COMPARATIVE STUDIES OF FOLIAR EPIDERMAL FEATURES OF SOME MEMBERS OF THE GENUS *IPOMOEA* L. IN NORTHERN GUINEA SAVANNAH AND SUDAN SAVANNAH ZONES OF NIGERIA

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APRIL, 2018

DECLARATION

I declare that the work in this thesis entitled “Comparative studies of foliar epidermal features of some members of the genus *Ipomoea* in Northern Guinea Savannah and Sudan Savannah zones of Nigeria” has been carried out by me in the Department of Botany. The information derived from the literature has been duly acknowledged in the text and the list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

Shehu, TALLE

Name of Student SignatureDate

CERTIFICATION

This thesis entitled "COMPARATIVE STUDIES OF FOLIAR EPIDERMAL FEATURES OF SOME MEMBERS OF THE GENUS *IPOMOEA* IN NORTHERN GUINEA SAVANNAH AND SUDAN SAVANNAH ZONES OF NIGERIA" by Shehu TALLE, meets the regulations governing the award of the degree of Master of Science (M.Sc.) in Botany of the Ahmadu Bello University, Zaria, and is approved for its contributions to knowledge and literacy presentation.

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DEDICATION

This work is dedicated to my Mum and Dad, who sponsored my education up to this level.

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ABSTRACT

The genus *Ipomoea*comprises the largest number of species within the family Convolvulaceaewhich are widely cultivated as ornamental because of their showy and beautiful flowers. The genus has a wide range of morphological diversity, comprising of annuals, perennial herbaceous plants, vines, shrubs and small trees. Widerange of morphological similarities exists between different taxa of this group which causes ambiguity in the identification of some members of the group. However, in an attempt to establish a stable taxonomic delimitation of different members of the genus, leaf anatomical studies were carried out to establish their relationships. Specimens were treated with bleaching agent (Sodium Hypochlorite 3.2% w/v) for 72 hours to clear the chlorophyll contents, a section of the resulting transparent tissue was then transferred to clean glass slide for microscopic examination. All microscopic measurements were made using a calibrated eyepiece graticules. Microphotographs were taking using Canon Zoom 5x camera.Results revealed the presence of three types of stomata;paracytic, anisocytic and anomocytic stomata were recorded on the abaxial and adaxial surfaces of all the examined species except in *I. purpurea* where it was not found on the adaxial surfaces of the leaves. Two types of epidermal cells were observed these are sinuous and polygonal, Trichomes were present on the abaxial and adaxial surfaces of *Ipomoea nil* of the two regions and *I. alba* of Sudan Savannah region, the margins of epidermal cells of *I. repens, I. alba* and adaxial surface of *I. nil*were wavy, the rest showed a straight wall margin. The two ecological locations have considerable effect on the leaves of this group. High significant different was observed on leaf length of *I. batatas, I. alba* and *I. nil*($p<0.001$).*I. nil* showed and mean length performance of 6.69±0.48µm in Northern Guinea Savannah and 6.66±0.34µm in Sudan Savannah region. The mean length of trichomes found on the abaxial surface of *I. nil*was 683.17µm and 390.50µm in Northern Guinea and Sudan regions respectively. Trichomes were absent on both the surfaces of *I. alba* of Northern Guinea Savannah, but recorded in Sudan Savannah region. The relatedness of *Ipomoea*species in this study showed that two clades exist; each clade is derived from common ancestral complex. The species that belong to the second clade includes *I. nil, I. repens* and *I. alba. I. purpurea* exhibit plesiomorphic character, these may explain their rather isolated position from the first and second cluster in the phenogram of these phenetic relationships. These relationships showed that *I. aquatica* and *I. carnea*are sister species. *I. carnea* and *I. repens* have common ancestor in addition to the common ancestral root that link all members of the first cluster.

Table of Contents

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

CHAPTER ONE

1.0INTRODUCTION

1.1 Background tothe Study

Convolvulaceae also known as “morning glory” is a large family, comprising approximately 50-60 genera with over 1700 species (Mabberly, 1987) as cited by Kadry *etal.* (2012). It exhibits a rich diversity of morphological characters and a wide range of ecological habit. More than one-third of the species are included in two major genera;*Ipomoea*and *Convolvulus*. The genus *Ipomoea* comprises the largest number of species within the family Convolvulaceae which are widely cultivated as ornamental because of their showy and beautiful flowers (Kadry *etal*., 2012). It comprises of over 600 species of vines and shrubs widely distributed throughout the tropics and sub-tropics (van Oostroom, 1953; Austin, 1975; Miller *et al*., 1999).Over half of the speciesare concentrated in the Americas and Asian countries (Judd *et al.,* 2002). *Ipomoea* is represented by 15 species in Nigeria. However, recent study shows that *Ipomoea*is represented by 34 species which are widely distributed among the Guinea Savannah, Sudan Savannah, Sahel Savannah, Mangrove Forest, Forest Mosaic and Tropical Forest zones of Nigeria (Ogunwenmo, 2003).The most widespread common name is morning glories, but there are also species in related genera bearing the same common name.The generic name is derived from the Greek words (*ipos*), meaning "worm" or "bindweed," and (*homoios*), meaning "resembling", refers to their twining habit.

The genus*Ipomoea* comprises annual and perennialherbaceous plants, lianas, shrubs and small trees; most of the species are twining climbing plants(Austin, 1975). kadry *et al.,* 2012, and House (1908) provided early treatments recognizing subgenera and additional infrageneric subdivisions within *Ipomoea*. Moreover, the relationships among Old World *Ipomoea* species

were further refined by van Ooststroom (1953), who recognized seven infra-generic taxa in his studies on Asianspecies. Verdcourt (1957, 1963) recognized eight infra-generic taxa in his treatment of African species. Austin's (1975; 1997; Austin and Ghazanfar, 1979; Austin and Huáman, 1996) divided *Ipomoea* into three subgenera proposed from three major lineages within the genus: subgenus Eriospermum, subgenus *Ipomoea* and subgenus Quamoclit. McDonald and Mabry (1992) carried out phylogenetic analysis of chloroplast DNA and RFLPs for 31 New World *Ipomoea* species, and their study supported the monophyly of several traditionally recognized taxa of *Ipomoea*. Das and Mukherjee (1997) studied seedling morphology and the isozyme profile of 12 species of *Ipomoea*, and they revealed two broad clusters or groups. Miller *et al*. (1999) studied phylogenetic analysis of 40 species representing the three subgenera and nine sections within the *Ipomoea* using sequence data from the ITS (Internal Transcribed Spacer) region and waxy sequences.They determined a close relationship between species of section *Pharbitis* subgenus*Ipomoea* and species of subgenus Quamoclit.

Willkin (1999) carried out a cladistic analysis of the tribe *Ipomoea* based on 45 morphological and palynological characters, and suggested that the *Ipomoea* is a monophyletic tribe. Manos *et al.* (2001) tested the phylogenetic relation of the genus *Ipomoea* with other genera from the tribe *Ipomoea* based on morphology and phylogeny and found that *Ipomoea* is paraphyletic. Ogunwenmo (2003) investigated morphometric and qualitative characters of matured cotyledons of 18 taxa of *Ipomoea*,and he revealed that cotyledon characters provided are of taxonomic significance in the evolution of Ipomoea. Miller *et al.* (2004) investigated phylogenetic analysis of 36 *Ipomoea* species using sequence data from the ITS region. They settled that the molecular studies agree generally with the results from cpDNA and RFLP analyses in forming of two large clades of species. Molecularmarkers were used to determine genetic similarity by scientists in

different fields more than a decade ago (Potokina *et al*., 1999; Cwiklinska *et al.,* 2010). Hallier (1893) recognised the usefulness of pollen characters as being palynologically and taxonomically important and divided the family into subfamily 'Echinoconiae' on the basis of distinct spiny pollen and put*Ipomoea* L. as echinate pollen (Echinoconiae). The pollen of 170 species in 30 genera was studied by Sengupta (1972) and described four pollen types, each with several sub-types. Van Campo (1976) included Convolvulaceae in the broad group of Angiospermic families with successive form pollen evolutionary pattern from tricolpate-pantoporate. Telleria and Daners (2003) also studied the pollen of 75 species of eleven genera, and three main pollen types were described; some subtypes were recognized in two of these. Kadry *et al.* (2012) studied the pollen morphology of Convolvulaceae in Egypt and observed three main pollen types. They investigated the seed morphology of 31 taxa belonging to 6 genera of Convolvulaceae from Egypt, three types of basic anticlinal cell wall boundaries and four different shapes of the outer periclinal cell wall were described.

Japanese workers in the early 1930's produced one of the first plant genetic maps using flower colour variants of *I. nil* (Imai, 1934) and recent work has positioned *Ipomoea* as a model genus for understanding the genes involved in the floral colour pathway (Durbin *et al.*, 2000; Zufall and Rausher, 2004; Streisfeld and Rausher, 2009). Current work with *Ipomoea* species addresses a range of evolutionary questions that are applicable to many organisms and biological processes, from the evolution of the mating system to plant-herbivore and plant-parasite interaction (Chang and Rausher, 1999). Some members of *Ipomoea* are invasive; they exhibit a range of mating systems fromselfing to obligately outcrossing both within and among species, and vary in form from vines to shrubs to trees.

1.1.1 General Characteristics of *Ipomoea*Genus

1.1.2 Stems

Stems are usually herbaceous although many become woody with age, at least toward the base. Woody stems are largely 1-5cm in diameter.Stem shape varies from cylindrical to 1-2 or 3-lobed, and is often asymmetrical or flat in some species. At least part of the variation results from the production of successive cambiathat produces concentric rings of xylem with included bands of interxylary phloem which can be continuous (Mennega 1969, Obaton 1960).

1.1.3Exudates

Many species, especially the herbaceous ones produce milky latex when the leaves or stems are cut, in many lianas the latex is clear or sometimes yellowish coloration of exudates is variable within genera or even within species, where the exudates is sometimes milky or clear. According to studies done by Austin (1997) most, if not all, species of *Ipomoea*have latex cells whether or not they show milky sap.

1.1.4 Leaves

Leaf blades are dominantly simple and cordiform, a shape that is often associated with the twining growth form. Most of the woody lianas have leaf blades that vary between ovate to oblong to lanceolate and are largely coriaceous while their bases are mostly obtuse to acute, less often subcordate. Much of the members have alternatesimple, unlobed leaves; others are variable from entire to 3-9-lobed (Austin, 1997). Lobing variesconsiderably even on the same individual. However, a fewhave pinnatifid e.g., *I. quamoclit* L. or *pedately* lobed (*I. ternifolia* Cav.)blades, and a group of *Ipomoea* mostly from the Caribbean is palmately compound, whileothers are deeply palmately lobed (Austin, 1997).Petioles are variable, with the tropical lianas mostly being rounded and canaliculate above (Austin,1997).

1.1.5 Inflorescence

Inflorescences are axillary or distal, and either simple or compound cymes. However, this basic pattern has been modified into racemose (monochasial cymes) in various species (Austin, 1997).

1.1.6 Pedicels Length varies markedly, from essentially absent to several centimeters.

1.1.7 Flowers

Flowers are mostly actinomorphic but symmetry varies depending on the pollinationsyndrome of the species. Those that are slightly zygomorphic are pollinated byhummingbirds (e.g., *Ipomoea lobata* (Cerv.) Thell., *Ipomoea lutea* Hemsl.), or bats (*Merremiaplatytphylla* (Fernald) O'Donell, *Ipomoea neei* (Spreng.) O'Donell). There are 5 separatesepals arranged in a quincuncial pattern; their shape and comparative lengths are importantfor determining taxa in several genera (e.g., *Ipomoea, Jacquemontia*). Five petals are thenorm, but occasionally flower will be lacking one or more because of some anomaly duringdevelopment (Austin, 1997). Petals are united into a tube; color varies markedly from white to yellow or,more commonly, some variation of mixtures of red and blue resulting in corollas that rangefrom lavender to purple to deep blue or even red or orange.

Flower buds are plaited ortwisted, resulting in 5 areas of the corolla called plicae (portions folded in bud) and 5interplicae (areas exposed in bud); absence or presence of indumenta and its type on theinterplicae may aid in generic or specific identification. There are appendages within thecorollas of *Ipomoea cuscuta* that are probably homologous to the glandular stamina trichomes on the bases of filaments in several other members of *Ipomoea*Nectaries areusually present, intrastaminal, ring or cup-shaped, often 5-lobed, but may be absent in somelineages that are autogamous (e.g., *Ipomoea minutiflora*).Stamens are 5 and may be equal or unequal in length, inserted within the corolla or exserted stamen length is likely associated with the breeding

system.Ovaries are superior, largely bicarpellate, less often 3-5-carpellate, mostly 2-locular, butmay be 4, 5, or 6 locular due to false septa; styles 1 or 2, elongate in most species; almostabsent in some species, stigmas 1 or 2, variable fromcylindrical to ligulate to globose. Placentation is axile; ovules 2 per locule (Austin, 1997).

1.1.8 Fruits

Recognition of several species depends, in part, on examination of the fruit type. Most are loculicidal capsules but some are either fleshy or dry baccate; others are highly specialized in unique ways and some have either indehiscent or tardily dehiscent fruits (Austin, 1997).

1.1.9 Seeds

Most species have a hard, woody seed coat that requires scarification to induce germination; glabrous, pubescent with long or short trichomes or both in varying patterns and some ornamented with bumps and tubercules. Species with hard seed coats have long life spans of up to at least 30 years; those of the tropical taxa lacking the hard seed coat live for a short time, perhaps as little as a week or so. Many species have a hard cartilaginous endosperm; others lack that and have distinctive perisperms (Austin, 1997).

1.1.10 Roots

Some *Ipomoea* are known to have large, fleshy roots that store nutrients, a well-known example is *I.batatas,* the common sweet potato, which is widely cultivated for its edible starchy roots (Austin, 1997).

1.1.11Plant Anatomy in Relation To Taxonomy

The use of anatomical characters in taxonomy began with the development of the microscope which provided the biologist a new tool to observe the internal structure of organs and tissues

(Wafaa, 2005). It was realized that anatomical characters are just as valuable as morphological ones. All parts of a plant provide numerous features which have been used for taxonomic purposes. Some anatomical features are very diagnostic and are commonly used in routine identification, the aspect of plant anatomy is also of great importance to scientists who are called upon to identify small samples/scraps of plant material for particular purposes such as pharrnacogonosist in the determination of the source of a drug, or by forensic experts who may be able to provide clues to a crime investigation, besides others (Wafaa, 2005). These and other similar observations have firmly established the role of anatomy in plant identification and classification.

The leaf is perhaps the most varied organ of the angiosperms and provides many anatomical characters of potential taxonomic significance (Wafaa, 2005). Investigation of the anatomy of leaves from plants following C_3 and C_4 pathways of photosynthesis has brought out several significant features associated with the two types. The most distinct character observed in the leaves, is the presence of prominent chlorenchymatous sheath surrounding the vascular bundles in the leaves of plants showing the C_4pathway and the absence in the leaves of plants showing the C_3 pathway. Thus, the leaf anatomy also provides information about the photosynthetic efficiency of a plant (Wafaa, 2005). Leaf venation for example, differs in the two major divisions of the angiosperms. Within each division there are numerous leaf venation patterns and this feature has been used by taxonomist for understanding taxonomic and phylogenetic relationships in various plant groups (Wafaa, 2005). In another interesting study,Wafaa, 2005 reported that laticifer cellsand scanning electron micrographs of the starch grains for interpreting the evolutionwithin the genus *Euphorbia.* Several other features of the leaf anatomy have been used for taxonomic purposes. Some of these include the nature of the epidermis, stomatal types, the

type of mesophyll, presence and type of sclereids and crystals. Foliar sclereids vary in their kind and distribution among various groups of angiosperms (Wafaa, 2005).Another important anatomical feature used in taxonomy and phylogeny, is the structure of the secondary wood. Wood anatomy has been used at all taxonomic levels. This data along with other characters provides useful evidence for determining the taxonomic position of taxa whenever two or more possibilities are suggested. The classification of a genus or a family in its appropriate higher category can be determined in this manner. Similarly, petiole vascularization pattern and nodal anatomy provide increasingly useful taxonomic evidences (Wafaa, 2005). Behnke and his associates have investigated more than 1500 species from 380 families to understand the ultrastructure of the sieve tube plastids. There are broadly two types of sieve tube plastids: one is called S-type that accumulates starch; while the other type is called P-type that accumulates protein. Anatomical information obtained using the transmission electron microscope (TEM) has been used for understanding relationships among different groups of both dicotyledons and monocotyledons (Wafaa, 2005).

1.2Statement of Research Problem

Many investigators (Saubhik and Kalyan, 1997; Adeniyi and Olatunde, 2012) studied different plant taxa of this broad group to infer their phylogenetic relationships. However, one of the most unifying factors in the taxonomic delimitation of this group is the presence of heart-shaped leaves and a funnel-shaped flowers (Austin, 1997; Adeniyi and Olatunde., 2012),because of this morphological similarities, ambiguous boundaries have been set between different taxa, and this causes ambiguity in the taxonomic classification of this genus (Austin, 1997).

1.3Justification of the Research

Leaf anatomical features play an important role in distinguishing different groups of plants. Anatomical characters such as stomata, trichomes and distribution of epidermal cells have been found instrumental in solving taxonomic problems (Ahmad, *et al.,* 2010). The taxonomic and phylogenetic significance of stomata, epidermal cells and trichomes have long been recognized by various workers (Ahmad *et al.,* 2010). However, stomatal density varies considerably even in a single species; this is noteworthy because stomatal index is typically considered to be a robust taxonomic character (Ahmed *et al.,* 2010).The role of anatomical data in traditional taxonomy has been long recognized since the variation within species, genera or a family is usually reflected in anatomical features as well (Ahmad *et al.,* 2010).

The use of data generated from foliar epidermal surfaces in resolving taxonomy of taxa has gained much recognition for long time (Aworinde *et al.,* 2009). Ayodole and Olowokudejo (2006) use foliar epidermal characters to distinguish different species of the family Polygonaceae.Aworinde *et al.* (2009) in their study with members of the family Euphorbiaceae reported that stomata, epidermal cells and trichomes are micromorphological features on leaves epidermal surfaces and can be used to identify, separate or distinguish different plant species.

This study will help in identification and authentication of the plant on the basis of anatomy for medicinal and economic uses. The study will be carried out in order to determine the taxonomic significance of leaf epidermis and other anatomical features with a view to further establishing stable taxonomic characters among the selected species.

1.4Aim of the Research

To investigate the relationshipsbetween foliar epidermal features among members of the genus *Ipomoea* found in parts of the Northern Guinea Savannah and partsof Sudan Savannah regions of Nigeria.

1.5Objectives of the research were to:

1. Evaluatethe distribution of epidermal features, types and sizes among different members of *Ipomoea* found in parts of the Northern Guinea Savannah and parts of Sudan Savannah regions.
2. Access the effect of different ecological locations on the architectural conformation in the leaves of selected members of the genus *Ipomoea* found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions.
3. Establish phenetic relationships among the species of *Ipomoea* in Northern Guinea Savannah and Sudan Savannah regions.

1.6 Research Hypotheses

1 There is no significant different in the distribution of epidermal features, types and sizes among different members of *Ipomoea* found in parts of the Northern Guinea Savannah and parts of Sudan Savannah regions.

2 Ecologicallocations have no significant effect on the architectural conformation in the leaves of selected members of *Ipomoea* that are commonly found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions.

3 There are no significant phenetic relationships between members of *Ipomoea*that are found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions of Nigeria.

CHAPTER TWO

2.0LITERATURE REVIEW

*Ipomoea*is an exceptionally large and diverse genus in the family Convolvulaceae, comprising of over 650 species in strict and traditional concepts of the group (Austin and Huáman, 1996) or up to 1000 species in recent phylogenetic conceptions of the group (Wilkin, 1999; Manos *et al*., 2001; Miller *etal*., 2002). Most of *Ipomoea* occur in tropical and subtropical climates throughout the world, but representative elements of the genus are in all known biomes (Wilkin, 1999).

2.1 Classification of *Ipomoea*

Kingdom	Plantae - plants
Sub kingdom	Tracheobionta – vascular plants
Superdivision	Spermatophyta – seed plants
Division	Magnoliophyta – flowering plants
Class	Magnoliopsida - dicotyledons
Sub class	Asteridae
Order	Solanales
Family	Convolvulaceae
Genus	*Ipomoea* L. (Usda, 2017)

2.2Taxonomic Description of Different Species of *Ipomoea*

Ipomoea aquatica

Marshy or aquatic herbs; stem is hollow, spongy; flowers purplish-pink; capsule globose. **Occurrence:** Abundant on marshy situations **Distribution:** Throughout India, Pakistan, Ceylon, China, Malaya, Tropical Africa and Australia. **Common name**: Swamp cabbage (Undirwade *et al.,* 2015)

Ipomoea pentaphylla (L.) Jacq.

Perennial glabrous twiner; stem much branched; flowers purple; capsule ovoid. **Occurrence:** Cultivated in gardens as showy plant.**Distribution:** Deccan peninsula with Ceylon, Tropical Asia, Africa, Australia and America. **Common Names:** Gandivel, Garvel(Undirwade *et al.,* 2015).

Ipomoea carnea

Also called *Ipomoea fistulosa* it is an erect or ascending Suffruticose shrubs; flowers purplish-pink, sometime white; capsule globose. **Occurrence:** Common in Maharashtra, India**Distribution:** Native of America and introduced in Asia and other continents. **Common name:** The pink morning glory, Bush morning glory(Undirwade *et al.*, 2015).

Ipomoea eriocarpa R. Br.

Annual, slender, hispid herbs; flowers pink; capsule globose or ovoid. **Occurrence:** Commonly grows as weed along the road sides **Distribution:** India, Ceylon, Afghanistan and Tropics of old world. **Common name:** The tiny morning glory(Undirwade *et al.*, 2015).

Ipomoea nil

Twining herbs; flowers bluish-purple; capsule ovoid, sepals hirsute-villous basally and with a slender tail-like appendage **Occurrence:** Common in jungles of Gadchiroli district.

Distribution: Throughout in India. **Common name:** Picotee morning glory, Ivy morning glory, Japanese morning glory. (Undirwade *et al.*, 2015)

Ipomoea hederifoliaL.

Scandant herbs; stem weak; flower scrimson or orange yellow; capsule ovoid. **Occurrence:** Seen as wild species throughout India, observed on road side in between Armori and Brahmapuri **Distribution:** Introduced from America, throughout India. **Common name:** Scarlet morning glory, scarlet creeper, star *Ipomoea*.(Undirwade *et al.*, 2015)

Ipomoea pandurata

Prostratly growing, herbs; flowers white creamy with pink throat; capsule ovoid.

Occurrence: Common in Chalisgaon, found growing in open places. **Distribution:** Native to North America, Florida, west to Texas, Kansas and Michigan. **Common name:** Wild Potato Vine, Man of the earth(Undirwade *et al.*, 2015).

Ipomoea ochracea (Lindl.) G. Don.

Twinning, herbs; flowers white creamy; capsule ovoid. **Occurrence:** Common in jungles of Tah. Armori, **Distribution:** It is native to parts of Africa, Asia, and certain Pacific Islands **Common name:** Fence Morningglory, Yellow morning glory(Undirwade *et al.*, 2015).

Ipomoea pes-tigridisL.

Twinning patentlyhirsute herbs; flowers pink; capsule ovoid. **Occurrence:** Common at Gadchiroli, Armori, Brahmapuri and throughout the Vidharbha region **Distribution:** Throughout India, Pakistan, Ceylon, Burma, Malaya, China, Polynesia and Tropical Africa. **Common name:** Tiger's footprint(Undirwade *et al.*, 2015).

Ipomoea quamoclit L.

Twining glabrous herbs; flowers deep-red; capsule ovoid. **Occurrence:** Commonly cultivated as a showy plant in overall Maharashtra, india. **Distribution:** Native of Tropical America usually cultivated in India. **Common name:** Cardinal creeper,Cardinal vine, Star morning glory(Undirwade *et al.,* 2015).

Ipomoea sinuate Jacq.

Prostrate hardy twining; hairy; flowers white with pink throat; capsule globose **Occurrence:** Widely distributed in tropical part of the world **Distribution:** West India, Ceylon, Tropical America, Australia. **Common name:** Snake vine, Alamo Vine, Tall morning glory(Undirwade *et al.,* 2015).

Ipomoea plebian R. Br.

Weak twiner, glabrous herbs; flowers white small **Occurrence:** Found at Chalisgaon near J.J. Anna Tower and in forest of patnadevi. **Distribution:** Oregon, north-eastern New South Wales, northern Australia, Malesia. **Common name:** Bell Vine(Undirwade *et al.,* 2015).

Ipomoea indicaL.

Twiner weak, glabrous herbs; flowerspale-purple **Occurrence:** Common at North Maharashtra, India **Distribution:** India, Pakistan, Ceylon, Burma and Japan and other continents**Common name:** Blue morning glory, Ocean morning glory(Undirwade *et al.,* 2015).

Ipomoea turpethum(L.) R. Br.

Twiner weak, glabrous herbs; flowers white-cream colored **Distribution:** Endemic to India. It is found in North Circars and Deccan region up to 3000 ft. **Common name:** Turpeth, Pithori, Shetvad (Undirwade *et al.,* 2015).

Ipomoea parasitica(Kunth) G. Don

Trailing, climber on bushes, velvety; yellow throated blue with purplish tinge flowers; capsule is globose **Distribution:** It is native to the Americas continents, but is well naturalized as an escape from cultivation in many parts of the world, including India, Mexico through Central and South America.**Common name:** Yellow throated morning glory(Undirwade *et al.,* 2015).

Ipomoea alba

Glabrescent, stout twiner; flowers white; capsules ovoid-globose. **Occurrence:** Widespread to tropical region of the new world and naturalized elsewhere in the tropics **Distribution:** Native of Tropical America **Common name:** Night blooming morning glory (Undirwade *et al.,* 2015)

Ipomoea triloba L.

Slender, creeper, twiner; flower spurple; capsule globose. **Occurrence:** Grown as food stuff in Maharashtra, india. **Distribution:** Native of America, India, Pan tropical. **Common name:** Little bell morning glory(Undirwade *et al.,* 2015)

Ipomoea batatas

Herbaceous perennial vine, bearing alternate heart-shaped or palmately lobed leaves and medium-sized sympetalous flowers, the edible tuberous root is long and tapered, with smooth skin whose colour ranges between yellow, orange, red, brown purple and beige. Its flesh ranges from beige through white, pink, red, violet (Gad and George, 2009). **Distribution:**Native to tropical region in the Americas **Common name:** sweet potato(Undirwade *et al.,* 2015).

2.3Diversity of *Ipomoea*

Ipomoea species occur in the tropics of the world although some species also reach temperate zones (Austin, 1997). The greatest species diversity occurs in the Americas and Africa. Some

genera extend around the world; others are endemic to one land mass. Ten (10) are endemic to the Americas, Africa has 13, and Asia has 10 (Austin, 1997).

*Ipomoea*range from tropical rainforest to savannahs, prairies, and deserts. Life-forms have been modified into low-creeping herbs or even tree species often grow at low elevations, but a few can reach 3000m (Austin, 1997). Mode of dispersal is comparatively poorly known, but animals, wind, and water are vectors. Fleshy fruits are dispersed by birds and other vertebrates. *Maripa* is known as "monkey syrup" in the Guianas, and is spread by them. Fruits of the tribe Poraneae (e.g., *Calycobolus*) are dispersed by wind. *Iseia, tetralocularia* and Old World *Stictocardia* fruits have internal flotation structures that facilitate spread by water. Water, and perhaps wind, spread the woolly seeds of many species. In addition, many seeds have cavities within the embryo and endosperm. A number of these "labyrinth seeds" are associated with water dispersal (e.g., *I. alba*) as reported by Austin (1997).

2.4Economic Importance of *Ipomoea*

Ipomoeabatatas is widely grown for its edible roots; its leaves are also eaten as greens (Austin and Huaman, 1996). *I. aquatica*is an Asian specialty cultivated as edible greens (leaves, stems). This Old World plant is now propagated in the Americas, often illegally, to supply the tables of immigrants who crave a familiar food. There are other *Ipomoea* that have local uses as food because of their edible roots (e.g. *I. jicama* Brandegee, *I. plummerae* Gray) as reported by Austin and Huaman, 1996. There are numerous bioactive chemicals in the genera, including alkaloids, alkanes, calystegines, flavonols, flavonoids, phenols, resin glycosides (glycoresins), saponins, ß-sitosterol, tannins, and terpenoids (Austin and Huaman, 1996). Historically the most well-known medicinal applications were as laxatives, due to the resin glycosides in several species (e.g. *Ipomoeajalapa* (L.) Pursh. *Ipomoea purga* (Wender) Hayne, although many species have these

compounds in lower concentrations (Austin and Huaman, 1996). Several American *Ipomoea* became famous in the 1930s and 1940s because of their hallucinogenic alkaloids used in religious context by indigenous peoples. There was a resurgence of use as a recreational drug in Western cultures during the 1960s and 1970s. Later a cultivated *Argyreia* was added to the list (Austin and Huaman, 1996). Regardless of the source, humans have made use of these compactly packaged mind-altering chemicals in several parts of the New World, either believing they are communicating with their deities or simply for recreation. It is now known that the plants themselves do not make ergoline alkaloids, but these chemicals are present in the epibiotic clavicipitaceous fungus *Periglandula*,*Steiner*, *Leistner* and *Leuchtm*. The original ergoline alkaloids and their derivatives, originally from *Claviceps purpurea* (Fr.) Tul. Clavicipitaceae are still used medicinally in obstetrics, and to treat migraine and Parkinson's disease; those derived from Convolvulaceae are not.

2.5Contributions of Anatomy in Resolving Taxonomic Positions of Some Taxa

1. The sepal vasculature of species of Myrteae exhibit one vascular bundle which is very different from eleven vascular bundles found in *Eugenia* of the same Myrtaceae family (Luana, 2017).
2. The occurrence of druses and a conspicuous secretory cavity is common in connectives of *Myrcegenia alpigena*, *Myrcia multiflora* and *Myrciariacuspidata*of Myrtaceae family (Luana, 2017).
3. *Boerhaavia diffusa* can be differentiated from it adulterant species *Trianthema portulacastrum*, and *Sesuvium portulacastrum* based on the presence of medullary bundle (Vidya, 2016).

4. Crescent central midrib,raphide crystals and starch-grains in leaves, stems and roots can also be used to distinguish *Boerhaavia diffusa* from its adulterant species *Trianthema portulacastrum*, and *Sesuvium portulacastrum* (Vidya, 2016).

2.6Contents and Traditional Uses of *Ipomoea*Species

The genus *Ipomoea* since time immemorial have been in continuous use for different purposes, such as, nutritional, medicinal, ritual and agricultural. The knowledge constitutes a rich source of ethno-medical information for effective selection of plants to be evaluated by chemical studies (Pereda-Miranda and Bah, 2003). With regard to nutritional purposes, it is necessary to highlight the importance of the *I. batatas* (Sweet potato). The richness of sweet potato in beta-carotene makes it highly recommendable in cases of circulatory disorders. Moreover, sweet potato contains no saturated fats as well as sodium, the two most deadly enemies of the circulatory system. This species originated from Central America, now it is widely cultivated and consumed almost throughout the world (Zhao *et al*., 2005; Bovell-Benjamin, 2007). *I. aquatica* is consumed as food in Sri Lanka, Hong Kong, Taiwan and China (Prasad *et al*., 2005a; Malalavidhane *et al.*, 2000). *I. aquatica* is one of the richests sources of carotenoids and chlorophylls (Wills and Azhari, 1996). The leaves of *I. aquatica* contain adequate quantities of most of the essential amino acids and are comparable to conventional foodstuffs such as soybean or whole egg, indicating the potential of *I. aquatica* for utilization as a food supplement. Moreover, the leaves of *I. aquatica* are an excellent source of bio-elements such as calcium, magnesium, iron, zinc, and copper (Rao *et al.*, 1990). Other species consumed for nutritional purposes are *Ipomoea alba,I.albivenia*, *I. involucrate* and *I. leptophylla* Torr.(Rao *et al.*, 1990).

Ipomoea aquatica

This is used in treatment of diabetes (indigenous medicine in Sri Lanka) (Jayaweera, 1982; Malalavidhane *et al.,* 2001). Scorpion venom antidote (Uawonggul, *et al.,* 2006), as emetic, diuretic, purgative, to treating debility, liver complaints, ringworm, leucoderma, leprosy, fever (Ghani, 1989; Mamun, *et al.,* 2003), against nosebleed and high blood pressure (Prasad *et al.,* 2005a).

Ipomoea asarifolia

The decoction of leaves can neutralize inflammation induced by *Tityus serrulatus*and can also be usedagainst itch (Silva, 2002). In Northern Nigeria, a leaf poultice is applied to guinea worm sores while the face is steamed over a hot decoction of the plant along with husk of bulrush millet (Jegede *et al.,* 2009)

Ipomoea batatas

Leaves decoctions are used as alterative, aphrodisiac, bactericide, demulcent, fungicide, laxative and tonic. Sweet potato is used in treating asthma, bugbites, burns, catarrh, ciguatera, convalescence, diarrhea, dyslactea, fever, nausea, renosis, splenosis, stomach distress, tumors and whitlows (Duke and Wain, 1981). In region of Kagawa, Japan, a variety of white sweet potato has been eaten raw to treating anemia, hypertension and diabetes (Ludvik *et al.,* 2004).

***Ipomoea cairica*:**It can be used in treatment of inflammations (Ferreira *et al.,* 2006).

***Ipomoea campanulata*:**Leaf powder or extract can be used as antidote to snake poison (Singh *et al.,* 2004).

Ipomoea carnea

It can be used against Immunodeficiency Syndrome (AIDS) (Woradulayapinij *et al.,* 2005) and to treat hypertension (Used in Gabon) (Lamidi *et al.,* 2000).

Ipomoea digitata

The powdered root is used in emaciation of children and also as tonic, alterative, aphrodisiac, demulcent, lactogogue, and cholagogue. Decoctions of root against constipation (Singh *et al.,* 2004).

***Ipomoea indica*:**Powdered leaves can be used as purgative and healing broken bones (Hawaii) (Abbott and Shimazu, 1985).

Ipomoea leptophylla

The smoke of burnedroots is used in treatment of nervousness (Native Americans Pawnee) (Gilmore, 1977). The decoction of root can also be used in treating stomach distress (Lakota people) also used as tonic (early European settlers) (Barnes *et al.,* 2003).

Ipomoeamuricata

This is used in treating several types of skin ailments such as chronic and gangrenous wounds, cuts and blisters due to burns (Philippines). Glycerol preparations of the crude drug of *Ipomoea muricata* are used for the treatment of pharyngitis and an otic preparation for the treatment of otitis (Ysrael, 2003).

***Ipomoea murucoides*:**

The smoke from the burned tree is used against mosquitoes (Mexico). Infusions of the leaves, bark and flowers are used to treat inflamations and against scorpion bites (León *et al.,* 2005).

***Ipomoea nil*:** Used for treatments against cancer (Used in East Asia) (Ko *et al.,* 2004). The plant is used as love charm in Northern Nigeria; the dried leaves are applied to burns (Ferreira, 2012).

***Ipomoea orizabensis*:**As purgative (American and European pharmacopeas) (Pereda-Miranda, 1995), anthelmintic and to treat abdominalfever, dysentery, epilepsy, hydrocephaly, meningitis and tumors (Martinez, 1990).

Ipomoea pes-caprae

Used in treatment of inflammatory and algesic processes (Souza *et al.*, 2000). Heated leaves are used for treating wound, skin infections, inflamed sores and stings from poisonous fish, manta-ray and insects (Used in Australian), Infusions havebeen recommended for treating hypertension, kidney ailments and decoctions to treat digestive disorders, colic,internal and external pain, dysentery, inflammations, fatigue, strain, arthritis and rheumatism. The roots are used in diuretic disorders and in constipation (Pereda-Miranda *et al.*, 2005; Lorenzi and Abreu, 2002; Diaz, 1976; Martinez, 1989).

***Ipomoea purga*:**Decoction of leaves can be used as purgative (Pereda-Miranda and Bah, 2003).

***Ipomoea purpurea*:**Infusions are used as diuretic, to stop hemorrhage (Bolivia), as purgative and to treat syphilis (Used in some parts of Africa) (Camargo, 1998).

Ipomoea stans Vac.Infusions of the roots have been used for treating epileptic seizures (In Mexico), nephrits, ophthalmic diseases andparalysis, as antiespasmodic and sedative agent (Diaz, 1976). As purgative (Pereda-Miranda and Bah, 2003).

***Ipomoea stolonifera*:**

As diuretic and to treat pain after childbirth, stomach problems, inflamations, furunculosis, swelling and wound (Paula *et al.*, 2003).

*I. nil*was first noted for its medicinal uses in China over 1000 years ago. From China *Ipomoea* moved to Japan where it was highly regarded as a garden-variety plant (Lee, 2015). *Ipomoea* was horticulturally important during the Edo period, approximately 200 years ago, but genetic studies of the genus only started in the early 20thcentury (Kajita and Nishino, 2009).

Yui, (2009) studied *I. nil* to compare the maple-willow (m^{w}Q0646) mutant with the wild-type species (TKS1065) to genetically analyze developmental and anatomical differences in morphology between these two species. The M^{w} 646 has the strongest change in phenotype

among the gene mutants, which makes it a prime mutant to study. M^{w} 646 is a recessive allele of the maple gene that controls growth along the medial lateral axis of lateral organs. Nishino surmised that a single gene mutation in the m^{w}646 seems to affect all lateral organs (Kajita and Nishino, 2009). This mutation decreases the width of the lamina of all lateral organs. The narrowing of leaves, sepals and petals was also determined to be a result of an inactive marginal meristem. Smaller and defective reproductive organs in the mw mutant also arise from inadequate marginal growth. Based on histological observations, it was determined in this study that there were certain homologous elements in m^{w} 646. Homologous parts of the mutant species include the lateral and floral organs, and overall give rise to unique characteristics that will need further study to understand developmental and gene-related expression during morphogenesis (early development; Kajita and Nishino, 2009).

2.7Shape and Development*Ipomoea* Leaves

Angiosperm (flowering plants) leaves differ greatly in morphology, expressing a wide range of characteristics including variations in number and/or form of marginal serrations, lobes, and leaflets. Leaves are typically flattened structures that come in a variety of shapes and sizes, which lends to their purpose of light capture and energy production (production of sugars). Without leaves and veins to transport the products of photosynthesis, plant growth would be gravely inhibited. Therefore, studying leaf shape development is at the core of understanding the overall growth habit of plants (Lee, 2015). Leaves develop from the shoot apical meristem (SAM), a dome-shaped structure that contains a population of meristematic (stem) cells located at the apex of the shoot (Dengler and Tsukaya, 2001). As leaf primordial initiate from the SAM, cell identity in the primordia changes from indeterminate to determinate, establishing adaxial (the side of the leaf closest to the SAM) and abaxial leaf polarity, and differentiation of internal

tissues (e.g. vascular tissue). It is during secondary morphogenesis that leaves increase in surface area. During this time, leaves may maintain or change their shape through differential patterns of expansion. The leaf margins (edges of leaves) still maintain meristematic properties that allow for the development of leaf serrations or lobes during secondary morphogenesis (Lee, 2015).

Despite the vast array of leaf morphologies in the angiosperm family, leaves are predominately classified into two broad groups; simple and compound. Simple leaves are distinguished by having a single continuous lamina (blade), while compound leaves have multiple separate laminar units called leaflets (Lee, 2015). In both cases, leaf margins can be smooth, serrated, or deeply lobed. Thus, simple leaves can also be lobed depending on the amount of changes that occur along the leaf margin. Ampelography is a technique that is used to assess typical traits among groups of species to determine if heritable traits like leaf shape are correlated with other measured traits (Lee, 2015). Use of this technique was first published in 1952 by Galet, in his (Précis d'Ampélographie Practique) and was subsequently translated in 1979 (A Practical Ampelography: Grapevine Identification; Galet, 1952) as quoted by Lee, 2015. Data produced from this technique can then be applied to morphometric techniques such as Principle Component Analysis (PCA), (Klingenberg *et al.,* 2012; Chitwood *et al*., 2014). By using an ampelographic technique, along with a developmental analysis, a comprehensive analysis of leaf shape can be conducted (Lee, 2015).

Morning glory interest and importance have spanned across centuries. While scientific research of the plant did not start until the beginning of the 20th century, it expanded full force for the first half of the century, focusing on the genes that lead to such great variance within the family. As time has gone on the research interest in genetics has shifted to an attention towards anatomy and morphology of *Ipomoea* and how these features may be affected by genetics (Lee, 2015).

2.8Plant Anatomical Characters

Various plant organs viz. root, stem, leaves, seeds show their typical anatomical structures after sectioning(Stuessy, 1990). The functions and adaptive values of anatomical features are often extremely useful as they help to reveal more clearly the homologies of structures for classification purposes and reconstruction of phylogeny (Stuessy, 1990). Structural aspect of some vegetative organs have contributed to the generic/infra-generic delimitation of many groups of plants (Calvente *et al.,* 2008; Cardoso *et al.,* 2009). The taxonomic and phylogenetic use of anatomical characters especially leaves has been helpful in delimitation of different genera of *Bromoliaceae* (Almeida *et al.,* 2009).

2.8.1 Trichomes

Trichomes, from Greek (Trichoma) meaning "hair", are fine outgrowths on plants, algae, lichens, and certain protists. There are two major types of trichomes, these are; glandular and non-glandular which are further sub-divided on the basis of branching, gross form, degree of branching, cellular constituents (Verma, 2011). Structurally, trichomes may be sub-divided into unicellular and multicellular. Multicellular trichomes may be unbranched or branched.Some multicellular trichomes may consist of single row of cells or of several layers, othersare branched in dendroid manner some others have branches oriented largely in one plane (stellate), Vema, (2011).

Another common type of trichome is the scale, also called peltate hair which consist of a discoid plate of cells, often borne on a stalk or attached directly to the foot. Many families like *Asteraceae, Labiatae, Solanaceae,* possesses characteristics types of trichomes and they are of immense value to taxonomic determinations (Verma, 2011). Cowan (1950) as quoted by Verma (2011), utilized the trichome characters in distinguishing the sub-genera and species of

Rhododendron. In *Eriocaulaceae*, Verma (2011) emphasized the form and structure of trichomes of the reproductive organs for taxonomic evaluation.

2.8.2 Leaf epidermis

The importance of epidermal characters of leaves in angiosperm systematics has been reviewed by Stace (1965). Epidermal features such as shape of epidermal cells, types of sculpturing on their walls, cell inclusions, etc. also provide useful information on taxonomic value. In *Poaceae*, Prat (1932) as quoted by Verma (2011) has shown the importance of papillate epidermal cells, shape of silicified cells and suberized cells in taxonomic determination at species level.

2.8.3Stomata

Systematic studies on developmental and morphological stomatal types have given clues on various evolutionary trends Verma (2011). Basically, the five stomatal types areRubiaceous or paracytic, Cruciferous or anisocytic, Caryophyllaceous or diacytic, Ranunculaceous or anomocytic, and Gramineos type. The stomata have three basic developmental types, viz. perigenous, mesoperigenos, and mesogenous. During stomatal development, following an unequal cell division in the protoderm the smaller cell may divide followed by another division in each daughter cell to form four cells. The two inner cells become the guard cells while the two outer cells become the subsidiary cells (typically seen in paracytic and diacytic development), this type of development, in which cells of the stomata and subsidiary cells are derived from the same mother cell, is referred to as (mesogenous development) also termed syndetocheilic (Lynn and Juan 2013) and if the guard cells and subsidiary cells are derived from different protodermal initial development it referred to as perigenous. However, as reported by Lynn and Juan (2013), it is difficult to be able to accurately explain these patterns of development by observing mature

stomata. Although the mechanism is not well understood, a subset of protodermal cells becomes meristemoid mother cells (MMC). Through an asymmetry entry division, an MMC produce small triangular cell called a stomatal lineage ground cell (SLGC). An SLGC can terminally differentiate into lobed pavement cell (PC) or alternatively, an SLGC can initiate an asymmetric spacing division to produce a satellite meristomoid which is always placed distal to an existing stomata or precursor. The orientation of spacing division is controlled by a signaling network that provides spatial cues to ensure that stomata are isolated and have at least one non stomatal cell between them (Hara *et al*., 2007; Hunt and Gray 2009). Verma (2011) support the classification of *Rubiaceae* proposed by Verdcourt, (1963), on the basis of structure and development of stomata. He also suggested the retention of *Elytraria* in *Acanthaceae* on the basis of stomatal ontogeny.

2.8.4 Leafvenation

The basic parallel and reticulate characteristics of monocot and dicot respectively show innumerable variations, which are often utilized in taxonomic studies. Verma (2011) has given detailed terminologies to describe different pattern of venation which have been classified into several sub-types. The number of primary and secondary veins, angle of secondary vein in relation to primary veins, and nature of tertiary and higher order of venation provides valuable characters for classification and evolutionary trends.Verma (2011) surveyed leaf venation pattern of *Glossopterids* and various groups of angiosperms, and suggested that at least three types of venation in *Glossopterids* exist, these are; gangamopteroid, glossopteroid, and taeniopteroid which are found in certain groups of angiosperm too. Angiosperms leaves with reticulate venation are unique in having “vein islet” freely ending the vein-endings. The number of such

veinlets in aeroles vary within narrow limits and in combination with other characters are of taxonomic importance.

2.9Plant Morphology in Relation To Taxonomy

Morphology is the basic tool of taxonomy, because identification is primarily based on the characters of the plant. The morphological characters are easily observable in both living plants and in herbarium specimens. They have provided the basic information for a majority of the classification systems in plant taxonomy. In recent years, electron microscopy has provided a valuable tool to the modern taxonomist to study different morphological characters at high magnification and this information is used for purposes of identification, classification and for establishing relationships (Wafaa, 2005). Heywood and Dakshini, 1971 used the scanning electron microscope (SEM) to study the surface patterns of the fruit (called mericarp) in 40 species from 12 genera of the family Umbelliferae. They found that many microcharacters on the fruit wall observed with the help of the SEM are of great value in clarifying the relationships of the different genera. They also observed a great diversity in the structure of the fruit in these species and this provides new information of significant practical value for taxonomic purposes (Wafaa, 2005). Most taxonomists have traditionally separated the genus *Glinus* Linn. from the genus *Mollugo* Linn. On the basis of seed characters; but sometimes there were difficulties in proper identification of the two genera. With the help of the SEM, the seed surface patterns have been examined in detail to establish the importance of seed surface microcharacters in the identification of the genera. Also, within the genus Mollugo, seed-coat micromorphology has helped in identifying different species. These and other similar studies show that even in the present era of specialized and sophisticated botany, morphological characters continue to provide valuable taxonomic information (Wafaa, 2005).

2.10Phenetic Study

Phnetics, from Greekword‘‘phainein” which means “to appear”. This is an attempt to classify organism based on overall similarities, usually morphological or other observable traits regardless of their phylogeny or evolutionary relationship (Sneath and Sokal 1973). Shape differences among organism can be analyzed by phenetic method. That uses precise quantitative measures and mathematical techniques to describe pattern of overall similarities and differences among individuals, populations and species (Wyles *et al.* 1983). Phenetic differences will reflect the evolutionary relationships among organisms, if evolution is primarily divergent and proceeded at a more or less uniform rate (Wyles *et al.* 1983). In some cases adaptive convergences between species cause them to be more similar than their degree of relatedness would predict. Alternatively, closely related species may diverge markedly due to contrasting ecologies.The tips of a phenetic tree can be living organisms or fossils, and represent the "end," or the present, in an evolutionary lineage.

CHAPTER THREE

3.0MATERIALS AND METHODS

3.1 Study Sites

The research was conducted in two different locations:Zariametropolis, in Northern Guinea Savannah region which lies between latitude 10˚57′ 0″ N - 11˚ 15′ 0″ N and longitude 7˚34′ 30″ E - 7˚ 48′ 0″ E (Fig. 3.1). Itis characterized by a distinct wet and dry seasons with an elevation of 613 m above sea level. The area has an average annual temperature range of 15.3- 36.25 ^{0}C and

receives an average of 1050mm of rainfall annually (Ogungbenro and Morakinyo, 2014). The second location was Gusau, in Sudan Savannah region whichlies between latitude 6˚20′ 0″ E - 7˚ 10′ 0″ Eand longitude 11˚ 20′ 0″ N - 12˚ 20′ 0″ N (Fig. 3.2).This area is characterized by distinct wet and dry seasons with an elevation of 451m (1479ft) above sea level, the area has an average annual temperature of 26.3^{0}C and receives precipitation of 888mm annually (Ogungbenro and Morakinyo, 2014). The area is characterized by shorter grasses and the trees are fewer and more scattered.

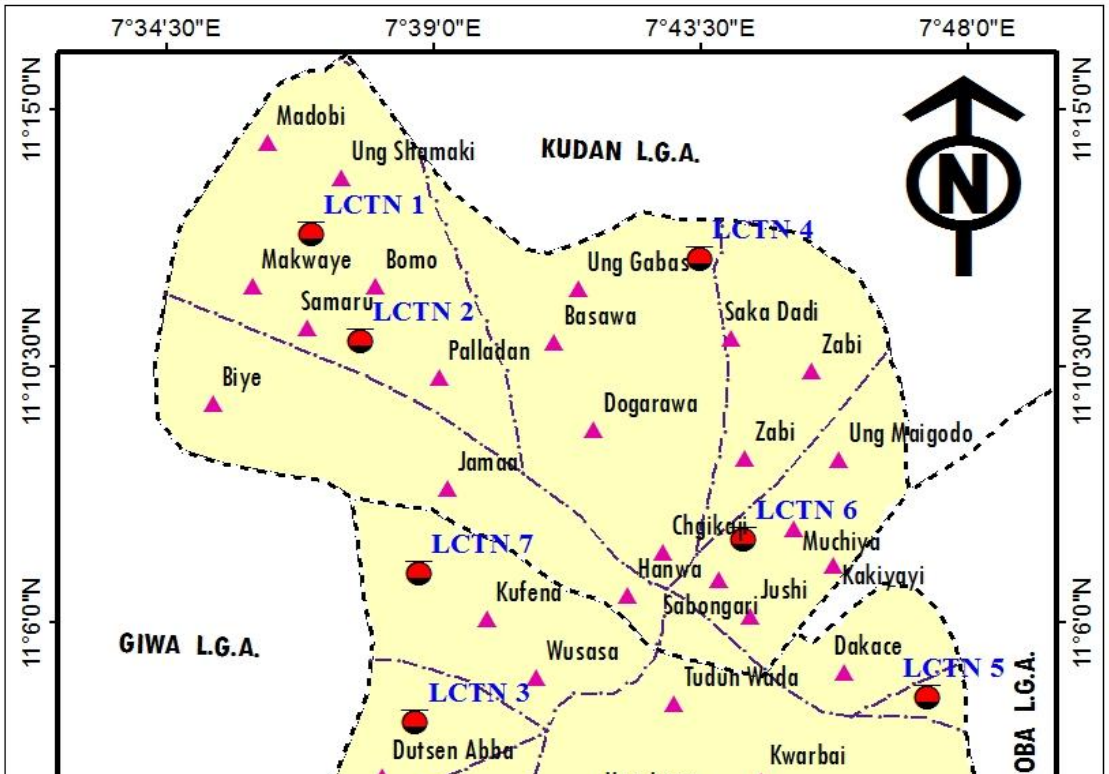

Figure:3.1 Map of Zaria Metropolis showing sampling locations.

Source: Modified From Administrative Map of Kaduna State.

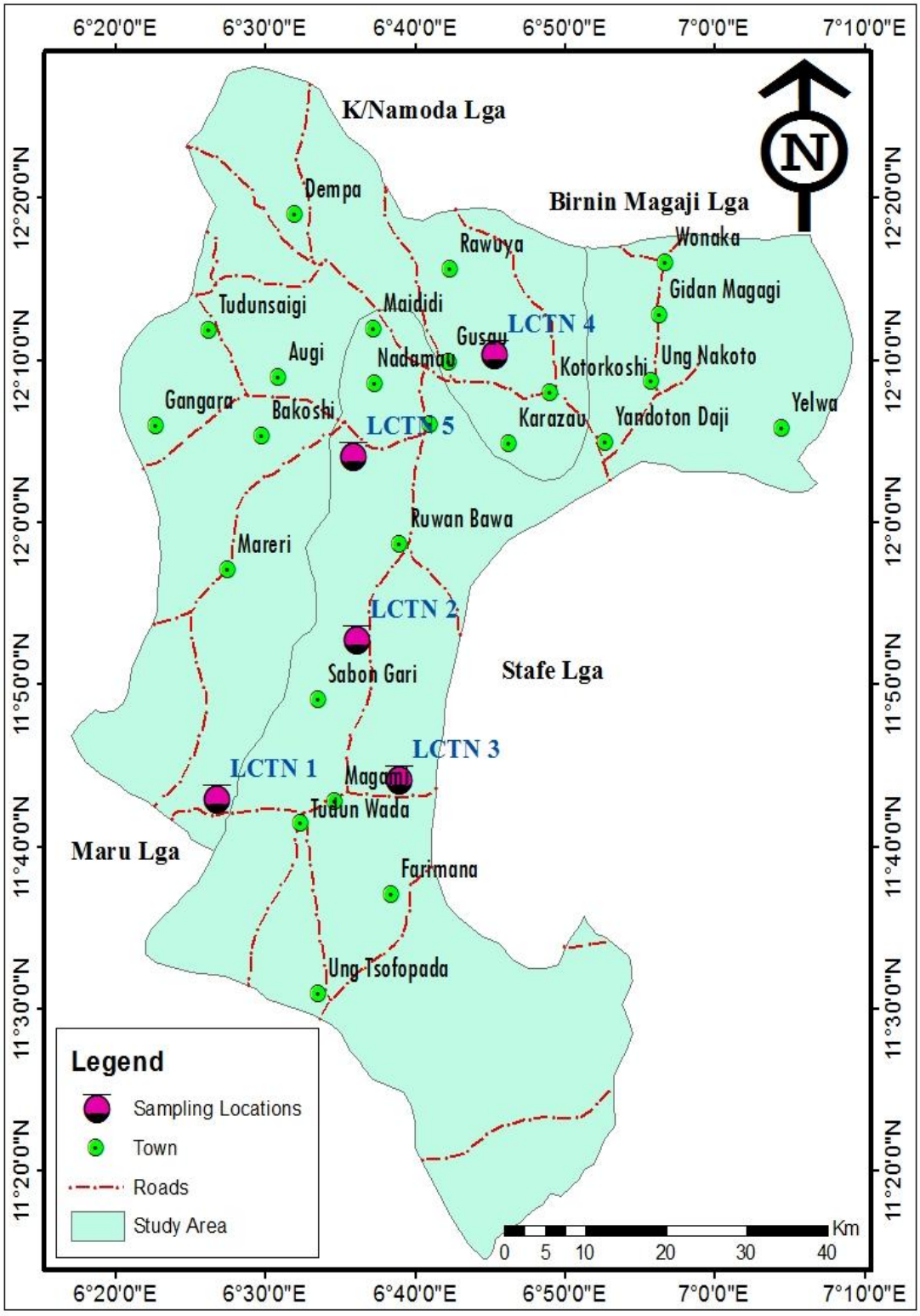

Figure: 3.2 Map of Gusau Metropolis Showing Sampling Locations.

Source: Modified From Administrative Map of Zamfara State.

3.2 Collection of Plant Materials

Leaves of species representing the Genus *Ipomoea*were collected from wild and cultivated lands of the two study locations. These species were collected and fixed in FAA (Formalin Acetic acid and Alcohol) from different areas of Zaria and Gusau metropolis, North-western Nigeria. The leaves of the species were authenticated at the Herbarium section of the Department of Botany Faculty of Life Sciences, Ahmadu Bello University Zaria, Nigeria (Table 3.1 and Table 3.2)

Table 3.1: Locations and coordinates of samples sites of Zaria metropolis, Northern Guinea Savannah Region

S/N	Location Locations	Coordinate Coordinate	Sample Sample
1	Samaru	Longitude 7.62 and Latitude 11.186	*Ipomoea aquatica* Forssk.(Plate 3.6)
2	Kubaina	Longitude 7.643 and Latitude 11.111	*Ipomoea alba* L. (Plate 3.3)
3	Sabon gari	Longitude 7.729 and Latitude 11.122	*Ipomoea nil*(L.) Roth. (Plate 3.4)
4	Jos road	Longitude 7.772 and Latitude 11.075	*Ipomoea repens* (L.) Lam. (Plate 3.5)
5	Kano road	Longitude 7.72 and Latitude 11.177	*Ipomoea carnea* Jace. (Plate 3.1)
6	Shika	Longitude 7.581 and Latitude 11.203	*Ipomoea batatas*(L.) Lam. (Plate 3.2)
7	Dumbi hill	Longitude 7.66 and Latitude 10.982	*Ipomoea purpurea* (L.) Roth.(Plate 3.7)

Table 3.2: Locations and coordinates of samples sites of Gusau metropolis, Sudan Savannah Region

1	Gusau Dam (Location 1)	Longitude 6.451 and Latitude 11.718	*I. batatas* and *I. carnea*
2	Location 2	Longitude 6.599 and Latitude 11.885	*I. repens*
3	Location 3	Longitude 6.644 and Latitude 11.743	*I. alba*
4	Location 4	Longitude 6.751 and Latitude 12.174	*I. aquatica*
5	Location 5	Longitude 6.591 and Latitude 12.072	*I. nil*

Plate 3.1:Representative sample of *Ipomoea carnea* gotten from Zaria

Plate 3.2:Representative sample of *Ipomoea batatas* gotten from Zaria

Plate 3.3:Representative sample of *Ipomoea alba* gotten from Zaria

Plate 3.4:Representative sample of *Ipomoea nil* gotten fromZaria

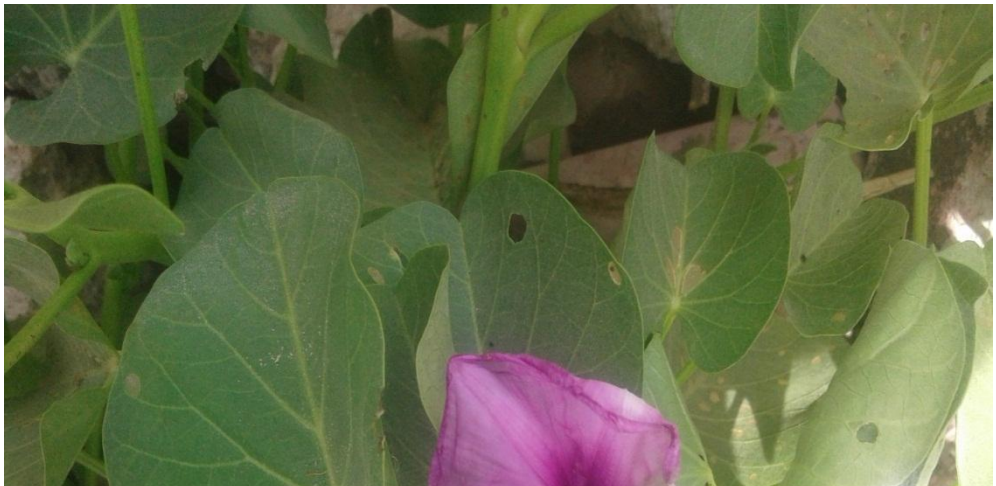

Plate 3.5:Representative sample of *Ipomoea repens* gotten from Zaria

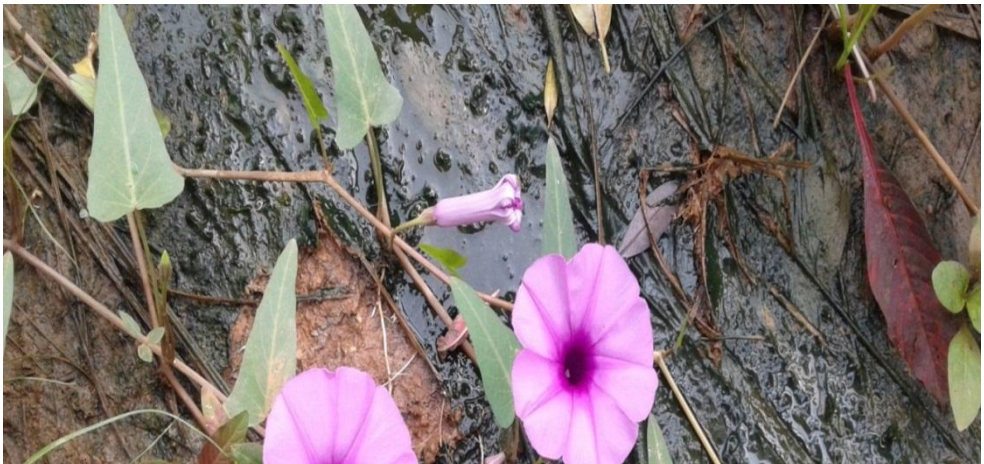

Plate 3.6:Representative sample of *Ipomoea aquatica* gotten from Zaria

Plate 3.7:Representative sample of *Ipomoea purpurea* gotten from Zaria

3.3 Macro-morphological Studies of *Ipomoea* Leaves

Thirty (30) leaves of each species studied were collected, macro-morphological characters which include leaf length, leaf breath, length of petiole, were assessed using a meter rule. The leaf margin, apex shape, apex angle, base shape and base anglewere physically examined and recorded accordingly.

3.4Microscopic Studies of Leaves: Free hand sectioning methods

This followed the methods employed by O'Brien and McCully (1981), and Purvis *et al*. (1966). Most plant parts are too thick to be mounted intact and viewed with a microscope. In order to study the structural organization of a plant, sections have to be made so that enough light can be transmitted through the specimen to resolve cell structures under microscope. A free hand section was used in preparing specimen for microscopic viewing. This method was suitable for a variety of plant materials, such as soft herbaceous stems and small woody twigs. Leaf is a flexible structure, and require some support during sectioning. Many leaves yield good transverse and vertical longitudinal sections if rolled or folded so that 10 or more thickness are cut at each stroke (O'Brien and McCully, 1981).

3.4.1Procedures:

1. Double edge razor blade was used for sectioning, to minimize risk of cutting oneself, one edge of the razor blade was covered with a masking tape. The blade was rinsed with warm tap water to remove traces of grease from the surface of the blade.
2. The leaf was then held firmly against the side of the first finger of the left hand by means of the thumb. The first finger was kept as straight as possible, while the thumb was below the surface of the leaf material out of the way of the razor blade edge.

3. To reduce friction during cutting, the razor blade was flood with water as sections can flood onto the surface of the blade. The razor blade will be taken by the right hand, placed on the first finger of the left hand, more or less at a right angle to the specimen.
4. The razor blade was drawn across the top of the specimen in such a way as to give the material a drawing cut, this result in less friction as the razor blade passes through the specimen. Several sections were cut at a time; the sections vary in thickness. However, the usable ones among the thick sections was selected for examination.
5. The thinnest among the sections was selected.
6. Mounting: The thinness section was then transferred to a clean glass slide containing a drop of water, the water was removed using tissue paper and stain with safranin.
7. To apply coverslip, the cover slip was held at an angle and was lowered gently to avoid air bubbles.
8. Finally, this preparation is called the temporal slide preparation. And ready for viewing under low and then high power microscope for microscopic examination of characters.

3.4.2Removal of Chlorophyll Content

This followed the method of Adenegan-Alakinde and Akinnubi (2015) which involve treating the leaftissues with a bleaching agent (Sodium Hypochlorite 3.2% w/v) for 72 hours to clear the chlorophyll contents, a section of the resulting transparent tissue was then transferred toclean glass slide for microscopic examination. All microscopic measurements were made using a calibrated eyepiece graticules.

3.5 Stomatal Index (SI)

The stomatal index (SI) was calculated using the formula described by Munir *et al.,* (2011) that is:

$$SI = \frac{S}{S+E} \times 100$$

Where:

S denotes the number of stomata per unit area and

E denotes the number of epidermal cells in the same unit area

The stomata were counted under the light microscope as described by Camargo and Marenco (2011) at x400, while stomatal sizes, trichomes and epidermal cell sizes were measured using optical graticle (accuracy of 1μm) mounted on the eyepiece and calibrated against a micrometer slide according to the method used by Camargo and Marenco (2011).Microphotographs were taking using Canon Zoom 5x camera.

3.6 Phenetic Studies

Cluster analysis was carried out using the data obtained to establish affinities between members of *Ipomoea*that are found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions of Nigeria, using SPSS version 20 software package.

3.7 Statistical Analysis

1. Numerical data obtained from parameters of leaves morphological and morpho-anatomical features were subjected to analysis of variance (ANOVA) to test relationships and their significance.

2. T-test was used to determine the difference between epidermal cells on both abaxial and adaxial surfaces of the studied taxa.
3. Cluster analysis was used to establish relationships between different members of *Ipomoea* found in the two region using SPSS version 20 software package
4. All analysis were tested at 0.05 level of significant.

CHAPTER FOUR

4.0RESULTS

4.1 Macro-morphological examination of *Ipomoea* leaves found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah Regions of Nigeria.

The leaves of different species of *Ipomoea* found within Northern Guinea Savannah region were examined, the shapes and forms of all the examined species showed a wide range of variation and some similarities. From the species studied, two types of base angle were recorded Obtuse and Wide-obtuse, the margins for all the examined species were found to be entire. The apex shapes for all the leaves were straight except for *I. repens*which showed rounded apex shape (Table 4.1).

The leaves of *Ipomoea* species that were examined within the Sudan Savannah region of Nigeria showed various degrees of variations and similarities in form, shape, and appearance. In all the examined species three types of apex angle were observed, *I. batatas* showed odd-lobed acute apex, acute apex was observed for *I. nil*. The apex angle of *I. repens* is obtuse while *I. aquatica,I. alba* and *I. carnea* all showed acute angle. The margin of all the examined leaves were entire. *I. alba* and *I. aquatica* revealed an obtuse base angle while the rest are wide-obtuse in appearance, the apex shape of all the examined species were straight except *I. repens* which is rounded, likewise, the base shapes of all the species were cordate while *I. aquatica* was hastate (Table 4.1).

4.2 Micro-morphological Features of Epidermal Cells of *Ipomoea* species found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah zones of Nigeria.

The forms and shapes of epidermal cells of all the examined species varied greatly from sinuous to polygonal shape. The shapes of epidermal cells on both surfaces varied greatly for some species; in *I. nil*, the shape was sinuous on the abaxial surface while on the adaxial surface it was found to have polygonal shape. Stomata were present on both the abaxial and adaxial surfaces of all the examined species except the adaxial surface of *I. purpurea*, two types of stomata were observed: paracytic and anisocytic. Trichomes were absent in all the examined species except *I. nil* where non glandular and unicellular trichome were found to be present on both the abaxial and adaxial surfaces. (Table 4.2).

Three different types of stomata were observed in all the examined species of *Ipomoea* found in Gusau, Sudan Savannah region, these types comprises of paracytic, anisocytic and anomocytic. Both surfaces of *I. nil* showed paracytic stomata. The shapes and forms of different epidermal cells varied from sinuous to polygonal, two types of cell margin were revealed which are straight and wavy. In all the examined species, stomata were present in both the abaxial and adaxial surfaces (Amphistomatic). Trichomes were present in *I. nil* and *I. alba* these trichomes were found to be unicellular and non-glandular for both species of *I. nil*, while those found on surfaces of *I. alba* were multicellular and non-glandular (Table 4.2)

Table 4.1: Comparison of qualitative features of *Ipomoea* leaves found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah Regions of Nigeria.

		Savannah Regions									
		Northern Guinea Savannah					Sudan Savannah				
S/N	**Taxa**	**AA**	**AS**	**BA**	**BS**	**LM**	**AA**	**AS**	**BA**	**BS**	**LM**
1	*I. carnea*	Acute	Straight	W. Obtuse	Lobate	Entire	Acute	Straight	W. obtuse	Lobate	Entire
2	*I. repens*	Acute	Rounded	W. Obtuse	Cordate	Entire	Acute	Rounded	W. obtuse	Cordate	Entire
3	*I. alba*	Acute	Straight	W. Obtuse	Cordate	Entire	Acute	Straight	W. obtuse	Cordate	Entire
4	*I. batatas*	O.L Acute	Straight	W. Obtuse	Cordate	Entire	O.L Acute	Straight	W. obtuse	Cordate	Entire
5	*I. nil*	Acute	Straight	W. Obtuse	Cordate	Entire	Acute	Straight	W. obtuse	Cordate	Entire
6	*I. aquatica*	Acute	Straight	Obtuse	Hastate	Entire	Acute	Straight	Obtuse	Hastate	Entire
7	*I. purpurea*	Acute	Straight	Obtuse	Cordate	Entire	-	-	-	-	-

Legend: AA= Apex angle, **AS=** Apex shape, **BA=** Base angle, **BS=** Base shape, **LM=** Leaf margin, **O.L Acute=** Odd-lobed acute, **W. obtuse=**Wide-obtuse.

Table 4.2:Comparison of qualitative features of foliar epidermal cells of *Ipomoea* found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah Regions of Nigeria.

		Northern Guinea Savannah region						Sudan Svannah region					
Epidermal cells		**Stomata**		**Trichomes**		**Epidermal cells**		**Stomata**		**Trichomes**			
S/N	**Taxa**	**S(Ab/Ad)**	**Margin**	**SD(Ab/Ad)**	**Types**	**D(Ab/Ad)**	**Types**	**S(Ab/Ad)**	**Margin**	**SD(Ab/Ad)**	**Types**	**D(Ab/Ad)**	**Types**
1	*I. carnea*	Pol.	Straight	Present	Parac.	Absent	-	Pol.	Straight	Present	Parac.	Absent	-
2	*I. repens*		Straight	Present	Parac.	Absent	-	Pol.	Straight	Present	Parac.	Absent	-
3	*I. alba*	Sin.	Wavy	Present	Parac.	Absent	-	Ab/Pol.	Straight	Present	Parac.	Present	NMT
								Ad/Pol.	Straight	Present	Ano.	Present	NMT
4	*I. batatas*	Pol.	Straight	Present	Parac.	Absent	-	Ab/Pol.	Straight	Present	Parac.	Absent	-
								Ad/Sin.	Wavy	Present	Parac.	Absent	-
5	*I. nil*	Ab/Sin.	Wavy	Present	Parac.	Present	NUT	Sin.	Wavy	Present	Parac.	Present	NUT
		Ad/Pol.	Straight	Present	Parac.	Present	NUT	Sin.	Wavy	Present	Parac.	Present	NUT
6	*I. aquatica*	Pol.	Straight	Present	Parac.	Absent	-	Pol.	Straight	Present	Parac.	Absent	-
7	*I. purpurea*	Ab/Pol.	Straight	Present	Anis.	-	-	-	-	-	-	-	-
		Ad/Pol.	Straight	Absent	-	-	-	-	-	-	-	-	-

Legend: S= Surfaces, **Ab=** Abaxial, **Ad=** Adaxial, **SD=** Stomatal distribution, **D=** Distribution of trichomes, **Parac.=** Paracytic stomata, **Ano.=** Anomocytic stomata, **Anis.=** Anisocytic stomata, **Pol.=** Polygonal,**Sin.**= Sinuous, **NUT**= Non-glandular Unicellular Trichome , **NMT**= Non-glandular Multicellular Trichome , **-**= Absent.

The mature intercostal epidermal cells of *I. carnea* was polygonal with straight anticlinal walls, the cells were mostly elongated and thick walled. Paracytic types of stomata were present on both surfaces (Amphistomatic), (Plate 4.1 and 4.2). The epidermal cells of abaxial and adaxial surfaces of *I. repens* was found to have polygonal shape, thicken and straight anticlinal wall, the cells on the abaxial surface was found to be smooth and glossy. Paracytic types of stomata were present on both surfaces (plate 4.3 and 4.4).The morpho-anatomical features of abaxial and adaxial surfaces of *I. alba* found in Nothern Guinea Savannah showed sinuous epidermal cells with wavy margins, the walls of the cells were thick. Paracytic stomata were present on both the upper and lower surfaces (plate 4.5 and 4.6).

The cells of epidermis found on abaxial and adaxial surfaces of *I. batatas* were large and polygonally shaped with thickened wall and straight wall margin, paracytic stomata were present on both surfaces (Amphistomatic) (Plate 4.7 and 4.8).The mature cells found on abaxial surface of *I. nil* have anticlinal wall with marked sinuous configurations and wavy margin while the epidermal cell on the adaxial surface was polygonal with straight margin. Stomata were present on both the abaxial and adaxial surfaces (Amphistomatic) two types of stomata (Anisocytic and Paracytic) were present on adaxial surface, for abaxial surface, paracytic stomata was present (Plate 4.9 and 4.10). The microscopic studies of epidermis of *I. nil* found in Northern Guinea Savannah region revealed the presence of non-glandular and unicellular trichomes, the distribution of this trichomes appeared to be uniform on both the abaxial and adaxial surfaces. The microscopy has also revealed that the trichomes is characterized with a swollen proximal end, the cell wall of these trichomes is covered with thick cuticle (Plate 4.11 and 4.12). Polygonal epidermal cells with straight wall margin, a wide course was observed between the

boundaries of epidermal cells. Paracytic stomata were observed on both surfaces and they were at the same level as the surrounding epidermal cells Trichomes were absent on the foliar epidermis of *I. aquatica*,(Plate 4.13 and 4.14).The mature cells of *I. purpurea* were polygonal with thickened cell wall and straight wall margin. Stomata were present only on the abaxial surface (Hypostomatic), the Stomata occur on same level as the surrounding epidermal cells and they were completely absent on the adaxial surface (Plate 4.15 and 4.16).

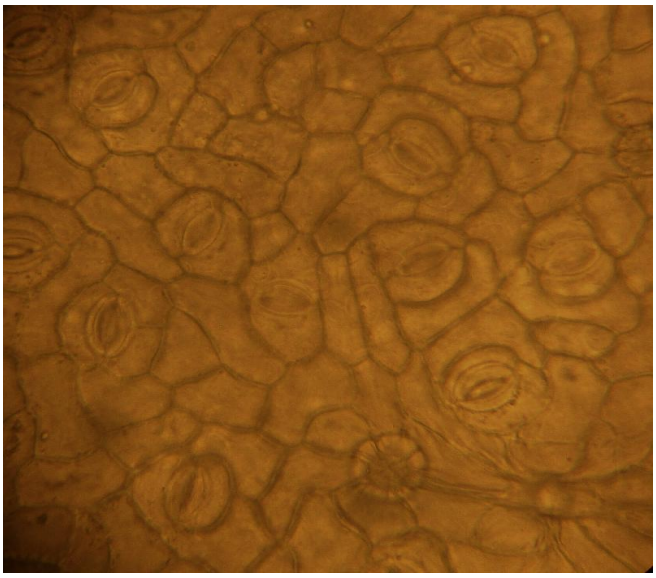

Plate 4.1 Anatomical features on abaxial surface of foliar epidermal cell of *I. carnea* of Zaria, Northern Guinea Savannah region. x400

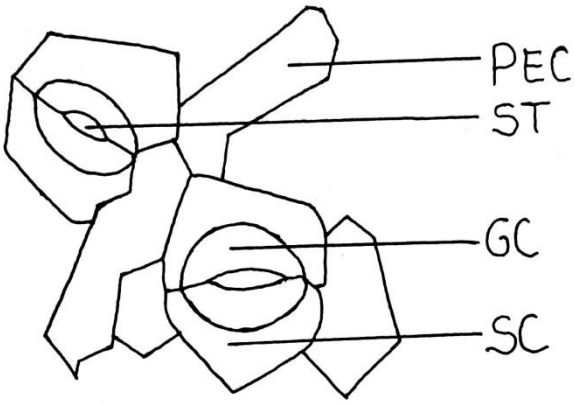

Fig. 4.1 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. carnea* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

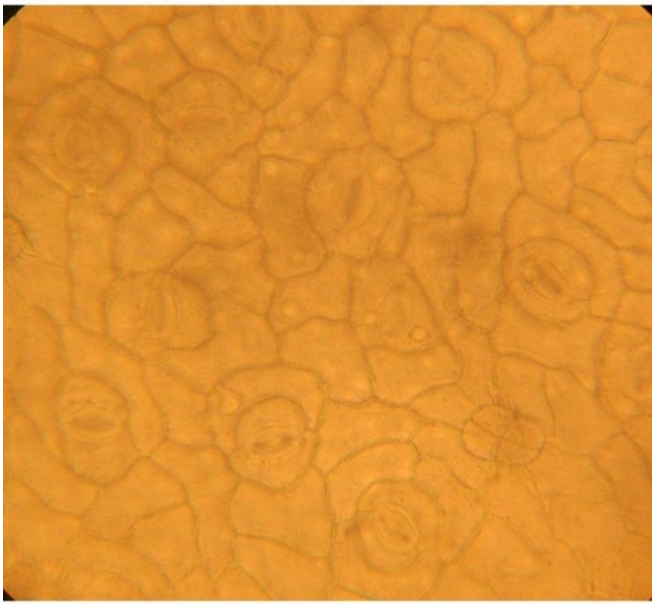

Plate 4.2 Anatomical features on adaxial surface of foliar epidermal cell of *I. carnea* of Zaria, Northern Guinea Savannah region. x400

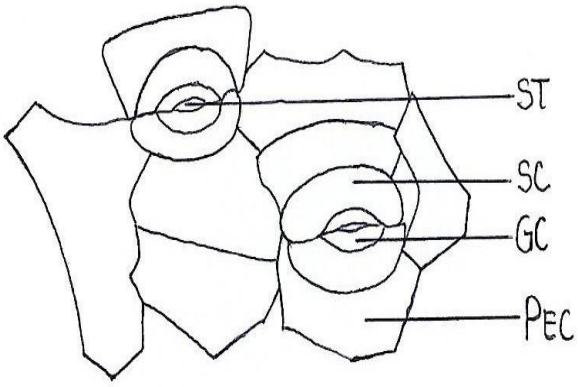

Fig. 4.2 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. carnea* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

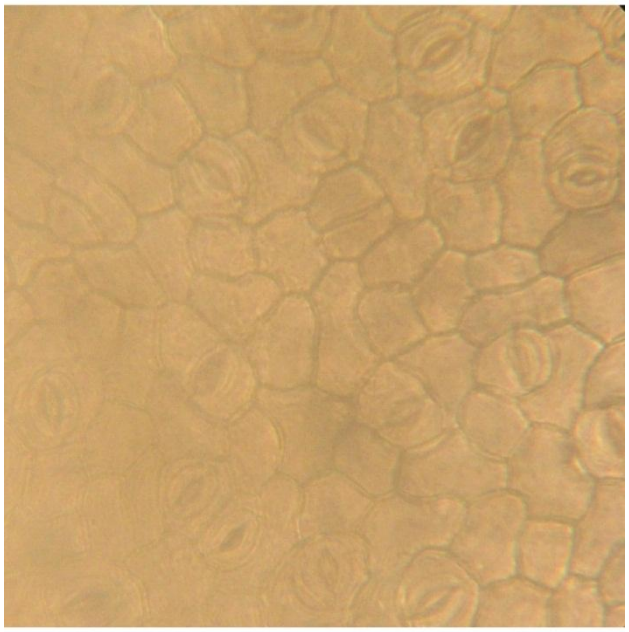

Plate 4.3 Anatomical features on abaxial surface of foliar epidermal cell of *I. repens* of Zaria, Northern Guinea Savannah region. x400

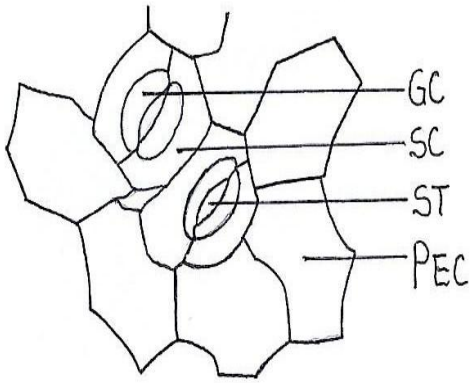

Fig. 4.3 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. repens*of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

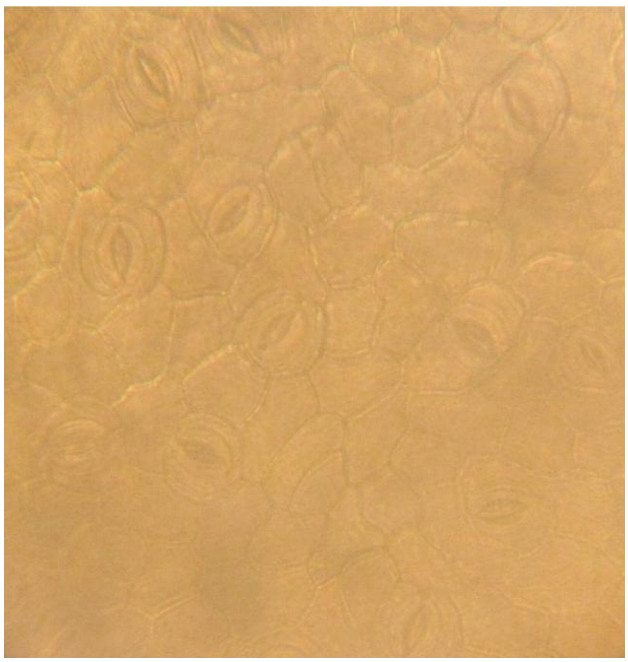

Plate 4.4 Anatomical features on adaxial surface of foliar epidermal cell of *I. repens* of Zaria, Northern Guinea Savannah region. x400

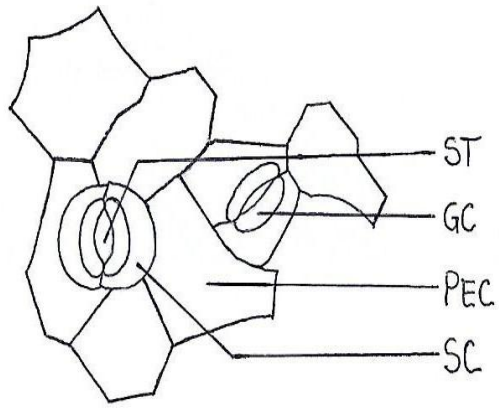

Fig. 4.4 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. repens* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

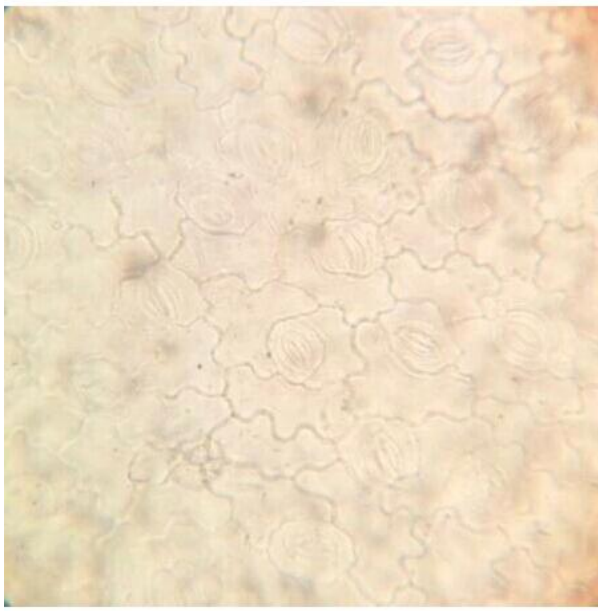

Plate 4.5 Anatomical features on abaxial surface of foliar epidermal cell of *I. alba* of Zaria, Northern Guinea Savannah region. x400

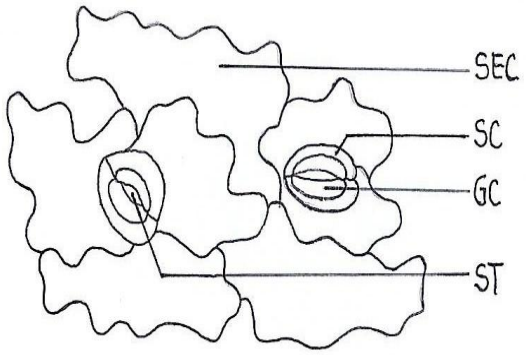

Fig. 4.5 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. alba* of Zaria, Northern Guinea Savannah region. ST= Stoma, SEC= Sinuous epidermal cell, GC= Guard cell, SC= Subsidiary cell.

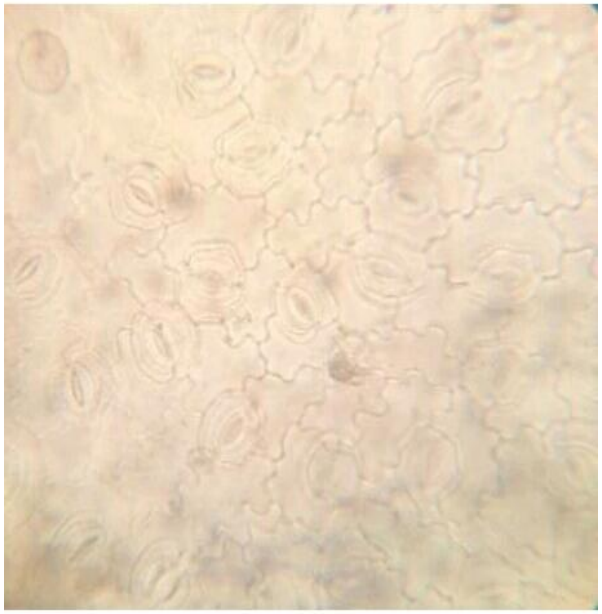

Plate 4.6 Anatomical features on adaxial surface of foliar epidermal cell of *I. alba* of Zaria, Northern Guinea Savannah region. x400

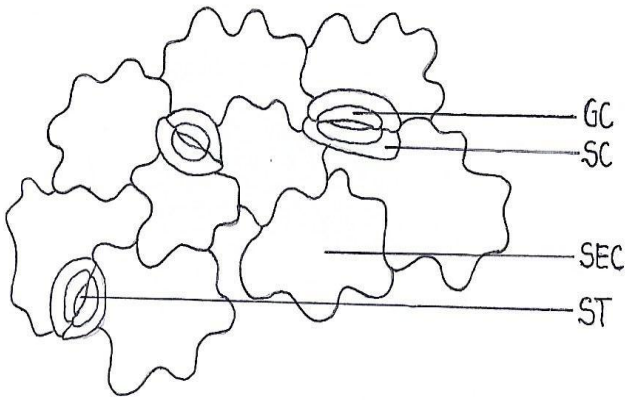

Fig. 4.6 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. alba* of Zaria, Northern Guinea Savannah region. ST= Stoma, SEC= Sinuous epidermal cell, GC= Guard cell, SC= Subsidiary cell.

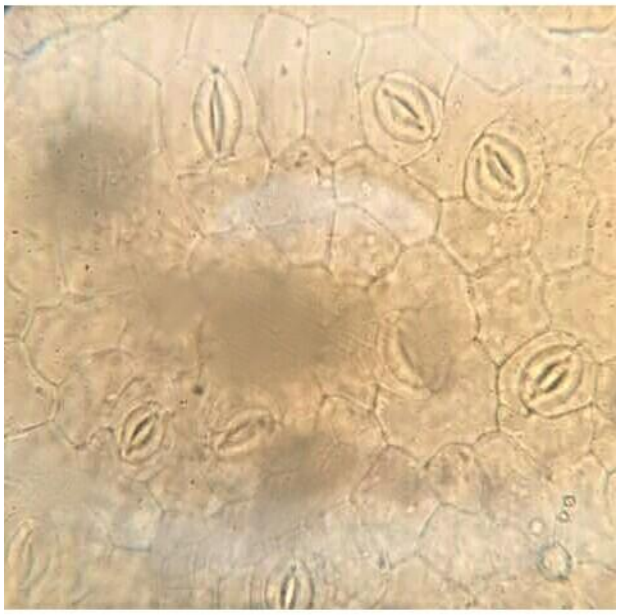

Plate 4.7 Anatomical features on abaxial surface of foliar epidermal cell of *I. batatas* of Zaria, Northern Guinea Savannah region. x400

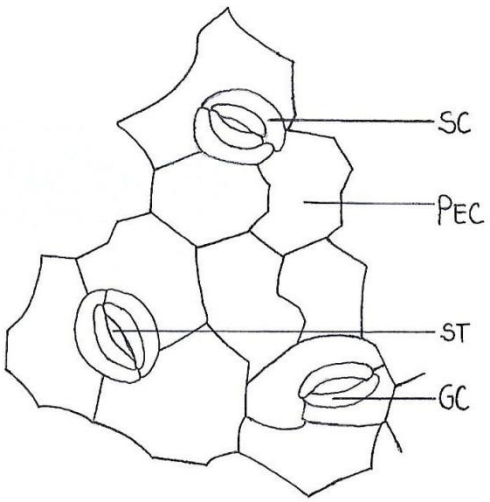

Fig. 4.7 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. batatas* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

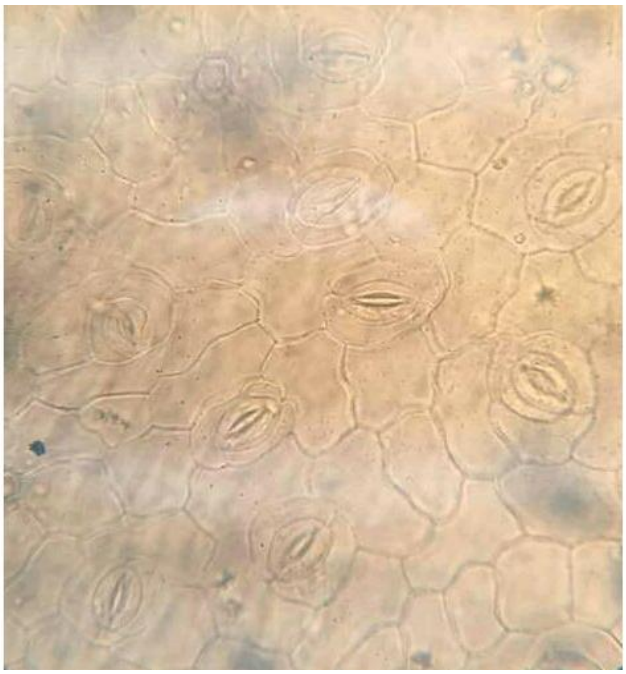

Plate 4.8 Anatomical features on adaxial surface of foliar epidermal cell of *I. batatas* of Zaria, Northern Guinea Savannah region. x400

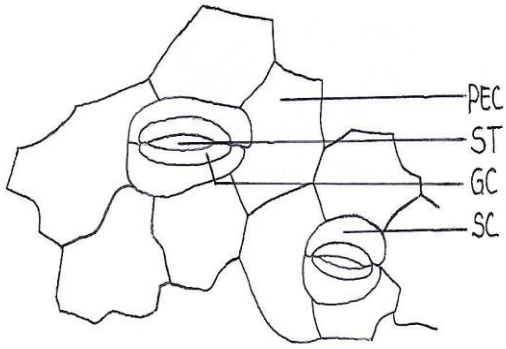

Fig. 4.8 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. batatas* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cells.

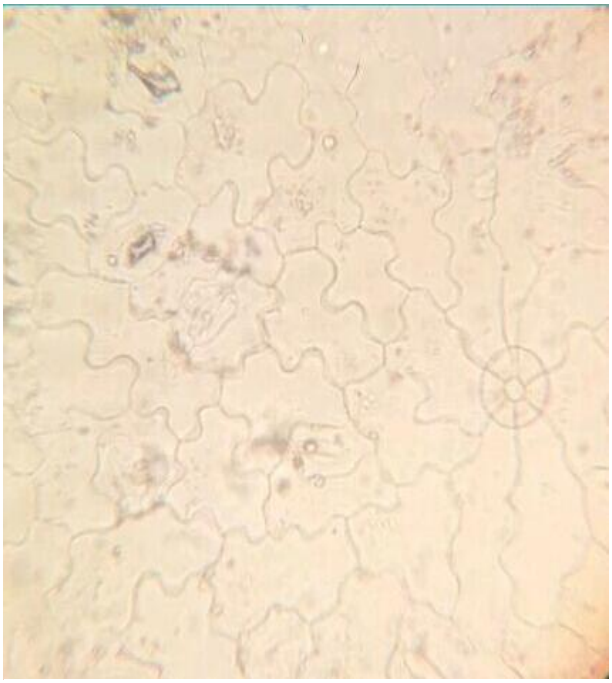

Plate 4.9 Anatomical features on abaxial surface of foliar epidermal cell of *I. nil* of Zaria, Northern Guinea Savannah region. x400

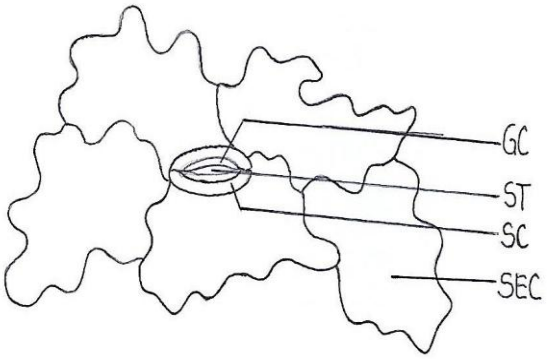

Fig. 4.9 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. nil* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

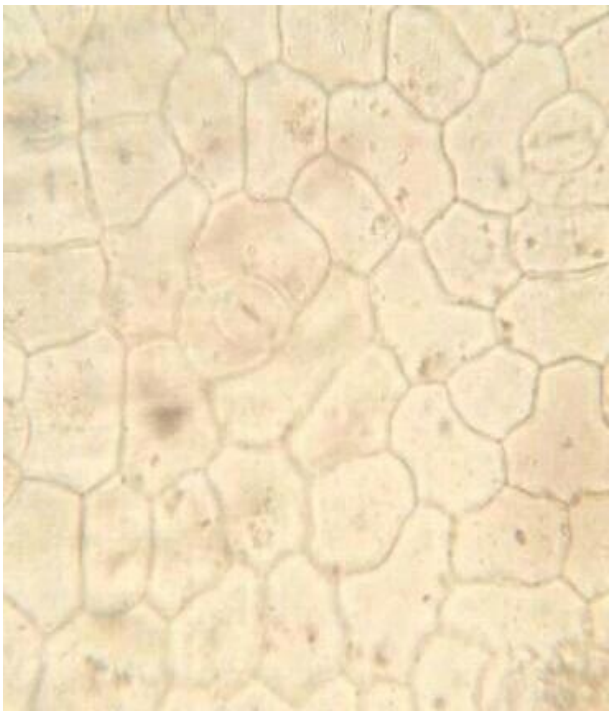

Plate 4.10 Anatomical features on adaxial surface of foliar epidermal cell of *I. nil* of Zaria, Northern Guinea Savannah region. x400

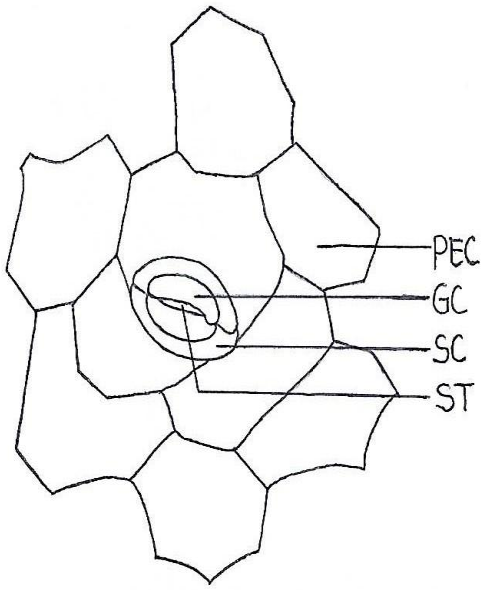

Fig. 4.10 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. nil* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

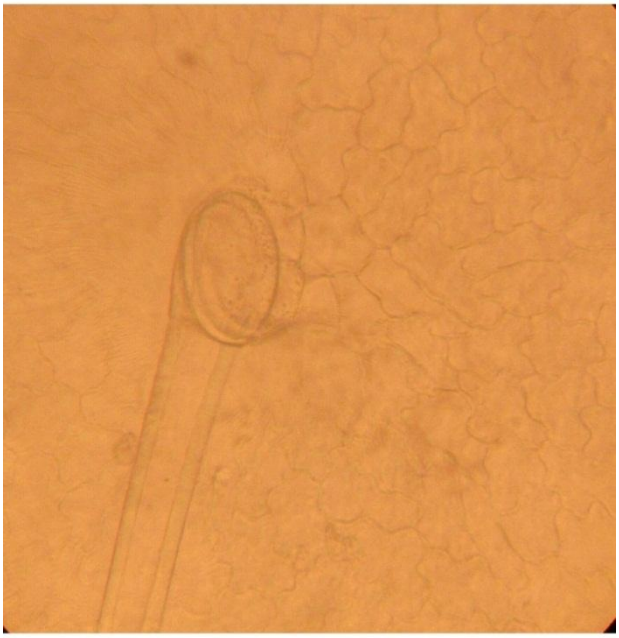

Plate 4.11 A light micrograph on proximal end of unicellular and non-glandular trichome of *I. nil* found in Zaria, Northern Guinea Savannah region. x400

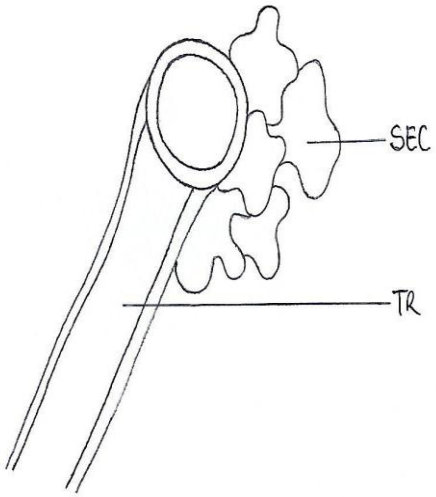

Fig. 4.11 Proximal end of unicellular and non-glandular trichome found on *I. nil* of Zaria, Northern Guinea Savannah region. SEC= Sinuous epidermal cell, TR= Trichome.

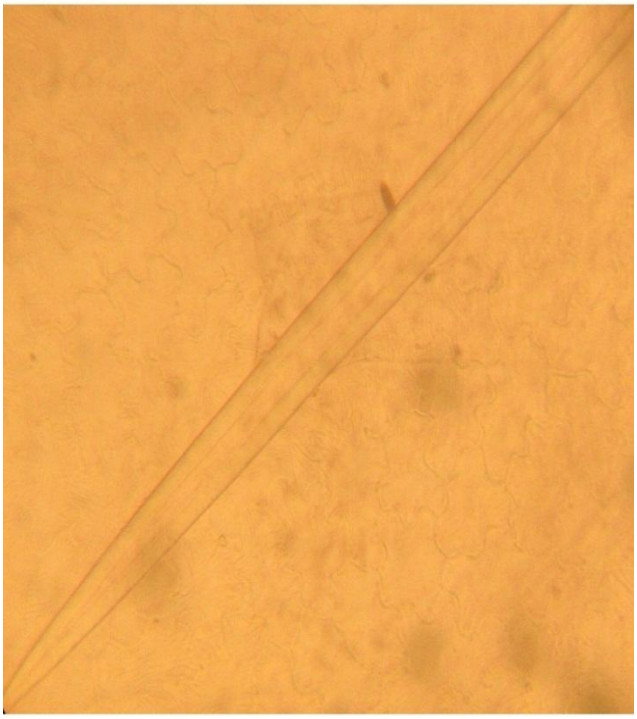

Plate 4.12 A light micrograph of distal end of unicellular and non-glandular trichomes found on abaxial surface of *I. nil* of Zaria, Northern Guinea Savannah region. x400

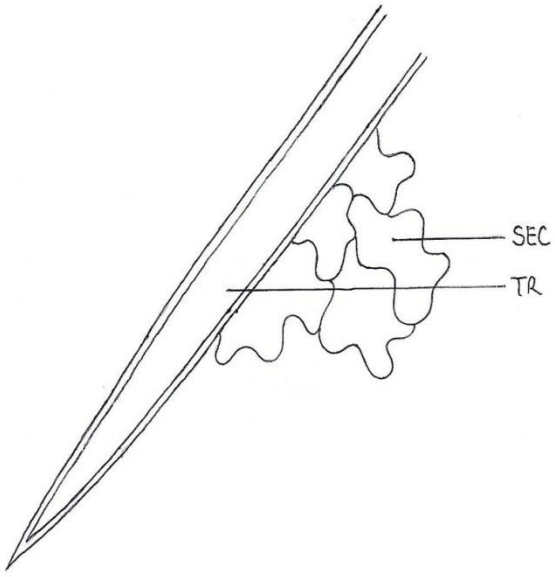

Fig. 4.12 Distal end of unicellular and non-glandular trichome found on *I. nil* of Zaria, Northern Guinea Savannah region.SEC= Sinuous epidermal cell, TR= Trichome.

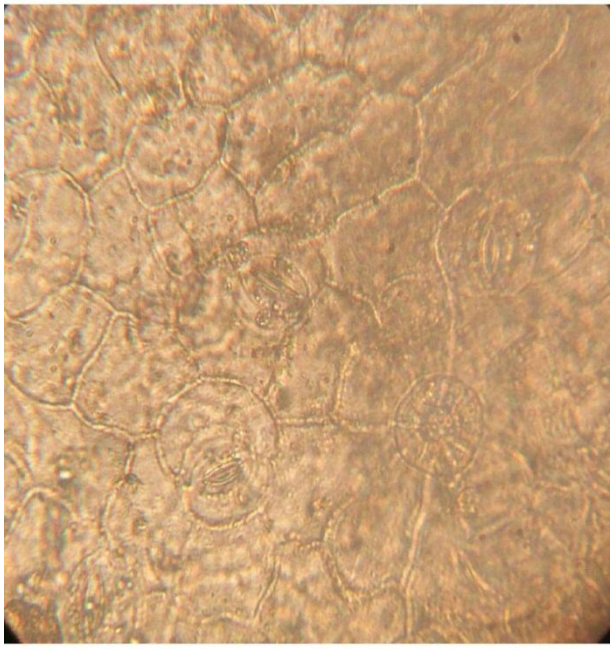

Plate 4.13 Anatomical features on abaxial surface of foliar epidermal cell of *I. aquatica* of Zaria, Northern Guinea Savannah region. x400

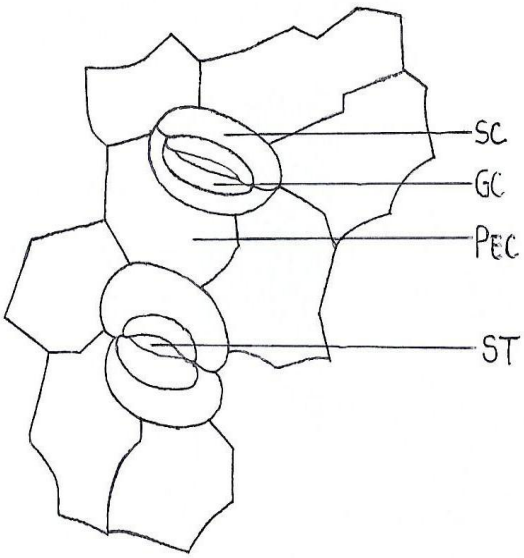

Fig. 4.13 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. aquatica* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

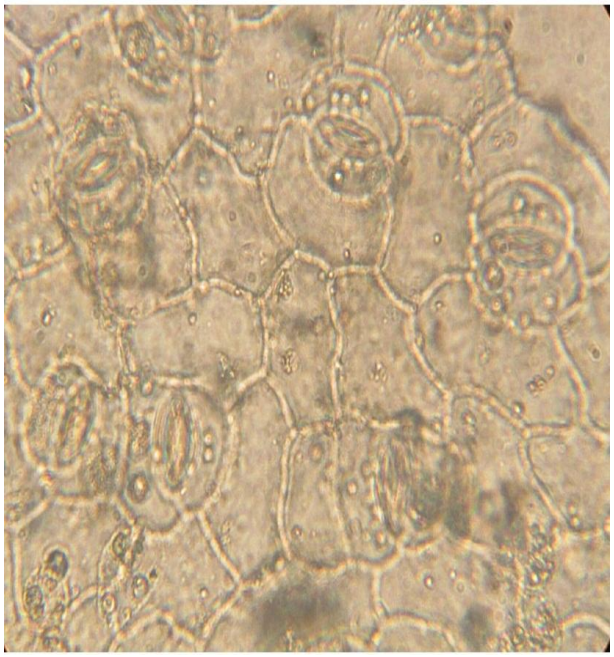

Plate 14: Anatomical features on adaxial surface of foliar epidermal cell of *I. aquatica* of Zaria, Northern Guinea Savannah region. x400

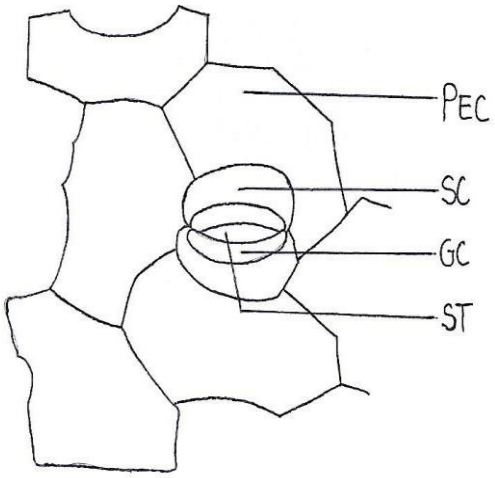

Fig. 4.14 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. aquatica* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

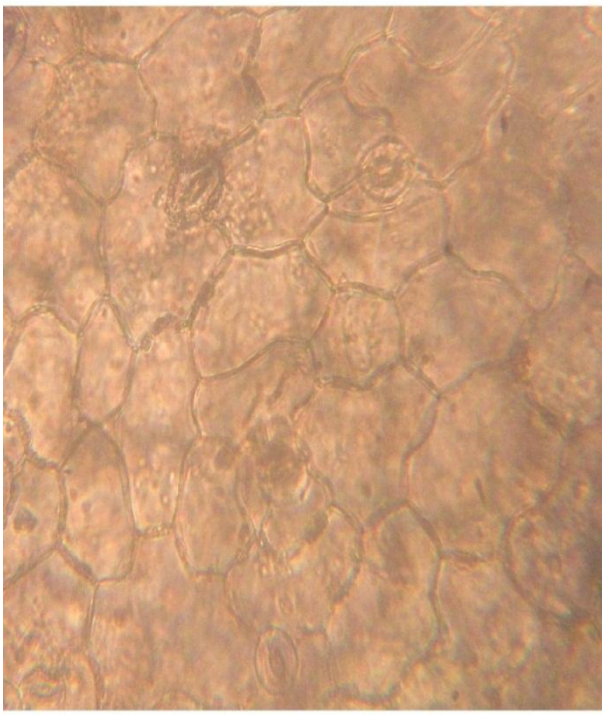

Plate 4.15 Anatomical features on abaxial surface of foliar epidermal cell of *I. purpurea* of Zaria, Northern Guinea Savannah region. x400

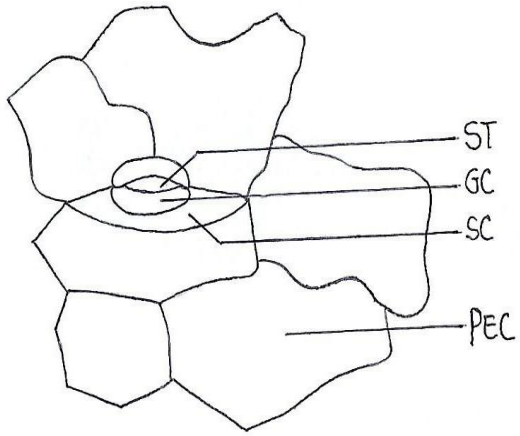

Fig. 4.15 Detailed epidermal cells and anisocytic stomata on abaxial surface of *I. purpurea* of Zaria, Northern Guinea Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

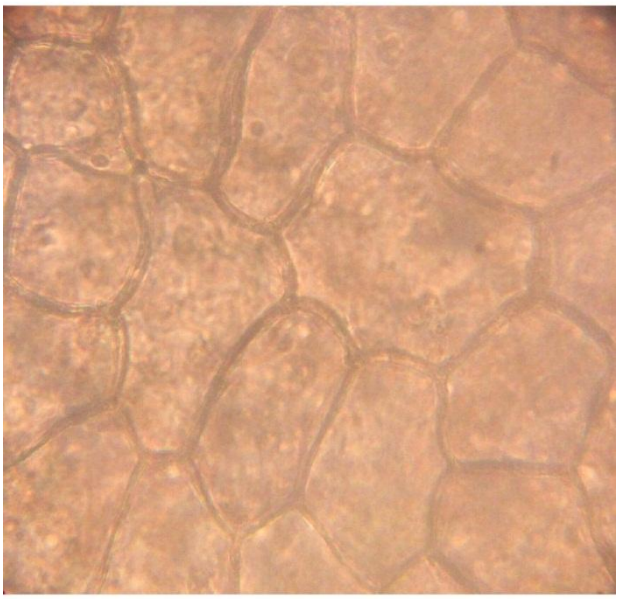

Plate 4.16 Anatomical features on adaxial surface of foliar epidermal cell of *I. purpurea* of Zaria, Northern Guinea Savannah region. x400

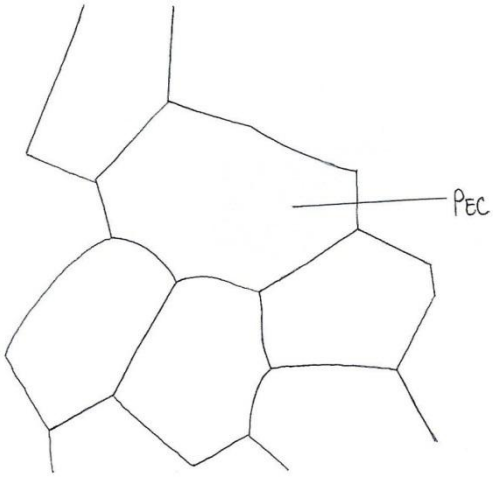

Fig. 4.16 Detailed epidermal cells on adaxial surface of *I. purpurea* of Zaria, Northern Guinea Savannah region. PEC= Polygonal epidermal cell.

The epidermal cells of *I. repens* found in Gusau, Sudan Savannah region of Nigeria revealed the presence of stomata on both abaxial and adaxial surfaces (Amphistomatic), the epidermal cells found were polygonal with straight anticlinal wall margin. Trichomes were absent on both surfaces. The types of stomata that were found are paracytic (Plates 4.17-4.18).For *I. batatas*,the epidermal cells on the abaxial surface was polygonal with straight wall margin while those found on the adaxial surfaces were sinuous with wavy anticlinal wall, paracytic stomata were present on both surfaces (Plates 4.19-4.20). Paracytic and anisocytic stomata were present on abaxial surface of *I. nil* while the adaxial surface showed on paracytic stomata. The epidermal cells were sinuous with wavy margin and thickened walled, non-glandular and unicellular trichomes was found on both surfaces (Plates 4.21-4.24).

The cells of *I. carnea* were polygonal with straight anticlinal walls and were associated with paracytic stomata. Trichomes were absent on both surfaces (Plates 4.25 and 4.26).The abaxial and adaxial surfaces of *I. aquatic*a showed polygonal epidermal cells with straight wall margin, paracytic stomata occur on both surfaces (Plates 4.27 and 4.28). Trichomes were present on both surfaces of *I. alba*, anomocytic stomata were observed with thickened epidermal cell walls, the trichomes are non-glandular and multicellular (Plates 4.29-4.30).

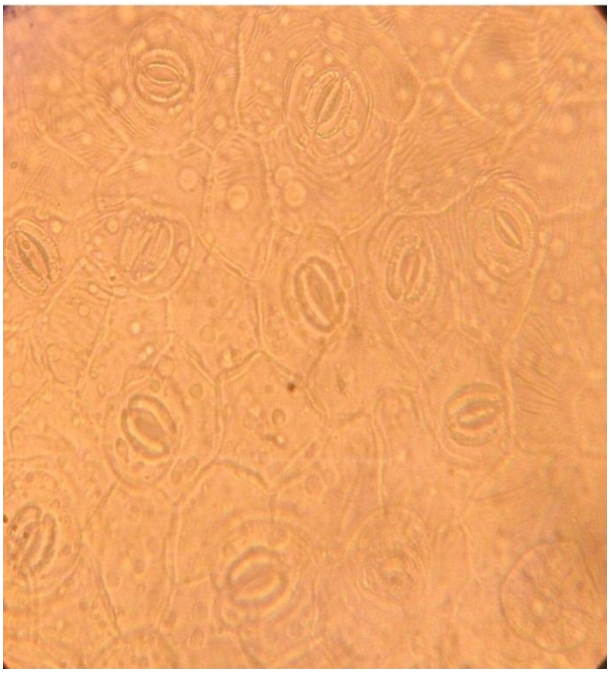

Plate 4.17 Anatomical features of abaxial surface of foliar epidermal cell of *I. repens* of Gusau, Sudan Savannah region. x400

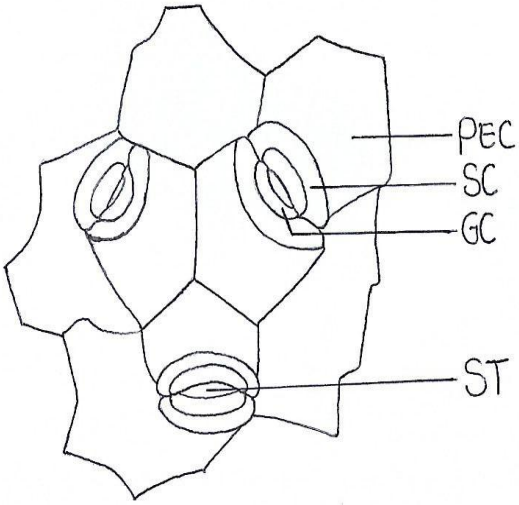

Fig. 4.17 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. repens* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

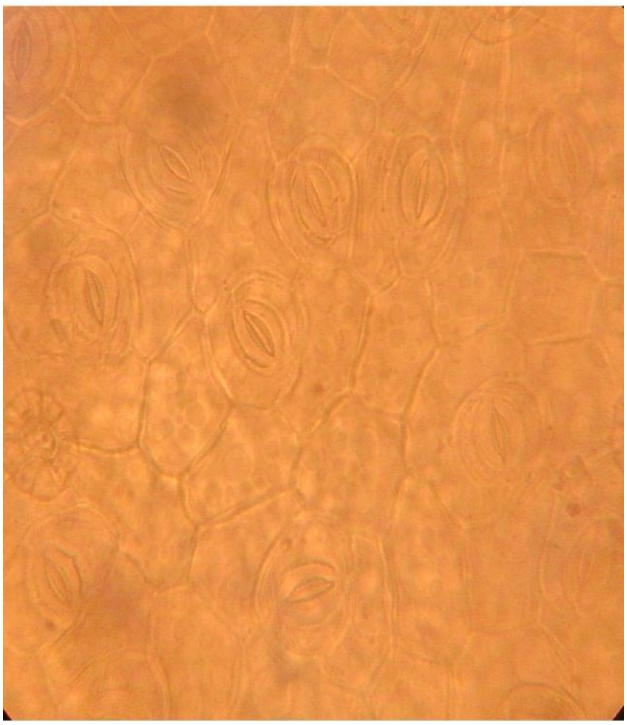

Plate 4.18 Anatomical features of adaxial surface of foliar epidermal cell of *I. repens* of Gusau, Sudan Savannah region. x400

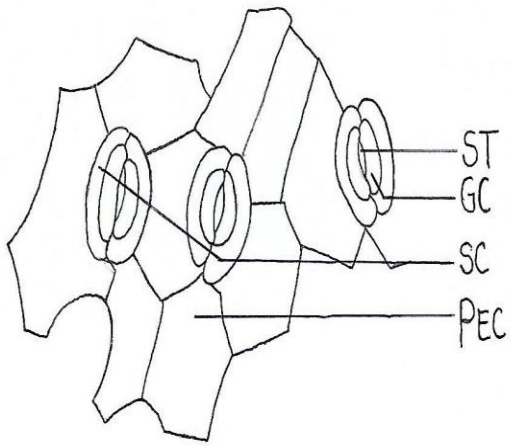

Fig. 4.18 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. repens* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

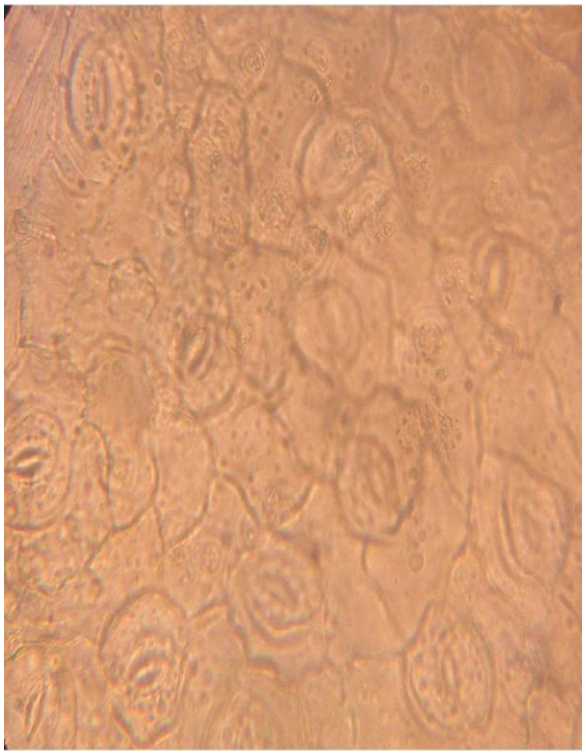

Plate 4.19 Anatomical features of abaxial surface of foliar epidermal cell of *I. batatas* of Gusau, Sudan Savannah region. x400

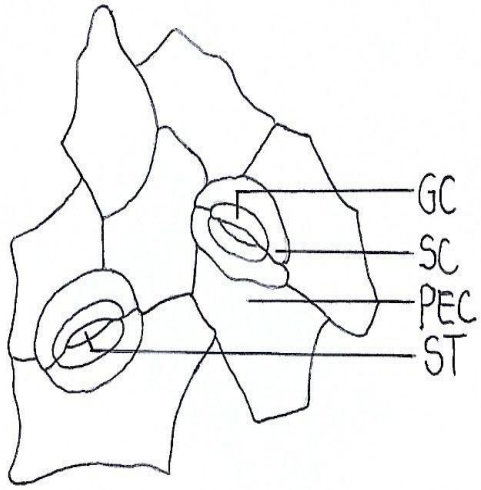

Fig. 4.19 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. batatas* of Sudan Gusau, Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

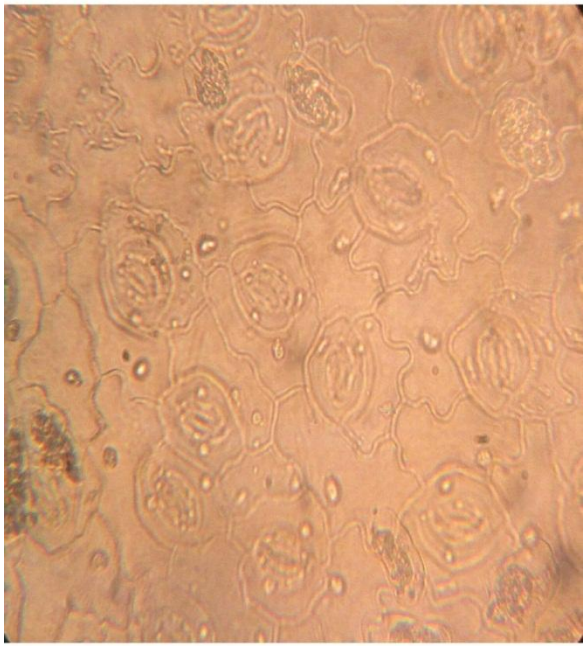

Plate 4.20 Anatomical features of adaxial surface of foliar epidermal cell of *I. batatas* of Gusau, Sudan Savannah region. x400

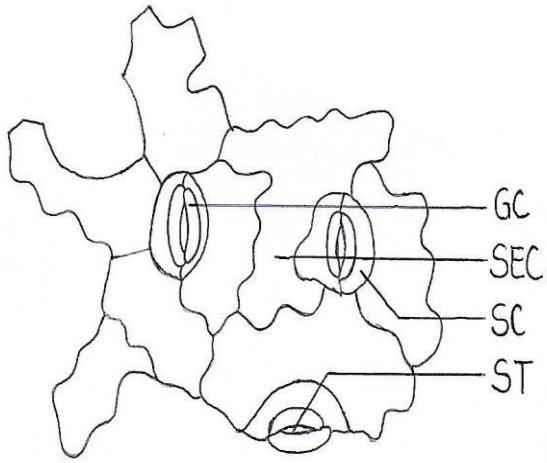

Fig. 4.20 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. batatas* of Sudan Gusau, Savannah region. ST= Stoma, SEC= Sinuous epidermal cell, GC= Guard cell, SC= Subsidiary cell.

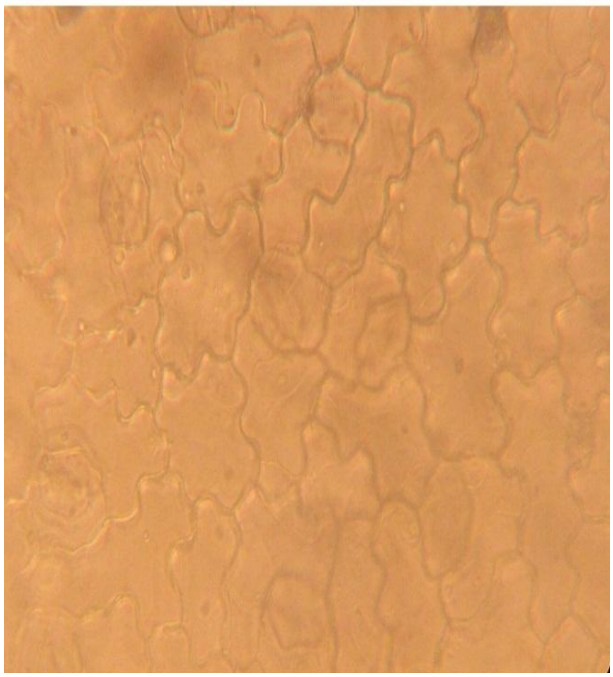

Plate 4.21 Anatomical features of abaxial surface of foliar epidermal cell of *I. nil* of Gusau, Sudan Savannah region. x400

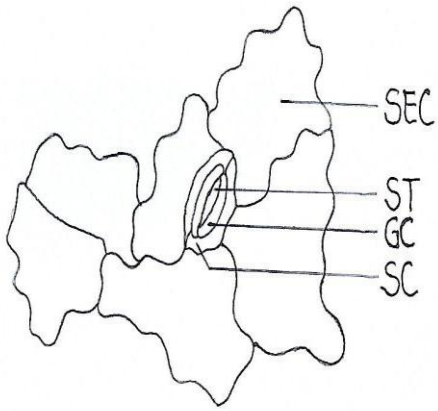

Fig. 4.21 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. nil* of Sudan Gusau, Savannah region. ST= Stoma, SEC= Sinuous epidermal cell, GC= Guard cell, SC= Subsidiary cell.

Plate 4.22 A light micrograph of non-glandular and unicellular trichomes recorded on abaxial surface of *I. nil* of Gusau, Sudan Savannah region. x400

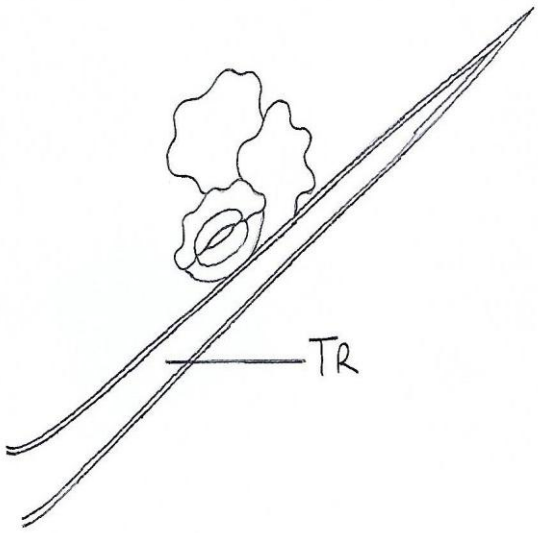

Fig. 4.22 Unicellular and non-glandular trichome found on abaxial surface of *I. nil* of Gusau, Sudan Savannah region TR= Trichome.

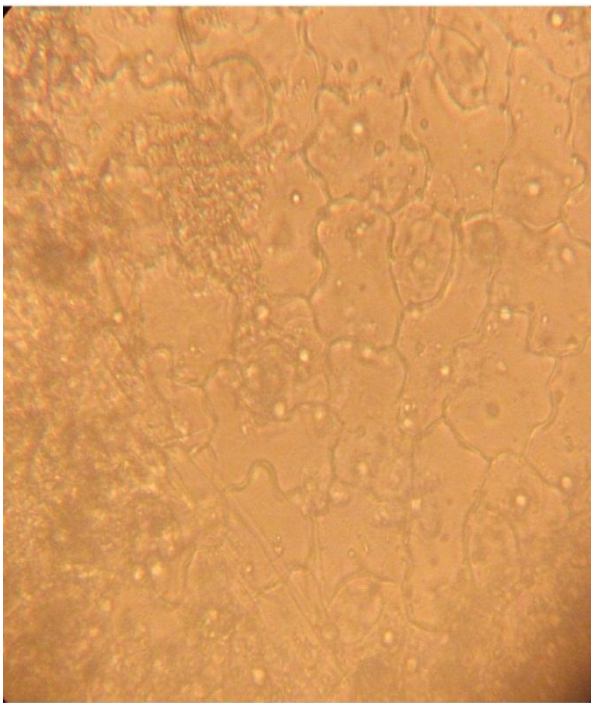

Plate 4.23 Anatomical features of adaxial surface of foliar epidermal cell of *I. nil* of Gusau, Sudan Savannah region. x400

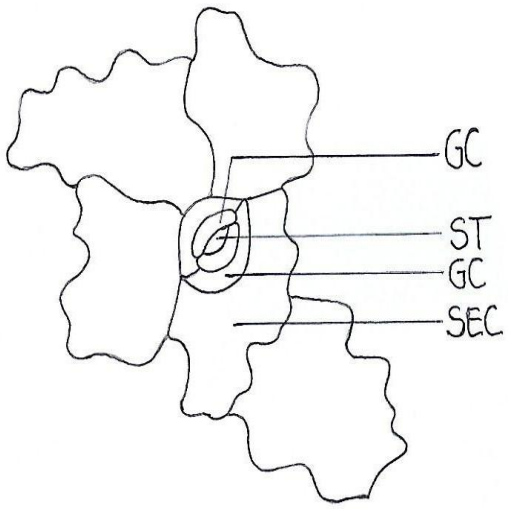

Fig. 4.23 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. nil* of Sudan Gusau, Savannah region. ST= Stoma, SEC= Sinuous epidermal cell, GC= Guard cell, SC= Subsidiary cell.

Plate 4.24 A light micrograph of non-glandular and unicellular trichomes recorded on adaxial surface of *I. nil* of Gusau, Sudan Savannah region. x400

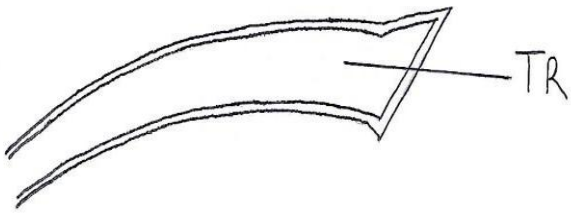

Fig. 4.24 Unicellular and non-glandular trichome found on adaxial surface of *I. nil* of Gusau, Sudan Savannah region. TR= Trichome.

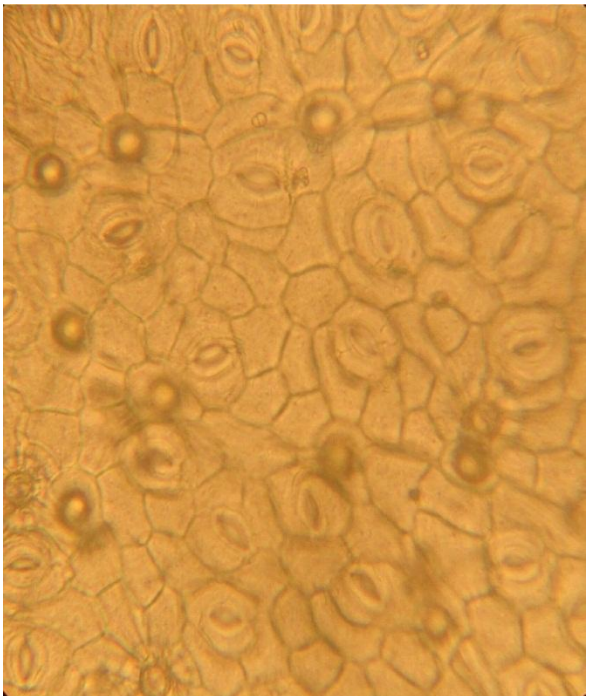

Plate 4.25 Anatomical features of abaxial surface of foliar epidermal cell of *I. carnea* of Gusau, Sudan Savannah region. x400

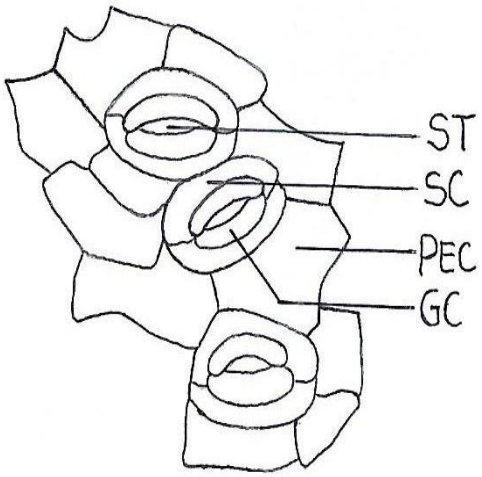

Fig. 4.25 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. carnea* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

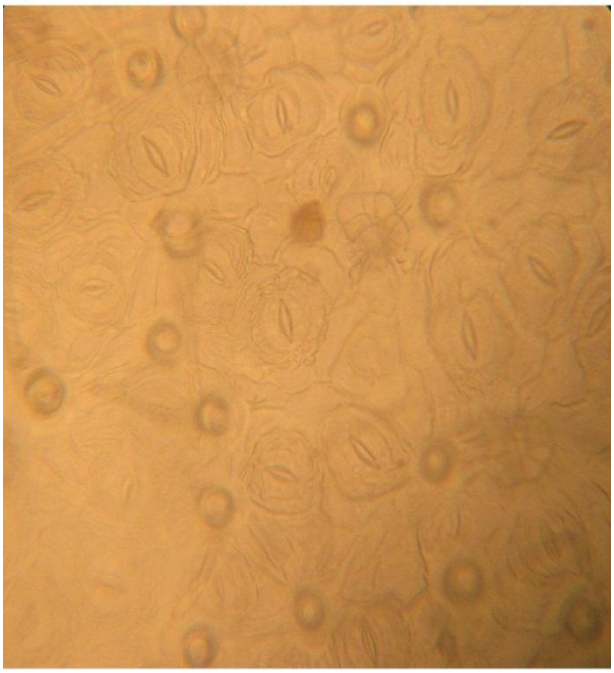

Plate 4.26 Anatomical features of adaxial surface of foliar epidermal cell of *I. carnea* of Gusau, Sudan Savannah region. x400

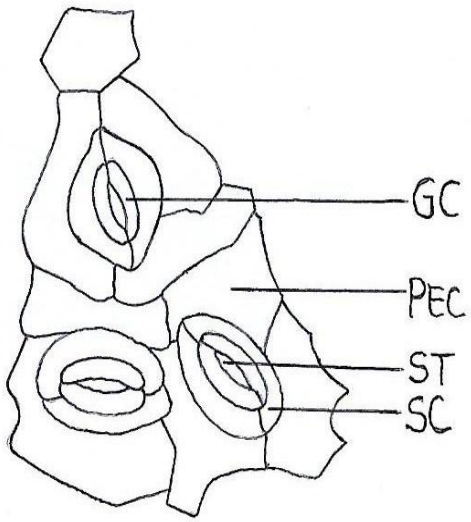

Fig. 4.26 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. carnea* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

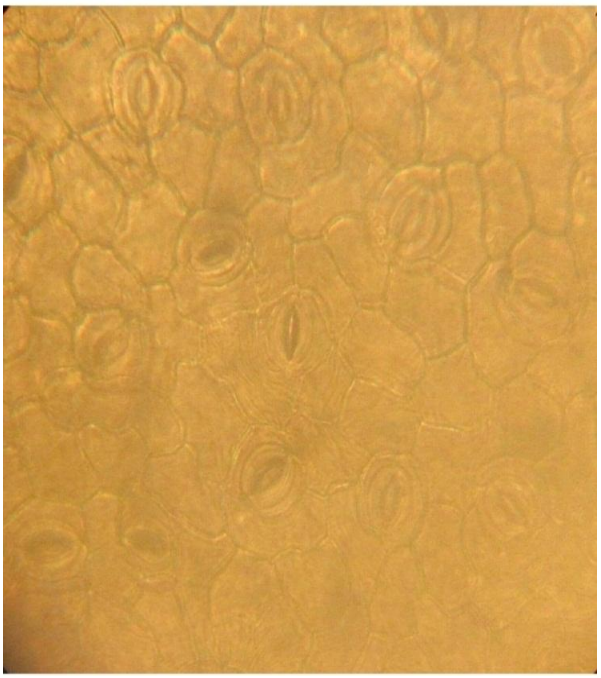

Plate 4.27 Anatomical features on abaxial surface of foliar epidermal cell of *I. aquatica* of Gusau, Sudan Savannah region. x400

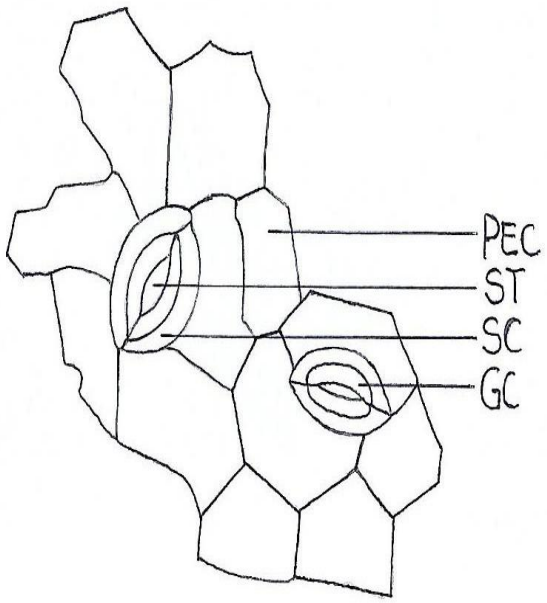

Fig. 4.27 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. aquatica* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

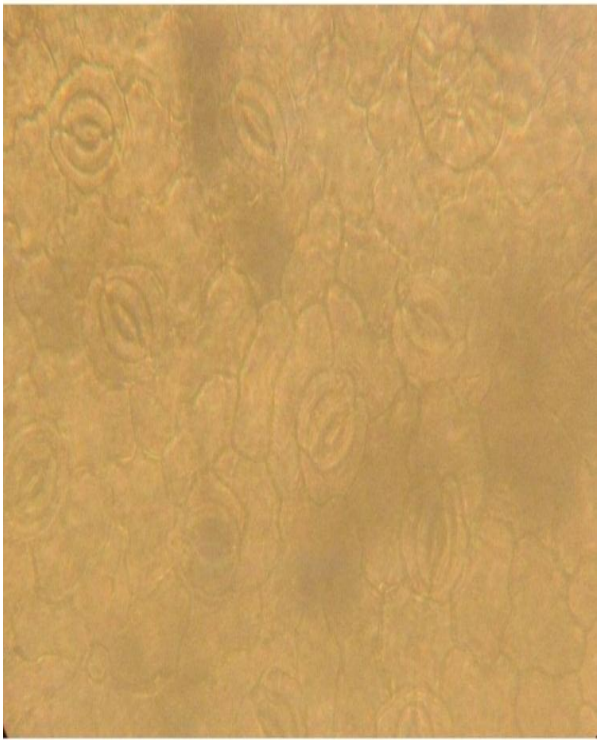

Plate 4.28 Anatomical features on adaxial surface of foliar epidermal cell of *I. aquatica* of Gusau, Sudan Savannah region. x400

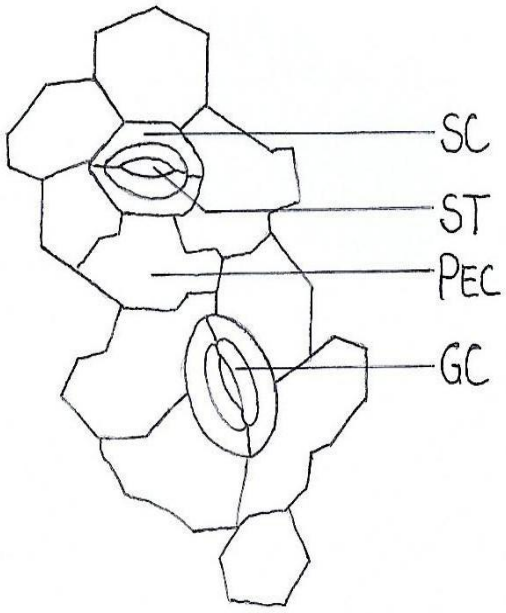

Fig. 4.28 Detailed epidermal cells and paracytic stomata on adaxial surface of *I. aquatica* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

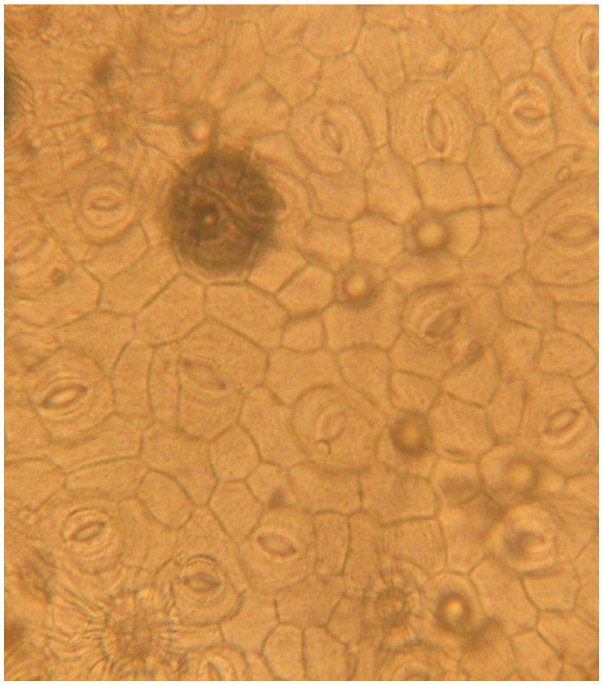

Plate 4.29 Anatomical features on abaxial surface of foliar epidermal cell of *I. alba* of Gusau, Sudan Savannah region. x400

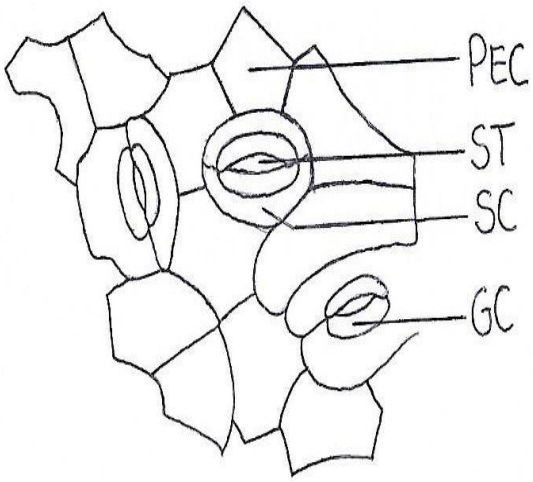

Fig. 4.29 Detailed epidermal cells and paracytic stomata on abaxial surface of *I. alba* of Gusau, Sudan Savannah region. ST= Stoma, PEC= Polygonal epidermal cell, GC= Guard cell, SC= Subsidiary cell.

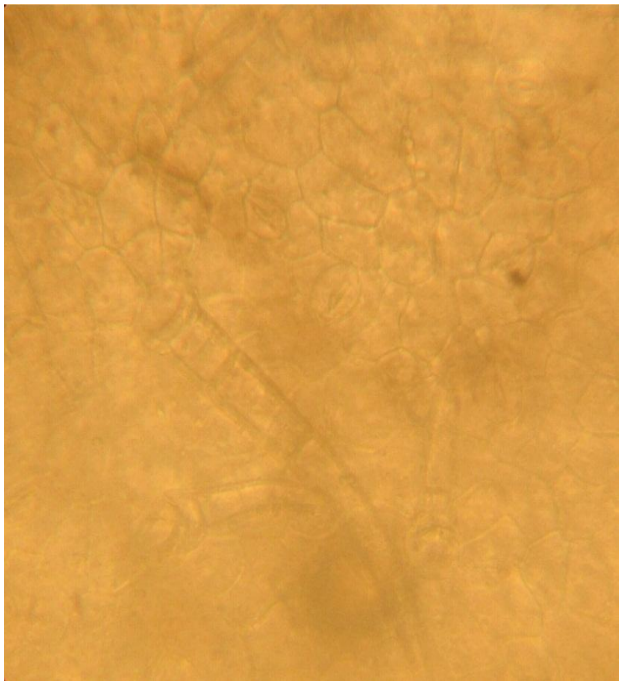

Plate 4.30 Anatomical features on adaxial surface of foliar epidermal cell of *I. alba* of Gusau, Sudan Savannah region. x400

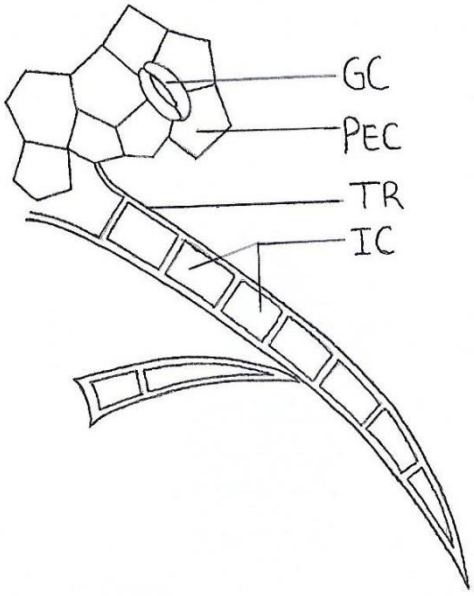

Fig. 4.30 Detailed epidermal cells and anomocytic stomata on abaxial surface of *I. alba* of Gusau, Sudan Savannah region. TR= Trcichome, PEC= Polygonal epidermal cell, GC= Guard cell, IC= Individual cells.

4.3Comparison of Leaves of *Ipomoea* species found inZaria, Northern Guinea Savannah and Gusau, Sudan Savannah Regions

Comparison of the mean performance levels of ordinary epidermal cells among the studied taxa showed a wide range of variation (Table: 4.3).Themeanand standard error of abaxial epidermal cell length of *I. batatas*ranged from 85.80±5.72µm to 81.40±7.21µm in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions respectively. The epidermal cell width also varies with values ranging from 41.80±2.91µm to 35.20±4.80µm respectively. The performance level of epidermal cell length of *I. nil* found in Gusau was higher than what was obtained in Zaria with mean and standard error levels of 88.00±6.13µm to 68.20±4.80µm respectively, it was found to be highly significant at p=0.009, but epidermal cell width for the same species showed no significant different at (p>0.05). The mature intercostal epidermal cells length performed well for *I. carnea* in Zaria with mean and standard error of 96.80±19.83 µm compared to 48.40±3.97µm of Gusau, although there was no significant different between the regions at p=0.093. The width of epidermal cells between the same species showed no significant different at (p>0.05) (Table 4.3)

The epidermal cell length on adaxial surfaces of *I. batatas* performed well in Gusau than what was obtained in Zaria with mean of 90.20µm and 74.80µm respectively, although there was no significant different at p=0.606 (Table 4.6) likewise the epidermal cell width of the same species showed no significant different with (p>0.05).The mean performanceand standard error of epidermal cell length of *I. nil* of Gusau was 106.70±25.87 µm while Zaria goes with 75.90±18.18µm. Significant different was observed between cells of *I. repens* at p=0.039. However, there was no significant between epidermal cell length and width of *Ipomoea alba* of the two regions at p=0.305 and p=0.695 respectively.

4.4Quantitative Stomatal Characters of the Studied Taxa

The mean stomatal length and standard error for *I. nil* ranges from 50.60±7.70µm to 49.50±1.91µm on abaxial surface in Sudan Savannah region and Northern Guinea Savannah. Their mean stomatal width was 26.40±1.91µm and 38.50±4.80µm respectively. There was no significant different between the mean levels of stomatal width observed on the abaxial surface between the two regions in *I. repens* at p=0.423 (Table 4.4), likewise, stomatal length was not significant with (p>0.05). The mean stomatal length of *I. repens* between the two regions was highly significant on the adaxial surface at p=0.008. However, there was no significant different between the mean of stomatal width at (p≥0.05) (Table 4.4).The mean and standard error of *I. aquatica* from Zaria was 52.80±6.87µm which was higher than 42.90±0.00µm from Gusau.

Table 4.3: Quantitative characteristics of foliar epidermal cells on abaxial and adaxial surfaces of the studied taxa in the two regions (Mean±SE)

		Savannah Regions											
NGSR	SSR	NGSR	SSR		NGSR	SSR		NGSR	SSR				
S/N	Taxa	Ab/ECL (μm)	Ab/ECL (μm)	P-value	Ab/ECW (μm)	Ab/ECW (μm)	P-value	Ad/ECL (μm)	Ad/ECL (μm)	P-value	Ad/ECW (μm)	Ad/ECW (μm)	P-value
1	*I. carnea*	96.80±19.83	48.40±3.97	0.093	38.40±7.70	44.10±19.56	0.691	86.77±25.73	63.80±2.91	0.449	50.60±12.69	39.60±8.31	0.370
2	*I. repens*	81.40±11.16	72.60±16.93	0.784	39.60±5.72	33.00±3.30	0.184	67.10±6.13	81.40±5.82	0.039	31.90±10.83	48.40±14.55	0.539
3	*I. alba*	72.67±11.96	47.30±6.12	0.050	41.80±1.10	20.90±7.21	0.113	84.70±15.52	58.30±0.49	0.305	34.10±8.50	27.50±6.13	0.691
4	*I. batatas*	85.80±5.72	81.40±7.21	0.423	41.80±2.91	35.20±4.80	0.478	74.80±6.69	90.20±21.92	0.606	52.20±6.60	39.60±8.73	0.456
5	*I. nil*	68.20±4.80	88.00±6.13	0.009	34.10±9.77	37.40±1.10	0.775	75.90±18.18	106.70±25.87	0.443	50.60±18.01	45.10±5.50	0.827
6	*I. aquatica*	94.60±10.49	62.70±5.04	0.101	46.20±5.72	33.00±191	0.225	6.60±3.81	67.10±1.10	0.042	60.60±12.79	29.70±3.30	0.174
7	*I. purpurea*	118.80±3.30	0.00±0.00	0.001	52.80±9.90	0.00±0.00	0.033	130.90±8.59	0.00±0.00	0.004	83.60±9.00	0.00±0.00	0.011

Legend: Ab= Abaxial surface, **Ad=** Adaxial surface, **ECL=** Epidermal cell length,**ECW**= Epidermal cell width, **NGSR**= Northern guinea savannah region, **SSR**= Sudan savannah region.

Table 4.4: Quantitative characteristics of foliar stomatal cells on abaxial and adaxial surfaces of the studied taxa in the two regions (Mean±SE)

		Savannah Regions											
		NGSR	SSR		NGSR	SSR		NGSR SSR NGSR SSR					
S/N	Taxa	Ab/SCL (µm)	Ab/SCL (µm)	P-value	Ab/SCW (µm)	Ab/SCW (µm)	P-value	Ad/SCL (µm)	Ad/SCL (µm)	P-value	Ad/SCW (µm)	Ad/SCW (µm)	P-value
1	*I. carnea*	41.80±2.91	40.70±1.10	0.667	25.30±4.40	20.90±2.91	0.456	48.40±7.70	35.20±2.91	0.339	28.60±4.80	24.20±1.01	0.529
2	*I. repens*	57.20±2.91	45.10±3.97	0.187	30.80±1.10	25.30±6.13	0.423	46.20±5.72	58.23±6.69	0.008	34.10±3.97	33.00±8.73	0.868
3	*I. alba*	47.30±6.12	34.10±7.21	0.427	28.60±2.20	22.00±1.10	0.074	43.00±8.21	36.30±5.04	0.214	37.40±2.91	23.17±6.82	0.095
4	*I. batatas*	55.00±3.97	49.50±6.87	0.300	49.50±6.87	34.10±3.97	0.210	43.73±3.66	47.85±2.13	0.391	32.18±2.13	30.53±2.08	0,391
5	*I. nil*	49.50±1,91	50.60±7.70	0.918	38.50±4.80	26.40±1.91	0.093	52.80±11.67	43,73±0.83	0.494	37.13±7.78	32.23±4.98	0.675
6	*I. aquatica*	53.90±5.50	46.20±3.81	0.483	25.30±1.10	35.20±2.91	0.095	52.80±6.87	42.90±0.00	0.286	31.90±5.82	28.60±2.20	0.667
7	*I. purpurea*	42.90±0.00	0.00±0.00	0.002	26.40±5.04	0.00±0.00	0.035	40.70±9.00	0.00±0.00	0.046	18.70±2.20	0.00±0.00	0.014

Legend: Ab= Abaxial surface, **Ad=** Adaxial surface, **SCL=** Stomatal cell length,**SCW**= Stomatal cell width, **NGSR**= Northern guinea savannah region, **SSR**= Sudan savannah region.

4.5Stomatal Index (SI) of the Studied Taxa

The stomatal index on the abaxial and adaxial surfaces varies slightly among the examined species, there was no significant different on the abaxial surfaces of all the studied species except the adaxial surface of *I. aquatica* which is significant p=0.041. (Table 4.5). The mean stomatal index on the abaxial and adaxial surfaces of *I. batatas* of Zaria were 31.88% and 17.85% respectively, while what was obtained in Gusau were higher with index means of 33.28% and 35.30%. Significant different was not observed in the stomatal index of abaxial surfaces of *I. carnea* in the two regions at ($p>0.05$) (Table 4.5).

4.6Effect of Different Ecological Location on the Trichomes found in twoof the Examined Taxa

Trichomes were present on both the surfaces of *I. nil* found in the two regions, the mean length of trichomes on the abaxial surface from Gusau was higher (683.17µm) than what was obtained from Zaria, Northern Guinea Savannah region (390.50µm), it present a level of significant difference with p=0.025. Significance difference was not observed in their width levels at ($p>0.05$). Trichomes were absent in *I. alba* from Zaria, however, the mean and standard error of the trichomes width on adaxial and abaxial surfaces of *I. alba* in Gusau were 42.81±2.26µm and 45.63±3.99µmrespectively (Table 4.6).

4.7Quantitave Characteristics of Morphological Features of leaves

Although similarities exist between members of the genus *Ipomoea*, there was high significant difference in all the examined species in the two regions ($p<0.05$). The mean levels of the leaf breadth were closely related for *I. alba*, *I. nil* and *I. repens* at 7.34cm< 7.58cm< 7.96cm respectively. The leaf length mean levels of *I. alba* (2.34cm) in Gusau varies significantly with that of *I. carnea* (20.38cm) of same region (Table 4.7).

Table 4.5:Stomatal index (SI) of *Ipomoea*leaves found in Zaria and Gusau,Nigeria

Species	Surface	Savanna regions		P-value
		Northern Guinea Savannah (%)	Sudan Savannah Region (%)	
I. batatas	Abaxial	**31.88**±5.58	33.28±1.47	0.809
	Adaxial	17.85±2.40	**35.30**±2.84	0.079
I. nil	Abaxial	**21.53**±4.05	11.45±1.18	0.115
	Adaxial	**12.13**±2.80	22.13±2.12	0.065
I. aquatica	Abaxial	27.57±2.89	20.03±2.31	0.274
	Adaxial	20.05±1.33	**16.98**±1.37	**0.041**
I. alba	Abaxial	29.18±2.87	25.51±4.08	0.528
	Adaxial	16.97±3.02	27.94±3.08	0.107
I. carnea	Abaxial	24.06±5.38	34.35±4.06	0.357
	Adaxial	**50.64**±12.72	26.66±4.44	0.297
I. repens	Abaxial	22.76±3.72	30.09±1.65	0.283
	Adaxial	29.36±8.54	29.66±1.38	0.975
I. purpurea	Abaxial	21.63±3.26	0.00±0.00	0.022
	Adaxial	17.86±1.68	0.00±0.00	0.009

(Mean±SE)

Table 4.6: Quantitative data of trichomes found in Zaria and Gusau, Nigeria

Species	Surface		Savannah regions		P-value
			Sudan	Northern Guinea	
I. alba	Abaxial	LT (μm)	764.57±33.52	0.00±0.00	0.002
		WT(μm)	**45.63±3.99**	0.00±0.00	0.008
	Adaxial	LT (μm)	620.73±38.25	0.00±0.00	0.004
		WT(μm)	**42.81±2.26**	0.00±0.00	0.003
I. nil	Abaxial	LT (μm)	**683.17±38.11**	**390.50±17.29**	**0.025**
		WT(μm)	42.90±3.30	28.60±4.80	**0.122**
	Adaxial	LT (μm)	705.10±52.10	331.10±40.43	0.022
		WT(μm)	35.20±3.97	26.40±1.91	0.270

Legend: LT= Length of trichome, **WT**= Width of trichome. **(Mean±SE).**

Table 4.7: Quantitative data of *Ipomoea*leaves found in Zaria and Gusau, Nigeria

	Northern Guinea Savannah Region			Sudan Savannah Region		
Species	**LL**(cm)	**LB**(cm)	**LP**(cm)	**LL**(cm)	**LB**(cm)	**LP**(cm)
I. batatas	17.87±0.43^{a}	7.34±0.28^{b}	22.75±2.40^{a}	11.66±0.28^{b}	6.67±0.28^{b}	14.00±0.43^{a}
I. nil	6.69±0.48^{d}	7.58±0.61^{b}	7.15±0.38^{b}	6.66±0.34^{c}	4.79±0.12^{c}	6.55±0.13^{b}
I. aquatica	8.52±0.26^{c}	3.15±0.11^{d}	5.63±0.23^{b}	7.48±0.25^{c}	2.58±0.10^{d}	4.88±0.27^{c}
I. alba	7.29±0.16^{cd}	5.77±0.14^{c}	7.60±0.24^{b}	**2.34**±0.17d^{e}	2.77±0.11^{d}	2.10±0.12^{e}
I. carnea	15.07±0.88^{b}	9.71±0.38^{a}	6.13±0.25^{b}	**20.38**±3.22^{a}	10.52±0.28^{a}	6.70±0.27^{b}
I. repens	7.72±0.18^{cd}	7.96±0.28^{b}	7.34±0.34^{b}	4.76±0.12^{d}	6.58±0.14^{b}	3.19±0.20^{d}
I. purpurea	7.77±0.34^{cd}	5.69±0.15^{c}	4.77±0.14^{b}	0.00±0.00^{e}	0.00±0.00^{e}	0.00±0.00^{f}
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Legend: LL= Leaf length, **LB=** Leaf breadth, **LP=** Length of petiole.**(Mean±SE)**

Values in column with same superscript are not significantly different ($p \leq 0.05$)

4.8Comparison of Differences of Ipomoea Leaves found in the Two Ecological Locations Quantitively

The epidermal cells are large for some species with their average mean length ranging from 68.20μm to 118.80μm for *I. nil* and *I. purpurea* respectively, in Zaria. Significant difference was not observed on the abaxial and adaxial epidermal cell lengths of all the examined species in same region (p= 0.080 and p= 0.110 respectively). The mean and standard error of epidermal cell length on abaxial and adaxial surfaces of *I. alba* in Gusau were 47.30±6.12 and 58.30±10.49respectively. At p=0.036, significant different was observed on the abaxial epidermal cell width of all the examined species found in Zaria. However, *I. purpurea* was absent. Mean epidermal cell width was highest for *I. purpurea* of Zaria and lowest in *I. nil* of same region, although there was no significant different between them (Table 4.8).

4.9Effect of Two Ecological Locations on Ipomoea Leaves

The leaf sizes unmask considerable variations within the genus studied in the two regions, the largest leaf length were recorded in *I. batatas* of Zaria, Northern Guinea Savannah region with mean level of 17.87cm while *I. carnea* of Gusau, Sudan Savannah region showed 20.38cm. The lengths of petiole ranges from 2.10cm in *I. alba* of Gusau, Sudan Savannah region to 14.0cm in *I. batatas* of same region (Table 4.13). However, a highly significant difference was observed on the effect of the two regions on *I. alba* ($p<0.05$). The lowest leaf breadth in Zaria, Northern Guinea Savannah region was found in *I. aquatica* 3.15cm, *I. carnea* showed the highest in Sudan Savannah region with 10.52cm. Significant different was not observed in leaf breadth of *I. batatas*found in the two regions with p=0.251 (Table 4.9).

Table 4.8: Quantitative data of foliar epidermal cells on abaxial and adaxial surfaces of the studied taxa in the two regions

	Zaria, Nothern Guinea Savannah				Gusau, Sudan Savannah			
	Surface				Surface			
	Abaxial		Adaxial		Abaxial		Adaxial	
Species	**ECL** (µm)	**ECW** (µm)	**ECL** (µm)	**ECW** (µm)	**ECL** (µm)	**ECW** (µm)	**ECL** (µm)	**ECW** (µm)
I. batatas	85.80±5.72^{ab}	41.80±2.91^{a}	74.80±6.69^{b}	52.80±6.60^{ab}	81.40±7.21^{a}	35.20±4.80^{a}	90.20±21.92^{ab}	39.60±8.73^{a}
I. nil	**68.20**±4.80^{b}	**34.10**±9.78^{a}	75.90±18.18^{b}	50.60±18.01^{ab}	88.00±6.12^{a}	37.40±1.10^{a}	106.70±25.87^{a}	45.10±5.50^{a}
I. aquatica	94.60±10.49^{ab}	46.20±5.72^{a}	85.80±3.82^{ab}	60.60±12.79^{ab}	62.70±5.04^{ab}	33.00±1.91^{a}	67.10±1.10^{ab}	29.70±3.30^{a}
I. alba	72.67±11.96^{b}	41.80±1.10^{a}	84.70±15.52^{ab}	34.10±8.59^{b}	**47.30±6.12^{b}**	20.90±1.91^{ab}	**58.30±10.49^{b}**	27.50±6.12^{a}
I. carnea	96.80±19.83^{ab}	38.50±7.70^{a}	86.77±25.73^{ab}	50.60±12.69^{ab}	48.40±3.97^{b}	44.10±19.56^{a}	63.80±2.91^{ab}	39.60±8.31^{a}
I. repens	81.40±11.16^{ab}	39.60±5.72^{a}	67.10±6.13^{b}	31.90±10.84^{b}	72.60±16.93^{ab}	33.00±3.30^{a}	81.40±5.82^{ab}	48.40±14.55^{a}
I. pupurea	**118.80**±3.30^{a}	**52.80**±9.90^{a}	130.90±8.59^{a}	83.60±9.00^{a}	0.00±0.00^{c}	0.00±0.00^{b}	0.00±0.00^{c}	0.00±0.00^{b}
P-value	0.080	0.610	**0.110**	0.108	**<0.001**	0.036	0.002	0.012

Legend: ECL= Epidermal cell length **ECW=** Epidermal cell width. **(Mean±SE).**

***Values in column** with same superscript are not significantly different (p≤0.05)

Table 4.9: Quantitative characteristics comparing the effect of two ecological locations on members of *Ipomoea* Leaves

	Savannah regions								
	Northern Guinea	Sudan		Northern Guinea	Sudan		Northern Guinea	Sudan	
Species	L.L (cm)	L.L (cm)	P-value	L.B (cm)	L.B (cm)	P-value	L.P (cm)	L.P (cm)	P-value
I. batatas	**17.87**±0.43	11.66±0.28	**<0.001**	**7.34**±0.28	**6.67**±0.28	**0.251**	22.75±2.39	**14.00**±0.43	**0.029**
I. nil	6.69±0.48	6.66±0.34	0.912	7.58±0.61	4.79±0.12	0.011	7.15±0.38	6.55±0.13	0.287
I. aquatica	8.52±0.26	7.48±0.25	0.101	**3.15**±0.11	2.58±0.10	0.002	5.63±0.23	4.88±0.27	0.195
I. alba	7.29±0.16	2.34±0.17	**<0.001**	5.77±0.14	2.77±0.11	<0.001	7.60±0.24	**2.10**±0.12	**<0.001**
I. carnea	15.07±0.88	**20.38**±3.22	0.236	9.710±0.38	**10.52**±0.28	0.259	6.13±0.25	6.70±0.27	0.085
I. repens	7.72±0.18	4.76±0.12	**<0.001**	7.96±0.28	6.58±0.14	0.007	7.34±0.34	3.19±0.20	**<0.001**
I. purpurea	7.77±0.00	0.00±0.00	**<0.001**	5.69±0.15	0.00±0.00	**<0.001**	4.77±0.14	0.00±0.00	**<0.001**

Legend:L.L= leaf length, **L.B**= Leaf breadth. **L.P**= Length of petiole

4.10Phenetic Relationships

The phenogram drawn from coefficient of similarities by clustering of data obtained from quantitative characteristics of leaves, epidermal cells, and stomata showed a varying degree of divergent (Fig. 4.1).*I. purpurea* appear to be pleisiomorphic, it is related to the rest of the groups but branch earlier in evolutionary history. Two clusters emerged separately, the first cluster comprises of *I. aquatica*, *I. carnea* and *I. babatas*; the second cluster comprises of *I. alba*, *I. repens* and *I. nil.*

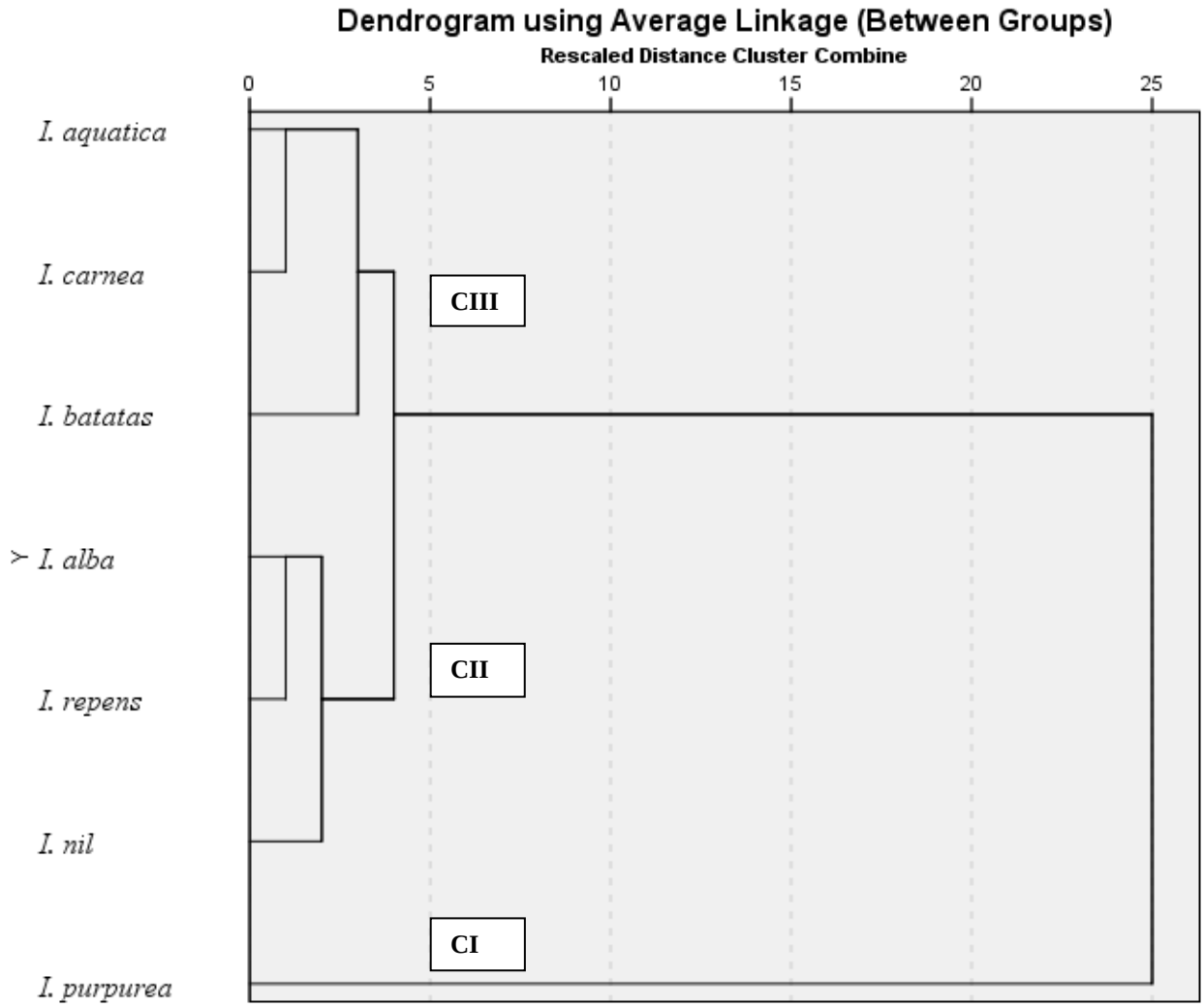

Figure 4.31 Phenetic relationships between investigated taxa of *Ipomoea* species based on coefficient of similarities obtained from leaves, epidermal cells and stomatal characteristics using average linkage between different taxa in Zaria, Northern Guinea Savannah region of Nigeria.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Distribution of Epidermal Cells

Epidermal cells were distributed on the abaxial and adaxial surfaces of all the examined species, the abaxial surface of *I. batatas* found in Zaria, Northern Guinea Savannah and both surfaces of *I. carnea, I. repens, I. alba,* and *I. aquatica* found in the two regions revealedpolygonal cells with straight anticlinal walls. This corresponds to what was obtained on both surfaces of *I.asarifolia* by (Fabiano*et al.,* 2012). It was also found to be in accord to what was described by Arruda *et al.* (2009) for *Ipomoea imperiati* and *Ipomoea pes-caprae.*

The adaxial surface of *I. batatas* of Gusau, Sudan Savannah region, abaxial and adaxial surfaces of *I. nil* of same region, both surfaces of *I. alba*, abaxial surface of *I. nil* of Northern Guinea Savannah showed the presence of epidermal cells with sinuous appearance. These are in agreement with what was reported for*Ipomoea grandifolia* by Monquero *et al.* (2004), it also agrees with what was found on the surfaces of *Ipomoea carica* by Procopio *et al.* (2003), which showed markedly wavy anticlinal walls.These cells with convex outer periclinal walls in the epidermis that showed sinuous cells correlate with what was described by Metcalfe and Chalk (1950) for Convolvulaceae; this characteristics is commonin plants that live in shady environment where papillose cells act as convex lenses that focus rays of light into mesophyll for photosynthesis (Fabiano *et al.* 2012). According to Fahn and Cutler (1992), as cited by Fabiano*et al.* 2012, the epidermis of plants that grow in xeric environment is composed of small cells with straight anticlinal walls; the authors believe that these features may be adaptations to drought conditions. Furthermore, according to Iljin (1957) there is an inverse correlation between

cell volume and ability of the plant to survive drought. Moreover, Cutler *et al.* (1977) state that the reduction of cell size appear to be one of the main responses to water stress; *I. carnea* found in Sudan Savannah region showed reduced cell sizes on both surfaces compare to what was obtain on the surfaces of the same species that was found in Northern Guinea Savannah region.

It was also reported that the epidermal cells of in vitro grown *Adiantum capillus-veneris* leaves form wavy anticlinal walls. This morphogenesis is achieved (according to them) by cortical microtubule organization, which is different from that observed in typical intercostal epidermal cells (Panteris *et al.*, 1993). However, it seems that the ability to organize radial micro-fibril arrays under the external periclinal walls actually exists in *Adinantum capillus-veneris*, but it is not expressed in normal condition. Local differences in growth pattern could be responsible for variation in epidermal cell morphorgenesis in which the adaxial surface of *I. nil* possess cells that are variously shaped with straight anticlinal walls despite the waviness or the sinuous appearance of cells on the abaxial surface.

According to Panteries *et al.* (1994), it seems likely that while the ability of achieving waviness or wavy wall exist, the mechanism is activated by certain tissue or organ-specific stimuli. It may well be that, even plants with straight wall epidermal cells, actually have the ability to form wavy ones, the absence of this feature being the matter of epigenesis. Factors such as light, growth pattern and growth regulator gradients may be able to switch on to modify, or even keep dormant the sinuous cell morphogenetic mechanism.

5.2 Types and Distribution of Stomta

This study confirmed the presence of stomata, which were distributed on both surfaces of all the examined species of the two regions except adaxial surface of *I. purpurea*were stomata is absent

(hypostomatic), this is in line with what was reported for *I. grandifolia* (Monqueiro *et al*., 2004) and *I. carica* (Procopio *et al*., 2003). The abaxial surface of *I. nil* from this study revealed the presence of paracytic stomata. While anomocytic stomata were obtained on the surfaces of *I. alba* of Sudan Savannah region which conflict with paracytic stomata obtained from same species in Northern Guinea Savannah region, this differences is produced (as reported by Zhao and Sack 1999; Lynn and Juan2013) by special epidermal lineage which undergoes an organized series of divisions and successive cell-state transitions, where each transitional state is distinct and demonstrate change in morphology, transcript, accumulation and protein localization.

The principal function of stomata is gas exchange that occur when the stomata is open during photosynthesis. With regard to stomatal typology of different members of *Ipomoea*, the information obtained is conflicting, in this study, three types of stomata were observed these are paracytic, anisocytic and anomocytic stomata. In previous studies conducted by other researchers, Solereder (1908) described paracytic stomata, and Metcalfe and Chalk (1979) reported anomocytic and paracytic stomata. Procopius *et al.* (2003) and Monqueiro *et al.* (2004) reported anomocytic stomata. Arruda *et al.* (2009) did not mention the types of stomata in their study of *I. imperiati* and *I. pes-caprae*. A recent study by Guterres *et al.* (2008) confirmed the presence of anisocytic stomata in *I. aquatica*, anisocytic and paracytic stomata in *I. squamosa*. According to Dickson (2000), as cited by Fabiano*et al.,* 2012, several taxonomic groups can be characterize by the types of stomata, however, some taxa possess a combination of two or more types.

Anisocytic stomatal complexes where found on the abaxial surface of *I. purpurea*, as confirmed in *Arabidopsis* and other members of Brassicaceae (Aniso meaning uneaqual) where a stomata is surrounded by three cells of different sizes that correlate with cell age (smallest cell is the youngest) (Lynn and Juan, 2013). This arrangement results from three consecutive asymmetric division of meristomoid mother cell (Berger and Altman, 2000). Anisocytic stomata make up 40-50% of all complexes in leaves and cotyledons (Geisler *et al.,* 2000) the inward spiral of asymmetric divisions can occur in clockwise or counter clockwise direction.

The stomatal cell length on the abaxial surface of *I. repens* in Zaria, Northern Guinea Savannah region was higher (57.20μm) than what was obtained in Gusau, Sudan Savannah region (45.10μm), however, no significant difference was observed on the performance of stomatal cell length and width on the abaxial surfaces of all the examined species in the two regions. On the adaxial surfaces of all the species studied, significantdifferences was obtained only on stomatal length of *I. repens*, the width for same observation showed no difference, this high level of correspondence observed could be attributed to similarities existing between some physical environmental factors such as temperature and availability of moisture.

The stomatal index examined from different species varies slightly. Significant differences was not observed on the abaxial and adaxial surfaces of all the studied species except adaxial surface of *I. aquatica,* the difference recorded in this case however could be as a result of the effect of environmental factors. As reported by Schoch, 1980 leaves exposed to high light intensity produce more stomata without dramatic changes in patterning than those expose to lower light intensity. More stomata, however, translate into higher percentage of stomatal index. Stomata are the major route for CO_2 uptake to use during photosynthesis which also helps inregulating both stomatal opening and development (Young *et al.,* 2006). Apart from environmental cues,

hormonal changes also feed into modulation of stomatal number. Brassinosteroids (BRs) are phytohormones that have been directly implicated in promoting stomatal development in hypocotyl (Fuentes *et al.,* 2012).

5.3 Effect of Ecological Location on the Performance of the studied Taxa

Effect of ecological location on different members of *Ipomoea* leaves varied highly. Three species showed highly significant different, ($p<0.01$), these are *I. batatas, I. alba,* and *I. repens.* Significance difference was not observe on leaf length and petiole development of *I. nil* in the two regions. These differences, however, could be as a result of consequence of environmental factors such as light, availability of water and temperature. Water for example; help to maintain the turgidity of cell walls, which invariably help in cell enlargement due to turgor pressure, and cell division which ultimately increase the growth of plant. As reported by Splittstoesser, 1966 increased CO_2 is known to promote protein synthesis in tissues of various higher plants as an indirect increase in dark fixation into organic acid. Thus, these factors explain why the mean length performance of leaf blade and petiole of *I. batatas* of Northern Guinea Savannah was higher than those obtain in Sudan Savannah region even though the differences is not significant.

5.4 Phenetic Relationships between the Studied Taxa

The phenetic relationships of *Ipomoea*species in this study revealed three clusters; each cluster is derived from common ancestral complex. The species that belong to the second cluster which includes *I. nil*,*I. alba* and*I. repens. I. purpurea* seem to be pleisiomorphic, these may explain their rather isolated position from the first cluster in the phenogram of these phenetic relationships. These relationships shows that *I. repens* and *I. alba* are sister species in this study. *I. carnea* and *I. aquatica* have common ancestor in addition to the common ancestral root that

link all members of the first cluster. Moreover, *I. aquatica* and *I. carnea* are sister species and are more closely related than *I. aquatica* and *I. batatas.*

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Two types of epidermal cell shapes exist between different species of *Ipomoea*found in Zaria, Northern Guinea Savannah and Gusau, Sudan Savannah regions of Nigeria; these includes polygonal and sinuous shapes. It has also been found that environmental factors and to a lesser extend growth regulators could have caused epidermal cell shapes to change or be modify from one form to another.

Stomatal complexes were distributed on both surfaces of all the examined species from the two regions, however, stomata were absent on the adaxial surface of *I. purpurea*. Three types of stomata were confirmed, these are; paracytic, anisocytic and anomocytic stomata. Although the mean levels of length and width of stomata varies for different species, significsnt different was not observed ($p>0.05$) on the abaxial surfaces of species of the two regions. *I. repens* showed a high significant effect on the stomatal length of the abaxial surface of the two regions.

Ecological location have no significant effect on the epidermal cell length and width of on the abaxial and adaxial surfaces of all the examined species in the two regions, however, *I. nil* and *I. alba* showed significant effect. The cell width on the adaxial surface showed no effect ($p>0.05$) for all the species, while the cell length of *I. aquatica* and *I. repens* revealed a slight level of significance difference, this difference is the result of difference in moisture availability.

6.2 RECOMMENDATIONS

- Further studies should be conducted to integrate these anatomical features at molecular level, this will provide a more accurate pathway to establishing relationships between the rest members of this genus

- Similarities to some extend exist between different leaves of this group; however, because of the remarkable variation that was observe on different colors of *Ipomoea* flowers, further studies should be carried out to determine at molecular level the different pigments that are responsible for this remarkable variation.
- Studies should be carried out on the anatomy of flowers, stems and roots of this broad group to further buttress our understanding on this genus.

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