0.62 | 4.43 ± 0.54 |
| 8 | <i>E. deightonii</i> | Cacti form (succulent) | Erect (segmented) | 9.05 ± 0.22 | 4.13 ± 1.38 | 0.00 |
| 9 | <i>E. depauperata</i> | Herb | Erect | 1.5 ± 0.38 | 0.67 ± 0.03 | 0.00 |
| 10 | <i>E. desmondii</i> | Cacti form (tree) | Erect | 10.00 ± 0.82 | 5.43 ± 0.32 | 0.00 |
| 11 | <i>E. glaucophylla</i> | Herb | Procumbent | 1.43 ± 0.29 | 0.97 ± 0.34 | 0.22 ± 0.09 |
| 12 | <i>E. glomerifera</i> | Herb | Procumbent | 1.80 ± 0.30 | 0.30 ± 0.01 | 0.20 ± 0.01 |
| 13 | <i>E. heterophylla</i> | Herb | Erect | 5.76 ± 0.27 | 2.78 ± 0.14 | 1.31 ± 0.12 |
| 14 | <i>E. hirta</i> | Herb | Semi erect | 2.73 ± 0.15 | 1.06 ± 0.06 | 0.24 ± 0.01 |
| 15 | <i>E. hyssopifolia</i> | Herb | Erect | 1.44 ± 0.21 | 0.64 ± 0.12 | 0.12 ± 0.01 |
| 16 | <i>E. ingens</i> | Cacti form (tree) | Erect | 0.52 ± 0.12 | 0.20 ± 0.01 | 0.00 |
| 17 | <i>E. kamerunica</i> | Cacti form (tree) | Erect | 0.60 ± 0.12 | 0.20 ± 0.01 | 0.00 |
| 18 | <i>E. kerstingii</i> | Herb (dwarf) | Procumbent | 1.15 ± 0.13 | 0.25 ± 0.03 | 0.09 ± 0.01 |
| 19 | <i>E. keithii</i> | Cacti form (tree) | Erect (segmented) | 0.65 ± 0.12 | 0.20 ± 0.01 | 0.00 |
| 20 | <i>E. lateriflora</i> | Cacti form (shrub) | Erect (segmented) | 1.20 ± 0.12 | 0.32 ± 0.04 | 0.00 |
| 21 | <i>E. leucophylla</i> | Shrub | Erect | 4.44 ± 0.92 | 1.14 ± 0.23 | 0.93 ± 0.04 |
| 22 | <i>E. macrophylla</i> | Herb | Erect | 5.76 ± 0.27 | 2.78 ± 0.14 | 1.31 ± 0.12 |
| 23 | <i>E. milii</i> | Shrub (semi- succulent) | Semi erect | 2.52 ± 0.39 | 3.20 ± 0.19 | 0.32 ± 0.04 |
| 24 | <i>E. prostrate</i> | Herb (dwarf) | Procumbent | 0.72 ± 0.12 | 0.38 ± 0.06 | 0.09 ± 0.01 |
| 25 | <i>E. pulcherrima</i> | Shrub | Erect | 5.3 ± 1.55 | 4.88 ± 0.73 | 4.37 ± 0.47 |
| 26 | <i>E. scordifolia</i> | Herb(dwarf) | Procumbent | 1.20 ± 0.01 | 0.60 ± 0.01 | 0.20 ± 0.01 |
| 27 | <i>E. sp. B</i> | Herb | Erect | 4.76 ± 0.27 | 2.75 ± 0.14 | 1.21 ± 0.12 |
| 28 | <i>E. sudanica</i> | Shrub (woody) | Erect (segmented) | 9.63 ± 0.82 | 4.13 ± 0.32 | 0.17 ± 0.01 |
| 29 | <i>E. thymifolia</i> | Herb(dwarf) | Procumbent | 1.30 ± 0.33 | 0.50 ± 0.08 | 0.48 ± 0.12 |
| 30 | <i>E. unispina</i> | Cacti form (tree) | Erect | 7.10 ± 1.02 | 5.43 ± 1.32 | 0.00 |

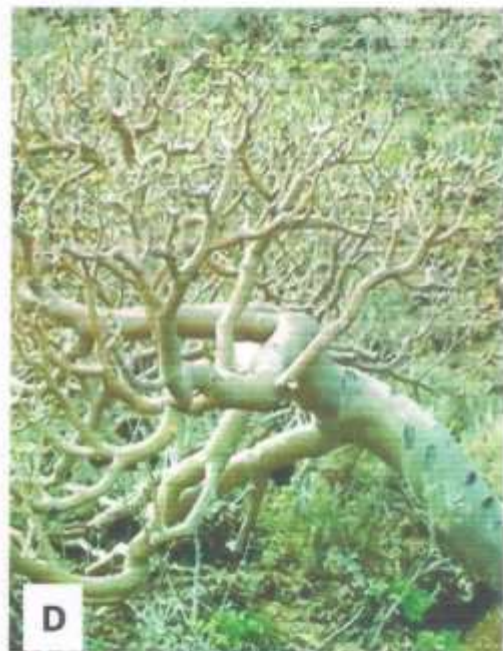


Plate 1: Photographs of habits of species of *Euphorbia* ($\times 0.1$)

(A) Erect herb (*E. hirta*)

(B) Procumbent or scrambling herb (*E. prostrata*)

(C) Woody shrub (*E. milii*)

(D) Woody tree (*E. balsamifera*)



Plate 2: Photographs of habits of succulent *Euphorbia species* ($\times 0.1$)

- (A) Succulent herb (*E. бага*)
- (B) Cacti form tree (white arrow) (*E. kamerunica*)
- (C) Succulent shrub (*E. lateriflora*)
- (D) Succulent shrub (*E. unispina*)

Table 6: Leaf macroscopic characters of *Euphorbia* species

| S/N | Taxa | Prominence | Types | Arrangement | Shape | Margin | Base | Apex | Indumentum | Petiole |
|-----|----------------------------------|------------|----------|---------------------|------------------------|--------------------|----------|------------------|------------|---------|
| 1 | <i>E. aegyptiaca</i> | Prominent | Simple | Opposite | Oblong/Elliptic | Serrulate | Obtuse | Sub-Acute | Pr | Pr |
| 2 | <i>E. ampla</i> | Prominent | Simple | Whorl | Lanceolate | Entire | Acute | Acute | Ab | Pr |
| 3 | <i>E. бага</i> | Prominent | Simple | Decussate | Ovate | Entire | Acute | Sub-Acute | Ab | Ab |
| 4 | <i>E. balsamifera</i> | Prominent | Simple | Decussate | Oblong | Entire | Acute | Sub-Acute | Ab | Ab |
| 5 | <i>E. calva</i> | Reduced | Simple | Alternate | Obovate/Ovate | Crenulated | Obtuse | Acute | Ab | Ab |
| 6 | <i>E. convolvuloides</i> | Prominent | Compound | Opposite/Alternate | Obovate/Ovate | Serrate/Tooth | Chordate | Acute | Pr | Pr |
| 7 | <i>E. cotinifolia</i> | Prominent | Simple | Decussate | Ovate | Entire | Truncate | Cuspidate | Ab/Glossy | Pr |
| 8 | <i>E. deightonii</i> | Prominent | Simple | Decussate | Obovate | Entire | Acute | Mucronate | Ab | Ab |
| 9 | <i>E. depauperata</i> | Reduced | Simple | Alternate | Linear Lanc/Obovate | Entire | Cuneate | Obtuse/Apiculate | Ab | Ab |
| 10 | <i>E. desmondii</i> | Prominent | Simple | Opposite | Obovate | Entire | Acute | Retuse | Ab | Ab |
| 11 | <i>E. glaucophylla</i> | Prominent | Compound | Opposite/Decussate | Oblong/Ovate | Serrulate | Obtuse | Acute | Ab | Pr |
| 12 | <i>E. glomerifera</i> | Prominent | Compound | Opposite | Elliptic | Serrulate | Obtuse | Acute | Ab | Pr |
| 13 | <i>E. heterophylla</i> | Prominent | Simple | Opposite/ Alternate | Oblong/Obovate/Ovate | Entire/Tooth/Serra | Truncate | Acute/Apiculate | Pr | Pr |
| 14 | <i>E. hirta</i> | Prominent | Simple | Opposite | Oblong/Ovate/Elliptic | Serrulate | Obtuse | Acute | Pr | Pr |
| 15 | <i>E. hyssopifolia</i> | Reduced | Compound | Opposite | Oblong/Ovate | Entire | Obtuse | Obtuse | Ab/Glossy | Pr |
| 16 | <i>E. ingens</i> | Reduced | Simple | Opposite | Elliptic | Entire | Acute | Acute | Ab/Glossy | Ab |
| 17 | <i>E. kamerunica</i> | Reduced | Simple | Opposite/Decussate | Obovate | Entire | Cuneate | Emarginated | Ab | Ab |
| 18 | <i>E. keithii</i> | Reduced | Simple | Opposite | Elliptic | Entire | Acute | Acute | Ab/Glossy | Ab |
| 19 | <i>E. lateriflora</i> | Reduced | Simple | Alternate/Decussate | Oblong/Ovate | Entire | Acute | Acute | Ab/Glossy | Ab |
| 20 | <i>E. leucophylla</i> | Prominent | Simple | Decussate | Oblong | Entire | Obtuse | Apiculate | Ab | Pr |
| 21 | <i>E. macrophylla</i> | Prominent | Compound | Opposite | Elliptic | Entire | Acute | Obtuse | Ab | Pr |
| 22 | <i>E. milii var. hislopii</i> | Prominent | Simple | Decussate | Oblong | Entire | Acute | Mucronate/Emargi | Ab/Glossy | Ab |
| 23 | <i>E. milii var. splendens</i> | Prominent | Simple | Decussate | Oblong | Entire | Acute | Mucronate/Emargi | Ab/Glossy | Pr |
| 24 | <i>E. milii var. tananarivae</i> | Prominent | Simple | Decussate | Oblong | Entire | Acute | Mucronate/Emargi | Ab/Glossy | Ab |
| 25 | <i>E. milii var. tenuispina</i> | Prominent | Simple | Decussate | Oblong | Entire | Acute | Acute | Ab/Glossy | Pr |
| 26 | <i>E. polycnemoides</i> | Prominent | Compound | Opposite | Oblong/Ovate | Serrulate | Obtuse | Acute | Ab/Glossy | Pr |
| 27 | <i>E. prostrata</i> | Prominent | Simple | Opposite | Oblong/Ovate | Serrulate | Obtuse | Acute | Ab/Glossy | Pr |
| 28 | <i>E. pulcherrima</i> | Prominent | Simple | Decussate | Elliptic/Ovate/Obovate | Entire/Tooth | Acute | Cuspidate | Ab/Glossy | Pr |
| 29 | <i>E. scordifolia</i> | Reduced | Compound | Opposite | Ovate | Serrate | Acute | Acute | Pr | Pr |
| 30 | <i>E. sp.B</i> | Prominent | Simple | Opposite | Elliptic | Entire | Obtuse | Acute | Pr | Pr |
| 31 | <i>E. sudanica</i> | Prominent | Simple | Whorl | Lanceolate/Ovate | Entire | Acute | Mucronate | Ab | Ab |
| 32 | <i>E. thymifolia</i> | Reduced | Compound | Opposite | Oblong | Serrulate | Rounded | Obtuse | Ab/Glossy | Pr |
| 33 | <i>E. unispina</i> | Prominent | Simple | Opposite | Lanceolate | Entire | Acute | Mucronate | Ab/Glossy | Ab |

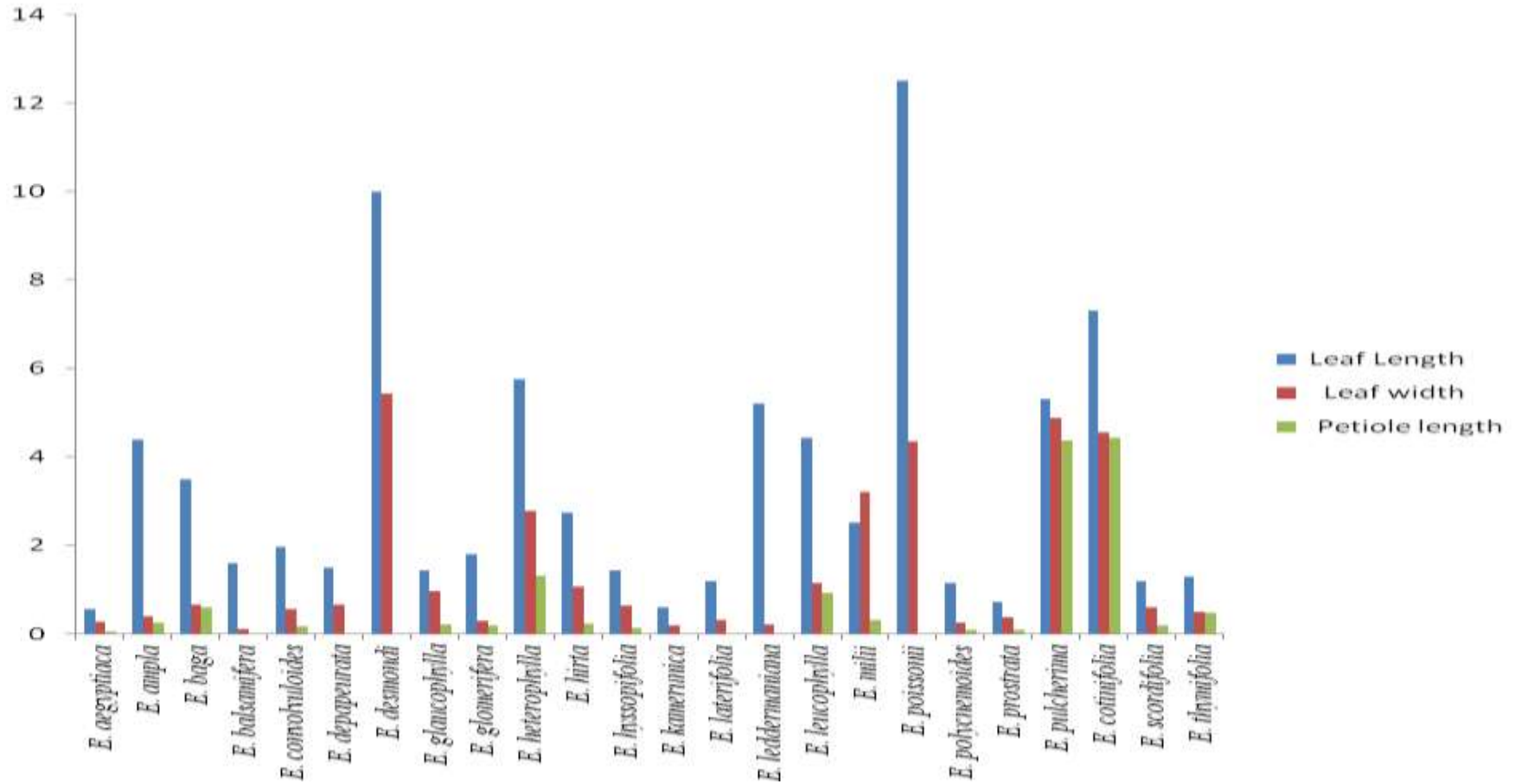


Fig. 7: A bar-chart showing the quantitative values (cm) of the leaves of *Euphorbia* species found in Nigeria



Plate 3: Photographs of herbarium specimens of some *Euphorbia* species showing:

- (A) *E. aegyptiaca* – opposite leaves (C) *E. ampla*- opposite leaves
 (B) *E. бага* – decussate leaves and tuberous stem (D) *E. calva* - alternate leaves



A



B



C



D

Plate 1: Photographs of herbarium specimens of *Euphorbia* species showing arrangements, shapes and apices of leaves.

- (A) *E. convolvuloides* – herbaceous nature of the stem ,
- (B) *E. deightonii* – succulent stem with spines along the margin
- (C) *E. depauperata* - alternate leaf arrangement
- (D) *E. desmondii* – opposite, obovate, entire and acute leaves.

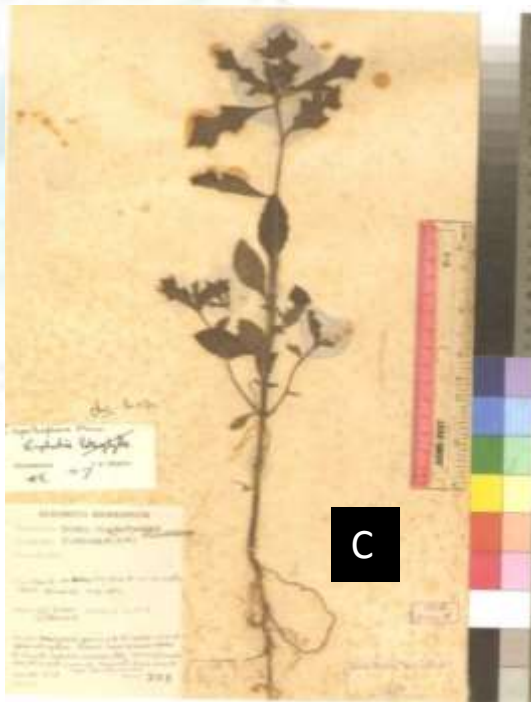
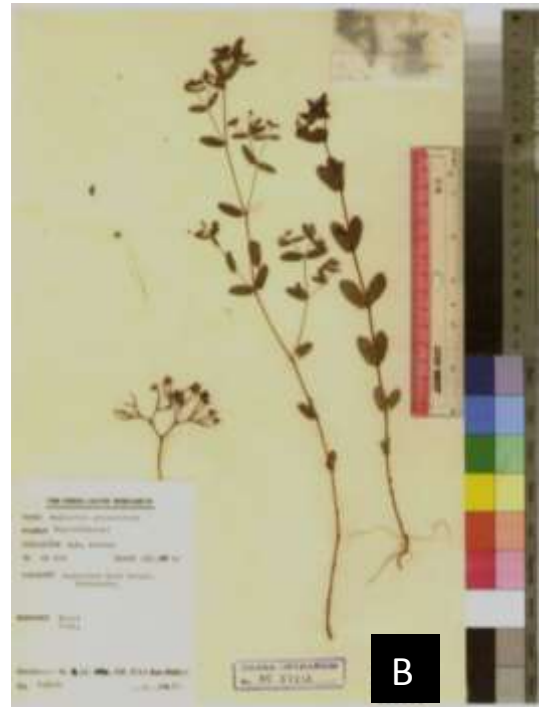


Plate 2: Photographs of herbarium specimens of *Euphorbia* species showing the nature of stem and inflorescence.

- (A) *E. glaucophylla*: herbaceous nature
- (B) *E. glomerifera*: elliptic and serrated leaves
- (C) *E. heterophylla* – elliptic leaf
- (D) *E. lateriflora* - inflorescence



Plate 3: Photographs of herbarium specimens of *Euphorbia* species showing spines, and leaf blades.

(A) *E. milii* misidentified as *E. monteiri* – leaf shape and spines

(B) *E. possonii* – leaf apex is mucronate

(C) *E. polycnemoides*- opposite leaves

(D) *E. thymifolia* – herbaceous in nature.



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Table 7: Stem morphological characters of the species of *Euphorbia* in Nigeria



| S/N | Taxa | Indumentum | Colour | Shape | Succulence | Spines | | |
|-----|---|------------|---------------------|------------|------------|--------|-----------------|-----------------|
| | | | | | | Pr/ab | Type | Arrangement |
| 1. | <i>E. aegyptiaca</i> | Pr | Brownish Grey/Pink | Not Angled | No | Ab | Ab | Ab |
| 2. | <i>E. ampla</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 3. | <i>E. бага</i> | Ab | Grayish | Not Angled | No | Ab | Ab | Ab |
| 4. | <i>E. balsamifera</i> | Ab | Grayish | Not Angled | No | Ab | Ab | Ab |
| 5. | <i>E. calva</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 6. | <i>E. convolvuloides</i> | Pr | Green/Pink | Not Angled | No | Ab | Ab | Ab |
| 7. | <i>E. cotinifolia</i> | Ab | Dark Reddish purple | Not Angled | No | Ab | Ab | Ab |
| 8. | <i>E. deightonii</i> | Ab | Green | Angled-3-6 | Yes | Pr | Paired | Along The Angle |
| 9. | <i>E. depauperata</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 10. | <i>E. desmondii</i> | Ab | Green | Angled-3-6 | Yes | Pr | Paired | Along The Angle |
| 11. | <i>E. glaucophylla</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 12. | <i>E. glomerifera</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 13. | <i>E. heterophylla</i> | Pr | Green | Not Angled | No | Ab | Ab | Ab |
| 14. | <i>E. hirta</i> | Pr | Green/Pink | Not Angled | No | Ab | Ab | Ab |
| 15. | <i>E. hyssopifolia</i> | Ab | Green/Pink | Not Angled | No | Ab | Ab | Ab |
| 16. | <i>E. ingens</i> | Ab | Green | Angled-3-6 | Yes | Pr | Paired/Solitary | Along The Angle |
| 17. | <i>E. kamerunica</i> | Ab | Green | Angled-3-6 | Yes | Pr | Paired/Solitary | Along The Angle |
| 18. | <i>E. keithii</i> | Ab | Green | Angled-3-6 | Yes | Pr | Solitary | Along The Angle |
| 19. | <i>E. lateriflora</i> | Ab | Green | Not Angled | Yes | Ab | Ab | Ab |
| 20. | <i>E. leucophylla</i> | Pr | Green | Not Angled | No | Ab | Ab | Ab |
| 21. | <i>E. milii</i> var. <i>hislopui</i> | Ab | Grayish | Not Angled | No | Pr | Tuft | All Over |
| 22. | <i>E. milii</i> var. <i>splendens</i> | Ab | Grayish | Not Angled | No | Pr | Paired | All Over |
| 23. | <i>E. milii</i> var. <i>tanamarivae</i> | Ab | Grayish | Not Angled | No | Pr | Solitary | All Over |
| 24. | <i>E. milii</i> var. <i>tenuispina</i> | Ab | Grayish | Not Angled | No | Pr | Solitary | All Over |
| 25. | <i>E. unispina</i> | Ab | Green | Angled | Yes | Pr | Solitary | All Over |
| 26. | <i>E. polycnemoides</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 27. | <i>E. prostrate</i> | Ab | Green/Pink | Not Angled | No | Ab | Ab | Ab |
| 28. | <i>E. pulcherrima</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 29. | <i>E. scordifolia</i> | Pr | Green | Not Angled | No | Ab | Ab | Ab |
| 30. | <i>E. sp. B</i> | Ab | Green | Not Angled | No | Ab | Ab | Ab |
| 31. | <i>E. sudanica</i> | Ab | Green | Not Angled | Yes | Pr | Paired | All Over |
| 32. | <i>E. thymifolia</i> | Pr | Green/Pink | Not Angled | No | Ab | Ab | Ab |

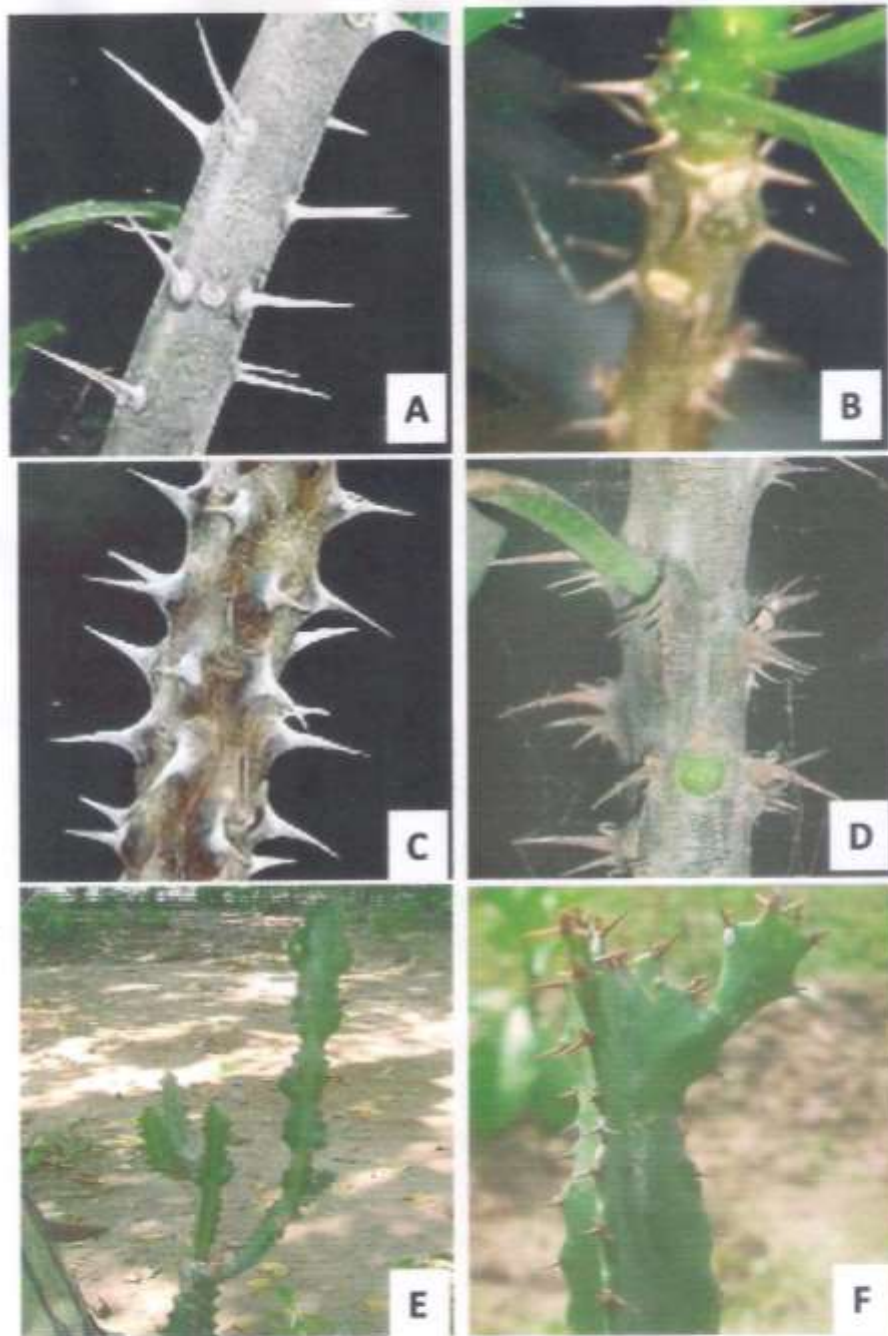


Plate 8 : Variation in the appearance of the spines on the stem of some *Euphorbia* spp. ($\times 1$).

- (A) *Euphorbia milii* var. *temuispina* (single spine)
- (B) *Euphorbia milii* var. *splendens* (single spine)
- (C) *Euphorbia milii* var. *tanancarivæ* (single and bifid spines)
- (D) *Euphorbia milii* var. *hislopii* (tuft spine)
- (E) *Euphorbia ingens* (single) (F) *Euphorbia kamerunica* (bifid spine)

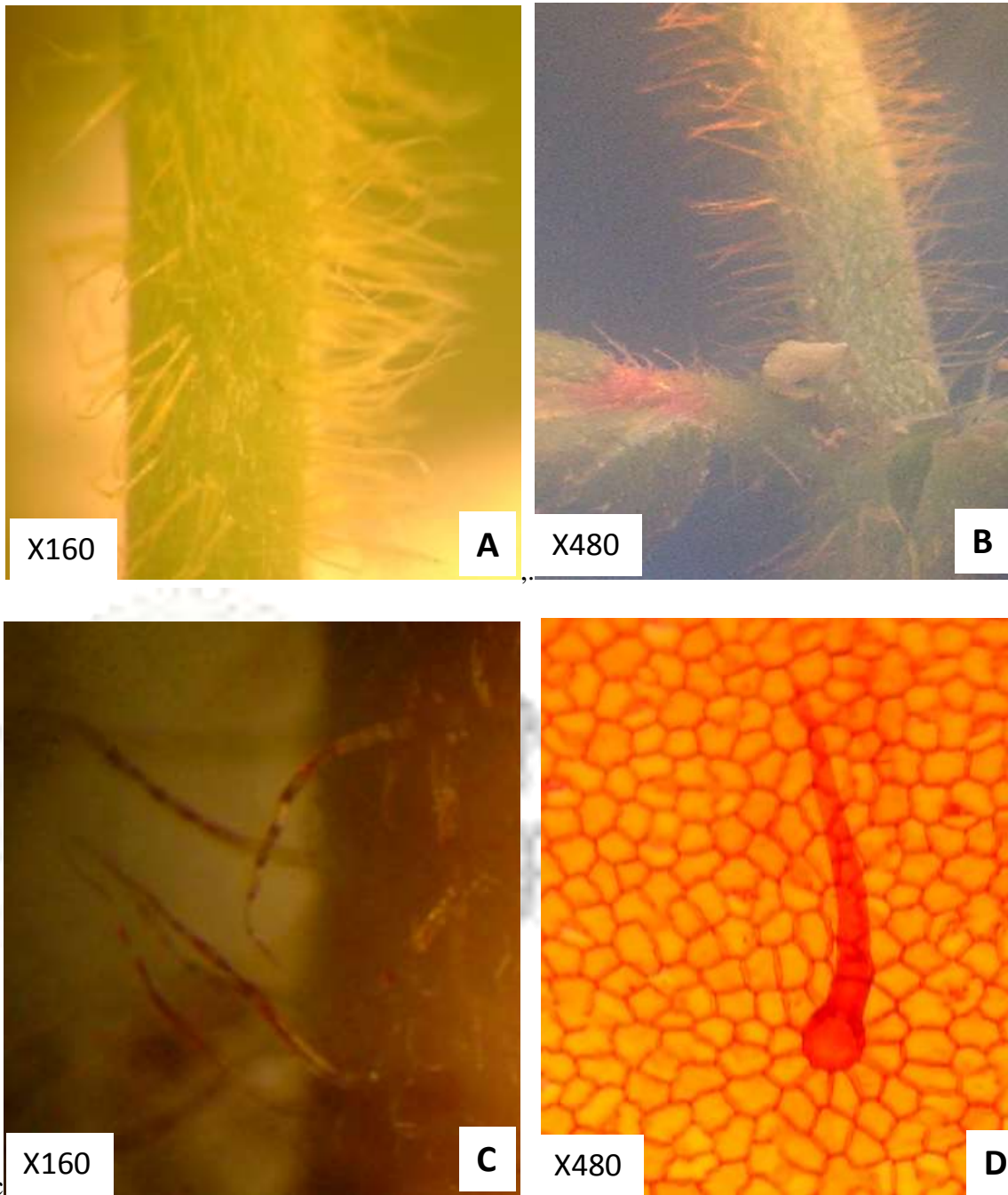


Plate 4: Different types of indumenta found in genus *Euphorbia*

(A -B) Smooth soft matted (tomentose) hair on the stem of *E. hirta*

(C) Sparse (pilose) hairs on the stem of *E.thymifolia*

(D) Single multicellular hair on the stem of *E. prostrata*

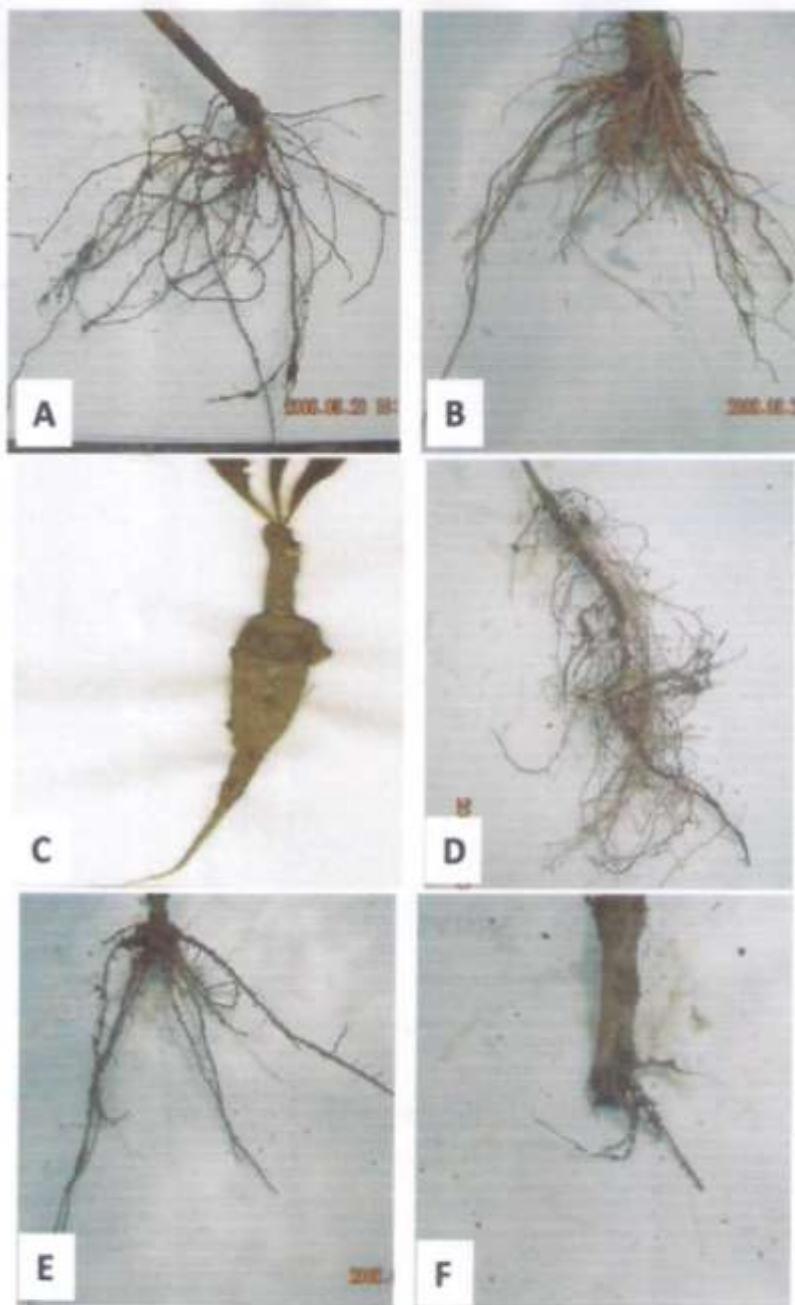


Plate 10: Photographs of the root system of specimens of *Euphorbia* species (×1)

(A) *E. hyssopifolia* showing fibrous root system (B) *E. miltii* showing the root system

(C) *E. calva* showing tuberous stem (D) *E. heterophylla* showing root hairs

(E) *E. cotinifolia* root system

(F) *E. kamerunica* (succulent species) showing the root system

4.3.2 Floral Morphology

The whole flower is achlamydeous and differs from the typical floral plan. The inflorescences are determinate as the first flowers limited the apical growth and the sequence of development is basipetal. Flowers occur singly, in a group of three or four or as bunch either sessile or stalked as shown in Plates 11 –15 and presented in Table 8. All the specimens of *Euphorbia milii* var. *tenuispina* examined had yellow inflorescences with smaller leaves as compared to *Euphorbia milii* var. *tananarivae* with same type of inflorescences. Likewise, *Euphorbia milii* var. *hislopilii* and *Euphorbia milii* var. *splendens* had red inflorescences but the latter had smaller leaves (Plate 12 and Table 8).

The position of the inflorescence may be Axillarylary, terminal and intercalary. Six species possess Axillarylary inflorescence. They are: *E. aegyptiaca*, *E. convolvuloides*, *E. polycnemoides*, *E. prostrata*, *E. scordifolia* and *E. thymifolia*. Nineteen species have terminal inflorescence. They include: *E. balsamifera*, *E. calva*, *E.cotinifolia*, *E. glaucophylla*, *E. glomerifera*, *E. heterophylla*, *E. hirta*, *E. hyssopifolia*, *E. lateriflora*, *E. leucophylla*, *E. milii*, *E. pulcherimma*, *E. ampla*, *E. бага*, *E.kerstingii* and *E. sp. B*. Intercalary inflorescences are found in succulent species. They are: *E. deghtonii*, *E. depauperata*, *E. desmondi*, *E. kamerunica*, *E. ingens*, *E. poissonii* and *E. unispina* (Plate 12D). The stamen is an extremely simplified male flower consisting of a single anther and filament. They are free and indefinite (polyandrous); tetra-dynamous, with the outer ones shorter than the inner ones (Fig. 10-11 and Plate 14).

The female flower consisted of a pedicel, a 3-carpellate (three-parted) superior ovary with one ovule per carpel (Fig. 11 and Plate 14). This tricarpellary ovary is trilocular and apocarpous.

Each flower has one or more glands attached to it, most often on the upper rim, and these glands and their appendages also vary greatly in number and shapes (Fig. 11, Plates 11- 13 and Table 8). All species have the same floral plan (although variations existed in the type, nature and number of the glands present on the cyathium). In all the specimens examined, the fruits are capsules with axile placentation while the seeds are oval with a caruncle.



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Table 8: Floral Morphological characters of *Euphorbia* species in Nigeria

| S/n | Taxa | Location | Arrangement | Involucre | | | Gland | | | | Fruit |
|-----|----------------------------------|-------------|----------------|-----------|--------|--------------|-------|------------|--------|--------|---------|
| | | | | Pr | colour | type | Pr | Shape | Number | colour | |
| 1. | <i>E. aegyptiaca</i> | Axillary | Single | Pr | Green | Leaf - Like | Pr | Tube Like | One | Green | Capsule |
| 2. | <i>E. ampla</i> | Terminal | Group of three | Ab | Yellow | Leaf-Like | Pr | Lip Like | Four | Yellow | Capsule |
| 3. | <i>E. бага</i> | Terminal | Single | Pr | Green | Leaf – Like | Pr | Oval | Five | Green | Capsule |
| 4. | <i>E. balsamifera</i> | Terminal | Single | Pr | Green | Leaf – Like | Pr | Oval | Five | Green | Capsule |
| 5. | <i>E. calva</i> | Terminal | Single | Pr | Green | Petaloid | Pr | Oval | Four | Green | Capsule |
| 6. | <i>E. convolvuloides</i> | Axillary | Single | Pr | White | Bract- Like | Pr | Lip-Like | Four | White | Capsule |
| 7. | <i>E. cotinifolia</i> | Terminal | Group of three | Pr | Yellow | Leaf-Like | Pr | Oval | Four | Yellow | Capsule |
| 8. | <i>E. deightonii</i> | Intercalary | Single | Pr | Yellow | Bract - Like | Pr | Oval | Four | Yellow | Capsule |
| 9. | <i>E. depauperata</i> | Intercalary | Single | Pr | Yellow | Petaloid | Pr | Lip-Like | Three | Yellow | Capsule |
| 10. | <i>E. desmondi</i> | Intercalary | Single | Pr | Yellow | Bract - Like | Pr | Oval | Four | Yellow | Capsule |
| 11. | <i>E. glaucophylla</i> | Terminal | Group of three | Pr | Yellow | Leaf-Like | Pr | Rim-Like | Three | Yellow | Capsule |
| 12. | <i>E. glomerifera</i> | Terminal | Group of three | Pr | White | Leaf-Like | Pr | Rim-Like | Three | White | Capsule |
| 13. | <i>E. heterophylla</i> | Terminal | Single | Pr | Green | Leaf- Like | Pr | Tube Like | One | Green | Capsule |
| 14. | <i>E. hirta</i> | Terminal | Bunch | Pr | Yellow | Leaf-Like | Pr | Tube-Like | Three | Yellow | Capsule |
| 15. | <i>E. hyssopifolia</i> | Terminal | Group of three | Pr | White | Leaf-Like | Pr | Rim-Like | Three | White | Capsule |
| 16. | <i>E. ingens</i> | Intercalary | Single | Pr | Yellow | Bract-Like | Pr | Oval | Four | Yellow | Capsule |
| 17. | <i>E. kamerunica</i> | Intercalary | Single | Pr | Yellow | Bract-Like | Pr | Oval | Four | Yellow | Capsule |
| 18. | <i>E. keithii</i> | Intercalary | Single | Pr | Yellow | Bract-Like | Pr | Oval | Four | Yellow | Capsule |
| 19. | <i>E. kerstingii</i> | Terminal | Group of three | Pr | White | Leaf-Like | Pr | Rim-Like | Three | White | Capsule |
| 20. | <i>E. lateriflora</i> | Terminal | Group of three | Pr | Green | Bract-Like | Pr | Oval | Four | Green | Capsule |
| 21. | <i>E. leucophylla</i> | Terminal | Single | Pr | Yellow | Leaf-Like | Pr | Leaf Like | Three | Yellow | Capsule |
| 22. | <i>E. milii var. hislopil</i> | Terminal | Group of three | Pr | Red | Petaloid | Pr | Lip-Like | Three | Red | Capsule |
| 23. | <i>E. milii var. splendens</i> | Terminal | Group of three | Pr | Red | Petaloid | Pr | Lip-Like | Three | Red | Capsule |
| 24. | <i>E. milii var. tananarivae</i> | Terminal | Group of three | Pr | Cream | Petaloid | Pr | Lip-Like | Three | Yellow | Capsule |
| 25. | <i>E. milii var. tenuispina</i> | Terminal | Group of three | Pr | Cream | Petaloid | Pr | Lip-Like | Three | Yellow | Capsule |
| 26. | <i>E. sudanica</i> | Intercalary | Single | Pr | Yellow | Bract-Like | Pr | Oval | Five | Yellow | Capsule |
| 27. | <i>E. prostrata</i> | Axillary | Single | Pr | White | Leaf-Like | Pr | Rim – Like | Three | White | Capsule |
| 28. | <i>E. pulcherimma</i> | Terminal | Single | Pr | Red | Leaf- Like | Pr | Oval | One | Red | Capsule |
| 29. | <i>E. scordifolia</i> | Axillary | Bunch | Pr | White | Bract-Like | Pr | Rim-Like | Three | White | Capsule |
| 30. | <i>E. sp. B</i> | Terminal | Group of three | Pr | White | Leaf-Like | Pr | Rim-Like | Three | White | Capsule |
| 31. | <i>E. thymifolia</i> | Axillary | Single | Pr | White | Leaf-Like | Pr | Rim-Like | Three | White | Capsule |
| 32. | <i>E. unispina</i> | Intercalary | Single | Pr | Yellow | Bract- Like | Pr | Oval | Four | Yellow | Capsule |

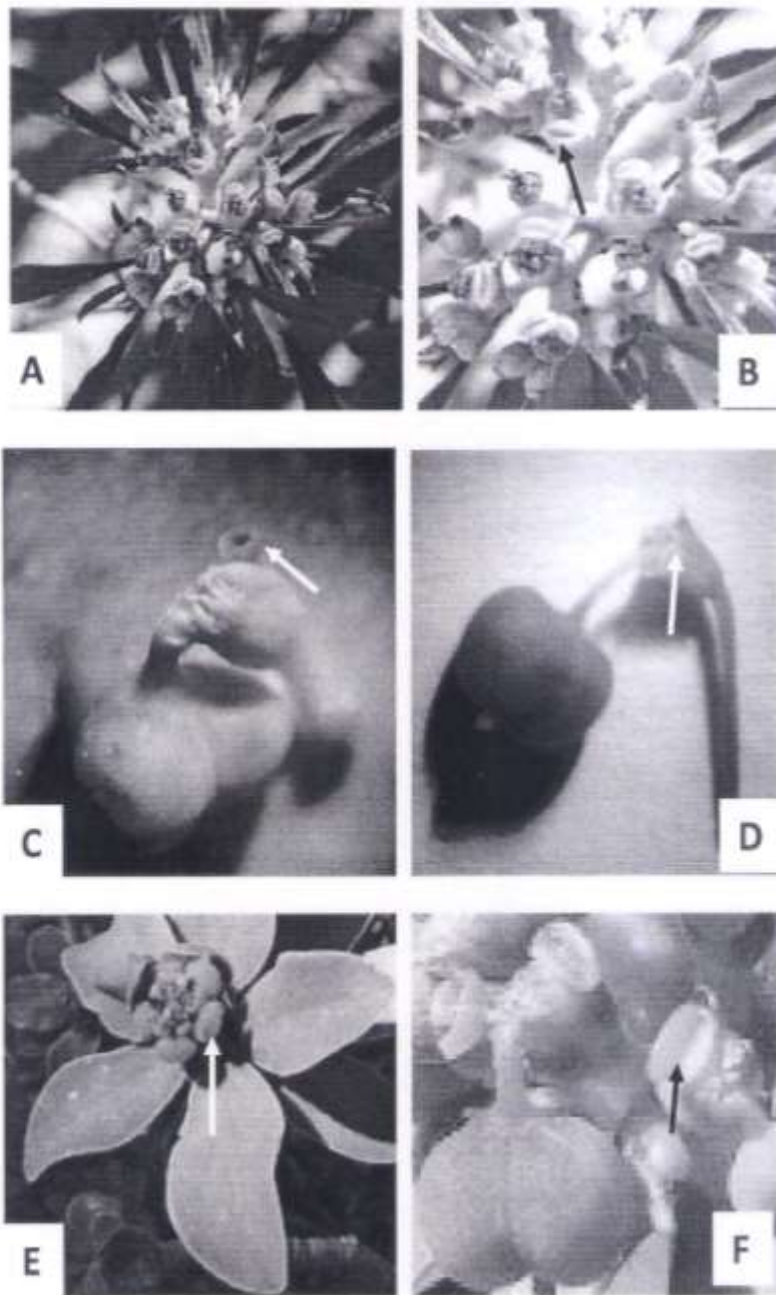


Plate 11 : Morphological differences between flowers of *Euphorbia* spp. showing the Glands (white arrow)

(A) inflorescence of *E. pulcherimma* $\times 1$ (B) inflorescence of *E. pulcherimma* $\times 2$

(C) a single flower of *E. heterophylla* $\times 4$ (D) a single flower of *E. sp. B* $\times 3$

(E) inflorescence of *E. balsamifera* $\times 1$ (F) inflorescence of *E. cyathophora* $\times 2$



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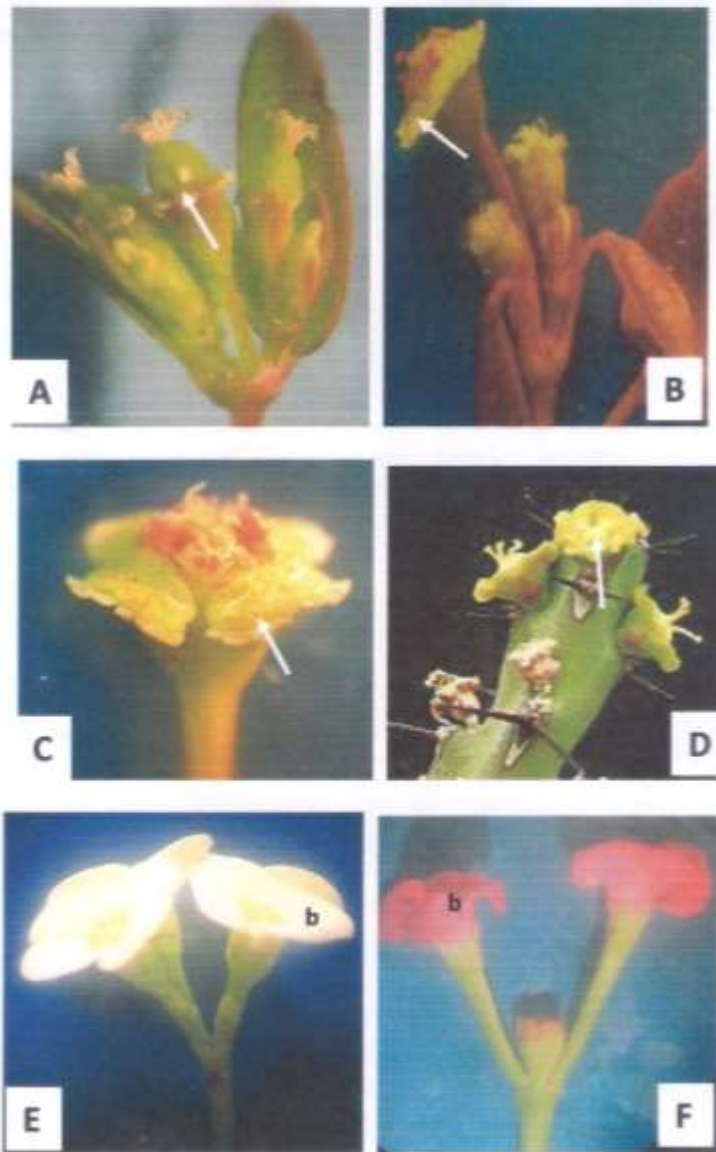


Plate 12: Morphological differences between flowers of *Euphorbia* species ($\times 1$)
 showing the bracts (b) and the glands (white arrow)

- (A) terminal inflorescence of *E. hyssopifolia*
- (B) inflorescence of *E. cotinifolia*
- (C) a single flower of *E. cotinifolia*
- (D) inflorescence of *E. poisonii*
- (E) inflorescence of *E. milii* var. *tenuispina*
- (F) inflorescence of *E. milii* var. *splendens*

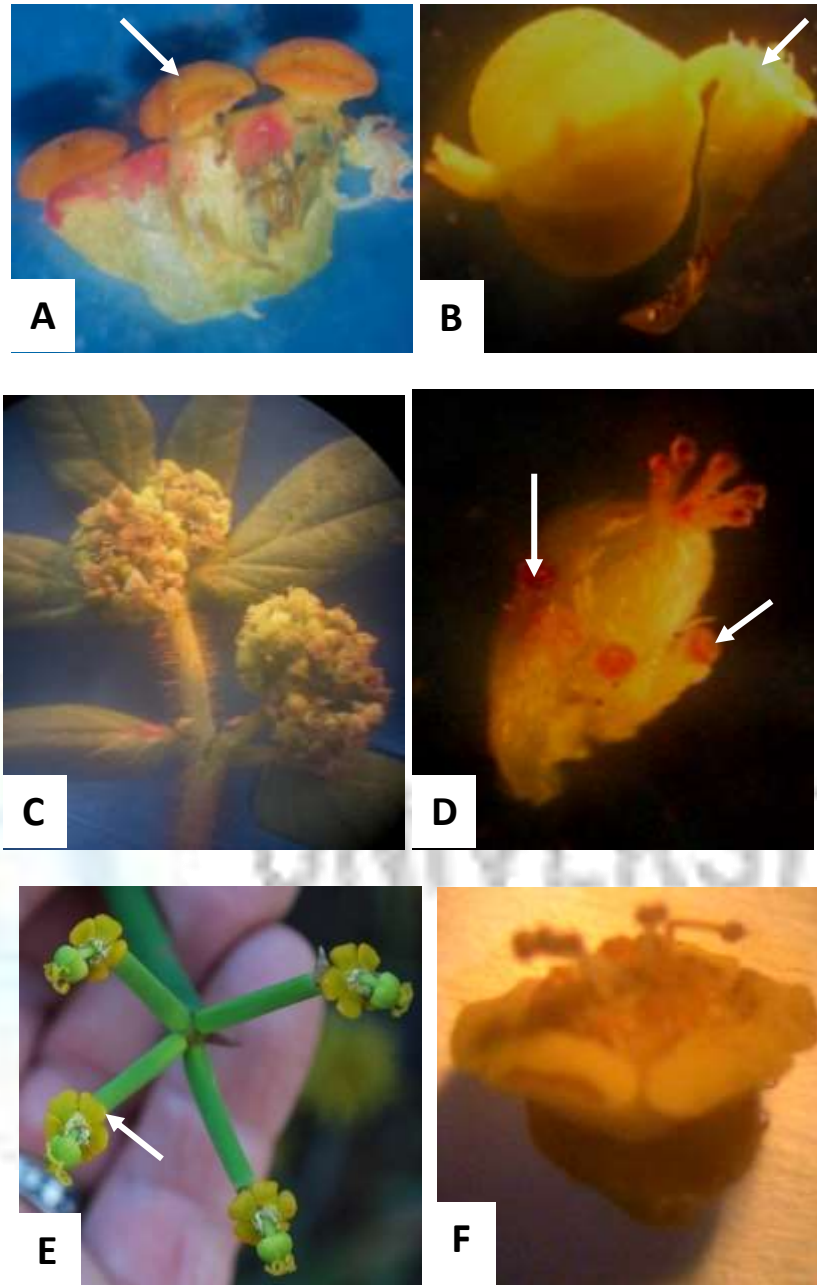


Plate 5: Morphological differences between inflorescences of *Euphorbia* species

(A) glands in *E. milii* $\times 100$

(B) a single flower of *E. prostrata* $\times 20$

(C) inflorescence of *E. hirta* $\times 2$

(D) a single flower of *E. hirta* $\times 20$

(E) inflorescence of *E. schimperiana* $\times 1$

(F) a single flower of *Euphorbia ingens* $\times 2$

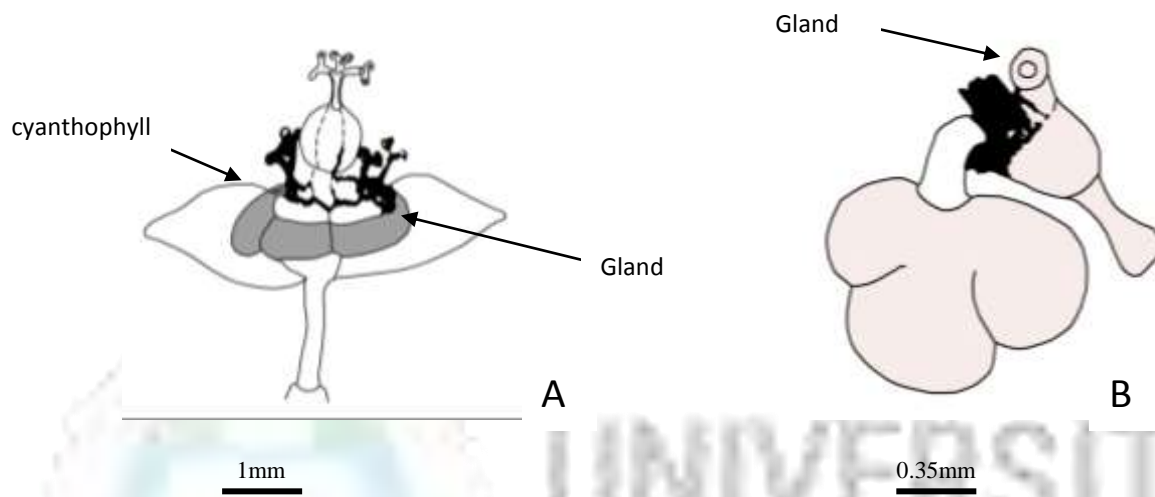


Fig. 8: Schematic representation of the cyathia found in *Euphorbia* species

(A) 5-glands type cyathium (*E. ingens*) (B) one gland-type cyathium (*E. heterophylla*)

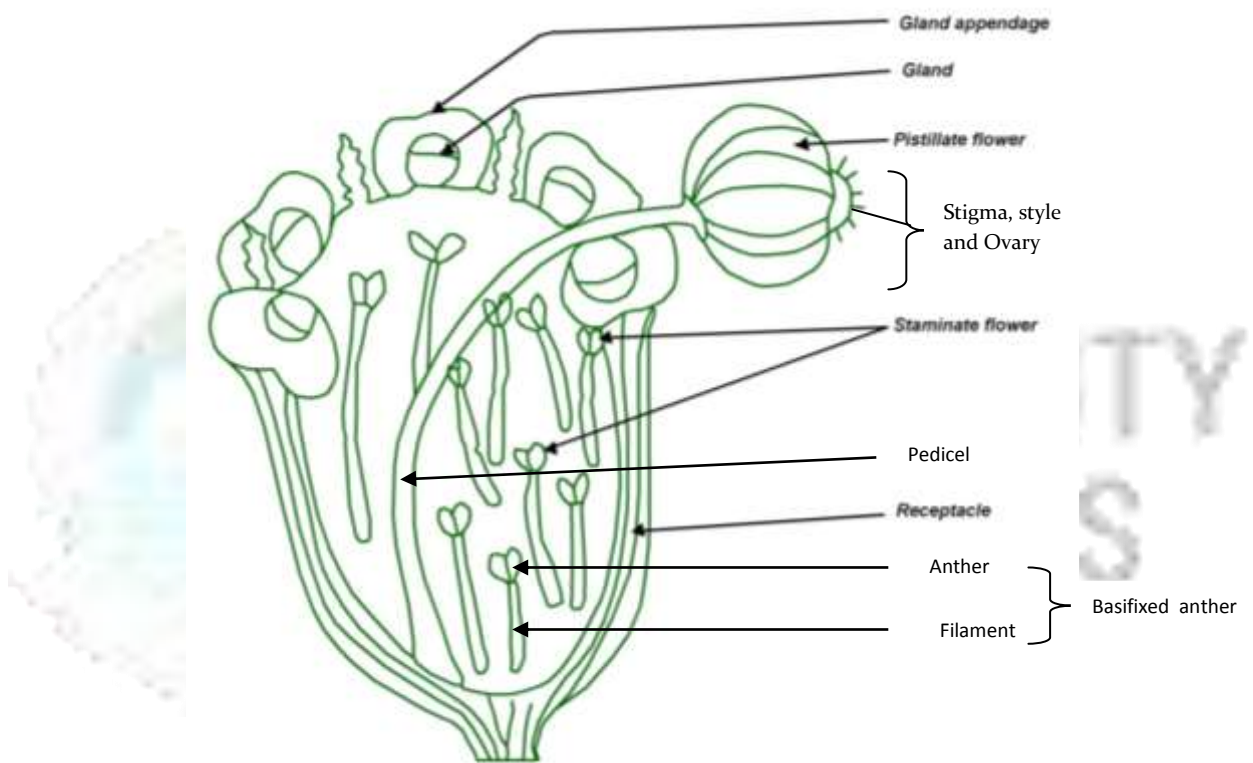


Fig. 9: Longitudinal section through *Euphorbia cotinifolia* inflorescence (cyathium)× 100

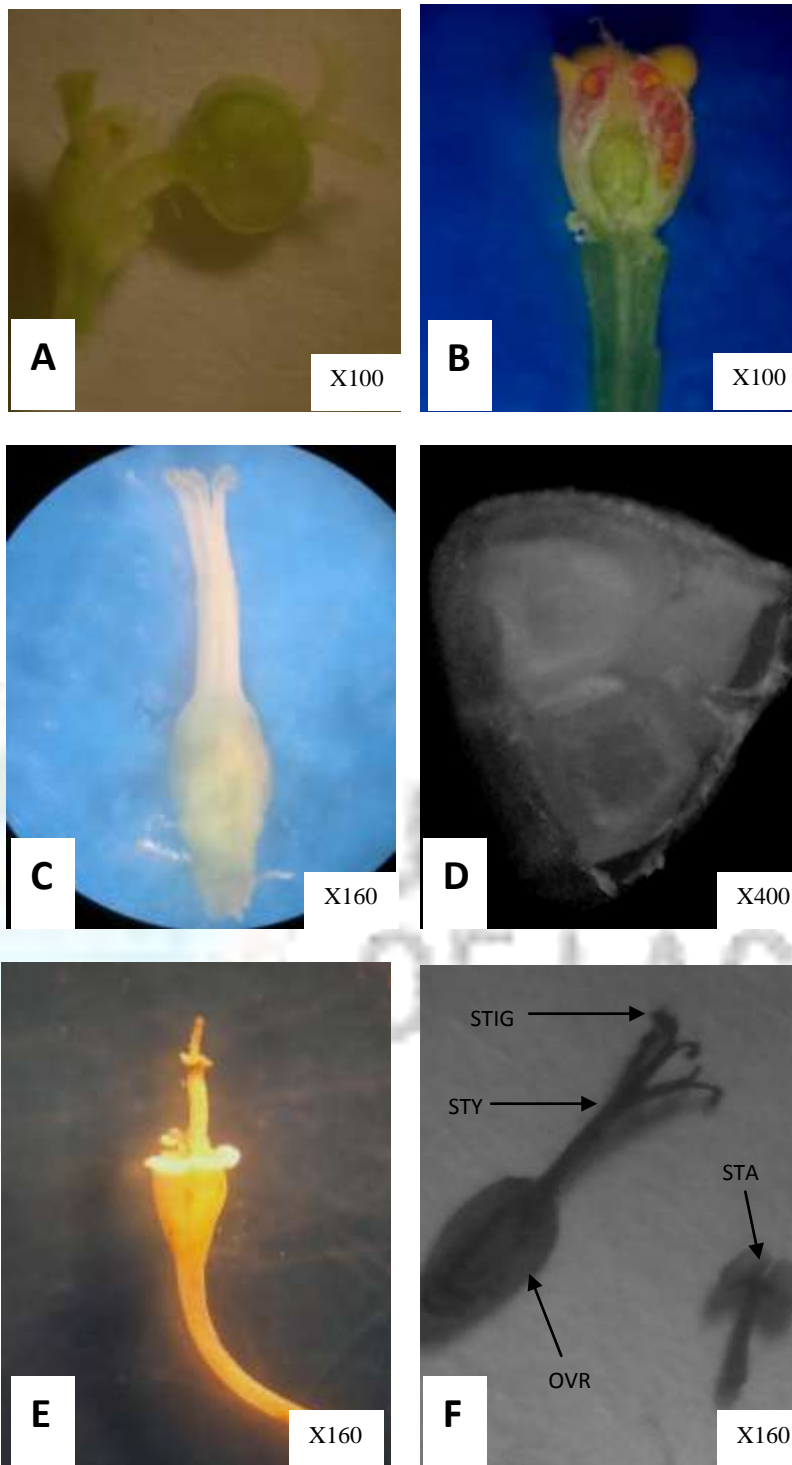


Plate 6: Photograph of the inflorescences of some *Euphorbia* species (OVR: Ovary, STIG: Stigma, STA: stamen, STY: style GLD: gland) showing

- (A) Longitudinal section (L.S) of *E. heterophylla* inflorescence
- (B) L.S. of *E. cotinifolia* inflorescence
- (C) Female flower
- (D) Cross section of young fruit showing Axillary placentation
- (E) Pollinated inflorescence
- (F) androecium and gynoecium of *E. heterophylla*

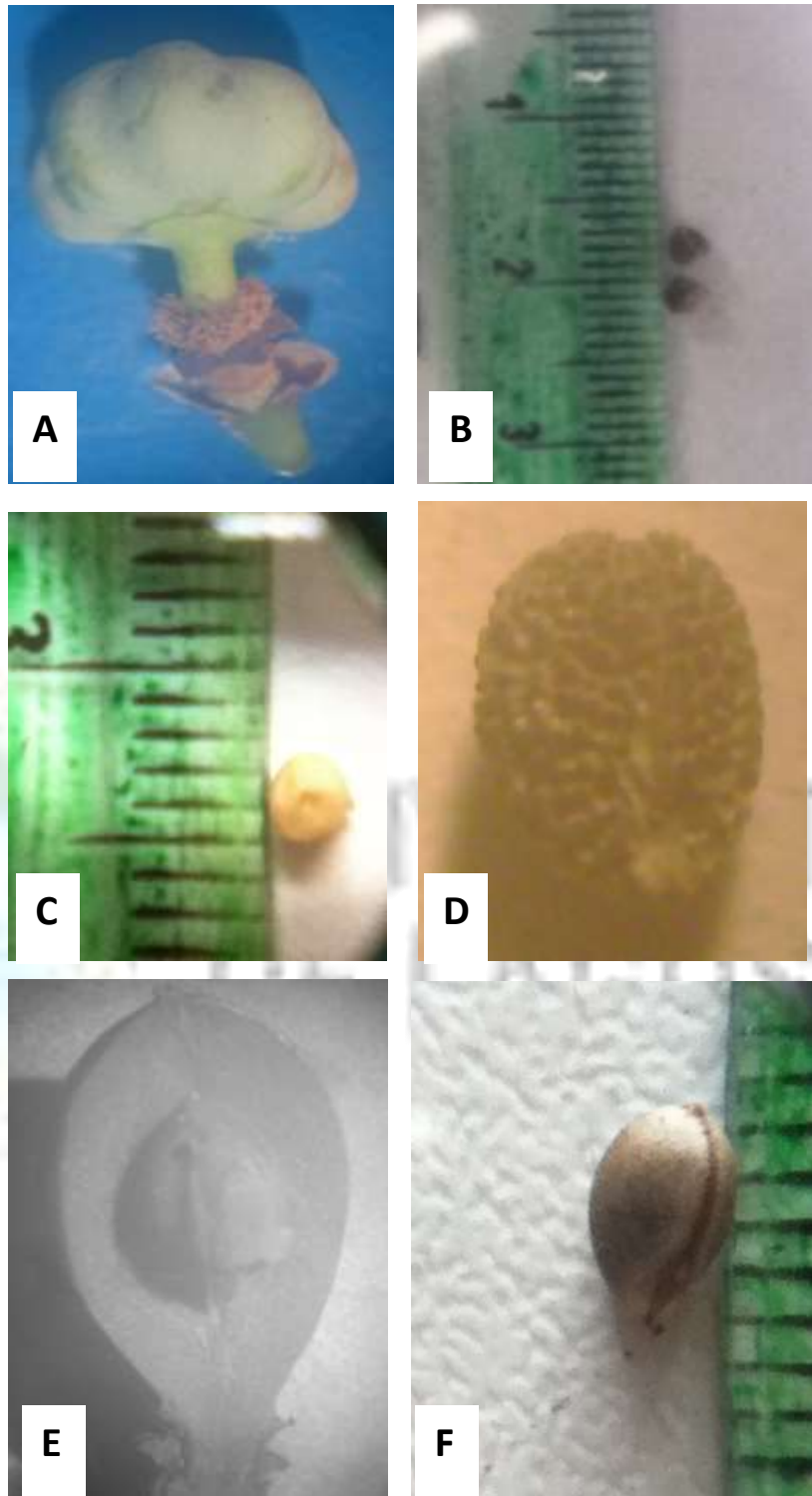


Plate 7: Fruit variation and seed morphology in *Euphorbia*

(A) *E. kamerunica* (capsule) $\times 2$ (B) *E. heterophylla* (seed)

(C) *E. polycnemoides* (seed) (D) *E. milii* var. *tenuispina* (seed) $\times 100$

(E) *E. poissonii* (Fruit) $\times 5$ (F) *E. poissonii* (seed)

4.3.3 Pollen Morphology

The results of the pollen morphology are summarized in Table 9 while the typical pollen grains are shown in Plates 16-17. All the taxa studied had simple, monad, tri-colporate grains with radial symmetry. The ratio of the equatorial axis to polar axis ranged from 1.04 to 1.49. *E. heterophylla* had the highest average values for both equatorial axis to polar axis i.e. 67.91 μm and 63.05 μm respectively while *E. hyssopifolia* had the least average values for both equatorial axis and polar axis i.e. 28.56 μm and 20.72 μm respectively. The relationships between the pollen grains are represented by Figs. 10 -11. Both *E. hyssopifolia* and *E. hirta* had same values of E (Equatorial diameter) i.e. 20.72 μm .

The sizes of the polar axis (P) of *E. aegyptiaca* ranged from 38.17 μm to 45.11 μm while the sizes of the equatorial diameter (E) ranged from 24.29 μm to 31.23 μm . Average values of P and E for *E. aegyptiaca* are 41.64 μm and 28 μm respectively while P/E is 1.49. The sizes of the polar axis (P) of *E. convolvuloides* ranged from 31.23 μm to 52.05 μm while the sizes of the equatorial diameter (E) ranged from 20.82 μm to 48.44 μm . Average values of P and E for *E. convolvuloides* are 40.60 μm and 31.23 μm respectively while P/E is 1.3. The sizes of the polar axis (P) of *E. cotinifolia* ranged from 27.76 μm to 34.7 μm while the sizes of the equatorial diameter (E) ranged from 24.29 μm to 27.76 μm . Average values of P and E for *E. cotinifolia* are 29.84 μm and 27.01 μm respectively while P/E is 1.1.

The sizes of the polar axis (P) of *E. depauperata* ranged from 41.64 μm to 45.11 μm while the sizes of the equatorial diameter (E) ranged from 34.7 μm to 41.64 μm . Average values of P and E for *E. depauperata* are 43.03 μm and 38.86 μm respectively while P/E is 1.11. The sizes of the polar axis (P) of *E. schimperiana* ranged from 34.7 μm to 52.05 μm while the sizes of the equatorial diameter (E) ranged from 38.17 μm to 45.11 μm . Average values of P and E for *E. schimperiana* are 49.27 μm and 42.92 μm respectively while P/E is 1.15. The sizes of the polar

axis (P) of *E. pulcherimma* ranged from 38.17 μm to 52.05 μm while the sizes of the equatorial diameter (E) ranged from 31.23 μm to 58.99 μm . Average values of P and E for *E. pulcherimma* are 46.26 μm and 42.58 μm respectively while P/E is 1.09.

The sizes of the polar axis (P) of *E. glaucophylla* ranged from 27.76 μm to 34.7 μm while the sizes of the equatorial diameter (E) ranged from 20.82 μm to 24.29 μm . Average values of P and E for *E. glaucophylla* are 31.13 μm and 23.35 μm respectively while P/E is 1.33. The sizes of the polar axis (P) of *E. polycnemoides* ranged from 31.23 μm to 34.7 μm while the sizes of the equatorial diameter (E) ranged from 27.76 μm to 31.23 μm . Average values of P and E for *E. polycnemoides* are 31.58 μm and 30.43 μm respectively while P/E is 1.04. The sizes of the polar axis (P) of *E. thymifolia* ranged from 27.76 μm to 31.23 μm while the sizes of the equatorial diameter (E) ranged from 20.82 μm to 27.76 μm . Average values of P and E for *E. thymifolia* are 30.99 μm and 27.31 μm respectively while P/E is 1.04. The sizes of the polar axis (P) of *E. prostrata* ranged from 31.23 μm to 38.17 μm while the sizes of the equatorial diameter (E) ranged from 27.76 μm to 31.23 μm . Average values of P and E for *E. prostrata* are 33.31 μm and 29.84 μm respectively while P/E is 1.12.

The sizes of the polar axis (P) of *E. heterophylla* ranged from 52.05 μm to 76.34 μm while the sizes of the equatorial diameter (E) ranged from 45.11 μm to 72.87 μm . Average values of P and E for *E. heterophylla* are 67.91 μm and 63.05 μm respectively while P/E is 1.08. The sizes of the polar axis (P) of *E. hyssopifolia* ranged from 27.76 μm to 31.23 μm while the sizes of the equatorial diameter (E) ranged from 17.35 μm to 24.29 μm . Average values of P and E for *E. hyssopifolia* are 28.56 μm and 20.72 μm respectively while P/E is 1.38. The sizes of the polar axis (P) of *E. hirta* ranged from 24.29 μm to 31.23 μm while the sizes of the equatorial diameter (E) ranged from 17.35 μm to 31.23 μm . Average values of P and E for *E. hirta* are 28.80 μm and 20.72 μm respectively while P/E is 1.39.

The sizes of the polar axis (P) of *E. lateriflora* ranged from 31.23 μm to 38.17 μm while the sizes of the equatorial diameter (E) ranged from 27.76 μm to 34.7 μm . Average values of P and E for *E. lateriflora* are 35.05 μm and 33.07 μm respectively while P/E is 1.06. The sizes of the polar axis (P) of *E. unispina* ranged from 45.11 μm to 52.05 μm while the sizes of the equatorial diameter (E) ranged from 31.23 μm to 45.11 μm . Average values of P and E for *E. unispina* are 45.22 μm and 37.58 μm respectively while P/E is 1.2. The sizes of the polar axis (P) of *E. ingens* ranged from 38.17 μm to 52.05 μm while the sizes of the equatorial diameter (E) ranged from 34.7 μm to 45.11 μm . Average values of P and E for *E. ingens* are 42.33 μm and 40.5 μm respectively while P/E is 1.05.

The sizes of the polar axis (P) of *E. milii* var. *tenuispina* ranged from 38.17 μm to 62.46 μm while the sizes of the equatorial diameter (E) ranged from 34.7 μm to 55.52 μm . Average values of P and E for *E. milii* var. *tenuispina* are 49.62 μm and 47.19 μm respectively while P/E is 1.05.

The sizes of the polar axis (P) of *E. milii* var. *tanarivae* ranged from 38.17 μm to 62.46 μm while the sizes of the equatorial diameter (E) ranged from 34.7 μm to 55.52 μm . Average values of P and E for *E. milii* var. *tanarivae* are 49.62 μm and 47.19 μm respectively while P/E is 1.04.

Based on the values of P/E, plant specimens were grouped into three viz: Prolate, prolate spheroidal and subprolate. Specimens with prolate pollens are: *E. aegyptiaca*, *E. glaucophylla*, *E. hirta* and *E. hyssopifolia*. Prolate spheroidal pollen grains are *E. cotinifolia*, *E. depauperata*, *E. heterophylla*, *E. ingens*, *E. laterifolia*, *E. milii* var. *tanarivae*, *E. milii* var. *tenuispina*, *E. polycnemoides* and *E. thymifolia*. While specimens with subprolate pollens are *E. convolvuloides*, *E. shimperiana* and *E. unispina*.

| S/N | Taxa | P (µm) | E(µm) | P/E | Pollen Shape |
|------------|--|------------------------|-----------------------|------------|---------------------|
| 1. | <i>E. aegyptiaca</i> | 41.64 (38.17 - 45.11) | 28.00 (24.29 - 31.23) | 1.49 | Prolate |
| 2. | <i>E. glaucophylla</i> | 31.13 (27.76 - 34.7) | 23.35 (20.82 - 24.29) | 1.33 | Prolate |
| 3. | <i>E. hirta</i> | 28.80 (24.29 - 31.23) | 20.72 (17.35 - 31.23) | 1.39 | Prolate |
| 4. | <i>E. hyssopifolia</i> | 28.56 (27.76 - 31.23) | 20.72 (17.35 - 24.29) | 1.38 | Prolate |
| 5. | <i>E. cotinifolia</i> | 29.84 (27.76 - 34.7) | 27.01 (24.29 - 27.76) | 1.11 | Prolate spheroidal |
| 6. | <i>E. depauperata</i> | 43.03 (41.64- 45.11) | 38.86 (34.7 - 41.64) | 1.11 | Prolate spheroidal |
| 7. | <i>E. heterophylla</i> | 67.91 (52.05 - 76.34) | 63.05 (45.11- 72.87) | 1.08 | Prolate spheroidal |
| 8. | <i>E. ingens</i> | 42.33 (38.17 - 52.05) | 40.5 (34.7 - 45.11) | 1.05 | Prolate spheroidal |
| 9. | <i>E. lateriflora</i> | 35.05 (31.23 - 38.17) | 33.07 (27.76 – 34.7) | 1.06 | Prolate spheroidal |
| 10. | <i>E. milii</i> var. <i>tanandarivae</i> | 57.26 (48.44 – 65.93) | 55.41(48.44 – 63.43) | 1.04 | Prolate spheroidal |
| 11. | <i>E. milii</i> var. <i>tenuispina</i> | 49.62 (38.17 - 62.46) | 47.19 (34.7 – 55.52) | 1.05 | Prolate spheroidal |
| 12. | <i>E. polycnemoides</i> | 31.58 (31.23 - 34.7) | 30.43 (27.76 - 31.23) | 1.04 | Prolate spheroidal |
| 13. | <i>E. prostrata</i> | 33.31 (31.23 - 38.17) | 29.84 (27.76 - 31.23) | 1.12 | Prolate spheroidal |
| 14. | <i>E. pulcherimma</i> | 46.26 (38.17 - 52.05) | 42.58 (31.23 - 58.99) | 1.09 | Prolate spheroidal |
| 15. | <i>E. thymifolia</i> | 30.99 (27.76 - 31.23) | 27.31 (20.82 - 27.76) | 1.04 | Prolate spheroidal |
| 16. | <i>E. convolvuloides</i> | 40.60 (31.23 - 52.05) | 31.23 (20.82 - 48.44) | 1.30 | Subprolate |
| 17. | <i>E. schimperiana</i> | 49.27 (34.7 - 52.05) | 42.92 (38.17 - 45.11) | 1.15 | Subprolate |
| 18. | <i>E. unispina</i> | 45.22 (45.11 - 52.05) | 37.58 (31.23 - 45.11) | 1.20 | Subprolate |

Measurements represent mean, low and high values,

P/E = ratio of polar axis and equatorial axis, P = polar axis, E= Equatorial diameter

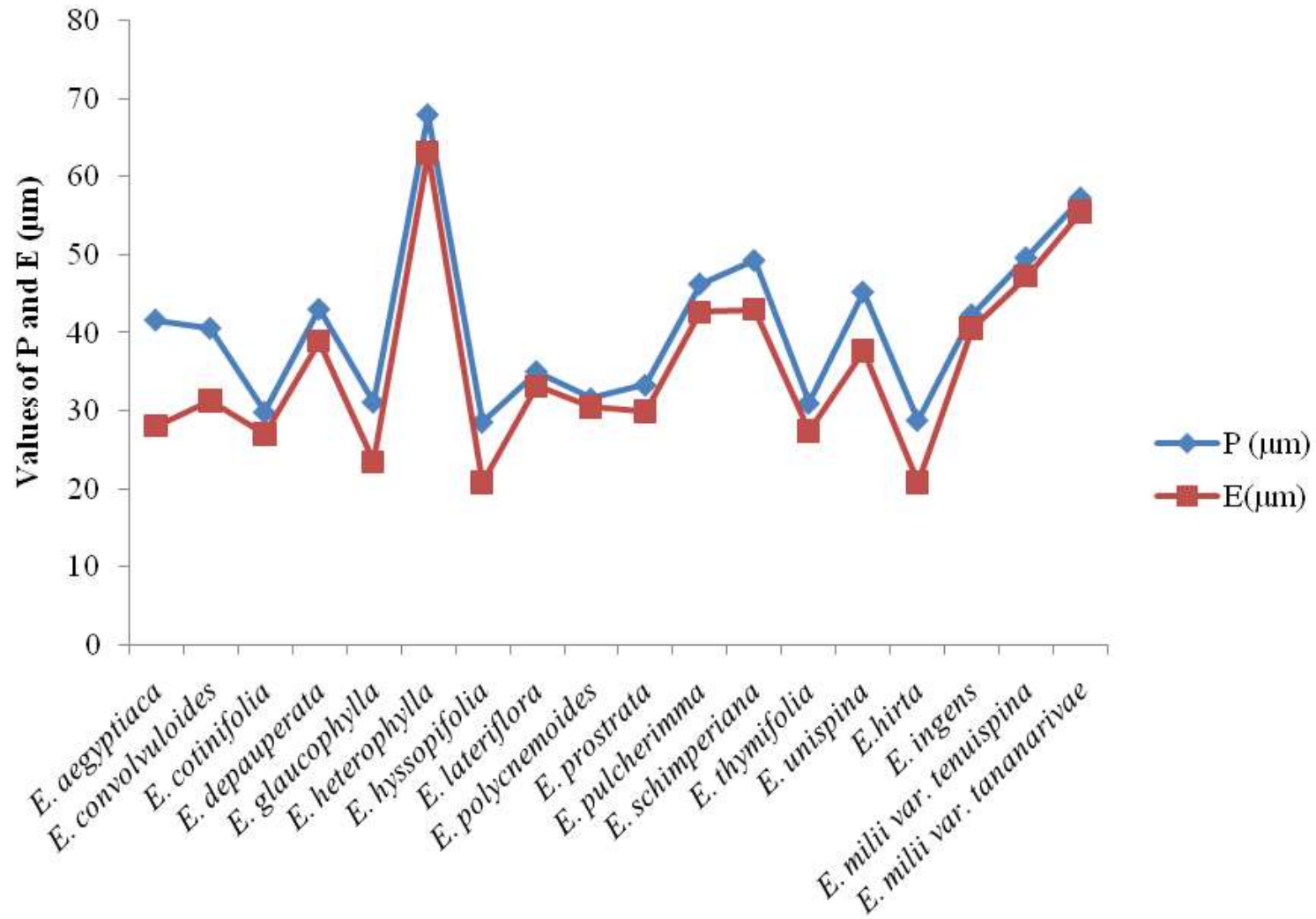


Fig. 10: Relationship between pollen sizes in genus *Euphorbia*

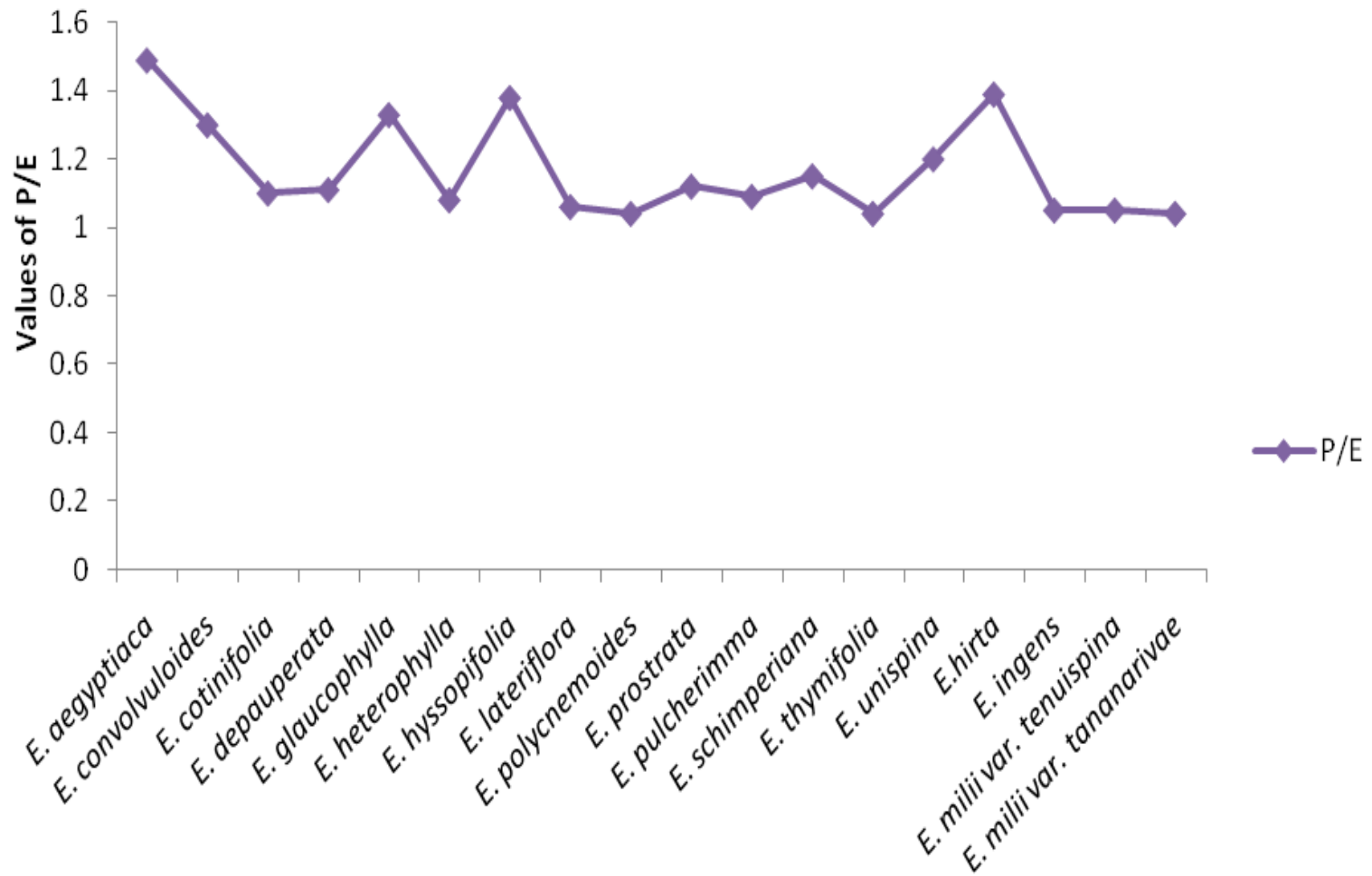


Fig. 11: Ratio of Polar axis to horizontal axis

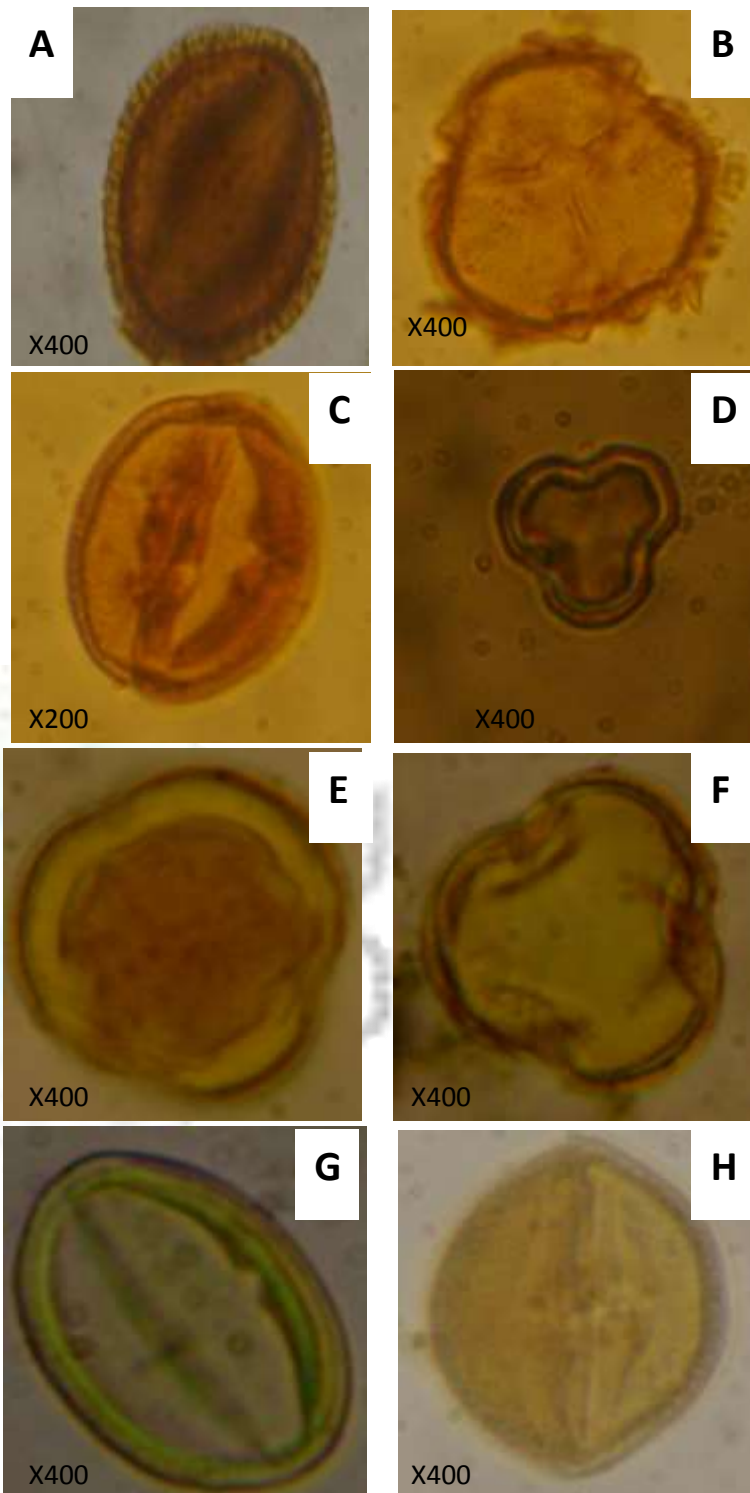


Plate 16: Photomicrographs of pollen grains in *Euphorbia* species

- | | |
|--|--|
| A. Polar view of <i>E. aegyptiaca</i> | B. Equatorial view of <i>E. convolvuloides</i> |
| C. Polar view of <i>E. cotinifolia</i> | D. Equatorial view of <i>E. depauperata</i> |
| E. Equatorial view of <i>E. milii</i> var. <i>tenuispina</i> | |
| F. Equatorial view of <i>E. heterophylla</i> | |
| G. Polar view of <i>E. pulcherimma</i> | H. Polar view of <i>E. schimperiana</i> |

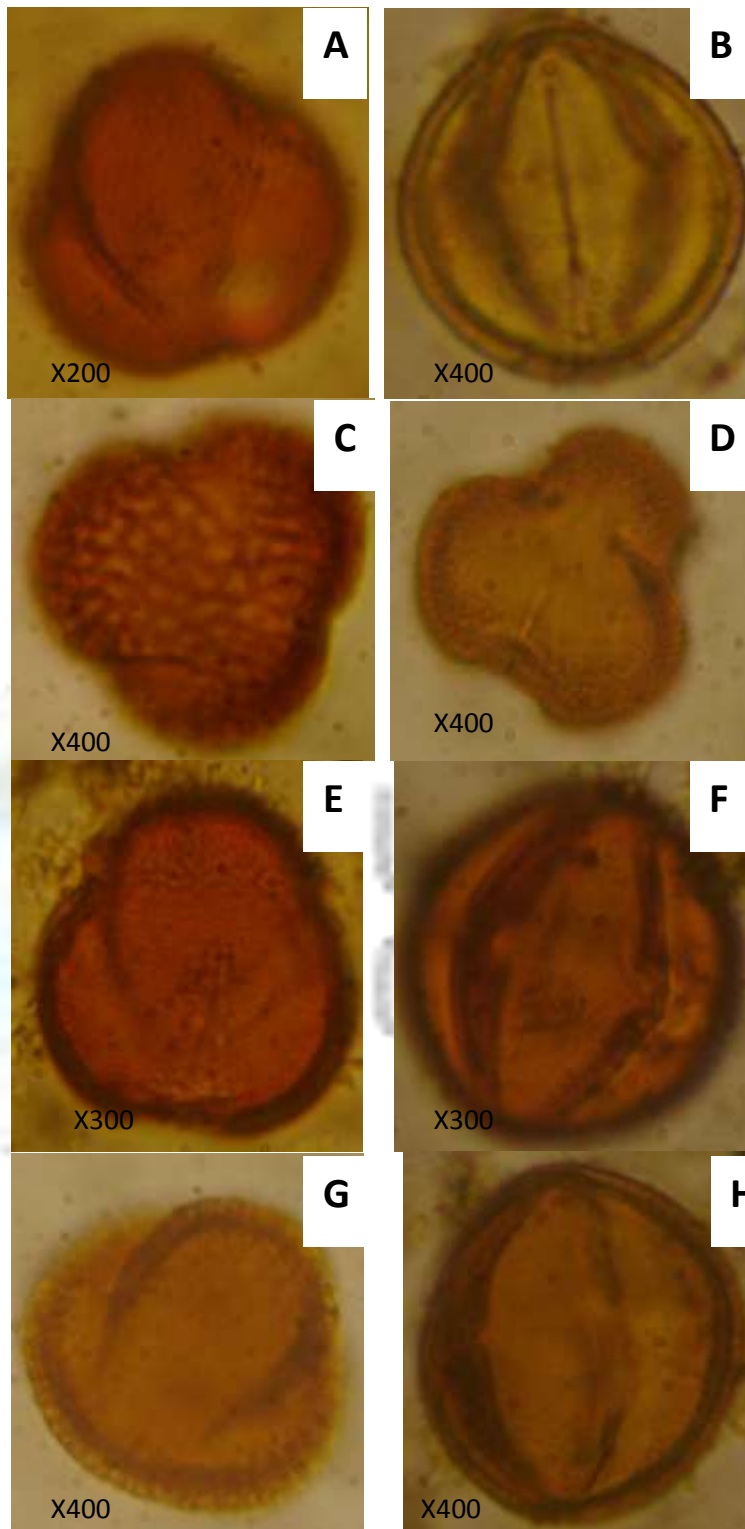


Plate 17: Photomicrographs of simple, monad tricolporate pollen grains in *Euphorbia* species (contd.)

- | | |
|---|--|
| A. Equatorial view of <i>E. hirta</i> | B. Polar view of <i>E. hyssopifolia</i> |
| C. Equatorial view of <i>E. lateriflora</i> | D. Equatorial view of <i>E. ingens</i> |
| E. Equatorial view of <i>E. prostrata</i> | F. Equatorial view of <i>E. polynemoides</i> |
| G. Equatorial view of <i>E. thymifolia</i> | H. Polar view of <i>E. unispina</i> |

4.4 Anatomical Characterization

4.4.1 Vegetative Anatomy

4.4.1.1 Leaf Epidermal Morphology

4.4.1.1.1 Light Microscopic Study (LMS)

Tables 10-11 and Plates 18-24 show the results of both qualitative and quantitative anatomical characters of the leaf epidermal characters.

- **Epidermal cell shape**

Examination of the leaf epidermises revealed that the shape of the epidermal cells on both surfaces were iso-diametric in all species. On the abaxial surface, the length of the epidermal cell wall ranged from 1.46(32.42 ± 3.53)40.00µm in *E. aegyptiaca* to 55.00(61.33±0.53)75.00µm in *E. deightonii*. The width of the epidermal cells ranged from 7.50(8.83±0.60)10.00µm in *E. cotinifolia* to 67.50(56.75±0.53)82.50µm in *E. leucophylla*. On the adaxial surface, the length ranged from 1.00(1.6±0.65)2.5µm in *E. desmondi* to 78.08(95.06±0.24)96.78µm in *E. poissonii*. The width of the epidermal cells ranged from 0.50(0.53±0.05)0.60µm in *E. desmondi* to 60.00(70±0.6)82.50µm in *E. poissonii*.

- **Anticlinal cell wall pattern**

The anti-clinal wall patterns were sinuate, undulate or straight. *E. balsamifera*, *E. scordifolia*, *E. glomerifera* and *E. leucophylla* had straight anticlinal wall patterns on the adaxial surface and undulated wall pattern on the abaxial surface while *E. glaucophylla* had undulated wall pattern on the adaxial surface and straight anticlinal wall pattern on the abaxial surface. *E. glomerifera* had straight pattern on adaxial and sinuate on abaxial surface. Taxa with straight wall pattern on both surfaces include: *E. aegyptiaca*, *E. calva*, *E. deightonii*, *E. depauperata*, *E. desmondii*, *E. heterophylla*, *E. ingens*, *E. kamerunica*, *E. lateriflora*, *E. milii* var. *tanamarivae*, *E. poissonii*, *E. pulcherimma* and *E. unispina*.

Taxa with undulated wall patterns on both surfaces include; *E. бага*, *E. ampla*, *E. convolvuloides*, *E. cotinifolia*, *E. hirta*, *E. milii* var. *splendens*, *E. milii* var. *tenuispina*, *E. polycnemoides* and *E. thymifolia*. Sinuate patterns were observed in *E. sp. B.*, *E. milii* var. *hislopii*, *E. hyssopifolia* and *E. prostrata* on both surfaces.

- **Stomatal features**

The leaves were either hypostomatic (confined to abaxial surface only) or amphistomatic (both surfaces). Six types of stomatal complexes were observed. They are: Paracytic, Hemiparacytic, amphi-paracytic, brachy-paracytic, anisocytic and anomocytic stomatal complexes. On the abaxial surface, both anisocytic and brachy-paracytic stomatal complexes were observed in *E. ampla* and *E. glomerifera*. Anisocytic and paracytic stomatal complexes were observed in *E. glaucophylla*, *E. milii* var. *tanaririvae* and *E. scordifolia*. Anisocytic and Anomocytic stomatal complexes were present in *E. thymifolia* and *E. бага*. Paracytic and anomocytic stomatal complexes were found in *E. sp B* and *E. heterophylla*.

On the adaxial surface, Paracytic and anomocytic stomatal complexes were observed on *E. бага* and *E. thymifolia*. Paracytic and anisocytic were found on *E. convolvuloides*, *E. hyssopifolia* and *E. scordifolia*. Hemiparacytic and anisocytic were found in *E. sp B* and *E. heterophylla*. Both brachy-paracytic and paracytic were found on *E. glomerifera*. Hemiparacytic was observed on both surfaces of *E. deightoni*. Paracytic stomatal complex was observed on both surfaces of *E. calva*, *E. ingens*, *E. lateriflora*, *E. kamerunica*, *E. prostrata* and *E. milii* var. *splendens*.

- **Trichomes**

Trichomes were either present or absent from both surfaces. Where present, they were either singly nucleated or non- nucleated that were either sparse or densely located on the surface. Trichomes were observed on *E. aegyptiaca*, *E. heterophylla*, *E. hirta*, *E. leucophylla*, *prostrata*, *pulcherimma* and *E. sp. B.* *E. leucophylla* had densely located single non - nucleated type while

E. aegyptiaca, *E. heterophylla*, *E. hirta*, and *E. sp. B* have densely located single but nucleated type. *E. prostrata* and *E. pulcherimma* had single nucleated, sparsely located trichomes. There were surface ornamentations on the abaxial surface of *E. hirta*.



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Table 10: Qualitative leaf Epidermal micro-morphological characters of *Euphorbia* species in Nigeria

| S/n | Taxa | Anticlinal wall | | Stomatal complex | | Trichomes | | | Surface ornamentation | |
|-----|---|-----------------|----------|------------------|---------|-----------|------|---------|-----------------------|---------|
| | | Adaxial | Abaxial | Adaxial | Abaxial | Pr | Type | Density | Adaxial | abaxial |
| 1. | <i>E. aegyptiaca</i> | Straight | Straight | C | C | Pr | S/N | Dense | Ab | Ab |
| 2. | <i>E. ampla</i> | Undulate | Undulate | A | C,F | Ab | Ab | Ab | Ab | Ab |
| 3. | <i>E. бага</i> | Undulate | Undulate | C | C,D | Ab | Ab | Ab | Ab | Ab |
| 4. | <i>E. balsamifera</i> | Straight | Undulate | A,C | A,C | Ab | Ab | Ab | Ab | Ab |
| 5. | <i>E. calva</i> | Straight | Straight | A | A | Ab | Ab | Ab | Ab | Ab |
| 6. | <i>E. convolvuloides</i> | Undulate | Undulate | A,C | A, | Ab | Ab | Ab | Ab | Ab |
| 7. | <i>E. cotinifolia</i> | Undulate | Undulate | Ab | C | Ab | Ab | Ab | Ab | Ab |
| 8. | <i>E. deightonii</i> | Straight | Straight | B | B | Ab | Ab | Ab | Ab | Ab |
| 9. | <i>E. depauperata</i> | Straight | Straight | Ab | D | Ab | Ab | Ab | Ab | Ab |
| 10. | <i>E. desmondii</i> | Straight | Straight | A | C | Ab | Ab | Ab | Ab | Ab |
| 11. | <i>E. glaucophylla</i> | Undulate | Straight | A | A,C | Ab | Ab | Ab | Ab | Ab |
| 12. | <i>E. glomerifera</i> | Straight | Sinuate | A,F | C,F | Ab | Ab | Ab | Ab | Ab |
| 13. | <i>E. heterophylla</i> | Straight | Straight | B,C | A,D | Pr | S/N | Dense | Ab | Ab |
| 14. | <i>E. hirta</i> | Undulate | Undulate | A,B,C | A,B,C | Pr | S/N | Dense | Ab | Pr |
| 15. | <i>E. hyssopifolia</i> | Sinuate | Sinuate | C | C | Ab | Ab | Ab | Ab | Ab |
| 16. | <i>E. ingens</i> | Straight | Straight | A | A | Ab | Ab | Ab | Ab | Ab |
| 17. | <i>E. kamerunica</i> | Straight | Straight | A | A | Ab | Ab | Ab | Ab | Ab |
| 18. | <i>E. keithii</i> | Undulate | Undulate | A | A | Ab | Ab | Ab | Ab | Ab |
| 19. | <i>E. lateriflora</i> | Straight | Straight | A | A | Ab | Ab | Ab | Ab | Ab |
| 20. | <i>E. leucophylla</i> | Straight | Undulate | Ab | C | Pr | S/Nn | Dense | Ab | Ab |
| 21. | <i>E. milii</i> var. <i>splendens</i> | Undulate | Undulate | A | A | Ab | Ab | Ab | Ab | Ab |
| 22. | <i>E. milii</i> var. <i>tanamarivae</i> | Straight | Straight | A | A,C | Ab | Ab | Ab | Ab | Ab |
| 23. | <i>E. milii</i> var. <i>tenuispina</i> | Undulate | Undulate | A | A | Ab | Ab | Ab | Ab | Ab |
| 24. | <i>E. milii</i> var. <i>hislopii</i> | Sinuate | Sinuate | Ab | A | Ab | Ab | Ab | Ab | Ab |
| 25. | <i>E. poissonii</i> | Straight | Straight | B | E | Ab | Ab | Ab | Ab | Ab |
| 26. | <i>E. polycnemoides</i> | Undulate | Undulate | A | A | Ab | Ab | Ab | Ab | Ab |
| 27. | <i>E. prostrata</i> | Sinuate | Sinuate | A | A | Pr | S/N | Sparse | Ab | Ab |
| 28. | <i>E. pulcherimma</i> | Straight | Straight | Ab | C | Pr | S/N | Sparse | Ab | Ab |
| 29. | <i>E. scordifolia</i> | Straight | Undulate | A,C | A,C | Ab | Ab | Ab | Ab | Ab |
| 30. | <i>E. sp. B</i> | Sinuate | Sinuate | B,C | A,D | Pr | S/N | Dense | Ab | Ab |
| 31. | <i>E. thymifolia</i> | Undulate | Undulate | C | C,D | Ab | Ab | Ab | Ab | Ab |
| 32. | <i>E. unispina</i> | Straight | Straight | B | E | Ab | Ab | Ab | Ab | Ab |

KEY:

A: Paracytic stomatal complex type
 B: Hemiparacytic stomatal complex types
 C: Anisocytic stomatal complex type
 D: Anomocytic stomatal complex type
 E: Amphiparacytic stomatal complex
 F: Brachyparacytic stomatal complex
 ab: absent
 pr: present
 s/n: single nucleated
 s/nn: single non- nucleated

Table 11: Quantitative leaf Epidermal micro-morphological characters of *Euphorbia* species in Nigeria

| S/N | Taxa | Abaxial Surface {Min(Mean±Se)Max} | | | | Adaxial Surface{Min(Mean±Se)Max} | | | |
|-----|---|-----------------------------------|-----------------------|------------------------|------------------------|----------------------------------|------------------------|----------------------|-----------------------|
| | | Epidermal Cell | | Stomatal Complex | | Epidermal Cell | | Stomatal Complex | |
| | | Length (µm) | Width(µm) | Length(µm) | Width(µm) | Length(µm) | Width(µm) | Length(µm) | Width(µm) |
| 1 | <i>E. aegyptiaca</i> | 1.46(32.42 ± 3.53)40.00 | 29.89(29.80±0.12)30 | 10(12.00±0.85)13.50 | 6.50(7.5±0.41)8.00 | 34.00(38.00±2.87)45.00 | 35.00(36.70±4.58)40.00 | 15.00(15.75±0.61)17. | 7.5(9.17±0.68)10.00 |
| 2 | <i>E. ampla</i> | 22.25(24.08±0.75)25.00 | 16(16.75±)17.25 | 16.00(17.83±0.95)20.00 | 5.00(8.00±1.25)10.0 | 10(13.67±1.52)16.00 | 15.00(15.33±0.27)16.00 | Ab | Ab |
| 3 | <i>E. бага</i> | X | X | 25.00(30.00±2.36)35.00 | 18.00(18.67±0.54)20.00 | X | X | 15(23.33±3.60)30.00 | 7.25(9.92±1.96)15 |
| 4 | <i>E. calva</i> | 40.00(40.67±0.54)42.00 | 45(55.00±4.65)65.00 | 31.00(31.67±0.27)32 | 22(22.23±0.28)23.00 | X | X | 28.00(30.00±0.94)32. | 18.00(19.33±0.54)20.0 |
| 5 | <i>E. convolvuloides</i> | X | X | 15.00(16.33±0.54)17.00 | 10.00(14.33±1.91)18.00 | 10.00(14.17±1.80)17.50 | 15.00(15.83±0.68)17.50 | 15.00(17.00±1.25)20. | 9.00(9.50±0.24)10.00 |
| 6 | <i>E. cotinifolia</i> | 15.00(15.83±0.68)17.50 | 7.50(8.83±0.60)10.00 | Ab | Ab | 15.00(16.17±0.60)17.50 | 12.00(13.17±0.76)15.00 | 12.00(14.00±1.25)17. | 6.00(8.33±1.19)11.00 |
| 7 | <i>E. deightonii</i> | 55.00(61.33±0.53)75.00 | 20(34.90±0.76)62.50 | 45(54.58±0.4)67.50 | 50(54.25±0.34)67.50 | 50.00(77.50±0.80)100.00 | 25.00(41.43±0.68)55.00 | 50.00(58.32±0.43)75 | 40(48.75±0.38)57.50 |
| 8 | <i>E. depauperata</i> | 18.50(22.83±2.95)30.00 | 17.50(18.00±0.41)19.0 | Ab | Ab | 35.00(37.00±1.25)40.00 | 20.00(21.65±0.81)25 | 17.40(17.83±0.26)18. | 10.00(10.48±11.34) |
| 9 | <i>E. desmondi</i> | X | X | 45(52.03±0.35)57.5 | 42.50(44.53±0.08)45 | 1.00(1.6±0.65)2.5 | 0.50(0.53±0.05)0.60 | 42.50(47.88±0.33)62. | 40.00(42.50±0.17)45.0 |
| 10 | <i>E. glaucophylla</i> | 17.50(20.00±1.18)22.50 | 15(19.17±3.12)22.5 | 5.00(5.80±0.34)6.40 | 2.00(2.87±0.38)3.00 | 15(19.17±1.80)22.50 | 17.25(20.45±3.32)25.00 | 16.25(16.58±0.31)17. | 6.90(7.23±0.23)7.8 |
| 11 | <i>E. glomerifera</i> | 35.00(36.67±2.36)40.00 | 20.00(21.33±0.54)22.0 | 8(13.33±2.23)17.00 | 4.00(4.67±2.17)5.00 | 37.00(43.17±2.59)47.5 | 20.00(20.75±1.43)22.25 | 12(13.92±1.47)17.50 | 6.00(7.50±1.03)10.00 |
| 12 | <i>E. heterophylla</i> | 37.50(50.50±0.6)57.50 | 20(23.50±0.22)27.50 | 25(26.58±0.13)30 | 15.00(16.00±0.09)17.50 | 40.00(53.00±0.49)57.50 | 25.00(32.00±0.6)57.50 | 27.50(31.58±0.23)37. | 17.50(20.33±0.09)22.5 |
| 13 | <i>E. hirta</i> | 25(58±1.29)97.50 | 30(71.25±1.62)95 | 20(32.63±0.59)47.50 | 12.50(22.20±0.35)35 | 25(54.43±1.2)90 | 35.00(66.08±0.73)87.50 | 20(29.00±0.18)35 | 12.50(17.80±0.19)22.5 |
| 14 | <i>E. hyssopifolia</i> | 22.5(23.55±0.04)24.00 | 20.00(33.00±0.54)40.0 | 10.00(11.17±0.75)12.50 | 6.00(6.33±0.14)6.50 | 22.25(25.42±)30.00 | 15.00(21.67±2.5)25.00 | 10.00(13.83±1.61)16. | 4.50(5.5±0.62)7.00 |
| 15 | <i>E. kamerunica</i> | 35.00(37.98±0.26)47.50 | 15.00(19.43±0.15)22.5 | 50(63.28±0.38)70 | 35.00(46.15±0.31)55 | 20.00(21.63±0.17)25.00 | 25.00(37.50±0.4)47.50 | 25.00(27.25±0.21)29. | 28.05(29.98±0.03)31.0 |
| 16 | <i>E. lateriflora</i> | 20(27.20±0.40)35 | 10(12.70±0.14)15.00 | 27.50(28.70±0.11)30 | 12.50(17.60±0.20)20.00 | 20(30.95±0.30)35.00 | 10(12.60±0.11)15.00 | 30(36.10±0.18)40.00 | 15(23.65±0.26)30 |
| 17 | <i>E. leucopylla</i> | 25.00(27.00±0.18)37.5 | 67.50(56.75±0.53)82.5 | 22.5(25.93±0.15)30 | 17.5(64.61±0.20)32.5 | 47.5(66.75±0.67)82.5 | 25.00(36.83±0.38)45.00 | Ab | Ab |
| 18 | <i>E. poissonii</i> | 46.85(75.90±1.46)91.09 | 31.23(49.17±0.54)69.4 | 40.00(50.00±2.34)55.00 | 41.00(45.33±2.13)50.00 | 78.08(95.06±0.24)96.78 | 60.00(70±0.6)82.50 | 48.54(52.19±0.29)62. | 48.44(77.57±0.43)86.4 |
| 19 | <i>E. polycnemoides</i> | 37.5(68.00±0.96)71.42 | 30.40(32.30±0.61)48.5 | 17.5(22.23±0.13)25.00 | 10(13.85±0.15)17.50 | 32.50(54.33±0.7)64.75 | 20(27.93±0.45)35.45 | 17.5(22.83±0.13)25.0 | 10(16.23±0.26)22.50 |
| 20 | <i>E. prostrata</i> | 37.50(57.34±1.32)63.50 | 30(40.73±0.81)52.50 | 20(21.78±0.27)25 | 62.5(13.23±0.13)15 | 65.00(78.5±1.2)95.00 | 17.50(23.03±0.37)30.00 | 20(23.25±0.25)25 | 15.00(16.50±0.25)20 |
| 21 | <i>E. pulcherima</i> | 25(50.00±0.56)55.00 | 17.5(25.00±0.4)35.00 | 25.00(30.80±0.29)37.50 | 15(17.70±0.18)20 | 32.50(40.30±5.17)55 | 17.25(25.70±0.46)35 | Ab | Ab |
| 22 | <i>E. scardifolia</i> | 27.50(55.50±.96)70.00 | 20.00(35.43±0.69)45.3 | 17.50(18.85±0.12)22.50 | 17.50(18.55±0.1)20.00 | 62.50(82.70±0.64)90.56 | 22.5(26.30±0.21)32.50 | 22.50(27.60±0.20)33. | 17.50(25.95±0.42)32.0 |
| 23 | <i>E. thymifolia</i> | 25.00(57.08±1.6)60.35 | 20(40.75±1.21)50.45 | 17.50(20.35±0.10)22.50 | 10(14.88±0.11)17.50 | 30.00(51.33±0.71)59.58 | 20(25.83±0.16)32.50 | 22.50(25.20±0.12)27. | 10.00(15.20±0.19)20.0 |
| 24 | <i>E. unispina</i> | 32.50(39.40±0.37)39.40 | 20(27.7±0.4)37.50 | 37.50(40.70±0.31)50.00 | 37.50(43.40±0.43)55 | 35.00(50.00±0.7)62.50 | 25.00(34.50±0.45)50.00 | X | X |
| 25 | <i>E. sp. B</i> | 17.50(50.00±5.17)70.00 | 10(19.38±0.39)30.00 | 15.00(22.06±0.19)25.00 | 10.00(15.98±0.27)20.00 | 37.25(51.88±0.3)62.50 | 20.00(23.93±0.35)33.13 | 30(33.75±0.19)37.50 | 5.0(24.38±0.37)34.79 |
| 26 | <i>E. milii</i> var. <i>tenuispina</i> | 50(57.47±7.9)68.4 | 41.46(49.26±5.62)54.5 | 29.00(34.00±2.16)38.00 | 21.00(22.67±0.72)24.00 | 65(71.82±5.19)78.45 | 39.23(45.70±4.55)49.0 | 36.0(38.00±0.94)40.1 | 20.0(24.67±1.96)28.0 |
| 27 | <i>E. milii</i> var. <i>hislopilii</i> | 17.1(19.3±3.08)23.7 | 12.9(15.06±1.76)17.2 | 16.00(17.00±0.24)17.50 | 10.00(1.67±0.83)13.50 | 19.25(22.92±3.4)27.5 | 13.28(14.36±0.89)15.5 | 16.0(16.33±0.27)17.0 | 9.00(9.33±0.27)10.00 |
| 28 | <i>E. milii</i> var. <i>tananarivae</i> | 45.7(50.43±3.99)55.45 | 30.47(34.91±3.35)38.5 | 20.00(20.33±0.21)21.00 | 11.00(14.68±1.57)17.50 | 44.6(48.01±2.74)51.3 | 23.49(29.33±4.43)34.2 | Ab | Ab |

x: no adequate information

ab: absent

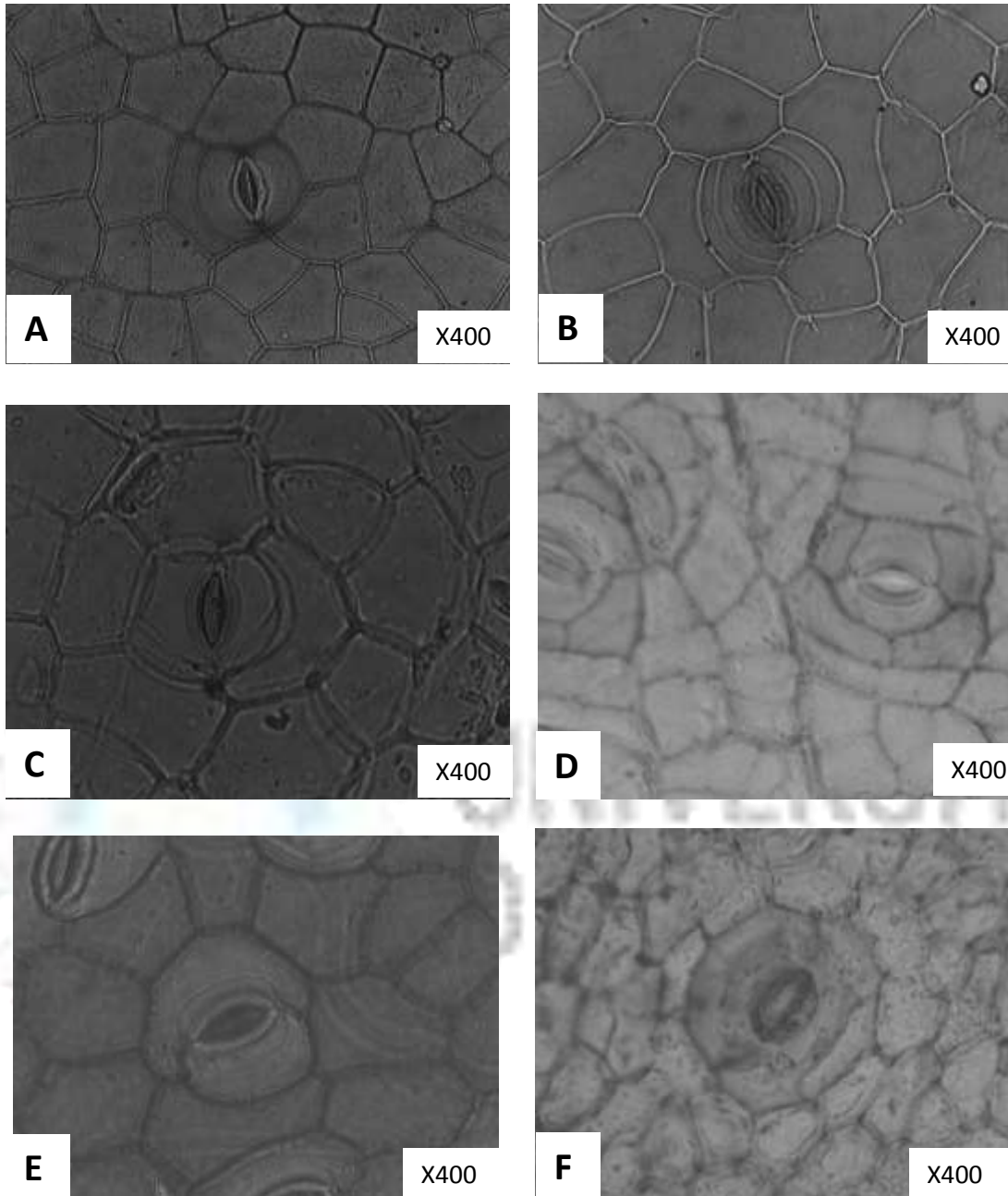


Plate 18: Light micrographs of leaf epidermis of some *Euphorbia* spp.

- (A) adaxial surface of *E. unispina* - hemiparacytic stomatal complex
- (B) abaxial surface of *E. poissonii* - amphiparacytic stomatal complex
- (C) adaxial surface of *E. poissonii* - hemiparacytic stomatal complex
- (D) adaxial surface of *E. desmondi* – paracytic stomatal complex
- (E) abaxial surface of *E. calva* – paracytic stomatal complex
- (F) adaxial surface of *E. kamerunica* –paracytic stomatal complex

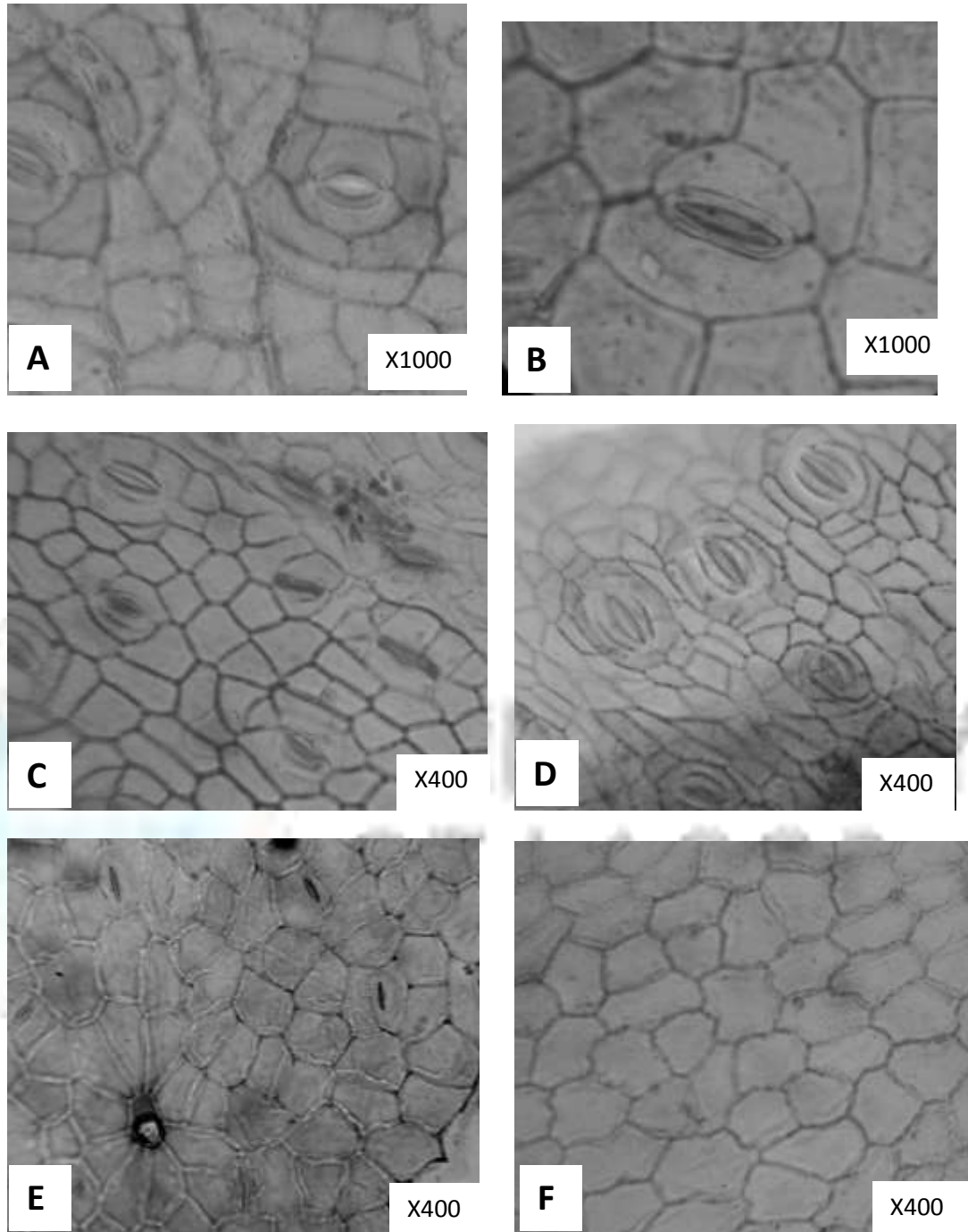


Plate 19: Light micrographs of leaf epidermis of some *Euphorbia* spp. showing:

- (A) abaxial surface of *E. ingens*: paracytic stomatal complex
- (B) abaxial surface of *E. deightonii*: anisocytic stomatal complex
- (C) adaxial surface of *E. lateriflora*: paracytic stomatal complex
- (D) abaxial surface of *E. lateriflora*: paracytic stomatal complex
- (E) abaxial surface of *E. pulcherimma*: anisocytic stomatal complex
- (F) adaxial surface of *E. pulcherimma*: absence of stomata complex

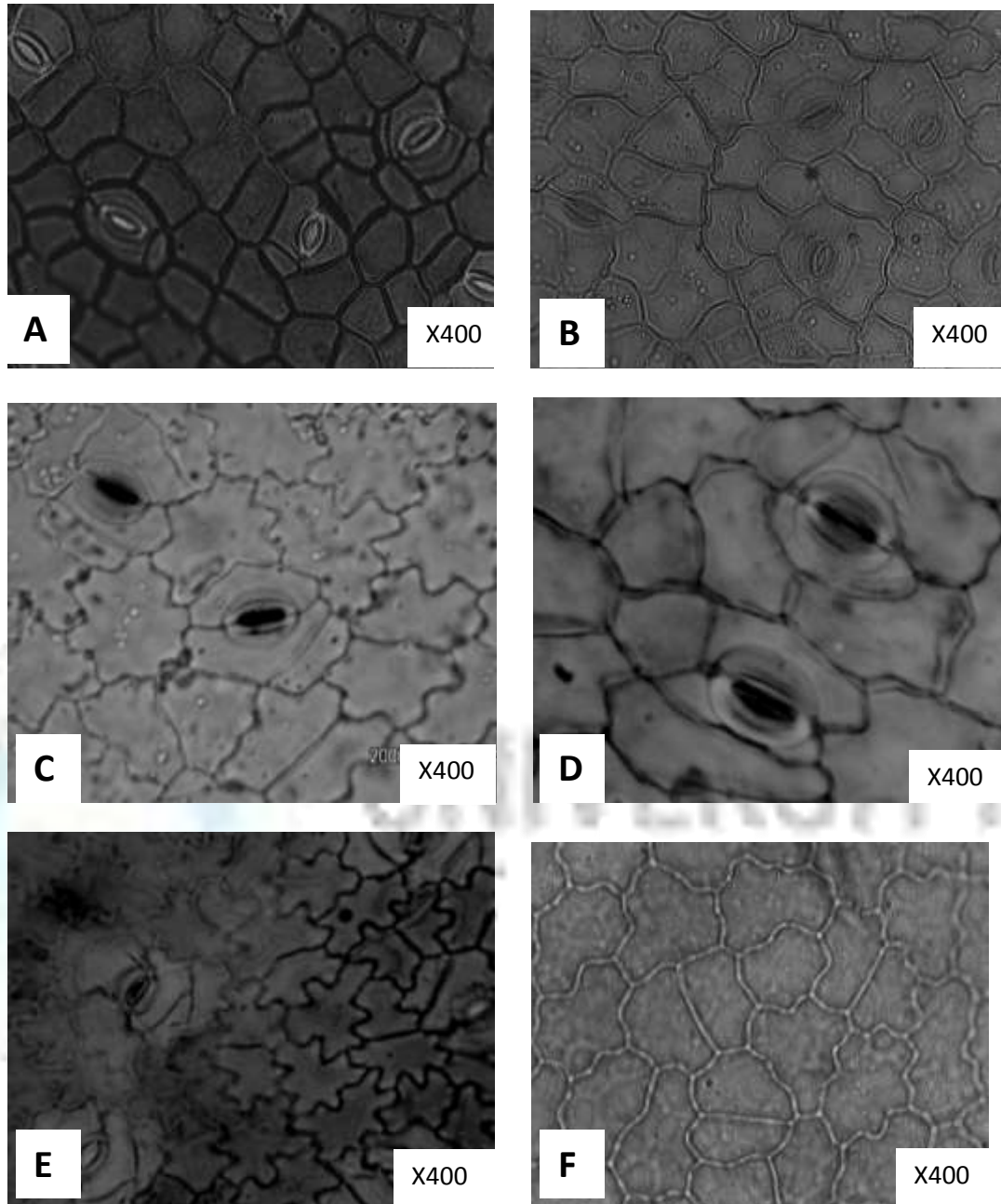


Plate 20: Light micrographs of leaf epidermis of some *Euphorbia* species:

- (A) Adaxial surface of *E. milii* var. *tananarivae*: paracytic stomatal complex
- (B) Abaxial surface of *E. milii* var. *tananarivae* paracytic stomatal complex
- (C) Adaxial surface of *E. milii* var. *tenuispina* paracytic stomatal complex
- (D) Abaxial surface of *E. milii* var. *tenuispina* paracytic stomatal complex
- (E) Abaxial surface of *E. milii* var. *hislopii* paracytic stomatal complex
- (F) Adaxial surface of *E. milii* var. *hislopii*: no stomatal complex

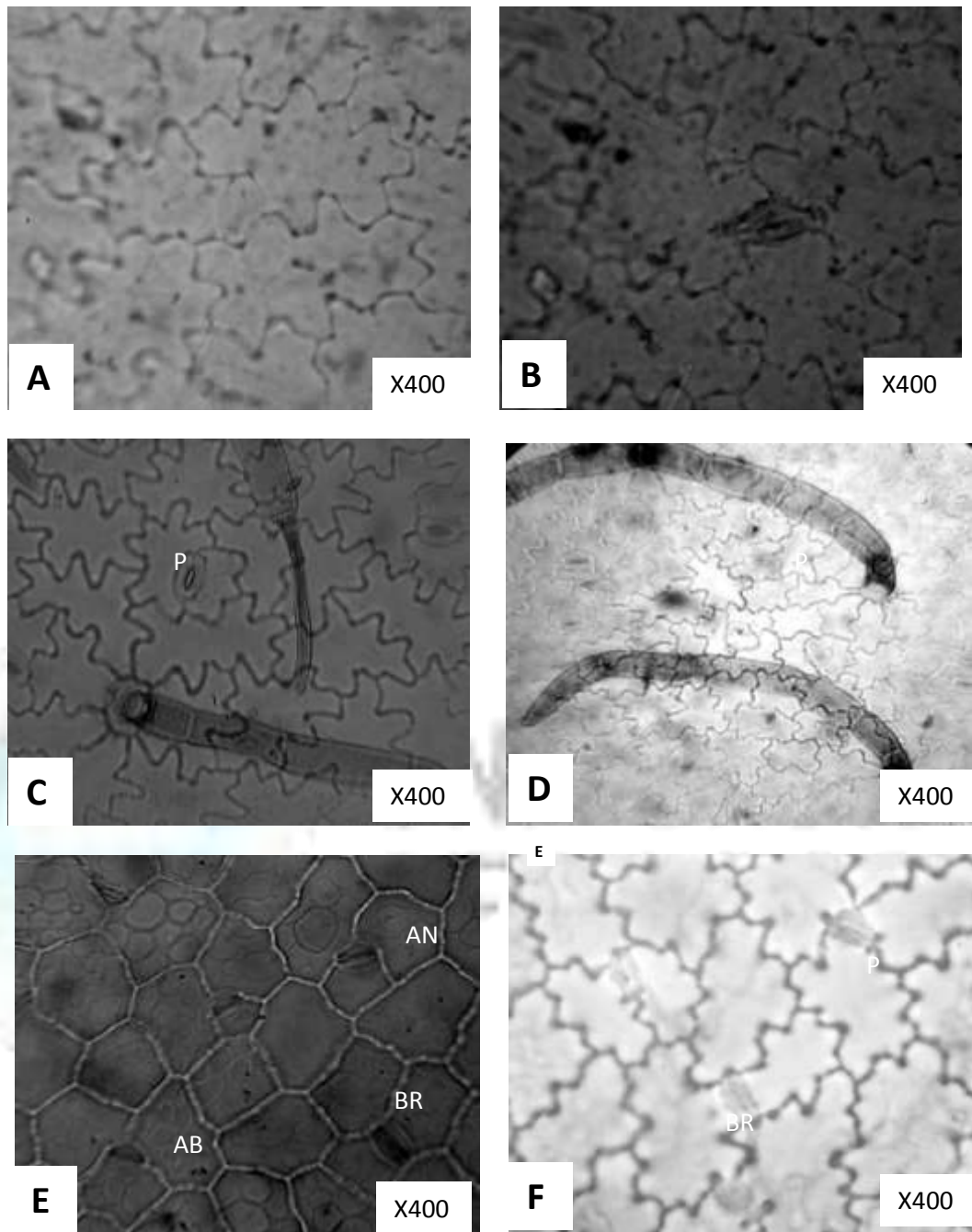


Plate 21: Light micrographs of leaf epidermis of some *Euphorbia* species showing stomatal complex types: AN: anisocytic; BR: Brachyparacytic; P: paracytic

- (A) abaxial surface of *E. hyssopifolia*
- (B) adaxial surface of *E. hyssopifolia*
- (C) adaxial surface of *E. prostrata*
- (D) abaxial surface of *E. prostrata*
- (E) abaxial surface of *E. glomerifera*
- (F) adaxial surface of *E. glomerifera*

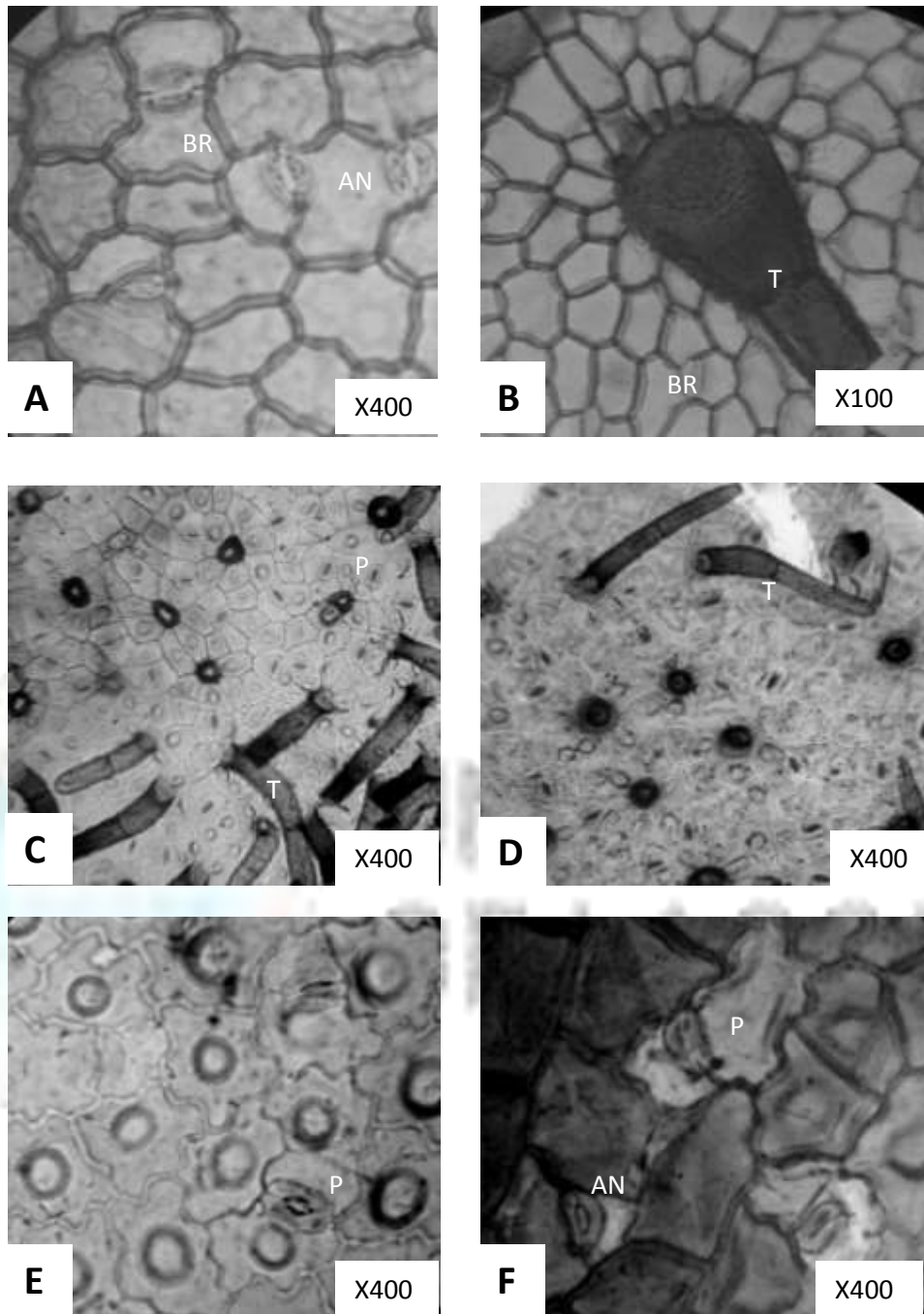


Plate 22: Light micrographs of *Euphorbia* species showing stomatal complex types:
 AN: anisocytic; BR: brachyparacytic; P: paracytic; T: trichome

- (A) abaxial surface of *E. heterophylla*
- (B) adaxial surface of *E. heterophylla*
- (C) abaxial surface of *E. aegyptiaca*
- (D) adaxial surface of *E. aegyptiaca*
- (E) adaxial surface of *E. glaucophylla*
- (F) abaxial surface of *E. glaucophylla*

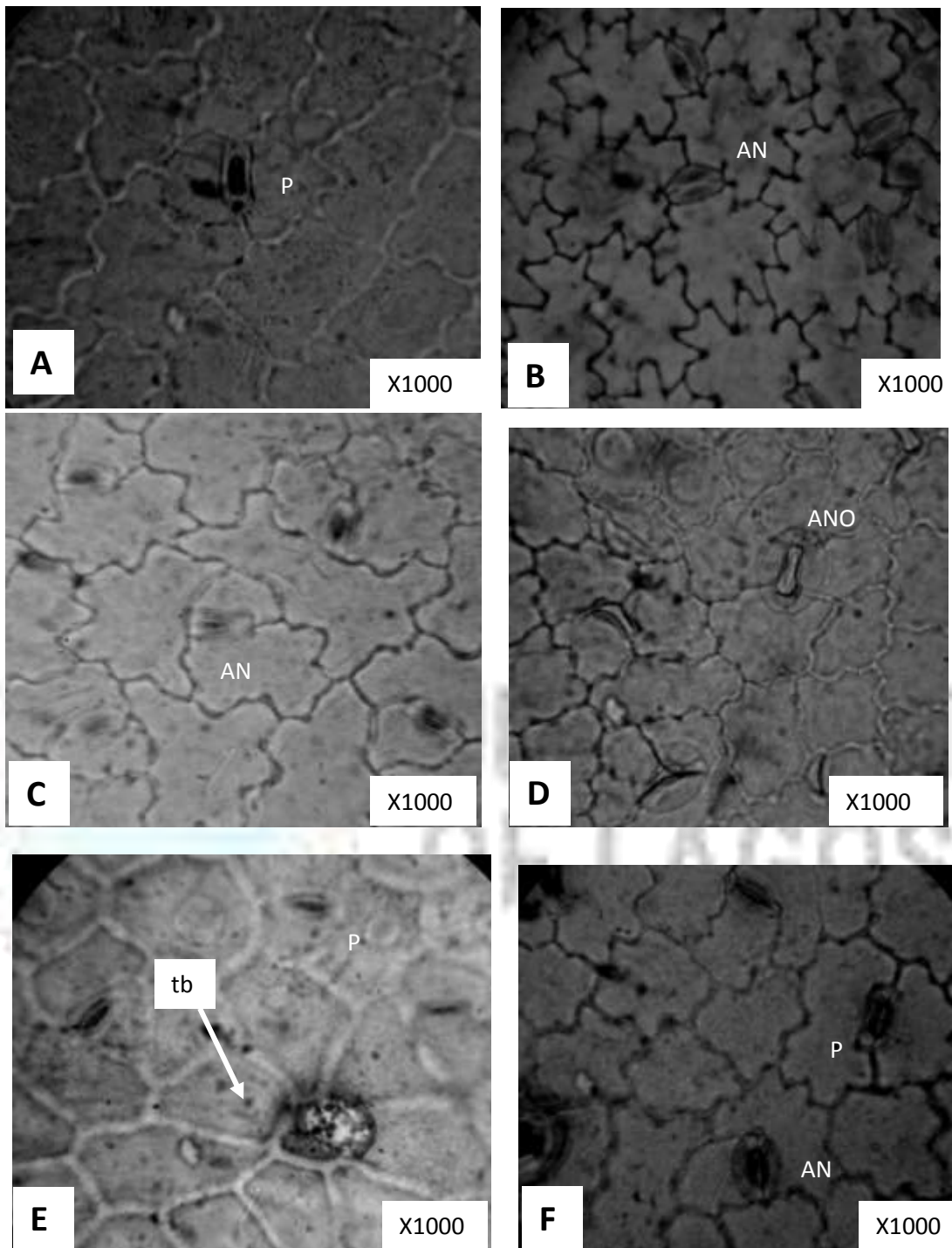


Plate 23: Light micrographs of *Euphorbia* species showing stomatal complex types: AN: anisocytic; BR: brachyparacytic; P: paracytic; T: trichome; ANO: Anomocytic:

- (A) adaxial surface of *E. polycnemoides* (B) abaxial surface of *E. leucophylla*
 (C) adaxial surface of *E. thymifolia* (D) abaxial surface of *E. thymifolia*
 (E) adaxial surface of *E. scordifolia* (tb- trichome base)
 (F) abaxial surface of *E. scordifolia*

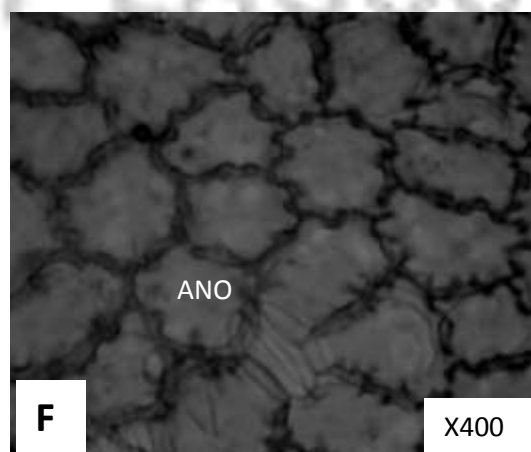
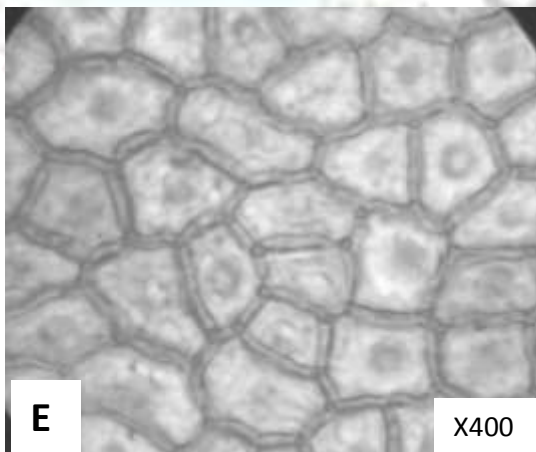
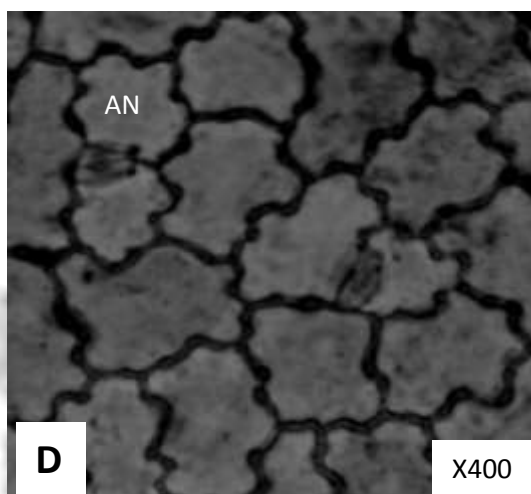
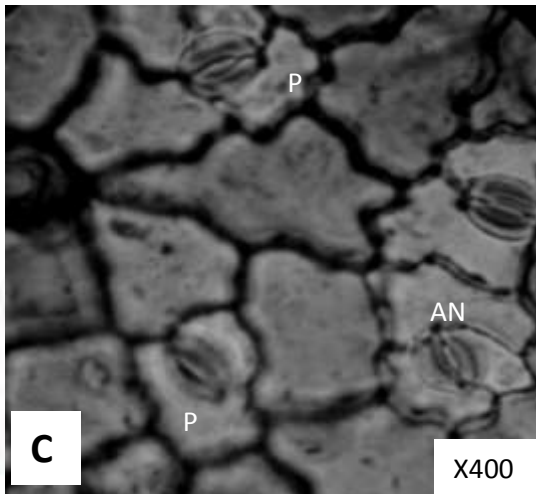
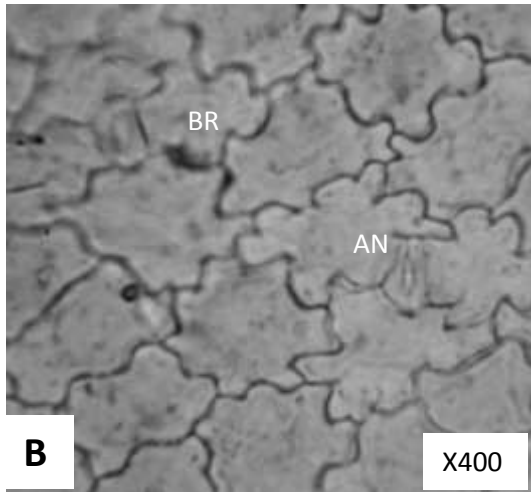
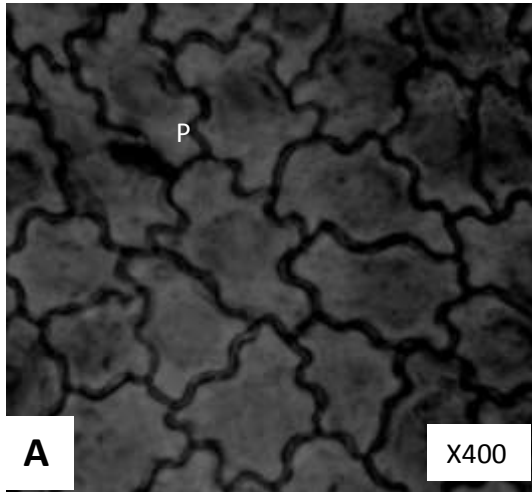


Plate 24: Light micrographs of *Euphorbia* species showing stomatal complex types:
 AN: anisocytic; BR: brachyparacytic; P: paracytic; T: trichome ANO: Anomocytic

(A) adaxial surface of *E. ampla* (B) abaxial surface of *E. ampla*

(C) abaxial surface of *E. convolvuloides* (D) adaxial surface of *E. convolvuloides*

(E) adaxial surface of *E. depauperata* (F) abaxial surface of *E. depauperata*

4.4.1.1.2 Scanning Electron Microscopic (SEM) Study

Detailed Electromicrographs of the species studied are presented in Plates 25- 29 and Table 12. Three types of trichomes were observable. These are: cylindrical (*E. aegyptiaca*, *E. ampla*, *E. convolvuloides*, and *E. scordifolia*), moniliform (*E. heterophylla*, *E. hirta*, *E. glaucophylla*, *E. lateriflora* and *E. sp B.*) and acicular (*E. milii* var. *tanarivae*). Trichomes were absent in *E. бага*, *E. balsamifera*, *E. leddermaniana*, *E. deightonii*, *E. desmondii*, *E. cotinifolia*, *E. depauperata*, *E. glomerifera*, *E. hyssopifolia*, *E. ingens*, *E. keithii*, *E. kamerunica*, *E. leucophylla*, *E. poissonii*, *E. Polycnemoides*, *E. prostrata*, *E. pulcherrima*, *E. thymifolia*, *E. cyathophora*, *E. unispina*, *E. milii* var. *splendens*, *E. milii* var. *hislopii*, and *E. milii* var. *tenuispina*.

The stomata were either superficially located (*E. aegyptiaca*, *E. ampla*, *E. convolvuloides*, *E. бага*, *E. balsamifera*, *E. leddermaniana*, *E. deightonii*, *E. desmondii*, *E. cotinifolia*, *E. scordifolia*, *E. ingens* and *E. kamerunica*) sunken (*E. depauperata*, *E. glomerifera*, *E. heterophylla*, *E. hyssopifolia*, *E. hirta*, *E. keithii*, *E. glaucophylla* and *E. cyathophora*) or raised (*E. milii* var. *tenuispina*, *E. poissonii*, *E. unispina*). Wax granules were present on *E. ampla*, *E. aegyptiaca*, *E. convolvuloides*, *E. ingens* and *E. scordifolia*. Wax flakes were present on *E. depauperata*, *E. glaucophylla*, *E. heterophylla*, *E. hyssopifolia*, *E. hirta*, *E. keithii*, *E. prostrata* and *E. pulcherrima*. Both wax granules and wax flakes were absent on the other *Euphorbia* specimens.

The cuticular patterns were corrugated (*E. aegyptiaca*), wrinkled (*E. бага*), ridge (*E. cyathophora*), striated (*E. milii* var. *tanarivae*, *E. milii* var. *tenuispina*, *E. sp. B*) or smooth (other *Euphorbia* specimens) while the epidermal relief were smooth, verrucose or Dome.

Table 12: Micro-morphological features of *Euphorbia* species using SEM

| S/N | Taxa | Trichome | | Epidermal Relief | Cuticular pattern | Epicuticular wax | Stomatal Orientation |
|-----|---------------------------------------|-----------|-------------|---------------------|----------------------|---------------------|-------------------------|
| | | Pr/ Ab | Type | | | | |
| 1. | <i>E. aegyptiaca</i> | Pr | Cylindrical | Smooth | Corronulate | Wax granules | Superficial |
| | | Ab | Ab | Smooth | Corronulate | Wax granules | Superficial |
| 2. | <i>E. ampla</i> | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| | | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| 3. | <i>E. бага</i> | Ab | Ab | Verrucose | Wrinkled | Ab | Superficial |
| | | Ab | Ab | Verrucose | Wrinkled | Ab | Superficial |
| 4. | <i>E. balsamifera</i> | Ab | Ab | Dome | Smooth | Ab | Superficial |
| | | Ab | Ab | Dome | Smooth | Ab | Superficial |
| 5. | <i>E. leddermaniana</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 6. | <i>E. convolvuloides</i> | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| | | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| 7. | <i>E. cotinifolia</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 8. | <i>E. deightonii</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 9. | <i>E. depauperata</i> | Ab | Ab | Dome | Smooth | Wax flakes | Sunken |
| | | Ab | Ab | Dome | Smooth | Wax flakes | Sunken |
| 10. | <i>E. desmondii</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 11. | <i>E. glaucophylla</i> | Pr | Ab | Verrucose | Smooth | Wax flakes | Sunken |
| | | Pr | Moniliform | Verrucose | Smooth | Wax flakes | Sunken |
| 12. | <i>E. glomerifera</i> | Ab | Ab | Dome | Smooth | Ab | Sunken |
| | | Ab | Ab | Dome | Smooth | Ab | Sunken |
| 13. | <i>E. heterophylla</i> | Pr | Moniliform | Verrucose | Smooth | Wax flakes | Sunken |
| | | Pr | Moniliform | Verrucose | Smooth | Wax flakes | Sunken |
| 14. | <i>E. hirta</i> | Pr | Moniliform | Verrucose | Smooth | Wax flakes | Sunken |
| | | Pr | Moniliform | Verrucose | Smooth | Wax flakes | Sunken |
| 15. | <i>E. hyssopifolia</i> | Ab | Ab | Verrucose | Smooth | Wax flakes | Sunken |
| | | Ab | Ab | Verrucose | Smooth | Wax flakes | Sunken |
| 16. | <i>E. ingens</i> | Ab | Ab | Dome | Smooth | Wax granules | Superficial |
| | | Ab | Ab | Dome | Smooth | Wax granules | Superficial |
| 17. | <i>E. kamerunica</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 18. | <i>E. keithii</i> | Ab | Ab | Verrucose | Smooth | Ab | Sunken |
| | | Ab | Ab | Smooth | Smooth | Wax flakes | Sunken |
| 19. | <i>E. lateriflora</i> | Pr | Moniliform | Verrucose | Smooth | Ab | Superficial |
| | | Pr | Moniliform | Verrucose | Smooth | Ab | Superficial |
| 20. | <i>E. leucophylla</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 21. | <i>E. milii</i> var. <i>splendens</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 22. | <i>E. milii</i> var. | Pr | Acicular | Verrucose | Striated | Ab | Superficial |

| | | | | | | | |
|-----|--|----|-------------|-----------|----------|--------------|-------------|
| | <i>tanandarivae</i> | Pr | Acicular | Verrucose | Striated | Ab | Superficial |
| 23. | <i>E. milii</i> var. <i>tenuispina</i> | Ab | Ab | Smooth | Striated | Ab | Raised |
| | | Ab | Ab | Smooth | Striated | Ab | Raised |
| 24. | <i>E. milii</i> var. <i>hislopii</i> | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| | | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| 25. | <i>E. poissonii</i> | Ab | Ab | Verrucose | Smooth | Ab | Raised |
| | | Ab | Ab | Verrucose | Smooth | Ab | Raised |
| 26. | <i>E. polycnemoides</i> | Ab | Ab | Dome | Smooth | Ab | Superficial |
| | | Ab | Ab | Dome | Smooth | Ab | Superficial |
| 27. | <i>E. prostrata</i> | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| | | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| 28. | <i>E. pulcherimma</i> | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| | | Ab | Ab | Smooth | Smooth | Wax flakes | Superficial |
| 29. | <i>E. scordifolia</i> | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| | | Pr | Cylindrical | Smooth | Smooth | Wax granules | Superficial |
| 30. | <i>E. sp. B</i> | Pr | Moniliform | Verrucose | Striated | Ab | Superficial |
| | | Pr | Moniliform | Verrucose | Striated | Ab | Superficial |
| 31. | <i>E. thymifolia</i> | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| | | Ab | Ab | Smooth | Smooth | Ab | Superficial |
| 32. | <i>E. cyathophora</i> | Ab | Ab | Verrucose | Ridged | Ab | Sunken |
| | | Ab | Ab | Verrucose | Ridged | Ab | Sunken |
| 33. | <i>E. unispina</i> | Ab | Ab | Verrucose | Smooth | Ab | Raised |
| | | Ab | Ab | Verrucose | Smooth | Ab | Raised |

Upper data are from adaxial surfaces while lower data are from abaxial surfaces

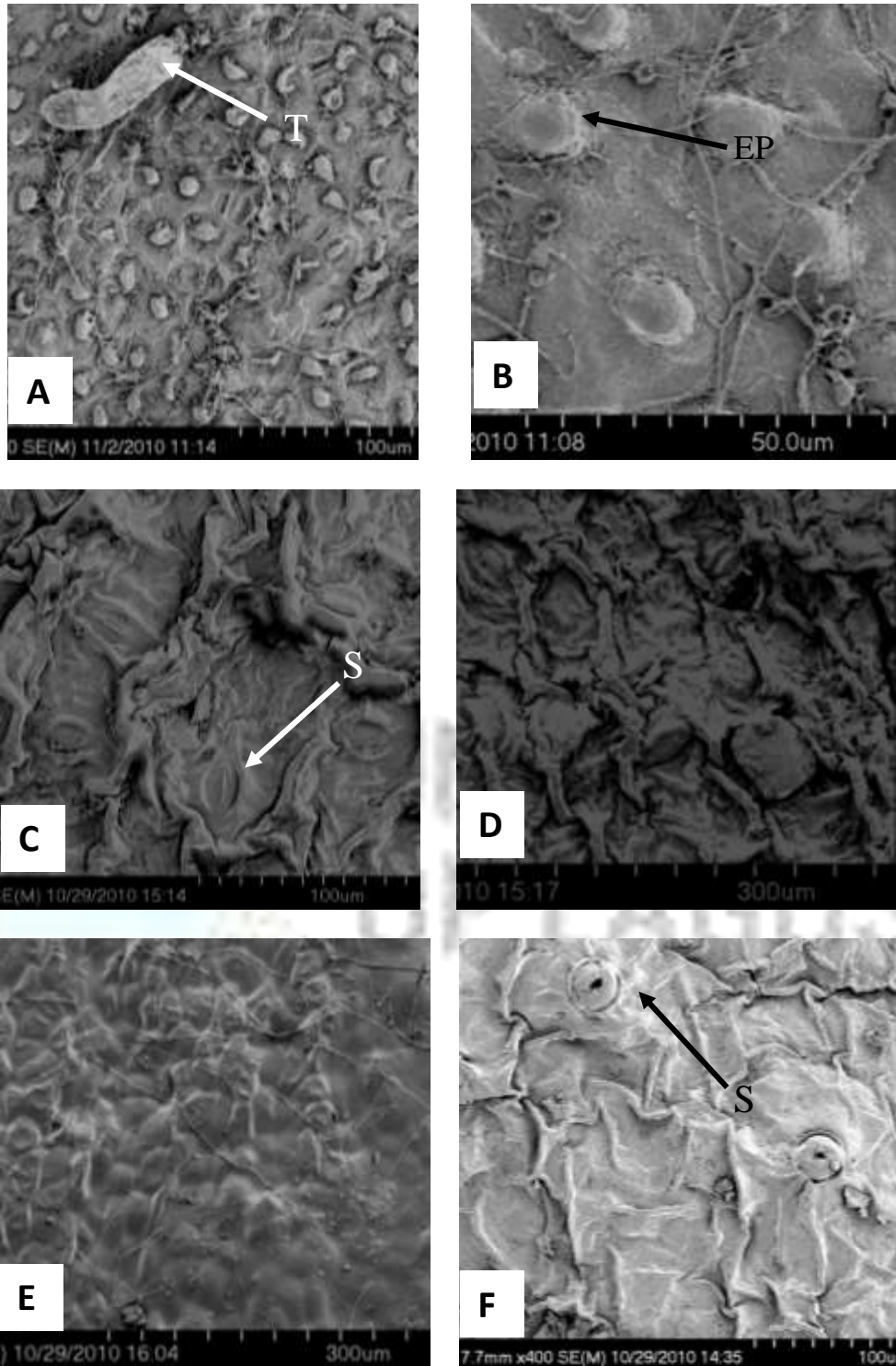


Plate 25: Scanning Electron micrographs of some *Euphorbia* species

(T: trichome, S: stomata, EP: Epicuticular wax

(A) abaxial surface of *E. ampla* (B) adaxial surface of *E. ampla*

(C) abaxial surface of *E. бага* (D) adaxial surface of *E. бага*

(E) abaxial surface of *E. balsamifera* (F) adaxial surface of *E. poissonii*

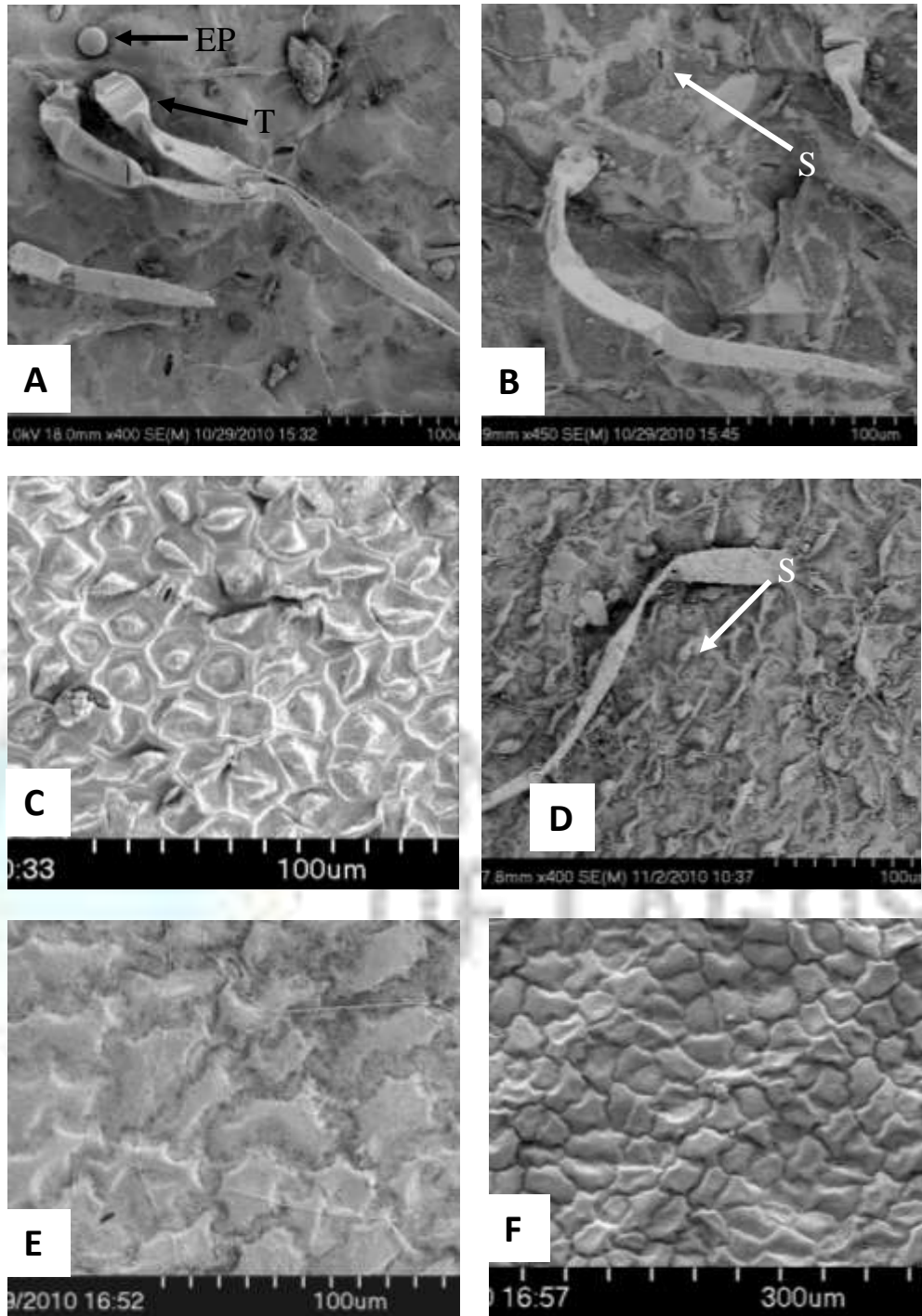


Plate 26: Scanning Electron micrographs of some *Euphorbia*. species (contd.)

(S: stomata, T: trichome, EP: epicuticular wax)

(A) adaxial surface of *E. convolvuloides*

(B) abaxial surface of *E. convolvuloides*

(C) adaxial surface of *E. hyssopifolia*

(D) abaxial surface of *E. hyssopifolia*

(E) adaxial surface of *E. glomerifera*

(F) abaxial surface of *E. glomerifera*

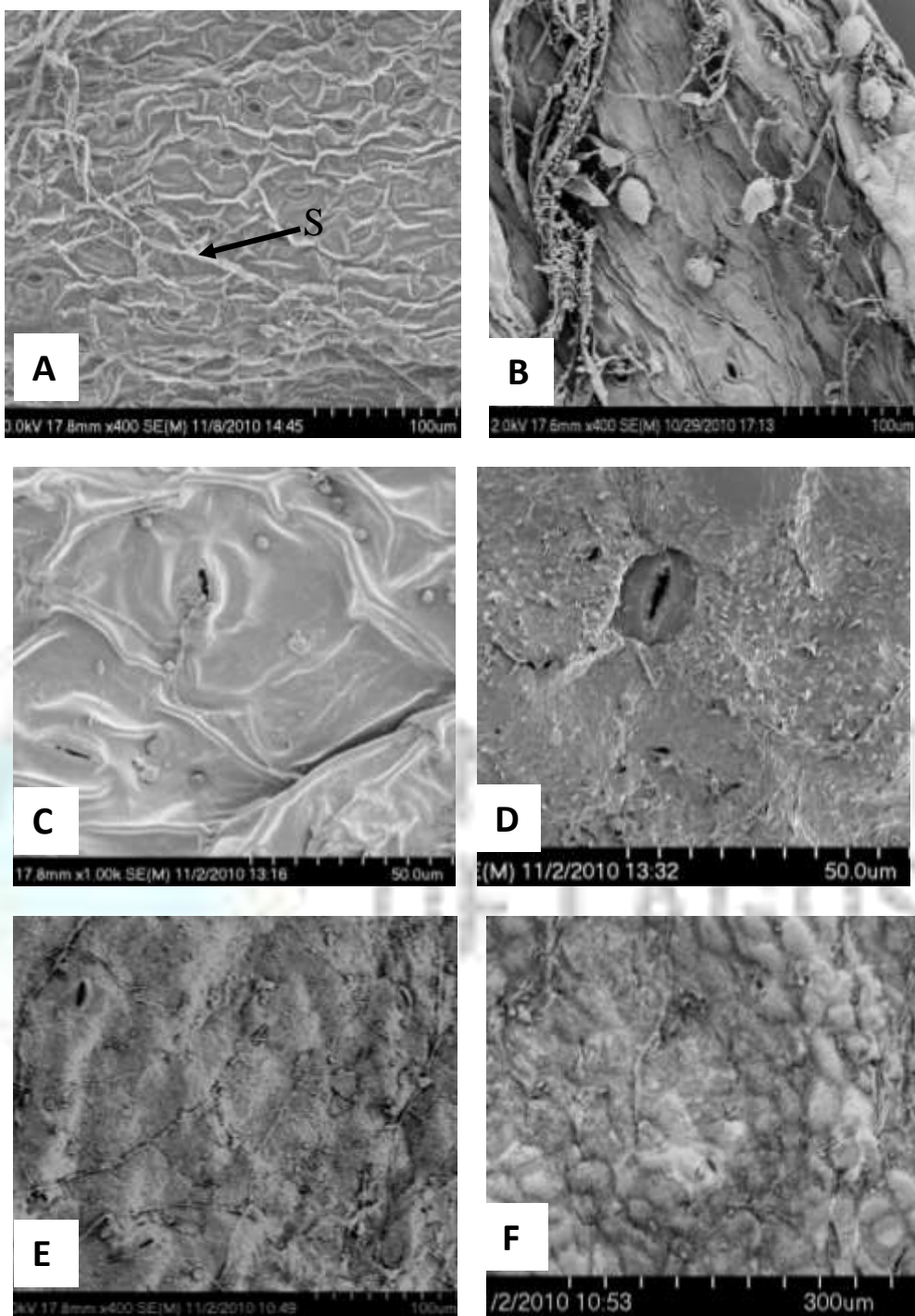


Plate 27: Scanning Electron micrographs of some *Euphorbia* species (contd.)

(S: stomata, T: trichome, EP: epicuticular wax)

- (A) abaxial surface of *E. lateriflora* (B) adaxial surface of *E. lateriflora*
 (C) adaxial surface of *E. keithii* (D) abaxial surface of *E. keithii*
 (E) abaxial surface of *E. kerstingii* (F) adaxial surface of *E. kerstingii*

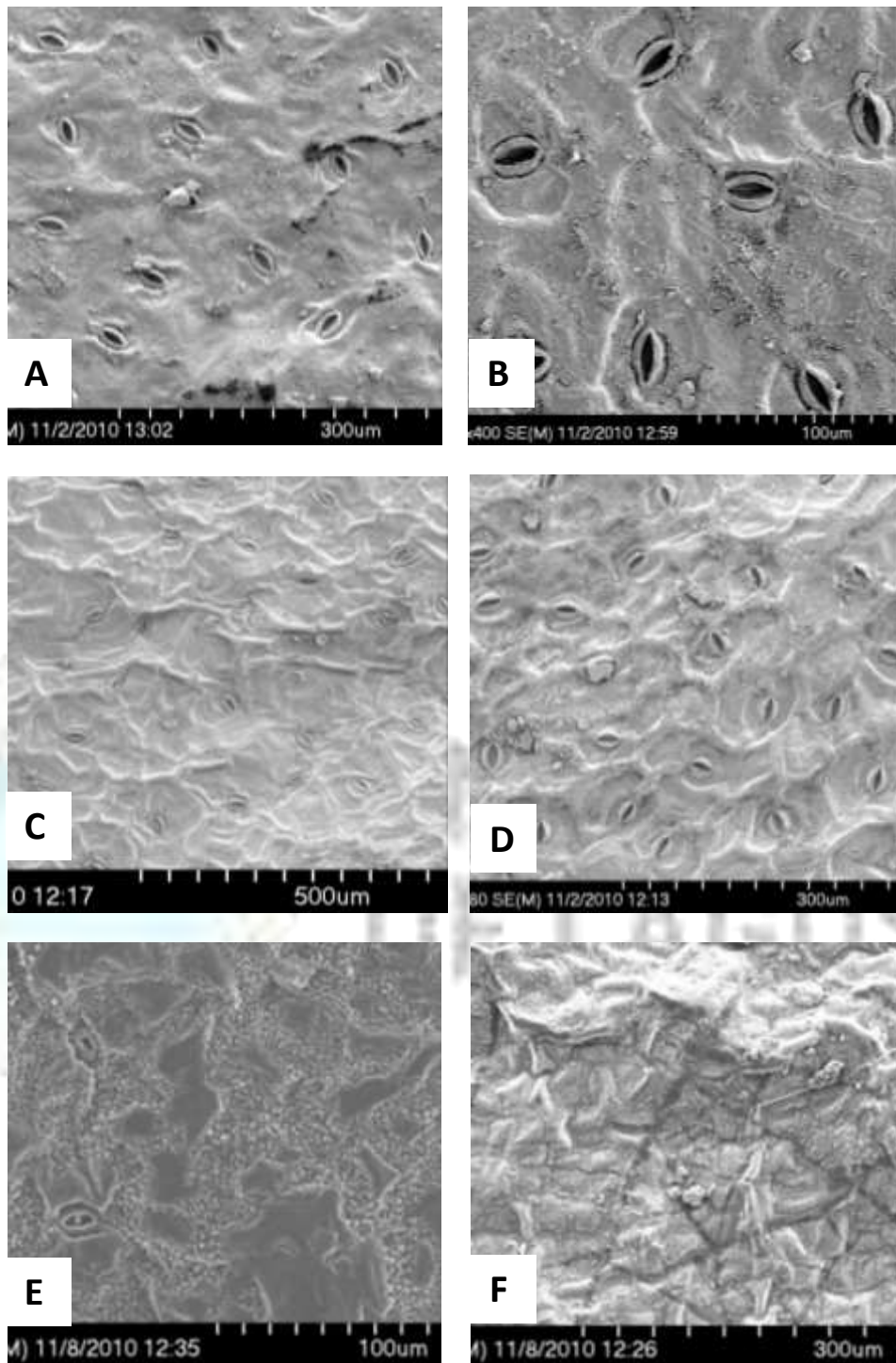


Plate 28: Scanning Electronmicrographs of leaf epidermises some *Euphorbia* species

(A) adaxial surface of *E. leddermaniana* (B) abaxial surface of *E. leddermaniana*

(C) adaxial surface of *E. macrophylla* (D) abaxial surface of *E. macrophylla*

(E) abaxial surface of *E. milii* var. *hislopii* (F) adaxial surface of *E. milii* var. *hislopii*

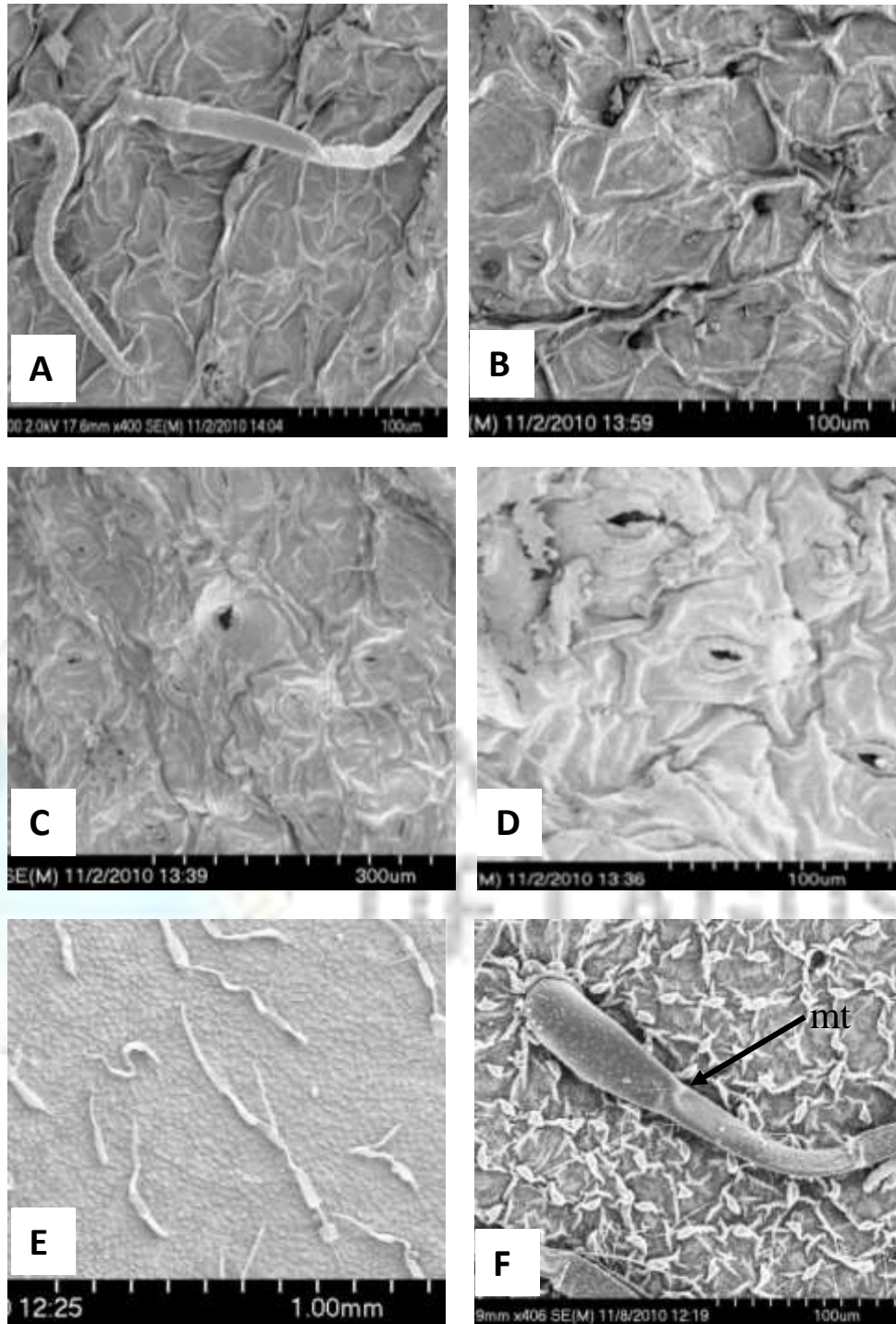


Plate 29: Scanning Electron micrographs of some *Euphorbia* species contd.
(mt: multi- serrated trichome)

- (A) abaxial surface of *E. milii* var. *tananarivae*
- (B) adaxial surface of *E. milii* var. *tananarivae*
- (C) adaxial surface of *E. milii* var. *tenuispina*
- (D) abaxial surface of *E. milii* var. *tenuispina*
- (E) adaxial surface of *E. sp. B*
- (F) abaxial surface of *E. sp. B*

4.4.1.2 Venation Pattern

Venation patterns of twenty one species (with four varieties of *Euphorbia milii*) were studied based on availability of specimens. All the specimens studied had pinnately netted veins with a single primary vein (mid-vein) serving as the origin for the higher order venation. They were craspedodromous with secondary veins terminating at the margin (Plates 30-32 and Table 13), semi-craspedodromous (with the secondary veins branching near the margin) e.g. *E. prostrata*, *E. hyssopifolia* and *E. lateriflora* or mixed-craspedodromous (with some secondary veins terminating at the margin and others terminating away from the margin).

Also, venation was hypodromous with only the primary veins evident and secondary veins either absent, very reduced or hidden within the leaf mesophyll in some taxa e.g. *E. poissonii*, *E. ampla*, *E. calva* and *E. schimperiana*. The secondary veins were right angled and divergent angles were nearly uniform, the thickness was fine with composite inter secondary veins. The angle of origin of the tertiary veins was acute while the pattern was orthogonal reticulate. The course of the quaternary veins was orthogonal with distinct resolution. However, on the basis of the number of strands entering the base of the leaf (in sessile leaves) or petiole (in petiolate leaves), the specimens are grouped in to uni-veined, bi-veined and tri-veined as presented in Table 12.

Table 13: Venation patterns in genus *Euphorbia*

| S/N | Taxa | Number of veins that entered leaf base | Type of vein | Pattern of venation | Order of venation |
|-----|---|--|--------------|-----------------------|-------------------------------|
| 1. | <i>E. ampla</i> | 1 | uni- veined | Hypodromous | 1 st (primary) |
| 2. | <i>E. calva</i> | 1 | uni- veined | Hypodromous | 1 st (primary) |
| 3. | <i>E. cotinifolia</i> | 1 | uni- veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 4. | <i>E. milii</i> var. <i>tenuispina</i> | 1 | uni- veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 5. | <i>E. milii</i> var. <i>hislopii</i> | 1 | uni- veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 6. | <i>E. milii</i> var. <i>splendens</i> | 1 | uni- veined | Mixed-Craspedodromous | 3 rd (tertiary) |
| 7. | <i>E. milii</i> var. <i>tananarivae</i> | 1 | uni- veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 8. | <i>E. lateriflora</i> | 1 | uni- veined | Semi-Craspedodromous | 4 th (quarternary) |
| 9. | <i>E. kamerunica</i> | 2 | bi-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 10. | <i>E. ingens</i> | 2 | bi-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 11. | <i>E. prostrata</i> | 3 | tri-veined | Semi-Craspedodromous | 4 th (quarternary) |
| 12. | <i>E. poissonii</i> | 2 | bi-veined | Hypodromous | 1 st (primary) |
| 13. | <i>E. hyssopifolia</i> | 3 | tri-veined | Semi-Craspedodromous | 2 nd (secondary) |
| 14. | <i>E. convolvuloides</i> | 3 | tri-veined | Mixed-Craspedodromous | 2 nd (secondary) |
| 15. | <i>E. glaucophylla</i> | 3 | tri-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 16. | <i>E. schimperiana</i> | 3 | tri-veined | Hypodromous | 1 st (primary) |
| 17. | <i>E. cotinifolia</i> | 3 | tri-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 18. | <i>E. heterophylla</i> | 3 | tri-veined | Hypodromous | 1 st (primary) |
| 19. | <i>E. hirta</i> | 3 | tri-veined | Mixed-Craspedodromous | 3 rd (tertiary) |
| 20. | <i>E. sp. B</i> | 3 | tri-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 21. | <i>E. prostrata</i> | 3 | tri-veined | Mixed-Craspedodromous | 3 rd (tertiary) |
| 22. | <i>E. pulcherimma</i> | 3 | tri-veined | Mixed-Craspedodromous | 4 th (quarternary) |
| 23. | <i>E. thymifolia</i> | 3 | tri-veined | Mixed-Craspedodromous | 3 rd (tertiary) |
| 24. | <i>E. keithii</i> | 3 | tri-veined | Mixed-Craspedodromous | 4 th (quarternary) |

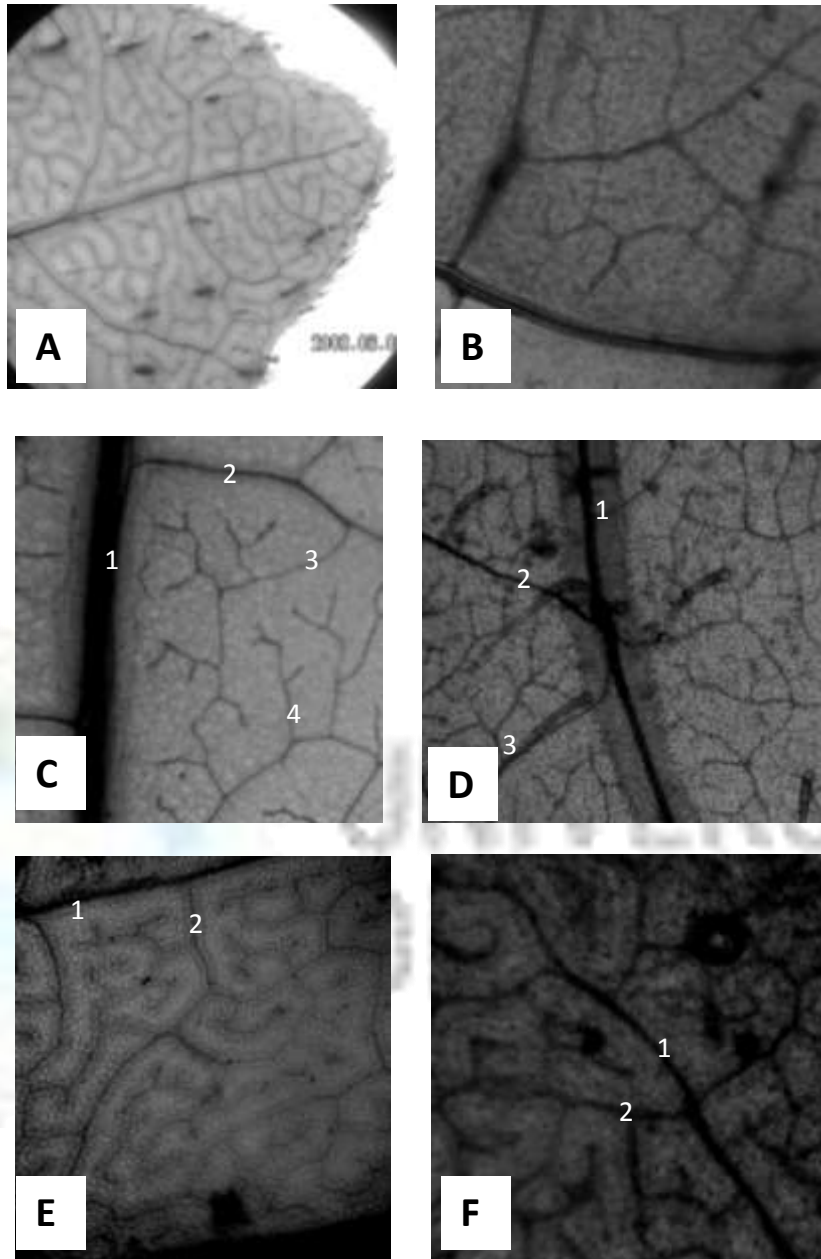


Plate 30: Photomicrographs of the veins showing venation patterns in *Euphorbia* spp. (1: 1st order, 2: 2nd order, 3: 3rd order, 4: 4th order) of:

- A. *E. hirta*
- B. *E. milii* var. *hislopii*
- C. *E. cotinifolia*
- D. *E. milii* var. *splendens*
- E. *E. hyssopifolia*
- F. *E. prostrata*

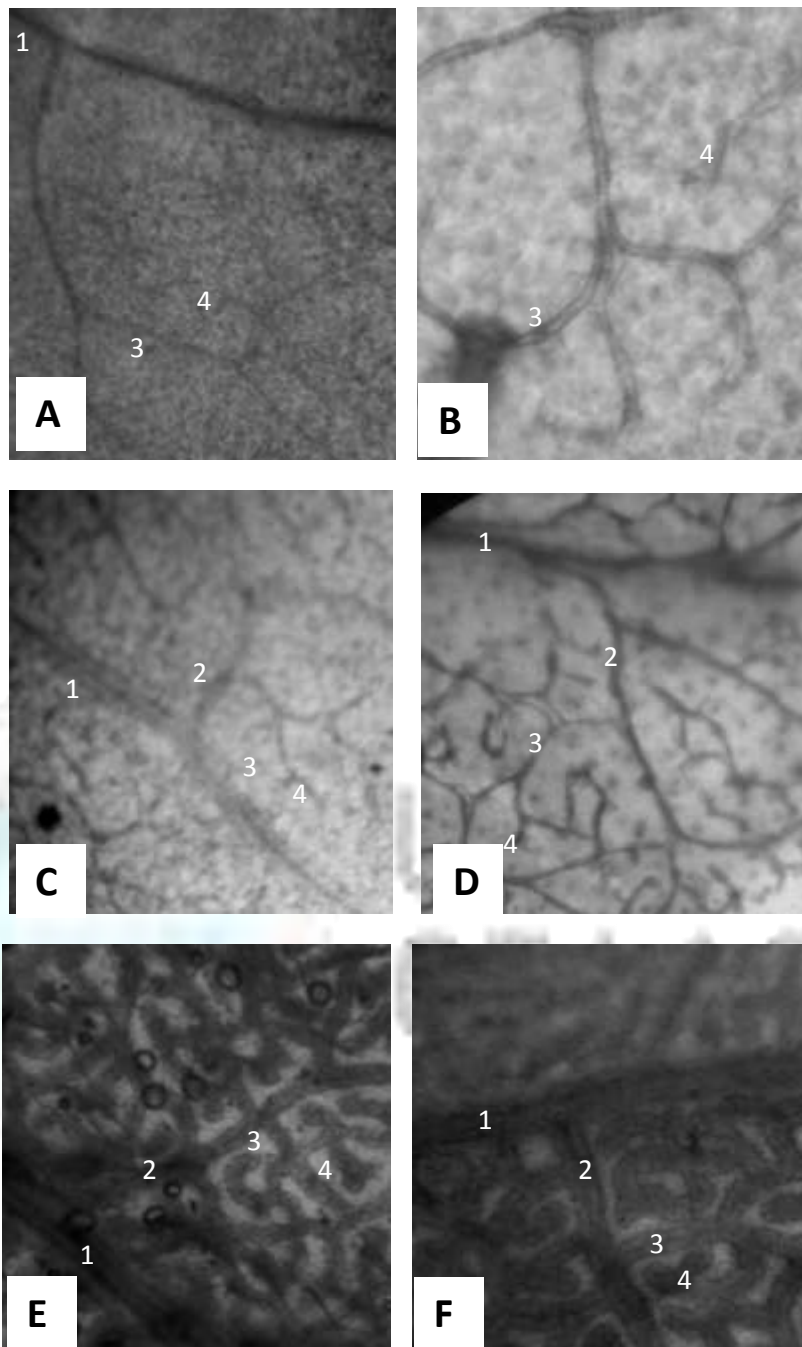


Plate 31: Photomicrographs of the veins showing venation patterns in *Euphorbia* spp. (contd.)

- A. *E. ampla*
- B. *E. heterophylla*
- C. *E. milii* var. *tenuispina*
- D. *E. lateriflora*
- E. *E. thymifolia*
- F. *E. convolvuloides*

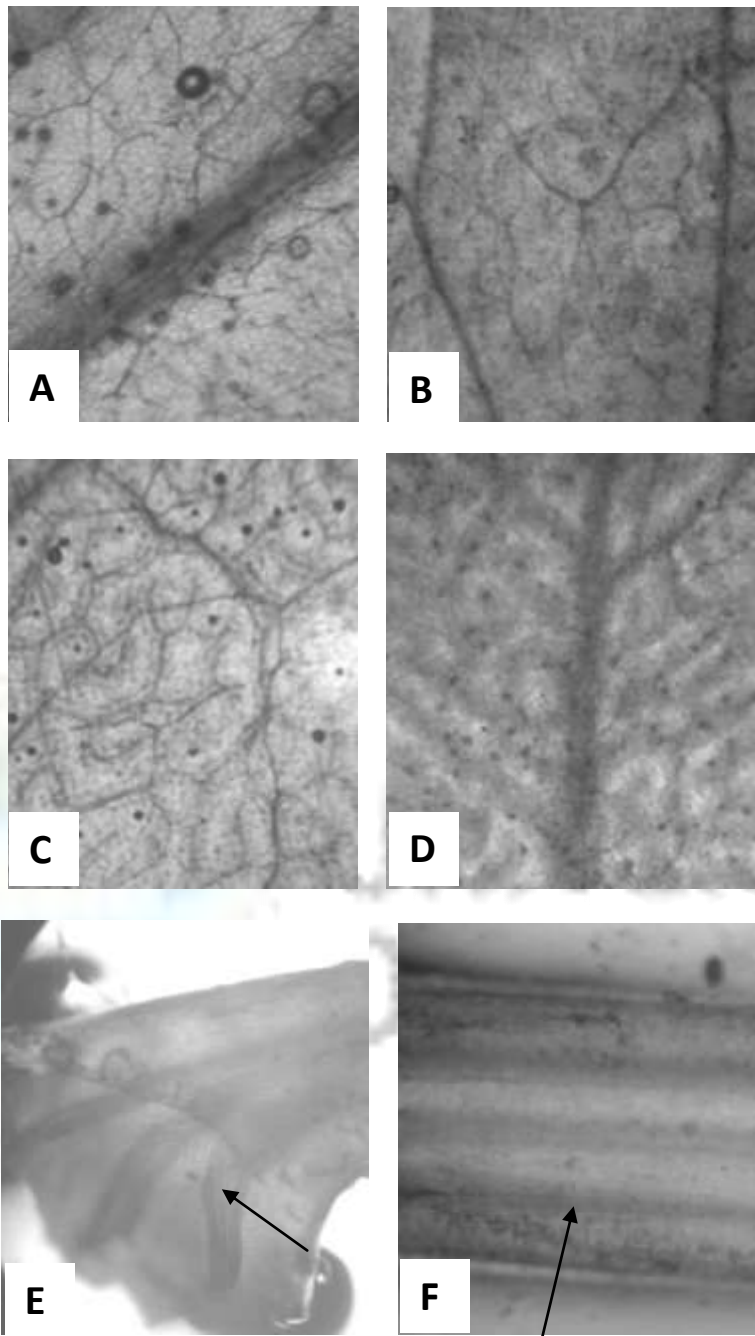


Plate 32: Photomicrographs of the veins showing venation patterns

in *Euphorbia* spp. (contd.)

- A. *E. prostrata*
- B. *E. schimperiana*
- C. *E. hyssopifolia*
- D. *E. glaucophylla*
- E. *E. hirta* (arrow showing 3 veins entering the petiole)
- F. *E. cotinifolia* (arrow showing 3 veins entering the petiole)

4.4.1.3 Nodal Anatomy

In all the species examined, the median bundle was broad with three leaf traces i.e. 3-lacunar, 3-traced nodes in most of the species except *Euphorbia poissonii* with 5-lacunar, 5-traced node (Plate 33). A median trace and two lateral traces entered in to the petiole without a division. The adaxial surface was deep furrowed in *E. hirta* (Plate 33A), slightly furrowed in *E. milii* var. *splendens* (Plate 33C), not furrowed in *E. milii* var. *tananarivae* (Plate 33D) and raised in *E. milii* var. *hislopii* (Plate 33B). There were three discrete vascular bundles in *E. milii* var. *tananarivae* and *E. milii* var. *splendens* (Plate 33C - 33D), more than three discrete vascular bundles in *E. poissonii* (Plate 3E), all U-shaped in *E. milii* var. *tenuispina* (Plate 33F). On the abaxial surface, the vascular bundles were centrally located and deep crescentiform in *E. milii* var. *tananarivae*, *E. poissonii* and *E. milii* var. *tenuispina* (Plates 33D - 33F) and simple crescentiform in *E. milii* var. *splendens* (Plate 33C).

4.4.2 Stem Anatomy

The cross section of the various stems examined during this study revealed that they were circular in outline. The epidermis which is the outermost delimiting layer is composed of small round shaped cells arranged in one layer. The outer layers had thick wall and thick cuticle in some species where the inside was 7-8 layered cortex. In the cortex, the 3 outer layers are parenchymatous while others are collenchymatous. Fewer cells of the cortex contain granular matters followed from within by a continuous ring of vascular tissue. Two layered patches of sclerenchymatous pericycle were present on the outside of the vascular tissue. Cells of the pith are also rounded, parenchymatous, thin walled and contain granular matter. The vascular tissues were in the form of bundles that were unequal in sizes and arranged in a ring. Many of the vascular bundles got interconnected to each other. The meta-xylem are large and distinct. The vessels have either uniseriate and/or biserate rays. The biserated rays are distinct (Plate 34).

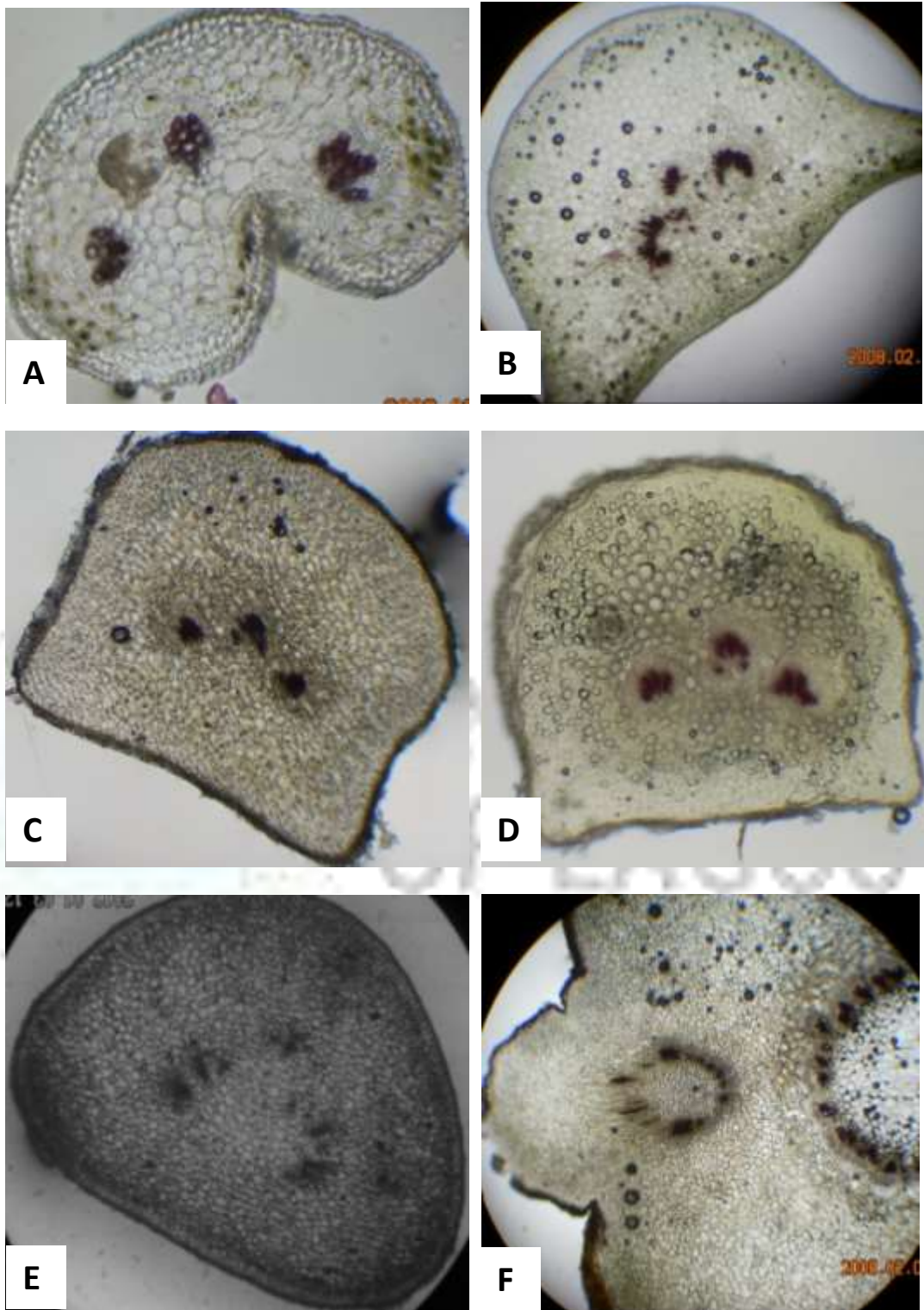


Plate 33: Transverse sections (x40) showing structure of the foliar nodes of *Euphorbia* species

(a) *E. hirta* (b) *E. milii* var. *hislopii* (c) *E. milii* var. *splendens*

(d) *E. milii* var. *tanamarivae* (e) *E. poissonii* (f) *E. milii* var. *tenuispina*

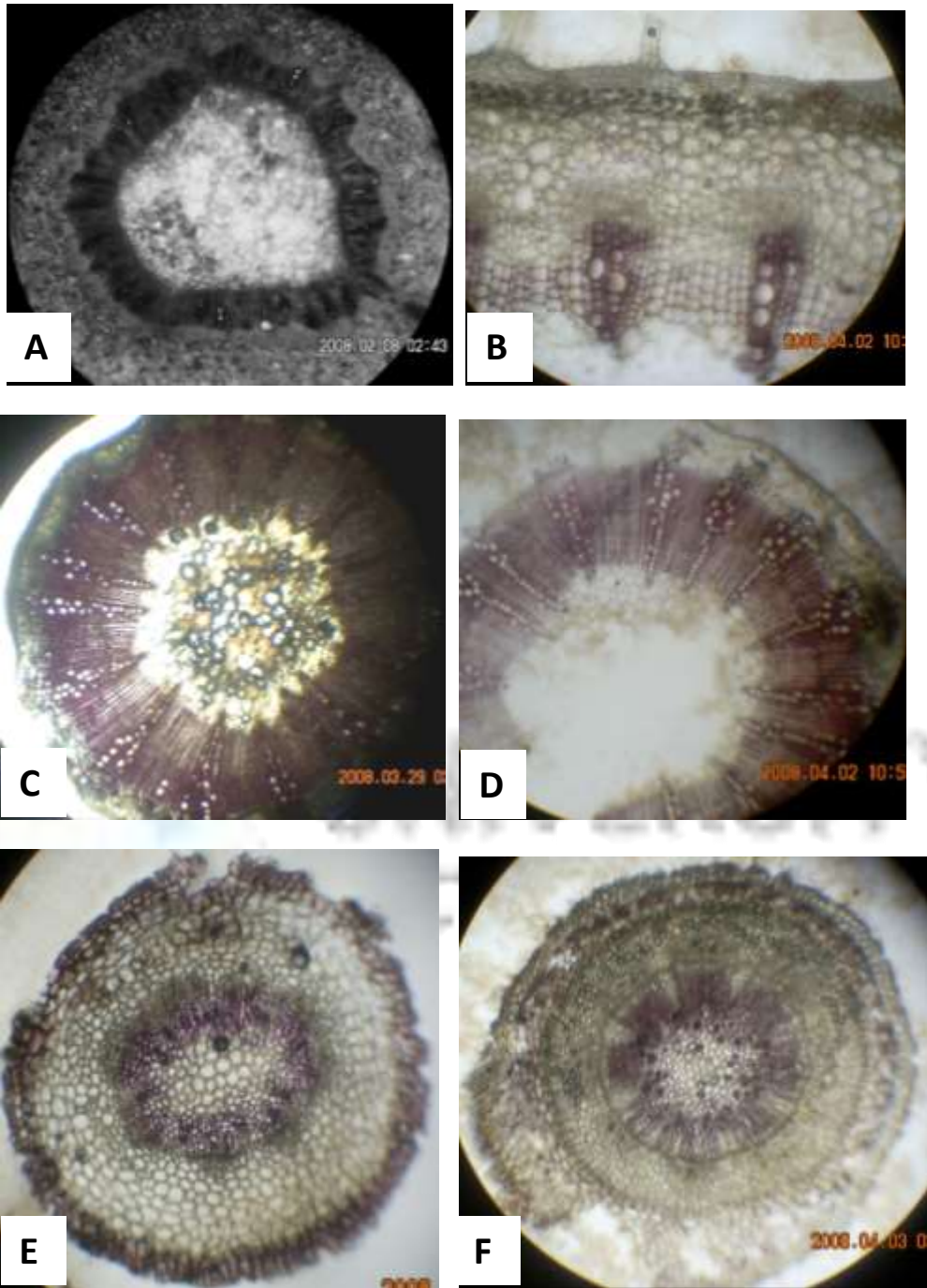


Plate 34: Transverse sections through the stem of *Euphorbia* species

- | | | | |
|---|---|---|------------------------|
| a | <i>E. milii</i> var. <i>tananarivae</i> | b | <i>E. poissonii</i> |
| c | <i>E. sp. B.</i> | d | <i>E. heterophylla</i> |
| e | <i>E. ingens</i> | f | <i>E. kamerunica</i> |

4.5 Population studies

4.5.1 Intra-specific variation patterns within *E. heterophylla*

Sampling locations notwithstanding, all the populations of *E. heterophylla* had erect stems with hispid indumentum, leaf-like bracts, single (tube-like) gland on the inflorescence and solitary involucre. The leaf margin was lobed, serrated or entire while the leaf base was either acute or acuminate (Table 14 and Fig. 12). In the populations, the leaf length varied from 1.50cm to 10.50cm, while values for width ranged 0.70cm to 5.70cm and petiole length varied from 0.1cm to 4.70cm respectively (Table 14).

4.5.2 Intra-specific variation patterns within *E. hirta*

All the populations of *E. hirta* under studied were herbaceous with simple, pinnate and petiolated leaves, margin, base, shape and apex of the leaves were serrulate/serrate, oblique/cuneate, elliptic and acute respectively, stem decumbent with rough surfaces while the indumentum on the stem surface was puberulent. The stem colours correlated with the leaf colours. They were either pink or green. This feature was not a subject of the location. Within a location, both green and pink colours were observable. This occurred in all the populations without any pattern. The leaf length, widths and petioles ranged from 1.34 to 4.67cm, 0.55cm to 2.55cm and 0.12cm to 0.29cm (Table 15 and Fig. 13).

4.5.3 Intra-specific variation patterns within *E. hyssopifolia*

All the populations studied were herbaceous with simple, petiolated leaves; margin, base, shape and apex of the leaves are serrate, oblique, ovate, and acute respectively. The stem was straight, no indumentum but smooth and shining (either pink or green in color). Stem coloration did not follow any specific pattern within the populations. The leaf lengths, widths and petioles ranged from 1.34 to 4.85cm, 0.55cm to 2.62cm and 0.12cm to 0.25cm (Table 16 and Fig. 14).

Table 14: Quantitative features of leaves in *E. heterophylla*

| S/N | Accession no. | Length (cm) | Width (cm) | Petiole (cm) |
|-----|---------------|-------------|------------|--------------|
| 1 | P1 | 9.00 | 5.60 | 4.2 |
| 2 | P2 | 8.50 | 5.20 | 3.4 |
| 3 | P3 | 8.50 | 5.00 | 4.5 |
| 4 | P4 | 4.00 | 1.80 | 0.2 |
| 5 | P5 | 7.80 | 4.70 | 1.7 |
| 6 | P6 | 10.50 | 5.70 | 4.7 |
| 7 | P7 | 1.50 | 0.70 | 0.1 |
| 8 | P8 | 5.50 | 2.50 | 2.5 |
| 9 | P9 | 4.70 | 2.60 | 2.1 |
| 10 | P10 | 7.90 | 3.50 | 3.1 |
| 11 | P11 | 8.50 | 4.00 | 3.5 |
| 12 | P12 | 9.00 | 4.60 | 4 |
| 13 | P13 | 7.90 | 3.60 | 4 |
| 14 | P14 | 6.80 | 3.00 | 3.67 |
| 15 | P15 | 4.50 | 2.00 | 2.45 |
| 16 | P16 | 6.90 | 3.00 | 2.56 |
| 17 | P17 | 2.90 | 1.00 | 0.1 |
| 18 | P18 | 7.20 | 3.50 | 2.78 |
| 19 | P19 | 7.50 | 3.65 | 2.8 |
| 20 | P20 | 8.50 | 5.30 | 3.48 |

Table 15: Quantitative features of leaves of *E. hirta*

| S/N | Accession no. | Length (cm) | Width (cm) | Petiole (cm) |
|-----|---------------|-------------|------------|--------------|
| 1 | P21 | 0.21 | 4.40 | 1.70 |
| 2 | P22 | 0.20 | 4.40 | 2.40 |
| 3 | P23 | 0.21 | 1.60 | 1.00 |
| 4 | P24 | 0.22 | 2.10 | 1.00 |
| 5 | P25 | 0.12 | 2.59 | 0.90 |
| 6 | P26 | 0.15 | 1.80 | 1.10 |
| 7 | P27 | 0.18 | 3.80 | 1.89 |
| 8 | P28 | 0.18 | 3.59 | 2.01 |
| 9 | P29 | 0.20 | 4.67 | 2.20 |
| 10 | P30 | 0.22 | 4.47 | 2.00 |
| 11 | P31 | 0.22 | 4.56 | 2.20 |
| 12 | P32 | 0.17 | 4.22 | 2.50 |
| 13 | P33 | 0.17 | 1.51 | 0.55 |
| 14 | P34 | 0.21 | 1.61 | 0.85 |
| 15 | P35 | 0.20 | 1.51 | 0.89 |
| 16 | P36 | 0.18 | 1.34 | 0.90 |
| 17 | P37 | 0.19 | 4.55 | 2.00 |
| 18 | P38 | 0.21 | 2.89 | 1.50 |
| 19 | P39 | 0.22 | 3.99 | 1.97 |
| 20 | P40 | 0.29 | 4.00 | 2.01 |

Table 16: Quantitative features of leaves of *E. hyssopifolia*

| S/N | Accession no. | Length (cm) | Width (cm) | Petiole (cm) |
|-----|---------------|-------------|------------|--------------|
| 1 | P41 | 0.21 | 4.40 | 1.70 |
| 2 | P42 | 0.20 | 4.40 | 2.40 |
| 3 | P43 | 0.21 | 1.60 | 1.00 |
| 4 | P44 | 0.22 | 2.10 | 1.00 |
| 5 | P45 | 0.12 | 2.59 | 0.90 |
| 6 | P46 | 0.15 | 1.80 | 1.10 |
| 7 | P47 | 0.18 | 3.80 | 1.89 |
| 8 | P48 | 0.18 | 3.59 | 2.01 |
| 9 | P49 | 0.20 | 4.85 | 2.20 |
| 10 | P50 | 0.22 | 4.47 | 2.00 |
| 11 | P51 | 0.22 | 4.56 | 2.20 |
| 12 | P52 | 0.17 | 4.22 | 2.62 |
| 13 | P53 | 0.17 | 1.51 | 0.55 |
| 14 | P54 | 0.21 | 1.61 | 0.85 |
| 15 | P55 | 0.20 | 1.51 | 0.89 |
| 16 | P56 | 0.18 | 1.34 | 0.90 |
| 17 | P57 | 0.19 | 4.55 | 2.00 |
| 18 | P58 | 0.21 | 2.89 | 1.50 |
| 19 | P59 | 0.22 | 3.99 | 1.97 |
| 20 | P60 | 0.25 | 4.00 | 2.01 |

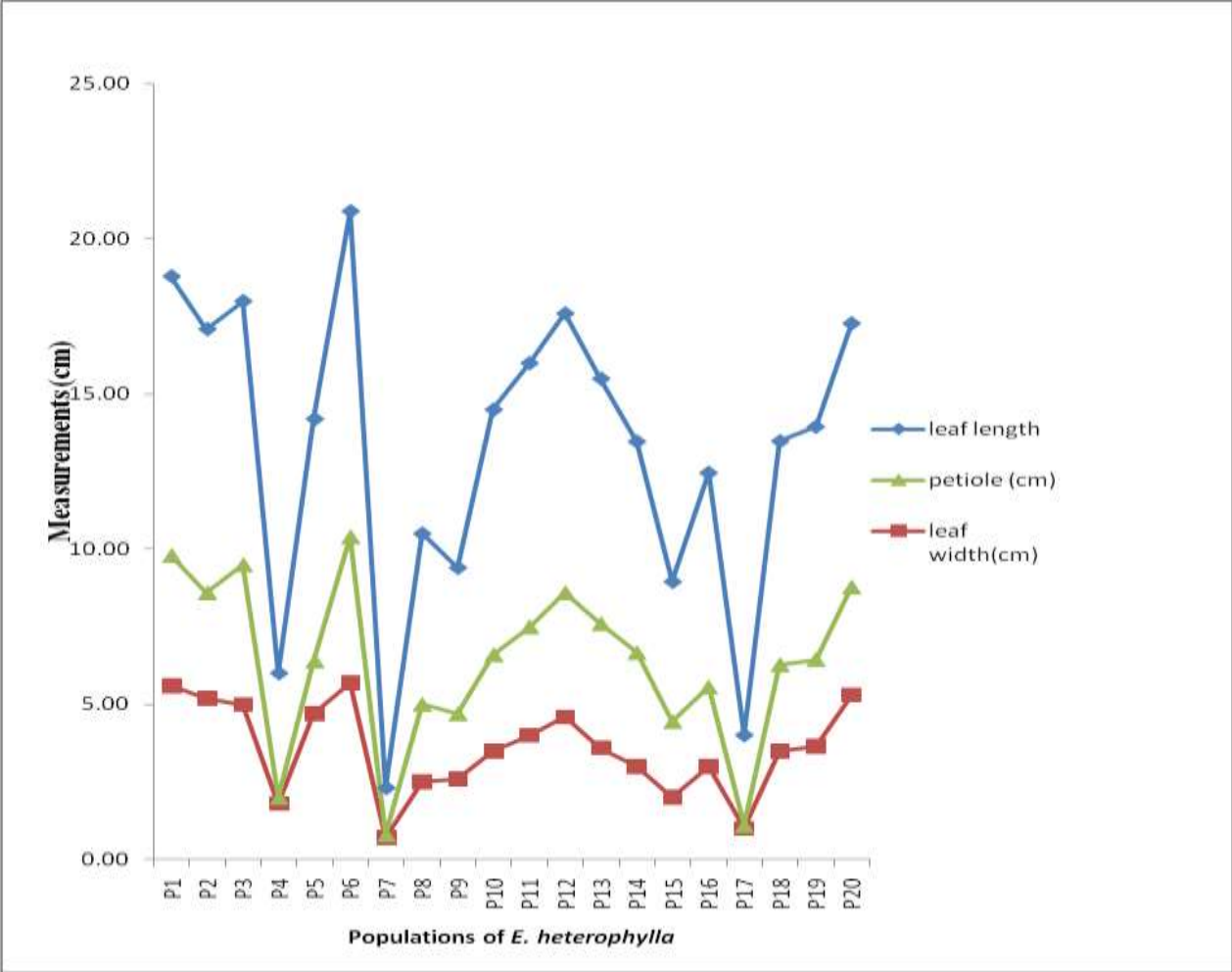


Fig. 12: Variation patterns within populations of *E. heterophylla*

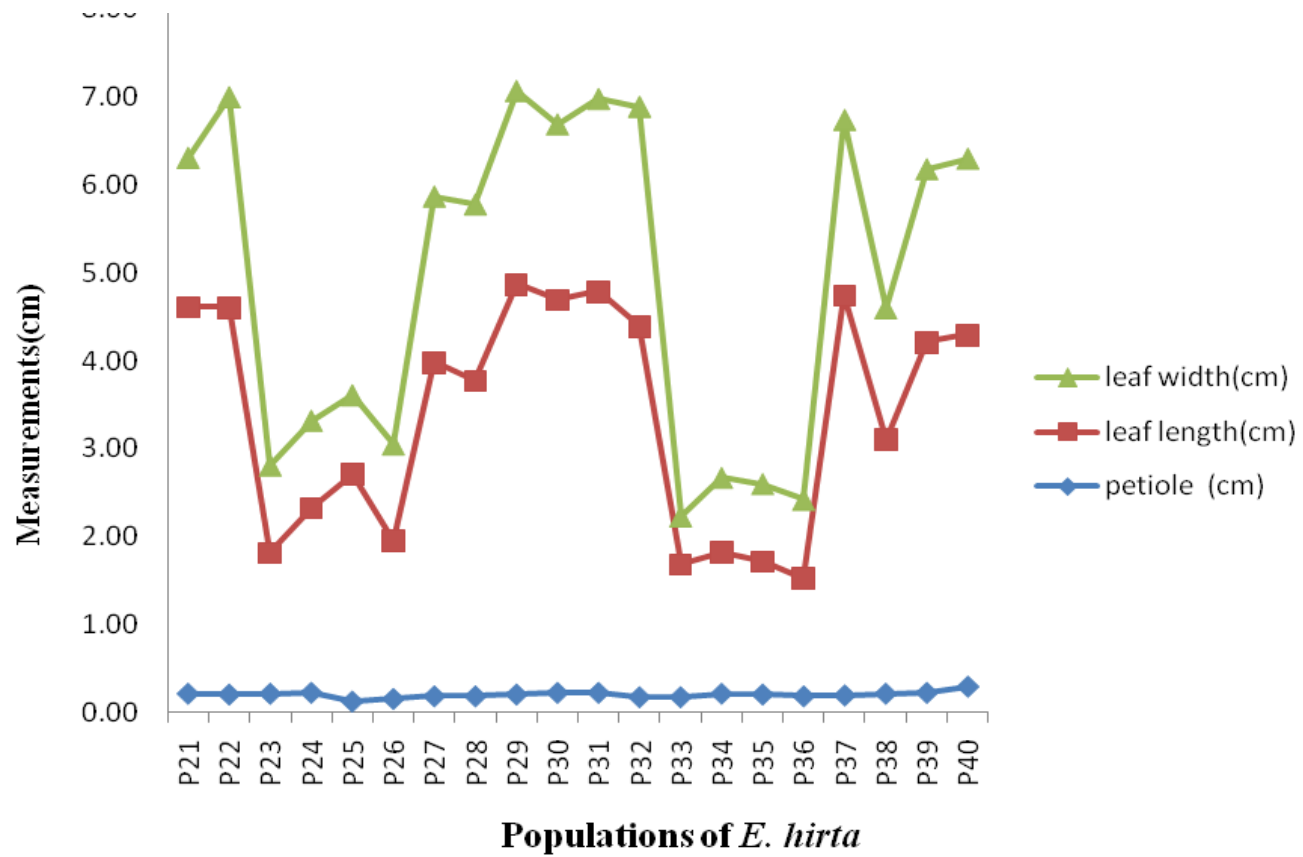


Fig. 13: Variation patterns within populations of *E. hirta*

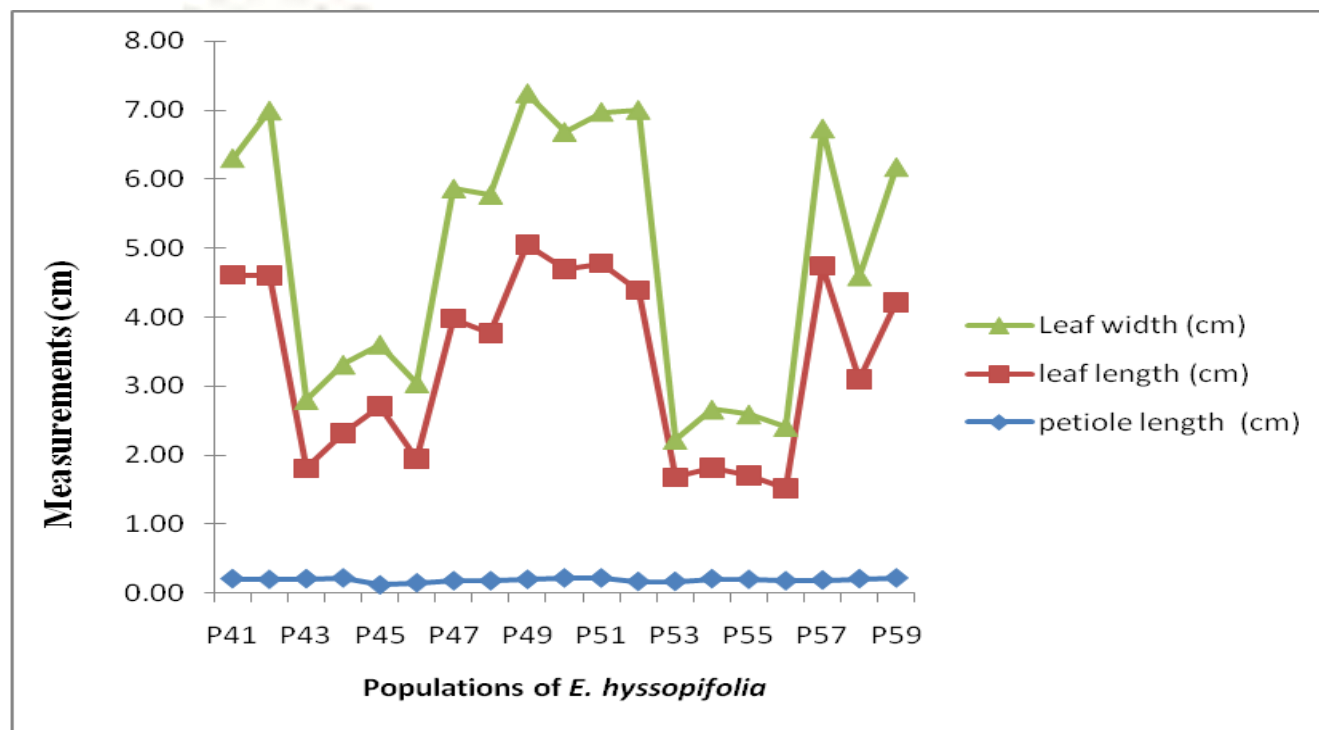


Fig. 14: Variation patterns within populations of *E. hyssopifolia*

4.6 Experimental Cultivation

Experimental cultivations were carried out in order to ascertain the phenotypic differences observed during field collection and population studies. Observations on the cultivated plant species showed that the species were self compatible. The phenetic differences observed in some of the species were plastic. The pink coloration of the stem and the leaves of *E. hyssopifolia* and *E. hirta* were not present at the early stages of growth. Both the stems and leaves were green. Indumenta were not present also at this stage (Plate 35). *E. cotinifolia* leaves became green inside the glass house (Plate 36).



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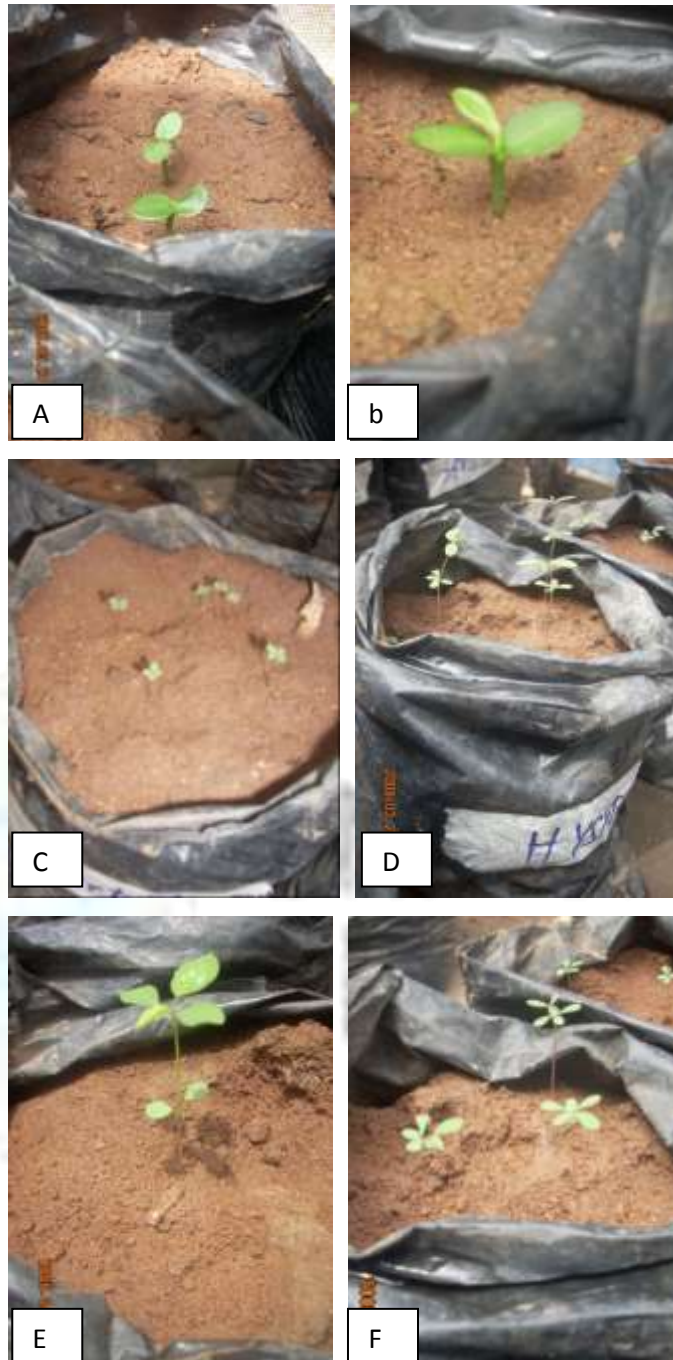


Plate 35: Photographs of seedlings of some species of *Euphorbia* showing the number and arrangements of leaves at germination

- (A) *E. poissonii* (7th day after germination)
- (B) *E. poissonii* (5th week after germination)
- (C) *E. hirta* (7th day after germination)
- (D) *E. hyssopifolia* (7th day after germination)
- (E) *E. sp. B.* (7th day after germination)
- (F) *E. heterophylla* (7th day after germination)



Plate 36: Photographs of actively growing *E. cotinifolia*:

(A) Specimen with green leaves in the glass house

(B) Specimen with ox- blood leaves under direct sunlight

4.6.2 Self Compatibility Test

Fruit sets were observed in all the bagged inflorescences. These were taken as indication of self compatibility. The seeds were allowed to dry and planted inside petri- dishes lined with cotton wool pre- soaked in distilled water. This was done to determine the viability of the seeds. Germination was observed in all the petri- dishes.

4.6.1 Viability test on the seeds produced

Viability tests were carried out on the seeds produced from the planted cultivated species. Germination started in both *E. hirta* and *E. hyssopifolia* on the second day and by the third day all the seeds had fully germinated. *E. heterophylla* started on the third day and by fifth day, germination was complete (Fig. 15). The germination was epigeal. Also, it was observed that all the seedlings appeared identical in the first two weeks. However, there were variations observable afterwards most especially the growth rate. The development also followed the same pattern. The inflorescences were stable in size, colour and type as compared to the herbarium studies. Plate 25 shows the photographs of seedlings of some species of *Euphorbia* showing the number of leaves at germination and leaf arrangements.

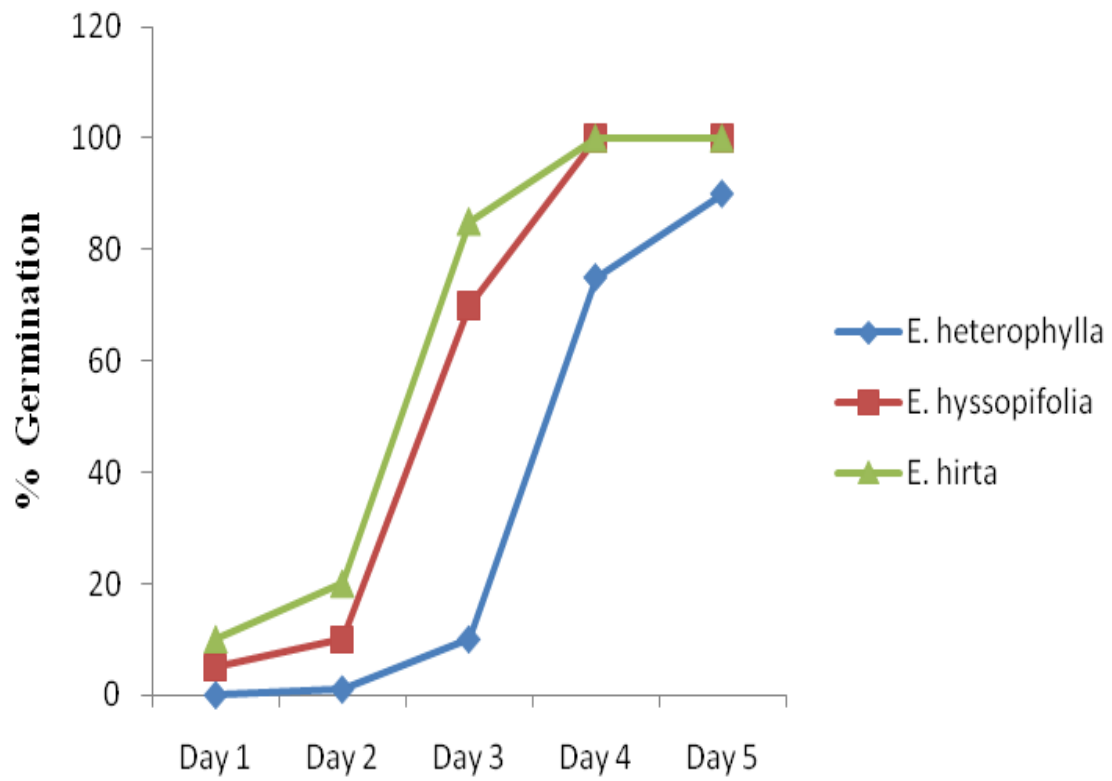
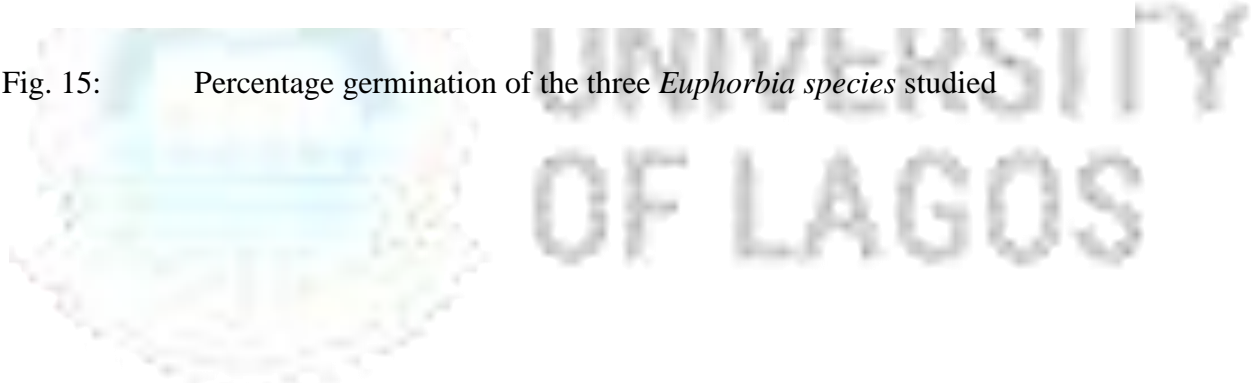


Fig. 15: Percentage germination of the three *Euphorbia species* studied



4.7 Cytological Study

Cytological investigations carried out on 16 taxa revealed that chromosome numbers in the genus vary from $2n= 7$ to $2n= 30$ (Table 17 and Plate 37). Both polyploidy and euploidy were observed. Instability of chromosome numbers was also recorded e.g. *E. milii* showed $2n= x$, $2x$ and $3x$.



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Table 17: Chromosome numbers in genus *Euphorbia*

| S/n | Taxa | Chromosome numbers | Source | Ploidy |
|-----|--|--------------------|--------|------------|
| 1. | <i>E. cotinifolia</i> | 30 | ES | Polyploidy |
| 2. | <i>E. heterophylla</i> | 30 | ES | Polyploidy |
| 3. | <i>E. hirta</i> | 24 | ES | Polyploidy |
| 4. | <i>E. kamerunica</i> | 11 | ES | Aeuploidy |
| 5. | <i>E. lateriflora</i> | 10,20 | ES | Polyploidy |
| 6. | <i>E. prostrata</i> | 18,20 | ES | Polyploidy |
| 7. | <i>E. pulcherimma</i> | 28,56 | LT | Polyploidy |
| 8. | <i>E. schimperiana</i> | 20 | LT | Polyploidy |
| 9. | <i>E. thymifolia</i> | 18 | ES | Polyploidy |
| 10. | <i>E. keithii</i> | 7 | ES | Aeuploidy |
| 11. | <i>E. ingens</i> | 9 | ES | Aeuploidy |
| 12. | <i>E. sp. B</i> | 8 | ES | Diploid |
| 13. | <i>E. milii</i> var. <i>tenuispina</i> | 14 | ES | Diploid |
| 14. | <i>E. milii</i> var. <i>hislopii</i> | 21 | ES | Polyploidy |
| 15. | <i>E. milii</i> var. <i>splendens</i> | 7 | ES | Aeuploidy |
| 16. | <i>E. milii</i> var. <i>tananarivae</i> | 7 | ES | Aeuploidy |

Key

ES: Experimental study

LT: Literature

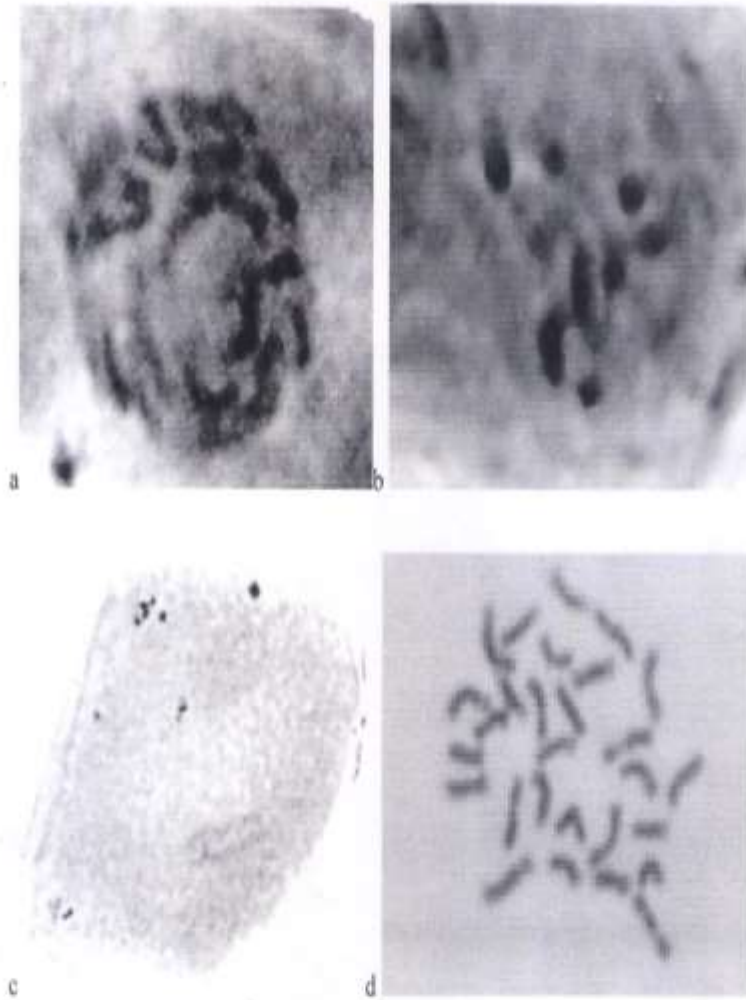


Plate 37: Photo- micrographs of actively growing root tips showing metaphase of:

a. *E. sp. B*

b. *E. kamerunica*

c. *E. ingens*

d. *E. heterophylla*

4.8 Numerical Taxonomy

The results of the clustering techniques used are presented as diagrams of phenetic relationships between taxa (Fig. 16). Appendix 10 shows the UTC used for this study. Appendix 11 shows the calculated coefficient of association, coefficient of correlation and measurements of taxonomic distances between OTUs used in estimating resemblances within the genus. 16 phenetic groups were recognized as:

| Phenetic group | OTUs |
|----------------|-------------------|
| 1 | 20, 31 |
| 2 | 8, 10, 28, 29 |
| 3 | 27 |
| 4 | 3, 4, 30 |
| 5 | 15 |
| 6 | 24 |
| 7 | 5, 12, 21, 26, 27 |
| 8 | 1, 32 |
| 9 | 7, 16 |
| 10 | 11 |
| 11 | 13, 25 |
| 12 | 14 |
| 13 | 3, 6 |
| 14 | 17, 18, 23 |
| 15 | 2 |
| 16 | 9, 33 |

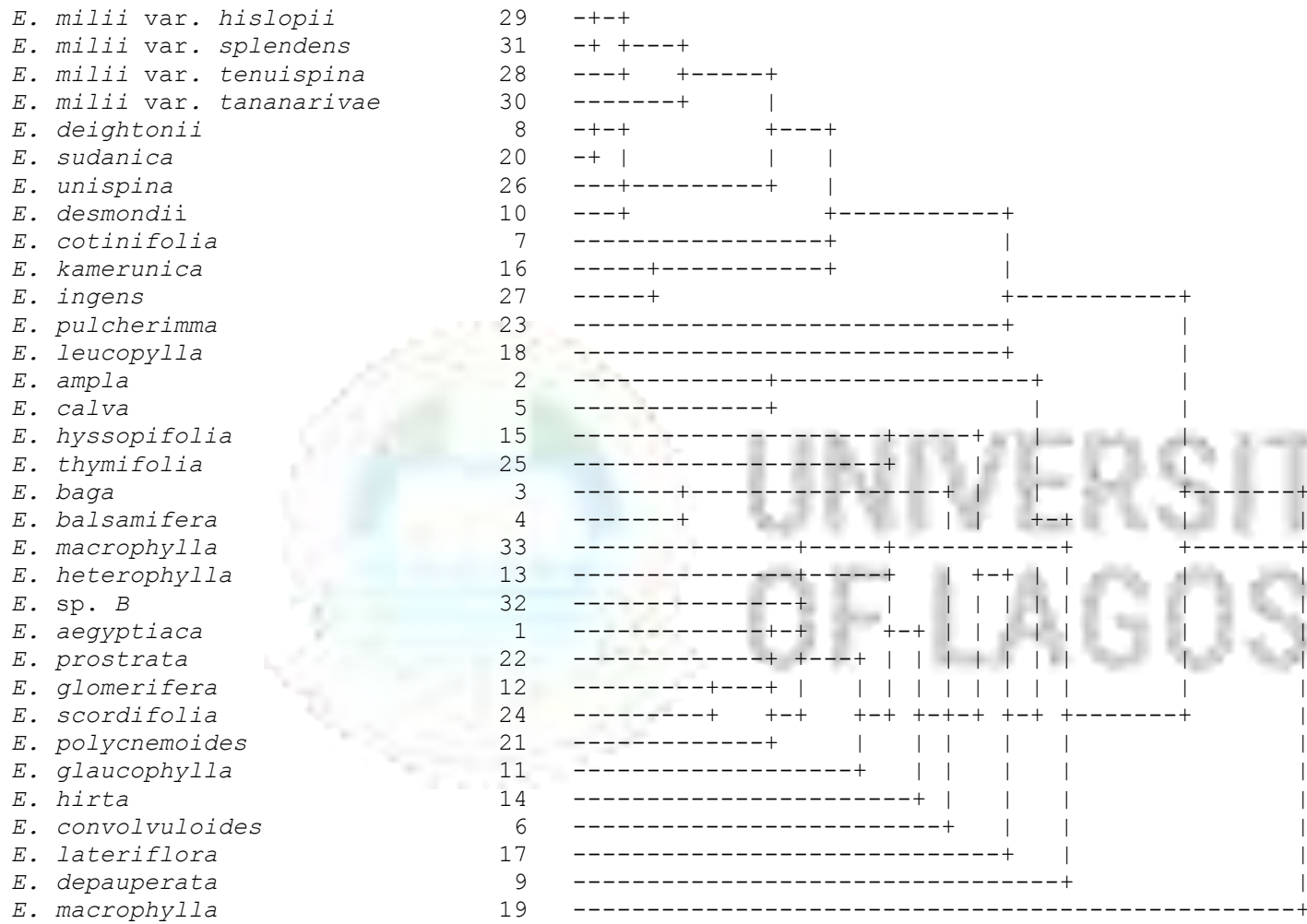
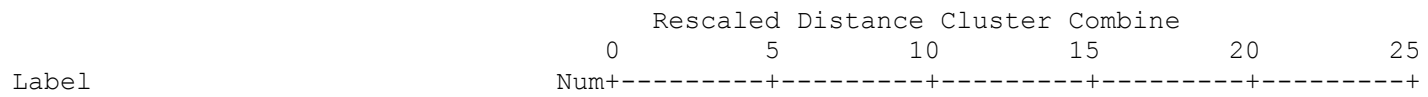


Fig. 16: H I E R A R C H I C A L C L U S T E R A N A L Y S I S



CHAPTER FIVE

5.0 DISCUSSION

This research discovered many cases of misidentification and synonymy especially in information provided by herbarium files. It was observed that there were many mix-ups in the names written on the herbarium files. For example, *E. milii* was misidentified as *E. monteiri* subsp. *monteiri*. No species was identified by this research as *E. monteiri* subsp. *monteiri* in all the herbaria specimens sighted. Also, *E. cotinifolia* was misidentified as *E. sanguinea*. Fern (2014) described *E. sanguinea* to be a prostrate, annual herb, freely branching and forming a loose mat of growth 50cm or more in diameter. The plant is sometimes decumbent, with branches up to 30 cm long.

The specimens designated as *Euphorbia sanguinea* in the herbaria sighted are shrubs. The identity of *E. cotinifolia* was confirmed and circumscribed to be new to literature in Nigeria. Also, the fruits of all the unmounted specimens of *E. poissonii* examined were drupes. This agreed with Hutchinson and Dalziel (1958) who described the fruits of *Elaeophorbium* to be drupes unlike *Euphorbia* whose fruits are capsules. This research therefore treated all unmounted *Euphorbia poissonii* as *Elaeophorbium*.

Haevermans *et al.* (2004) observed that most species are poorly preserved was confirmed by this research. Proper preservation efforts need to be put in place by *Euphorbia* collectors (since most of them are useful in traditional medicine). It was discovered that many species were poorly collected for herbarium preservation. For example, *E. kerstingii*, *E. depauperata*, *E. бага* and *E. aegyptiaca* appeared to be rarely collected for herbarium preservation. *E. hirta*, *E. convolvuloides*, *E. heterophylla*, *E. glaucophylla*, *E. prostrata* and most herbaceous species were found to be collected in abundance while most succulent species such as *E. poissonii*, *E. lateriflora*, *E. desmondii* and *E. deightonii* were poorly collected and preserved.

According to Groombridge (1992), rare species are taxa usually localized within restricted geographical areas or habitats or those that are thinly scattered over a more extensive range. Endangered species are taxa in danger of extinction or those whose habitats have been reduced so drastically that they are deemed to be in immediate danger of extinction while abundant species are those taxa with wide distribution along their range and most commonly collected for herbarium preservation. It therefore follows that many succulent species are in danger of extinction. Most of these succulent species were found to be confined to restricted areas where they were being collected for traditional medicine.

The study of vegetative morphology, floral morphology, leaf epidermal morphology, venation pattern, nodal anatomy, pollen morphology, geographical distribution and the numerical taxonomy in *Euphorbia* shows that there are remarkable similarities in all the species of the genus. The observation of White *et al.* (1941) whose classification was based on the habit of *Euphorbia* species was supported by this research. Wheeler (1943) based his classification on the stature of the plants and recognized nine subgenera of *Euphorbia*. Although, heights varied within species and within populations, taxa were easily recognized as herbs, shrubs and trees using the approach of Wheeler *et al.* (1941) instead of Hutchinson and Dalziel (1958) who grouped the genus into two.

The taxonomic usefulness of many vegetative characters within the genus was obscured and some features were overlapping in many taxa. Yet, some species possess distinct characteristic features that are systematically significant. The overall sizes of the leaves supported the separation of taxa within the genus into 3 groups which are: herbs, shrubs and succulents. Succulent species had ephemeral leaves while small perennials had prominent but drastically reduced leaves. Shrubby species had prominent and conspicuous leaves. Leaf margins of succulent species were entire while the leaf bases were acute except *E. kamerunica* and *E. calva* with cuneate and obtuse bases respectively. *E. kamerunica* was separated from *E. keithii* based on the leaf apices and leaf bases.

The former had cuneate base and emarginate apex while the latter had obtuse base and acute apex. The arrangement of leaves of three species (*E. ampla*, *E. sp B.* and *E. sudanica*) was whorled. However, the leaves were variously shaped. The shapes observed include; elliptic, lanceolate, ovate, obovate and oblong. Indumenta were either present or absent on both leaves and stem.

Previous workers such as Inamdar and Rao (1983), Mulligan (1995) and Khalik (2005) have utilized trichomes in the identification of families and classification of both genera and species. According to Olowokudejo (1984), comparative trichome and indumentum data have potential importance in the studies of evolution and systematic relationship. This study supports this observation because some species were found to possess trichomes at the early stages of their life although lacked it at the later stage. They resembled each other and difficult to identify until the later stage.

Apart from this, there are only few information on the use of leaves as a basis for classification in genus *Euphorbia*, this research points at the arrangement, types, shape, margin and colour of the leaves. This was observed to be a stable character in the genus as the environment had no effect on the shapes nor sizes of the leaves. The species with indumentum on their stem only are; *E. aegyptiaca*, *E. convolvuloides*, *E. heterophylla*, *E. hirta*, *E. leucophylla*, *E. scordifolia* and *E. thymifolia*. Hairs were conspicuously observed on the stems of the following species; *E. scordifolia*, *E. aegyptiaca*, *E. hirta*, *E. convolvuloides* and *E. sp B.*

The taxonomic significance of pollen morphology has long been recognized. For example: Erdtman (1952), El- Chaudhary and Ghazaly (1994), Hsiao and Kuoh (1995), Menemen and Jury (2002), Perveen and Quaiser (2005), Narbona *et al.* (2008) and Thakur and Patil (2011). Data from pollen can help in suggesting relationships at the specific level or to determine variation within a species or even below the species level (Stuessy, 1990). Tryton (1986) examined 250 genera of the Pteridophyta and was able to divide them into five main spore types based on shape, aperture,

surface ornamentation and wall structure. The groups correspond well with classifications of their genera on whole plant morphological characters. The same results have been obtained by Guinet (1986) on the taxonomically complex genus *Acacia*. Also, Palynology of the Euphorbiaceae and related families has been fairly investigated. Erdtman (1952) described the pollen grains in the family as colporate, forate, rugorate, foraminoidate or non-aperturate, oblate to perprolate. The observations in this research conformed to the previous authors.

SEM studies have been made primarily on pollen grains, small seeds, trichomes and surface features of various organs. In most of these organs (except pollen grains), the studies involved the epidermis. The value of the epidermal studies lies in the fact that an epidermis covers almost all the organs and is always present. It is thick and stable in SEM preparations and less affected by the environment. Important tools for taxonomic evaluation on inter and intra generic levels are anatomic markers of leaf epidermis. Their characteristics are important in resolving existing taxonomical confusions. They are also of particular value to identify small parts of plant materials.

Many taxonomic studies have benefitted from the use of anatomical data e.g. Oladele (1983;1986), Oladele *et al.* (1985), Olowokudejo (1980; 1984; 1993), Raju and Rao (1987), Ogundipe and Olatunji (1991), Ayodele and Olowokudejo (1997), Ogundipe and Akinrinlade (1998), Ogundipe and Daramola (1998), Ogunkunle and Oladele (2000), Ogundipe and Chase (2009), Olowokudejo and Ayodele (1997), Olowokudejo and Pereira-Sheteolu (1998), Ayodele (2000), Agbagwa and Ndukwu (2004), Ayodele (2005), Ayodele and Olowokudejo, (2006), Al-Edany and Al-Saadi (2012) and Akinnubi *et al.* (2013).

The present investigation identified the leaf epidermal markers that can be utilized for the solution of some of the existing taxonomic problem of species which overlap in most of their morphological characters and to evaluate the relationship of the critical taxa. Presence, types and density of stomata complex proved to be useful in this regard. Foliar venation has been generally ignored by

the past workers. Sehgal and Paliwal (1974) categorized the species belonging to *Euphorbia* into uni -, bi-, tri- veined and special categories based on the number of vascular strands entering the petiole or the base of the leaf. Binojkumar and Balakrishnan (2010) and Devi *et al.* (2013) studied the foliar micro – morphology and architecture of the epidermis and venation pattern of closely related *Euphorbia* species and deduced taxonomic information. This study also produced taxonomic data from venation patterns.

Previous researchers have examined petiole and stem anatomy of species in *Euphorbiaceae* for taxonomic information. For example, Sehgal and Paliwal (1974) noted the nodal anatomy of many species of *Euphorbia*. Some species were unilacunar, 1-traced and some are bilacunar, 2-traced. Thakur and Patil (2011) studied mature nodes of *Euphorbia* and observed all the types mentioned in *Euphorbiaceae*. Tadavi and Bhadane (2013) observed three- traced and three-lacunar condition to be more prominent and basic for *Euphorbiaceae*. This study is in agreement with these observations.

The morphology and number of chromosomes are of great value for the understanding of the evolutionary processes of a species (Gupta and Tsuchiya, 1991). Some mechanisms have been identified as responsible for the evolution of plants among them, structural chromosomal changes and polyploidy (Narayan, 1998). Such chromosomal modifications can occur spontaneously or by induction both in somatic cells and in the gametes (Sybenga, 1992). Polyploidy, or genomic multiplication, is a common and continuous phenomenon in the evolution of plants (Adams and Wendel, 2005), and about 70% of the angiosperms are polyploids (Leitch and Bennet, 1997).

In general, polyploids are good colonizers (De Wet, 1980) and some invasive species can be considered as such, since they exhibit fast chromosomal evolutionary events (Reznick and Ghalambor, 2001). Also, the genomic reorganization and chromosomal re patterning that occur in polyploids (Schifino-Wittmann, 2004) can modify their tolerance to the environment (Lee, 2002).

This actually explained why most herbaceous *Euphorbia* species were observed to be good colonizers and others can tolerate any environment. It was observed that the chromosome numbers in genus *Euphorbia* varied. Some species lost or gain one whole chromosome which according to Olowokudejo and Heywood (1984) could result in speciation.

The dendrogram produced 16 phenetic groups, six of which were monotypic. They are: OTUs 2, 11, 14, 15, 24 and 27. There were many species with overlapping characteristic features. No doubt, there has been controversies over the classification of the the genus *Euphorbia*. Numerical taxonomy does not produce new data nor is it a new system of classification but rather a method of organizing data and obtaining from them a classification or some other form of presentation. Without a clearer understanding of the morphology of the groups understudy, the result of numerical taxonomy in this research will be vague in interpretation.

This result revealed the taxonomic importance of the following features within the genus:

- stem (succulence and presence of spines): Succulent *Euphorbia* species were distinct and separated into two groups (with or without spines)
- inflorescence (location, arrangement, colour, stamens, ovary, glands): although all specimens examined had cyathium as the basic inflorescence, three groups of *Euphorbia* specimens were encountered. The locations are: axillary, terminal, intercalary. Succulent specimens had intercalary inflorescence. Terminal inflorescences were observed in both herbaceous and shrubby specimens while most herbaceous specimens had axillary inflorescence.
- involucre (type and color)
- leaf apex, petiole, leaf base, leaf shape, leaf arrangement, leaf colour, leaf margin,
- stomata, trichome, epidermal cell shape, anticlinal cell wall and surface ornamentation.
- Chromosome: number
- Venation pattern

- Leaf traces
- stem outline
- pollen grains

Recognised Species:

This research recognized thirty *Euphorbia* species (Appendix 9) viz: *Euphorbia aegyptiaca* Boiss, *Euphorbia ampla* Hook. f. (*Euphorbia schimperiana* Schecl.), *Euphorbia бага* A. Chev., *Euphorbia balsamifera* Ait., *Euphorbia calva* N. E. Br. (*Euphorbia leddermaniana* Pax and Hoffm.), *Euphorbia convolvuloides* Hochst. ex. Benth, *Euphorbia deightonii* Croizat., *Euphorbia depauperata* Hochst. et A. Rich., *Euphorbia desmondii* Keay and Milne-Redhead, *Euphorbia glaucophylla* Poir., *Euphorbia glomerifera* Mill., *Euphorbia heterophylla* Linn., *Euphorbia hirta* Linn., *Euphorbia hyssopifolia* Linn., *Euphorbia kamerunica* Pax., *Euphorbia polycnemoides* Hochst ex Boiss. (*Euphorbia kerstingii* Pax), *Euphorbia lateriflora* Schum et. Thonn., *Euphorbia leucophylla*, *Euphorbia macrophylla*, *Euphorbia milii* Des. Moul. (four varieties), *Euphorbia prostrata* Ait., *Euphorbia pulcherrima* Willd, *Euphorbia cotinifolia*, *Euphorbia sudanica* A. Chev., *Euphorbia unispina* N.E.Br., *Euphorbia thymifolia* Linn., *Euphorbia scordifolia* Jacq., *Euphorbia ingens*, *Euphorbia keithii* and *Euphorbia* sp B.

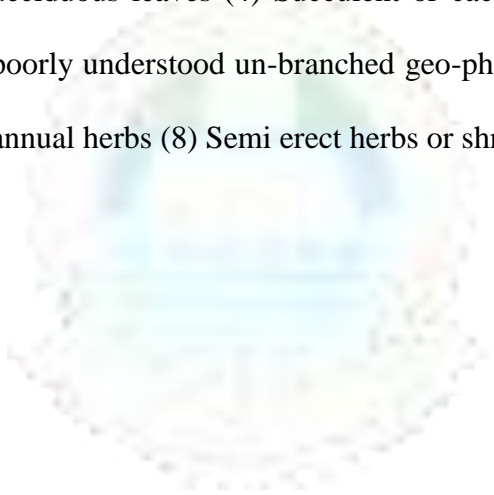
Subgenera

The genus *Euphorbia* has been variously classified by different researchers from Linnaeus (1753) to Riina *et al.* (2013). The result obtained from this research support all the four recently recognized subgenera viz: subgenus *Euphorbia* L. (*Euphorbia ingens*, *Euphorbia kamerunica* Pax., *Euphorbia keithii*, *Euphorbia sudanica* A. Chev., *Euphorbia unispina* N.E.Br., *Euphorbia desmondii* Keay and Milne-Redhead and *Euphorbia deightonii* Croizat.), subgenus *Chamaesyce* RAF. (*Euphorbia aegyptiaca* Boiss, *Euphorbia schimperiana* Schecl., *Euphorbia бага* A. Chev., *Euphorbia* sp B, *Euphorbia thymifolia* Linn., *Euphorbia prostrata* Ait., *Euphorbia scordifolia* Jacq., *Euphorbia glaucophylla* Poir., *Euphorbia glomerifera* Mill., *Euphorbia heterophylla* Linn., *Euphorbia hirta*

Linn., *Euphorbia hyssopifolia* Linn., and *Euphorbia polycnemoides* Hochst ex Boiss. , subgenus *Esula* PERS. (*Euphorbia balsamifera* Ait., *Euphorbia leddermaniana* Pax and Hoffm., *Euphorbia depauperata* Hochst. et A. Rich., *Euphorbia leucophylla*, *Euphorbia macrophylla*, *Euphorbia pulcherrima* Willd. and *Euphorbia convolvuloides* Hochst. ex. Benth,)and subgenus *Rhizanthium* (Boiss.) Wheeler (*Euphorbia lateriflora* Schum et. Thonn., *Euphorbia milii* Des. Moul.,and *Euphorbia cotinifolia*).

Sections

The Nigerian *Euphorbia* are divided into eight groups according to the research: (1) Woody shrubs with spines (2) Woody shrubs without spines (3) Succulent shrubs without spines and with deciduous leaves (4) Succulent or cacti form shrub or tree with spines and deciduous leaves (5) poorly understood un-branched geo-phyte (with tuberous root) (6) Dwarf perennial herbs (7) Erect annual herbs (8) Semi erect herbs or shrubs with stems and leaves that have indumenta.



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5.1 SUMMARY OF FINDING

| S/N | Research Objectives | Findings |
|-----|---|--|
| 1 | <p>Evaluate the pattern of variations displayed by constituent species over their geographical range in order to:</p> <ul style="list-style-type: none"> • Clarify and define limits of the various taxa • Elucidate inter- specific relationship | <ul style="list-style-type: none"> • Two different infra specific ranks were recognized below species level i.e. Sub species and variety. • <i>Euphorbia sensu lato</i> was supported • In Nigeria, the genus is represented by thirty species |
| 2 | <p>Investigate previously explored sources of taxonomic data in order to:</p> <ul style="list-style-type: none"> • provide new sources of taxonomic data for the classification and identification of species | <ul style="list-style-type: none"> • This research produced new reliable sources of taxonomic data for proper naming and identification. They are: <ol style="list-style-type: none"> 1. Chromosome numbers 2. leaves (both anatomy and morphology) 3. inflorescences (apart from the cyathium) 4. stem (morphology and anatomy) |
| 3 | <p>Assess and evaluate the evolutionary and genomic affinities among species, subspecies and varieties documented in the genus in order to:</p> <ul style="list-style-type: none"> • resolve some of the nomenclatural and classification problems | <ul style="list-style-type: none"> • Mono-phyletic relationship exist within the genus. • Problems of misidentification and synonymy was identified <ul style="list-style-type: none"> ➤ <i>E. cotinifolia</i> was misidentified as <i>E. sanguinea</i> |
| 4 | <p>Provide critical botanical and taxonomic information to generate dichotomous identification keys which will: Enhance its optimal utilization in traditional medicine and horticulture thereby facilitating conservation efforts.</p> | <ul style="list-style-type: none"> • Systematic descriptions and dichotomous keys have been produced from all the evidences gathered from this research. |

5.2 Contributions to knowledge

This systematic study has made the under listed contributions to knowledge:

1. Four species new to Nigerian Flora were identified as: *Euphorbia ingens*, *Euphorbia cotinifolia*, *Euphorbia keithii* and *Euphorbia* sp *B*. These have increased the biodiversity database in Nigeria.
2. Chromosome numbers of eleven taxa have been added to the cytological data bank of Angiosperms.
3. Critical botanical and taxonomic information that can enhance the optimal utilization of *Euphorbia* species in traditional medicine and horticulture have been provided.

5.3 Taxonomic key to indigenous and cultivated species based on morphological features

- 1a. Plants shrubs, trees, semi- succulents or cactiform.....2
- 2a. Semi-succulent or woody with persistent leaves.....3
- 3a. Spines solitary, involucre bract like with conspicuous bright colours.....*E. unispina*
- 3b. Spines solitary or in groups, involucre petaloid with conspicuous bright colours.....4
- 4a. Spines solitary, involucre colour yellow..5
- 5a. Leaf apex acute, petiole present.....*E. milii* var. *tenuispina*
- 5b. Leaf apex mucronate/emarginated, petiole absent.....*E. milii* var. *tanandarivae*
- 4b. Spines in paired or in tuft, involucres colour, red.....6
- 6a. Spine in tuft, leaf apex emarginated, petiole absent.....*E. milii* var. *hislopii*
- 6b. Spine in pair, leaf apex emarginated, petiole present.....*E. milii* var. *splendens*
- 2b. Succulents or cactiform with inconspicuous deciduous leaves.....7
- 7a. Stem non spiny and segmented, inflorescence terminal.....*E. lateriflora*
- 7b. Stem spiny and segmented, inflorescence along the stem.....8
- 8a. Cactiform trees, leaf apex emarginated.....9
- 9a. Leaf base acute, Leaf shape elliptic.....*E. kamerunica*
- 9b. Leaf base cuneate, leaf shape obovate.....*E. keithii*
- 8b. Cactiform shrubs, leaf apex non emarginated.....10
- 10a. Stem variagated succulent, leaf shape obovate.....*E. ingens*
- 10b. Stem non variagated succulent, leaf shape obovate.....11
- 11a. Leaf arrangement decussate, leaf apex mucronate.....*E. deightonii*
- 11b. Leaf arrangement decussate, leaf apex retuse.....*E. desmondi*
- 1b. Plants leafy shrub or herbaceous.....12

| | |
|---|-------------------------|
| 12a. Woody shrubs..... | 13 |
| 13a. Stem spiny, leaf arrangement whorled..... | <i>E. sudanica</i> |
| 13b. Stem non spiny, leaf arrangement not whorled..... | 14 |
| 14a. Leaf colour reddish purple, leaf base truncate..... | <i>E. cotinifolia</i> |
| 14b. Leaf colour not reddish purple, leaf base acute..... | 15 |
| 15a. Leaf colour variegated, leaf arrangement decussate | <i>E. pulcherrima</i> |
| 15a. Leaf colour greenish, leaf arrangement decussate or not decussate..... | 16 |
| 16a. Stem hairy, leaf arrangement decussate..... | <i>E. leucophylla</i> |
| 16b. Stem not hairy, leaf arrangement not decussate..... | 17 |
| 17a. Leaf reduced and simple, leaf arrangement alternate..... | <i>E. depauperata</i> |
| 17b. Leaf prominent and compound, leaf arrangement opposite..... | <i>E. macrophylla</i> |
| 12b. Perennial to annual herbs..... | 18 |
| 18a. Dwarf perennial procumbent herbs..... | 19 |
| 19a. Stem procumbent and pinkish, leaves without indumentums..... | <i>E. thymifolia</i> |
| 19b. Stem procumbent and pinkish or greenish, leaves with or without indumentum.... | 20 |
| 20a. Stem pinkish, leaf with indumenta..... | 21 |
| 21a. Inflorescence single, involucre greenish and leaf-like..... | <i>E. aegyptiaca</i> |
| 21b. Inflorescence in bunch, involucre whitish and bract-like..... | <i>E. scordifolia</i> |
| 20b. Stem greenish or pinkish, leaf without indumentum..... | 22 |
| 22a. Stem greenish but occasional pinkish, leaves glossy petiolate..... | <i>E. prostrata</i> |
| 22b. Stem greenish, leaves non glossy petiolate..... | 23 |
| 23a. Leaf prominent oblong-ovate, involucre yellowish..... | <i>E. glaucophylla</i> |
| 23b. Leaf reduced and elliptic, involucre whitish..... | 24 |
| 24a. Leaf entire and simple, base acute..... | <i>E. polycnemoides</i> |
| 24b. Leaf serrulate compound, base obtuse..... | <i>E. glomerifera</i> |
| 18b. Tall perennial erect or semi erect herbs..... | 25 |
| 25a. Stem semi-erect, leaves with indumentum..... | 26 |
| 26a. Single inflorescence, involucre bract-like, lip-like whitish gland. <i>E. convolvuloides</i> | |
| 26b. Bunch of inflorescence, involucre leaf-like, tube-like yellowish gland..... | <i>E. hirta</i> |
| 25b. Stem erect, leaves with or without indumentum..... | 27 |
| 27a. Stem and leaves covered with smooth hairs..... | 28 |
| 28a. Leaf blade covered with white patches in the middle, margin entire..... | <i>E. sp. B</i> |
| 28b. Leaf blade without white patches, margin toothed, serrated..... | <i>E. heterophylla</i> |

- 27b. Stem and leaf without hairs , leaf base not truncated.....29
 - 29a. Petiole present, leaf margin crenulated.....*E. calva*
 - 29b. Petiole absent, leaf margin not crenulated.....30
 - 30a. Leaf prominent, apex acute to sub- acute.....31
 - 31a. Root tuberous, inflorescence single terminal*E. бага*
 - 31b. Roots not tuberous, inflorescence single Axillarylary.....32
 - 32a. Leaves opposite, margin serrulate, base obtuse.....*E. polycnemoides*
 - 32b. Leaves whorled, margin entire, base acute.....*E. ampla*
 - 30b. Leaves reduced, leaf apex acute.....33
 - 33a. Inflorescence on the stem, involucre petaloid and yellowish
.....*E. balsamifera*
 - 33b. Inflorescence terminal, involucre leaf-like and whitish
.....*E. hyssopifolia*



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5.4 Systematic Description

Genus: *Euphorbia* L. Sp. Pl.: 450 (1753). Boiss. in DC., Prodr. 15, 2: 7. 1862; Benth., Gen. Pl. 3: 258. (1880); Pax and K. Hoffm., Natürl. Pflanzenfam. ed. 2, 19c: 208. 1931; Radcl.-Sm., Kew Bull. 26: 261. 1972; G.L.Webster, Ann. Missouri Bot. Gard. 81: 128. 1994; Radcl. Sm., Gen. Euphorb.: 405. (2001); Esser in Chayamarit and Welzen, Fl. Thailand 8, 1: 263 (2005).

Homotypic Synonym:

Tithymalus antiquorus (L.) Moench, Methodus: 665 (1794).

Heterophytic Synonyms:

Euphorbia arborescens Roxb., Fl.Ind. ed. 1832, 2: 468 (1832), nom.illeg.

Euphorbia antiquorum var. *polygona* Wight, Icon. Pl. Ind. Orient. 2: t. 897 (1843).

Euphorbia mayuranathanii Croizat, Hooker's Icon. Pl.35: t.3403 (1940).

Type species: *Euphorbia antiquorum* L., Sp. Pl.:450 (1753).

Description:

Small low growing (dwarf) perennial herbs to prostrate annuals; leafy shrubs and well-developed trees, succulents/cacti forms (with thickened well developed segmented photosynthetic stems) or spiny (occasionally spiral or angled) or not; main axis continued by sympodial growth or unbranched; Stem colors usually greenish, greyish or pinkish but rarely reddish purple; latex white; Leaves, inflorescences and fruits prominently covered with dense wooly soft matted hairs which occur singly as multicellular unbranched hairs mainly tomentose indumentum (some pilose); rarely glabrous in nature most especially succulent species (with spines on their stems); Stipules absent, transformed into spines, variously fused, or simple to divided (bifid); Leaves, prominent or ephemerals alternate, opposite, whorled or decussate usually stipulate but rarely estipulate; petiole distinct to absent, eglandular; blade simple, symmetric or oblique, variable in shape and margin,

eglandular. In succulent species, ephemeral leaves are mostly small and short-lived; stipules usually small and partly transformed into spines or glands, or completely missing; Inflorescences as cyathia, radially symmetric, usually bisexual, the fused bracts forming a cupular involucre, with 1-5 glands and often variously shaped petaloid appendages, 5 alternating erect lobes; cyathia solitary or grouped in dichotomous or Axillary cymes, bracts variously colored and often showy; Individual flowers with much reduced to absent sepals, without petals. Staminate flowers lateral, in condensed monochasia, reduced to a single stamen; stamen with anthers 2-locular, basifixed; Pistillate flowers terminal consisting only of the reduced to absent calyx and the ovary; ovary 2-or 3-locular, smooth, with 1 ovule per carpel; style column present or absent, stigmas apically bifid. Fruits 2-or 3-locular, small to large, smooth, pubescent to glabrous, dry and dehiscent. Seeds 2 or 3 per fruit, 4 angled, oval or spherical, glabrous, with smooth or variously sculptured surface, dry, with or without caruncle; Roots fine or thick and fleshy or tuberous.

Species Description

1. *Euphorbia aegyptiaca* Boiss. F. T. A. 6 (1): 511 (1860)

Homotypic Synonym:

Anisophyllum aegyptiacum (Boiss.) Schweinf. (1867)

Heterotypic Synonyms:

Anisophyllum forskalii (J. Gay) Klotzsch and Garcke

Euphorbia forskalii J. Gay (1847)

Euphorbia burmanniana J. Gay (1847)

Chamaesyce forskalii (J. Gay) Figueiredo (1996)

Description

A prostrate or scrambling herb with stems about 30cm long; Leaves grayish with indumentum, simple, opposite, oblong/elliptic, serrulate, obtuse, sub-acute and

petiolate; Leaf length c. 0.55 ± 0.05 cm, leaf width c. 0.28 ± 0.03 cm and petiole length c. 0.05 ± 0.004 cm; Stem brownish grey/pink; Inflorescence Axillarylary single cluster, involucre leaf like, greenish, gland one, tube-like; Pollen grains simple, monad tricolporate, polar axis c. $41.64 \mu\text{m}$, mean equatorial diameter c. $28 \mu\text{m}$, mean P/E c. $1.49 \mu\text{m}$; ovary superior, glabrous, 3-celled, styles 3. Anticlinal wall pattern straight; stomata anisocytic; trichome filiform; single nucleated, surface ornamentation absent; epidermal surface granula; epicuticular wax present, cuticle smooth; venation pinnate, semi-craspedodromous.

Habitat: Occurs on lawns, under trees, river-banks and sandy places;

Flowering period: January to August.

Distribution and Ecology: Widespread in Northern Nigeria: Nupe, Katagum, Kukawa, Baga and Yola.

Common names: ARABIC: Huwa um lebeina - maker of milk, kùùráár sháánuu; dust of cattle FULA-FULFULDE: bire, badi, rafasa,

Representative specimens examined: NIGERIA: Baga, N Nigeria, 20th April, 1972, Gbile, Wit, Daramola, 1150 (FHI 65379).

2. *Euphorbia schimperiana* Scheele Linnaea 27: 344 (1843)

Heterotypic Synonyms

Euphorbia ampla Hook. f. in F.T.A. 6 (1): 533 (1862)

Euphorbia dilatata Hochst. ex A. Rich. Tent. Fl. Abyss. 2: 240 (1851)

Euphorbia lehmbachii Pax (1901)

Euphorbia monticola Hochst. ex A. Rich. (1850)

Euphorbia preussii Pax (1894)

Type from Ethiopia

Description

An annual or short-lived perennial herb up to 2 m tall; glabrous or with long crisped hairs on the stem below the leaves or on the fruit; stems with conspicuous leaf scars, with latex; Leaves alternate, simple and entire; petiolate; stipules absent; blade lanceolate, base acute; apex acute; mid-vein winged on lower surface; Leaf length c. 4.40 ± 0.05 cm, leaf width c. 0.4 ± 0.01 cm and petiole length c. 0.25 ± 0.01 cm; Inflorescence terminal cyme consisting of clusters of flowers, bracts sessile, long-acuminate; cyathia with peduncle up to 3 mm long hairy at margin; glands 4, yellow involucre, leaf like. Flowers unisexual; male flowers sessile; ovary superior, glabrous or hairy, 3-celled, styles 3, fused at base, apex 2-bifid; Seeds oblong; anticlinal wall pattern undulate; stomata anisocytic on abaxial surface; trichome absent; surface ornamentation absent; Epidermal surface granula; epicuticular wax present; cuticle smooth; trichome filiform. Venation pinnate; hypodromous; uni-veined.

Habitat: Among grasses in savanna, forest edges and clearings.

Flowering period: January to August.

Chromosome number: $2n=20$

Distribution and Ecology: A weed in cultivation and also occurs in grassland and montane forest.

Common name: Wambara (Central Euthopia)

Representative specimens examined: NIGERIA: Northern Nigeria, 19th Dec., 1934, Plumptre, E.D. (FHI 224).

3. *E. бага* A. Chev. in *Rev. Bot. Appl. Agric.* **13: 569, fig. 18 (1933).**

Homotypic Synonym

Euphorbia бага A. Chev. var. *бага*

Infra-specific Taxon

Euphorbia бага var. *parvifolia* Newton

Euphorbia бага A. Chev. var. *бага*

Description

A perennial, erect herb with stems 30 cm to 1 ft. long with red tubular flowers from a flesh root stock with latex; Leaves prominent, simple, decussate, shape ovate, margin entire, base acute, apex sub acute; Leaf length c. 3.50 ± 0.01 cm, leaf width c. 0.65 ± 0.01 cm and petiole length c. 0.6 ± 0.01 cm; Stem grayish; Inflorescence terminal single, involucre leaf like, red, gland one, tube-like; anticlinal wall pattern undulate; stomata sunken; abaxial surface anisocytic; adaxial surface both anisocytic and anomocytic; trichome absent; surface ornamentation present; epidermal surface granular; epi-cuticular wax present; cuticle rough.

Habitat: flat-topped lateritic hills and sandy places.

Chromosome number: $2n = 20$

Distribution and Ecology: Northern Nigeria on flat-topped lateritic hills, Bauchi Plateau

Common name: бага (poison)

Taxonomic note: Recorded only from Northern Nigeria. The plant is poisonous. The fleshy stem may be mistaken for the tuber of certain edible asclepiads and it is recorded as causing headache and drowsiness if eaten.

Representative specimen examined: NIGERIA: Jos, 1964, King, FHI 48079

4. *Euphorbia basalmifera* Aiton. Hortus Kew. 2: 137 (1789)

Homotypic Synonym

Euphorbia balsamifera Aiton subsp. *balsamifera*

Heterotypic Synonyms

Euphorbia rogeri N.E. Brown 1911

- *Euphorbia balsamifera* ssp. *rogeri* (N.E. Brown) Maire 1938
- *Euphorbia sepium* N.E. Brown 1911
- *Euphorbia balsamifera* ssp. *sepium* (N.E. Brown) Maire 1938

- *Euphorbia: adenensis* Deflers 1887
- *Euphorbia balsamifera ssp. adenensis* (Deflers) P.R.O. Bally In: Candolea 29: 390. 1974
- *Euphorbia capazii* Caballero 1935
- *Euphorbia balsamifera ssp. eubalsamifera* Maire 1938 (Nom inval. Art. 26.1)

Infra-specific Taxa

Euphorbia balsamifera Aiton subsp. *balsamifera*

Euphorbia balsamifera subsp. *adenensis* (Deflers) P.R.O. Bally

Description:

Shrub of variable height from very short bushes (hardly rising above the ground) to small trees up to 5 m tall; Stem thick, semi-succulent, spineless, arising from a perennial root; Leaves entire, lanceolate, acute, tapering from about the middle into an acutely sessile base, glabrous on both sides; stipules none; clustered at branches tips (whorled); Mean leaf length 1.60 ± 0.05 (cm) and leaf width 0.10 ± 0.01 (cm); inflorescences terminal cymes; usually reduced to a single sessile cyathium up to 6 mm on each branch which stay central above light yellowish-green; green involucre solitary and terminal; 5 glands oval in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms. Seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe. Ovary superior, glabrous, 3-celled, styles 3; anticlinal wall pattern undulate on abaxial, straight on adaxial surface; Paracytic and anisocytic stomata complex on both adaxial and abaxial surfaces, trichome absent, surface ornamentation absent; epidermal surface granular, epicuticular wax present, cuticle smooth, venation pinnate uni-veined and hypodromous.

Habitat: The plant forms dense communities in rocky places and on sand dunes

Flowering period: January and February

Distribution and Ecology: Found in Northern Nigeria.

Common names: English: Balsam spurge (Hausa): agwaje, Bida-selsi, aguwa, alyara, ayyara, Kaaguwaa, Kwakka uwar-yaaraa, yaro, SUA: guu

Representative specimens examined: NIGERIA: Northern Nigeria, 3rd May 1950, Akpabla, G.K., GC 1408

5. *Euphorbia calva* N.E.Br. Hort. Kew.ed.1 (2):137 (1911)

Synonym: *Euphorbia ledermanninna* Pax. and Hoffm. Engl.Bot.Jahrb.45:241(1910)

Description:

An erect perennial herb; stem thick, non- succulent, spineless, arising from a perennial root. Leaves alternate; margin crenulate; shape obovate; base obtuse; apex acute; glabrous on both sides; stipules none; clustered at branches tips; Mean leaf length 5.20 ± 0.08 (cm) and leaf width 0.21 ± 0.01 (cm). The inflorescences are terminal cymes usually reduced to a single sessile cyathium up to 6 mm on each branch; green involucre solitary; petaloid and terminal; 4 glands oval in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; anticlinal wall pattern straight; paracytic stomatal complex present on both surfaces; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax present, cuticle smooth, venation pinnate uni-veined and hypodromous.

Habitat: Dry mashes

Flowering period: Dry season

Distribution and Ecology: Northern Nigeria

Representative specimen examined: NIGERIA: Northern Nigeria, March 1929, Lely, O. P190

6. *Euphorbia convolvuloides* Hochst. ex. Benth. Hook., Niger Fl.: 499 (1849)

Homotypic Synonym

Anisophyllum convolvuloides (Hochst. ex Benth.) Klotzsch and Garcke

Heterotypic Synonym

Chamaesyce prieuriana (Baill.) Soják (1972)

Description:

A semi erect herb. Leaves greenish with indumentum, compound, opposite, shape; obovate/ovate, margin; serrate/toothed base; chordate, apex; acute; petiolate. Mean leaf length 1.96 ± 0.08 (cm) and leaf width; 0.56 ± 0.03 (cm). Stem colour either green or pink; Inflorescence Axillarylary single cluster involucre; lip like, greenish, gland; one, tube-like. Pollen grains simple, monad tricolporate, polar axis c. $40.60 \mu\text{m}$, mean equatorial diameter; c. $31.27 \mu\text{m}$, mean P/E c. $1.3 \mu\text{m}$, ovary superior, glabrous, 3-celled, styles 3. Anticlinal wall pattern undulate; stomata complex; anisocytic on the adaxial surface, both paracytic and anisocytic on the abaxial surface; trichome absent; surface ornamentation absent. Epidermal surface granula; epicuticular wax present; cuticle smooth; trichome filiform; Venation; pinnate, tri-veined, mixed-craspedodromous.

Habitat: Occurs in savanna, waste places and along roadsides, sometimes as a weed in crops, usually on sandy soil widely distributed in Nigeria.

Distribution and Ecology: Edo, Shaki, Utuwang, Gombe and Jebba

Common names:

ENGLISH: Asthma herb. EDO: aswn-uloko, iroko (Elugbe), EFIK: etinkeni-ekpo, FULA-FULFULDE: endednde, yindamhi, GWARI: lukwe bebe, HAUSA: nonon kurciyaa IGBO: udani, TIV: mbasaombol mingem, YORUBA: amuyinu, egele, emi-ile.

Representative specimens examined: NIGERIA: Utuwang, 8th July 1978, Ariwaodo FHI 89275; Borgu, 13th August 1971, Daramola and Geerling FHI 45594; Jebba, June 1957, Clayton FHI 39772; Shaki, 18th Oct 1968, Gbile and Olorunfemi FHI 20469; Gombe, 14th Dec. 1968, Lowe FHI 26241/ UIH 11241.

7. *Euphorbia cotinifolia* L. Sp. Pl. 1: 453. 1753

Synonyms

Tithymalus cotinifolius (L.) Haw.

Aklema cotinifolia (L.) Millsp.

Euphorbia cotinoides Miq.

Euphorbia caracasana (Klotzsch & Garcke) Boiss.

Description:

A shrub with prominent leaves (reddish purple in colour); Leaves decussate; margin entire; shape ovate; base truncate; apex cuspidate; glossy on both sides; stipules nil; clustered at branches tips; Mean leaf length 7.30 ± 1.62 (cm), leaf width 4.55 ± 0.62 (cm), petiole length 4.43 ± 0.54 (cm); The inflorescences are terminal cymes in a group of three; yellow leaf like involucre; 4 glands oval in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. $29.84 \mu\text{m}$, mean equatorial diameter; c. $27.01 \mu\text{m}$, mean P/E c. 1.1, ovary superior, glabrous, 3-celled, styles 3. anticlinal wall pattern undulate; anisocytic stomatal complex present on abaxial surface and no stomata on adaxial surface; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate uni-veined and mixed craspedodromous.

Habitat: Hedge plant

Flowering period: Dry season

Chromosome number: 30

Representative specimen examined: NIGERIA: Sango ota, 17th April 2004, Faboyede017, Ife, 23rd June 2004, Faboyede030

8. *Euphorbia deightonii* Croizat Bull. Misc. Inform. Kew 1938 (2): 58

Description:

Candelabra-like shrub or tree up to 4.5-6 m tall without a distinct trunk forming large angles somewhat winged, often planted as a hedge plant; simple decussate leaves; shape obovate; margin entire; base acute; apex mucronate; petiole absent; single inflorescence located along the stem bract-like involucre; four yellowish glands present; polygonally shaped epidermal cells on both surfaces; anticlinal wall patterns straight; no surface ornamentation.

Distribution: Idanre, Ibadan, Aweba

Common name: Yoruba: oro adete, atroku, egakk, бага-ни-финг, bura, ngele-gonu

Representative specimens examined: Akor, 21st January 1957, Onochie, CFA FHI 36095; Aweba, 3rd January, 1948 Brenan, JPM and Keay, RWJ FHI 37052; Ibadan 22nd April, 1958 Ntima, O. O. FHI 41771; Ibadan, 14th October, 1963, Onyeachusim and Binuyo FHI 47897.

9. *Euphorbia depauperata* Hochst .ex. A. Rich Tent. Fl. Abyss. 2: 241 (1851).

Synonyms

Euphorbia lepidocarpa Pax (1903)

Euphorbia multiradiata Pax and Hoffm. (1910)

Euphorbia shirensis Baker f. (1894)

Description:

Perennial herb; rootstock thick woody, producing numerous simple or sparsely branched annual stems; stems erect to 60 cm high, or spreading and decumbent, rarely more;

glabrous or pilose with long spreading hairs. Leaves sub sessile; petiole about 1 mm long, flattened, with a short tuft of hairs in the Axillary; linear-lanceolate to obovate or broadly obovate, obtuse to rounded at the apex and usually shortly apiculate, abruptly cuneate to rounded at the base, narrowly cartilaginous and sometimes \pm revolute at the margin, glabrous. Cymes Axillary and in (3)5(6)-branched umbels around a terminal bisexual cyathium, with primary rays to 7(10) cm long, each forking c. 3 times. Bracts sessile, about $1.5\text{--}2.5 \times 1.5\text{--}3$ cm, deltoid to suborbicular, longer below the umbel, apex obtuse to rounded, base with a tuft of hairs on the upper surface. Cyathia sessile, glabrous or occasionally sparsely pilose, about 3.5×5.5 mm, with broadly cup-shaped involucre; glands 4–6, spreading, 1.5–3 mm broad, orbicular to transversely oblong, yellow; lobes 1 mm long, rounded, densely ciliate on the inner surface. Capsule exerted on a pedicel to 6 mm long, about 5×6.5 mm, shallowly 3-lobed, densely and strongly verrucose, usually tinged reddish.

Distribution: Adamawa, Mambilla, Ibadan

Representative specimens examined: Adamawa, 19th April, 1962, Horseman, S., FHI 44781; Mambilla, 16th February, 1972, Chapman, J.D. FHI 45117; Mambilla, 26th August, 1973, Meddler, J., IFE 2590; Ibadan, 1st November, 1984, Lowe, J., UIH 20457/4572/FHI 104324

10. *Euphorbia desmondi* Keay and Milne- Redhead Kew Bull. 10(1): 139. 1955.

Description

Succulent shrub or tree 4-6 m tall, with erect rather stiff branching and large deciduous leaves; leaf length 10.00 ± 0.82 ; leaf width 5.43 ± 0.32 cm cactus-like; branches thick, fleshy, 1.5-3.5 cm thick, 3-6-angled with spines in pairs along the edges not conscribed into segments; single inflorescence located along the stem; yellowish bract-like

involucres; four yellowish oval glands present; epistomatic; randomly arranged epidermal cells on both surfaces; anticlinal wall pattern straight on both surfaces.

Common name: Oro agogo

Distribution: found on rocky hills in savanna; sometimes planted around villages

Representative specimens examined: Tula (Gombe), November 17th, 1968, Lowe, J. FHI 27353; Tula (Gombe), November 17th, 1968, Lowe, J., UIH 12026

11. *Euphorbia glaucophylla* Poir F.T.A.6 (2): 499

Description:

A perennial decumbent herb; Leaves opposite/decussate; margin serrulate; shape oblong/ovate; base obtuse; apex acute; glossy on both sides; stipules none; Mean leaf length 1.43 ± 0.29 (cm), leaf width 0.97 ± 0.34 (cm), petiole length 0.22 ± 0.09 (cm); The inflorescences are terminal cymes in a group of three; yellow leaf like involucre; 3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. $31.13 \mu\text{m}$, mean equatorial diameter; c. $23.35 \mu\text{m}$, mean P/E c. 1.33; ovary superior, glabrous, 3-celled, styles 3. anticlinal wall pattern undulate on adaxial surface, straight on abaxial surface; anomocytic stomatal complex present on adaxial surface and paracytic stomatal complex on abaxial surface; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate tri-veined and mixed craspedodromous.

Habitat: A littoral dune colonizer forming carpet on the sand.

Flowering period: All year round

Representative specimens examined: NIGERIA: Bacita, 14th September, 1971, Gbile, Z.O. ZOG-531/ FHI 29014; Kauwa, 29th September, 1980, Ekwuno/ Fagbemi EF 200/ FHI 93975; Abeokuta, 16th October, 1981 Olorunfemi/Binuyo Babagbemi OBB41, FHI 96343;

12. *Euphorbia glomerifera* (Mill Spp) Wheeler in contrib. Gray Hb. 127:78 (1939).

Description:

A perennial decumbent herb; Leaves opposite; margin serrulate; shape elliptic; base obtuse; apex acute; glossy on both sides; stipules none; Mean leaf length 1.80 ± 0.30 (cm), leaf width 0.30 ± 0.01 (cm), petiole length 0.20 ± 0.01 (cm); The inflorescences are terminal cymes in a group of three; white leaf like involucre; 3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; anticlinal wall pattern undulate on abaxial surface, straight on adaxial surface; hemiparacytic and anisocytic stomatal complex present on abaxial surface and anisocytic and anomocytic stomatal complex types on abaxial surface; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate uni-veined and mixed craspedodromous.

Habitat: Perennial herb in crevices

Flowering period: All year round

Representative specimens examined: NIGERIA: Shaki, 19th October, 1968, Gbile & Olorunfemi J. FHI 20476; Gambari, February, 1973, Wit. PW -97/ FHI 27763; Ibadan, 7th September, 1981, Arasi, G.A. GAA.17/ FHI 95234; Ijebu-igbo, 29th January, 1987, Gbile, Z.O. OSU.17/ FHI 102637.

13. *Euphorbia heterophylla* Linn. Sp. pl. 1: 453 (1753)

Homotypic Synonyms

Poinsettia heterophylla (L.) Klotzsch and Garcke

Heterotypic Synonym(s)

Poinsettia geniculata (Ortega) Klotzsch and Garcke

Euphorbia geniculata Ortega (1797)

Description:

Monoecious, annual, sparsely branched herb up to 100 cm tall; stems often tinged red towards the apex. Leaves arranged spirally, crowded at stem apex, simple; stipules modified into purplish glands; petiole up to 2(–4) cm long; blade ovate to lanceolate, up to 12 cm × 6 cm, base cuneate, apex obtuse to slightly acuminate, margins with minute gland-tipped teeth, glabrous to sparsely hairy on the main veins; upper leaves often with whitish or reddish base. Inflorescence a compact Axillary or terminal cyme consisting of clusters of flowers, basal bracts similar to the leaves but paler green, progressively smaller and more lanceolate, almost sessile; cyathia almost sessile, about 3.5 mm × 2.5 mm, with an urn-shaped involucre, lobes circular, about 1.5 mm long, toothed, margin hairy; gland 1, peltate, funnel-shaped, about 1 mm in diameter, red-rimmed, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles few, fringed, perianth absent, stamen about 4 mm long; female flowers with pedicel about 6 mm long in fruit, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, about 1 mm long, 2-fid. Fruit a deeply 3-lobed capsule about 4.5 mm × 5.5 mm, glabrous, 3-seeded. Seeds ovoid, about 2.5 mm in diameter, warty, blackish brown. Seedling with epigeal germination; cotyledons elliptical, about 1.5 cm long, apex acute; hypocotyl, up to 4 cm long; first leaves nearly opposite, lanceolate, later alternate, toothed or not.

Flowering period: Throughout the year

Chromosome number: $2n = 30$

Distribution and Ecology: It is generally a weed found mostly on uncultivated lands widely distributed in Nigeria.

Common names: English: annual poinsettia, Fiddler's spurge, mole plant, and wild poinsettia, Yoruba: Oputu

Representative specimens examined: Ilorin, 23rd January, 1958, Dickson, S.M., FHI 41794; Ife, 24th July, 1973, Akabogu- 34, IFE 2607; Gashaka, 30th August 1977, Odewo, TKO.824/ FHI 87877; Okorshie, 19th January, 1981 Ekwuno & Others E & O. 934/ FHI 97008; Ibadan, 8th September, 1981, Aboderin, K., FHI 100363; Ibadan, 13th November 1991, Akanmu, O., UCI 22051.

14. *Euphorbia hirta* Linn. F.T.A.6 (2): 496 (1753)

Homotypic Synonym

Chamaesyce hirta (L.) Millsp. (1909)

Heterotypic Synonyms

Euphorbia hirta var. *procumbens* (Boiss.) N.E. Br

Euphorbia pilulifera var. *procumbens* Boiss.

Description:

Annual, branched herb, prostrate to ascending, with branches up to 50 cm long, with latex; all parts short-hairy and with sparse yellow hairs about 1.5 mm long. Leaves opposite, distichous, simple; stipules linear, up to 2.5 mm long; petiole up to 3.5 mm long; blade ovate, 1–4 cm × 0.5–2 cm, base very unequal, one side cuneate, the other side rounded, apex almost acute, margin finely toothed. Inflorescence, a terminal or Axillarylary cluster of flowers with several cyathia densely clustered into a cyme about 15 mm in diameter; peduncle up to 15(–20) mm long; cyathia with a cup-shaped involucre about 1 mm in diameter, tinged purple, lobes triangular, fringed; glands 4, tiny, elliptical, green or purplish, with minute white to pink appendages, each involucre

containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, fringed, perianth absent, stamen 1, about 1 mm long; female flowers with short pedicel, perianth a rim, ovary superior, short-hairy, 3-celled, styles 3, minute, apex 2-fid. Seeds oblong-conical, about 1 mm long, slightly wrinkled, pinkish brown, without caruncle.

Flowering period: All year round

Chromosome number: $2n = 24$

Distribution and Ecology: a weed, and can be a nuisance in crops due to the large number of seedlings. It is widely distributed in Nigeria.

Common names: ENGLISH: Snakeweed, pill-bearing spurge, asthma herb, YORUBA: akun esan, buje, bije, egele, loloaikuku, loloarikuko, adendende, bije, agbaje, emileidere, EDO: ozigban FULA-FULFULDE: endamyel, HAUSA: nóónôn kürçiyáà, IGBO: obu ani, OWERRI: Oba ala, IJAW (Kolokuma): obiirima, oburu anga (prawn egg).

Representative specimens examined: Ibadan, 13th November, 1991 Aderibigbe, IA. UCI 22058; Agbor, 22nd September, 1981 Ariwaodo/ Adesina AA135/FHI 102458; Katsina, 10th, January, 1964, Bell, G.S. FHI 48130; Okomu, 26th February, 1948, Brenan JPM- Brenan 9147/FHI 36380; Ogori-magongo, 2nd May, 1978, Daramola and Ibh. BO238/FHI 86183; Lagos, 30th July, 1937, Doherty, J. UIH 1875; Igbetti 7th November, 1974, Faremi, I.B. 521/IFE 2615; Adugongo, 11th February, 1942, Jones JPD 917/ FHI 796.

15. *Euphorbia hyssopifolia* Linn. F.T.A.6 (2): 496

Description:

A perennial erect herb; reduced compound leaves; opposite, margin entire; shape oblong/ovate; base obtuse; apex obtuse; glossy on both sides; stipules none; mean leaf length 1.44 ± 0.21 (cm), leaf width 0.64 ± 0.12 (cm), petiole length 0.12 ± 0.01 (cm); stem green/pinkish; inflorescences, terminal cymes in a group of three; white leaf like involucre;

3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. 28.56 μm , mean equatorial diameter; c. 20.72 μm , mean P/E c. 1.38; ovary superior, glabrous, 3-celled, styles 3. anticlinal wall pattern undulate on both surfaces; anisocytic stomatal complex present on both surfaces; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, secondary order venation, pinnately tri-veined and mixed craspedodromous.

Flowering period: All year round

Chromosome number: $2n=12$

Distribution and Ecology: Nuisance farm weeds

Representative specimens examined: Ekenwa, 1st August, 1978, Ekwuno, Fagbemi, Osanyinlusi FHI 8890; Kano, 6th February, 1976 Faremi, I.B.1632/ IFE 2632; Port-harourt 12th July, 1982, Freeman, R.A- 4C/ UIH 19800; Ibadan, 8th April, 1979, George, E.Pilz. 2286/ FHI 988750

16. *Euphorbia ingens* E. Mey. ex Boiss.

Description

Succulent catiform tree, with erect but segmented photosynthetic stem; reduced simple leaves; opposite, margin entire; shape elliptic; base acute; apex acute; glossy on both sides; stipules present; leaf length 0.52 ± 0.12 cm; leaf width 0.20 ± 0.01 cm; branches thick, fleshy, 1.5-3.5 cm thick, 3-6-angled with spines in pairs along the edges; single inflorescence located along the stem; yellowish bract-like involucre; four yellowish oval glands present; pollen grains simple, monad tricolporate, polar axis c. 42.33 μm , mean equatorial diameter; c. 40.5 μm , mean P/E c. 1.05; ovary superior, glabrous, 3-celled, styles 3; randomly arranged epidermal cells on both surfaces; paracytic stomatal complex on both

surfaces; anticlinal wall pattern straight on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quaternary, pinnately bi-veined and mixed craspedodromous.

Flowering period: Dry season

Chromosome number: $2n=9$

Distribution and Ecology: hedge plants

Representative specimens examined: Lagos, 22nd April, 2005, Fab.128; Lagos, 3rd August, 2005, Fab. 135

17. *Euphorbia kamerunica* Pax. Chev. in Rev. Bot. Appliq. 13: 565

Synonym:

Euphorbia barteri N. E. Br var. *barteri*

Description:

Succulent cactiform tree, with erect but segmented photosynthetic stem; reduced simple leaves; opposite/decussate, margin entire; shape obovate; base cuneate; apex emarginate; glossy on both sides; stipules present; leaf length 0.60 ± 0.12 cm; leaf width 0.20 ± 0.01 cm; branches thick, fleshy, 1.5-3.5 cm thick, 3-6-angled with spines in pairs along the edges; single inflorescence located along the stem; yellowish bract-like involucre; four yellowish oval glands present; ovary superior, glabrous, 3-celled, styles 3; randomly arranged epidermal cells on both surfaces; anomocytic stomatal complex on both surfaces; anticlinal wall pattern straight on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quaternary, pinnately bi-veined and mixed craspedodromous.

Habitat: Shallow soil or rock locality, hedge plants

Flowering period: Dry season

Chromosome number: $2n=9$

Distribution and Ecology: Ibadan, Idanre,

Representative specimens examined: Ibadan, Jan, 1964, Okafor, J.C. FHI 47791; Idanre, 20th April, 1969 Hall, J.B. 1250/ IFE 2634b; Idanre, 8th January, 1983, Ogwuleleka, A. IFE 13744.

18. *Euphorbia keithii* R. A. Dyer

Description:

Succulent catiform tree, with erect but segmented photosynthetic stem; reduced simple leaves; opposite, margin entire; shape elliptic; base acute; apex acute; glossy on both sides; stipules present; leaf length 0.65 ± 0.12 cm; leaf width 0.20 ± 0.01 cm; branches thick, fleshy, 5.0-6.5cm thick, 3-6-angled with solitary spines along the edges; single inflorescence located along the stem; yellowish bract-like involucre; four yellowish oval glands present; ovary superior, glabrous, 3-celled, styles 3; randomly arranged epidermal cells on both al complex on both surfaces; anticlinal wall pattern straight on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quaternary, pinnately tri-veined and mixed craspedodromous.

Habitat: shallow soil or rock locality,

Common name: Swazi Euphorbia

Flowering period: Dry season

Chromosome number: 7

Distribution and Ecology: Lagos and Ibadan

Taxonomic note: Red book information: CR B1B2ceC2a. Endemism: Near endemic threat.

Found within protected areas only

Representative specimens examined: Ibadan, 25th Jan, 2004, Faboyede030; Lagos, 17th June, 2006, Faboyede045.

19. *Euphorbia kerstingii* Pax. F.T.A.6 (1):500

Synonym: *Euphorbia polycnemoides Hochst. ex. Boiss*

Description:

A procumbent herb, leaves greenish with indumentum, compound, opposite, shape; oblong/ovate, margin; serrulate, base; obtuse, apex; acute; petiolate. Mean leaf length 1.15 ± 0.13 (cm) leaf width; 0.25 ± 0.03 (cm) and petiole length 0.09 ± 0.01 (cm). Stem colour green; Inflorescence terminal, cluster involucre group of three; leaf like, whitish, gland; three, rim-like. Pollen grains simple, monad tricolporate, polar axis c. $31.48 \mu\text{m}$, mean equatorial diameter; c. $30.43 \mu\text{m}$, mean P/E c. $1.04 \mu\text{m}$, ovary superior, glabrous, 3-celled, styles 3. Anticlinal wall pattern undulate; stomata complex, anomocytic on both surfaces; trichome absent; surface ornamentation absent. Epidermal surface granula; epicuticular wax present; cuticle smooth.

Habitat:

Occurs in waste places and along roadsides, sometimes as a weed in farmland, usually on sandy soil widely distributed in Nigeria.

Common names:

HAUSA: geron tsuntsaye = bird millet, noonon Kurciyaa

Representative specimens examined: NIGERIA: Igbetti, 15th February, 1942, Collies FG (FHI 16272); Igboora, 15th April 1977, Ibh and Adejimi- GJ.65 (FHI 89473); Zaria, 13th July 1950, Keay, RWJ (FHI 25971); Katsina, 21st Oct 1967, S.O Magaji (FHI 17979); Borgu, 10th Jan. 1977, Faremi, I. B. (IFE 2635).

20. *Euphorbia lateriflora Schum. et. Thonn F. T. A. 6(1): 552*

Description:

Semi succulent shrub, with erect photosynthetic stem; reduced simple leaves; alternate/decussate, margin entire; shape oblong/ovate; base acute; apex acute; glossy on both sides; stipule absent; leaf length 1.20 ± 0.12 cm; leaf width 0.32 ± 0.04 cm; branches

thick, fleshy, 0.5-1.5 cm thick; terminal inflorescence group of three; green bract-like involucre; four green oval glands present; ovary superior, glabrous, 3-celled, styles 3; Pollen grains simple, monad tricolporate, polar axis c. 35.05 μm , mean equatorial diameter; c. 33.07 μm , mean P/E c. 1.06 μm , ovary superior, glabrous, 3-celled, styles 3. randomly arranged epidermal cells on both surfaces; paracytic stomatal complex on both surfaces; anticlinal wall pattern straight on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quaternary, pinnately uni-veined and semi craspedodromous.

Habitat: shallow soil or rock locality

Flowering period: Dry season

Chromosome number: 10, 20

Distribution and Ecology: Kano, Zaria, Maiduguri,

Representative specimens examined: Kano, 29th October, 1947, Keay, RWJ (FHI 2139); Afunremu, 29th July, 1980, Olorunfemi/Oguntayo/Adesina (FHI 93663); Zaria, 29th May, 1963, Onochie, CFA (FHI 47706); Maiduguri, 3rd July, 1948, Ujo, CFA (FHI 2949); Ibadan, April, 1967, Guile, DPM (IFE 2636A). Ilesha, 26th October, 2000, Daramola, B.O. (IFE 764). Bichu, April, 1957, Clayton, D. (FHI 39768)

21. *Euphorbia leucophylla*

Description

A shrub with prominent simple leaves; decussate, margin entire; shape oblong; base obtuse; apiculate; stipules none; mean leaf length 4.44 ± 0.92 (cm), leaf width 1.14 ± 0.23 (cm), petiole length 0.93 ± 0.04 (cm); stem green; inflorescences, terminal cymes in a group of three; white leaf like involucre; 3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; 3. Anticlinal wall pattern undulate on

abaxial surface and straight on abaxial surfaces; paracytic stomatal complex present on abaxial surfaces and no stomata on adaxial; trichome present, single non nucleated; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth,

Representative specimens examined: NIGERIA: Ibadan, April, 1967, Guile, D.P.M. (IFE 2640)

22. *Euphorbia macrophylla* Pax

Description

An herb with simple leaves; decussate, margin entire; shape oblong; base obtuse; apiculate; stipules none; mean leaf length 5.76 ± 0.27 (cm), leaf width 2.78 ± 0.14 (cm), petiole length 1.31 ± 0.12 (cm); stem green; inflorescences, terminal cymes in a group of three; white leaf like involucre; 3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; 3. Anticlinal wall pattern undulate on abaxial surface and straight on abaxial surfaces; paracytic stomatal complex present on abaxial surfaces and no stomata on adaxial; trichome present, single non nucleated; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, **var. *splendens***

Semi succulent shrub, with erect grayish stem; simple leaves; decussate, margin entire; shape oblong; base acute; apex mucronate/emarginate; glossy on both sides; stipule present; leaf length 5.75 ± 0.12 cm; leaf width 2.48 ± 0.04 cm; paired spines present all over the stem; terminal inflorescence group of three; red petaloid involucre; three red lip-like glands present; ovary superior, glabrous, 3-celled, styles 3; both surfaces; paracytic stomatal complex on adxial surface; anticlinal wall pattern undulate on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quaternary (4th order) pinnately uni-veined, pattern and mixed craspedodromous.

Chromosome number: 7

Flowering period: All year round

Common names: Crown of thorn

Representative specimens examined: Ibadan, 12th February 2005, Faboyede188; Lagos, 14th February, 2005, Faboyede190; Sango Ota, 16th February, 2005 Faboyede 191; Igbesa, 16th February, 2005 Faboyede192

23. *Euphorbia milii*

Euphorbia milii var. *hislopilii*

Semi succulent shrub, with erect grayish stem; simple leaves; decussate, margin entire; shape oblong; base acute; apex mucronate/emarginate; glossy on both sides; stipule present; leaf length 2.52 ± 0.39 cm; leaf width 3.20 ± 0.19 cm; tuft spines present spirally all over the stem; terminal inflorescence group of three; red petaloid involucre; three red lip like glands present; ovary superior, glabrous, 3-celled, styles 3; both surfaces; paracytic stomatal complex on adxial surface; anticlinal wall pattern undulate on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation tertiary (3rd order) pinnately uni-vein pattern and mixed craspedodromous.

Chromosome number: 21

Flowering period: All year round

Common names: Crown of thorn

Representative specimens examined: Ibadan, 11th March 2005, Faboyede201; Lagos, 18th June, 2005, Faboyede211; Sango Ota, 21st June, 2005 Faboyede 215; Igbesa, 21st June, 2005 Faboyede216.

Euphorbia milii var. *tanandarivae*

Semi succulent shrub, with erect grayish stem; simple leaves; decussate, margin entire; shape oblong; base acute; apex mucronate/emarginate; glossy on both sides; stipule present;

leaf length 6.75 ± 0.10 cm; leaf width 1.95 ± 0.03 cm; solitary spines present all over the stem; terminal inflorescence group of three; three petaloid involucre; three cream lip-like glands present; ovary superior, glabrous, 3-celled, styles 3; both surfaces; paracytic stomatal complex on adxial surface; anticlinal wall pattern undulate on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation quarterly (4th order) pinnately uni-veined, pattern and mixed craspedodromous.

Chromosome number: 7

Common names: Crown of thorn

Representative specimens examined: Ibadan, 15th August 2005, Faboyede223; Lagos, 18th August, 2005, Faboyede224; Sango Ota, 22nd July, 2005 Faboyede219; Igbesa, 10th June, 2005 Faboyede212

Euphorbia milii* var. *tenuispina

Semi succulent shrub, with erect grayish stem; simple leaves; decussate, margin entire; shape oblong; base acute; apex mucronate/emarginate; glossy on both sides; stipule present; leaf length 2.12 ± 0.11 cm; leaf width 1.95 ± 0.11 cm; solitary spines present all over the stem; terminal inflorescence group of three; three petaloid involucre; three cream lip-like glands present; ovary superior, glabrous, 3-celled, styles 3; both surfaces; paracytic stomatal complex on adxial surface; anticlinal wall pattern undulate on both surfaces; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, order of venation tertiary (3rd order) pinnately uni-veined, pattern and mixed craspedodromous.

Habitat: Hedge plant

Flowering period: All year round

Chromosome number: $2n = 14$

Common name: Crown of thorn

Representative specimens examined: Ibadan, 15th August 2005, Faboyede235; Lagos, 18th August, 2005, Faboyede234; Sango Ota, 22nd July, 2005 Faboyede240; Igbesa, 10th June, 2005 Faboyede241

24. *Euphorbia prostrata* Ait. F.T. A. 6 (1): 510

Description:

A perennial procumbent herb; simple leaves; opposite, margin serrulate; shape oblong/ovate; base obtuse; apex acute; glossy on both sides; stipules none; mean leaf length 0.72 ± 0.12 (cm), leaf width 0.38 ± 0.06 (cm), petiole length 0.09 ± 0.01 (cm); stem green/pinkish; inflorescences, Axillary cymes in a group of three; white leaf like involucre; 3 glands rim like in shape; capsule smooth, indumentums present; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. $33.31 \mu\text{m}$, mean equatorial diameter; c. $29.84 \mu\text{m}$, mean P/E c. 1.12; ovary superior, glabrous, 3-celled, styles 3. anticlinal wall pattern undulate on both surfaces; paracytic stomatal complex on adaxial surface, anisocytic stomatal complex on abaxial surface; trichome absent; surface ornamentation absent epidermal surface polygonally arranged, epicuticular wax absent, cuticle smooth, secondary order venation, pinnately tri-veined and semi craspedodromous.

Flowering period: All year round

Chromosome number:

Habitat: Nuisance farm weeds

Common names: ARABIC-SHUWA unlebeina, FULA-FULFULDE: bire badi, HAUSA:

kuürar shaanuu, rafasa, tafar biri, IGBO: Ogwashi, okazi, YORUBA: ewe biyemi.

Representative specimens examined: NIGERIA: Hunta- Ibere, February, 1982 Ariwaodo and Others (FHI 99529); Bida, 1st March, 1968, Brenan J.P.M. (FHI 36027); Ife, 17th October, 2000, Daramola, O.B. (IFE 1471); Ikom, 11th February, 1982, Ekwuno & Others (FHI 95903); Amarawa (Sokoto) 3rd August, 1969 Latilo, MG (FHI 62763); Ibadan 1st March, 1968 Gledhill, D, (UIH 10173); Igbajo, 25th April, 1966 Latilo, M.G. (UIH 13453/FHI 58426).

25. *Euphorbia pulcherrima* Willd. FWTA, ed. 2, 1: 419.

Annual shrub; Leaves decussate; margin entire/tooth; shape elliptic/ovate/obovate; base acute; apex cuspidate; glossy on both sides; stipules none; Mean leaf length 5.3 ± 1.55 (cm), leaf width 4.88 ± 0.73 (cm), petiole length 4.37 ± 0.47 (cm); The inflorescences are terminal single cyme; red leaf like involucre; one gland oval in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. $46.26 \mu\text{m}$, mean equatorial diameter; c. $42.58 \mu\text{m}$, mean P/E c. 1.09; anticlinal wall pattern straight on both surfaces; hemiparacytic stomatal complex present on abaxial surface and absent adaxial surface; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate tri-veined and mixed craspedodromous.

Common name: English: poinsettia

Representative specimens examined: NIGERIA: Ibadan 1st October, 1955, Alasoadura, S. (UIH 11069); Ife, October, 1966, Guile, D.P.M. (IFE 2663); Mambilla, 7th January, 1955, Latilo and Daramola (FHI 34364); Nsukka, 27th May, 1972 Oguntayo and Ibh (FHI 65171)

26. *Euphorbia scordifolia* Jacq. F. T. A. 6 (1): 501

Description:

Procumbent herb; Leaves opposite; margin serrate; shape ovate; base acute; apex acute; stipules none; indumentum present; Mean leaf length 1.20 ± 0.01 (cm), leaf width 0.06 ± 0.01 (cm), petiole length 0.20 ± 0.01 (cm); The inflorescences are Axillary cyme in a bunch;

white bract like involucre; three gland rim-like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; anticlinal wall pattern straight on adaxial surface, undulate on abaxial surface; paracytic and anisocytic stomatal complex types on both surfaces; trichome present; surface ornamentation present; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate tri-veined and mixed craspedodromous.

Representative specimens examined: NIGERIA; Markudi 7th July, 1957 Keay, RWJ (FHI 37127); Imeko, 2nd June, 1977 Oyayomi and Osanyinlusi (FHI 82904).

27. *Euphorbia sudanica* A. Chev. F.T.A.6, 1: 511

Synonym: *Euphorbia trapaeifolia* A. Chev. *tellieri* A. chev.

Description:

Woody shrub; Leaves whorl; margin entire; shape lanceolate/ovate; base obtuse; apex acute; glossy on both sides; stipules none; Mean leaf length 9.63 ± 0.82 (cm), leaf width 4.13 ± 0.32 (cm), petiole length 0.20 ± 0.01 (cm); paired spine all over the stem; The inflorescences are terminal single cyme; yellow leaf like involucre; five gland oval in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; anticlinal wall pattern straight on both surfaces; anisocytic stomata complex on adaxial and paracytic stomatal complex present on abaxial surface; trichome absent; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, venation pinnate tri-veined and mixed craspedodromous.

Representative specimens examined: NIGERIA: Ilorin, 9th April, 1994, Olawale, J.A.

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28. *Euphorbia thymifolia* Linn. Sp. pl. 1: 454(1753):

Description

A perennial herb; simple leaves; opposite, margin serrulate; shape oblong; base rounded; apex obtuse; glossy on both sides; stipules none; mean leaf length 1.30 ± 0.33 (cm), leaf width 0.50 ± 0.08 (cm), petiole length 0.48 ± 0.12 (cm); stem green/pinkish; inflorescences, Axillary single cyme; white leaf like involucre; 3 glands rim like in shape; capsule smooth, indumentum present; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small caruncle, smooth, dark brown or grey when ripe; pollen grains simple, monad tricolporate, polar axis c. $30.99 \mu\text{m}$, mean equatorial diameter; c. $27.31 \mu\text{m}$, mean P/E c. 1.04; ovary superior, glabrous, 3-celled, styles 3. anticlinal wall pattern undulate on both surfaces; anisocytic stomatal complex on adaxial surface, anisocytic and anomocytic stomatal complexes on abaxial surface; trichome absent; surface ornamentation absent epidermal surface polygonally arranged, epicuticular wax absent, cuticle smooth, secondary order venation, pinnately tri-veined and mixed craspedodromous.

Chromosome number: 18

Representative specimens examined: NIGERIA: Ibadan, 28th September, 2000, Daramola, (IFE 2659); Kotonkarifi, 21st March, 1973, Eimujeze/ Ekwuno/ Onijamowo (FHI 70356); Bukana, 25th January, 1971, Ekwuno (FHI 63813); Baga, 26th September, 1980, Ekwuno/ Fagbemi (FHI 93943); Onitsha, 2nd June, 1956, Onochie CFA (FHI 35857); Kainji, 5th March, 1956, Onyeachusim/ Binuyo (FHI 58139).

29. *Euphorbia unispina* NE Br. FWTA, ed. 2, 1: 422

Description

Cactiform tree 4-6 m tall, with erect rather stiff branching and large deciduous leaves; simple leaves; whorl arrangement, margin entire; shape lanceolate; base acute; apex mucronate; glossy on both sides; stipules present; leaf length 7.10 ± 1.02 ; leaf width 5.43 ± 1.32 cm; branches thick, fleshy, 1.5- 3.5 cm thick, 3-6-angled with spines in pairs along the edges; single inflorescence located along the stem; yellowish bract-like involucre; four yellowish oval glands present; epistomatic; randomly arranged epidermal cells on both surfaces; pollen grains simple, monad tricolporate, polar axis c. $45.22 \mu\text{m}$, mean equatorial diameter; c. $37.58 \mu\text{m}$, mean P/E c. 1.20; anticlinal wall pattern straight on both surfaces. hemiparacytic stomatal complex on adaxial surface, paracytic stomatal complex on abaxial surface; trichome absent; surface ornamentation absent epidermal surface polygonally arranged, epicuticular wax absent, cuticle smooth, secondary order venation, pinnately tri-veined and mixed craspedodromous.

Common names: FULA-FULFULDE: buurohi (p1. buuroje), rawandu, hetjere (p1. ketje), GWARI: magaba, HAUSA, bida serti, tinyaá, tumniya, tunya, KANURI: garuru, TIV: koroko, YORUBA: oro adete, FULAFULDE (Adamawa) borooje

Representative specimens examined: Ifon, 30th October, 1959, Oladoyinbo, A. (FHI 43367).

30. *Euphorbia* sp. B

Description:

A perennial erect herb; simple variegated leaves with white patterns in the middle; opposite, margin entire; shape elliptic; base obtuse; apex acute; glossy on both sides; stipules none; indumentum present; mean leaf length 4.76 ± 0.27 (cm), leaf width 2.75 ± 0.14 (cm), petiole length 1.21 ± 0.12 (cm); stem green; inflorescences, terminal cymes in a group of three; white leaf like involucre; 3 glands rim like in shape; capsule smooth, glabrous; styles shortly united at the base, bifid with recurving arms; seeds oblong-ellipsoid with a small

caruncle, smooth, dark brown or grey when ripe; anticlinal wall pattern wavy on both surfaces; hemiparacytic and anisocytic stomatal complexes present on adaxial surface, pacytic and anomocytic stomatal complex types on abaxial surface; trichome present; surface ornamentation absent; epidermal surface granular, epicuticular wax absent, cuticle smooth, secondary order venation, pinnately tri-veined and mixed craspedodromous.

Habitat: Noxious weed

Flowering period: All year round

Chromosome number: 8

Representative specimens examined: Ibadan, 10th January, 2004, Faboyede010; Lagos, 16th March 2004, Faboyede015.



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Appendix 1: Definition of terms and acronyms

| Terms | Definitions |
|---------------------------|--|
| Achlamydeous | An epithet applied to plants which have neither calyx nor corolla. |
| Aneuploidy | Loss or gain of whole chromosomes. |
| Aperturate | Presence of aperture |
| Apertures | Any thinning, thickening or other modification of the wall of the pollen that serves as an exit for its contents. |
| Character state | An inherited attribute distributed among all comparable individuals of the same historical, clade or terminal lineage. |
| Circumscription | The definition of what does and does not belong to a given taxon, from a particular taxonomic viewpoint or taxonomic system. |
| Clade | A group consisting of an organism and all its descendants (biological systematics, a clade is a single branch on the tree of life). |
| Colpate | Furrows other than across the middle of outer surface |
| Epistomatic | Having stomata on the upper surface only. |
| Flora | A descriptive list of all the plant life of a given place or time, often including a key for identification. |
| Genus | A taxonomic category consisting of a group of species exhibiting similar characteristics. |
| Hypostomatic | Having stomata (mostly) on the underneath (foliar abaxial surface) |
| Monophyletic group | A clade, comprising an ancestral form and all of its descendants forming one (and only one) evolutionary group. |
| Node | Region of a stem where one or more leaves are attached. |

| | |
|-------------------------|---|
| Species | Morphologically definable units, made up of groups of individuals (populations), which it is assumed are usually interbreeding, the containers and expression of one or more gene pools |
| Taxon (Taxa Pl.) | A taxonomic unit. |
| Tricolpate | Three colpi |

Acronyms

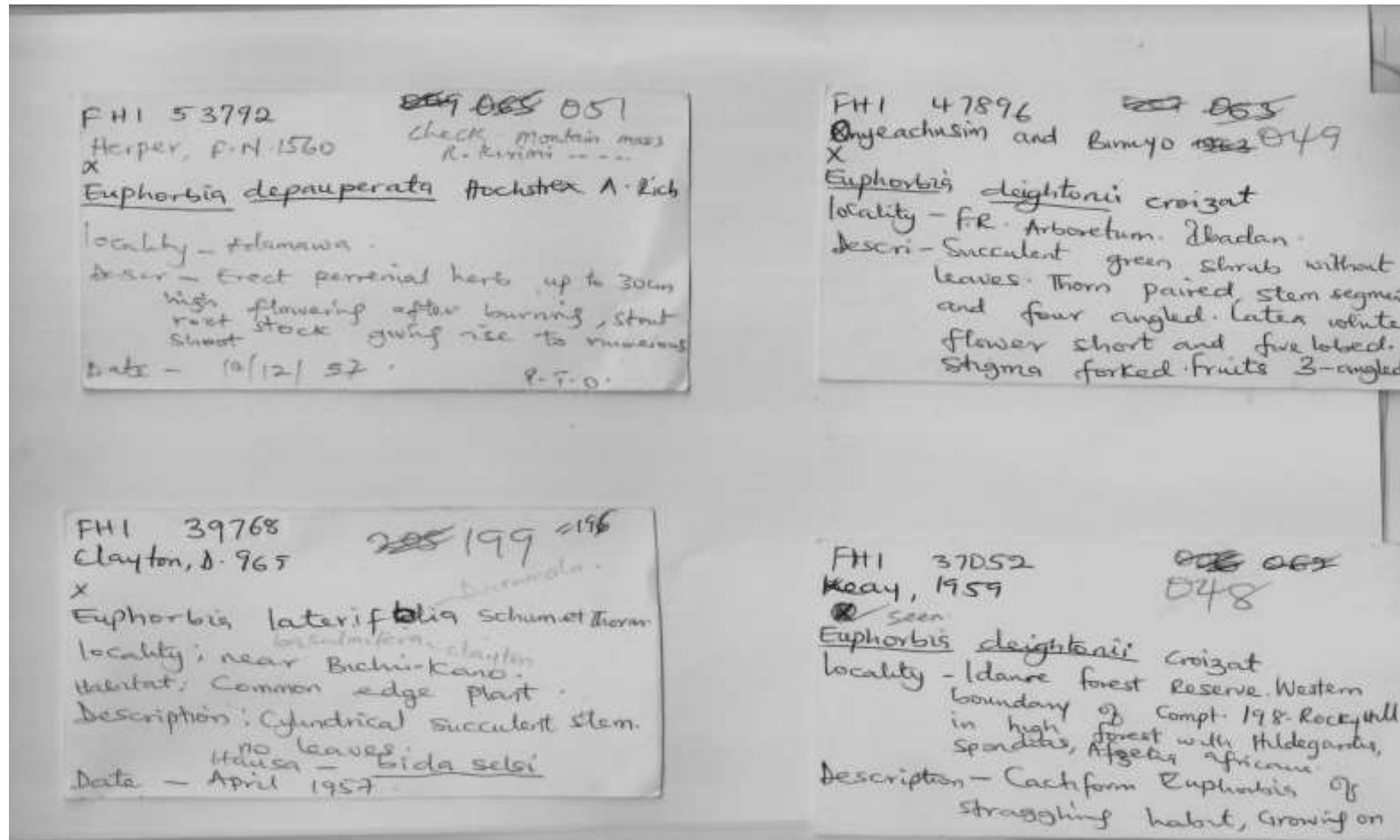
FHI
GC
IFE
IUH
LUH
OTU
UIH
UTC
APG
CJBG



Definitions

Forestry Herbarium Ibadan
University of Ghana Herbarium
University of Ife Herbarium
University of Ilorin Herbarium
University of Lagos Herbarium
Operational Taxonomic Units
University of Ibadan Herbarium
Unit Taxonomic Characters
Angiosperm Phylogeny Group
Les conservatoire et jardin botaniques de la Ville de Genève

Appendix 2: Example of Cards used to record herbarium information



Appendix 3: Query form used for morphological study

depend

MORPHOLOGICAL STUDIES ON EUPHORBIA SPP

| | | | |
|-----------------------|---|-----|-----|
| Index Number | | 390 | 391 |
| Herbarium Number | | | |
| Collectors Number | | | |
| Habitat | | | |
| Nature | Herb Shrub Tree | | |
| Habit | Prostrate Erect | | |
| Annual / Perennial | | | |
| LEAF | | | |
| Presence / Absence | | | |
| Prominence | Reduced Prominent | | |
| Number | | | |
| Types (one or two) | | | |
| Simple / Compound | | | |
| Arrangement | Above Below | | |
| Shape | | | |
| Margin | | | |
| Base | | | |
| Apex | | | |
| Venation | (Distinct or not) (Raised thickness) | | |
| Midvein | (Prominent / not prominent) (Raised thickness) | | |
| Length | | | |
| Width | | | |
| Position of max-width | | | |
| Indumentum (Pr/ab) | Type (curly or densely wooly) | | |
| Stipule | (Pr/ab) Type Form scale or not Length | | |
| Peduncle | Pr/ab Length | | |
| Surface | smooth/rough | | |
| Petiole | Pr/Ab Length | | |

Appendix 4: Query form on stem and floral morphological study

| | | | |
|---|--------------------------------|--|--|
| Bracts | Size | | |
| STEM MORPHOLOGY | | | |
| Branching pattern spiral / ascending branches | | | |
| Indumentum (Pr/ab) | | | |
| Colour | | | |
| Diameter / girth | | | |
| Shape | Angled or not angled | | |
| Spines | Pr/ab | | |
| | Type (Paired / solitary) | | |
| | Arrangement – Along the margin | | |
| | Spirally | | |
| INFLORE SCENCE (FLORAL MORPHOLOGY) | | | |
| Colour | | | |
| Arrangement | Cluster (type) | | |
| | Solitary (type) | | |
| Cyanthia | location | | |
| Involucre | Pr/ab | | |
| | Glands – Pr/abs | | |
| | Shape | | |
| | Number | | |
| | Paired / solitary/several | | |
| | Colour | | |
| Sexuality | Monoecious / dioecious | | |
| Capsule | Location | | |
| | Hairy or glabrous | | |
| | Dehiscent / not dehiscent | | |
| | Pubescent / glabrous | | |
| Androecium | Number | | |
| | Staminal tube – Pr/ab | | |
| | Fused / free | | |
| | Position of anthers | | |
| Gynoecium | Number of carpels | | |
| | Placentation | | |
| | Type of ovary | | |
| | Nature of ovary | | |
| | Paired / solitary | | |
| | Type of stigma | | |
| Aestivation | | | |
| No of petals | | | |
| No of sepals | | | |
| Flowering period | | | |

Appendix 5: Query form on anatomical study

| TAXA 7 5 8 | | | | | | | | | |
|------------|--|---------|-------------------------|---------|---------------|---------|----------|------|---------|
| S/N | Qualitative leaf micromorphological characters | | | | | | | | Density |
| | shape of epidermal cell | | Anticlinal wall pattern | | Stomatal type | | Trichome | | |
| | Abaxial | Adaxial | Abaxial | Adaxial | Abaxial | Adaxial | Pr | Type | |
| 1 | | | | | | | AS | - | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | | | | | | | | | |

Appendix 6: Query form on anatomical study (contd.)

| TAXA | | | | | | | |
|------|---------|-----------|-----------|-------------|-----------------|--------|-----|
| S/N | Min/Max | Epidermal | cells | | stomatal system | | |
| | | number | thickness | size at wid | number | length | wid |
| 1 | min | 7 | | 5x5 | 18 | 12 | 7 |
| | max | 72 | | 12x6 | 26 | 12 | 6 |
| 2 | min | | | 3x4 | 20 | 11 | 5 |
| | max | 46 | | 12x6 | 27 | 12 | 7 |
| 3 | min | | | 8x5 | 28 | 11 | 7 |
| | max | | | 8x5 | 20 | 15 | 10 |
| 4 | min | | | 13x4 | 28 | 12 | 7 |
| | max | | | 12x5 | 20 | 14 | 10 |
| 5 | min | | | 12x5 | 30 | 12 | 8 |
| | max | | | 14x5 | 20 | 15 | 10 |
| 6 | min | | | 12x6 | 26 | 11 | 8 |
| | max | | | 12x5 | 22 | 15 | 10 |
| 7 | min | | | 14x5 | 30 | 11 | 7 |
| | max | | | 12x5 | 20 | 15 | 10 |
| 8 | min | | | 13x5 | 35 | 11 | 5 |
| | max | | | 8x6 | 17 | 14 | 10 |
| 9 | min | | | 12x5 | 30 | 12 | 7 |
| | max | | | 10x4 | 17 | 15 | 10 |
| 10 | min | | | 12x6 | 31 | 11 | 8 |
| | max | | | 8x5 | 30 | 14 | 10 |
| 11 | min | | | 14x6 | 16 | 12 | 8 |
| | max | | | 8x4 | 25 | 15 | 12 |
| 12 | min | | | 13x5 | 26 | 12 | 5 |
| | max | | | 12x5 | 24 | 15 | 10 |
| 13 | min | | | 13x5 | 31 | 12 | 8 |
| | max | | | 12x5 | 27 | 15 | 8 |
| 14 | min | | | 12x6 | 36 | 12 | 7 |
| | max | | | 12x6 | 26 | 15 | 10 |
| 15 | min | | | 14x5 | 27 | 11 | 7 |
| | max | | | 14x5 | 26 | 14 | 10 |
| 16 | min | | | 12x5 | 30 | 11 | 6 |
| | max | | | 12x5 | 26 | 15 | 10 |
| 17 | min | | | 13x4 | 36 | 12 | 6 |
| | max | | | 13x5 | 27 | 14 | 10 |
| 18 | min | | | 12x6 | 35 | 12 | 8 |
| | max | | | 12x5 | 20 | 14 | 10 |
| 19 | min | | | 13x5 | 29 | 11 | 8 |
| | max | | | 10x5 | 22 | 14 | 10 |
| 20 | min | | | 12x6 | 37 | 11 | 5 |
| | max | | | 12x5 | 17 | 14 | 10 |
| 21 | min | | | 12x5 | 30 | 11 | 5 |
| | max | | | 10x5 | 20 | 15 | 8 |
| 22 | min | | | 14x5 | 32 | 11 | 8 |
| | max | | | 8x5 | 28 | 15 | 10 |
| 23 | min | | | 13x4 | 26 | 12 | 6 |
| | max | | | 8x4 | 26 | 15 | 10 |
| 24 | min | | | 12x6 | 19 | 15 | 6 |
| | max | | | 12x5 | 22 | 15 | 8 |
| 25 | min | | | 13x4 | 19 | 12 | 6 |
| | max | | | 13x5 | 17 | 16 | 10 |
| 26 | min | | | | 27 | 11 | 6 |



Appendix 7: Query form on Population studies

| S/n | Population Accession Number | Leaf | | | | | | | Stem colour | Plant height (cm) | Inflorescence length (cm) | Capsule | |
|-----|-----------------------------------|-------|-----------|---------|--------|-----------------|----------------|---------------|----------------|-------------------------|---------------------------------|----------------|---------------|
| | | Shape | Margin | Base | Apex | Petiole (cm) | Length (cm) | Width (cm) | | | | Length (cm) | Width (cm) |
| 1 | FAO 073 | ovate | serrulate | oblique | acute | 0.20 | 3.40 | 1.20 | green | 25.00 | 0.50 | 0.20 | 0.10 |
| 2 | FAO 074 | ovate | serrulate | oblique | acute | 0.20 | 3.30 | 1.20 | green | 33.50 | 0.50 | 0.20 | 0.10 |
| 3 | FAO 075 | ovate | serrulate | oblique | acute | 0.20 | 2.80 | 1.10 | green | 35.04 | 1.00 | 0.20 | 0.09 |
| 4 | FAO 076 | ovate | serrulate | oblique | obtuse | 0.18 | 3.10 | 1.50 | pink | 30.09 | 1.00 | 0.25 | 0.09 |
| 5 | FAO 077 | ovate | serrulate | oblique | obtuse | 0.19 | 3.10 | 1.40 | green | 27.66 | 0.89 | 0.22 | 0.09 |
| 6 | FAO 078 | ovate | serrulate | oblique | obtuse | 0.20 | 3.15 | 1.34 | green | 30.50 | 0.55 | 0.20 | 0.09 |
| 7 | FAO 079 | ovate | serrulate | oblique | acute | 0.18 | 3.30 | 1.46 | pink | 33.46 | 0.55 | 0.20 | 0.08 |
| 8 | FAO 079 | ovate | serrulate | oblique | obtuse | 0.17 | 3.30 | 1.23 | pink | 28.90 | 0.55 | 0.20 | 0.09 |
| 9 | FAO 082 | ovate | serrulate | oblique | acute | 0.21 | 3.35 | 1.24 | green | 27.50 | 0.52 | 0.22 | 0.09 |
| 10 | FAO 083 | ovate | serrulate | oblique | acute | 0.22 | 3.10 | 1.22 | green | 28.50 | 0.69 | 0.22 | 0.10 |
| 11 | FAO 089 | ovate | serrulate | oblique | acute | 0.20 | 2.75 | 1.20 | green | 28.10 | 0.75 | 0.22 | 0.10 |
| 12 | FAO 090 | ovate | serrulate | oblique | acute | 0.18 | 2.78 | 1.20 | green | 28.10 | 0.55 | 0.25 | 0.10 |
| 13 | FAO 091 | ovate | serrulate | oblique | acute | 0.19 | 2.78 | 1.17 | pink | 30.33 | 0.57 | 0.25 | 0.09 |
| 14 | FAO 092 | ovate | serrulate | oblique | acute | 0.17 | 2.56 | 1.17 | pink | 30.27 | 0.65 | 0.22 | 0.12 |
| 15 | FAO 093 | ovate | serrulate | oblique | acute | 0.19 | 3.45 | 1.27 | green | 28.35 | 0.59 | 0.20 | 0.15 |
| 16 | FAO 095 | ovate | serrulate | oblique | obtuse | 0.17 | 3.51 | 1.25 | pink | 37.89 | 0.55 | 0.22 | 0.10 |
| 17 | FAO 096 | ovate | serrulate | oblique | acute | 0.19 | 3.21 | 1.25 | pink | 39.35 | 0.55 | 0.20 | 0.15 |
| 18 | FAO 097 | ovate | serrulate | oblique | acute | 0.20 | 2.80 | 1.10 | green | 28.19 | 0.55 | 0.20 | 0.10 |
| 19 | FAO 098 | ovate | serrulate | oblique | acute | 0.21 | 2.81 | 1.11 | pink | 28.35 | 0.56 | 0.19 | 0.15 |
| 20 | FAO 099 | ovate | serrulate | oblique | obtuse | 0.21 | 2.81 | 1.09 | green | 19.50 | 0.90 | 0.20 | 0.12 |
| 21 | FAO 100 | ovate | serrulate | oblique | acute | 0.20 | 2.80 | 1.10 | green | 28.16 | 0.45 | 0.18 | 0.10 |

Appendix 8: Query form on daily experimental study

Daily Experimental records in genus Euphorbia

Location..... Index number: Species

| | Week 1 | Week 2 | Week 3 | Week 4 |
|------------------------|--------|--------|--------|--------|
| Month | | | | |
| Date | | | | |
| Growth habit | | | | |
| Nature of stem | | | | |
| Branching pattern | | | | |
| Number of branches | | | | |
| Leaves pr/abs | | | | |
| Shape | | | | |
| Number | | | | |
| Arrangement | | | | |
| Length | | | | |
| Width | | | | |
| Margin | | | | |
| Base | | | | |
| Apex | | | | |
| Plant height | | | | |
| Color | | | | |
| Girth | | | | |
| Inflorescence pr/abs | | | | |
| Type | | | | |
| Pediceal pr/abs | | | | |
| length | | | | |
| Peduncle pr/abs | | | | |
| length | | | | |
| Bract pr/abs | | | | |
| Color | | | | |
| Shape | | | | |
| Length | | | | |
| Width | | | | |
| Petiole pr/abs | | | | |
| Length | | | | |
| Stipule pr/abs | | | | |
| Type | | | | |
| Length | | | | |
| Stem indumentum pr/abs | | | | |
| Color | | | | |
| Succulence | | | | |
| Spines pr/abs | | | | |
| Type(number) | | | | |
| Length | | | | |

Appendix 9: Index to the names of *Euphorbia* species

| S/n | Taxa | Vernacular/ common names |
|-----|---|---|
| 1 | <i>E. sp B.</i> | |
| 2 | <i>E. aegyptiaca Boiss.</i> | ARABIC: HUWA um lebeina, FULA-FULFULDE: bire, badi, rafasa |
| 3 | <i>E. ampla</i> | |
| 4 | <i>E. бага A. Chev.</i> | Mali : manding-bambara |
| 5 | <i>E. balsamifera Ait.</i> | English: balsam spurge (Hausa): agwaje, aguwa, alyara, ayyara, Kaaguwaa, Kwakka uwar-yaaraa, yaro, SUA: guu |
| 6 | <i>E. calva N.E.Br</i> | |
| 7 | <i>E. convolvuloides Hochst. ex. Benth.</i> | EDO: aswn-uloko, iroko(Elugbe), EFIK: etinkeni-ekpo, FULA-FULFULDE: endednde, yindamhi ,GWARI: lukwe bebe, HAUSA: nonon kurciyaa IGBO ;udani, TIV: mbasaombol mingem, YORUBA: amuyinu, egele, emi-ile |
| 8 | <i>E. cotinifolia</i> | Mexican shrubby spurge, red Spurge, tropical smoke bush or Caribbean copper plant |
| 9 | <i>E. deightonii Croizat</i> | YORUBA: oro adete |
| 10 | <i>E. depauperata Hochst .ex. A. Rich</i> | |
| 11 | <i>E. desmondi Keay and Milne-Redhead</i> | Oro agogo |
| 12 | <i>E. glaucophylla Poir</i> | |
| 13 | <i>E. glomerifera Mill spp</i> | |
| 14 | <i>E. heterophylla Linn.</i> | English: annual poinsettia, Mole plant, fiddler's spurge, Yoruba:Oputu |
| 15 | <i>E. hirta Linn.</i> | English: Australian (or Queensland) asthma herb, YORUBA: akun esan, buje, bije, egele, loloaikuku, loloarikuko adendende, bije, agbaje, emile-idere, EDO: ozigban FULA-FULFULDE: endamyel, HAUSA: nóónòn kùrciyàà, IGBO: obu ani, Owerri: Oba ala, Ijaw (Kolokuma): bou obirima ,indóù beni diri, oburu anga(prawn egg) |
| 16 | <i>E. hyssopifolia Linn.</i> | hyssop-leaf broom spurge |
| 17 | <i>E. ingens</i> | English: candelabra tree |
| 18 | <i>E. kamerunica Pax.</i> | EFIK : akpa mbiet, FUIA-FULFULDE: kwidehi, widihi HAUSA: keraana, kyànáráá, IBIBIO: rjwat, ywat, IGBO: abananya, KAMBARI: maringu, KANURI: garuru kimbilimbili, TIV: agondo karikassa kariki YORUBA: orò agogo |
| 19 | <i>E. kerstingii Pax.</i> | HAUSA: geron tsuntsaye = bird millet, noonon Kurciyaa |
| 20 | <i>E. lateriflora Schum. et. Thonn.</i> | ARABIC-SHUWA: Uumm libeine, FULA-FULFULDE: cangalabanni, fidasarudehi, HAUSA: bi sartse, fid da sarudda, fid da saruttsa, fid-dà-sàrtse, KANURI: tjaina, YORUBA: enu ekure, enu enu-òpire, oro were English: milk bush. |
| 21 | <i>E. leucophylla</i> | |
| 22 | <i>E. macrophylla</i> | |
| 23 | <i>E. milii Des Moul.</i> | Christ's thorn /crown of thorn |
| 24 | <i>E. prostrata Ait</i> | English: Gulf sandmat, chamber bitter, ARABIC-SHUWA unlebeina, FULA-FULFULDE: bire badi, HAUSA: kuùrar shaanuu, rafasa, tafar biri, IGBO: Ogwashi, okazi, YORUBA: ewe biyemi. |
| 25 | <i>E. pulcherrima</i> | English: poinsettia |
| 26 | <i>E. scordifolia Jacq.</i> | |
| 27 | <i>E. sudanica A.Chev.</i> | BURA: hira |
| 28 | <i>E. thymifolia Linn.</i> | English: Thyme-leaf broomspurge |
| 29 | <i>E. tirucalli Linn</i> | Hausa: bidaselise, English: Finger tree, finger euphorbia, petroleum plant, pencil tree, rubber hedge euphorbia, rubber euphorbia, African milk bush |
| 30 | <i>E. unispina NE Br</i> | FULA-FULFULDE: buurohi (p1. buuroje), rawandu, hetjere (p1. ketje), GWARI: magaba, HAUSA, bida serti, tinyaá, tumniya, tunya, KANURI: garuru, TIV: koroko, YORUBA: oro adete, FULAFULDE (Adamawa) boroje. |

Appendix 10: List of Characters, character states and character codes

| S/N | Characters (UTC) | Character states and codes |
|------------------------|---|--|
| 1. | Life forms (q1) | 1. herb 2. shrub 3. succulents 4. tree |
| 2. | Habit (q2) | 1. erect 2. scrambler/prostrate /decumbent |
| Stem character | | |
| 3. | Colour (q3) | 1. green 2. grey 3. dark reddish purple 4. pink 5. green and/pink 6.variagated |
| 4. | Surface (q4) | 1. glabrous 2. pubescent |
| 5. | Spines (q5) | 0. absent 1. Present |
| 6. | Number of spine (if present)(q6) | 0. absent 1. one 2. two 3. Tuft |
| 7. | Arrangement of spines (q7) | 0. absent 1. spiral 2. Straight |
| 8. | Bole (q8) | 1. straight 2. Angled |
| Leaf characters | | |
| 9. | Presence (q9) | 1. absent 2. Present |
| 10. | Leaf colour (q10) | 0. leaf absent 1. green 2. dark reddish purple 3. Variegated |
| 11. | Prominence (q11) | 0. leaf absent 1. prominent 2. Reduced |
| 12. | Leaf type (q12) | 0. leaf absent 1. simple 2. compound 3. simple/compound |
| 13. | Leaf arrangement (q13) | 0. leaf absent 1.opposite 2. alternate 3. decussate 4. opposite/alternate 5. alternate/decussate 6.opposite/decussate |
| 14. | Leaf shape (q14) | 0. leaf absent 1. oblong 2. ovate 3.obovate 4.elliptic 5.oblong/elliptic 6.oblong/ovate 7. oblong/obovate 8. oblong/obovate/ovate 9. oblong/ovate/elliptic 10.obovate/ovate/elliptic |
| 15. | Leaf margin (q15) | 0. leaf absent 1. tooth 2.serrulate 3. serrate 4.entire 5. crenulated 6.tooth/serrate 7. tooth/entire 8. tooth/entire/serrate |
| 16. | Leaf base (q16) | 0. leaf absent 1.obtuse 2. acute 3. chordate 4. truncate 5. cuneate 6.rounded |
| 17. | Leaf apex (q17) | 0. leaf absent 1.acute 2. sub acute 3. apiculate 4.acute/apiculate 5. obtuse 6. retuse 7. mucronate 8. emarginate 9. mucronate/emarginate 10. Cuspidate |
| 18. | Leaf surface (q18) | 0. leaf absent 1. indumentum present 2. indumentum absent but glossy 3. indumentum absent but not glossy |
| 19. | Petiole (q19) | 1. present 2. absent |
| 20. | Leaf length (actual mean length) (q20) | 0. leaf absent 1.(0.5-1.99cm) 2.(1.99- 2.99cm) 3.(3.0-3.99) 4. (4.0-4.99cm) 5. (5.0-5.99cm) 5. > 6.00cm |
| 21. | Leaf width (actual mean length) (q21) | 0. leaf absent 1. (0.01-0.09cm) 2. (0.10-0.9cm) 3. (1.0-1.9cm) 4. (2.0-2.9cm) 5. >3.0cm |
| 22. | Petiole length(actual mean length)(q22) | 1. petiole absent 2. (0.01 -0.09cm) 3. (0.1-0.9cm) 4. (1.0-1.9cm) 5. >2.0cm |

| Inflorescence characters | | |
|--|---|--|
| 23. | Location of inflorescence(q23) | 1. Axillary 2. terminal 3. along the stem |
| 24. | No of cyanthium per inflorescence(q24) | 1. one 2. group of two 3. group of three 4. > group of three |
| 25. | Type of cyanthophyll(q25) | 1. leaf like 2. bract like 3.petaloid 4. Absent |
| 26. | Colour of gland(q26) | 1. red 2. yellow 3. cream 4. white 5. pink 6. Green |
| 27. | Number of glands(q27) | 1. one 2. two 3. three 4. four 5. five |
| 28. | Colour of inflorescence(q28) | 1. red 2. yellow 3. green 4. White |
| 29. | Shape(q29) | 1. rim like 2. tube like 3. lip like 4.oval |
| 30. | Type of fruit(q30) | 1. capsule 2. drupe |
| Leaf Epidermal micro-morphological characters | | |
| 31. | Arrangement of epidermal cell(abaxial surface) (q31) | 1. random 2. polygonal 3. Pentagonal |
| 32. | Arrangement of epidermal cell(adaxial surface) (q32) | 1. random 2. polygonal 3. Pentagonal |
| 33. | Anticlinal wall patterns(abaxial) (q33) | 1. straight 2. undulate 3. Wavy |
| 34. | Anticlinal wall patterns(adaxial) (q34) | 1. straight 2. undulate 3. Wavy |
| 35. | Presence of stomatal complex on abaxial surface (q35) | 1. present 2. Absence |
| 36. | Presence of stomatal complex on adaxial surface (q36) | 1.present 2. Absence |
| 37. | Stomatal complex types on adaxial surface (q37) | 0. absent 1. paracytic 2. hemiparacytic 3. anisocytic 4. Anomocytic 5. anisocytic and paracytic 6. paracytic, hemiparacytic and anisocytic 7. hemiparacytic and anisocytic |
| 38. | Stomatal complex types on abaxial surface (q38) | 0. absent 1. paracytic 2. hemiparacytic 3. anisocytic 4. Anomocytic 5. paracytic and anisocytic 6. paracytic and anomocytic 7. anisocytic and anomocytic 8. paracytic, hemiparacytic, anisocytic |
| 39. | Presence of trichomes (q39) | 1. present 2. Absence |
| 40. | Types of trichome (q40) | 0. absent 1. single nucleated 2. single non-nucleated |
| 41. | Density of trichome (q41) | 0. absent 1. sparse 2. dense 3.absent |