1.0 INTRODUCTION

1.1 GENERAL INTRODUCTION

The family Lamiaceae (Labiatae) contains about 200 - 260 genera including 3500 species (Chaudhary, 2002; Collenette, 1999; Mandaville, 1996; Migahid, 1989). The members of this family are distributed through-out the world. They are distributed in both temperate and tropical regions. The main distribution of the family is the Mediterranean region.

In Saudi Arabia, this family is represented by 26 important genera including about 70 species, (Appendix 1) such as: *Salvia, Mentha, Marrubium, Thymus, Stachys, Nepeta, Otostegia, Lavandula, Ajuga, Leucus, Ocimum, Lamium, Ballota, Phlomes, Merandra,* etc. Fourteen species out of 70 species are endemic to Saudi Arabia or to the region, while other species are endangered, vulnerable or rare in the Kingdom of Saudi Arabia (Collenette, 1999). The majority of the species are annual or perennial herbs. Certain plants are xerophytes with extremely reduced leaf and stems are usually four sided or quadrangular. Leaves are simple opposite, decussate, sometimes whorled. Stems and leaves are hairy, commonly with glandular trichomes which secrete characteristic scents of the genus or species. Inflorescence consists of condensed or loose axillary flowers, arranged in false spikes or racemes; flowers are hermaphrodite zygomorphic. Calyx is gamosepalous, tubular, bilabiate (hence the family name). Corolla consists of five petals, gamopetalous, tubular and bilabiate. The posterior pair of petals form the upper lip and the anterior of 3 petals form the lower lip. Androecium consists of 2 – 4 epipetalous stamens, often didynamous. Anthers are 1 or 2, thecate (*Salvia*) one chamber is fertile and the other is sterile, the two chambers are separated by an elongated connective forming a lever-like

arrangement with the filament, nectariferous, hypogynous disc often present: Gynoecium is bicarpellate, syncarpous superior, 1-4 lobed to the base with 1-4 seeded chambers, style is single usually gynobasic, stigma has 2 lobes. Fruit consists of four to one-seeded nutlets, included within the persisted calyx (Chaudhary, 2002).

1.1.1. Economic Importance:

The family Lamiaceae is of considerable economic importance due to the presence of essential oils produced by glandular structures (Maffei et al., 1985), these trichomes, secrete low molecular weights, volatile terpenes (Fahn, 1979).

Tremendously, a long list of the Lamiaceae species are familiar and very important to us, they are used in food preparation; the culinary herbs, which include sage (*Salvia officialis* L.), mint (*Mentha spp*.), thyme (*Thymus vulgaris* L.) or for their aromatic oils as perfumes and cosmetics including rosemary (*Rosmarinus officialis* L.), peppermint (*Mentha piperita* L.) or as pharmaceutical preparations, which has given the family species great economic value (Dearden and Nicholson 1984). In folk medicine they are employed for headaches, sores, burns, dermatitis and against nausea and scorpion stings (Bown, 1995). Several species are assembled in flower garden. Most garden encyclopedias devote considerable space to lengthy lists of Lamiaceae species within the famous genera e.g. *Salvia, Ajuga, Stachys, Thymus, Lavandula, Nepeta* (Baumgardt, 1982).

Many Lamiaceae species have been investigated because of the diversity of their glandular trichomes, these trichomes may be a site of synthesis of secondary metabolites, which play a significant role in plants (Levin, 1973; Herms and Mattson, 1992). There is also a hypothesis that the gland produces active agents which are related to photoperiodic

induction of flowering and are involved in synthesis of steroid hormones and giberellins (Vassilyev, 1977; Danilova and Kashina, 1987).

Although much work has been done on a phytochemical analysis during the last 20 years none has reported on species growing in Saudi Arabia.

1.1.2. The aim of this work

a. To give a comprehensive anatomical study on the epidermal and internal vegetative organs (leaves and stems), flowers and pollen grains of some members of the family Lamiaceae represented by some members of the subfamily stachyoideae, which are growing naturally in Saudi Arabia.

b. We hope to offer valuable anatomical characters to help in the determination of genera and species, in order to put these genera in their proper tribes or subfamilies

1.2. ANATOMY

1.2.1. Leaf epidermal characters:

1.2.1.1. Epidermal cells:

Epidermal cells (in surface view) were described as generally having sinuous anticlinal cell walls or polyhedral straight anticlinal cell walls, in species of *Ajuga, Lavandula, Rosmarinus* and *Thymus* (Buch, 1926). Occasionally papillose were observed in species of *Bystropogon* (Etienne, 1919).

The epidermal cells in most *Lamiaceae* species are characterized by thick cutinized outer walls and cells, polygonal isodiametric or elongated in various directions, the anticlinal epidermal cell walls are either straight, arched or sinuous in *Lavandula burmanii, Dysophyll*

auricalaria, Coleus ambonicus, C. blamei, Leucas asper and *L. gibsoni* (Inamdar and Bhatt, 1972).

Bokhari and Hedge (1979) in their work on some *Salvia* species, reported that the epidermal cells in surface view are with slightly sinuous walls, (except on nerves), and a well-developed cuticle is always present on both surfaces of the leaf which is ± smooth.

Azizian and Cuttler (1982) in their work on *Phlomis* L and *Eremostachys* Bunge reported that the epidermial cells in both speices are isodiametric, polygonal, slightly longer than wide, anticlinal walls sinuous, slightly wavy or curved; cells in the coastal areas arranged in more or less polygonal parallel rows, elongated along axis of veins, rectangular up to four times longer than wide, with straight walls.

1.2.1.2. Stomata:

Stomata occasionally occur in both upper and lower leaf epidermises, but more frequently distributed in the lower epidermis. Diacytic stomata occur frequently in *Dysophylla*. Anomocytic stomata in *Cunila mariana* L. (Holm, 1908).

Metcalfe and Chalk (1950) suggested the term **diacytic stomata,** that the two guard cells are surrounded by two subsidiary cells with their common walls at right-angles to the long axis of the stomata. Similarly, Inamdar and Bhatt (1972) studied the structure and ontogeny of stomata in 33 species of the Lamiaceae; they concluded that the mature stomata are diacytic, and anomocytic types (**anomocytic stomata** surrounded by 4-6 ordinary epidermal cells) which occur on one or both surfaces of the leaf (Wilkinson, 1979). Azizian and Cutler (1982) confirmed the existence of anomocytic and diacytic stomata on both surfaces of the leaves of *Phlomis* and *Eremostachys*, but more abundant on the abaxial surface of the leaf, intercostal areas or evenly distributed, rare or absent on adaxial surface of the leaves of some species, e.g. *Phlomis agaria, P.*

alpina and *P. pratensis* (section phlomoides). However, Cantino (1990) in an extensive survey of stomatal position in 127 genera of Lamiaceae mentioned that leaves with diacytic, anisocytic and anomocytic stomata that occur on one or both surfaces were common in members of the family. **Anisocytic** (**stomata** surrounded by three subsidiary cells, one of which is markedly smaller than the other two, Dilcher (1974) and Wilkinson (1979). Elena et al. (1993) in a comparative study on leaves of *Salvia officinalis* L. and *S. tomentosa* Mill, showed the clearance of the even disturbution of the diacytic stomata upon the upper and the lower epidermis of both species. Ezer et al. (1998) reported that *Ballota* (which is most closely allied to *Marrubium* and it is difficult to be separate from *Stachys,* Davis, 1982) have diacytic stomata on the lower epidermis in *Ballota nigra* L. subsp. *anatolica*. Bosabalidis and Kokkini(1997) studied diacytic stomata in *Oreganium vulgare* subsp. *hirtum,* subsp. *viridulum* and subsp. *vulgare* which grew wild in Greece and were characterized by higher numbers of diacytic stomata on the upper surface of the leaf in these subspecies.

Leaves of *Thymus capitatus* with no stomata on their upper surface were observed by Christodoulkis and Bazos (1990).

Stomata were found only on the abaxial surface of the lamina (190/mm^2), in *Coleus blumei*,diacytic, with kidney shaped guard cells, with starch grains present in the guard cells (Fisher, 1985).

Doaigey and Gawad (1984) studied three species of *Salvia (S. aegyptiaca* L.*, S. deserti* Decne and *S. spinosa* L.*),* they found that all the three species showed similar frequencies of diacytic stomata.

Gavalas et al. (1998), in a comparative study of the leave anatomy on the genus *Mentha*, detected the absence of stomata on the leaf upper epidermis of *M. longifolia* or very small, in *M. spicata,* many more stomata were detected in M. x *villoso-nervata* leaf upper surface, where

as many stomata on the leaf lower epidermis were detected in all the above three species. The greatest number was found in *M. longifolia*, (815/mm^2)

12.1.3. Trichomes:

They are very variable, the occurrence and diverse kinds of non glandular trichomes and glandular trichomes with short-stalked, glands with unicellular or multicellular heads is characteristic of the whole family. Cell walls of the non glandular trichomes are stiff and lignified in many species, other cell walls are composed of cellulose, but strongly cutinized (Eteinne 1919). Different kinds of trichomes were reported as follows:

Non glandular trichomes: have two types.

Type 1

Form 1: Uniseriate, unbranched with varying length sometimes curved, commonly with swollen basal cells or seated on pedestals of several epidermal cells e.g. in *Galeopsis, Hedeoma, Lamium, Origanum* and *Stachys* (Etienne, 1919).

Form 2: Bicelluar trichomes, unbranched with short basal and long terminal cells recorded in species of *Stachys* and *Westringia* (Buch, 1926).

Form 3: Multicelluar trichomes, uniseriate unbranched occur in *Stachys Lamium* and *Origanum* (Metcalfe and Chalk, 1950).

Type 2. Multicellular trichomes branched or tufted occur in *Ballota, Lavandula, Marrubium, Mentha, Nepeta, Phlomis, Stachys* and *Teucrium* and other genera (Metcalfe and Chalk, 1950).

Glandular trichomes: They vary in the number of cells in the head, the length of the stalk, the amount of secretion accumulated beneath the cuticle, and the degree to which sunk in the epidermis forming several

forms of glandular trichomes frequently occur together in a single leaf as follows:

The presence of peltate and capitate glandular trichomes is a characteristic feature of Lamiaceae species, (**peltate trichomes**: having short one-celled stalks and large flattened heads, about 60 – 90 μm in diameter they are formed by four or eight cells in a single disc or 12 – 18 cells arranged in two concentric circles, (Amelunxen et. al., 1969). Werker, et. al. (1985) listed three types of **capitate trichomes**; generally consist of rounded to pear-shaped heads with one or two cells supported by stalks with variable length; they were found on vegetative and reproductive organs of several Lamiaceae species.

Type 1. Heads unicellular and stalk unicellular (capitate 1) and stalk up to 3 cells long (capitate 2): were observed in species of *Lamium, Lavandula, Mentha, Monaroda, Ocimum, Pogostemon, Rosmarinus, Salvia* and *Thymus*. Others are similar but with longer stalks were observed in species of *Ajuga, Salvia, Horminum* and *Lophanthus*.

Type 2. Glandular trichomes with bicellular heads, short stalks 1 – 3 or 4 (capitate 3) were very common and could be seen in species of *Lavandula, Lophanthus, Nepeta, Perilla,* others are similar but with longer stalks in species of *Ballota, Salvia,* and *Stachys*.

Type 3. Glandular trichomes with 4-8-16 celled heads, short stalk, (1 cell), (peltate): usually in three forms:

Form a. Glandular trichomes with 4 celled heads, short stalk, sometimes mixed with trichomes having a larger number of cells in their heads were recorded in species of *Ballota, Galeopsis, Lamium, Leonotis, Leucas, Marrubium, Nepeta, Salvia, Stachys* and *Teucrium*.

Form b. Glandular trichomes with 8 celled heads; usually having very short stalk and frequently sunk in pits are widespread in the

Lamiaceae species. Similar trichomes but with longer stalks were recorded in a few species of *Lavandula* and *Salvia.*

Form c. Glandular trichomes with heads having 16 or more cells; and short or long stalks, this form relatively infrequent, and was recorded in species of *Scutellaria* and *Galeopsis*.

Type 4. Glandular trichomes being multicellular, multiseriate, branched with one branch having a unicellular head, were recorded in few species by Bokhari and Hedge (1971) on the vegetative parts of *Meiandra* and reported that this form being unusual in the family Lamiaceae. Such trichomes were found on the leaf of *Phlomis pungens*, by Bech (1963). Azizian and Cutler (1982) found them to be common on most of species of *phlomis* which grow in dry habitat (*Phlomis* section *Phlomis*). Branched glandular trichomes are also reported in *Hyptis* by Rudall (1980).

Bokhari and Hedge (1977) studied the desert group of *Salvia* species and noticed that the hairs are mostly non-glandular, 1-5 celled and simple; branched hairs were noticed in some specimens of *S. scantolinifolia*, most of them with thin, non cutinized cell walls, e.g. in *S. aegyptiaca*; there are also some non-glandular trichomes with 1-3 cells long and thick strongly cutinized cell walls which were noticed only on the lamina of *S. aegyptiaca* and were not observed in other species of this group. Glandular trichomes were noticed as having unicellular stalk and unicellular head or bicellular to multicellular stalk with unicellular head; these are quite common in the *Salvia* species. Glandular trichomes with one or two celled stalk and 8-16 celled heads with a thin layer of cuticle, which have been named by Kissler (1958) as terpene secreting trichomes, or by Solereder (1908) as Intequmentary glands and were found to be quite common in the species examined. They were also found to be more

numerous on the leaf margin and at the base of stomatal groove, in *Salvia* species Bokhary and Hedge (1977).

Azizian and Cutler (1982) subdivided the trichomes of the genera *Phlomis* L. and *Ermostachys* bunge, into three major groups:

1. glandular unbranched with four forms,
2. non-glandular with six forms
3. compound glandular with one form.

The variability in morphology and ultrastructure in secretory trichomes of Lamiaceae makes them a good subject for comparative analysis, they pass through similar stages in their ontogenesis which has been described for some members of the Lamiaceae such as *Origanum dictamnus* (Bosabalidis and Tsekos, 1982), *Perilla ocymoides* (Danilova and Kashina, 1987) and *Nepeta cataria* (Kolalite, 1998). Glandular trichomes of the Lamiaceae originate from a single epidermal cell which undergoes a series of anticlinal divisions followed by periclinal divisions of the apical cell. A mature gland consists of a basal cell, a stalk and a head, there is a correlation between the structure of secretory cells and the terpenes composition (Carde et al., 1982; Telepova et al. 1992).

Maffei, et al. (1985; 1989) studied the genera *Mentha* and *Phenolypicly* and found a variability of hybridization with each other. Halliday and Beadle (1972) reported that *Mentha piperita L.*, (peppermint) is a natural hybrid between *M. aquatica and M. spicata*. They also noticed the strong relationship between the trichome numbers and their distribution (especially peltate and capitate glandular) and quantity of essential oils in developing peppermint leaves.

Fisher (1985) has investigated the leaf epidermis of *Coleus blumei* (Lamiaceae) and found that the lower epidermis has four types of trichomes:

1. unbranched, long, uniseriate with pointed ends.

2. short stalk uniseriate (one or two cells) densely staining head.
3. long stalk and round or oval celled head.
4. small golden glands having a single basal cell and a broad four celled head.

Presence of nonglandular and glandular trichomes was clearly observed by Doaigey and Gawad (1984) on some *Salvia* species living in Saudi Arabia showing with three types of glandular trichomes:

1. unicellular head, unicellular stalk.
2. multicellular head, unicellular stalk.
3. unicellular head, multicellular stalk.

They also found that nonglandular trichomes of unicellular, bicellular to multicellular, 3-11 cells long with thin or thick warty lignified cell walls were frequent in their distribution on the stems and leaves of *Salvia aegytiaca, S. deserti* and *S. spinosa*.

Doaigey *et al*. (1985) studied the type of trichomes on the aerial parts of some Lamiaceae species: *Ajuga bracteosa* Benth*, Lamium album* L.*, Lavandula dentata* L.*, Lavandula pubescens* Decane*, Lavandula stricta* Del.*, Mentha piperita* L.*, Micromeria biflora* Benth.*, Micromeria longifolia,* Borss, et. Hoh.*, Nepeta septemecrenata* Benth*, Ocimum basilicum* L.*, Otostegia fruticosa* Forssk. Brig.*, Otostegia fruticosa var, schemperi* Boiss. Tack*, Salvia aegyptiaca, Stachys aegyptiaca* Pres. In this study, 42 forms of non glandular trichomes and 22 forms of glandular trichomes were observed and classified on the basis of cell wall structure, cell numbers and the branching characteristics of the trichomes.

Cantino (1990) found that most of the Lamiaceae species examined have glandular and nonglandular trichomes: and noticed that simple unicellular, multicellular, uniseriate trichomes and branched multicellular trichomes are present in 16 percent of the genera of Lamiaceae including *Comanthosphace, Gomphostemma Bentham, Leucosceptrum, Marrubium*

L. Perovskia, Karelin, Phlomis and *Rostrinucula*. The same author recorded several forms of peltate and capitate trichomes on the vegetative parts of some Lamiaceae species.

Doaigey (1991) studied the morphology of trichomes on the aerial parts (stems, leaves and floral parts) of the genus *Otostegia* which is represented in Saudi Arabia by two varieties: *O. fruticosa var. Fruticosa* and *O. fructicosa var. Schimperi*, and grouped the trichomes into seven types including 15 forms of non glandular and ten forms of glandular trichomes.

Doaigey (1992) studied the types and occurrence of trichomes in two species of *Lavandula, L. stricta* and *L. coronopifolia* (Lamiaceae) and noticed the two species showed the presence of non-glandular trichomes with cells having warty walls, and glandular trichomes with unicellular, bicellular or multicellular heads, branched glandular and nonglandular trichomes were observed in *L. stricta*. The trichomes of the two species grouped into 8 types comprising 17 forms of non glandular and 13 forms of glandular trichomes.

Elena et al. (1993) in a result of a comparative anatomical study on *Salvia* species, *S. officinalis* and *S. tomentosa* (collected from Bulgaria, Poland, respectively). They noticed that the leaves of the two species having four varieties of glandular trichomes;

1. glandular trichomes with unicellular head and unicellular stalk
2. glandular trichomes with unicellular head and bicellular stalk.
3. glandular trichomes with bicellular head and unicellular stalk (capitate).
4. glandular trichomes with unicellular or bicellular stalk and muticellular head (peltate).

Bosabalidis and Kokkini (1997) reported that the leaves of *Origanum vulgare* have a peltate glandular trichomes and they were numerous on both leaf surfaces.

Bini-Malec, et al. (1997) have done comparative observations on *Thymus striatus* Vahl and *T. striatus* var. o*phioliticus*, *Lacaita* in central Italy reporting peltate trichomes which were previously described by Bruni and Modenesi (1983) and by Modenesi, *et al*. (1984) in *Thymus vulagri*. They also mentioned the presence of many non glandular trichomes and suggested that both taxa are very similar.

Ezer, et al. (1998) studied *Ballota nigra* L. subsp. *anatolica* and observed 5 types of trichomes (two non glandular and three glandular) on the leaves as follows:

1. branched multicelluar non-glandular trichomes.
2. glandular trichomes with 4 cells heads and long stalk
3. glandular with 4 celled heads and short stalk.
4. glandular with 8 celled heads and a very short stalk.
5. non glandular trichomes with 1 – 3 cells of varying lengths.

Kolalite (1998) in a comparative study on two species of *Nepeta*: *Nepeta cataria* and *N. cataria* var *citriodora* by the means of TEM and SEM and reported the presence of peltate and capitate trichomes on both species.

Gavalas, et al. (1998) in a comparative study of leaf anatomy of the hybrid *Mentha x villoso-nervata* and *M. longifolia* and *M. spicata*. They found that leaf surface of *M. longifolia* were covered with non-glandular trichomes, 0.2 mm long. While the leaves of *M. spicata* were covered with non glandular trichomes which were not so densely arranged and their length about 0.6 mm long (about three times longer than those of *M. longifolia)*. They also reported a few branched, non glandular trichomes on the lower leaf surface of *M. spicata* and *M.x villoso-nervata*.

Ascensao et al. (1999) reported five types of trichomes in *Plectranthus ornatus*:

1. peltate glandular trichomes.
2. capitate, glandular trichomes with long stalk.
3. capitate glandular trichomes with short stalk.
4. Digitiform trichomes (unusual conoidal trichomes with long unicellular conical heads which do not show a clear distinction between the apical glandular cell and the subsidiary cells).
5. Non glandular trichomes, uniseriate, multicellular, (erect or leaning towards the leaf apex, vary in length between 130-350 μm and consists of 3 to 7 cells long and supported by a cellular pedestal formed by a group of six to twelve epidermal cells arranged in a circle around the base).

Mucciarelli and Sacco (1999) noticed the presence of peltate and capitate glandular trichomes and counted them by means of scanning electron microscope (SEM) in the upper and lower epidermises of the leaves of *Mentha requieni*. They also found that the leaves contained non glandular trichomes.

Turner *et al*. (2000) examined the ultrastructure development of peltate glandular trichomes in peppermint, (*Mentha x piperita*) and confirmed the existence of peltate trichomes in this species.

1.2.2. Leaf Internal Structure

1.2.2.1. Epidermal cells:

The *Salvia* species were with uniseriate adaxial and abaxial surfaces. The thickness of the adaxial surface is more than the abaxial one, with thick cuticle in *Salvia* (Fahmy, 1997). The upper and the lower epidermis consist of cubical parenchyma cells in *Marrubium vulgare* (Al Yahya, et al., 1990).

Hydathodes recorded at the leaf margins in *Dysophylla* (Metcalfe and Chalk, 1950).

Hypodermis consists of large cells present below the upper epidermis in *Rosmarinus officialis L*., (Metcalfe and Chalk, 1950).

1.2.2.2. Mesophyll: Mesophyll consists of palisade tissue in species of *Salvia* (Etienne, 1930) or isobilateral (palisade tissue under the upper and lower epidermises) in *Lavandula bucheri* Webb et Benth; Centric in *Lavandula pinnata* L. Cells of the spongy mesophyll mostly orientated at right angles to the lower epidermis in few species of *Bystropogan, Leucrium* and *Thymus*. The type of mesophyll is reported to be unreliable for diagnostic purposes owing to variations in responses to environmental conditions (Buch, 1926).

The transverse sections of the leaves of the three *Salvia* species *S. aegyptiaca, S. deserti* and *S. spinosa* showed that these species are characterized by the presence of collenchymatous cells in the midrib region and palisade tissue in the intercostal region (Doaigey and Gawad, 1984).

Christodoulakis and Bazos (1990) found tannin in the mesophyll specially in winter leaves of *Ballota acetabulosa* and *Inthyllis hermaniae* (Lamiaceae).

In a study on the mesophyll of *Origanum vulgare* by Bosabalidis and Kokkini (1997) the leaves of subspecies *viridulum* were found to have thin lamina, short palisade parenchyma, with large intercellular spaces. Aerenchyma also observed in the spongy tissue, and the spongy cells were very small compared to other subspecies leaves.

1.2.2.3. Vascular Tissue:

Vascular bundles are accompanied by sclerenchyma in some species in particular those showing xerophytic features, while others are frequently surrounded by a parenchymatous sheath (Metcalfe and Chalk, 1950). Large strands of fibers connected with the vascular bundle were observed in *Micromeria* (Etienne, 1930).

Midrib contains a single vascular bundle supported by collenchyma above and below in *Monarda* (Holm, 1911) or two vascular bundles partly fused laterally in *Cunila* or with a circle of 5 collateral bundles with xylem towards the center in *Colinsonia* and *Canadensis* L. (Holm, 1909).

Metcalfe and Chalk (1950) reported that the vascular tissue of leaf petiole is appearing as a simple shallow to moderately deep arc of widely spaced strands in species of *Coleius*, *Horminum* and *Monarda* or medium, crescentic vascular bundle in species of *Ballota, Lavandula, Melissa* and *Nepeta*. The main vascular bundles occurred in the form of a continuous arc with very curved ends or even tending to become cylindrical in species of *Leonurus, Phlomis, Stachys* and *Teucrium*. A dissected vascular arc occurred in species of *Elsholtzia, Galeopsis, Plectranthus* or with an adaxially concave cylinder of numerous separate bundles presented in *Phlomis tuberose L*. Additional subsidiary vascular bundles presented in the petiolar wings in all the species examined. Holm (1908) reported a single broad bundle surrounded by thin walled parenchyma and hypodermal collenchyma in leaf petiole of *Hedeome*.

1.2.2.4. Secretory Structures:

In the mesophyll of *Brazoria* and *Physostegia*, large sac-like secretory cells were observed and oil was recorded in *Leucus aspera L*. by Mullan (1932).

1.2.2.5. Crystals:

Calcium oxalate crystals as small needles, raphides, rods or octahedra, often occurring in considerable numbers in one cell. Cluster (Druses) crystals were comparatively rare and were recorded according to Solereder (1914) in species of *Lycopus*, *Salvia*, and were reported by Etienne (1930) in *Lavandula pinnata* L. These crystals and ordinary solitary crystals occurred more frequent in the floral organs.

Crystalliferous sclerechyma were recorded by Solereder (1914) in the lowest part of the leaf in *Salvia*. Metcalfe and Chalk (1950) said that the scutellarin substances occur in the epidermis especially on the abaxial surface of the leaf in *Scutellaria,* as well as *Galeopsis*, *Tetrahit* L. and *Feucrium chamaedrys* L. Test for this substance in species of *Mentha, Nepeta* and *Thymus* were negative according to Solereder (1914).

Statoliths occur in a layer of cells just outside the phloem of the midrib axis and secondary veins, in *Coleus blamei* (Lamiaceae) leaves (Fisher, 1985).

1.2.3. Stems: Internal Structures

1.2.3.1. Epidermal Cells:

Cuticle is often thick, especially in xerophytes, e.g. *Lavandula, Micromeria* and *Thymus* (Etienne, 1930). Epidermal cells with papillose were noted by the same author in species of *Lavandula* and *Thymus*.

1.2.3.2. Cortex:

Stem is in many genera and species quadrangular in transverse section. Well-defined groups of collenchyma in the stem angles were reported in species of *Acanthomintha, Cedromella, Ceranthera, Orthosiphon* and *Poliomintha* (Lemesle, 1928). Sub-epidermal collenchyma was also noted by the same author in *Eriope, Meriandra, Perilomia* and *Zataria*; a large group of collenchyma present against each of the four sides of the stem in *Pycnostachys reticulate* Benth., small groups of collenchyma occur between the largest ones in the corners were reported in species of *Anisomele, Dysophylla, Hormium, Haslandia, Lasiocorys, Leonurus, Lycopus* and *Marsupianthus*; as well as a continuous ring of collenchyma in primary cortex was recorded in species of *Aeolanthus, Anisochilus, Chelonopsis, Coleus* and *Colquhaunia* (Metcalfe and Chalk, 1950).

Individual fibers occur among the collenchyma in *Cunila galiorde* Benth; fibers with thick lignified cell walls were observed in the cortex of *Anisochilus* and *Geniosporum;* whereas fibers with thick unlignified cell walls were found in *Eriope* and *Keithia*; fibers with thin and thick lignified cell walls united to form a complete ring were observed in *Gardoquia* (Metcalfe and Chalk, 1950).

Other features of the primary cortex are characteristic of particular genera and species such as: Presence of palisade tissue was found in *Lavandula*, a hypodermal layer of lignified cell walls were observed in *Parsium*; large intercellular spaces were reported in *Pranella* and *Stachys*. Primary cortex of the *Dysophylls verticillata* Benth including a well-developed system of intercellular spaces (Metcalfe and Chalk, 1950).

Transverse sections of the stems show that the cortex is made of collenchymatous tissue in the corners immediately below the epidermis interchanged with 3 or 4 layers of well developed palisade chlorenchymatous cells in *Salvia aegyptiaca* and *S. deserti* and with 2 to 4 layers of small rounded chlorenchyma cells in *S. spinosa*. The remainder of the cortex is a distinct single layer of large parenchymatous cells in *S. aegyptiaca* and *S. deserti*, while in *S. spinosa* it consists of 4-7 layers of parenchymatous tissue (Doaigey and Gawad, 1984).

Collenchyma is well developed in the corners of the stem below the epidermis; stem cortex with parenchymatous cells and a closed ring of endodermis both having groups of sclerotic cells were reported in *Ballota nigra* subsp *anatolica* (Ezer et al., 1998).

i. **Cork** is generally rare, but well developed cork was reported in certain genera and species (Metcalfe and Chalk, 1950), various researchers observed that it is arising in the sub-epidermal region in species of *Aeolanthus, Anisochilus, Cedronella, Coleus, Eriope, Stachys* and *Salvia*. Cork formed in the primary cortex of species of *Hyssopus,*

Lasiocorys and Lavandula, or arising in the pericycle in some species of *Ballota, Bystropogon, Elsholtzia and Gardoquia*. Cork formed in the pericycle first but later developed in the secondary phloem in species of *Meriandra* and *Poliomintha*. Successive zones of cork also arose at progressively deeper levels, including the phloem, in stems of various strongly xerophytic species of *Salvia*; early cork formed in the pericycle and late cork formed in the xylem of some species *Hymenocrater bitruminosus* Fisch. (Lemesle, 1928).

ii. Endodermis:

Cells with thin walls often differentiated from cortical cells were reported (Metcalfe and Chalk, 1950); large cells with completely suberized cell walls were observed in species of *Bystropogon, Thymus* and *Micromeria* (Etienne, 1930). Lemesle (1928) also described the endodermal cells as large cells but not suberized, in some species *Orthosiphon*. Casparian strips noted by Mullan (1932) in *Leucos aspera* Link and observed in few species of *Ballota, Galeopsis, Prunella, Scutellaria* and *Stachys*.

1.2.3.3. Outer Phloem Fibers (Pericycle):

Lemesle (1928) has reported the following features or characters concerning the outer phloem fibers (pericycle fibers):

a. In species with differentiated endodermis, outer phloem fibers were absent eg. *Acanthominta, Ceranterosolier* and *Zataria*; or occurring as isolated elements or small groups in *Chelonopsis, Caraniotome, Cunila and Dysophylla* or forming arc shaped opposite to the angles of the stem in *Cedronella, Marsypianthus* and *Orthosiphon*; or numerous in *Perilona,* and arranged in large groups in *Colquhounia*.

b. In species with no well defined endodermis, outer phloem fibres absent from *Garoquia*, generally occurred; in other genera and

species examined in closely placed groups in *Hemiandra, Haslundia, Meriandra* and *Pysnostachys*, forming compound continuous rings in *Eriope* and *Geniospermum*.

Discontinuous ring of fibers recorded by Solereder (1914) in species of *Ajuga, Cymaria* and *Marrubium.* Large strands of fibers opposite to the angles of the stem in species of *Cedronella, Lavandula, Salvia* and *Hymeoerater* by Lemesle (1926). Separate strands of outer phloem fibers noted in *Marrubium* by Holm (1911), outer phloem fibers were absent from species of *Mentha* and *Thymus* (Metcalfe and Chalk, 1950).

1.2.3.4. Phloem:

The phloem consists of groups in 4 large vascular bundles opposite the 4 angles of the stem and are occasionally connected to one another either by sclerenchymatous cells in species of *Hyssopus, Ocimum* and *Phyllostegia* or by groups of elongated sclerotic cells in the secondary phloem of *Salvia broussonetil* Benth (Etienne, 1930), or connected by fibers (Lemesle, 1928) in *Cunila, Meriandra and Tinnea* or the outer phloem fibers forming a continuous ring in old stems of *Hemiandra* (Metcalfe and Chalk, 1950), phloem cells are crushed and small in *Ballota nigra* subsp. *anatolica* (Ezer et al. 1998).

1.2.3.5. Xylem:

Xylem composes of a continuous cylinder at a very early stage in most of the genera and species examined at kew, except *Horminum pyrenaicum*, because of the development of interfascicular fibres between the xylem groups of vascular bundles (Metcalfe and Chalk, 1950).

Xylem in the form of continuous cylinder were reported in species of *Bystropogon, Lavandula, Micromeria, Sideritis, Teucrium* and *Thymus.* Xylem in the form of discontinuous cylinder were found in other species endemic to the Canary Islands. In the continuous xylem,

vascular bundles being separated from one another by interfascicular sclerenchyma (Etienne, 1930).

Lemesle (1926) observed four large vascular bundles in the angles of the stem separated from one another by sclerenchyma with small secondary vascular strands embedded in it in *Aeolanthus, Anisochilus, Cedreonella, Chelonopsis* and *Marsypianthus*. An eccentric growth in thickness with subsequent formation of new strands of xylem in the secondary phloem of old stems of *Thymus* were reported by Solereder (1914). Four primary vascular bundles with secondary strands between them presented in some herbaceous species e.g. in *Nepeta* (Holm, 1911).

A few strands of cambium were observed between phloem and xylem. Xylem is well developed in the bundles and the bundles were connected by tracheids (Ezer et al., 1998).

1.2.3.6. Pith (Medulla):

The pith is commonly homogeneous and frequently becoming hollow in herbaceous species. Pith of most of the species endemic to the Canary Islands described as persistent and becoming sclerified, large groups of isodiametric sclerotic cells embedded in the mainly unlignified pith in some species of *Salvia* and *Broussonetic* (Etienne, 1930). Pith having cells with lignified cell walls was reported in *Leucas* and *Aspera*, according to Mullan (1932). Pith with cells having cellulosic cell walls was reported in *Anicocious* and *Mariandria*, while pith having cells with wholly lignified cell walls and sometimes very small in diameter were mentioned in the remaining genera and species examined by Lemesle (1928).

1.2.3.7. Crystals:

Calcium oxalate crystals are similar to those described in the leaf but additional crystals, e.g. sphaero-crystals, believed to consist of hesperedin recorded in the phloem of *Mentha piperita* by Kudelka,

(1926) and observed at kew in a few species of *Hyssopus, Mentha* and *Monarda* (Metcalfe and Chalk, 1950). Some crystals idioblasts were observed in the pith region by Ezer et al. (1998).

1.2.4. Pollen Grain Characters:

The importance of palynological studies in solving some taxononmic and phylogenetic considerations is well known. Contribution to the pollen morphology of some members of the Lamaiaceae have been studied by Erdtman (1945), Nabilis (1972), Belkin (1972) and Mukherjee (1972).

Some morphological studies on pollen grains of the genus *Salvia* were done by Emboden (1965), pollen grains in the genus *Salvia*, section *Audibertia* revealed some differences in their sizes, shape and exine stratification, which suggested their pollen might be identified on the basis of these observations by Harley et al., (1992).

1.3 TAXONOMY

Different classification have been applied on the family Lamiaceae, based on morphological differences, subdividing the family into subfamilies, tribes and subtribes.

Bentham (1876) divided the family Lamiaceae to eight tribes (Appendix 1.2).

On the basis of floral characters. Briquet (1895 – 1897) classified the Lamiaceae into five subfamilies, (Appendix 1.3) then divided the subfamilies into eight tribes and sub-tribes.

Bessey (1895) separated Lamiaceae from Verbernaceae and placed them under Lamiales. Hutchinson, (1948) followed Bessey (1895) but considered the families as two separate entity, placed Lamiaceae in his Herbaceae and Verbenaceae in his Lignosae.

Stauffer (1937), on the basis of a comparative study of floral anatomy of the Lamiaceae concluded that the ovule – attachment region appear to be the most reliable anatomical character to use in tracing phylogeny within the mint and other genera in Lamiaceae, suggested the following arrangement of its sub-families from a primitive to an advance subfamily as follows:

Primitive
1. *Stachoideae*
2. *Scutellarioideae*
3. *Lavanduloideae*
4. *Catopherioideae*
5. *Ocimoideae*
6. *Parsioidea*
7. *Prostantheroideae*

Advanced
8. *Ajugoideae*

Hillson (1959) also mentioned that if the marginal position of the ventral capillary trace is interpreted to be an advance, then the complete reversal of the series suggested by Stauffer (1937) was proposed, so the arrangement can not be definite until more genera are investigated.

Thonner (1962) divided the family Lamiaceae into six subfamilies, according to the stamen characters, one of which is the Stachyoideae, which consists of 8 tribes with 37 genera, including numerous species distributed all over the world (Appendix 1.4).

Erdtman (1971) divided the family Lamiaceae into two groups on the bases of their pollen grains morphology, one with three aperturate and the second with six aperturate pollen grains, which supported the classification of Lamiaceae into two sub-families, namely: Lamioideae

and Nepetoideae. The primitive genera belong to Lamioideae have close links with Verbenaceae due to their intermediate gynoecial morphology.

Most recently, Cantino et al. (1992) on the basis of phylogenetic analysis classified the genera of Lamiaceae under seven sub-families which consists of six tribes (Appendix 1.5).

1.4. MORPHOLOGICAL CHARACTERS OF THE SPECIES

The morphology of the species under study was described by Migahid (1989) and Chaudhary (2002) and summarized as follows:

1.4.1. *Marrubium vulgare* L.

Arabic Name: Zaqqum, Frasyoon

Perennial plant, 40-60cm high with branched stems, white-woody siniple or sparingly. Leaves finely dentate rounded, often dark green, 1.3 cm long with whorled dense flowers. Bracts subulate, hooked at apex, calyx with 10 minute teeth, spreading, hooked in apex. Corolla small white with minute teeth. (Migahid, 1989) (Appendix B1).

Saudi Arabia: Asir and Western Heights.

1.4.2. *Micromeria biflora* Benth.

Perennial herbs, leaves simple dark green, 6 mm long 3 mm broad. Flowers very small, pure white calyx tubular, 5-tooth, corolla bilabiate (Migahid, 1989).

1.4.3. *Mentha microphylla* C. Koch

Arabic Name: Naana

Perennial herbs, leaves broad, serrate sessile or nearly so, densely grey-pubescent of branched hairs. Inflorescence narrow with spike like racemes (Appendix B2) (Migahid, 1989).

Saudi Arabia: Western mountain range

1.4.4. *Nepeta deflersiana* Schweinf.

Arabic Name: Firuwak, Khausha

Perennial herb with small crenate leaves. Inflorescence spike with blue flower whorls; calyx and corolla two lipped, stamens 4, nutlets smooth (Appendix B3) (Migahed, 1989).

Saudi Arabia: Asir

1.4.5. *Nepeta septemecrenata L.*

Woody base, white-tomentose, perennial herb, branched from base, up to 25 cm tall; leaves petiolate, many flowers, calyx 8 mm long, corolla white two lobed (Appendix B4) (Chaudahry, 2002).

Saudi Arabia: Northern Hijaz mountains

1.4.6. *Otostegia fruticosa* var*: Fruticosa* (Forssk.) Brig.

Arabic Name: Sharm, Shakab

Shrub with ascending long slender branches. Large leaves. Bracts filiform palmate-parted at the base of the calyx, with small ovate upper lip and squared entire lower lip (Appendix B5) (Migahid, 1989).

Saudi Arabia: Western heights

1.4.7. *Otostegia fruticosa* var*: Schimperi* (Boiss.) Täckh.

Shrubby, minutely ovate leaves, densely wooly, with short petioled. Bracts few, short linear. Calyx hairy with small, bilabiate limb, corolla bilabiate (Appendix B6) (Migahid, 1989).

Saudi Arabia: Western heights

1.4.8. *Salvia aegyptiaca* L.

Arabic Names: Ghashba, Ghashbama, Raala, Shajrat al Ghazal

Green dwarf shrub, canescent, up to 20 cm high, intricately branched with stiff almost spinescent branches. Leaves opposite, few, oblong-linear, sessile or almost sessile base, toothed. Flowers 2-4 whorls. Calyx 2-lipped, puberulent or hispid of long white hairs. Corolla

glabrous about one and a half times as long as calyx. (Appendix B7) (Migahid, 1989).

Saudi Arabia: Widespread

1.4.9. *Salvia deserti* Decne

Arabic Name: Jana'a

The whole shrub white-hispid with simple branches few leaves, small obtuse. Flowers sessile in dense of 4-8 flowered whorls. Calyx hirsute, ovate with the 2 lips about equal. Corolla glabrous, white 1.5 times as long as the clayx (Appendix B8) (Migahid, 1989).

Saudi Arabia: Central and Northern region

1.4.10. *Salvia spinosa* L.

Arabic Name: Harsha, Taala, Shajrat al Jamal

Perennial spreadingly hairy; leaves both radical and floral: radical leaves very long rosette, floral leaves smaller, simple crenate to dentate, ovate. Bracts and calyx with rigid spines. Flowers whorls 2-6 flowered. Calyx tubular bilabiate; corolla white 1.5 times as long as the calyx (Appendix B9) (Migahid, 1989).

Saudi Arabia: Patchily distributed.

1.4.11. *Stachys aegyptiaca* Pers.

Woody based white to grey herb. With leafy to twiggy branches. Stem and leaf hairs very finely branched. Leaves short petiolate, 2-4 flowers. Calyx tubular. Corolla rosy lilac (Appendix B10) (Chaudary, 2002).

Saudi Arabia: Northern Hijaz

1.4.12. *Stachys schimperi* Vatke

Yellowish white shrub, branched. Leaves thick, shortly petiolate to sessile, crenate. 6-8 flowers in the axils of short leaf-like bracts. Calyx cylindrical. Corolla deep pink to magenta violet. (Appendix B11) (Chaudhary, 2002).

Saudi Arabia: Asir, Northern Sarawat

1.4.13. *Stachys yemensis* Hedge

Shrub, stems white, leaves short-petiolate, green above, white beneath. Four to six (-14) flowered in the axils of upper leaves forming terminal racemes. Calyx white-tubular, corolla pink. (Appendix B12) (Chaudhary, 2002).

Saudi Arabia: Asir

1.4.14. *Thymus decussatus* Benth.

Small, twiggy shrublet; leaves narrow few flowers arranged in terminal heads, white. Corolla externally densely pilose (Appendix 13) (Chaudhary, 2002).

Saudi Arabia: Northern Hijaz

1.4.15. *Thymus aff. vulgaris*

Small woody shrublet, leaves lanceolate to broad elliptic, flowers white or purple, calyx densely pubescent. Corolla, externally dense pubescent and with a dense cover of oil globules (Appendix 14) (Chaudhary, 2002).

2.0 PLANT MATERIALS AND METHODS

2.1. Plant materials

Materials for the species under investigation were obtained from fresh plants during their flowering seasons, preserved in 70% ethanol or from herbarium specimens deposited either at the herbarium of King Saud University (KSU) or at the National Herbarium of Saudi Arabia (RIY) (Table 2.1).

2.2. METHODS OF INVESTIGATION

2.2.1. Epidermal Preparation

Surface preparations of **leaves** of plant material under investigation were made from mature plants. In species obtained from dried material (Herbarium), 1 or 2 leaves were taken and soaked in water for 1 or 2 days, then 5 to 10 epidermal strips were examined after mounting in 50% v/v glycerol solution. In species obtained from preserved materials, at least 5 samples were taken sample were chosen and 5 to 10 epidermal strips of each leaf area (midrib region, intercostal regions) were taken, and mounted in 50% v/v glycerol solution.

Surface preparations of **stems** preserved and dry material (after soaking in water 1-2 days) were made by stripping the epidermis and three epidermal strips were taken from each lower, middle and upper areas of stems, and then mounted in 70% v/v glycerol solution.

Surface preparations of **floral parts** were mounted in 50% v/v glycerol solution either directly or by clearing the organ with chloral hydrate solution, followed by mounting in 50% v/v glycerol solution (Doaigey, 1416 H in arabic).

2.2.2. Section Preparation:

2.2.2.1. Temporary preparation:

Sections of 20-25μm thick were cut by rotary microtome, when tested for the following cell contents:

1. Cellulose: Sections were mounted in iodine solution and 66% sulfuric acid.
2. Hemicelluloses: Sections were mounted in Ruthenium Red.
3. Cutin: Sections were mounted in Sudan 3 or 4.
4. Lignin: Sections were mounted in phloroglucinol (in alcohol) and concentrated HCl.
5. Suberin: Sections were mounted in Sudan 3 or 4.
6. Fats and Oils: Sections were mounted in Sudan 3 or 4 with heating.
7. Tannins: Sections were mounted in ferric chloride solution.
8. Calcium oxalate: Sections were mounted in 66% sulfuric acid (H_2SO_4).
9. Silica and Silica bodies: Sections were mounted in Hydrofluaric acid.
10. Starch grains: Sections were mounted in iodine solution.

2.2.2.2. Permanent Preparation:

Parts of ½-1 cm of the leaves and stems of species under study were cut and prepared by paraffin method according to Alkazraqi and Aziz (1989 in arabic) for studying their internal structures (anatomy) which summarized as follows:

1. Fixation: using FAA (formalin, acetoalcohol) for 12 hours.
2. Dehydration: using ethanol (in graduate concentrations of 70, 80, 96 and 100%).

3. Clearing: using xylene, starting with 1:3 v/v xylene:ethanol, for 2 hours; 1:1 v/v xylene:ethanol for 2 hours, 3:1 v/v xylene:ethanol for 2 hours, lastly absolute xylene for 24 hours.
4. Embedding: using paraffin wax (adding paraffin wax gradually till reaching saturation for 24 hours, then to pure paraffin at 60^{o}C in oven for 24 hours.
5. Cutting: using rotary microtome at 15-30 μm thick for sections of the leaves and the stems.
6. Staining: using graduate concentrations of ethyl alcohol 100%, 96%, 80%, 70%, 50% in each for 1 minute in each, followed by safranin for ½ hour and light green for 15 seconds.
7. Mounting: using Canada Balsam or DPX solutions.
8. Photographs were taken, by Light Microscope (Olympus BX41TF with camera video TK – C1381EG).

2.2.4. Pollen grain preparations

2.2.4.1. Light Microscope (LM):

Pollen grains were prepared for the light microscope examinations, using the usual acetolysis method (Punt, 1962).

1. Preserved buds or young flowers were used, then with the aid of dissecting microscope and by using the tip of a needle and a glass rod to mix and facilitate the release of the pollens.
2. They were transferred to a test tube, and a few drops of glacial acetic acid were added to facilitate the removal of water from the sample.
3. The acetolysis mixture (2 cm^{3}) was added (consisting of 9 parts of acetic anhydride to 1 part concentrated sulfuric acid) and the container containing the mixture put in boiling water bath or a hot plate at 100^{o}C for 5 min.

4. Methylate spirit (ethyl alcohol + methanol) was added to get rid of the dark ring which rises up the spots, leaving the pollen grains down, again more drops of ethanol were added to prevent the grains from drying.
5. The pollen grains were stained by adding a small drop of safranin or acetocarmine and mixed carefully with a Pasteur pipette.
6. A small volume of the mixture was pipetted on to a clean slide then a drop of glycerin was added then the cover slip was lowered carefully over the glycerin.

Measurements for the LM were taken within two to four days period to avoid the possibility of error introduced by differential swelling. Twenty pollen grains were measured with the aid of an ocular micrometer. Measurements include polar length (D_1), Equatorial Diameter = (D_2). Colpi length = (D_3).

2.2.4.2. Scanning electron microscope samples (SEM):

Step 1: as above (Steps 1 – 4).

*Step 2***:** Samples of pollen grains placed onto stubs previously prepared for pollen work as indicated below:

Stub Preparation: Stubs cleaned and labeled by using small squares of self-adhesive label coded and stuck to the bottom of the stub, a small square of double sided tape applied to the top of the stub on top of which a section of clean cover slip was placed to give a neutral smooth background.

Step 3: The pollen sample was run through an alcohol series 50%, 95% and 100% on the stub using micro-pipettes, (without losing any pollen), the sample was then put in a vacuum dessicator for c. 1hour.

Step 4: Stubs were then coated usually to about 30 nm with gold and was then ready for scanning.

Step 5: Photographing the pollen grains was done using a JSM-5800LV (JEOL) Scanning Electron Microscope.

2.3 Measurements

2.3.1. Cell measurement:

Cell wall thickness was measured according to Doaigy *et al.* (1989). [very thick > 12 μm, thick from 6-12 μm, slightly thick, 2.5 – 6 μm, thin < 2.5 μm, by using an eyepiece micrometer. Stomata measurements (width and length) were measured by eyepiece micrometer, number of stomata per 1 mm^2 epidermal surface were taken by square graticule.

2.3.2. Pollen grain measurement:

Measurements for the pollen grains were taken according to Erdtman (1971) [very small less than 10 μm diameter; small, 10-25 μm; medium; 25-50 μm; large, 50 - 100 μm; very large; 100-200 μm; huge: larger than 200 μm], using the LM.

2.3.3 Photographs:

Pictures were taken for the epidermal and internal characters, using the Light Microscope, Olympus BX41TF picture image, with camera video TK – C1381EG (Appendix C1).

3.1. *Marrubium vulgare L.*

3.1.1. EPIDERMAL CHARACTERS

3.1.1.1. Leaf, Midrib Region

Upper epidermis: Cells polygonal elongated 95 – 89 – 62 μm long, 28.6 – 25 – 23 μm wide with thin straight anticlinal walls exhibiting beading (Figure 3.1.1 A). **Cuticle** striated. **Stomata:** absent. **Trichomes*:*** are glandular and nonglandular. (Figure 3.1; Table 3.1)

Nonglandular: Trichomes:

a. Unicellular, unbranched with thick warty walls wide lumina and acute apex, 2.5 – 7.5 μm in cell wall thickness, occasionally papillose (Figure 3.1A).
b. bicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.1.1 E).
c. Multicellular (3), uniseriate, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.1.1D).

All of the above trichomes irregularly distributed, heading towards the apex of the leaf blade, and with cellulosic and hemicellulosic cell walls.

Glandular: Trichomes:

a. Stalk unicellular, unbranched, head unicellular (Figure 3.1.1. A, C).
b. Stalk unicellular unbranched, head bicellular (Figure 3.1.6 b).
c. Stalk unicellular unbranched, head multicellular (4 - 16cells), spherical in surface view (Figure 3.1.6 d).

Lower epidermis: Cells polygonal elongated 170 – 90 – 59 μm long 60.5 – 45.9 – 28.5 μm wide with thin cellulosic beaded cell walls (Figure 3.1.1 B). **Cuticle** striated longitudinally. **Stomata*:*** absent.

Trichomes: Similar to those of the upper midrib region (Figures 3.1.1 B, C, D, E and 3.1.6 a, b, Table 3.1).

3.1.1.2 Leaf, Intercostal Region

Upper epidermis: Cells polygonal, 162.5 – 82.5 – 50 μm long, 62– 47.9 – 30 μm wide with slightly thick straight cellulosic and hemicellulosic anticlinal walls beaded, **cuticle** striated (Figures 3.1.2 A, B; Table 3.2). **Stomata**: numerous (300/mm^2) diacytic ovate or circulate 17 – 32 – 25 μm wide 17 – 40 – 30 μm long. Circular type, occasional, 17 ± 3 μm in diameter both commonly at the same level of the epidermal cells, irregularly distributed (Figure 3.1.2A, B). **Trichomes*:*** similar to those of the upper midrib region (Table 3.2).

Lower epidermis: Cells polygonal with slightly sinuous cellulosic anticlinal walls, walls slightly thick, exhibiting beading, 105 – 78.5 - 50 μm long, 62.5 – 50 – 43.2 μm wide (Figure 3.1.2C; Table 3.2). **Cuticle** striated (Figure 3.1.2C). **Stomata:** numerous (300/mm^2) diacytic, ovate or circulate. Ovate type, 37.5 – 28.7 – 12μm long, 28 – 24 – 12 μm wide, circulate type 25 ± 2 μm wide, both irregularly distributed. **Trichomes:** Similar to those of the midrib region (Figure 3.1.2. C) (Table 3.2).

3.1.1.3. Stem Epidermis

Epidermis: Cells are polygonal elongated with thin straight anticlinal walls at stem angles, or polygonal in between stem angles with thin, straight, cellulosic anticlinal walls, exhibiting beading (Figure 3.1.3A, Table 3.3). Cells 75 – 50.2 – 35 μm long and 47 – 26.25 – 17.5 μm wide; cells showing some solitary crystals (Figure 3.1.3 C). **C*uticle*** smooth. **Stomata:** few, 50/mm^2, commonly diacytic, occasionally anisocytic ovate, 30 – 28.7 – 25 μm long 25 – 21 – 20 μm wide.

Trichomes: are glandular and nonglandular (Figure 3.1.3 A,B,C; Table 3.3).

Non glandular:

a. Unicellular, unbranched, with thick, warty walls, wide lumina, and acute apex (Figure 3.1.3A, B, C).

b. bicellular, unbranched, uniseriate with thick warty walls, wide lumina and acute apex (Figure 3.1.3 B).

c. Multicellular (3 – 5) cells, unbranched, uniseriate with thick warty walls, wide lumina and acute apex (Figure 3.1.3 C).

All of the above trichomes are covered with thick cuticle and their density 200/mm^2 and similar to those on the leaf blade.

Glandular:

a. Stalk unicellular, unbranched and heads unicellular with spherical shape (Figure 3.1.3A).

b. Stalk unicellular, unbranched and head bicellular (Figure 3.1.3 B, 3.1.6 b).

c. Stalk unicellular, unbranched and head multicellular (4 – 16 cells) with spherical shape (Figure 3.1.6 d).

3.1.1.4. Flower

3.1.1.4.1. Calyx

3.1.1.4.1.1 Abaxial surface

Cells polygonal with thin sinuous anticlinal cellulosic walls exhibiting beading (Figure 3.1.4 A; Table 3.4); cells, 39 – 35 – 22 μm long 37.5 – 30.4 – 27 μm wide (Figure3.1.4 A). **Cuticle** striated especially on calyx leaf bases. **Stomata*:*** numerous, (200/m^2) diacytic, ovate or circulate, and occasionally anisocytic ovate. **Trichomes*:*** very dense 250/mm^2 especially on the calyx margins (Table 3.4).

Nonglandular:

a. unicellular, unbranched with thin warty wall, wide lumina and acute apex (Figure 3.1.4 A).
b. bicellular, uniseriate, unbranched with thin warty walls wide lumina and acute apex (Figure 3.1.4 C).
c. multicellular (3-4 cells) uniseriate, unbranched with thick warty walls wide lumina and acute apex. Some cells are collapsed (Figure 3.1.4 D, Table 3.1.4 C).

Glandular:

a stalk unicellular unbranched, heads unicellular with spherical shape (Figure 3.1.4 B).
b. stalk unicellular unbranched, heads bicellular (Figure 3.1.4 B).
c. stalk unicellular, unbranched, heads multicellular (4 – 16) with spherical shape (Figure 3.1.4 B).
d. stalk multicellular (3 – 5), unbranched, heads unicellular rounded (Figure 3.1.4 C, Table 3.4).

3.1.1.4.1.2 Adaxial surface

Cells polygonal with sinuous anticlinal cellulosic thin walls exhibiting beading 39 – 32 – 25 μm long, 30 – 20 – 14μm wide (Figure 3.1.4 B). **Cuticle** striated (Figure 3.1.4 B, Table 3.4). **Stomata:** numerous (200/mm^2) commonly diacytic ovate occasionally anisocytic 31 – 23 – 21 μm wide and circulate. **Trichomes:** are nonglandular and glandular (Figure 3.1.4 C, Table 3.4).

Nonglandular: Very dense, 500/mm^2. Similar to that of the abaxial surface.

Glandular: Similar to those of the abaxial surface.

3.1.1.4.2. Corolla:

3.1.1.4.2.1. Abaxial surface

Cells elongated with sinuous anticlinal cellulosic thin walls, exhibiting beading (Figure 3.1.5 A; Table 3.4). Cells, 58 – 30 – 23.5 μm long, 37.5 – 27.5 – 17.5 μm wide **Cuticle** smooth. **Stomata*:*** numerous 200/mm^2 diacytic, ovate, occasionally anisocytic (Figure 3.1.5A). **Trichomes*:*** are nonglandular and glandular intermixed, similar to those of the calyx abaxial surface, mainly distributed at the corolla margin. Numerous solitary crystals where found at the base of the corolla (Figure 3.1.5 C).

3.1.1.4.2.2. Adaxial surface

Cells isodiametric elongated with thin sinuous anticlinal cellulosic cell walls exhibiting beading (Figure 3.1.5 B; Table 3.4). **Cuticle** smooth cells, 52– 35.4 –15 μm long, 50 – 29.1 – 20 μm wide. **Stomata:** similar to those at the abaxial surface (Figure 3.1.5 B). **Trichomes: nonglandular** and **glandular** are similar to those of the calyx (Figure 3.1.4 B,C; Table 3.4).

3.1.2. INTERNAL STRUCTURE

3.1.2.1. Leaf, Midrib Region

Upper epidermis: Cuticle thin, cells tabular with thick slightly cutinized outer walls and thin inner walls (Figure 3.1.7 B; Table 3.6). **Messophyll:** consist of 2 or 3 layers of lamellar collenchymatous cells (hypodermal) followed by 3 – 6 rounded parenchymatous cells devoided of chloroplasts, with thin cellulosic walls, surrounding the vascular bundle. **Vascular tissue*:*** consist of one large arched vascular bundle, primary xylem element with wide lumina and lignified cell walls, vessels arranged in rows. Primary phloem elements as one group of sieve tube

elements, companion cells and fibers with thin unlignified walls (Figure 3.1.7 B, Table 3.5).

Lower epidermis: characters similar to those of the upper epidermis.

3.1.2.2. Leaf, Intercostal Region

Upper epidermis: Cuticle thin, cells tabular with the outer walls are thick and inner walls are thin (Figure 3.1.7 A, C, Table 3.6). **Messophyll:** Differentiated into palisade and spongy tissue, the palisade, consisted of 2 or 3 layers of palisade type cells below the upper epidermis with numerous chloroplasts and large intercellular spaces, followed by 3 or 4 layers of spongy type cells round in shape with numerous chloroplasts and large intercellular spaces (Figure 3.1.7 A, C, Table 3.6).

Lower epidermis: characters similar to those of the upper epidermis.

3.4.2.3. Stem

The transverse section of the stem is quadrangular in outline, exhibiting some glandular and nonglandular trichomes (Figure 3.1.8 A, B, C; Table 3.7).

Epidermis: One layer of rounded to tabular cells, with thick outer walls, radial walls are thin, and both cellulosic. **Cuticle** is thin.

Cortex: Consist of patches of 8 or 9 cells of lamellar collenchyma at stem angles only and one cells layer of hypodermal in between the stem angles, 1–3 layers of small round chlorenchyma cells, filled with chloroplasts, and with conspicuous intercellular spaces; followed by large rounded parenchyma cells reaching to 2 or 3 layers especially in between stem angles devoided of chloroplast with cellulosic cell walls and conspicuous intercellular spaces. The Bundle Sheath*:* Consists of 1 layer

of rounded cells devoided of chloroplasts or starch and with unlignified cell walls (Figure 3.1.8 A, B, C, Table 3.7).

Vascular tissue: Consists of four large vascular bundles at stem angles and many small vascular bundles in between the stem angles forming a discontinuous cylinder, connected with fibers. Outer phloem fibers consist of small groups of polygonal cells, with thick unlignified cell walls, arranged in an arc shaped connected with parenchyma cells. *Phloem:* Consists of sieve tube elements, companion cells and fibers making a discontinuous cylinder with the xylem elements. Xylem: consists of vessels and tracheids with thick lignified cell walls, average width of the vessels (19.7 μm), only a few strands of cambium were observed, the protoxylem vessels with narrow lumina and the metaxylem vessels with wide lumina, both arranged in radial rows a few strands of secondary xylem were observed in the 4 main groups of the vascular bundle (Figure 3.1.8 A, B, C, Table 3.8).

Medulla (pith): Homogenous parenchymatous cells polygonal, large with thin cellulosic walls, the outer cells which are located immediately below the xylem are smaller than those in the central part of the medulla (pith). Cells contain some crystals (solitary crystals) (Figure 3.1.9, Table 3.7).

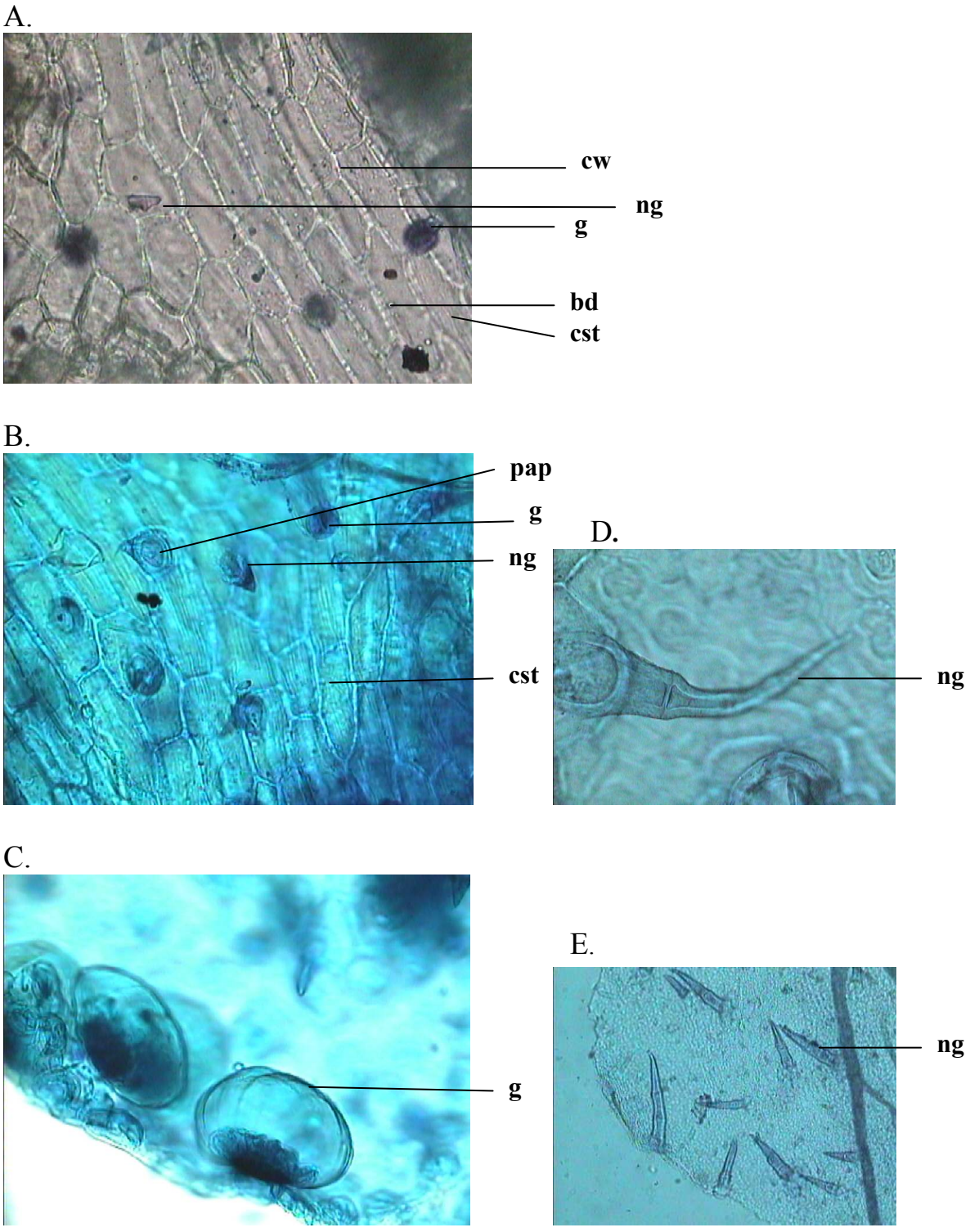
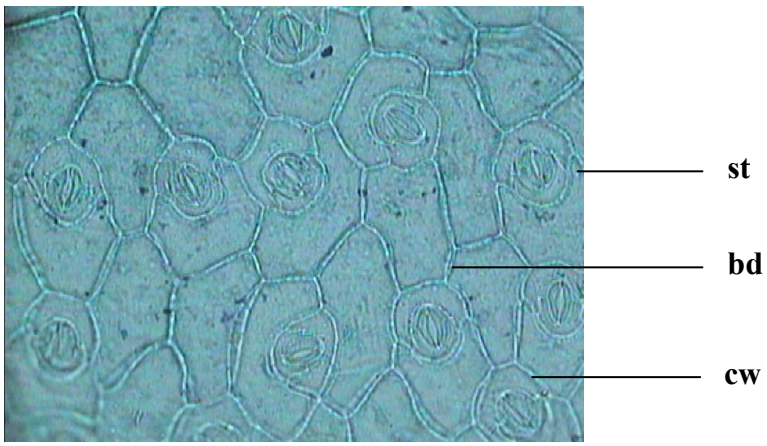
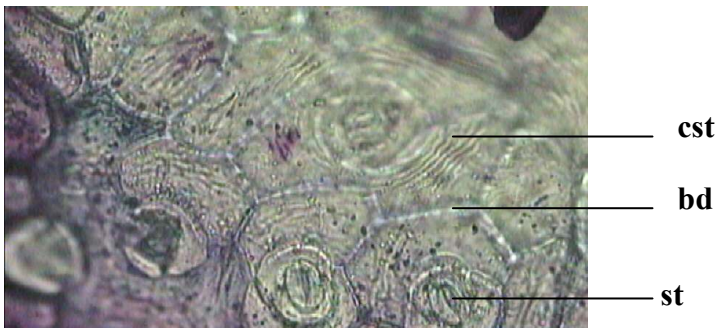


Figure (3.1.1) Leaf midrib region of *M. vulgare,* leaf. A – Upper epidermis; B – Lower epidermis, C – Glandular trichomes (A – C x 400), D – Nonglandular trichomes (x 100), E – Nonglandular trichomes (x 400).

A.



B.



C.

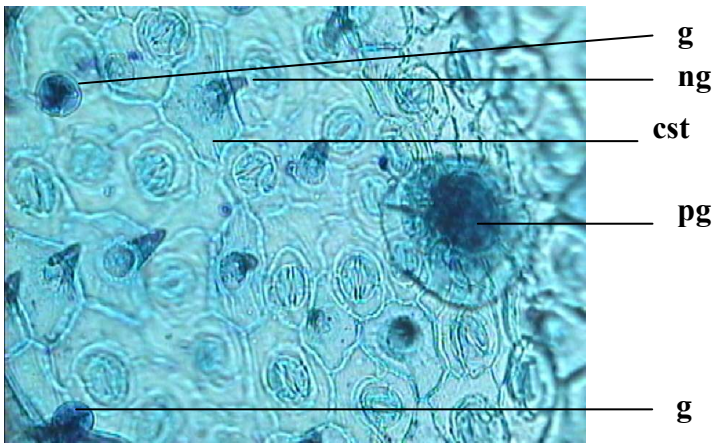
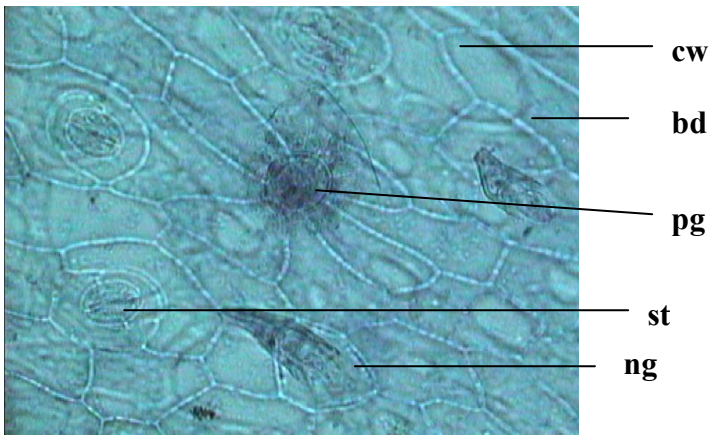


Figure (3.1.2): Leaf lumina intercostal region of *M. vulgare.* A, B – Upper epidermis, C – Lower epidermis (A – C x 400).

A.



B.

C.

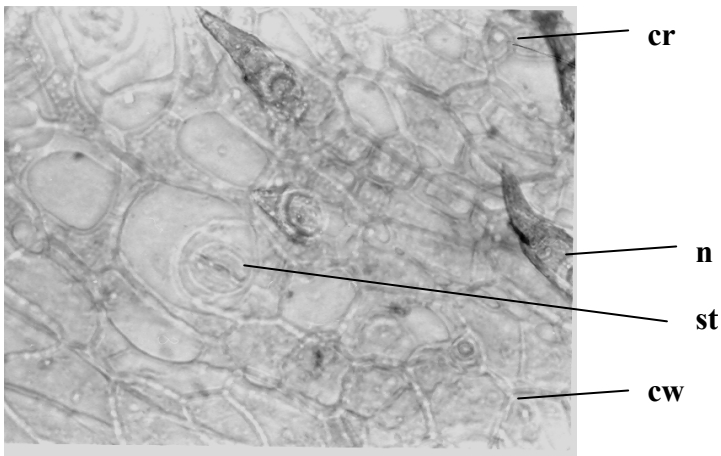
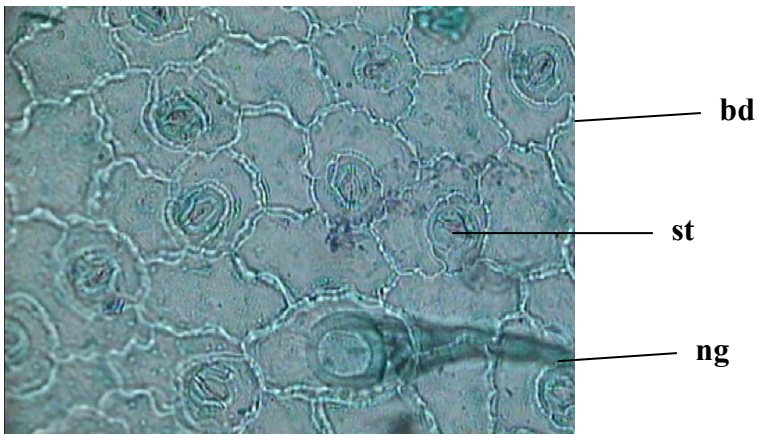
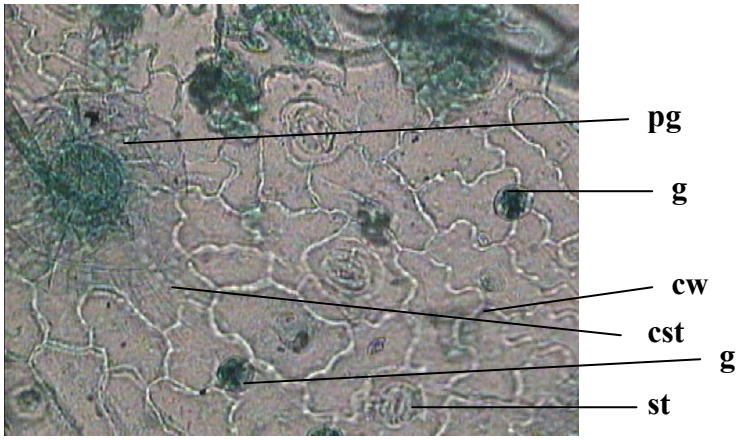


Figure (3.1.3): A – C Stem epidermis of *M. vulgare*. (A – C x 400).

A.



B.



C.

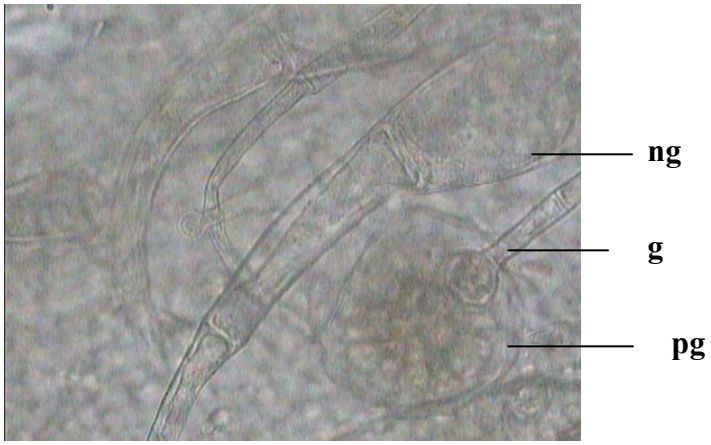
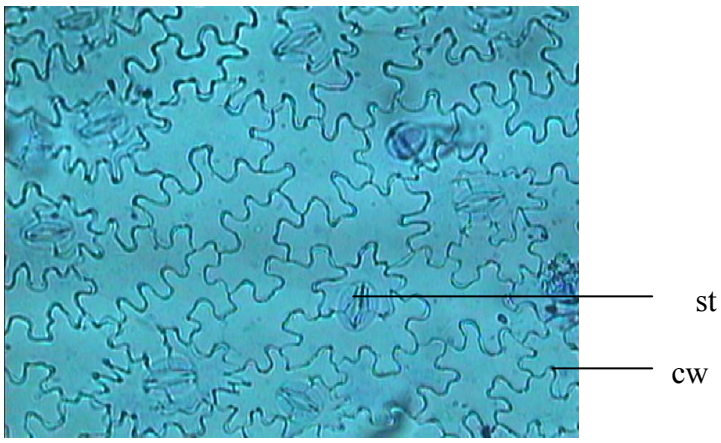
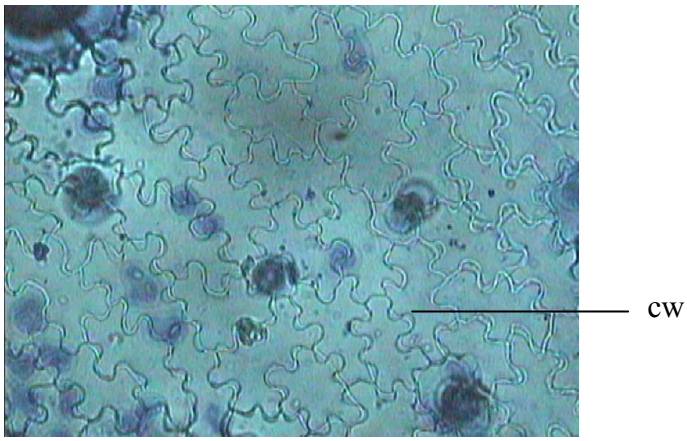


Figure (3.1.4): Floral parts of *M. vulgare*. A – Calyx, abaxial surface; B. – Calyx, adaxial surface, C – Trichomes (A – C x 400).

A.



B.



C.

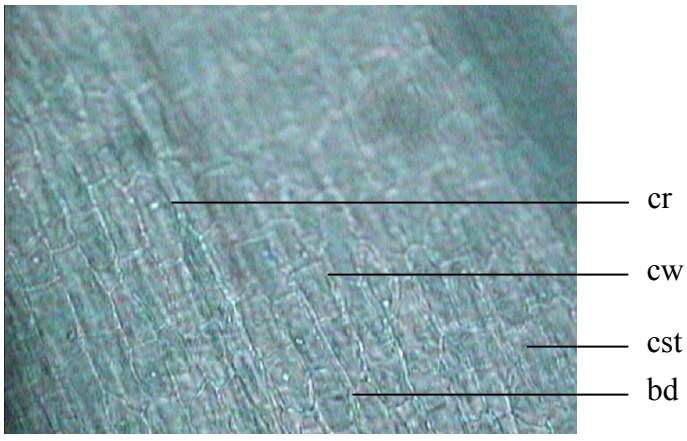


Figure (3.1.5.). Floral parts of *M. vulgare*. A – Corolla, abaxial; B – Corolla, adaxial surface, C – Corolla, basal parts with cells exhibiting solitary crystals (A – C x 400).

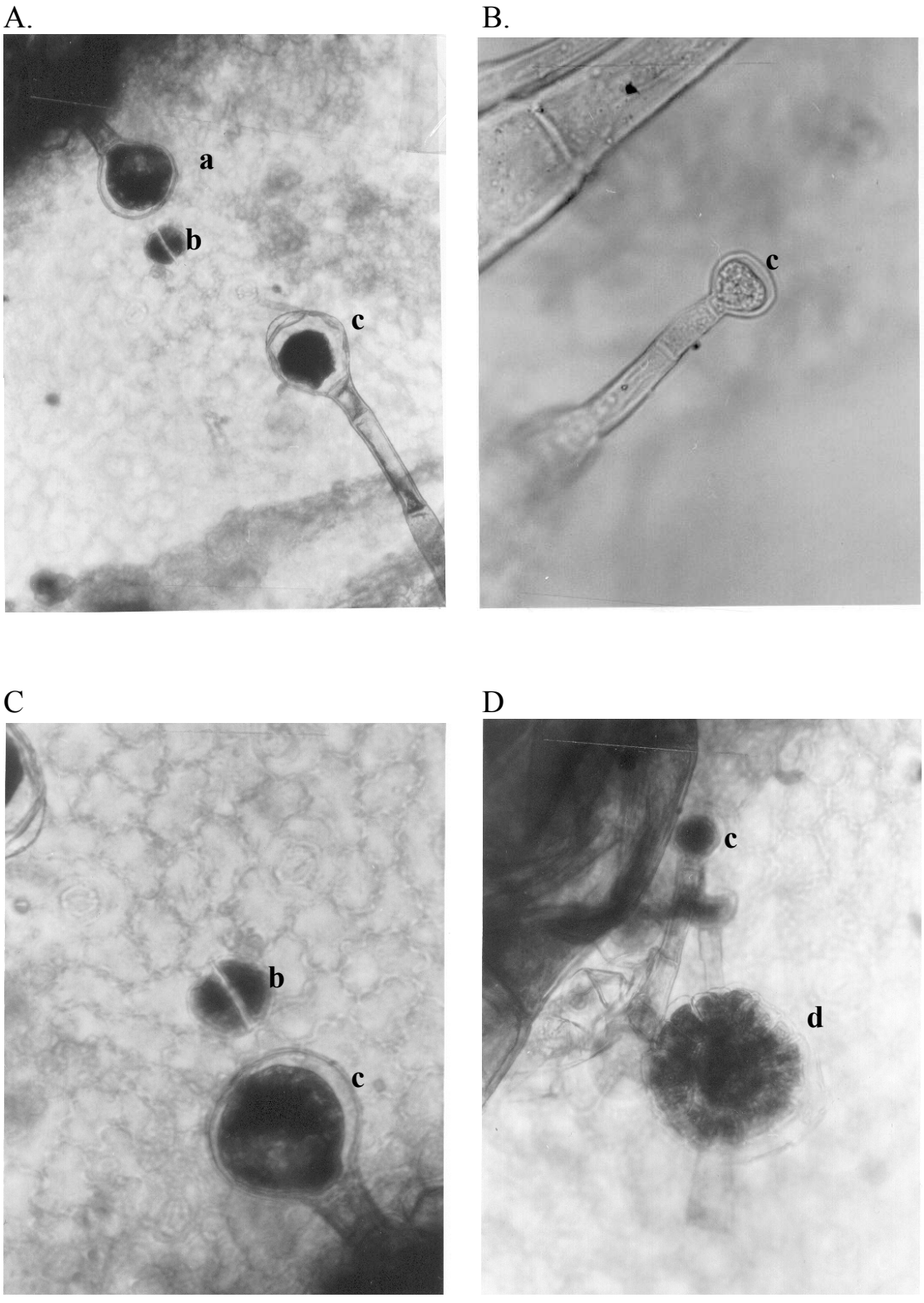
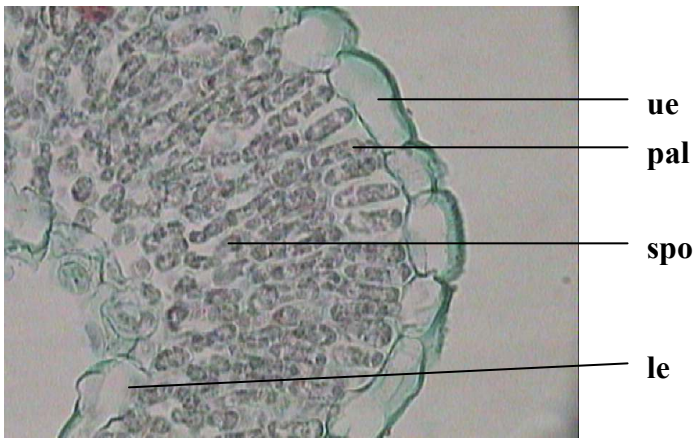
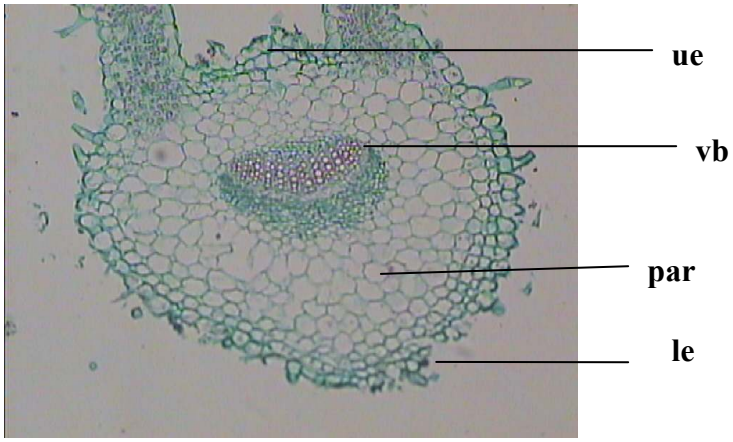


Figure (3.1.6): A – D leaf epidermis trichomes of *M. vulgare*.
a: Stalk unicellular, head unicellular; b: Stalk unicellular, head bicellular; c: stalk 3-5 cells long, head unicellular; d: Stalk unicellular head multicellular (3 – 16). (A, B,C, D x 400).

A.



B.



C.

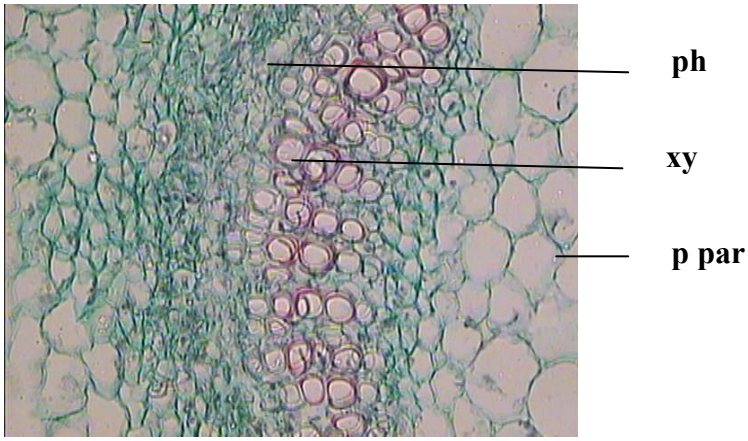
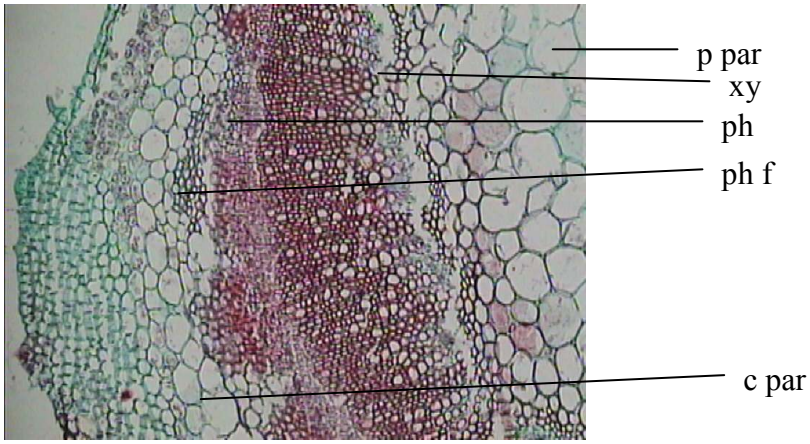
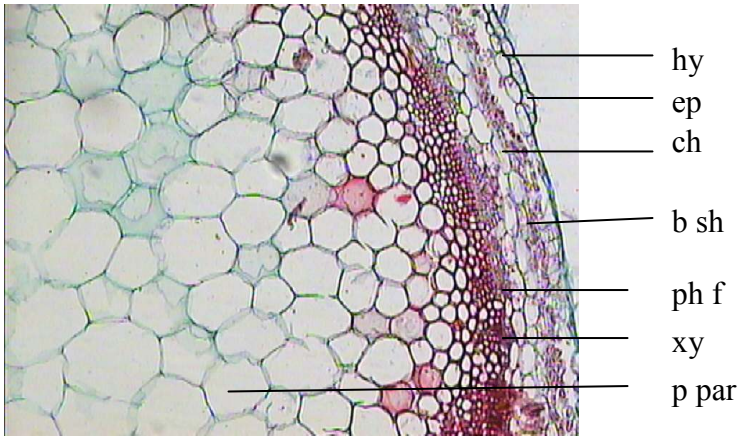


Figure (3.1.7): Leaf transverse sections of *M. vulgare*. A – Intercostal regionx (x 400); B – Midrib region (x 100); C – Vascular bundle region (x 400).

A.



B.



C.

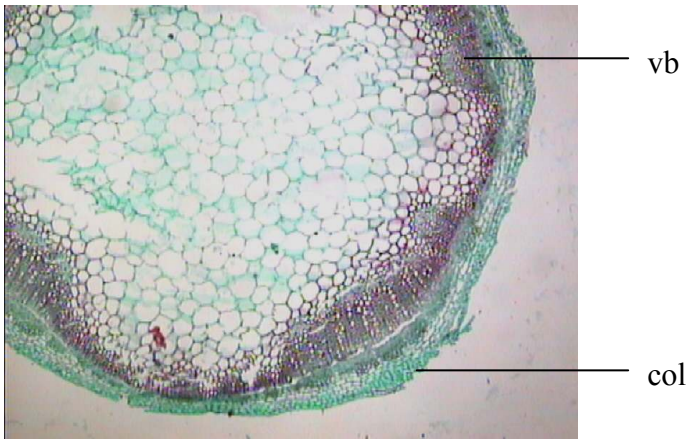


Figure (3.1.8) Stem transverse sections of *M. vulgare*. A – Stem angles; B – Stem between angles (A, B x 400); C – Stem (x 100).

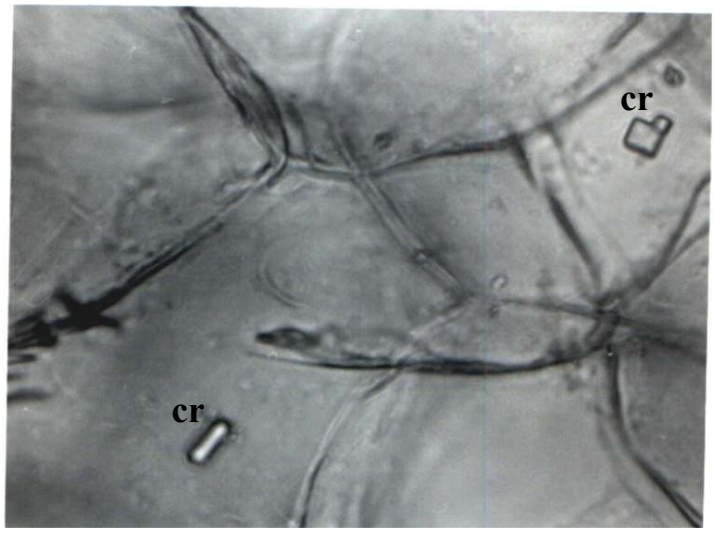


Figure (3.1.9): Pith parenchyma of *M. vulgare* showing solitary crystals (x 400).

3.2. *Micromeria biflora* Benth.

3.2.1. EPIDERMAL CHARACTERS

3.2.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular elongated with straight anticlinal walls (60 – 52.5 – 45.7 μm long, 35 – 23.7 – 17.5 μm wide) with thin cellulosic cell walls, beaded (Figure 3.2.1A; Table 3.1). **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes** consists of nonglandular and glandular intermixed (Figure 3.2.1 C, Table 3.1).

Non glandular: with three forms: (Figure 3.2.1 C)

a. unicellular, unbranched with thick warty cell walls (papillose), wide lumina and acute apex.
b. bicellular, uniseriate unbranched with thick warty cell walls, wide lumina and acute apex.
c. multicellular (3-8), uniseriate unbranched with thick warty cell walls.

All of the above trichomes with cellulosic walls, very dense 500/mm^2 (mostly the unicellular form). Some of the multicellular type with hooked apex, which is very rare.

Glandular: with one form - stalk is unicellular unbranched and head is unicellular with spherical form (Figure 3.2.1 C).

Lower epidermis: Cells are rectangular elongated (80 – 55.5 – 30.1 μm long, 33 – 15 – 11 μm wide), with slightly thin sinuous cellulosic, beaded anticlinal walls, (Figure 3.2.1 B; Table 3.1). **Cuticle** is longitudinally striated. **Stomata**: absent. **Trichomes** are glandular and non glandular intermixed and similar to those of the upper epidermis (Figure 3.2.1 C).

3.2.1.2. Leaf Intercostal Region

Upper epidermis: Cells are isodiametric to slightly elongated, (87.5 – 79 – 55 μm long), (45 – 36 – 25 μm wide) mainly with sinuous slightly thick (2.5 μm) anticlinal cellulosic and hemicellulosic walls, (Figure 3.2.2 A, B, C; Table 3.2). **Cuticle** is striated, striations radiate from the trichome base. **Stomata**: diacytic very rare only at the bases of the leaf lamina close to the midrib. **Trichomes**: are nonglandular and glandular intermixed.

Nonglandular: with three forms:

a. unicellular, unbranched with thin warty cell walls (some papillose) (Figure 3.2.2 A,B).
b. bicellular, uniseriate unbranched with thin warty cell walls (Figure 3.2.1 C).
c. multicellular, uniseriate unbranched with thin warty cell walls(Figure 3.2.1 C).

Glandular: with two forms:

a. Stalk unicellular and heads unicellular (Figure 3.2.1 C).
b. Stalk is unicellular and head is multicellular (4 – 12) cells with spherical shape (Figure 3.2.1 C; 3.2.3 A).

Lower epidermis: Cells are isodiametric to slightly elongated 65.6 – 57.5 –25 μm long, 35 – 28.75 – 25 μm wide with slightly thick (2.5 μm) sinuous, cellulosic and hemicellulosic beaded cell walls (Figure 3.2.3 A,B, C; Table 3.2). **Cuticle** is smooth. **Stomata**: are numerous 400/mm^2, ovate, diacytic or anisocytic (17.8 – 17.5– 13.1 μm long, 17.5 – 15.3 – 11 μm wide) irregularly distributed. **Trichomes**: are nonglandular and glandular, similar to those of the upper epidermis of the intercostal region (Figure 3.2.3 A, B, C).

3.2.4.3. STEM

Epidermis: Cells are polygonal or rectangular elongated with thick, straight cellulosic anticlinal walls beaded, (75 – 53.5 – 23.5 μm long and 32.5 – 25 – 21.25 μm wide) (Figure 3.2.4 A, B; Table 3.3). **Cuticle** striated longitudinally. **Stomata**: absent from stem angles and numerous, between stem angles only, ovate, commonly diacytic, (25 – 23.5 – 22.5 μm long), (25 – 17.5 –12.5 μm wide) occasionally ovate anisocytic with a density of 200/mm^2. **Trichomes**: are nonglandular and glandular (Figure 3.2.4 A, B; Table 3.3)

Nonglandular:

a. unicellular, unbranched with thick warty cell walls, wide lumina and acute apex, some papillose (Figure 3.2.4 A).
b. bicellular, uniseriate, unbranched with thick warty cell walls, wide lumina and acute apex (Figure 3.2.4 A).
c. Multicellular (3 – 8 cells), uniseriate, unbranched with thick warty cell walls.

Glandular:

a. Stalk unicellular, unbranched head, unicellular with round or ovate shape (Figure 3.2.4 A).
b. Stalk unicellular unbranched head multicellular (4 – 8), with spherical shape (similar to those on the intercostals region).

3.2.1.4. FLOWER
3.2.1.4.1. Calyx:
3.2.1.4.1.2. Abaxial surface

Cells are isodiametric with thin sinuous beaded anitclinal walls and polygonal elongated at the calyx veins, 50 – 25 – 15 μm long, 15 – 10 – 5.2 μm wide (Figure 3.2.5 A; Table 3.4). **Stomata**: are very rare 50/mm^2 diacytic near the calyx base. **Cuticle** striated. **Trichomes**: glandular and non glandular.

Nonglandular:

a. unicellular, unbranched with thick warty walls, wide lumina and acute apex.
b. bicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex.
c. multicellular (3 – 8 cells) uniseriate, unbranched with thick warty walls wide lumina and acute apex.

Glandular:

a. Stalk unicellular and head unicellular with round shape (Figure 3.2.5).
b. Stalk unicellular, head multicellular with spherical shape (Figure 3.2.5).

3.2.1.4.1.2. Adaxial surface

Cells are polygonal elongated with thin anticlinal walls at calyx veins and polygonal isodiametric with thin sinuous cellulosic beaded anticlinal walls in between the calyx veins 40.5 – 20 – 10 μm long 20 – 8.5 – 6 μm wide (Figure 3.2.5 B; Table 3.4). **Cuticle** longitudinally striated. **Stomata** are absent. **Trichomes** glandular and nonglandular are similar to those of the abaxial surface.

3.2.1.4.2. Corolla:

3.2.1.4.2.1 Abaxial surface

Cells polygonal elongated with anticlinal thin cellulosic walls at the corolla veins and polygonal isodiametric with thin sinuous cellulosic beaded walls in between corolla veins, 93.1 – 70.5 – 45 μm long 35.4 – 25 – 12 μm wide. ***Cuticle*** longitudinally striated especially at the base of corolla. **Stomata** are absent. **Trichomes** glandular and nonglandular (Figure 3.2.6 A, Table 3.4).

Nonglandular: are numerous and consists of three forms.

a. unicellular, unbranched with thick warty cell walls, wide lumina and acute apex.
b. bicellular, unbranched with thick warty cell walls, wide lumina and acute apex.
c. multicellular (3-8) uniseriate unbranched with thick warty cell walls, wide lumina and acute apex.

Glandular: consists of 2 forms:

a. stalk is unicellular, unbranched head is unicellular ovate.
b. stalk is unicellular, unbranched head is multicellular, (4 – 8 cells) with spherical shape in surface view.

3.2.1.4.2.2. Adaxial surface

Cells isodiametric, with sinuous anticlinal thin cellulosic walls, 75 – 50.3 – 30 μm long, 25 – 15 –5.7 μm wide, in between corolla veins, and polygonal with sinuous walls at the corolla veins (Figure 3.2.6 B; Table 3.4). **Stomata**: are absent. **Trichomes** Similar to those of the corolla abaxial surface.

3.2.2. INTERNAL STRUCTURE

3.2.2.1. Leaf, Midrib Region

Upper epidermis: Cells are large rounded with thick outer walls and inner thin walls (Figure 3.2.7 A, B; Table 3.5). **Cuticle** thick. **Ground tissue** consists of a small group of paranchymatous cells, occurring below the upper epidermis **Vascular tissue** consists of one small rounded vascular bundle. Vessels with lignified cell walls, phloem elements with thin slightly lignified cell walls and one large group of outer phloem fibers with thick unlignified cell walls. One layer of bundle sheath with thin cellulosic cell walls. Lamellar collenchyma tissue occurs above lower epidermis with thick unlignified cell walls (Figure 3.2.7 A, B, Table 3.5).

Lower Epidermis: Epidermis cells are similar to those of the upper midrib region but smaller in size (Figure 3.2.7 A, B, Table 3.5).

3.2.2.2. Leaf, Intercostal Region

Epidermis: Cells are rounded with thick outer walls (6 – 8 μm) and thin inner cells walls (Figure 3.2.7 B, C; Table 3.6). **Cuticle** very thick. **Messophyll** is differentiated into palisade and spongy tissue: Palisade tissue consists of 2 layers of long palisade type cells, with many chloroplasts and large intercellular spaces. Spongy tissue consists of 3 or 4 layers of small paranchymous cells, filled with chloroplasts and with thin cellulosic cell walls and large intercellular spaces.

Lower Epidermis: Similar to those of the upper intercostal region epidermis but cells are smaller (Figure 3.2.7 A; Table 3.6).

3.2.2.3. Stem

The transverse section of the stem is quadrangular in outline, exhibiting some glandular and nonglandular trichomes (Figure 3.2.8 A, B; Table 3.7).

Epidermis: cells are tabular the outer cell walls are thick (8.5 μm) inner cell walls are slightly thick (5 μm) cellulosic. **Cuticle** is thick.

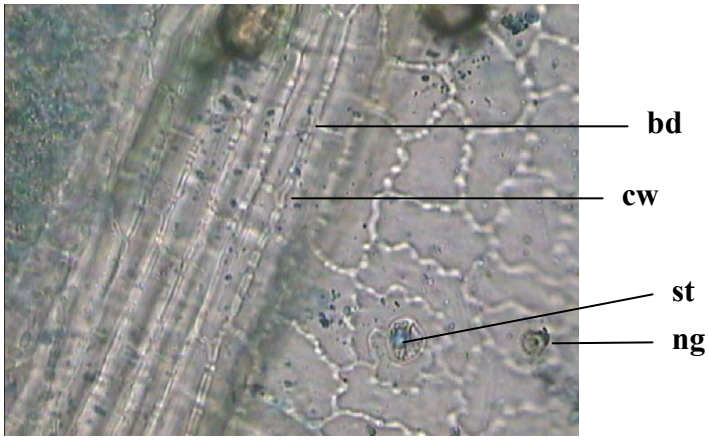
Cortex: Consists of lamellar collenchyma cells (5 - 6 layers) at the stem angles and 3 – 5 layers of rounded small chlorenchyma cells wall with developed chloroplasts with cellulosic walls and conspicuous intercellular spaces. **Bundle Sheath** consist of a single layer of large tabular cells with cellulosic lignified cell walls devoided of chloroplasts or starch.

Vascular tissue: Outer phloem fibers forming groups of slightly thick cell walls with 4 main vascular bundles at stem angles and small secondary vascular bundles in between stem angles, patches of primary phloem elements, at the angle of the stem, unnoticeable slightly crushed vascular cambium, xylem consist of vessels with lignified pitted cell wall.

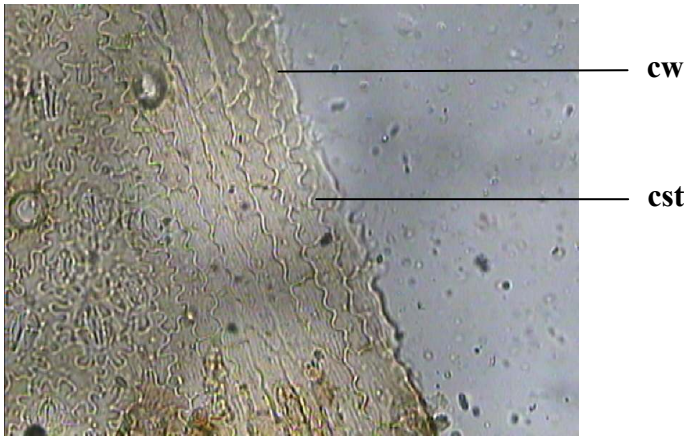
The metaxylem with large (20.5 μm) vessels, protoxylem with small vessels (15 μm) wide both arranged in radial rows making a discontinuous cylinder.

Pith (Medulla): Consists of polygonal homogenous paranchymatous cells with thick cellulosic cell walls and with conspicuous intercellular spaces (Figure 3.2.8 A, B; Table 3.7).

A.



B.



C.

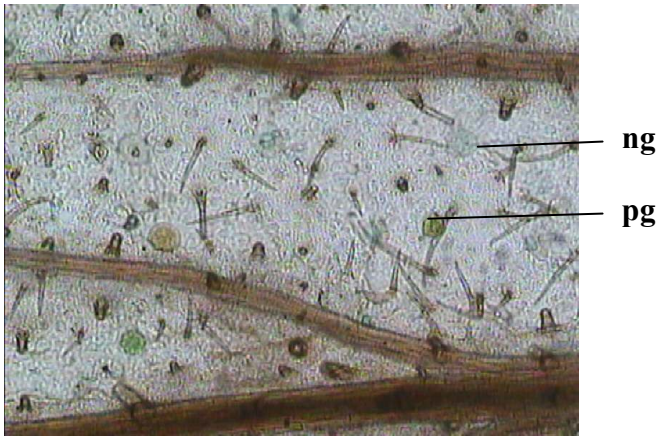


Figure (3.2.1) Leaf, midrib region of *Micromeria biflora*. A- Upper epidermis; B – Lower epidermis (A-B x 400); C – Trichomes on the lower epidermis (x 100).

A.

B.

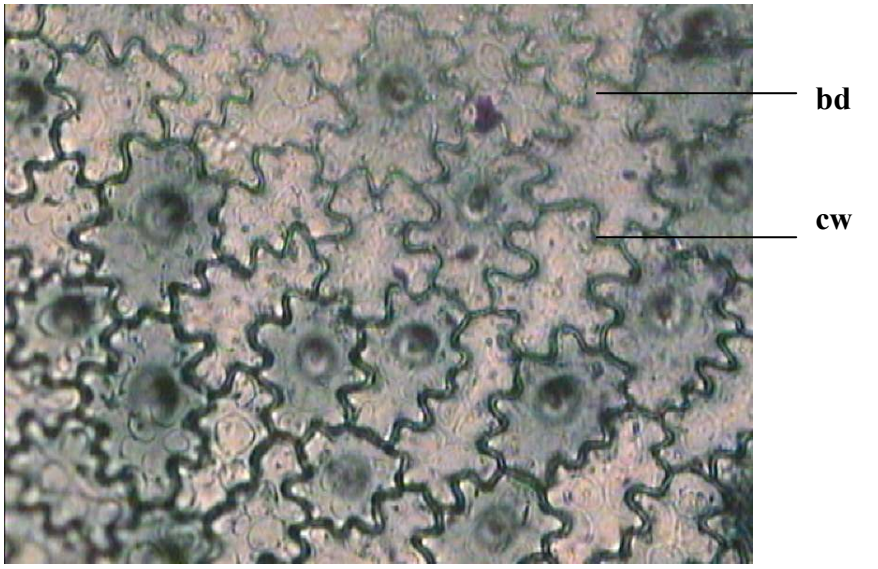
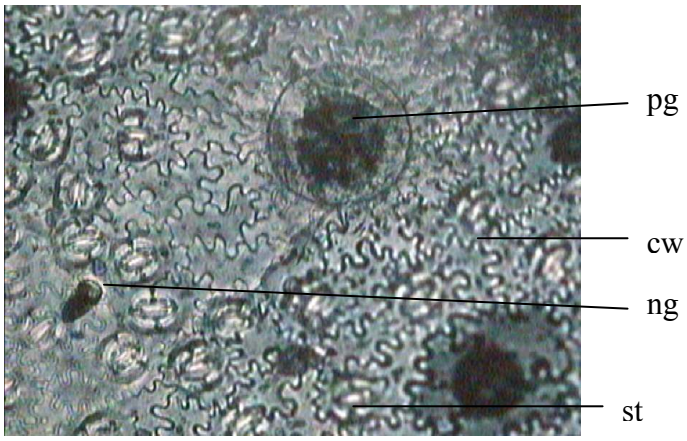


Figure (3.2.2) Leaf intercostal region of *M. biflora*. A, B – Upper epidermis (x 400).

A.

B.



C.

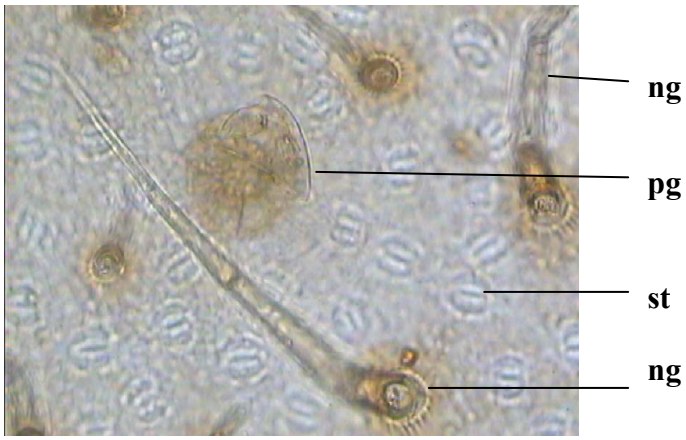
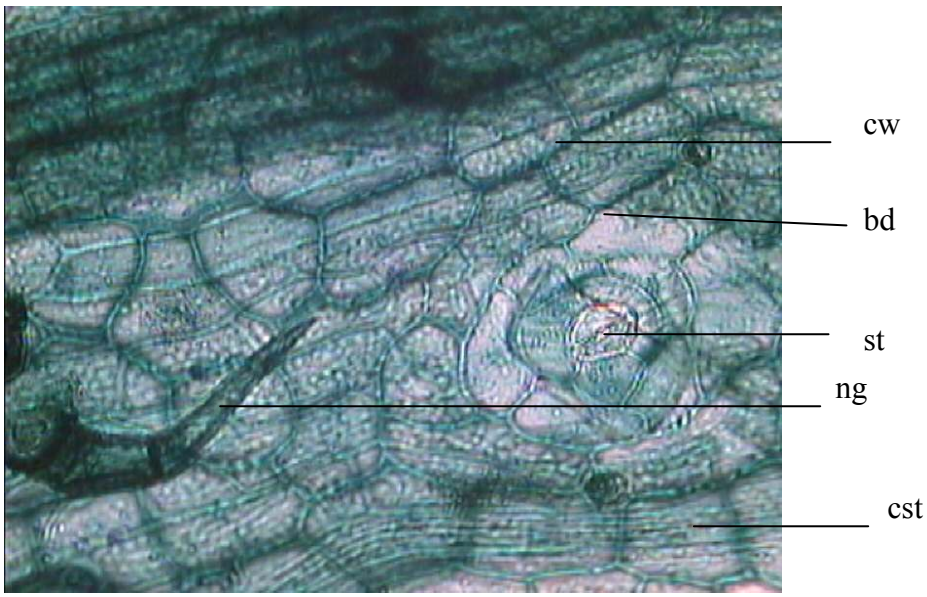


Figure (3.2.3): Leaf, intercostal region of *M. biflora*. A, B, C – Lower epidermis (x 400).

A.



B.

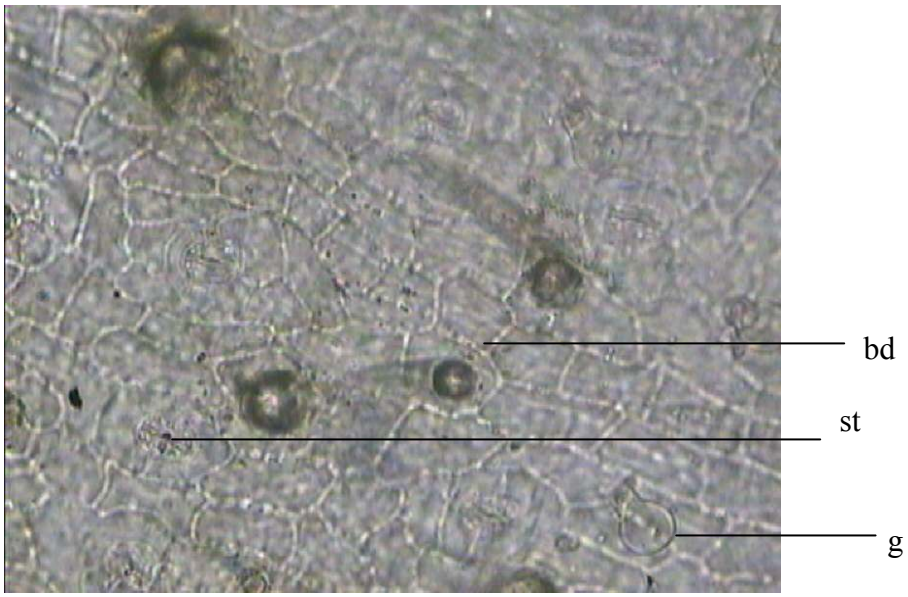
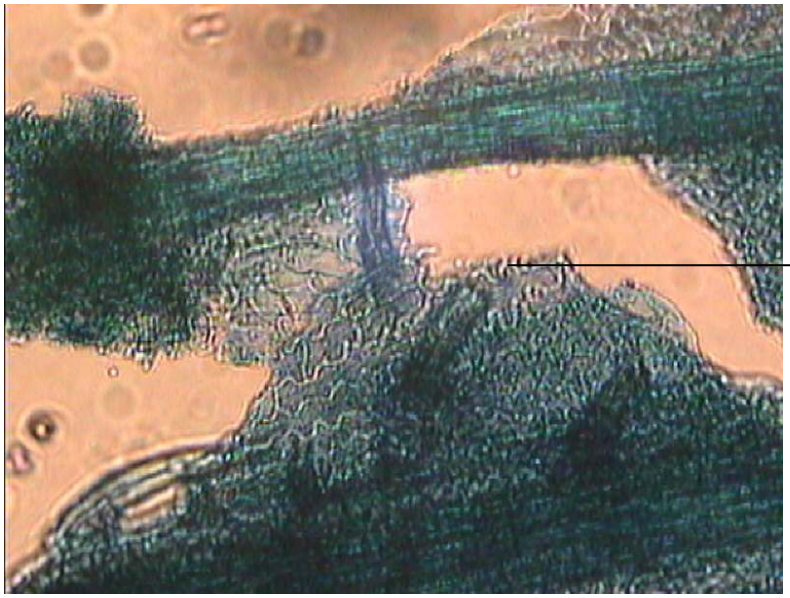


Figure (3.2.4): A, B, Stem epidermis of *M. biflora* (x 400).

A.



B.

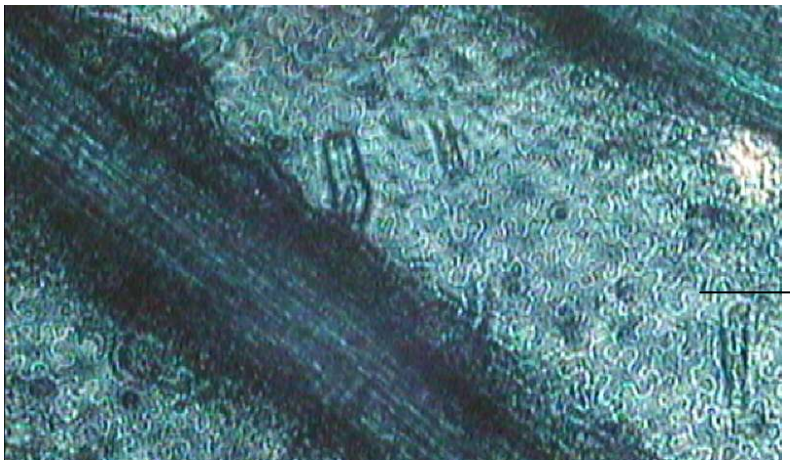
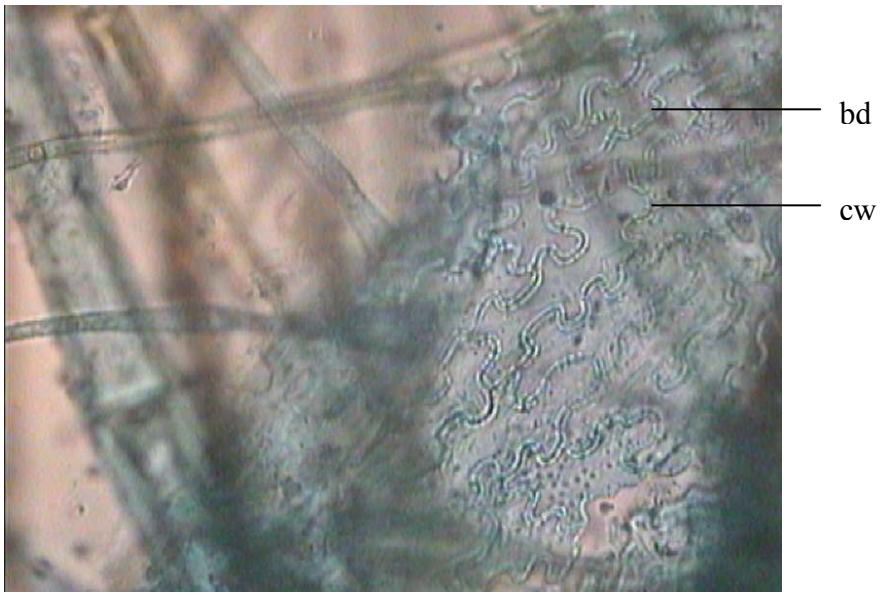


Figure (3.2.5): Floral parts of *M. biflora*. A – Calyx, abaxial surface; B – Calyx, adaxial surface (A, B x 400).

A.



B.

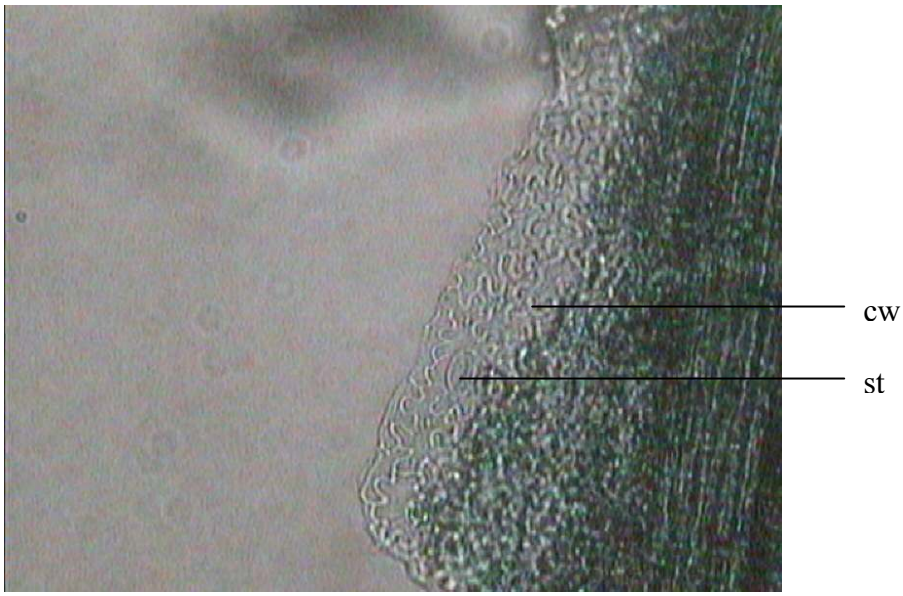
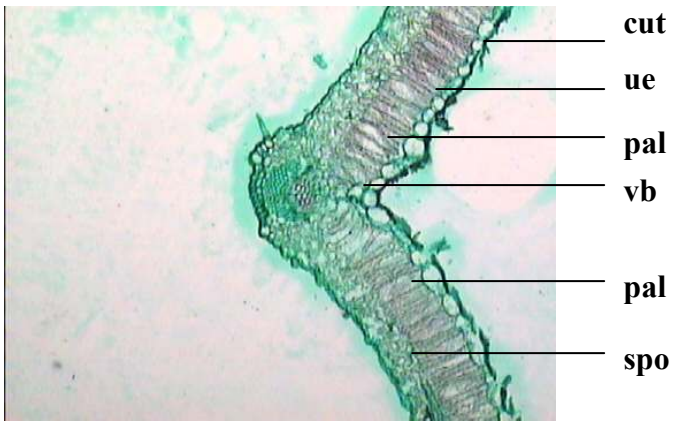
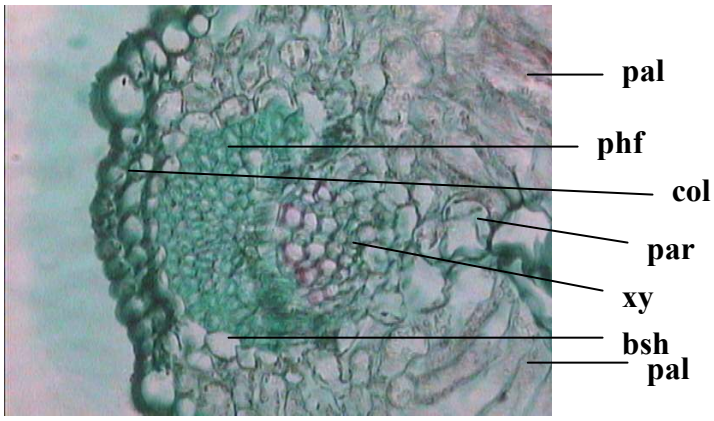


Figure (3.2.6): Floral parts of *M. biflora*, flowers. A – Corolla, abaxial surface; B – Corolla, adaxial surface (A, B x 400).

A.



B.



C.

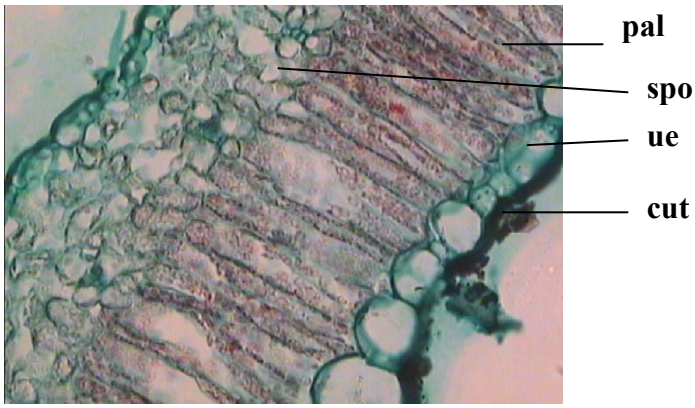
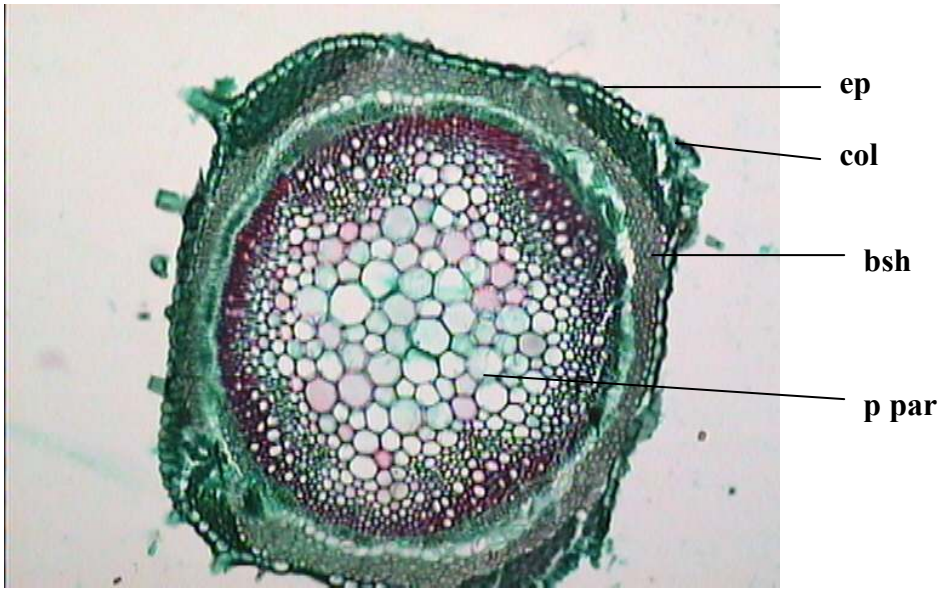


Figure (3.2.7): Leaf transverse sections of *M. biflora.* A – Midrib region (x 100); B – Leaf vascular bundle (x 400); C – Intercostal region (x 400).

A.



B.

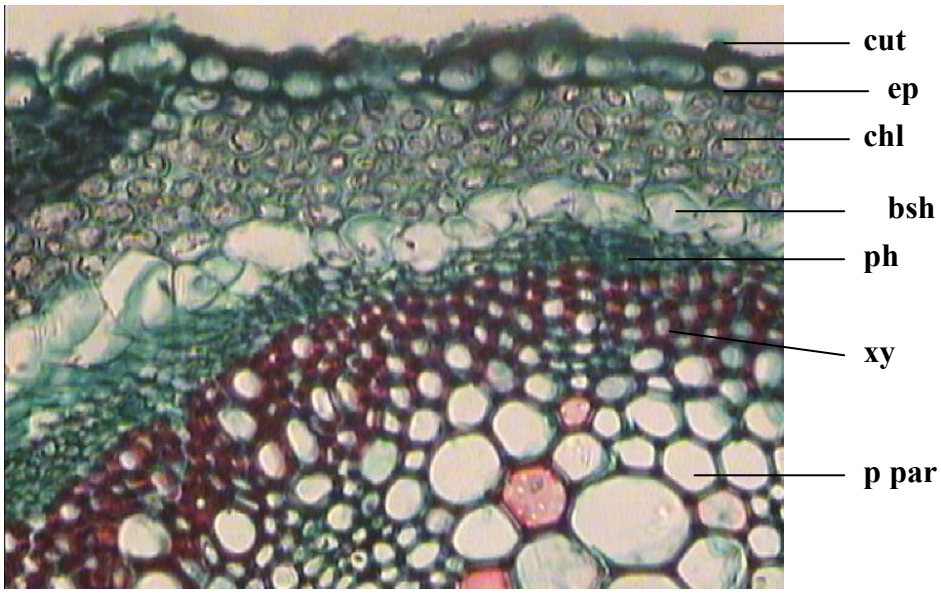


Figure (3.2.8): A – B Stem, transverse section of *M. biflora*. A – Stem (x 100); B – Stem corners (x 400).

3.3. *Mentha microphylla* C. Koch.

3.3.1. EPIDERMAL CHARACTERS

3.3.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular, elongated with thin straight, cellulosic beaded walls, 84.5 – 75 - 65 μm long, 30 – 23.5 – 20 μm wide (Figure 3.3.1 A; Table 3.1). **Cuticle** is irregularly striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular (Figure 3.3.1 C).

Nonglandular: Numerous (500/mm^2).

a. unicellular, unbranched with thin warty walls,

b. bicellular uniseriate unbranched with thin warty walls,

c. Multicellular (3 – 8 cells) uniseriate, unbranched with thin warty cellulosic walls.

All with wide lumina and acute apex some with collapsed cells (Figure 3.3.1 C).

Glandular: consists of one form, stalk is unicellular, unbranched, head is unicellular (Figure 3.3.1.B).

Lower epidermis: Cells are rectangular, elongated with thin straight anticlinal cellulosic beaded walls, 60 – 51.5 – 37.5 μm long, 25 – 15 – 11.4 μm wide (Figure 3.3.1 B; Table 3.1). **Cuticle** is irregularly striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular and are similar to those of the upper epidermis of the midrib region but more dense, 600/mm^2**.**

3.3.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin straight, anticlinal cellulosic beaded walls, 55.0 – 44.5 – 27.5 μm long, 42.5– 32.5 – 31.5 μm wide (Figure 3.3.2 A; Table 3.2). **Cuticle** is smooth. **Stomata**: are few, 50/mm^2 irregularly distributed, diacytic and anisocytic, ovate

25.0 – 24 – 22.5 μm long, 20 – 15.8 – 10 μm wide. **Trichomes** glandular and nonglandular are present.

Nonglandular:

Numerous, 300/mm^2 one form, multicellular, uniseriate unbranched with thin, warty cell walls, wide lumina and acute apex; some cells are collapsed, similar to those at the midrib region (Figure 3.3.2 C; Table 3.2).

Glandular: numerous, two forms.

a. stalk unicellular, head unicellular, rounded (Figure 3.3.2 C).

b. stalk unicellular and head multicellular 4 – 12 cells, with spherical shape (Figure 3.3.2 A Table 3.2).

Lower epidermis: Cells are polygonal with thin cellulosic straight beaded anticlinal walls, 50 – 41 – 25 μm long, 35 – 26.5 – 22.5 μm wide (Figure 3.3.2 B, C; Table 3.2). **Cuticle** is smooth. **Stomata** are few, 50/mm^2, irregularly distributed, diacytic and anisocytic, ovate, 13.1 – 11.5 – 8.5 μm long, 18.5 – 15.5 – 7.5 μm wide. **Trichomes:** glandular and nonglandular are similar to those of the upper epidermis (Figure 3.3.2 B, C).

3.3.1.3. Stem

Epidermis: Cells are polygonal with thin straight cellulosic, beaded walls, 52.5 – 42 – 25 μm long, 40 – 26.2 – 17.5 μm wide. **Cuticle** is longitudinally striated. **Stomata** are few 50/mm^2 diacytic ovate 25 – 15 – 10 μm long, 15 – 9 – 8.5 μm wide. **Trichomes** are glandular and nonglandular intermixed (Figure 3.3.3 A, B, C; Table 3.3).

*Nonglandular**:***

a. Unicellular, uniseriate, unbranched with thin warty cell walls, wide lumina, acute apex.

b. Bicellular, uniseriate unbranched with thin warty cell walls wide lumina and acute apex (Figure 3.3.3 A, B, C).

c. multicellular, uniseriate unbranched, 3 – 8 cells with thin warty cell walls, wide lumina and acute apex (Figure 3.3.3 A), and some of the cells very narrow (collapsed) and few with hooked apex.

Glandular:

a. Stalk unicellular, unbranched, head unicellular with round shape (Figure 3.3.3 A).

b. Stalk unicellular, unbranched, head multicellular (4 – 12) with spherical shape in surface view (Figure 3.3.3 B, C, Table 3.3).

3.3.1.4. Flowers

3.3.1.4.1. Calyx:

3.3.1.4.1.1 Abaxial surface

Epidermal cells are isodiametric with thin cellulosic straight anticlinal cell walls, 45.1 – 35.1 – 20 μm long; 25 – 13 – 12.1 μm wide and polygonal elongated with straight cell walls at the calyx veins. **Cuticle** is striated striation coming from the trichome bases. **Stomata** are not observed. **Trichomes** are numerous, intermixed of glandular and nonglandular (Figure 3.3.4 A; Table 3.4).

Non glandular trichomes are three forms:

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex (Figure 3.3.5 A).

b. bicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex (Figure 3.3.5 A).

c. multicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex (Figure 3.3.5 A, B).

Glandular Trichomes are showing two forms:

a. stalk is unicellular and head is multicellular with 4 – 8 cells having rounded large shape

b. stalk bicellular, head unicellular (Figure 3.3.4 B).

3.3.1.4.1.2. Adaxial surface

Epidermal characters are similar to those of the calyx abaxial surface (Figure 3.3.4 B, C; Table 3.4).

3.3.1.4.2. Corolla:

3.3.1.4.2.1 Abaxial surface

Epidermal cells are isodiametric to elongated with thin sinuous anticlinal walls 65.5 – 55 – 40 μm long, 45 – 30 – 25 μm wide, cellulosic, with striated **cuticle** (Figure 3.3.5 A; Table 3.4). **Stomata** are absent. **Trichomes** are numerous, with the same forms observed at the calyx (Figure 3.3.5 A).

Adaxial surface - Cells are similar in their epidermal characters to those observed at the corolla abaxial surface (Figure 3.3.5 B, C; Table 3.4).

3.3.2. INTERNAL STRUCTURE

3.3.2.1. Leaf, Midrib Region

Upper epidermis: Cells are tabular with thick outer cellulosic cell walls and covered with thick cuticle. **Messophyll** consists of lamellar collenchyma, 1 or 2 layer under upper and lower epidermis, 2 to 4 layers of parenchymatous tissue with thin cellulosic walls and conspicuous intercellular spaces (Figure 3.3.6 B,D; Table 3.5). *Vascular tissue* consists of one large arched vascular bundle. Xylem consists of vessels with wide lumina and lignified cell walls, arranged in rows. Primary phloem consists of sieve tube elements and companion cells, phloem are covered with groups of outer phloem fibers with thick lignified walls.

Lower epidermis: Characters are similar to those of the upper epidermis (Figure 3.3.6 B, D; Table 3.5).

3.3.2.2. Leaf, Intercostal Region

Upper epidermis: Cells are tabular with thick outer walls and thin inner walls (Figure 3.3.6 A, C, D; Table 3.6). **Cuticle** thick. **Messophyll** is differentiated into palisade and spongy tissue; palisade tissue is one or two layers of long palisade like cells containing chloroplasts, and large intercellular spaces. Spongy tissue consists of 3 or 4 layers of round small chlorenchymatous cells with large intercellular spaces.

Lower epidermis: Characters are similar to those of the upper epidermis (Figure 3.3.6 A, C, D; Table 3.6).

3.3.2.3. Stem

The transverse section is quadrangular in outline, exhibiting some glandular and non glandular trichomes (Figure 3.3.7 A, B, C, D; Table 3.7).

Epidermis: The epidermal cells are tabular, outer walls are thin (2.5 μm) radial walls are thinner than those of the outer walls (1.5 μm) all cell walls are cellulosic, cuticle thin.

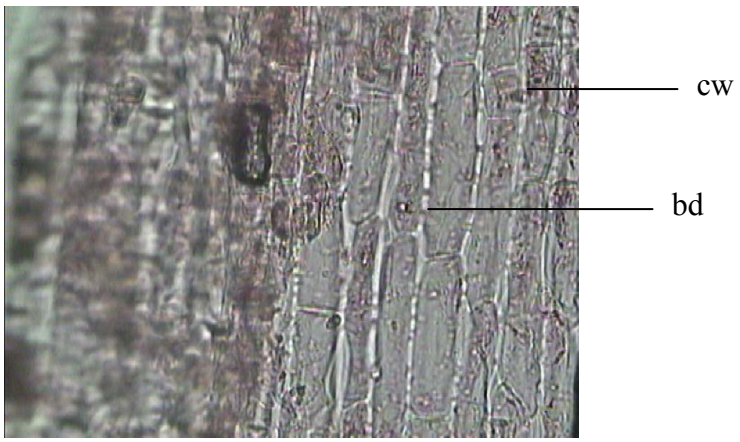
Cortex: Consists of one layer of hypodermal cells with thin cellulosic cell walls followed by 4 main groups of cortex collenchyma tissue consisting of 8 or 9 layers opposite to stem corners, and 3 – 5 layers of chlorenchyma tissue filled with chloroplasts and with cellulosic cell walls in between stem corners. Bundle sheath: Consists of one layer of rectangular cells with no starch or chloroplasts, cells with cellulosic cell walls forming a continuous full ring.

Vascular tissue: Outer phloem fibers consist of groups of fibers with narrow lumina and unlignified cellulosic thick walls. Xylem consists of tracheary elements with lignified pitted walls, its average diameter (15 – 12.6 – 10 μm), the protoxylem with narrow tracheary

elements and the metaxylem with wide vessels both arranged in radial rows and well developed at stem angles, forming a continuous cylinder.

Pith: Consists of homogenous paranchymatous cells, rounded or polygonal, with thin cellulosic walls and with large intercellular spaces (Figure 3.3.7 A, B, C, D; Table 3.7).

A.



B.

C.

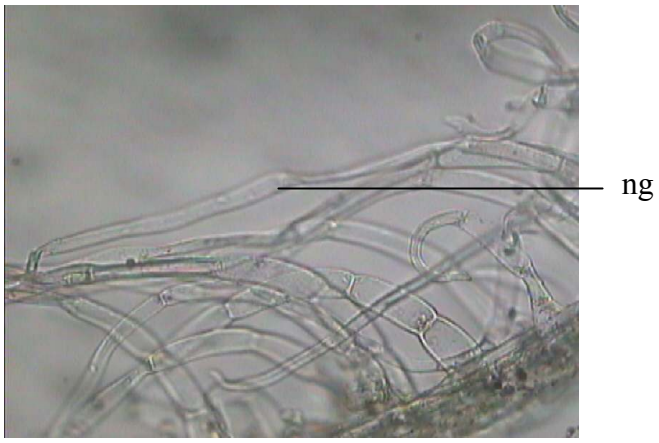
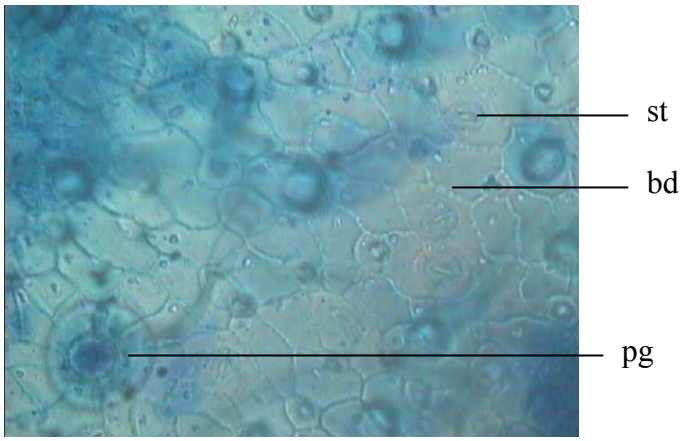


Figure (3.3.1) Leaf, midrib region of *M. microphylla*. A – Upper epidermis; B, C – Lower epidermis showing glandular and nonglandular trichomes (A – C x 400).

A.

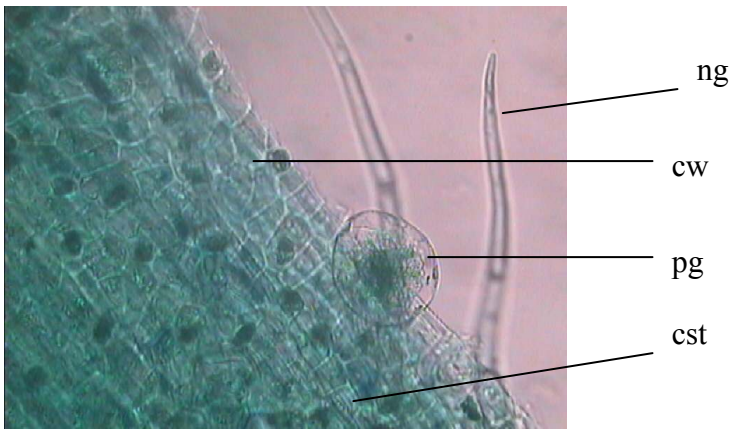
B.



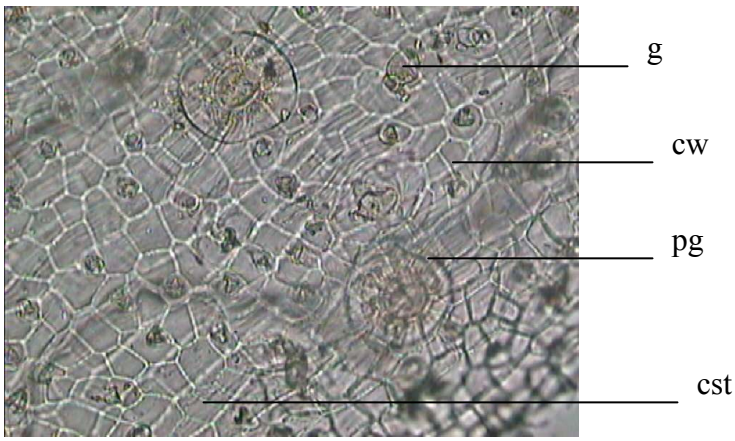
C.

Figure (3.3.2) Leaf, intercostal region of *M. microphylla*. A – Upper epidermis; B – Lower epidermis; C. Trichomes (A – C x 400).

A.



B.



C.

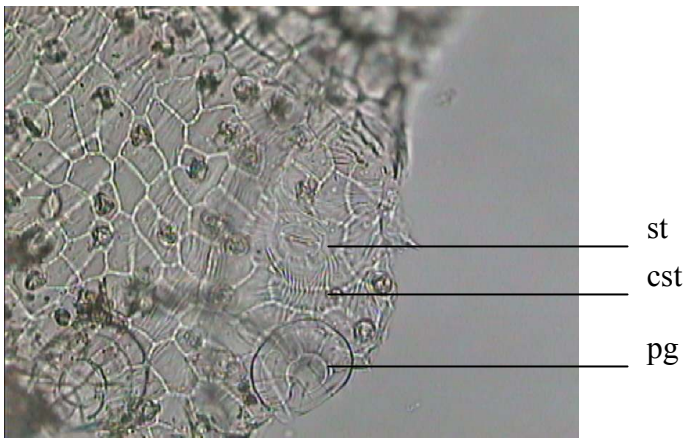
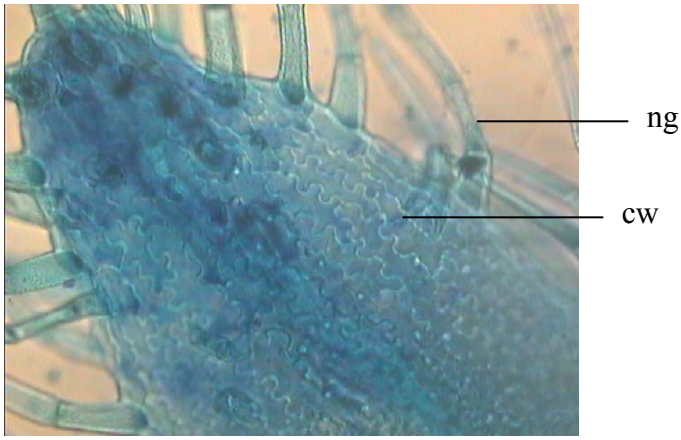


Figure (3.3.3): A – C Stem epidermis of *M. microphylla*. (x 400).

A.



B.

C.

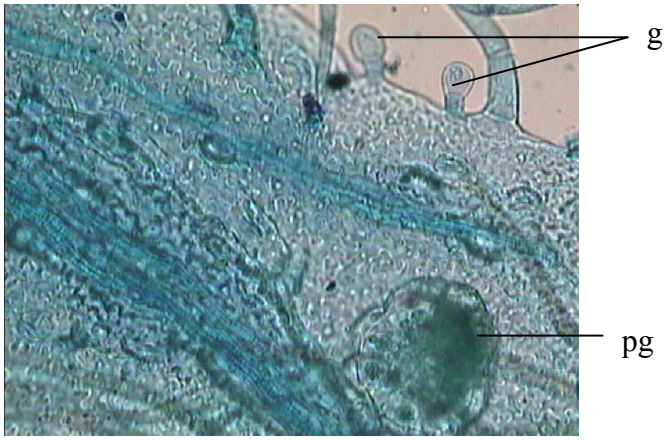
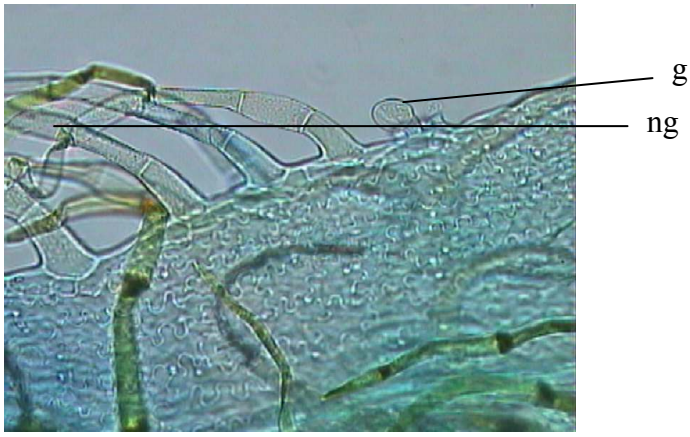
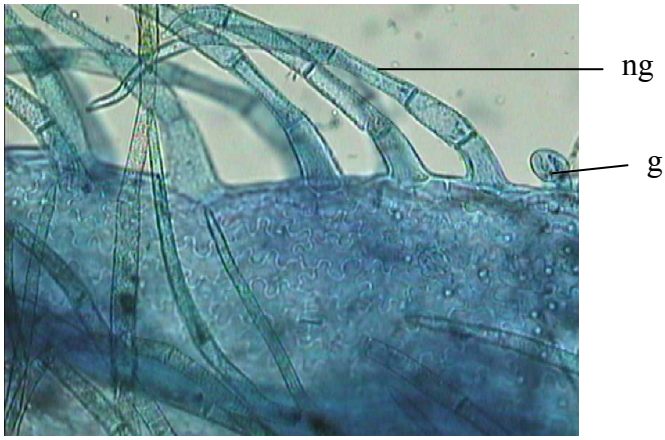


Figure (3.3.4) Floral parts of *M. microphylla*. A – Calyx, abaxial surface; B – Calyx, adaxial surface.; C – Calyx glandular trichomes. (A – C x 400)

A.



B.



C.

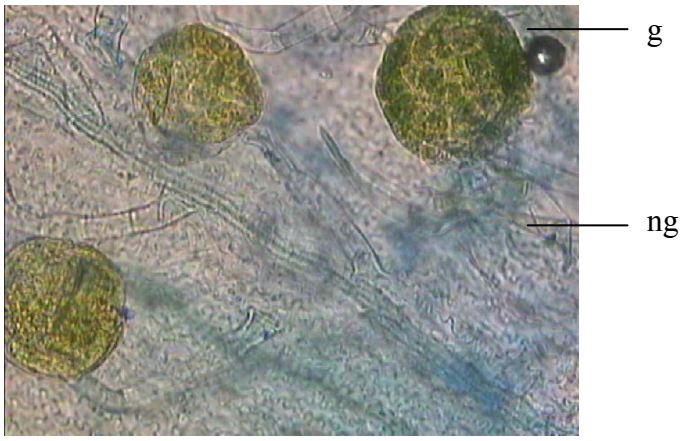


Figure (3.3.5) Floral parts of *M. microphylla*. A – Corolla, abaxial surface; B, C – Corolla, adaxial surface showing glandular and nonglandular trichomes. (A – C x 400)

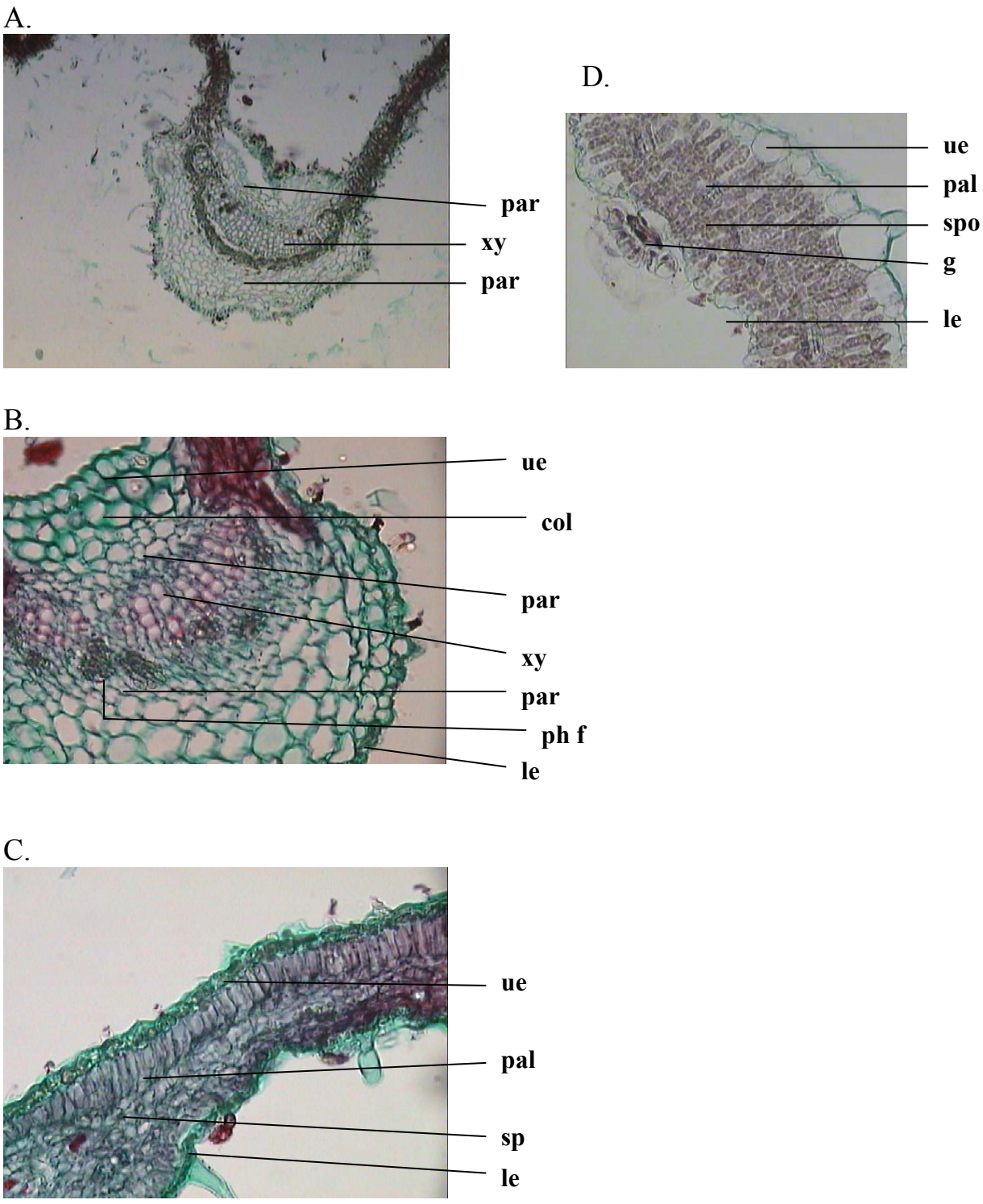
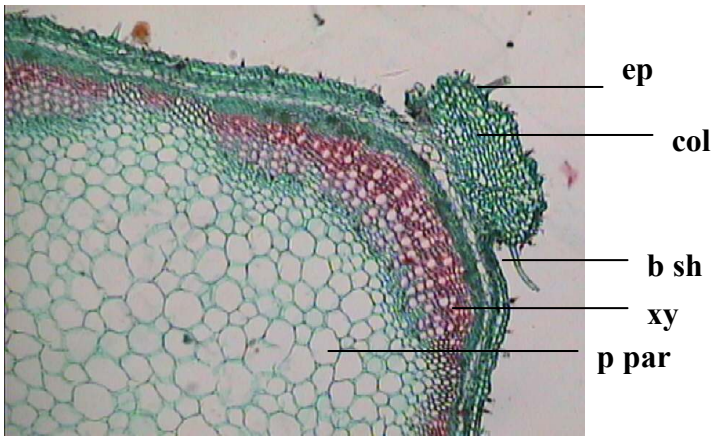
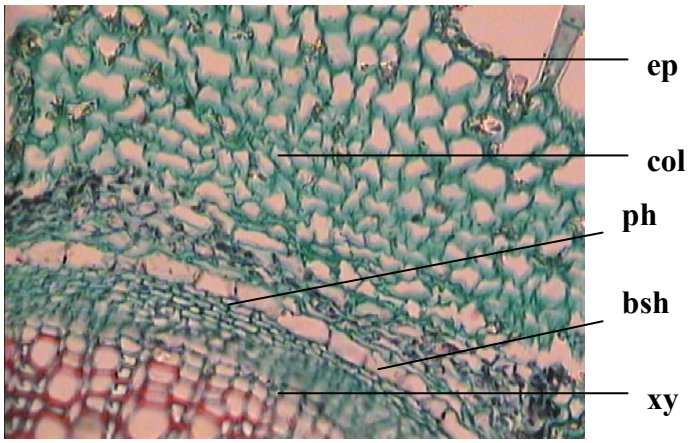


Figure (3.3.6): Leaf transverse section of *M. microphylla*. A – Leaf (x 100); B – Midrib region; C, D – Intercostal region (B – D x 400).

A.



B.



C.

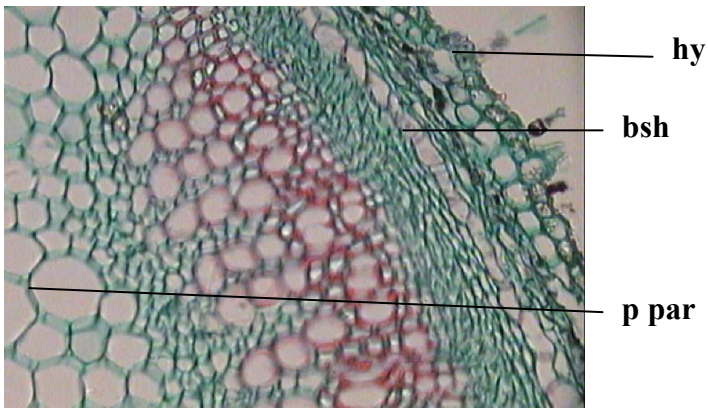


Figure (3.3.7): A – C Stem transverse section of *M. microphylla.* (A x 100); (B, C, x 400).

3.4. *Nepeta deflersiana* Schweinf.

3.4.1. EPIDERMAL CHARACTERS

3.4.1.1 Leaf, Midrib Region

Upper epidermis: Cells are rectangular or polygonal elongated with straight thin beaded anticlinal walls, 85 – 73.2 – 40.1 μm long, 35 – 15.2 -12.1 μm wide. **Cuticle** smooth. **Stomata**: absent. **Trichomes:** they are glandular and nonglandular intermixed (Table 3.1).

Non-glandular: occurs in 3 forms:

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex (Figure 3.4.1 D).

b. bicellular, uniseriate, unbranched with thin warty walls, wide lumina and acute apex (Figure 3.4.1 D).

c. multicellular (3 – 7 cells), uniseriate, unbranched with thin warty walls wide lumina and acute apex (Figure 3.4.1 D).

Glandular: trichomes occur in 7 forms.

a. stalk unicellular, unbranched and head unicellular (Figure 3.4.1 C).

b. stalk unicellular, unbranched and head bicellular (Figure 3.4.1 D).

c. stalk bicellular, unbranched and head unicellular (Figure 3.4.1 D).

d. stalk bicellular, unbranched and head bicellular (Figure 3.4.1 D).

e. stalk multicellular (3 or 4 cells) unbranched and head unicellular (Figure 3.4.1 C, D).

f. stalk multicellular (3 or 4 cells), unbranched and head bicellular (Figure 3.4.1 C).

g. stalk multicellular (3 or 4 cells) unbranched and head multicellular (4 cells) (Figure 3.4.1 C). All the glandular trichomes with ovate shape heads.

Lower epidermis: Cells rectangular or polygonal elongated with thin straight beaded anticlinal walls, 25 – 22.3 – 17.5 μm long, 15 – 9.5 – 7.2 μm wide (Figure 3.4.1B; Table 3.1). **Cuticle** is striated. **Stomata**

absent. **Trichomes** they are glandular and nonglandular intermixed and are similar to those of the upper epidermis.

3.4.1.2 Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin sinuous beaded anticlinal walls (50 – 41.5 – 35 μm long, 36 – 26.6 – 18 μm wide) (Figure 3.4.2A; Table 3.2). **Cuticle** smooth. **Stomata:** They are numerous (150/mm^2), ovate, anisocytic, anomocytic and diacytic, 36.3 – 35.5 – 20.5 μm long, 19.5 – 15.5 – 10 μm wide. **Trichomes**: They are glandular and nonglandular intermixed (Table 3.2).

Nonglandular: occur in three forms:

a. unicellular, unbranched with thin warty walls.
b. bicellular, uniseriate, unbranched with thin warty walls.
c. multicellular, 3 to 7 cells, uniseriate, unbranched with thin warty walls. All with wide lumina and acute apex.

Glandular: occur in 7 forms.

a. stalk unicellular, unbranched and head unicellular.
b. stalk unicellular, unbranched and head bicellular..
c. stalk bicellular unbranched, and head unicellular.
d. stalk bicellular, unbranched and head bicellular.
e. stalk multicellular (3 or 4), unbranched and head unicellular (Figure 3.4.2 A, C).
f. stalk multicellular (3 0r 4), unbranched and head bicellular (Figure 3.4.2 B, C).
g. stalk multicellular (3 or 4), unbranched and head multicellular (4 cells) (Figure 3.4.2 C).

All of the above with ovate glandular, heads.

Lower epidermis: Cells are polygonal with sinuous anticlinal thin cellulosic beaded walls, 75 – 40 – 32.5 μm long, 36.5 – 30 – 15 μm wide (Figure 3.4.2 B; Table 3.2). **Cuticle** is smooth. **Stomata** are numerous,

200/mm^2 mostly anisocytic, anomocytic and rarely diacytic. **Trichomes** are glandular and nonglandular (Table 3.2).

Nonglandular: occur in three forms:

a. unicellular, unbranched with thin cellulosic warty walls.

b. bicellular, uniseriate, unbranched with thin warty walls.

c. multicellular 3 to 7 cells, uniseriate, unbranched with thin warty walls.

All of the above nonglandular trichomes are with cellulosic walls and some of the multicellular trichomes with few collapsed cells.

Glandular: Occur in 7 forms as in the upper epidermis of intercostals region (Figure 3.4.2 B,C; Table 3.2).

3.4.2. Stem Epidermis

Cells are polygonal almost rectangular, elongated with thin, straight anticlinal cellulosic, beaded walls (Figure 3.4.3 A, B; Table 3.4). Cells 75 – 56.07 – 37.5 μm long, 25 – 22 – 20 μm wide. **Cuticle** smooth. **Stomata**: few (100/mm^2) ovate, occasionally arranged in pairs, commonly anomocytic occasionally anisocytic (Figure 3.4.3. A, B; Table 3.3). **Trichomes**: are glandular and nonglandular.

Nonglandular: two forms

a bicellular uniseriate unbranched with warty thin walls, wide lumina and acute apex.

b. multicellular, (3 to 7 cells) uniseriate unbranched with warty thin walls, wide lumina and acute apex.

Some of the above trichomes are with collapsed cells.

Glandular: Similar to those of the lower epidermis of intercostals region of the leaf (Figure 3.4.3 C).

3.4.3. Floral Parts

3.4.3.1. Calyx:

3.4.3.1.1. Abaxial surface

Epidermal cells are isodiametric with cellulosic thin sinuous anticlinal walls, 35 – 22.5 – 13.4 μm long, 23.3 – 17.1 – 15.7 μm wide (Figur3.4.4 A,B; Table 3.4). **Cuticle** smooth or slightly striated at the calyx base. **Stomata**: (50/mm^2) at the calyx apex, anomocytic, and diacytic ovate. **Trichomes**: They are glandular and nonglandular.

Nonglandular: three forms:

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex.
b. bicellular, uniseriate, unbranched with thin warty walls, wide lumina and acute apex.
c. multicellular, 3 – 6 cells, uniseriate, unbranched with thin warty walls, wide lumina and acute apex.

Glandular: five forms:

a. Stalk unicellular and head unicellular.
b. Stalk unicellular and head bicellular.
c. Stalk bicellular and head unicellular (figure 3.4.4 B).
d. Stalk bicellular and head bicellular.
e. Stalk multicellular (3 or 4 cells), unbranched and head multicellular (3 or 4 cells) ovate shape.

3.4.3.1.2. Adaxial surface

Epidermal cells are polygonal at calyx veins, isodiametric in between stem veins with thin sinuous anticlinal walls 38 – 36.2 – 20.5 μm long, 28 – 15 – 12.5 μm wide (Figure 3.4.4 B; Table 3.4). **Cuticle** smooth and slightly striated at the calyx base. **Stomata** few 50/mm^2 anomocytic and diacytic distributed at the calyx apex. **Trichomes** glandular and nonglandular intermixed and are similar in their characters to those of the adaxial surface (Figure 3.4.4 B; Table 3.4).

3.4.3.2. Corolla

3.4.3.2.1 Abaxial surface

Epidermal cells are isodiametric with thin cellulosic sinuous beaded anticlinal walls or polygonal elongated with straight walls, in between calyx veins, 47 – 35 – 20.5 μm long, 28 – 15 – 12.5 μm wide, (Figure 3.4.5 A; Table 3.5). **Cuticle** longitudinally striated. **Stomata** absent. **Trichomes** are glandular and nonglandular intermixed.

Nonglandular are one form which is multicellular, 3 – 6 cells long uniseriate unbranched with thin warty walls, wide lumina and acute apex.

Glandular: trichomes are 5 forms similar to those that occur in the calyx adaxial region (Figure 3.4.5 A; Table 3.5).

3.4.3.2.2. Adaxial surface

Epidermal cells isodiametric with thin cellulosic sinuous anticlinal walls, 55.2 – 25.7 – 13.8 μm long, 32 – 24.1 – 20.5 μm wide or polygonal elongated at the calyx veins (Figure 3.4.5B; Table 3.5). **Cuticle**, smooth. **Stomata** absent. **Trichomes** are glandular and nonglandular, similar to those at the corolla abaxial surface.

3.4.4. INTERNAL STRUCTURE

3.4.4.1. Leaf, midrib region

Upper epidermis: Cells are tabular with thin, cellulosic walls, thick outer walls cuticle thin (Figure 3.4.6 A, B; Table 3.5).

Messophyll: Consist of single layer of lamellar collenchyma under the abaxial and adaxial surfaces. Ground tissue consists of 2 – 4 layers of parenchyma cells, round, surrounding the vascular bundle devoided of chloroplasts and with conspicuous intercellular spaces.

Bundle sheath: Consist of 1 layer of unlignified large parenchyma cells, devoided of chloroplasts or starch (Figure 3.4.6 B).

Vascular tissue: Consist of one large arched vascular bundle, xylem elements in radial rows, primary phloem consist of groups of sieve

tubes and companion cells. A group of outer phloem fibers also observed (Figure 3.4.6 A, B) with thick unlignified cell walls.

Lower epidermis: similar to those of the upper epidermis.

3.4.4.2. Leaf, Intercostal Region

Upper epidermis: Cells are tabular with outer thin walls cellulosic. Cuticle thin (Figure 3.4.6 C; Table 3.6).

Messophyll: Consist of 3 or 4 layers of palisade type cells, followed by 5 – 7 layers of spongy tissue of small round parenchymous cells both with conspicuous intercellular spaces (Figure 3.4.6 C).

Lower epidermis: Similar to those of the upper epidermis (Figure 3.4.6 C).

3.4.4.3. Stem

The transverse section of the stem is round in outline, exhibiting some glandular and non glandular trichomes (Figure 3.4.7 A, B, C, D; Table 3.7).

Epidermis: Cells tabular, cuticle thin, outer epidermal cell walls, thick, (8 μm), radial walls thin 2 μm both cellulosic (Figure 3.4.7 B).

Cortex: Consist of one layer of hypodermal cells with thick walls followed by several layers, 2 – 5 of round chlorenchymatous cells with conspicuous intercellular spaces. Bundle Sheath*:* Consist of one layer of a large paranchyma cells devoided of chloroplasts or starch (Figure 3.4.7 B).

Vascular Tissue: Xylem forming a continuous cylinder, vessels with wide lumina arranged in radial rows with secondary growth. **Phloem:** making a continuous cylinder of sieve tubes elements, companion cells (Figure 3.4.7 A, D).

Medulla (pith): Consist of polygonal homogenous parenchymatous cells with slightly thick cellulosic walls and conspicuous intercellular spaces (Figure 3.4.7 C).

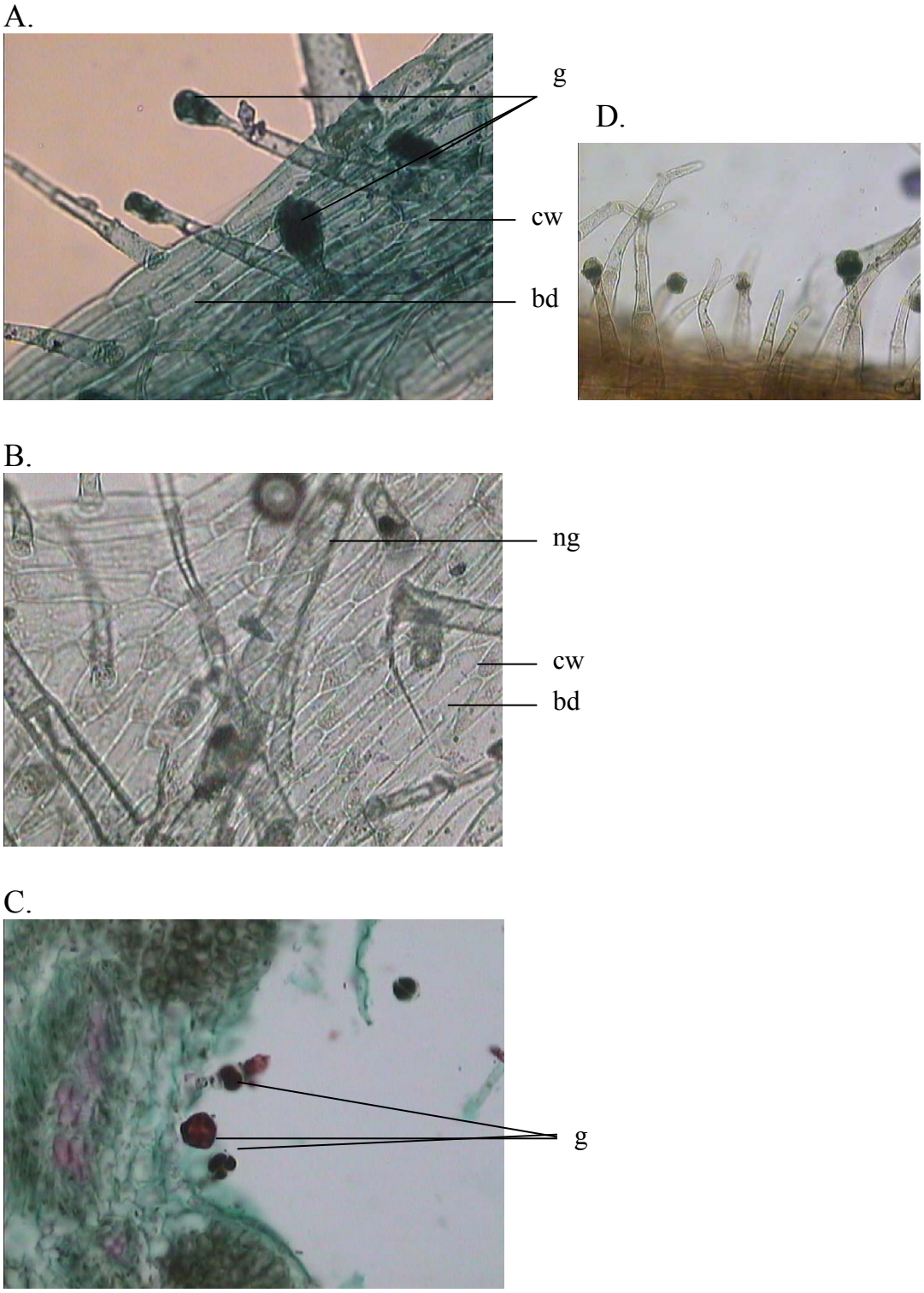
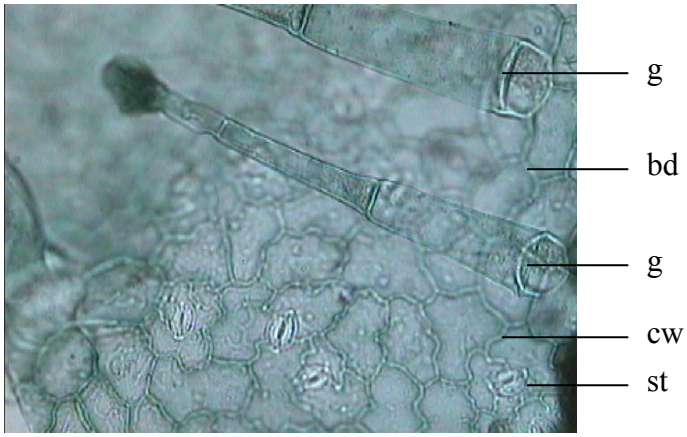
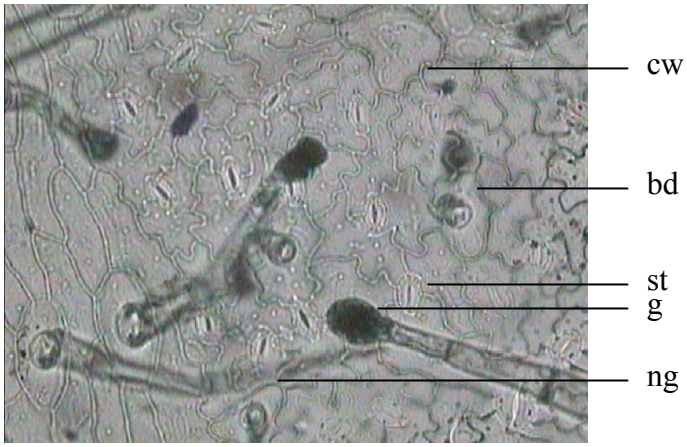


Figure (3.4.1): Leaf, midrib region of *Nepeta deflersiana*. A – Upper epidermis; B – Lower epidermis; C, D – trichomes (A – D x 400).

A.



B.



C.

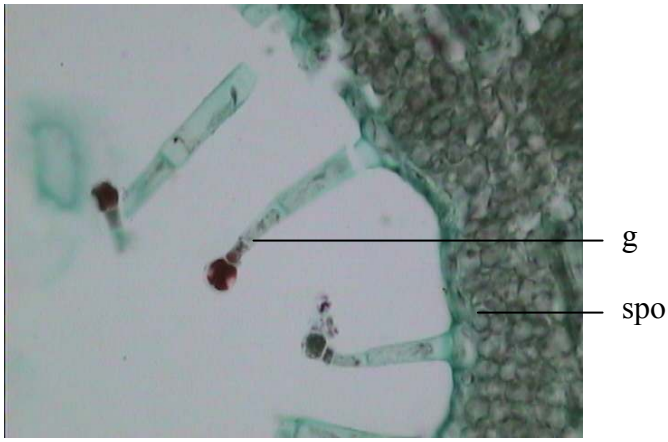
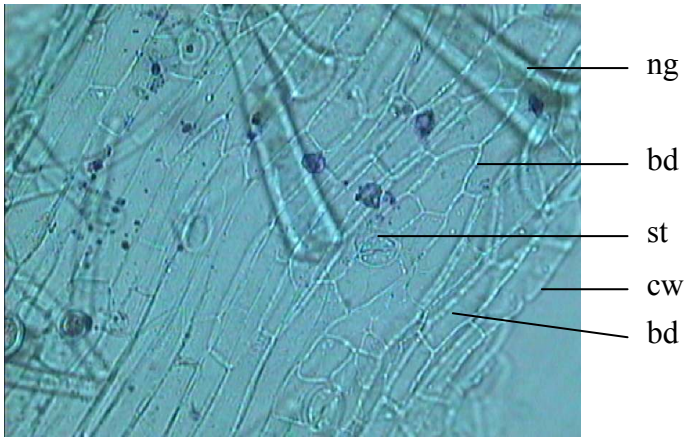
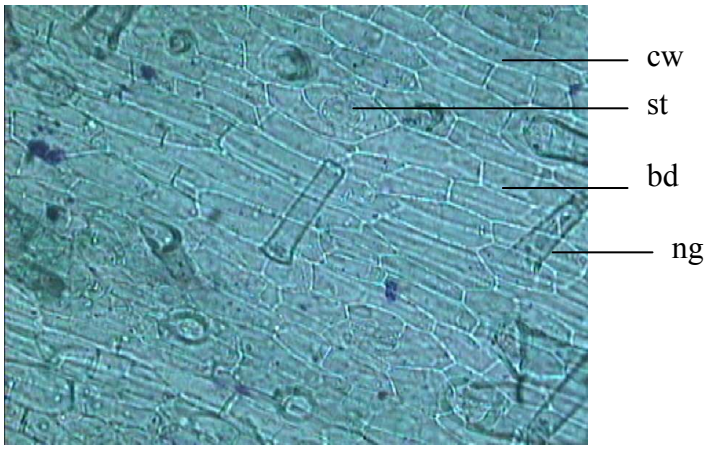


Figure (3.4.2): Leaf, intercostal region of *N. deflersiana.* A – Upper epidermis; B. Lower epidermis; C – Glandular trichomes on the lower intercostal region (A – C x 400).

A.



B.



C.

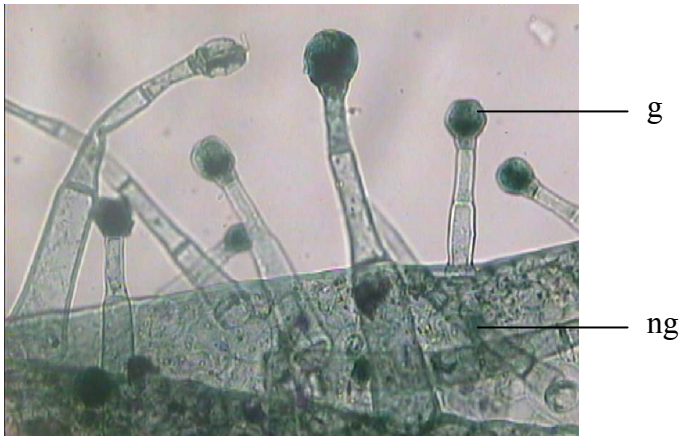
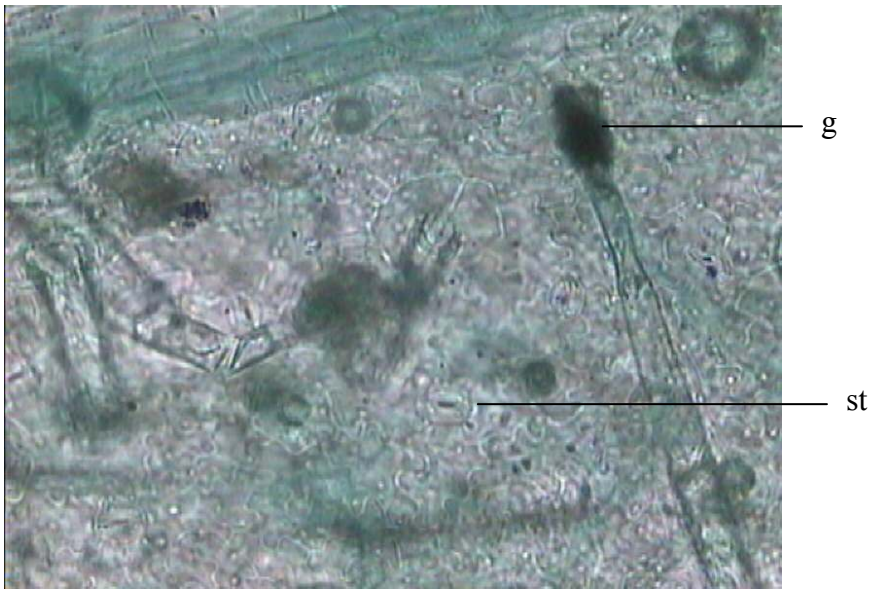


Figure (3.4.3): A – C Stem epidermis of *N. deflersiana* stem. C – Stem epidermis showing glandular and nonglandular trichomes (A – C x 400).

A.



B.

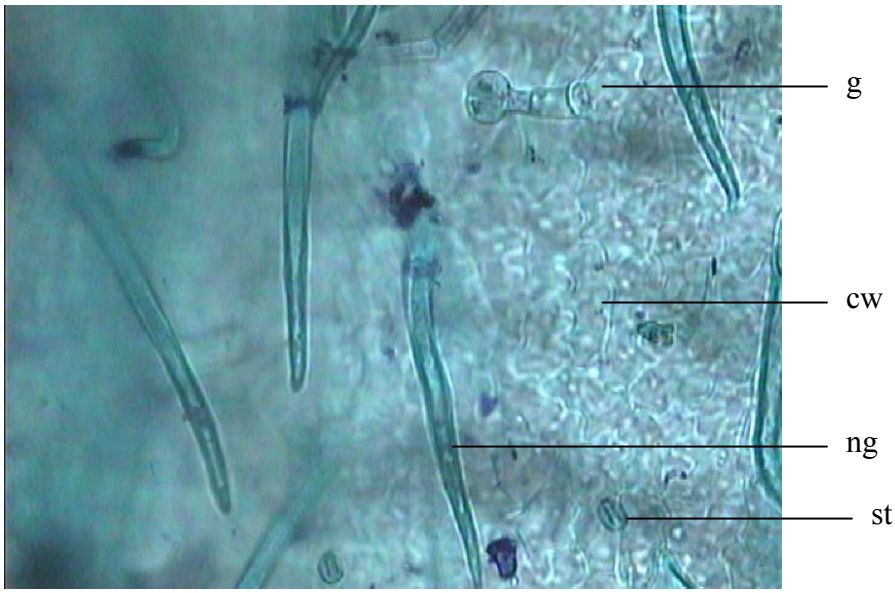
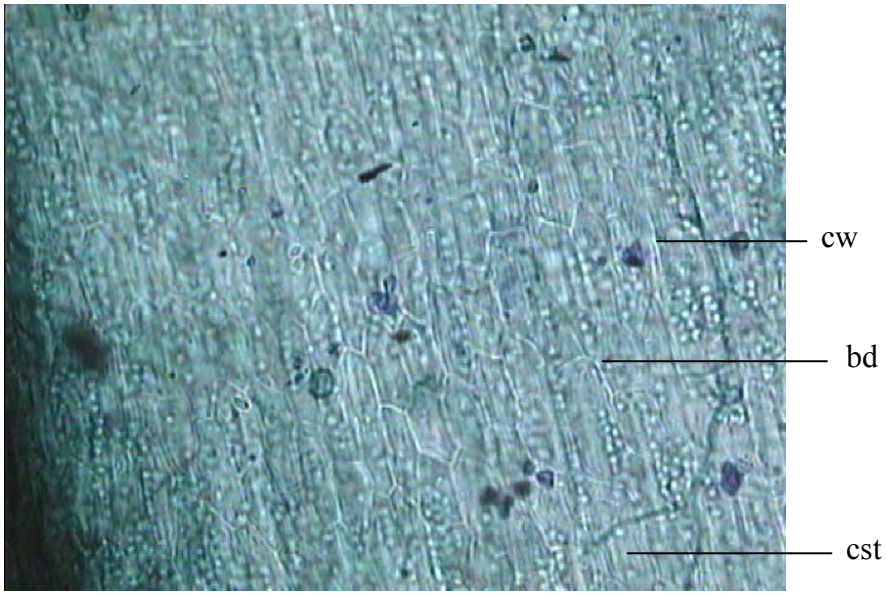


Figure (3.4.4): Floral parts of *N. deflersiana.* A – Calyx, abaxial surface; B – Calyx, adaxial surface (A, B x 400).

A.



B.

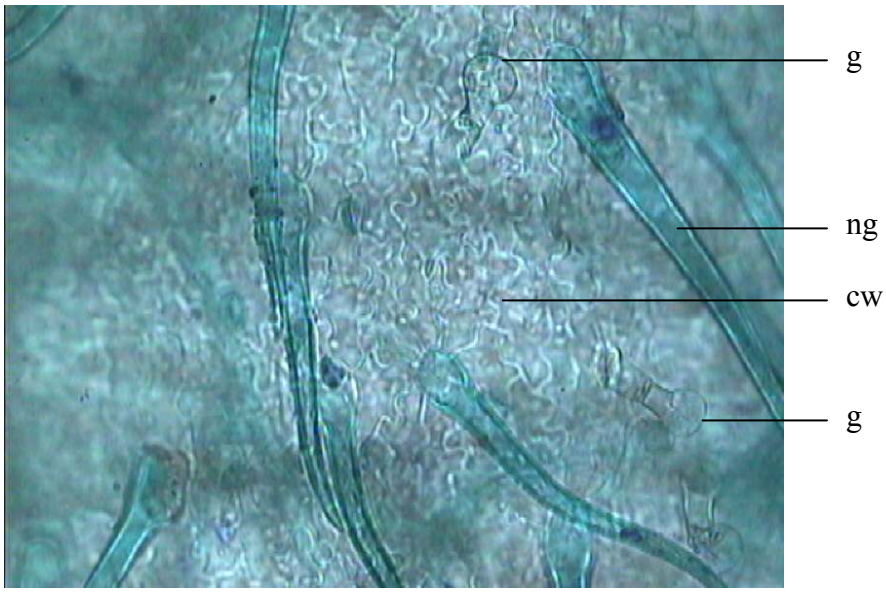


Figure (3.4.5): Floral parts of *N. deflersiana*. A. Corolla, abaxial surface; B. Corolla, adaxial surface (A, B x 400).

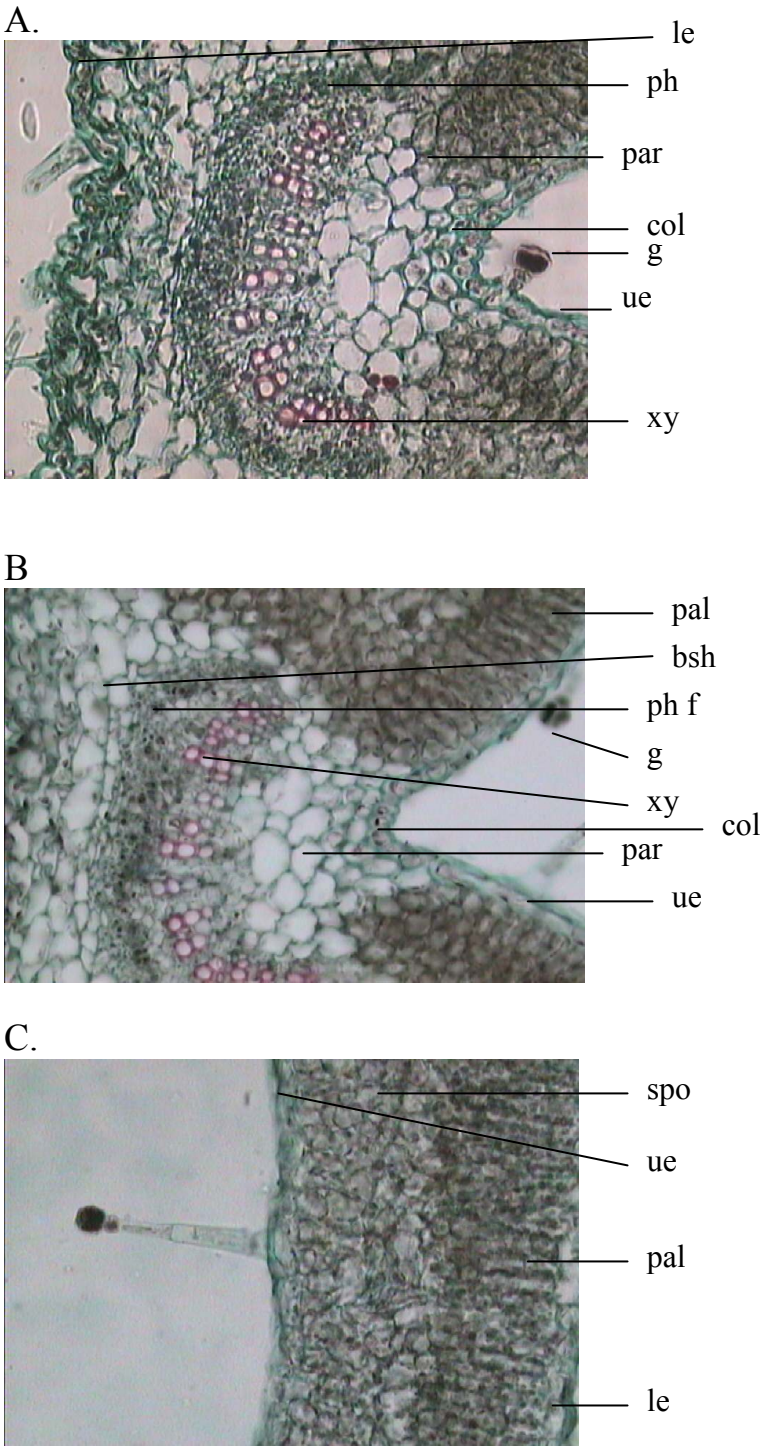
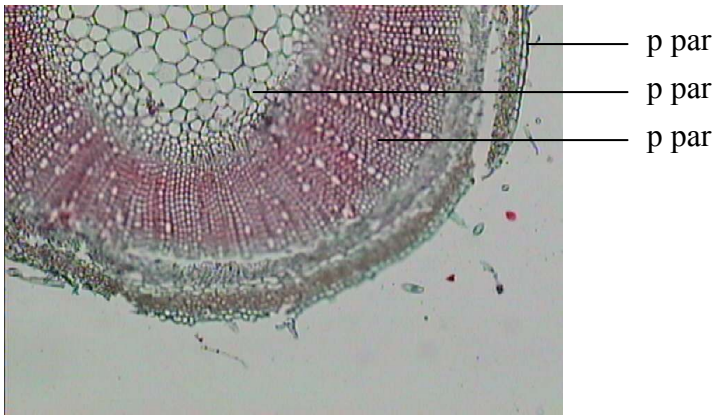
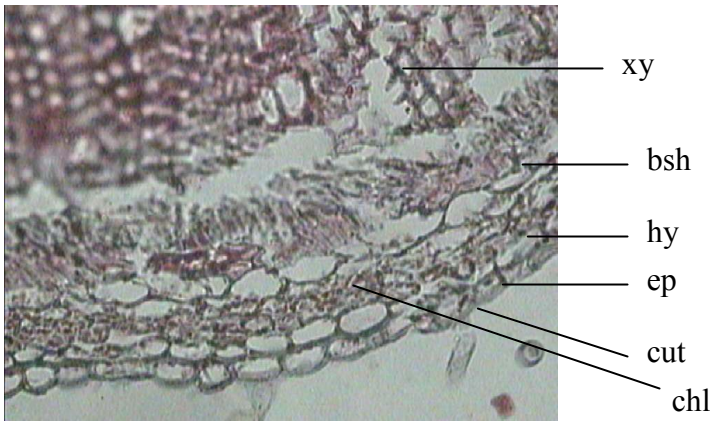


Figure (3.4.6): Leaf transverse section of *N. deflersiana*. A, B – Midrib region; C – Intercostal region (A – C x 400).

A.



B.



C.

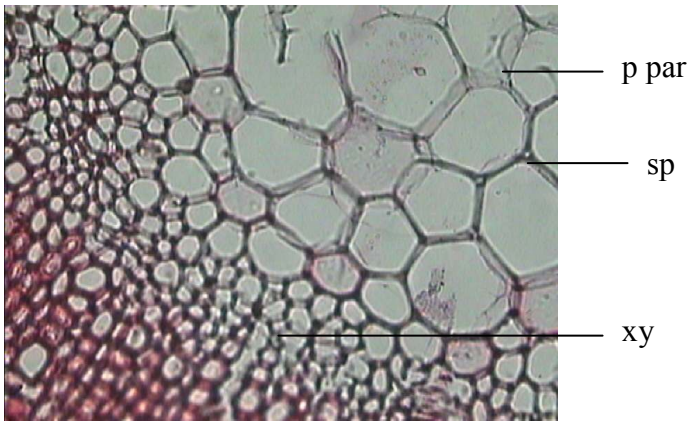


Figure (3.4.7): A – C Stem transverse sections of Nepeta deflersiana. A, (x 100); B, C (x 400).

3.5. *Nepeta septemecrenata L.*

3.5.1. EPIDERMAL CHARACTERS

3.5.1.1 Leaf, Midrib Region

Upper epidermis: Cells are polygonal elongated with thin straight cellulosic anticlinal cell walls, (55.6 – 26.1 – 17.7 μm long, 35 – 30 – 12.2 μm wide); the epidermis is covered with **cuticle** thin which is longitudinally striated (Figure 3.5.1 A; Table 3.1). **Stomata** are absent. **Trichomes:** they occur in two types, glandular and non-glandular intermixed.

Nonglandulars: numerous and occur in 3 forms:

a. unicellular unbranched with thin warty cell walls, wide lumina and acute apex;
b. bicellular, uniseriate unbranched with thin warty cell walls, wide lumina and acute apex.
c. multicellular, 3 – 5 cells uniseriate unbranched with thin warty walls wide lumina and acute apex.

All the above trichomes with cellulosic cell walls and some with collapsed cells (Figure 3.5.1 A,C,D, Table 3.1).

Glandular: are numerous and occur in two forms:

a. stalk unicellular, unbranched with unicellular head with spherical shape (Figure 3.5.1 C, Table 3.1).
b. stalk bicellular, head unicellular, round shape (Figure 3.5.1 C).

Lower epidermis: Cells are polygonal elongated, and thin straight anticlinal walls, cellulosic, 50.5 – 40.5 –30.1 μm long, 30.5 – 20 – 10.1 μm wide; **cuticle** longitudinally striated (Figure 3.5.1B; Table 3.2). **Stomata** are absent. **Trichomes** are similar to those of the upper epidermis region but with an additional form of glandular trichome

having: unicellular stalk with multicellular head (3 or 4 cells) which is large and spherical.

3.5.1.2 Leaf, Intercostal Region

Upper epidermis: Cells polygonal with thin sinuous anticlinal cellulosic walls, 45.5 – 40.6 – 20.5 μm long, 32.6 – 30.1 –25.5 μm wide; cells covered with smooth **cuticle** (Figure 3.5.2 A ; Table 3.2)**. Stomata** are numerous, ovate, 150/mm^2 mainly anisocytic and rarely anomocytic or diacytic intermixed; 20.1 – 15.5 – 10.5 μm long, 20.1 – 10.5 – 7.5 μm wide. **Trichomes**: their characters are similar to those of the lower epidermis of the midrib region.

Lower epidermis: Characters are similar to those of the upper epidermis (Figure 3.5.2 B; Table 3.2). **Stomata** are more frequent, 250/mm^2.

3.5.1.3. Stem Epidermis

Cells are rectangular or polygonal elongated with thin cellulosic, beaded anticlinal walls, 37.2– 20.7 – 10.5 μm long, 10.5– 7.5 – 4.5 μm wide covered with thin longitudinally striated **cuticle** (Figure 3.5.3 A, B; Table 3.3). **Stomata** are few (100/mm^2) ovate anomocytic and anisocytic rarely diacytic, 17.5 – 12.5 – 10 μm long, 12.5 – 10 – 6 μm wide. **Trichomes** are glandular and nonglandular intermixed, similar to those of the lower epidermis of the midrib region.

3.5.1.4. Floral Parts

3.5.1.4.1. Calyx:

3.5.1.4.1.1 Abaxial surface

Cells are polygonal isodiametric with sinuous thin cellulosic anticlinal beaded walls, 46 – 30 – 20.5 μm long, 35 – 25.5 – 20.5 μm wide (Figure 3.5.4 A). **Cuticle** striated. **Stomata** are few 50/mm^2 commonly diacytic and anomocytic intermixed, ovate, 20.5 – 15 – 7.5 μm

long, 10.5 – 8 – 5.5 μm wide. **Trichomes:** They are glandular and nonglandular intermixed (Table 3.4).

Nonglandular: in three forms

a. unicellular, unbranched with wide lumina and acute apex (Figure 3.5.4 A).
b. bicellular, uniseriate unbranched, wide lumina and acute apex (Figure 3.5.4 A).
c. multicellular (3 – 7 cells) uniseriate, unbranched, wide lumina and acute apex (Figure 3.5.4 C).

All the above trichomes are with cellulosic thin warty walls (Figure 3.5.4 A,C).

Glandular: in 4 forms;

a. stalk unicellular and head unicellular with large spherical shape.
b. stalk bicellular, head unicellular.
c. stalk bicellular and head bicellular.
d. stalk unicellular, head multicellular (4 – 8), heads large with spherical shape (Figure 3.5.4 B).

3.5.1.4.1.2. Adaxial surface

Cells are polygonal isodiametric with thin sinuous, cellulosic beaded anticlinal walls, 55.7– 30.5 – 20.5 μm long, 33.7 – 30 – 20μm wide (Figure 3.5.4 B, C; Table 3.4). **Cuticle** striated especially at the calyx base. **Stomata** are few, 50/mm^2, diacytic and anomocytic, ovate. **Trichomes**: glandular and nonglandular, their characters are similar to those of the calyx abaxial surface (Figure 3.5.4 B, C; Table 3.4).

3.5.1.4.2. Corolla:

3.5.1.4.2.1. Abaxial surface

Cells are polygonal with thin sinuous, cellulosic beaded anticlinal walls, 60 – 55 – 40 μm long, 33 – 24 – 20 μm wide, (Figure 3.5.5 A,

Table 3.4). **Cuticle** smooth. **Stomata** are few 50/mm^2 diacytic and anomocytic. **Trichomes**: glandular and nonglandular intermixed.

Nonglandular: occur in one form; multicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex (Figure 3.5.5 A).

Glandular: occur in 4 forms – similar to those at the calyx surface (Figure 3.5.4 C).

3.5.1.4.2.2. Adaxial surface

Cells are similar in their characters to those of the abaxial surface (Figure 3.5.5 B; Table 3.4).

3.4.2. INTERNAL STRUCTURE

3.4.2.1. Leaf, Midrib Region

Upper epidermis: Cells are tabular with slightly thick outer walls and radial walls are thin (Figure 3.5.6 B, D; Table 3.5). Cuticle thick. **Mesophyll:** consist of one or two layers of lamellar collenchyma cells under the upper and lower epidermis with thick cellulosic walls followed by 2 to 6 layers of large round parenchymous cells devoided of chloroplasts, surrounding the vascular bundle. **Vascular tissue:** One round vascular bundle, xylem elements consists of tracheary elements in rows. Vessels with thick lignified cell walls and wide lumina. Primary phloem elements are present procambium clear. Outer phloem fibers are in groups of unlignified narrow cell walls.

Lower epidermis: Cells are tabular with thick outer walls and thin inner walls with thick cuticle (Figure 3.5.6 C,D,E; Table 3.5).

3.4.2.2. Leaf, Intercostal Region

Upper epidermis: cells are tabular, cuticle is thin, outer walls are slightly thick, inner walls are thin (Figure 3.5.6 A; Table 3.6). **Mesophyll:** differentiated into palisade and spongy tissues. Palisade tissue consists of 2 or 3 layers of palisade type cells with many

chloroplasts and conspicuous intercellular spaces. Spongy tissue consists of 3 or 4 layers of parenchymous cells with many chloroplasts and conspicuous intercellular spaces (Figure 3.5.6 A,C).

Lower epidermis: cells are small, tabular with slightly thick outer walls and thin inner walls (figure 3.5.6 A, C, D; Table 3.6). Cuticle thin.

3.4.2.3. Stem

The transverse section of the stem is quadrangular in outline, exhibiting some glandular and non glandular trichomes (Figure 3.5.7 A, B, C; Table 3.7).

Epidermis: Epidermal cells are covered with thin cuticle (2.5 μm), cells are small tabular, with thin cellulosic walls. The outer walls are thick and the radial walls are thin (Figure 3.5.7 C, D; Table 3.7).

Cortex: It consists of lamellar chollenchyma 3 – 5 layers at stem angles 4 or 5 layers of paranchymatous cells contain chloroplasts (chlorenchyma tissue), reaching to 8 to 10 layers near the stem corner. **Bundle Sheath:** It consist of a single layer of a large tabular cells with thin unlignified cell walls, devoided of chloroplasts or starch grains.

Vascular Tissue*:* It consists of several vascular bundles arranged in a discontinuous cylinder, well developed at stem angles as 4 main groups. Outer phloem fibers: consist of groups of fibers with thick unlignified cell walls covering the main vascular bundles as an arc shape. Primary phloem: consist of groups of sieve tubes and companion cells. Primary xylem: with tracheary elements in rows, vessels radially arranged as a discontinuous cylinder with large lignified xylem elements opposite stem corners.

Medulla (pith): It consists of homogenous parenchymatous cells polygonal, with thin celulosic cell walls and conspicuous intercellular spaces (Figure 3.5.7 A, B).

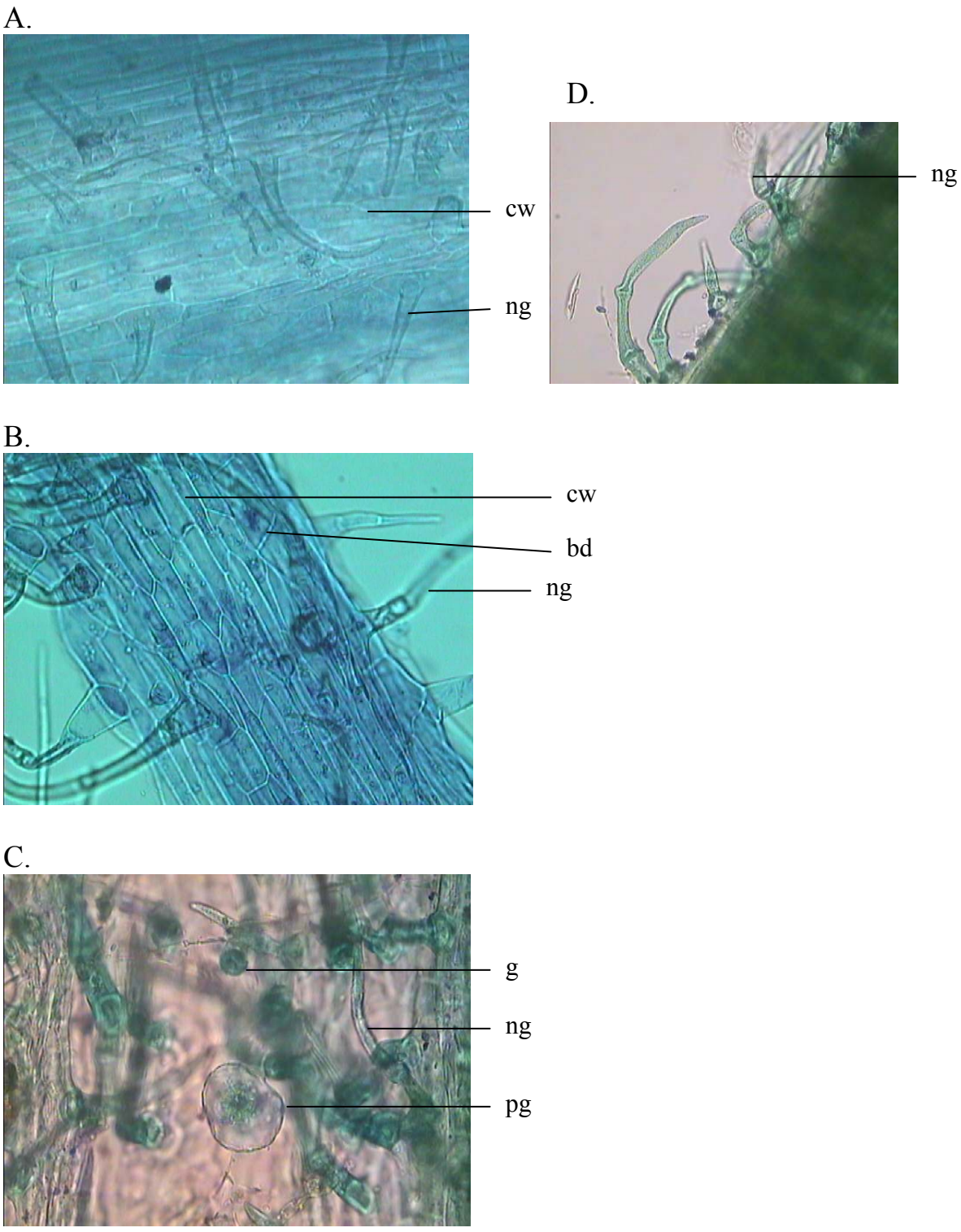
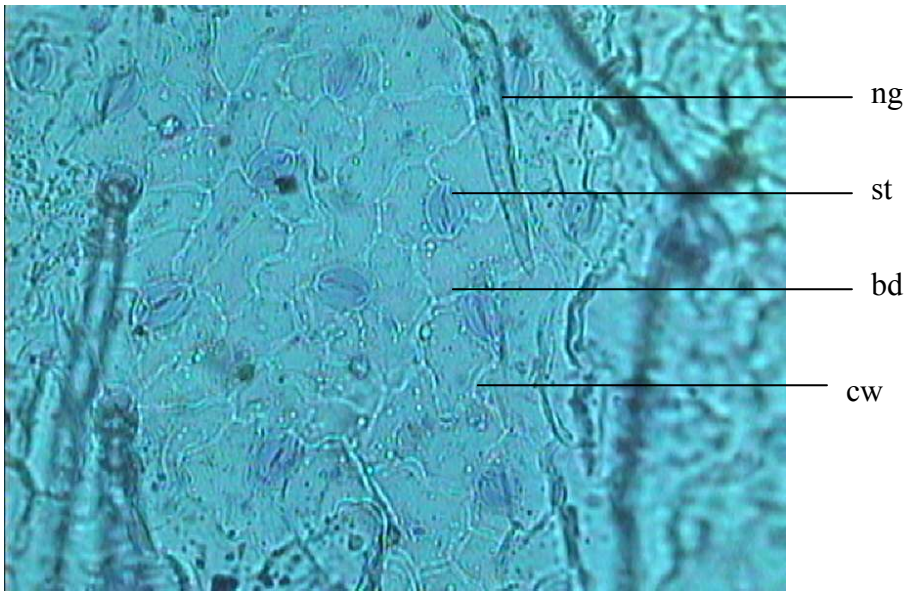


Figure (3.5.1): Leaf midrib region of *Nepeta septemecrenata*. A – Upper epidermis; B – Lower epidermis; C, D – Trichomes on the midrib region (A – D x 400).

A.



B.

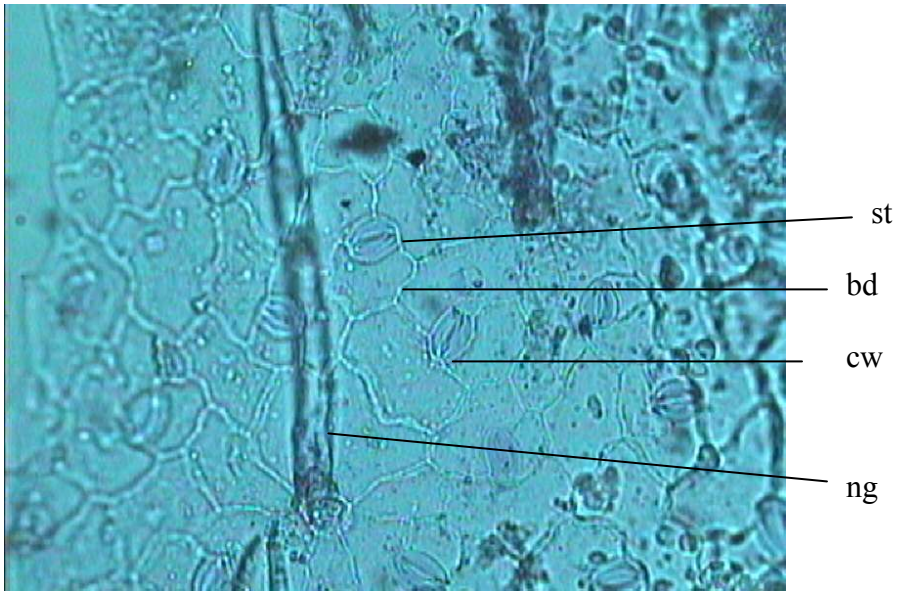
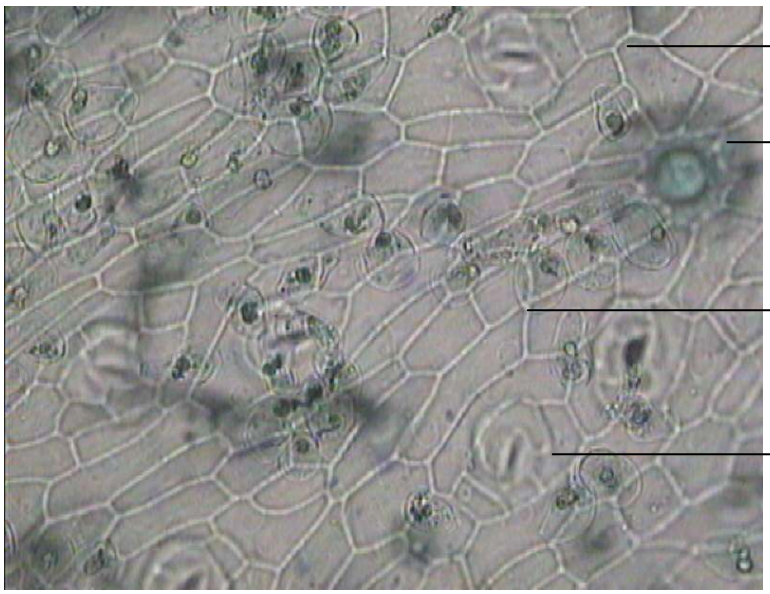


Figure (3.5.2): Leaf, intercostal region of *N. septemecrenata.* A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.



B.

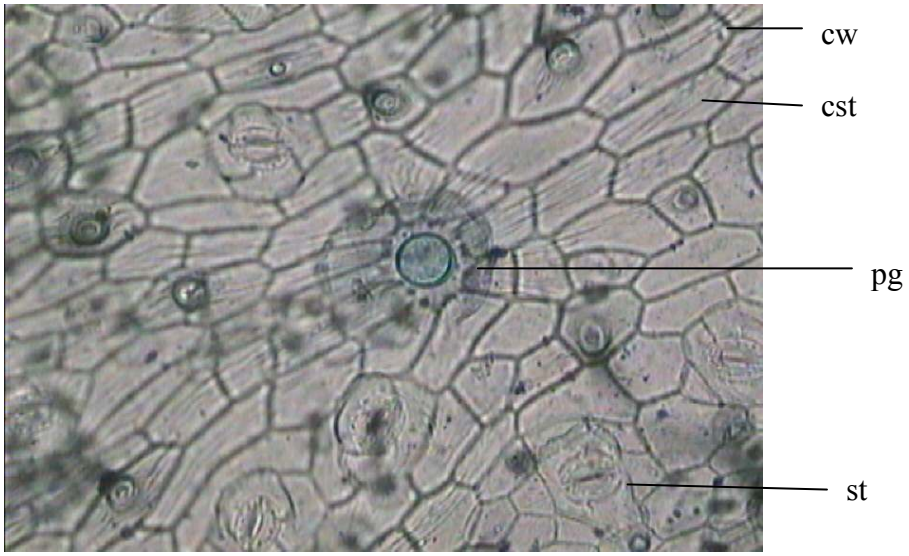
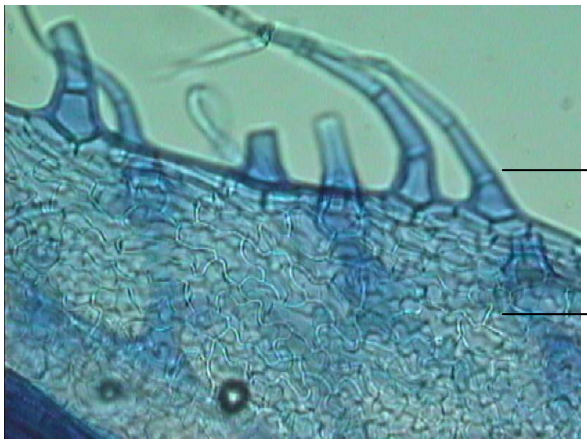
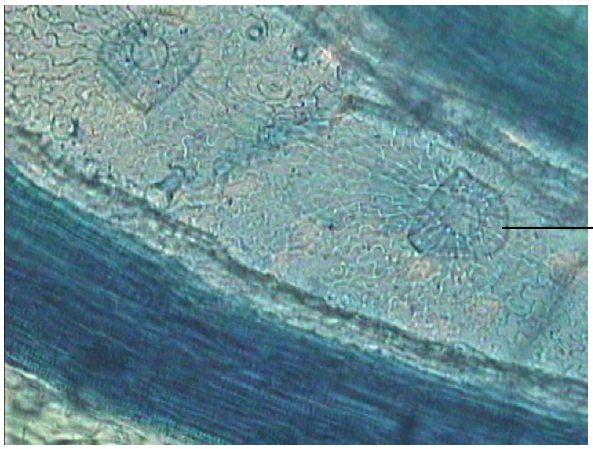


Figure (3.5.3): A, B Stem epidermis of *N. septemecrenata* (x 400).

A.



B.



C.

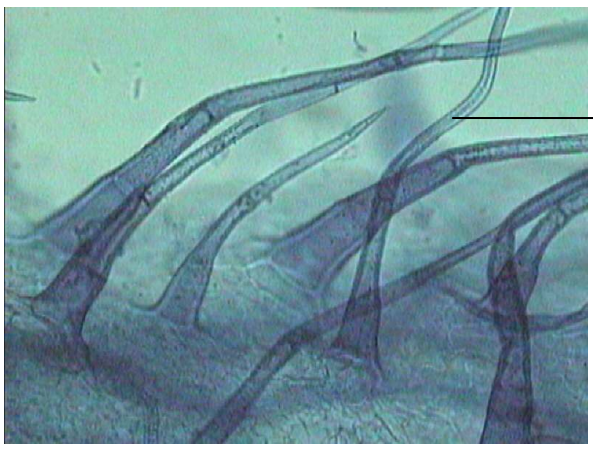
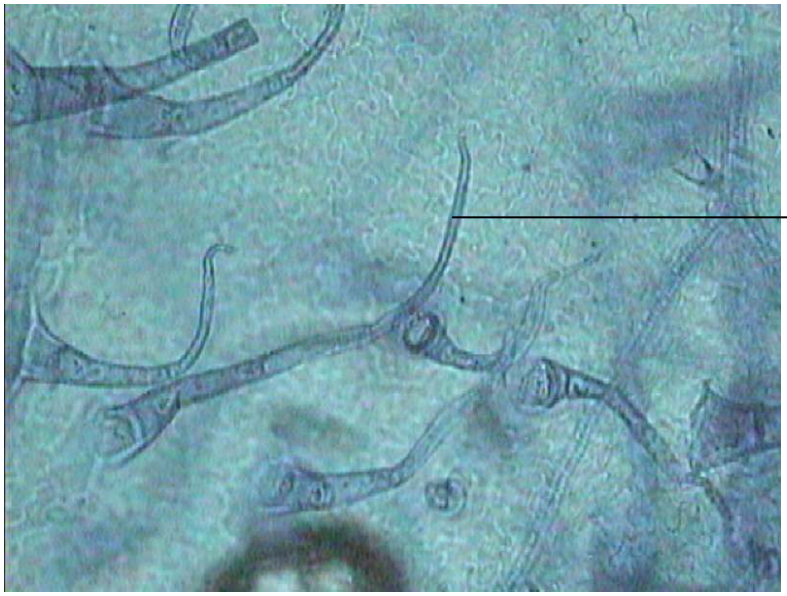


Figure (3.5.4): Floral parts of *N. septemecrenata* flowers. A – Calyx, abaxial surface; B – Calyx, adaxial surface; C – Calyx, nonglandular trichomes (A – C x 400).

A.



B.

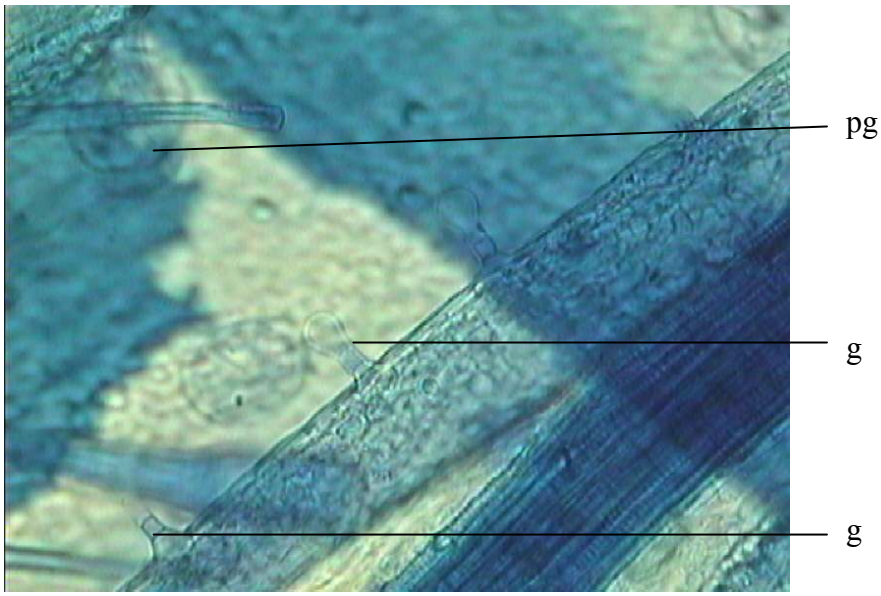


Figure (3.5.5): Floral parts of *Nepeta septemecrenata*. A – Corolla, abaxial surface; B – Corolla, adaxial surface (A, B x 40).

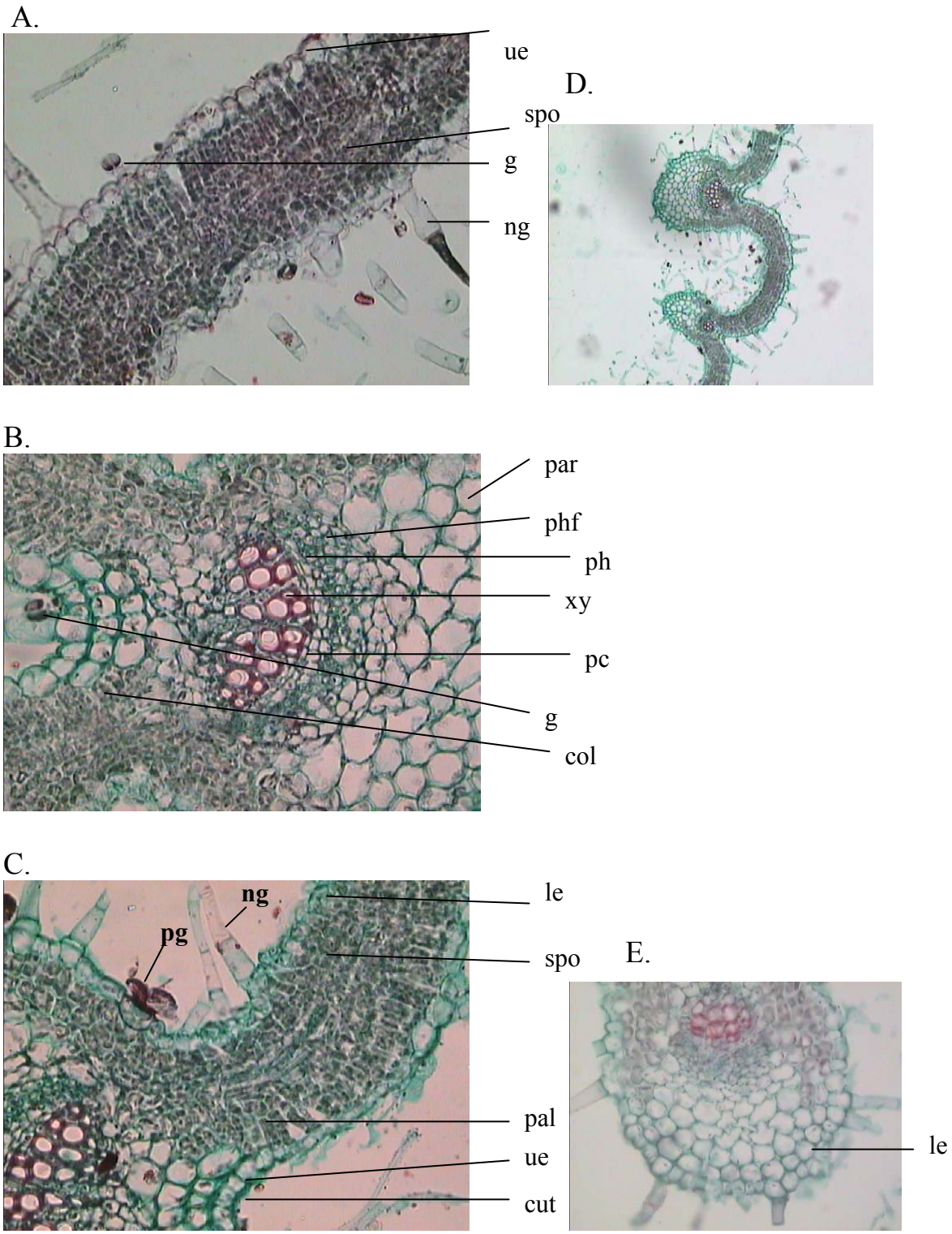
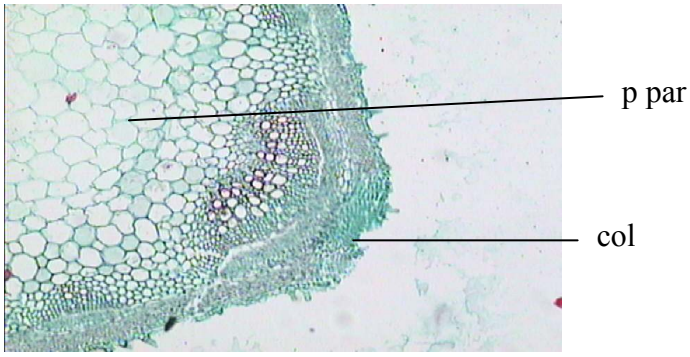
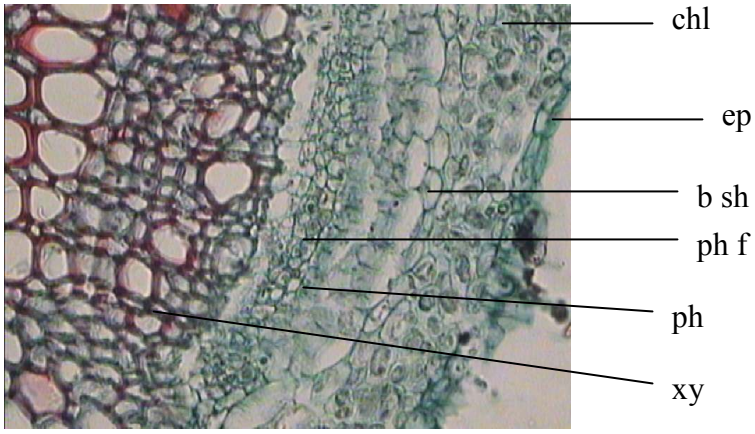


Figure (3.5.6): Transverse sections of leaf of Nepeta spetemecranata. A, C – Intercostal region; B, D, E – Midrib region, (A, B, C, E x 400; D x 100).

A.



B.



C.

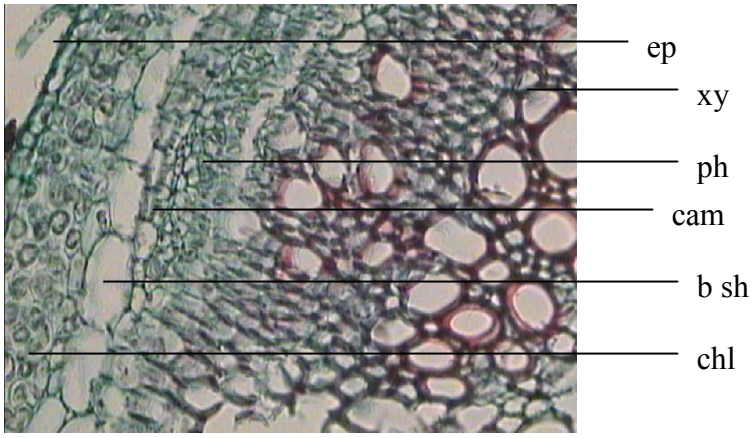


Figure (3.5.7): A – C Stem transverse sections of *Nepeta septemecrenata*. A – Stem corners (x 100); B, C – Stem between corners (x 400).

3.6. *Otostegia fruticosa var. fruticosa* (Forssk.) Brig.

3.6.1. EPIDERMAL CHARACTERS

3.4.1.1. Leaf, Midrib Region

Upper Epidermis: Cells are polygonal elongated with some rectangular elongated, 87.5 – 65-9 –42.5 μm long, 22.5 – 15.3 – 12.5 μm wide, with thin, straights beaded cellulosic anticlinal cell walls. **Cuticle** is smooth. **Stomata** are absent. **Trichomes** are glandular and nonglandular intermixed, very dense, 250/mm^2 (Figure 3.6.1 A; Table 3.1).

Nonglandular: consists of two types.

a. unicellular, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.6.1 D).
b. bicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.6.1 C, D).

All the above trichomes seated on pedestals of 2 – 4 epidermal cells, well cutinized and heading towards the leaf apex.

Glandular: consist of 3 forms.

a. stalk unicellular unbranched, head unicellular (Figure 3.6.1 A,C).
b. stalk unicellular, unbranched head bicellular (Figure 3.6.1 A,C).
c. stalk unicellular, unbranched head multicellular (3 or 4 cells) with small spherical shape (figure 3.6.1 C, D).

Lower Epidermis: Cells are polygonal elongated with some rectangular elongated 87.5– 55.9 – 42.5 μm long, 22.5 – 15.3 – 12.5 μm wide with thin cellulosic straight anticlinal cell walls. **Cuticle** smooth. **Stomata** are absent. **Trichomes** are glandular and nonglandular intermixed (Figure 3.6.1 B, C, D; Table 3.1).

Nonglandular: consist of two types.

a. unicellular, unbranched with thick warty cell walls, wide lumina and acute apex (Figure 3.6.1 B, C, D).

b. bicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.6.1 B, C, D).

All the above trichomes seated on pedestals of 2-4 epiderma cells well cutinized, heading towards the leaf apex (Figure 3.6.1 B).

Glandular: consist of 3 types.

a. stalk unicellular, unbranched, head unicellular (Figure 3.6.1 C, D).

b. stalk unicellular, unbranched, head bicellular (Figure 3.6.1 C, D).

c. stalk unicellular, unbranched, head multicellular (3 or 4 cells) with spherical shape (figure 3.6.1 C, D).

3.6.1.2 Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin cellulosic slightly sinuous anticlinal cell walls, 77.5– 66 – 26 μm long, 42 – 28 – 25 μm wide, beaded. **Cuticle** is smooth. **Stomata** are ovate diacytic, anomocytic occacionally anisocytic, 150/mm^2, 25 – 24.5 – 22.5 μm long, 22.5 – 18 – 15 μm wide. **Trichomes:** are glandular and nonglandular intermixed (Figure 3.6.2 A, B, C; Table 3.2).

Nonglandular: occur in 2 forms

a. unicellular unbranched, with warty thick cell walls wide lumina and acute apex (Figure 3.6.2 A, B, C).

b. bicellular uniseriate unbranched, with warty thick cell walls, wide lumina and acute apex (Figure 3.6.2 C).

Glandular: occurs in 3 forms

a. stalk unicellular, unbranched head unicellular (Figure 3.6.2 C).

b. stalk unicellular, unbranched head bicellular (Figure 3.6.2 C).

c. stalk unicellular, unbranched, head multicellular (from 3 – 4) (Figure 3.6.2 A, B, C).

Lower epidermis: Cells are polygonal with thin slightly sinuous, cellulosic beaded anticlinal walls 78.5– 41.3 – 36 μm long, 40.5 – 29.1 – 26.5 μm wide, (Figure 3.6.3 A, B, C; Table 3.2). **Cuticle** smooth. **Stomata:** ovate commonly diacytic, anomocytic and anisocytic, 200/mm^2, 26.1– 23.5 – 22.3 μm long, 23.5 – 19 – 1.5 μm wide. **Trichomes** are glandular and nonglandular intermixed, are similar to those of the upper epidermis of intercostal region (Figure 3.6.3 A, B, C; Table 3.2).

3.6.1.3 Stem Epidermis

Cells are polygonal, 75 – 56.25 – 30 μm long, 27.5– 25 – 15.5 μm wide, with thin cellulosic straight beaded anticlinal cell walls, with smooth cuticle. **Stomata** are ovate, 30 – 18 – 21μm long, 20 – 19 – 17.5 μm wide, anomocytic and diacytic, 150/mm^2. **Trichomes** glandular and nonglandular intermixed, similar to those of the upper epidermis of the intercostals region (Figure 3.6.4 A; Table 3.3).

3.6.1.4. Floral Parts

3.6.1.4.1 Calyx

3.6.1.4.1.1 Abaxial surface

Cells are isodiametricwith thin sinuous cellulosic beaded anticlinal cell walls, 57.5 – 49 – 45 μm long, 30 – 19.6 – 10 μm wide. **Cuticle** is smooth. **Stomata** are absent. **Trichomes** They occur in glandular and nonglandular intermixed.

Nonglandular: are similar to those of the upper epidermis of the intercostals region with the addition of the multicellular (3 – 5 cells) uniseriate form which exist with thin warty walls, wide lumina and acute apex (Figure 3.6.5 A, B, C; Table 3.4).

Glandular: occur in 2 forms.

a. stalk unicellular unbranched with unicellular head round in shape.

b. stalk unicellular unbranched, head multicellular, (3 or 4) cells with round in shape (Figure 3.6.5. C).

3.6.1.4.1.2. Adaxial surface

Cells are isodiametricwith thin sinuous cellulosic beaded anticlinal walls, 75 – 45.5 – 23.1 μm long, 58.5 – 22.8 – 15 μm wide. **Stomata** is absent. **Trichomes:** They are similar to those of the calyx abaxial surface (Figure 3.6.5 C; Table 3.4).

3.6.1.4.2. Corolla

3.6.1.4.2.1. Abaxial surface

Cells are isodiametric and some rectangular (at the corolla veins) (Figure 3.6.6 C) with thin, cellulosic beaded walls, 42.5 – 31.4 – 25 μm long, 20 – 16.6 – 15 μm wide. **Cuticle** smooth. **Stomata** are absent. **Trichomes:** They occur in glandular and nonglandualr intermixed (Figure 3.6.6 A, B, C; Table 3.4).

Nonglandular: occur in three forms;

a. unicellular with thin warty cell walls, wide lumina and acute apex.
b. bicellular, uniseriate with thin warty cell walls, wide lumina, and acute apex (Figure 3.6.6 C).
c. multicellular, 3 – 5 cells, uniseriate with thin warty walls wide lumina and acute apex.

Glandular: occur in 2 forms.

a. stalk is unicellular, unbranched and head is unicellular round in shape.
2. stalk is unicellular, unbranched and head is multicellular (3 or 4 cells) round in shape.

3.6.1.4.2.2. Adaxial surface

Cells are isodiametric with very thin sinuous beaded anticlinal cell walls, and some cell are rectangular at the corolla veins. **Cuticle** is

smooth. **Stomata** are absent. **Trichomes:** they are similar to those of the abaxial but the trichomes more dense (Figure 3.6.6 B, D; Table 3.4).

3.6.2 INTERNAL STRUCTURE

3.6.2.1 Leaf Midrib Region

Upper epidermis: Cells are tabular with cellulosic cell walls. The outer cell walls are thin, radial cell walls are thin, cuticle is thin (Figure 3.6.7 A, B, C; Table 3.5).

Ground tissue: it consists of 1 layer of lamellar collenchyma. The rest of ground tissue is parenchymatous cells round in shape, 10-13 layers devoided of chloroplasts with thin cellulosic cell walls surrounding the vascular bundle (Figure 3.6.7 A, B).

Vascular tissue: It consists of one large boat shaped, arched vascular bundle, with vessels in rows commonly with wide Lumina and wide rays, with thick lignified cell walls. Primary phloem elements are with thin unlignified cell walls. Groups of outer phloem fibers are present with thick unlignified cell walls (Figure 3.6.7 A, B).

Lower epidermis: Its characters are similar to those of the upper epidermis (Figure 3.6.7 A, B ; Table 3.5).

3.6.2.2. Leaf, Intercostal Region

Upper epidermis: Cells are tabular with cellulosic walls. The outer walls are thick and the radial walls are thinner. Cuticle thin (Figure 3.6.7 C; Table 3.6).

Messophyll: It consists of palisade and spongy tissues. Palisade tissue consist of (2 – 3) layers of palisade like cells with large intercellular spaces and many chloroplasts. Followed by 3 or 4 layers of spongy parenchyma cells with chloroplast and a large intercellular spaces.

Lower epidermis: Its characters are similar to those of the upper epidermis (Figure 3.6.7 C; Table 3.6).

3.4.2.3. Stem

The transverse section of the stem is quadrangular in outline exhibiting glandular and non glandular trichomes (Figure 3.6.8 A, B, C; Table 3.7).

Epidermis: Cuticle is thick. Cells tabular with cellulosic thick outer walls and thin cellulosic inner walls.

Cortex: It consists of 4 or 5 layers of parenchymatous round cells contain chloroplasts (chlorenchyma) and having thin cellulosic with some parenchyma cells in between stem corners, with conspicuous intercellular spaces.

Bundle sheath: It consists of large rounded cells with thin cellulosic cell walls, devoided of chloroplasts and starch grains.

Vascular tissue: it consists of 4 main groups of large well developed vascular bundle at the 4 stem angles, and small secondary vascular bundles in between stem angles. Groups of outer phloem fibers with unlignified thick cell walls forming an arc shape covering the main vascular bundles. Primary phloem elements slightly crushed with thin unlignified walls. Xylem elements with lignified pitted cell walls, protoxylem with more wide, narrow lumina and metaxylem wide lumina, both forming a radial rows as a discontinuous cylinder of well developed elements.

Medulla (Pith): It consists of homogenous parenchymatous tissue, polygonal to slightly rounded cells with thin, cellulosic cell walls and with conspicuous intercellular spaces (Figure 3.6.8 A, B, C).

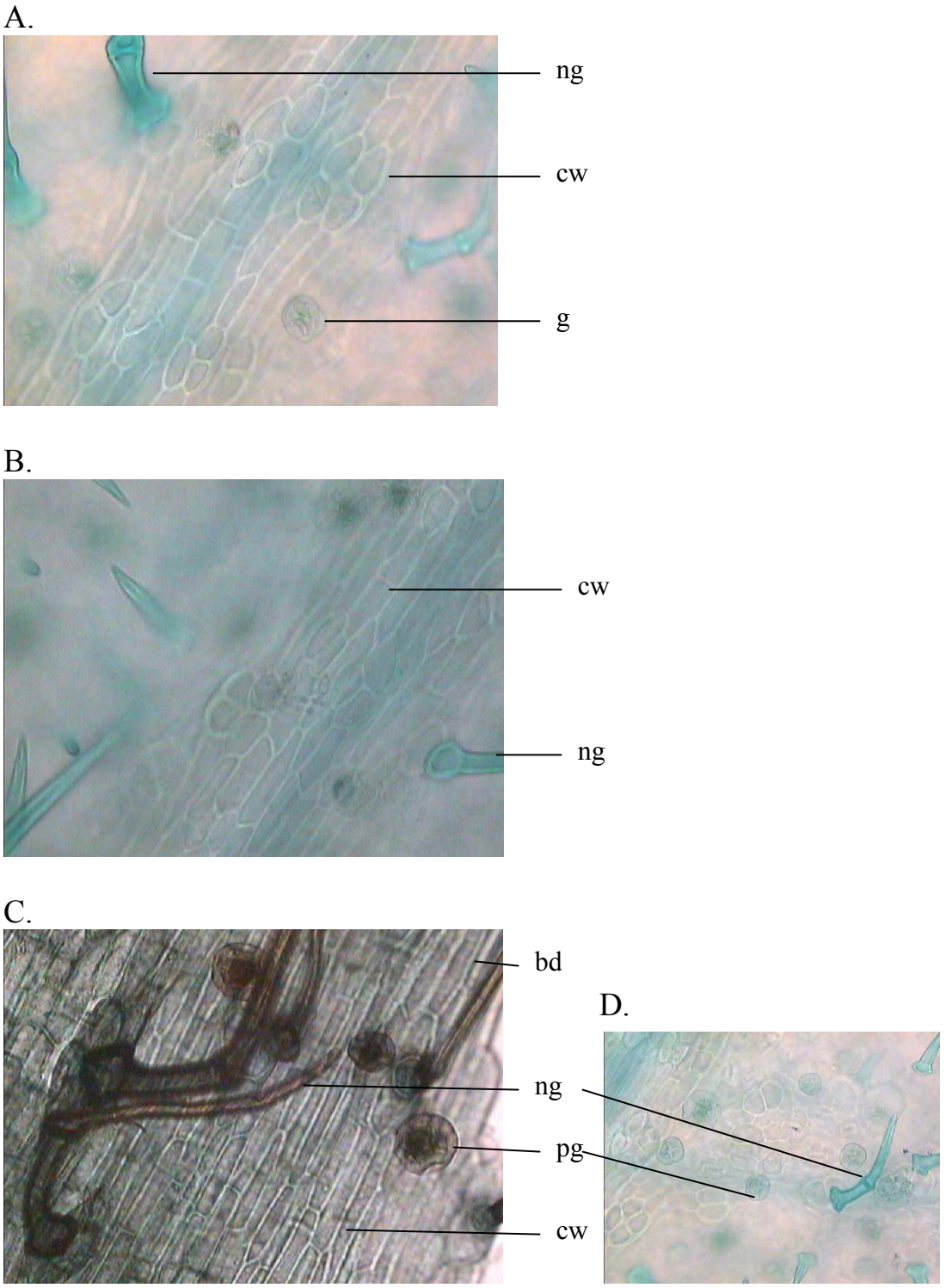
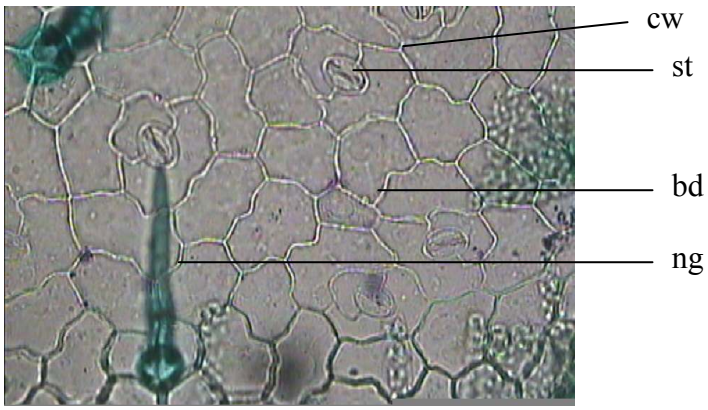
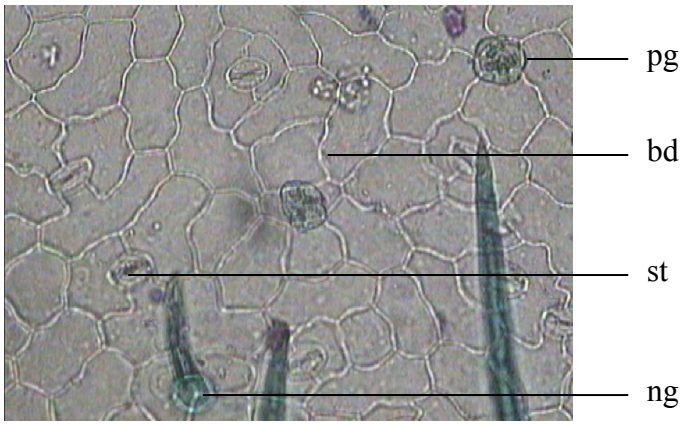


Figure (3.6.1): Leaf, midrib region of *Otostegia fruticosa var. fruticosa*. A – Upper epiderms, B – Lower epidermis; C, D – Trichomes at the midrib region (A – D x 400).

A.



B.



C.

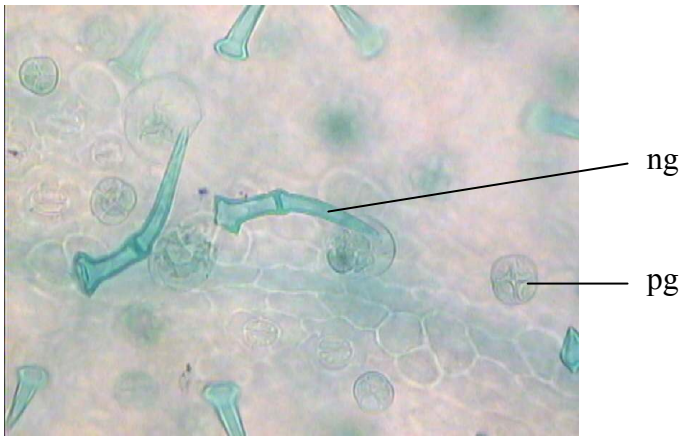
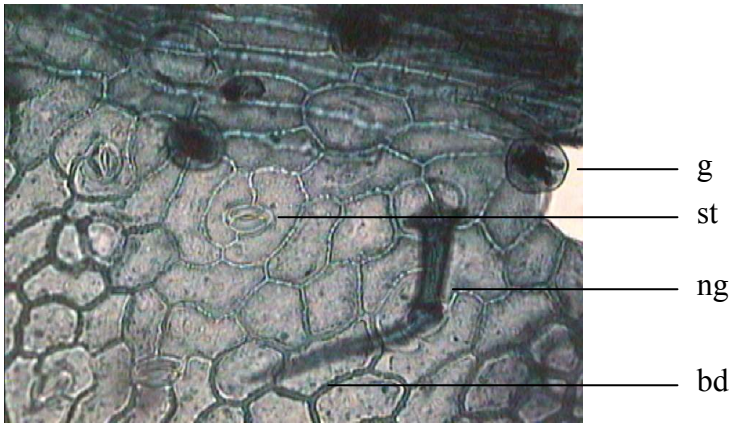
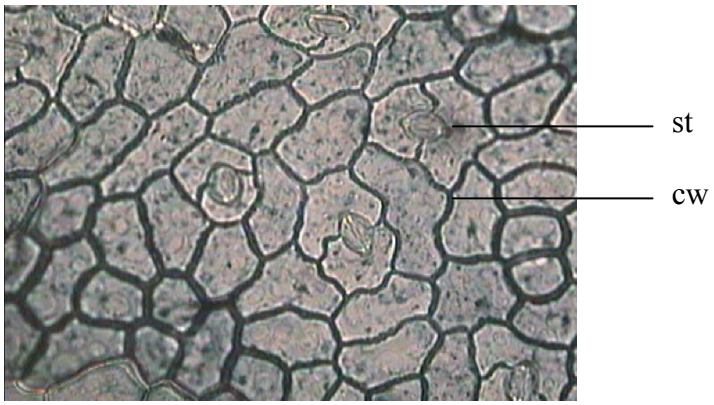


Figure (3.6.2) Leaf, intercostal region of *Otostegia frutiosa var. frutiosa*. A, B – Upper epidermis; C, – Trichomes at upper epidermis of intercostal region (A – C x 400).

A.



B.



C.

Figure (3.6.3): Leaf, intercostal region of *Otostegia fruticosa var: fruticosa*. A, B – Lower epidermis; C – Glandular and nonglandular trichomes in lower epidermis (A – C x 400).

A.

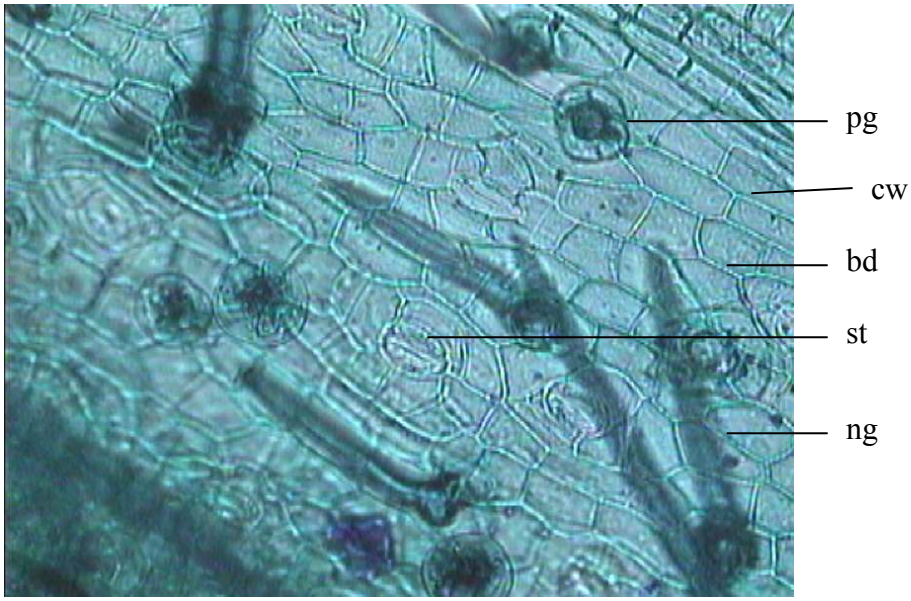
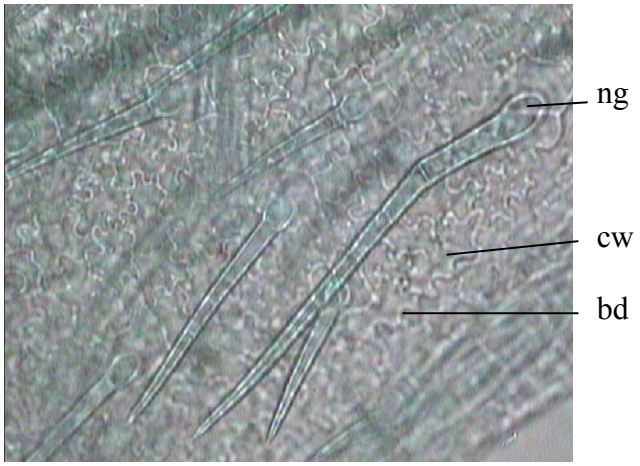
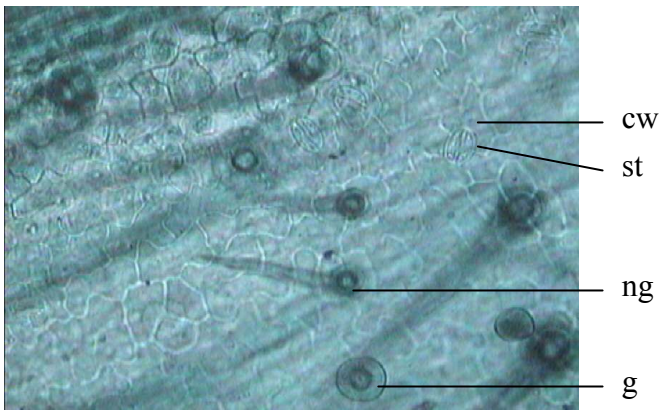


Figure (3.6.4): A, Stem epidermis of *Otostegia fruticosa var: fruticosa*. (x 400).

A.



B.



C.

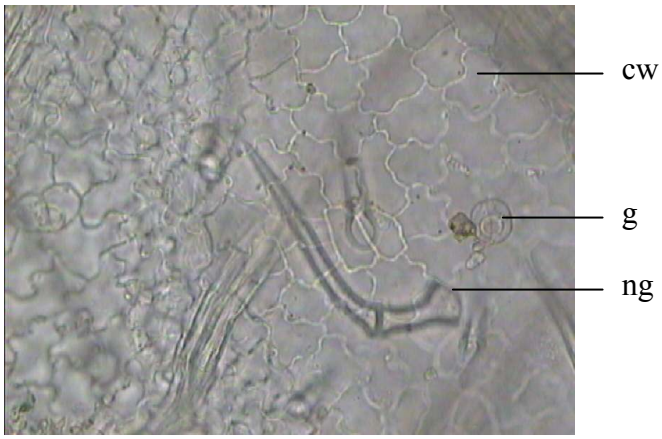


Figure (3.6.5): Floral parts epidermis of *Otostegia frutiosa var: frutiosa*. A – Calyx, abaxial surface; B,C,D – Calyx, adaxial surface (A – C x 400).

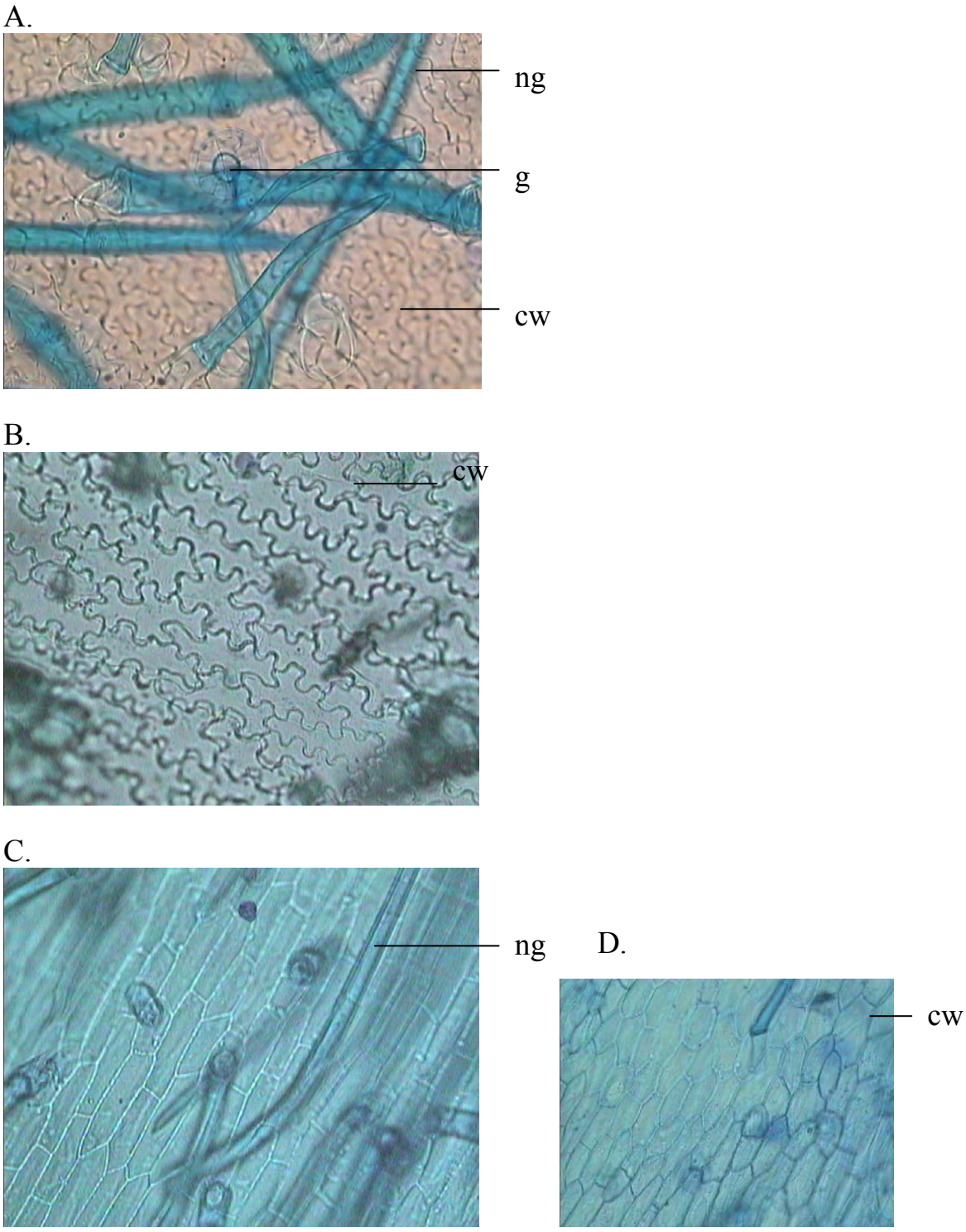
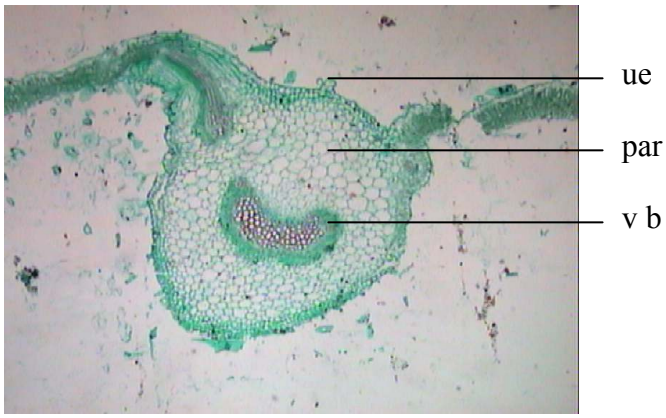
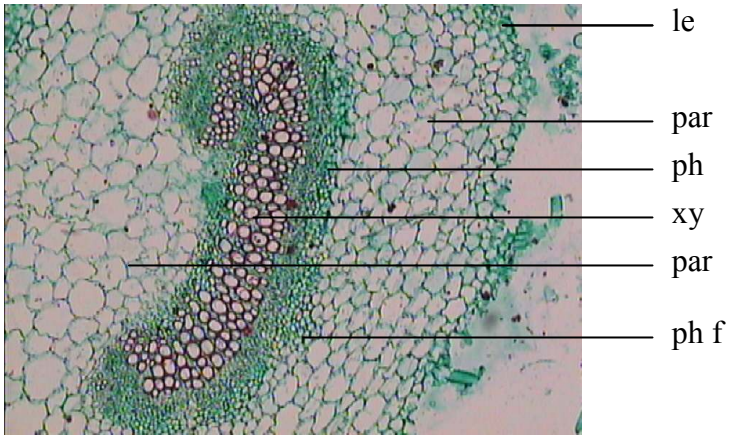


Figure (3.6.6): Floral parts *Otostegia fruticosa var: fruticosa*. A – Corolla, abaxial surface; B – Corolla, adaxial surface; C – Corolla, abaxial veins; D – Corolla, adaxial veins (A – D x 400).

A.



B.



C.

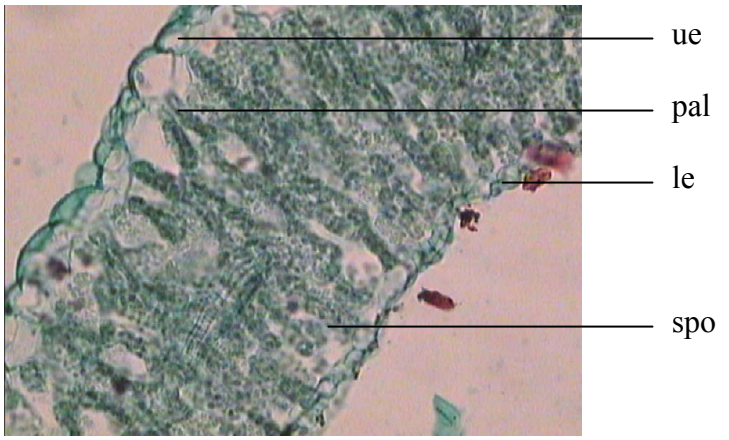
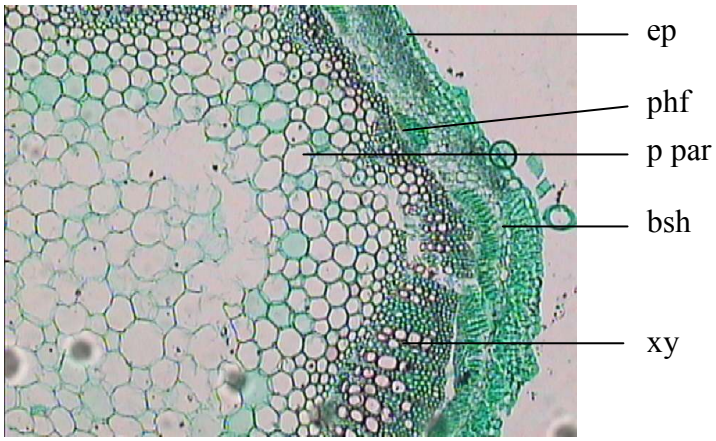


Figure (3.6.7): Leaf transverse section of *Otostegia fruticosa var: fruticosa*. A – Midrib region (x 100); B – Midrib region showing the vascular bundle; C – Intercostal region (B, C x 400).

A.

B.



C.

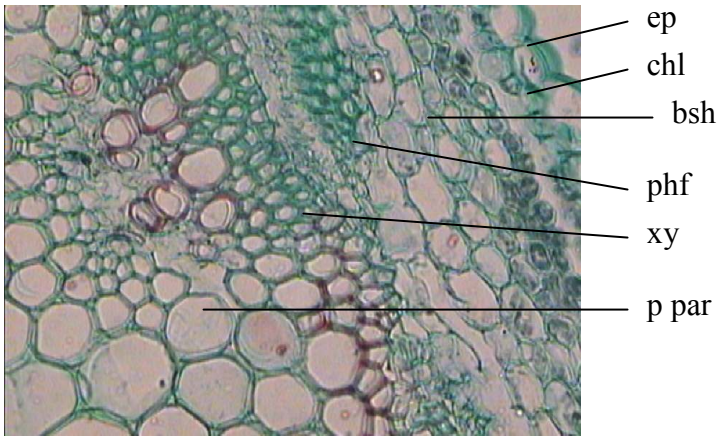


Figure (3.6.8): A – C Stem transverse sections of *Otostegia fruticosa var: fruticosa*. (A x 40); (B x 100); (C x 400).

3.7. *Otostegia fruticosa var. schimperi* (Boiss) Tockh.

3.7.1. EPIDERMAL CHARACTERS

3.7.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular elongated with straight thin cellulosic and hemicellulosic anticlinal walls, 55 – 45 – 37.5 μm long, 25 – 24.1 – 22.5 μm wide. **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular intermixed, numerous with a density of 500/mm^2 (Figure 3.7.1 A; Table 3.1)

Nonglandular: occurring in three forms:

a. unicellular, unbranched with thick warty walls wide lumina and acute apex (Figure 3.7.1 A).
b. bicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex (Figure 3.7.1. A)
c. multicellular, uniseriate unbranched with thick warty walls, wide lumina cell and acute apex (Figure 3.7.1 A).

Trichomes heading towards the leaf apex, seated on pedestals of 2 – 4 epidermal cells.

Glandular: are very few showing two forms:

a. stalk unicellular, unbranched and head unicellular.
b. stalk unicellular, unbranched and head multicellular (3 or 4).

Lower epidermis: Epidermal characters are similar to those of the upper epidermis surface (Figure 3.7.1 B; Table 3.1).

3.7.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin slightly, sinuous cellulosic and hemicellulosic beaded walls, 23 – 21 – 20.5 μm wide, 45 – 37 – 31 μm long. **Cuticle** striated, striations come from the trichome

base. **Stomata** are few, 50/mm^2, ovate, anisocytic. **Trichomes** are glandular and nonglandular intermixed (Figure 3.7.2 A, C; Table 3.2).

Nonglandular: are having the same 3 forms which exist at the midrib region (upper and lower).

Glandular: are very few with two forms:

a. stalk unicellular and head unicellular spherical in shape.

b. Stalk unicellular and head multicellular (3 or 4) with spherical shape.

Lower epidermis: Are similar to those of the upper epidermis of intercostals region but with stomata higher density, 250/mm^2 anomocytic and anisocytic intermixed (Figure 3.7.2 B; Table 3.2).

3.7.1.3. Stem Epidermis

Epidermis: Cells are rectangular elongated 112.5 – 67.5 – 40 μm long and 15.5 – 11.25 – 7.2 μm wide with straight anticlinal slightly thick cellulosic and hemicellulosic, beaded. **Cuticle** longitudinally striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular intermixed, numerous and similar to those of the epidermis of the intercostal region of the leaf (Figure 3.7.3 A, B; Table 3.3).

3.7.1.4. Floral Parts
3.7.1.4.1 Calyx:
3.7.1.4.1.1. Abaxial surface

Cells are polygonal elongated with straight anticlinal walls at the calyx veins and with sinuous anticlinal walls in between calyx veins. Both cell walls are thin cellulosic and hemicellulosic and beaded. **Cuticle** is smooth. **Stomata** are not observed. **Trichomes** are glandular and non glandular, intermixed (Figure 3.7.4 A, C; Table 3.4).

Nonglandular: occur in three forms:

a. unicellular, unbranched with thick warty walls wide lamina and acute apex.

b. bicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex.

c. multicellular uniseriate, unbranched with thick warty walls, wide lumina and acute apex.

Glandular: are of 4 forms mostly distributed between the calyx veins:

a. stalk unicellular and head unicellular (Figure 3.7.4 C).

b. stalk unicellular and head bicellular (Figure 3.7. 4 C).

c. stalk bicellular and head unicellular Figure 3.7.4 C)

d. stalk unicellular and head multicellular (3 or 4 cells) (Figure 3.7.4 C; Table 3.4).

3.7.1.4.1.2. Adaxial surface

Characters are similar to those at the abaxial surface of the calyx (Figure 3.7.4 B,C; Table 3.4).

3.7.1.4.2. Corolla

3.7.1.4.2.1. Abaxial surfaces

Cells are polygonal elongated with thin straight walls at the corolla veins and polygonal elongated with sinuous anticlinal walls in between corolla veins both cell walls are thin, beaded covered, with striated **cuticle**, **stomata** few, 50/mm^2 distributed in between corolla veins, usually ovate, anomocytic. **Trichomes** are numerous, the nonglandular showing three types and glandular are of two types (Figure 3.7.5. A; Table 3.4).

Nonglandular:

a. unicellular, unbranched with thick warty walls, wide lumina and acute apex.

b. bicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex.

c. multicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex.

Glandular:

a. Stalk unicellular and head unicellular round small,

b. Stalk unicellular and head multicellular (3 or 4) round large.

3.7.1.4.1.2. Adaxial surface

Cell characters are similar to those of the corolla abaxial surface and differs only by the absence of the **stomata** and the existence of smooth **cuticle** (Figure 3.7.5 B; Table 3.4).

3.7.2. INTERNAL STRUCTURE

3.7.2.1. Leaf, midrib region

Upper epidermis: One layer of large round cells with thin outer walls and thin inner walls. **Cuticle** thin. **Ground Tissue:** consist of 1 layer of lamellar cholenchyma below the upper and lower epidermis 3 or 4 of parenchyma tissue large round with slightly thick unlignified cells walls with conspicuous intercellular spaces. **Vascular tissue** consists of one large arched vascular bundle. Primary xylem vessels with well lignified cell walls and arranged in a radial rows. Primary phloem, with companion cells and sieve-tube elements. The outer phloem fibers occur in or large group, of polygonal cells with thick unlignified cell walls (Figure 3.7.6 A, B; Table 3.5)

Lower epidermis: A single layer of large round cells with thick outer walls and thin inner walls, cuticle thick (Figure 3.7.6 A, B; Table 3.5).

3.7.2.2. Leaf, Intercostal Region

Upper epidermis: Epidermal cells are tabular with thick outer walls and the inner wall is thin. Cuticle thin. **Messophyll:** consists of one layer of long palisade type cells and 3 - 6 layers of spongy type cells, both with conspicuous intercellular spaces (Figure 3.7.6 C; Table 3.6).

Lower epidermis: Are similar in their characters to those of the upper epidermis of intercostals region (Figure 3.7.6 C; Table 3.6).

3.7.2.3. Stem

Epidermis: Cells are one layer of small round cells with thick outer walls. Cuticle thick. **Cortex:** consist of groups of lamellar chollenchyma at stem angles, and 5 or 6 layers of chlorechyma tissue and 1 layer of bundle sheath devoided of chloroplasts or starch. **Vascular tissue:** consist of groups of outer phloem fibers with unlignified cell walls which is crushed and showing a full cylinder. Vascular bundles are the primary xylem elements (vessels and tiracheds) and primary phloem elements (sieve tube and companion cells) xylem elements with lignified pitted cell walls, protoxylem with narrow lumina and metaxylem wide lumina, both forming a radial rows as a continuous cylinder of well developed elements. **Medulla (pith):** Cells are homogenous polygonal paranchymatous with thin cellulosic walls and conspicuous intercellular spaces (Figure 3.7.7 A, B; Table 3.7).

A.

B.

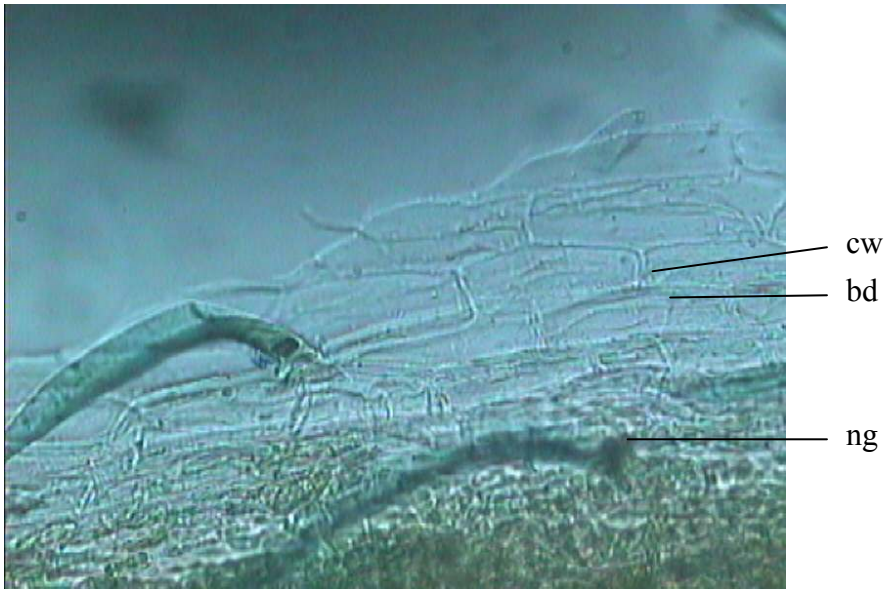
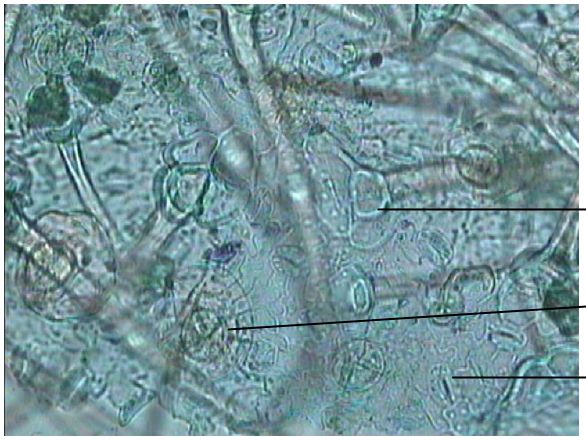


Figure (3.7.1): Leaf, midrib region of *Otostegia fructicosa var. schimperi*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.

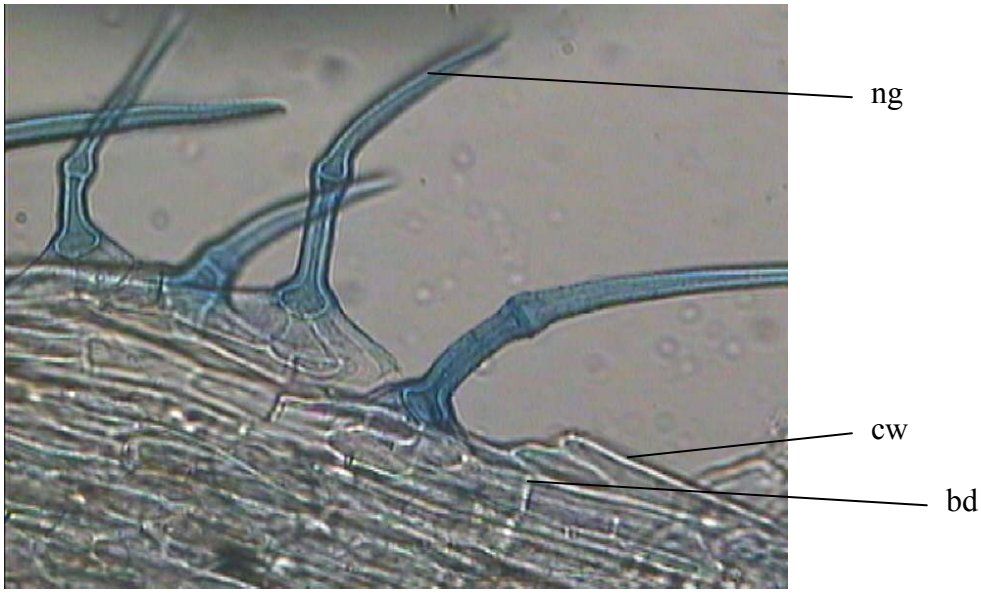
B.



C.

Figure (3.7.2): Leaf intercostal region of *Otostegia fructicosa var. schimperi*. A – Upper epidermis; B – Lower epidermis (A, B x 400); C – Lower epidermis trichomes (x 100).

A.



B.

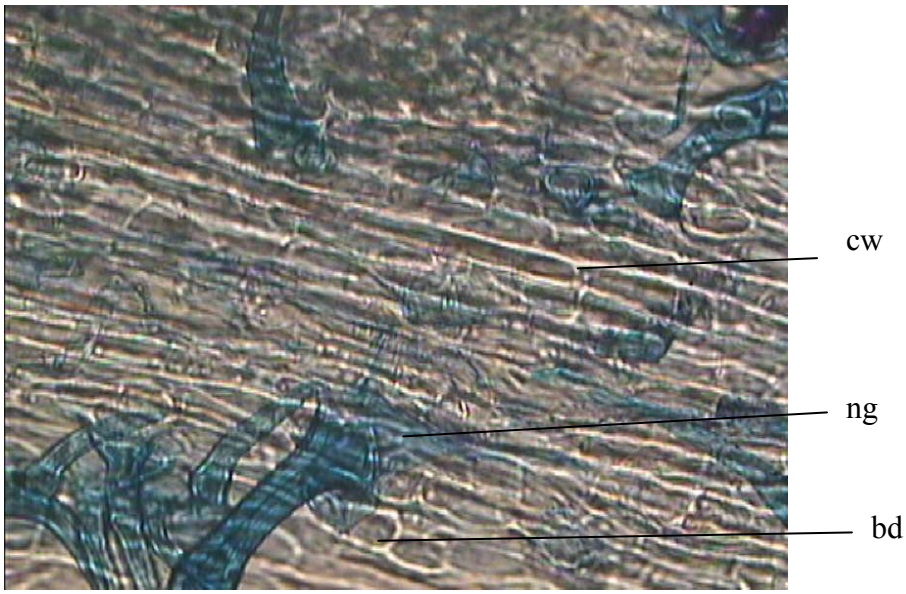
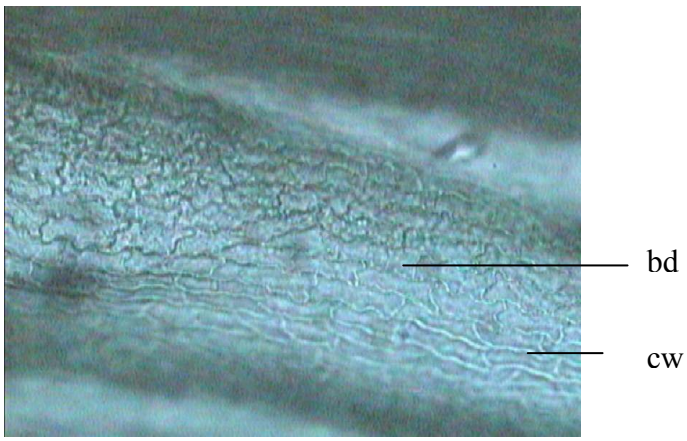
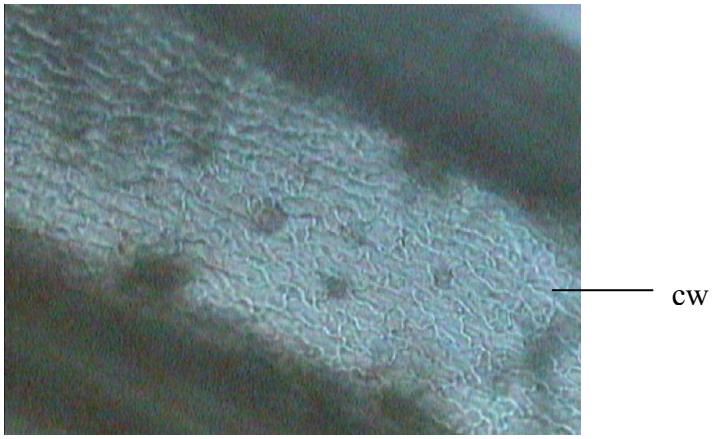


Figure (3.7.3): A – B Stem epidermis of *Otostegia fructicosa var: schimperi* (x 400).

A.



B.



C.

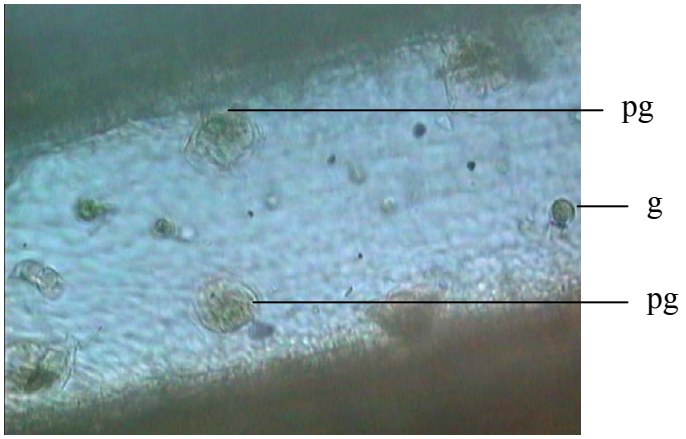
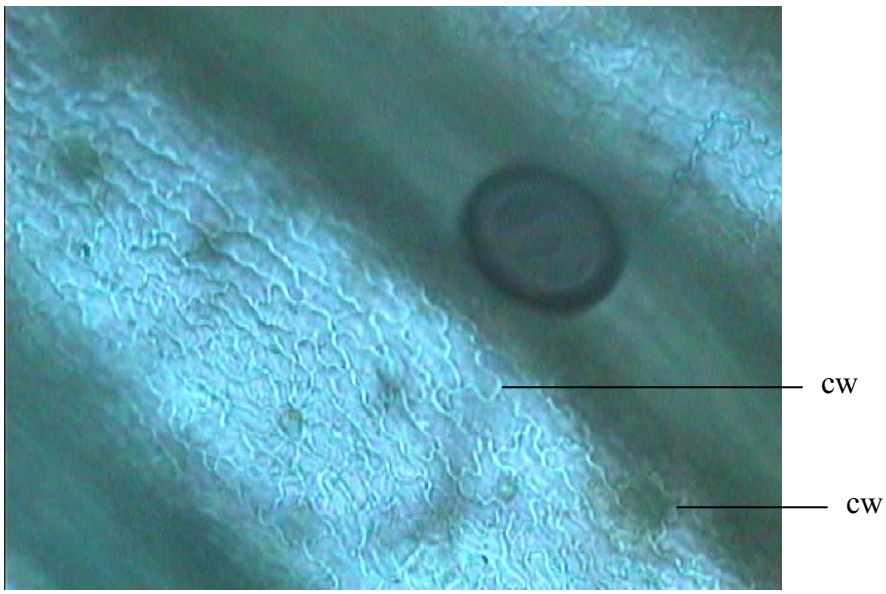


Figure (3.7.4): Floral parts of *Otostegia fructicosa var: schimperi*. A – Calyx, abaxial surface; B – Calyx, adaxial surface; C – Calyx, glandular trichomes (A – C x 400).

A.



B.

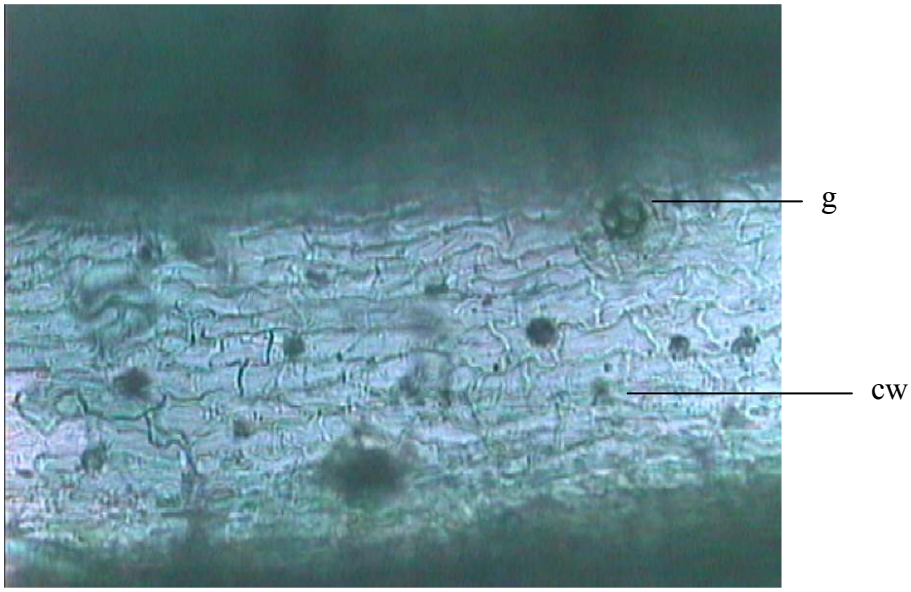
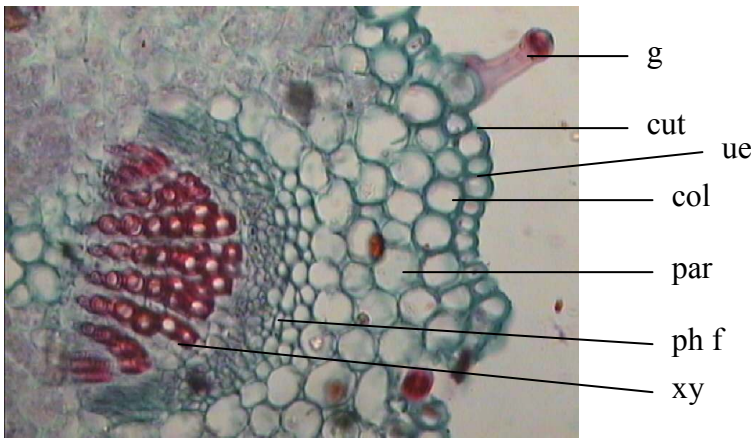
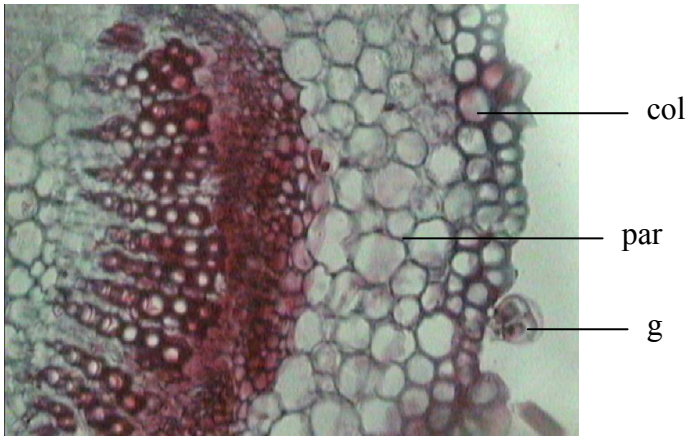


Figure (3.7.5): Floral parts of *Otostegia fructicosa var: schimperi*. A – Corolla, abaxial surface; B – Corolla, adaxial surface (A, B x 400).

A.



B.



C.

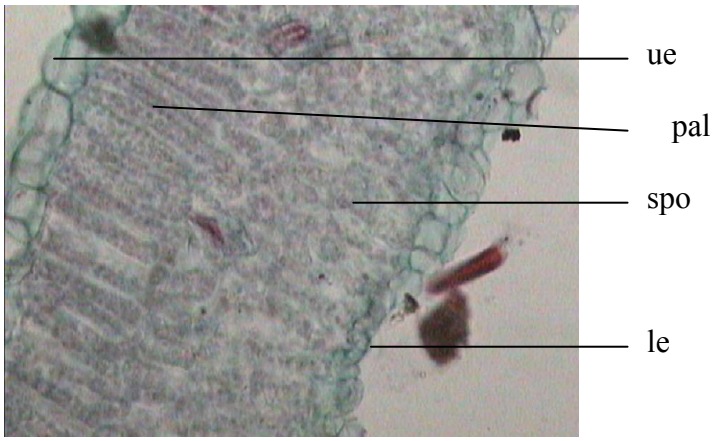
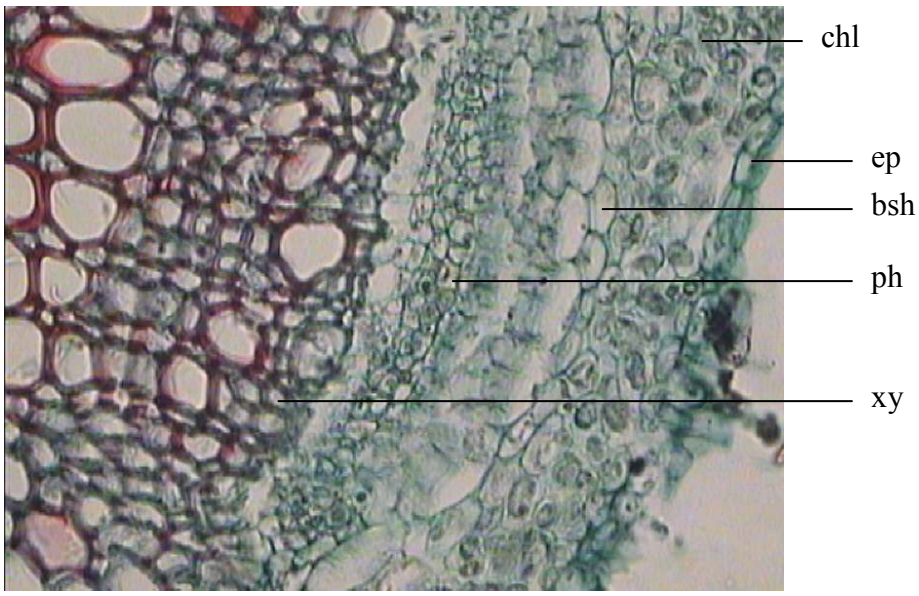


Figure (3.7.6): Leaf transverse sections of *Otostegia fructicosa var: schimperi*. A, B – Midrib region; C – Intercostal region (A – C x 400).

A.



B.

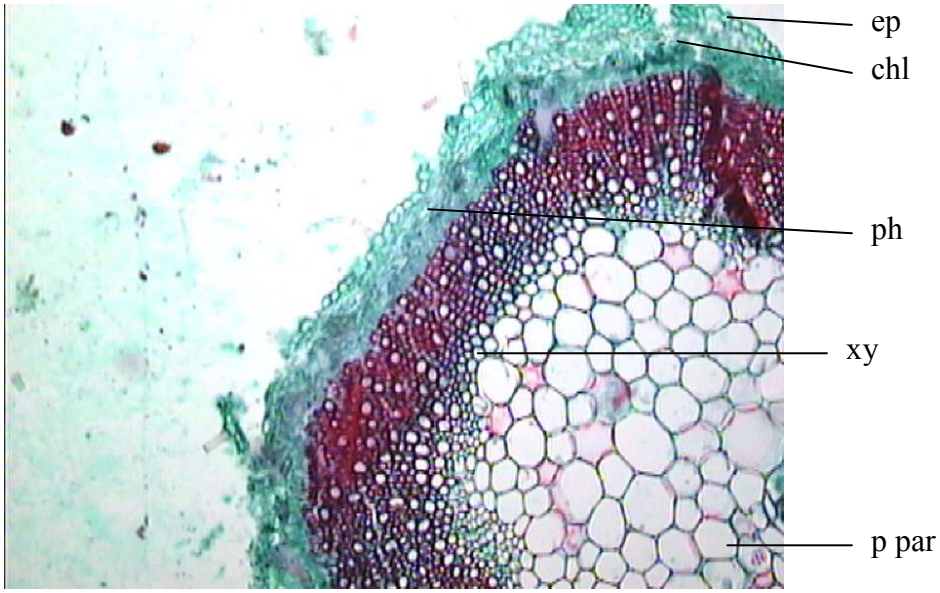


Figure (3.7.7): A, B – Stem transverse sections of *Otostegia fructicosa var: schimperi*. (A x 400); (B x 100).

3.8. *Salvia aegyptiaca L.*

3.8.1. EPIDERMAL CHARACTERS

3.8.1.1. Leaf, Midrib Region

Upper epidermis: Epidermal cells are polygonal elongated with thin straight cellulosic anticlinal walls beaded, covered with smooth **cuticle**, 88 – 70.5 – 66.7 μm long, 30 – 25 – 15 μm wide. **Stomata** are absent. **Trichomes** are glandular and nonglandular intermixed (Figure 3.8.1 A; Table 3.1).

Nonglandular: occur in three forms:

a. unicellular, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.8.1 A).
b. bicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex (Figure 3.8.1 A).
c. multicellular, uniseriate, unbranched with thick warty walls wide lumina and acute apex.

Glandular: occur in 2 forms.

a. Stalk unicellular, head unicellular.
b. Stalk unicellular, head multicellular (4 – 8) round shape.

Lower epidermis: Epidermal cells are polygonal elongated with thin straight cellulosic anticlinal walls, exhibiting beading. Cells, 71.5 – 65.2 – 30 μm long, 33 – 25 – 20.5 μm wide, covered with thin striated **cuticle** striation were longitudinal, **stomata** are absent. **Trichomes** showing an intermixed of glandular and nonglandular. The glandular and nonglandular trichomes are similar in their characters to those of the upper surface (Figure 3.8.1 B, C; Table 3.1).

3.8.1.2. Leaf, Intercostal Region

Upper epidermis: Epidermal cells are polygonal with thin, cellulosic slightly sinuous anticlinal walls beaded, 198.3 – 160.5 –

110 μm long, 97.5 – 95 – 60.6 μm wide. Covered with smooth **cuticle**. **Stomata** are diacytic and anisocytic intermixed, numerous, 200/mm^2, ovate and circulate. **Trichomes** are intermixed of glandular and nonglandular. *Nonglandular:* occurred in three forms similar to those of the upper epidermis of midrib region (Figure 3.8.2 A; Table 3.2).

a. unicellular, unbranched with thick warty walls, wide lumina and acute apex.
b. bicellular, uniseriate, unbranched with thick warty walls wide lumina and acute apex.
c. multicellular, uniseriate,, unbranched with thick warty walls, wide lumina and acute apex. This form is very few.

Glandular: occur in two forms:

a. Stalk unicellular and head unicellular.
b. Stalk unicellular and head multicellular (4 – 8).

Lower epidermis: Characters of this surface are similar to those of the upper surface of the same region with the exception of the epidermal cells are smaller in their size, 55.6 – 35 – 25 μm long, 25 – 20 – 12 μm wide, higher density of the stomata which is 600/mm^2 (Figure 3.8.2 B; Table 3.2).

3.8.1.3. Stem

The epidermal cells are polygonal elongated with thin straight anticlinal walls at stem angles or polygonal slightly rounded with thin straight beaded anticlinal walls in between stem angles, 82.1 – 70.5 – 66.7 μm long and of 30 – 25 – 10 μm wide. Cell covered with longitudinally striated **cuticle** at the stem angles and smooth in between the angles. **Stomata** are diacytic and anisocytic, ovate numerous, 300/mm^2 and absent at the stem angles. **Trichomes** are intermixed of glandular and nonglandular (Figure 3.8.2 C; Table 3.3).

Nonglandular: occurring three forms.

a. unicellular unbranched with thick warty walls wide lumina and acute apex (Figure 3.8.2 C).

b. bicellular, uniseriate unbranched with thick warty walls, wide lumina and acute apex (Figure 3.8.2 C).

3. Multicellular, uniseriate, unbranched with thick warty walls, wide lumina and acute apex.

Glandular: occur in two form:

1. stalk unicellular with unicellular head

2. stalk unicellular with multicellular heads (4 – 8) with round shape.

3.8.1.4. Floral Parts
3.8.1.4.1 Calyx:
3.8.1.4.1.1 Abaxial surface

Epidermal cells are polygonal with thin cellulosic straight anticlinal walls at the calyx veins and isodiametric with sinuous walls in between the calyx veins, 75.3 – 65.2 – 43.5 μm long, 55.5 – 49.4 – 30.1 μm wide. **Cuticle** smooth. **Stomata** absent. **Trichomes**: They are glandular and nonglandular intermixed (Figure 3.8.3 A; Table 3.4).

Nonglandular: occur in three forms:

a. unicellular, unbranched with thick warty walls (Figure 3.8.3 A).

b. bicellular, uniseriate, with thick warty walls (Figure 3.8.3 C).

c. multicellular (3 – 7 cells), uniseriate, unbranched with thick warty walls (Figure 3.8.3 C).

Glandular: occur in 2 forms:

a. Stalk unicellular and head is unicellular round shape.

b. Stalk unicellular and head is multicellular (4 – 8 cell) with spherical shape.

3.8.1.4.1.2. Adaxial surface

Epidermal cells are similar in their characters to those of the abaxial surface (Figure 3.8.3 B; Table 3.4).

3.8.1.4.2 Corolla

3.8.1.4.2.1. Abaxial surface

Epidermal cells are isodiametric with thin sinuous walls, 76.7 – 53.5 – 20 μm long, 45.5 – 23 – 20.1 μm wide. **Cuticle** is smooth. **Stomata** are absent. **Trichomes:** glandular and nonglandular intermixed are similar in their characters to those of the calyx abaxial surface (Figure 3.8.4 A; Table 3.4).

3.8.1.4.2.2. Adaxial surface:

Epidermal cells are isodiametric with thin cellulosic sinuous anticlinal walls, 65.7 – 48.9 – 35 μm long, 55.1 – 42.3 – 25.5 μm wide. **Stomata** are absent. **Cuticle** is smooth. **Trichomes** glandular and nonglandular are similar to those existing at the calyx abaxial surface (Figure 3.8.4 B; Table 3.4).

3.4.2. INTERNAL STRUCTURE

3.4.2.1. LEAF, Midrib Region

Upper epidermis: Epidermal cells are rounded with thick outer walls and thin inner walls both cellulosic. **Cuticle** is thick. **Ground tissue** consists of one layer of lamellar chollenchyma below the upper and lower epidermis and 4 or 5 layers of parenchyma cells of wide rounded cells with thin cellulosic walls above and below the vascular bundle, devoided of chloroplasts and with conspicuous intercellular spaces. The vascular bundle is a small round in shape. Primary xylem elements are polygonal cells with thick lignified walls. Primary phloem

with sieve tubes and companion cells. Outer phloem fibers small group with thin unlignified cell wall (Figure 3.8.5 A; Table 3.5).

Lower epidermis: Similar in their characters to those of the upper epidermis.

3.8.2.2. Intercostal Region

Upper epidermis: Epidermis cells are tabular large with thick outer walls and thin inner walls, both cellulosic. Cuticle thick. **Messophyll** consists of 4 to 7 layers of palisade type cells filled with chlorophyll and having intercellular spaces.

Lower epidermis: Cells are tabular, small with Similar characters to those of the upper epidermis (Figure 3.8.5 B,C; Table 3.6).

3.8.2.3. STEM

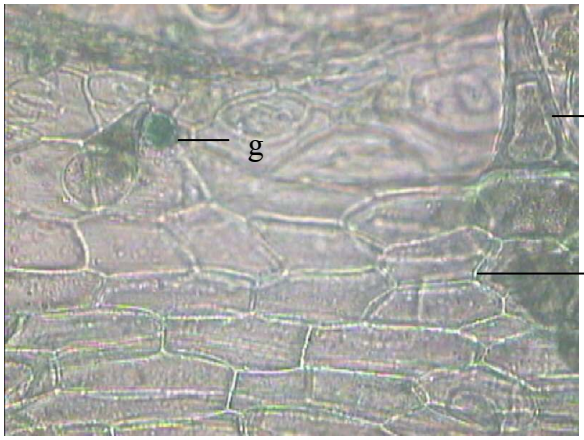
Transverse section is quadrangular in outline exhibiting some glandular and nonglandular trichomes (Figure 3.8.6 A,B,C; Table 3.7).

Epidermal cells are rounded with thick outer walls and thin inner walls, both cellulosic, cuticle is thick.

Cortex: consists of 4 main groups of lamellar chollenchyma tissue at the stem angles replaced by 4 or 5 layers of chlorenchyma tissue in between the stem angles, bundle sheath is clear as one layer of tabular parenchymatous cells with thin cellulosic walls which is devoided of starch or chloroplasts, surrounding the vascular bundles. **Vascular tissue**: consists of 4 large main vascular bundles at the stem angles, and small secondary vascular bundles in between. Outer phloem fibers well developed at stem angles with thick unlignified cell walls forming arc shape. Primary phloem elements with thin cellulosic cell walls. The primary xylem consists of vessels in radial rows with thick lignified walls the protoxylem has narrow vessels and the metaxylem has wide vessels. The vascular cambium present as strands between the phloem and xylem at stem angles. **Medulla (pith):** Cells are homogenous polygonal to

almost rounded, large with thin cellulosic cell walls and with large intercellular spaces (Figure 3.8.6 A,B,C; Table 3.7).

A.



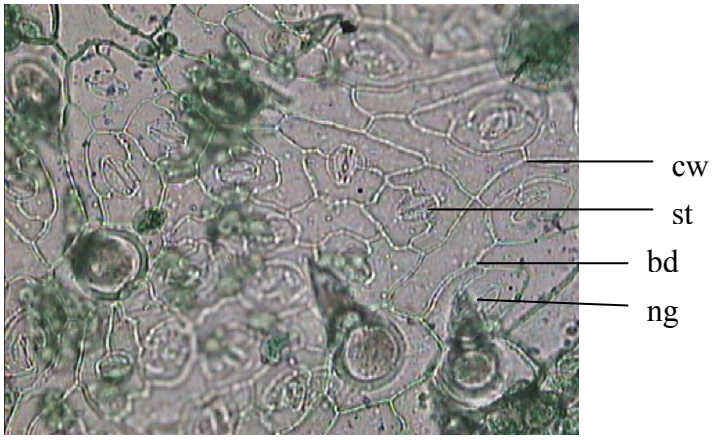
B.

C.

Figure (3.8.1): Leaf, midrib region of *Salvia aegyptiaca.* A – Upper epidermis; B – Lower epidermis; C – Glandular trichomes on the lower intercostals region (A – C x 400).

A.

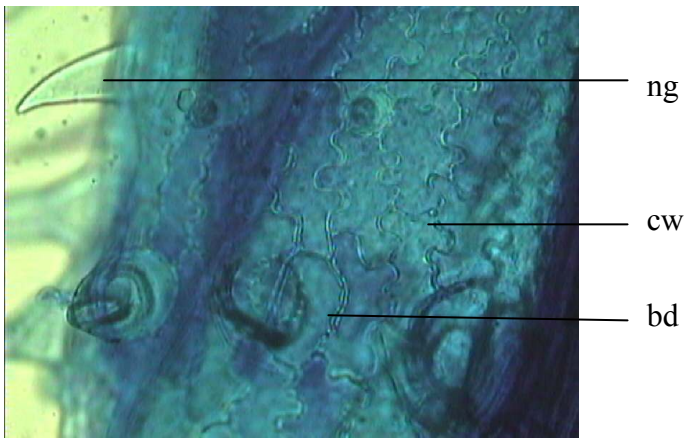
B.



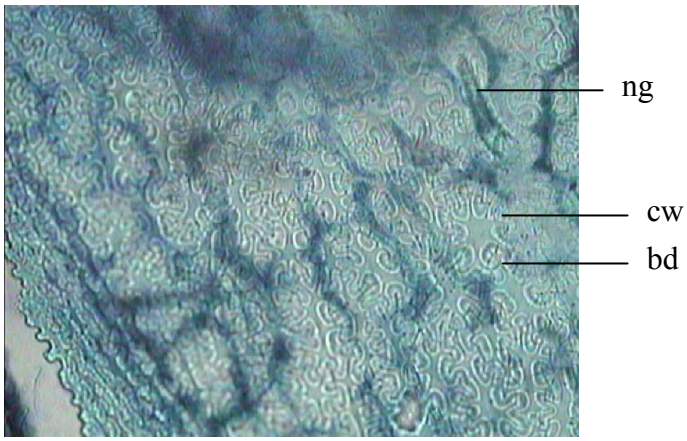
C.

Figure (3.8.2): Leaf, intercostal of *Salvia aegyptiaca*. A. – Upper epidermis; B, – Lower epidermis; C. Stem epidermis (A – C x 400).

A.



B.



C.

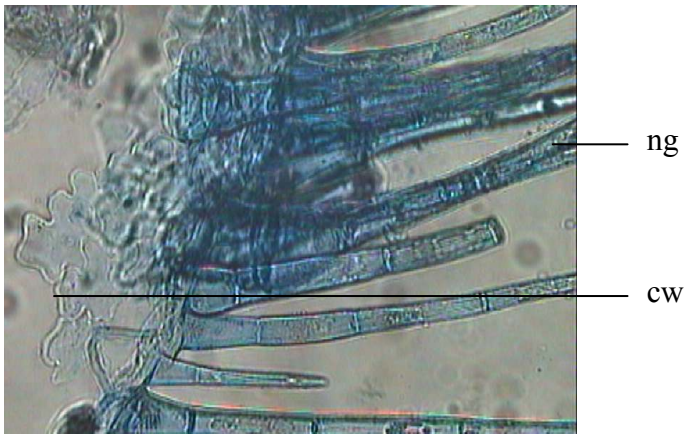


Figure (3.8.3). Floral parts of *S. aegyptiaca*. A – Calyx, abaxial surface; B. Calyx, adaxial surface; C – Calyx, nonglandular trichomes (A – C x 400).

A.

B.

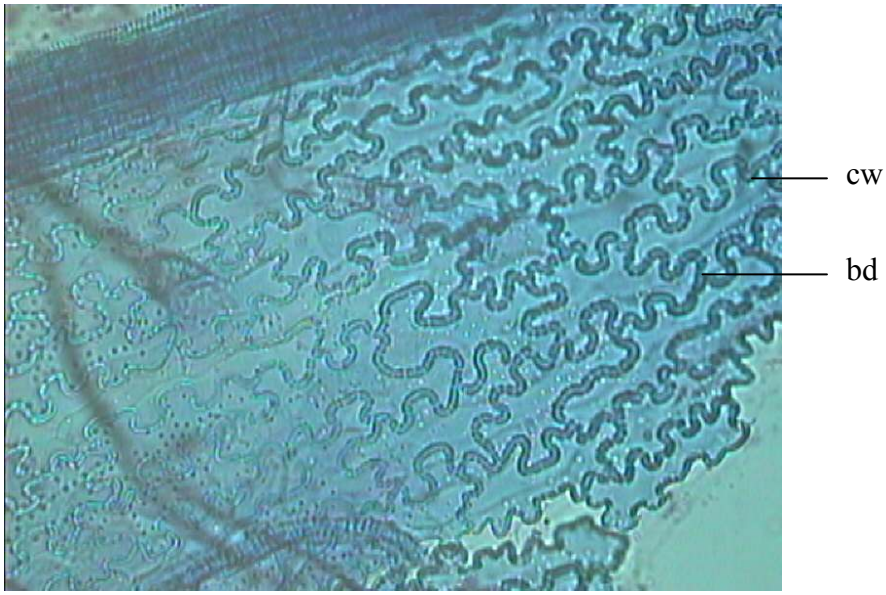
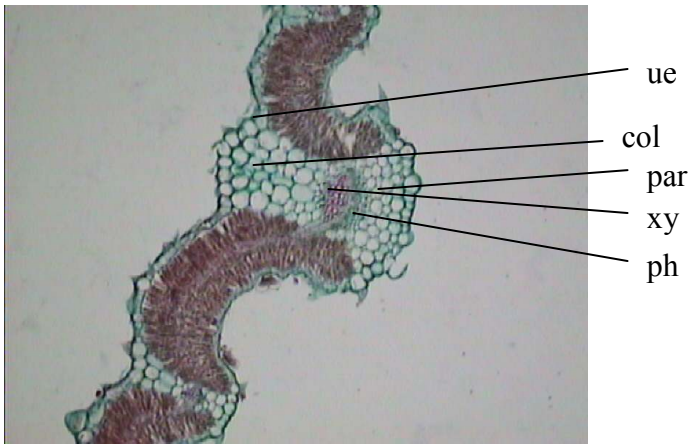
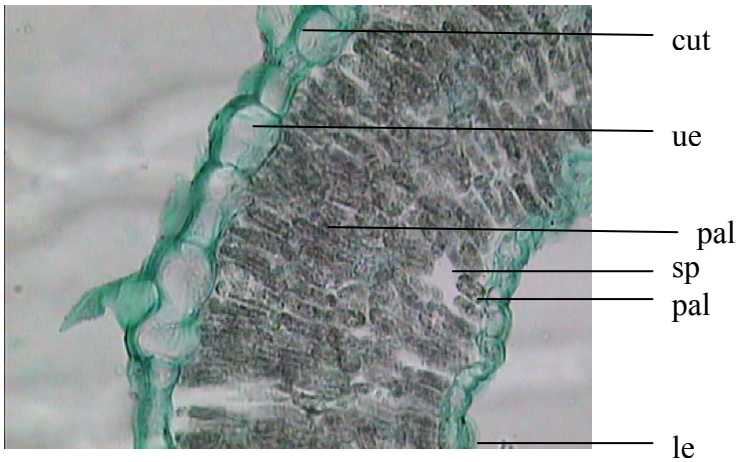


Figure (3.8.4): Floral parts of *S. aegyptiaca*. A – Corolla, abaxial surface; B, – Corolla, adaxial surface (A, B x 400).

A.



B.



C.

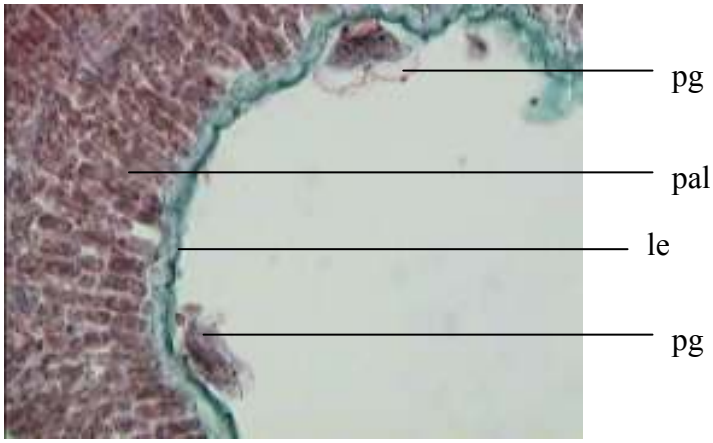
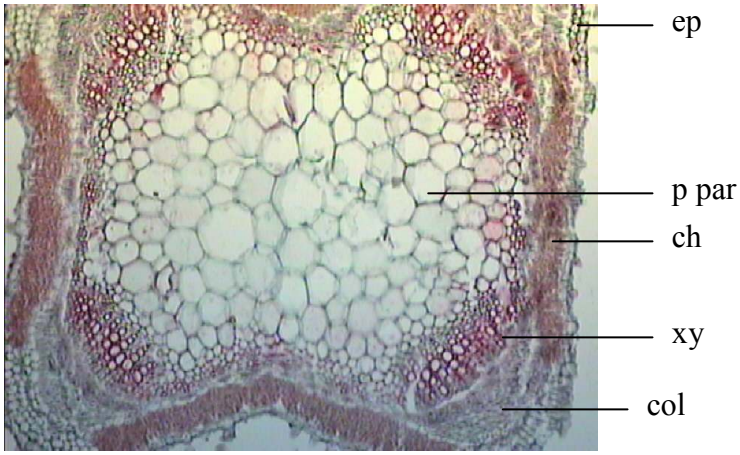
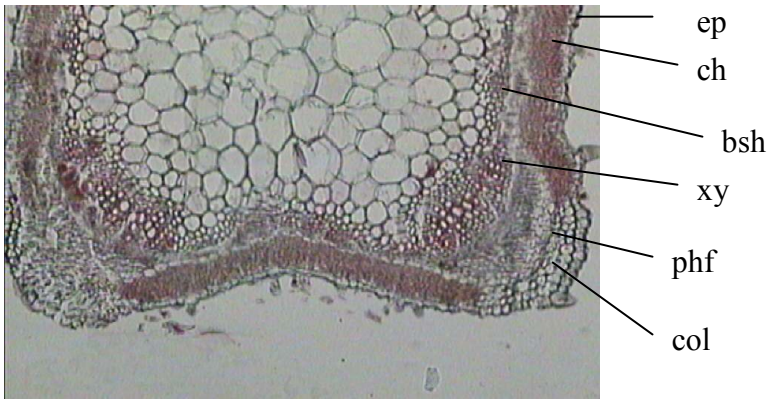


Figure (3.8.5): Leaf transverse section of *S. aegyptiaca*. A – Leaf midrib region and intercostal (x 100); B – Leaf intercostal region; C – Glandular trichomes in lower epidermis of intercostal region (B, C x 400).

A.



B.



C.

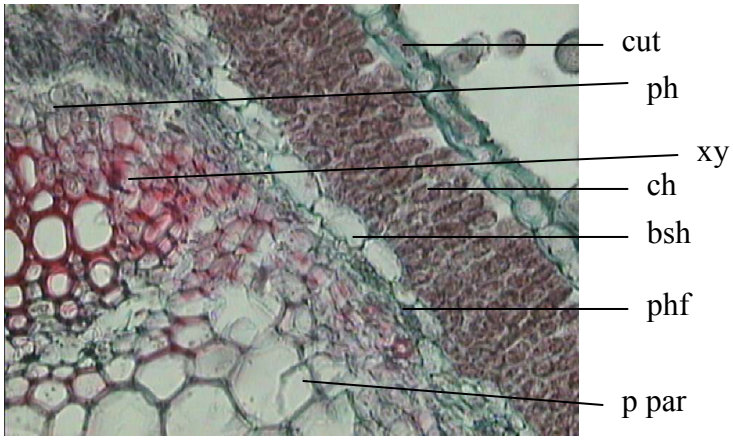


Figure (3.8.6): Stem transverse section of *S. aegyptiaca*. A, B – Stem (x 100); C – Stem (x 400).

3.9. *Salvia deserti* Decne.

3.9.1. EPIDERMAL CHARACTERS

3.9.1.1 Leaf, Midrib Region

Upper epidermis: Epidermal cells are polygonal elongated with cellulosic thin straight anticlinal walls, exhibiting beading, 35 – 25 – 17.5 μm long, 25.5 – 12.5 – 10.4 μm wide. **Cuticle** longitudinally striated. **Stomata** are not observed. **Trichomes**: nonglandulars and glandular (Figure 3.9.1 A; Table 3.1).

Nonglandular: occur in three forms.

a. unicellular, unbranched with thin warty walls.

b. bicellular, unbranched with thin warty walls.

c. multicellular, unbranched with thin warty walls.

All uniseriate and with cellulosic cell walls heading towards the leaf apex.

Glandular: occur in two forms:

a. Stalk unicellular, head unicellular, rounded.

b. stalk unicellular, head multicellular (4 – 8 cells) with spherical shape.

Lower epidermis: Cells are polygonal elongated with thin, straight anticlinal cellulosic beaded walls, 45 – 35.2 – 21 μm long, 20 – 15 – 12.5 μm wide, **cuticle** covered with longitudinally striations. **Stomata** are not observed, trichomes observed as glandular and non glandular intermixed with the same forms that occur at the upper epidermis (Figure 3.9.1 B,C; Table 3.1).

3.9.1.2. Leaf, Intercostal Region

Upper epidermis: Epidermal cells are polygonal with straight thin, beaded anticlinal walls cellulosic, 17.5 – 11.5 – 10.5 μm long, 15.5 – 12.5 – 5.2 μm wide, covered with striated **cuticle**. **Stomata** are

diacytic (150/mm^2). **Trichomes** occur in glandular and nonglandular intermixed: (Figure 3.9.2 A; Table 3.2)

Nonglandular: are three forms:

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex (Figure 3.9.2 A).
b. bicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex (Figure 3.9.2 A).
c. multicellular (3 – 6 cells), uniseriate unbranched with thin warty walls, wide lumina and acute apex.

Glandular: occur in two forms similar to those at the upper epidermis of midrib region.

Lower Epidermis: Epidermal cells are polygonal with thin straight beaded cellulosic anticlinal walls, 35 – 27.5 - 17 μm long, 30.1 22 – 19.5 μm wide, cells covered with striated **cuticle**. **Stomata** is diacytic, 500/mm^2. **Trichomes** are glandular and nonglandular intermixed (Figure 3.9.2 A,B; Table 3.2).

Nonglandular: are showing the same forms which occur at the upper intercostals region.

Glandular: observed as two forms

a. Stalk unicellular, head unicellular.
b. stalk unicellular, head multicellular, 4 – 8 cells.

3.9.1.3. Stem epidermis

Epidermis: Cells are polygonal with thin, straight beaded anticlinal walls, and have the shape of polygonal elongated with straight anticlinal walls at stem angles. **Cuticle** is striated covering the stem angles, and is smooth in between the stem angles. **Stomata**, numerous in between the stem angles, ovate, diacytic and anomocytic, 250/mm^2 and absent from the stem angles. **Trichomes** are glandular and nonglandular intermixed (Figure 3.9.2 C; Table 3.3).

Nonglandular: are occurring with the same forms which were observed at the leaf blade.

Glandular: occur in two forms. Similar to those existing at the leaf blade.

3.9.1.4. Floral parts

3.9.1.4.1. Calyx

3.9.1.4.1.1. Abaxial surface:

Cells polygonal with thin straight beaded anticlinal walls at calyx veins and isodiametric in between calyx veins 55.2 – 35 – 25.2 μm long, 25.1 – 12.2 – 10.5 μm wide. **Cuticle** smooth. **Stomata** absent. **Trichomes** are glandular and nonglandular (Table 3.4).

Nonglandular: are numerous showing 3 forms.

a. unicellular, unbranched with thin warty walls (Figure 3.9.3 C).
b. bicellular, uniseriate unbranched with thin warty walls (Figure 3.9.3 D).
c. multicellular, 3 – 6 uniseriate unbranched with thin warty walls (Figure 3.9.3 C, D).

All of the above with cellulosic cell walls and high density (Figure 3.9.3 A,C,D).

Glandular: are three forms.

a. stalk unicellular, head unicellular (Figure 3.9.3 C).
b. stalk bicellular, head unicellular (Figure 3.9.3 D).
c. stalk unicellular, head multicellular, 4 – 8 cells.

3.9.1.4.1.2. Adaxial surface

Cells polygonal with straight beaded anticlinal walls at calyx veins and isodiametric in between calyx veins. **Cuticle** smooth. **Stomata** absent. Trichomes are numerous similar to those of abaxial surface (Figure 3.9.3 B,C; Table 3.4).

3.9.1.4.2. Corolla

3.9.1.4.2.1. Abaxial surface:

Epidermal cells are polygonal with thin beaded anticlinal walls at corolla veins and isodiametric with thin sinuous walls in between corolla veins (65.3 – 45.5 – 35.5 μm long, 35.5 – 23.1 – 18.1 μm wide), (Figure 3.9.4 A; Table 3.4). **Cuticle** smooth. **Stomata** absent. **Trichomes** are intermixed of glandular and nonglandular, numerous.

Nonglandular: are three forms.

a. unicellular, unbranched with thin warty walls.

b. bicellular, uniseriate unbranched with thin warty walls.

c. multicellular (3 – 6 cells), uniseriate unbranched with thin warty walls (Figure 3.9.4 C).

Glandular: are three forms.

a. stalk unicellular and head unicellular (Figure 3.9.4 C).

b. stalk bicellular and head unicellular (Figure 3.9.4 C)

c. stalk unicellular and head multicellular (4 – 8) with spherical form.

3.9.1.4.1.2. Adaxial surface:

Epidermal cells are similar in their characters to those of the abaxial surface (Figure 3.9.4 B,C; Table 3.4).

3.9.2. INTERNAL STRUCTURE

3.9.2.1. Leaf, Midrib Region

Upper epidermis: Epidermal cells are tabular to round with outer thick and inner walls thin. **Cuticle** thick. **Messophyll** consists of one layer of lamellar chollenchyma below upper and lower epidermis, 3 or 4 layers of parenchyma tissue with thin cellulosic walls and conspicuous intercellular spaces surrounding the vascular tissue. **Vascular tissue**: consists of one, small arched to round. **Vascular bundle** with xylem elements in rows of lignified vessels and primary phloem elements of

sieve tube and companion cells both with thin cellulosic cell walls (Figure 3.9.5 A, B; Table 3.5).

Lower epidermis:

Epidermal cells are similar in their characters to those of the upper epidermis of midrib region (Figure 3.9.5 A,B,C; Table 3.5).

3.9.2.2. Leaf, Intercostal Region

Upper epidermis: Epidermal cells are one layer of tabular large cells, with thick outer walls and thin inner ones covered with thick **cuticle**. **Messophyll** consists of 2 layers of palisade type cells and 3 or 4 spongy type cells both with large intercellular spaces.

Lower epidermis: Epidermal cells are tabular small with thin outer and inner walls, cuticle is thin (Figure 3.9.5 B,C).

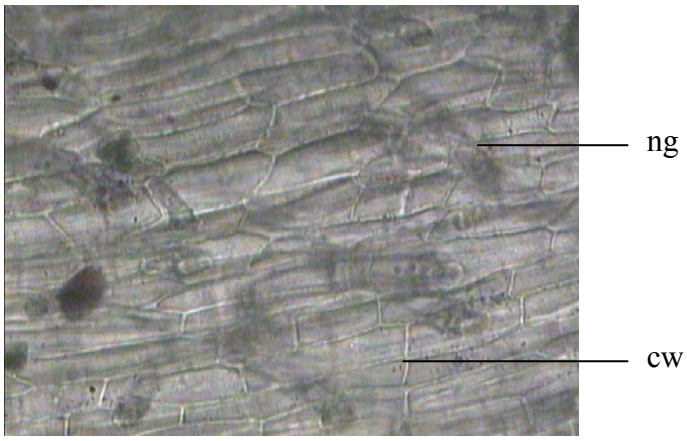
3.9.2.3. STEM:

The transverse section of the stem is quadrangular in outline exhibiting some glandular and nonglandular trichomes (Figure 3.9.6 A, B, C, D; Table 3.7).

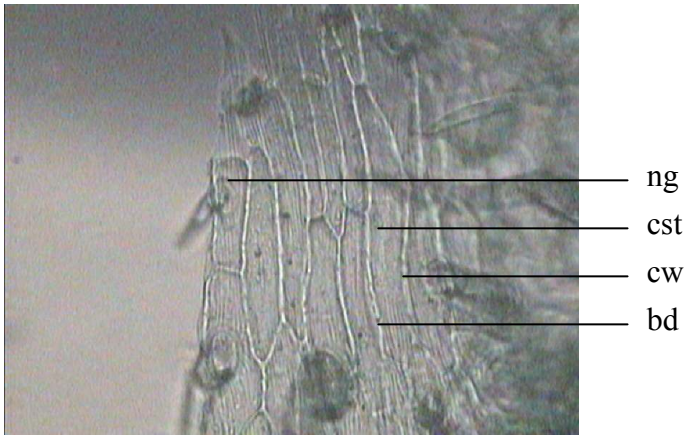
Epidermis: Cells are tabular small with thick outer walls and thin inner walls, both cellulosic. **Cuticle** thick. **Cortex** consists of 5 or 6 layers of lamellar cholenchyma at stem angles, replaced by 4 or 5 layers of chlorenchyma tissue in between the stem angles which is filled with chlorophyll and conspicuous intercellular spaces followed by 1 or 2 parenchyma tissues. The bundle sheath is clear as one layer of large parenchyma cells devoid of chloroplasts forming a continuous ring surrounding the vascular bundles. **Vascular bundle** consists of 4 main large bundles at the stem angles with small secondary bundle in between stem angles, all bundles with the primary phloem is well developed with sieve tube elements and companion cells, the primary xylem forming a discontinuous cylinder of xylem elements. Vessels in groups with lignified cell walls. The outer phloem fibers occur in groups of polygonal

cells, with thick unlignified cell walls covering the vascular bundles as an arc. **Pith (Medulla):** Parenchyma cells are homogenous polygonal with thick unlignified cell walls and large intercellular spaces. The inner cells of the pith which occur in the stem center are larger than the outer which occur immediately below the xylem (Figure 3.9.6 A,B,C; Table 3.7).

A.



B.



C.

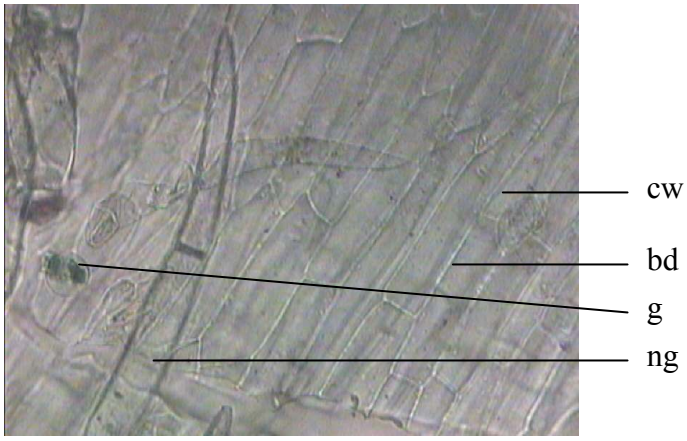
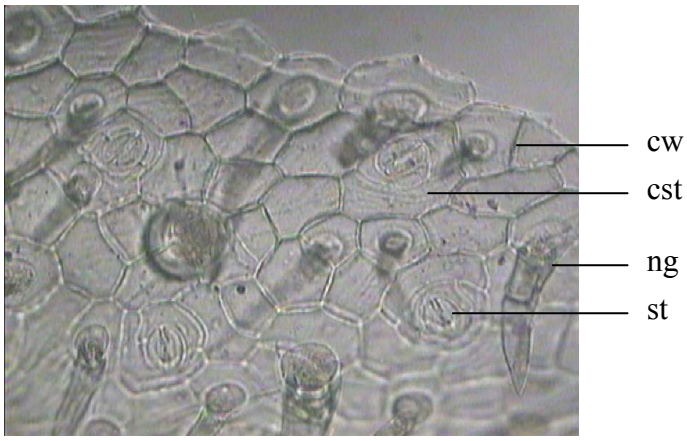
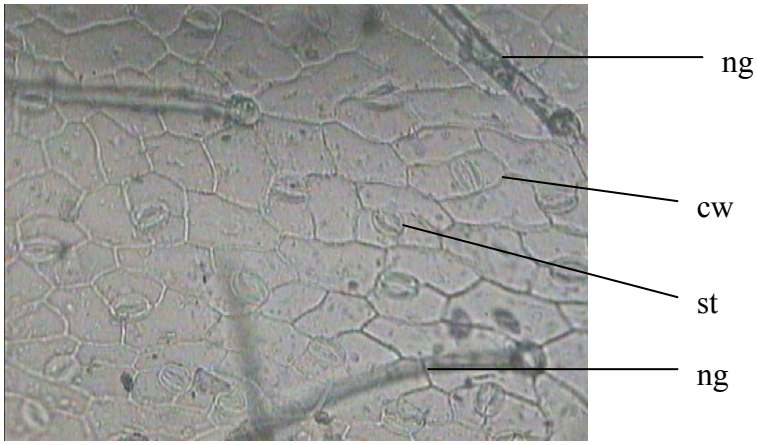


Figure (3.9.1): Leaf, midrib region of *Salvia deserti*. A – Upper epidermis; B, C – Lower epidermis (A – C x 400).

A.



B.



C.

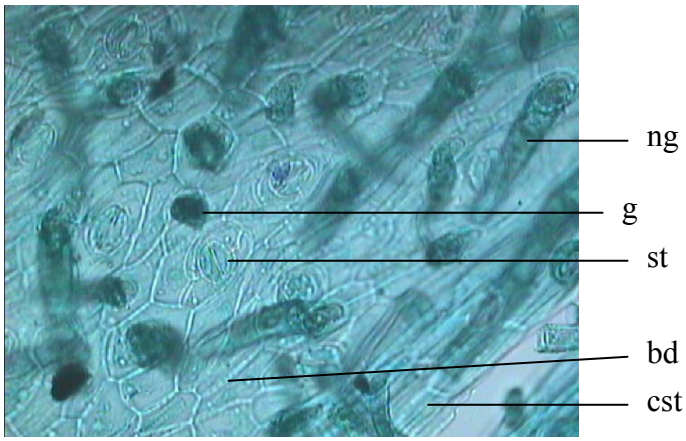


Figure (3.9.2) Leaf, intercostal region of *S. deserti.* A, – Upper epidermis; B – Lower epidermis; C. Stem epidermis (A – C x 400).

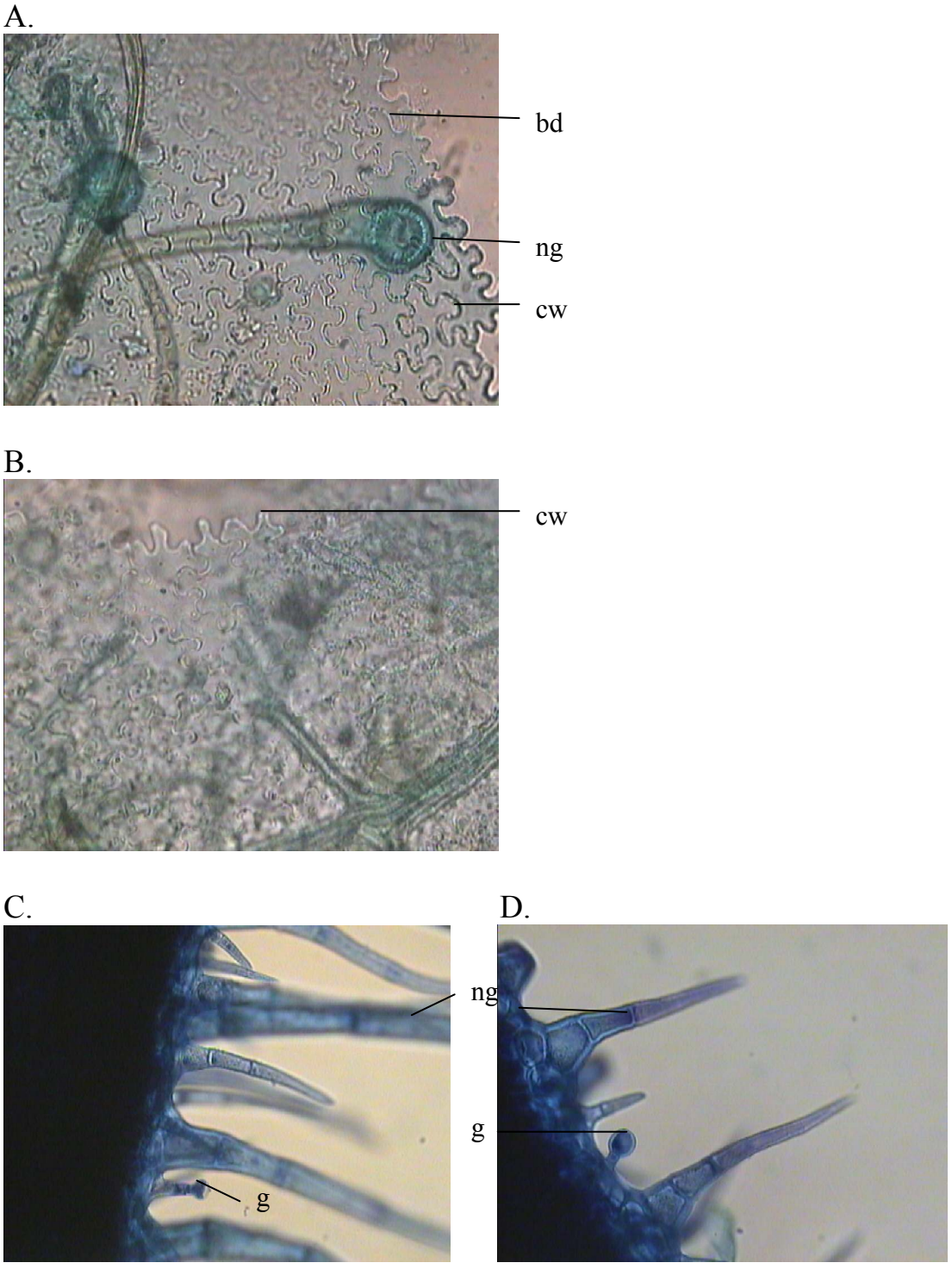
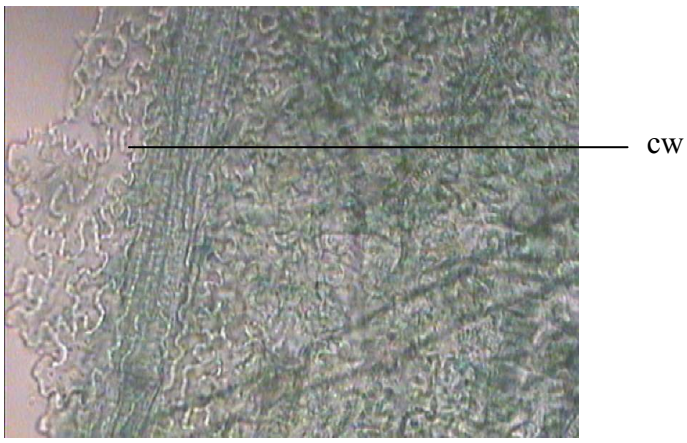
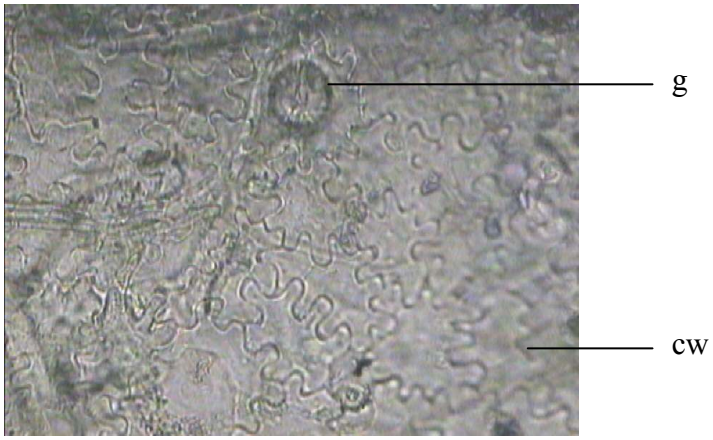


Figure (3.9.3) Floral parts of *S. deserti*. A – Calyx, abaxial surface; B – Calyx, adaxial surface; C, D – Calyx, trichomes (A – D x 400)

A.



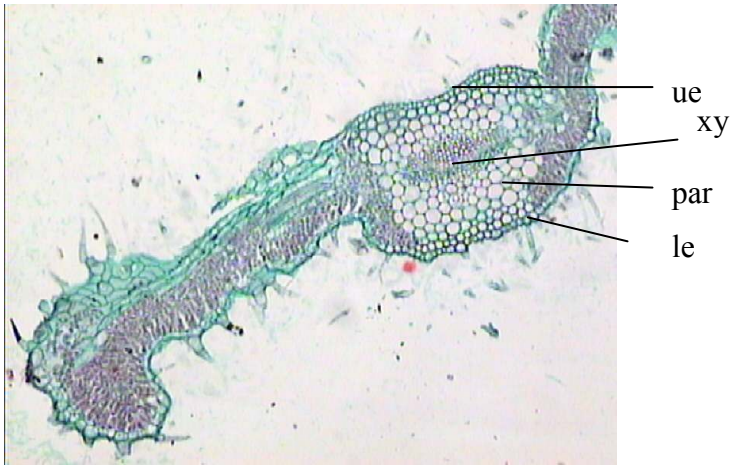
B.



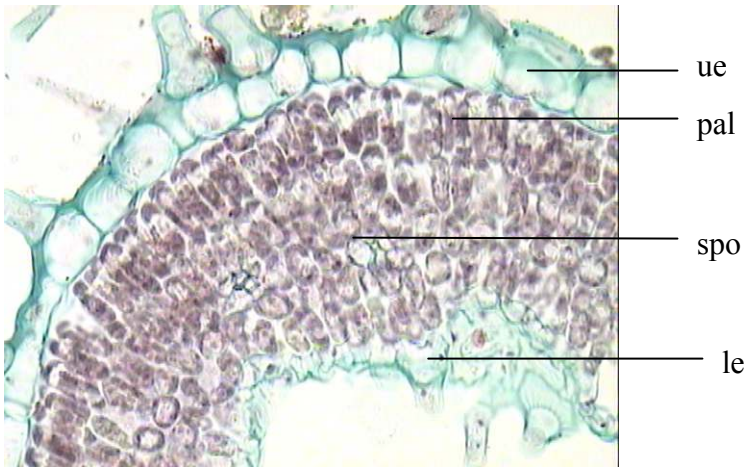
C.

Figure (3.9.4): Floral parts of *S. deserti*. A – Corolla, abaxial surface; B – Corolla, adaxial surface; C – Corolla trichomes (A – C x 400).

A.



B.



C.

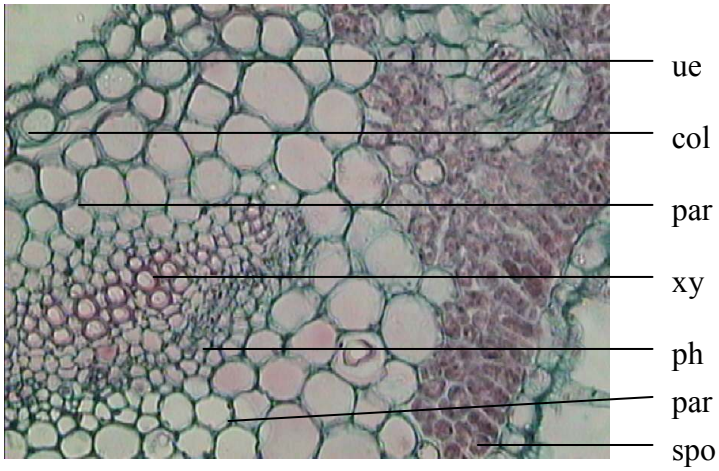
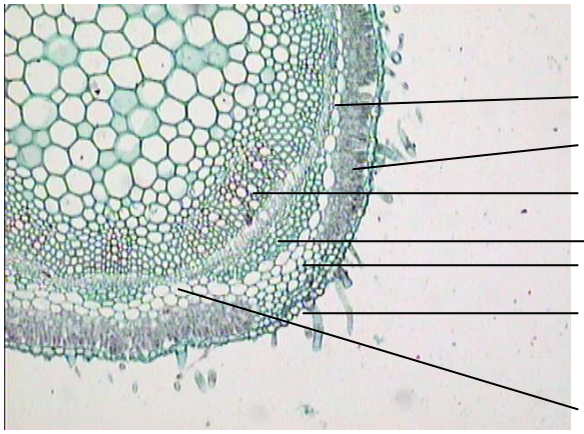


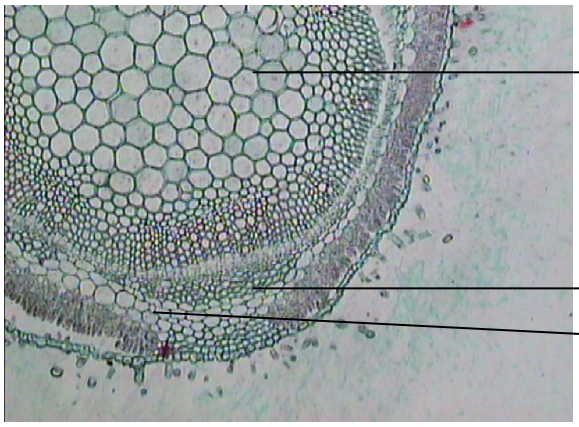
Figure (3.9.5): Leaf transverse sections of *S. deserti*. A – Midrib (x 100); B – Intercostal region; C – Vascular bundle region (B, C x 400).

A.



D.

B.



C

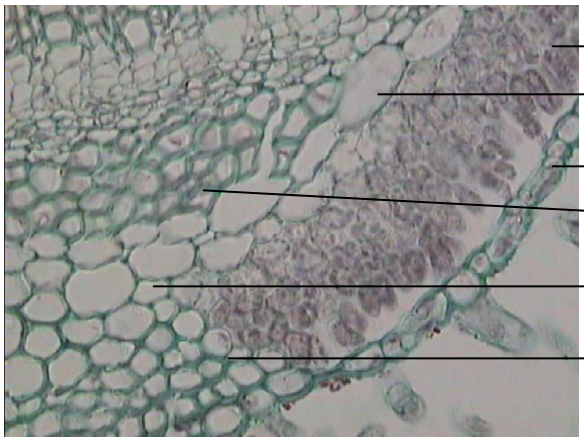


Figure (3.9.6): A – D Stem transverse sections of *S. deserti*. A, B – Stem (x 100); C – Stem (x 400); D – (x 40).

3.10. *Salvia spinosa L.*

3.10.1. EPIDERMAL CHARACTERS

3.10.1.1. Leaf, Midrib Region

Upper epidermis: Epidermal cells are polygonal elongated with thin straight cellulosic beaded anticlinal walls, covered with striated **cuticle**, 66.7 – 40.5 – 28 μm long, 35 – 33 – 15 μm wide. **Stomata** absent. **Trichomes** are glandular and nonglandular intermixed.

Nonglandular: occur in three forms: (Figure 3.10.1; Table 3.1)

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex.
b. bicellular, uniseriate, unbranched with thin warty walls wide lumina and acute apex.
c. multicellular, uniseriate, unbranched with thin warty walls.

Glandular: observed in 3 forms:

a. stalk unicellular, head unicellular.
b. stalk unicellular, unbranched, head bicellular.
c. stalk unicellular, unbranched, head multicellular, (4 – 8 cells) round shape.

Lower epidermis: Epidermal cells are polygonal elongated with thin cellulosic straight anticlinal walls, exhibiting beading. Cells, 73.5 – 68.2 – 40 μm long, 33 – 25 – 20.5 μm wide, covered with thin smooth **cuticle**, striation occur longitudinally. **Stomata** are absent, trichomes showing an intermixed of glandular and nonglandular, both are similar in their characters to those of the upper midrib surface (Figure 3.10.1 B; Table 3.1).

3.10.1.2. Leaf, Intercostal Region

Upper epidermis: Epidermal cells are polygonal with thin cellulosic sinuous beaded anticlinal walls, 98.3 – 50.5 – 40 μm long, 60.6 – 35 – 17.5 μm wide; covered with smooth **cuticle**. **Stomata** are diacytic, 100/mm^2 ovate or circulate. **Trichomes** are intermixed of glandular and nonglandular (Figure 3.10.2 A; Table 3.2).

Nonglandular: occurred in three forms as those of the upper midrib region which are:

a. unicellular, uniseriate, unbranched short with thin warty walls with wide lumina and acute apex.
b. bicellular, uniseriate, unbranched short with thin warty walls with wide lumina and acute apex (Figure 3.10.2 A).
c. multicellular, uniseriate unbranched with thin warty walls wide lumina and acute apex.

Glandular: showing two forms:

a. stalk unicellular and head unicellular.
b. stalk unicellular and head bicellular.

Lower epidermis: Epidermis polygonal with thin cellulosic sinuous anticlinal walls (55.8 – 35.4 – 32 μm long, 43 – 33.1 – 25 μm wide). **Cuticle** smooth. **Stomata** numerous ovate, diacytic, 450/mm^2. **Trichomes** are glandular and nonglandular, intermixed (Figure 3.10.2 B).

Nonglandular: are similar to those of the upper intercostal surface.

Glandular: occur in three forms.

a. stalk unicellular, unbranched, head unicellular.
b. stalk bicellular, unbranched, head unicellular.
c. stalk unicellular, unbranched, head multicellular (4 – 8 cells) (Figure 3.10.2 B).

3.10.1.3. Stem

The epidermal cells are polygonal elongated at stem angles, and polygonal to rounded with straight beaded anticlinal walls in the cells occur in between the angles, 66.7 – 70.5 – 82.1 μm long and 30 – 25 – 10 μm wide; covered with striated **cuticle** at the stem angles and smooth **cuticle** in between the angles. **Stomata**: frequent diacytic and anisocytic, numerous, 250/mm^2 and absent at the stem angles. **Trichomes** are intermixed of glandular and nonglandular (Figure 3.10.3 A,B,C; Table 3.3).

Nonglandular: are showing three forms.

a. unicellular unbranched with thin warty walls wide lumina and acute apex.
b. bicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex (Figure 3.10.3 C).
c. multicellular uniseriate unbranched with thin warty walls wide lumina and acute apex (Figure 3.10.3 C).

Glandular: occur in three forms:

1. stalk unicellular, head unicellular.
2. stalk unicellular, head bicellular.
3. stalk unicellular, head multicellular, (4 – 8 cells) with spherical form (Figure 3.10.3 C).

3.10.1.4. Floral parts
3.10.1.4.1. Calyx:
3.10.1.4.1.1. Abaxial surface

Epidermal cells are isodiametric elongated with thin sinuous beaded anticlinal walls. 80 – 75.6 – 55.1 μm long, 33 – 25.2 – 15 μm wide. **Cuticle** smooth. **Stomata** absent. **Trichomes**: glandular and nonglandular intermixed.

Nonglandular: are three forms:

1. unicellular, unbranched with thin warty walls wide lumina and acute apex.
2. bicellular, uniseriate, unbranched with thin warty walls, wide lumina and acute apex.
3. multicellular (3 – 7 cells), uniseriate, unbranched with thin warty walls, wide lumina and acute apex.

Glandular: are one form: stalk is unicellular and head is unicellular round shape (Figure 3.10.4 A; Table 3.4).

3.10.1.4.1.2. Adaxial surface

Epidermal cells are similar in their characters to those of the abaxial surface with numerous **stomata**, diacytic, 150/mm^2 (Figure 3.10.4 B; Table 3.4).

3.10.1.4.2. Corolla

3.10.1.4.2.1. Abaxial surface

Epidermal cells are isodiametric with thin sinuous anticlinal walls. ***Cuticle*** smooth. ***Stomata*** are absent. ***Trichomes*** are glandular and nonglandular intermixed, similar in their characters and forms to those of the calyx abaxial surface (Figure 3.10.5 A; Table 3.4).

3.10.1.4.2.2. Adaxial surface:

Epidermal cells are isodiametric with thin cellulosic sinuous beaded anticlinal walls. **Cuticle**, smooth. **Stomata** are few, diacytic 50/mm^2. **Trichomes** are similar to those existing at the corolla abaxial surface (Figure 3.10.5 B; Table 3.4).

3.10.2. INTERNAL STRUCTURE

3.10.2.1 Leaf, Midrib Region

Upper epidermis: Epidermal cells are rounded with outer thick and inner thin walls, both cellulosic. **Cuticle** thick, **ground tissue** consists of one layer of lamellar colenchyma, present below the upper and

lower epidermises. Parenchyma cells 6 – 12 layers, wide rounded with thin cellulosic walls surrounding the vascular bundle; these cells devoid of chlorophyll and with conspicuous intercellular spaces. The vascular tissue is represented by one large arched (as a boat) shape; primary xylem elements as a polygonal cells with thick lignified walls, two layers of procambium are observed; primary phloem with sieve tubes elements and companion cells; outer phloem fibers occur in two groups, with thick unlignified cell walls (Figure 3.10.6 A, C; Table 3.5).

Lower epidermis: Similar in their characters to those of the upper epidermis (Figure 3.10.6 A,C; Table 3.5).

3.10.2.2. Leaf, Intercostal Region

Upper epidermis: Epidermis cells are rounded with thick outer walls and thin inner walls, both cellulosic. **Cuticle** thick. Messophyll consists of 4 to 6 layers of palisade type cells contains chlorophyll and having large intercellular spaces (Figure 3.10.6 B, C; Table 3.6).

Lower epidermis: cells rounded small with thin outer and inner walls; cuticle thin (Figure 3.10.6 B; Table 3.6).

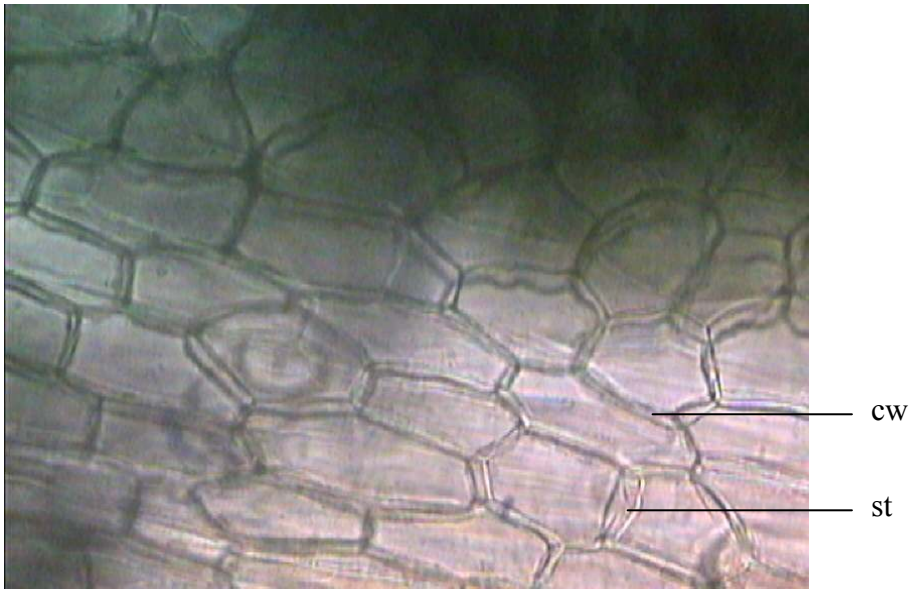
3.10.2.3. Stem

Epidermal cells are tabular with thick outer walls and thin inner walls, both cellulosic, **cuticle** is thick. **Cortex** consists of hypodemol layer, then groups of 4 or 5 layers of lamellar collenchyma tissue at the stem angles replaced by 4 or 5 layers of well developed, chlorenchyma tissue in between the stem angles and parenchyma tissue. Bundle sheath is a clear ring of one layer of tabular parenchyma cells with thin cellulosic cell walls which is devoid of starch or chloroplasts, surrounding the vascular bundle. **Vascular tissue** consists of 4 large vascular bundles at the stem 4 angles, outer phloem fibers with thick unlignified cell walls covering the main vascular tissue as arc shape. The primary phloem with elements having thin cellulosic cell walls. The

primary xylem consists of radial rows of vessels with lignified cell walls; the protoxylem has narrow vessels and the metaxylem has wide vessels vessels. The vascular cambium not observed; the outer phloem fibers and the xylem elements are forming a discontinuous cylinder in the stem.

Pith (Medulla): Cells are polygonal homogenous almost rounded, large with thin cellulosic walls and large intercellular spaces (Figure 3.10.7 A, B; Table 3.7).

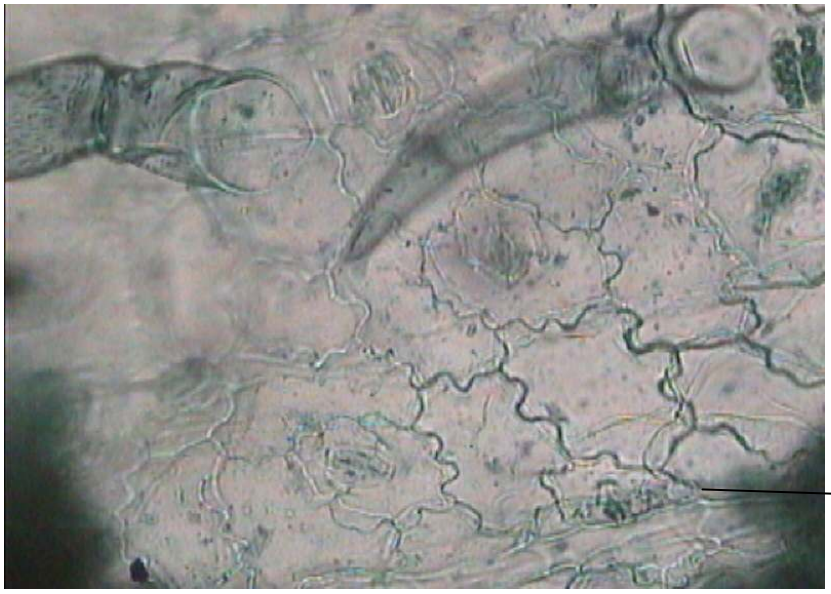
A.



B.

Figure (3.10.1): Leaf, midrib region of *Salvia spinosa*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

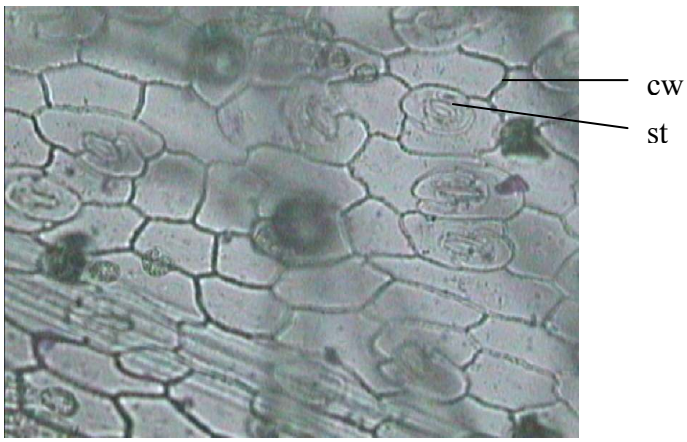
A.



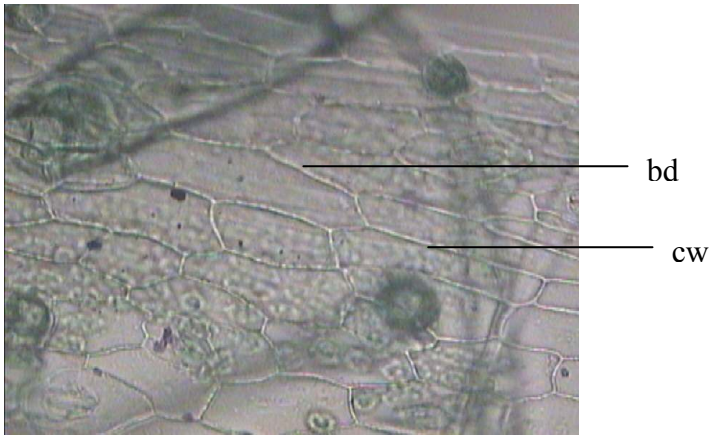
B.

Figure (3.10.2): Leaf, intercostal region of *Salvia spinosa*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.



B.



C.

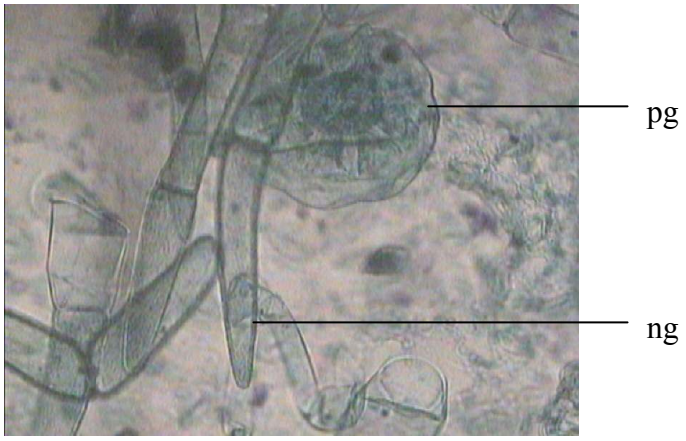
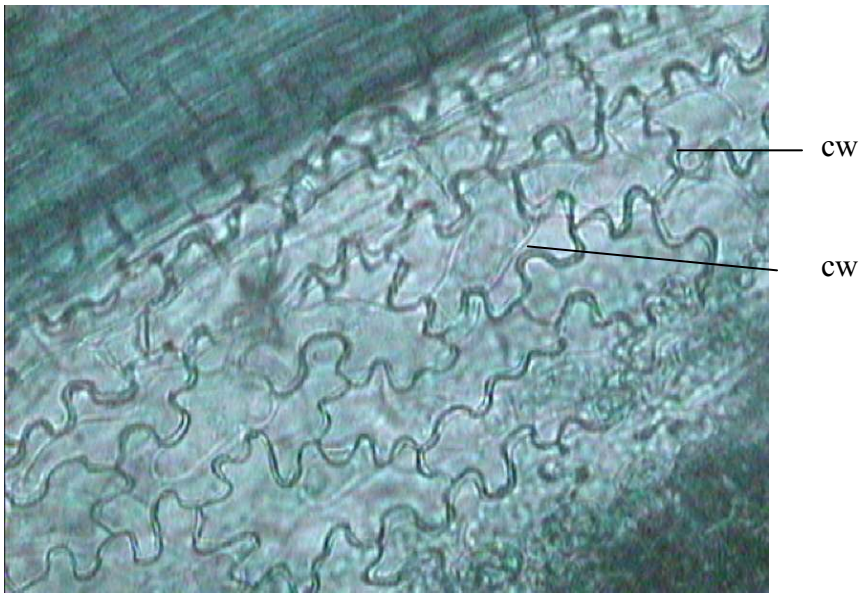


Figure (3.10.3): Stem, epidermis of *S. spinosa*. A – Epidermis between stem angles; B – Epidermis at stem angles; C – Stem trichomes (A – C x 400).

A.



B.

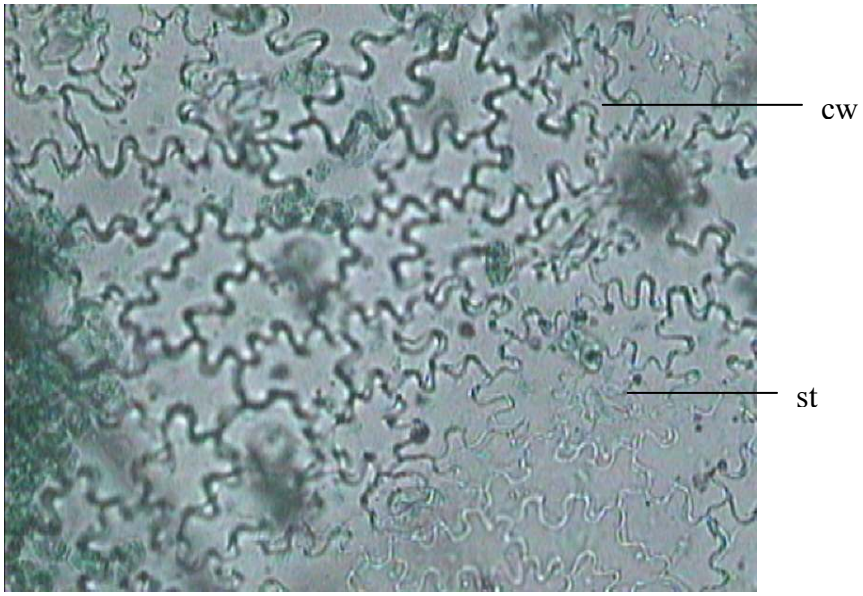
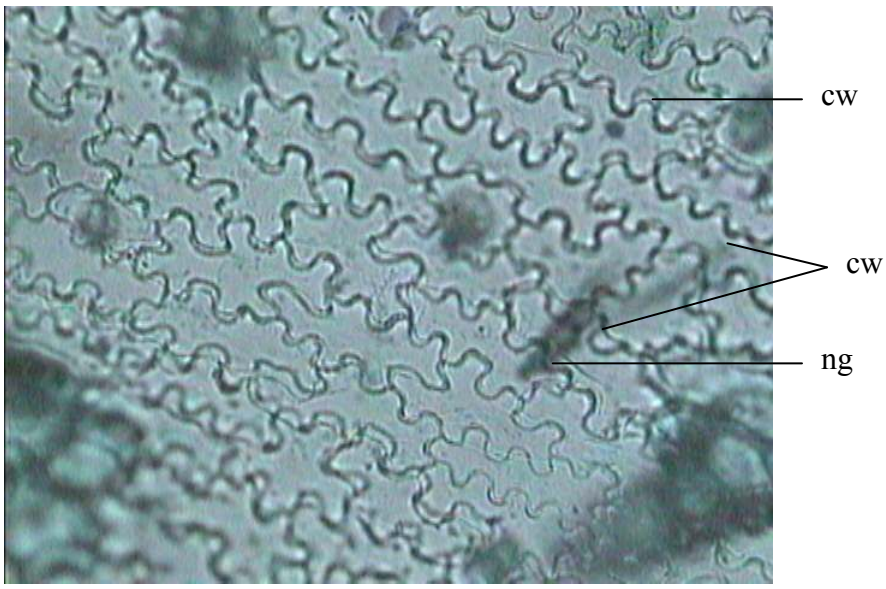


Figure (3.10.4): Floral parts epidermis of *S. spinosa*. A – Calyx, abaxial surface; B – Calyx, adaxial surface (A, B x 400).

A.



B.

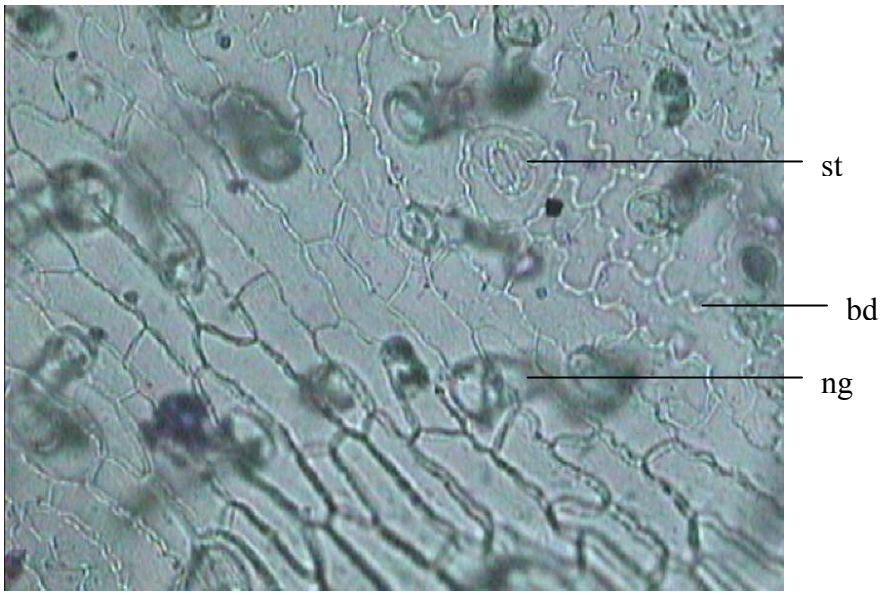
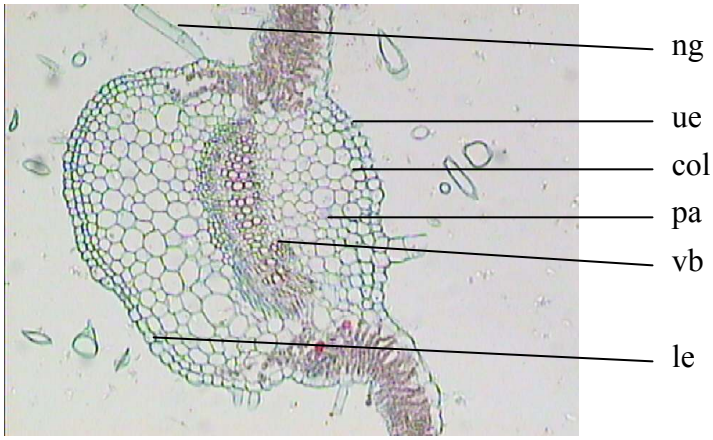
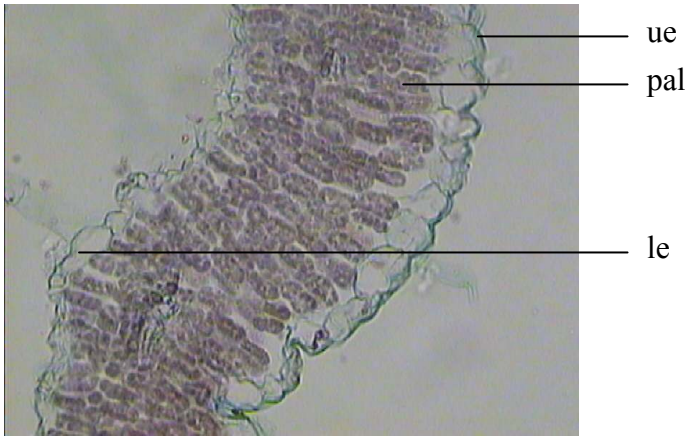


Figure (3.10.5): Floral parts epidermis of *S. spinosa*. A – Corolla, abaxial surface; B - Corolla, adaxial surface (A, B x 400).

A.



B.



C.

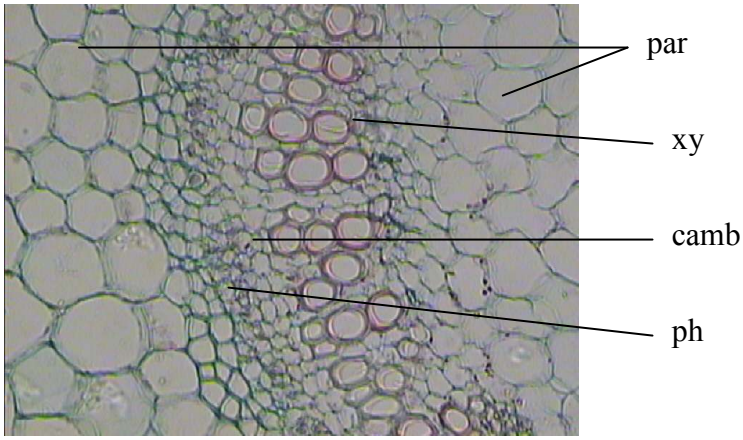
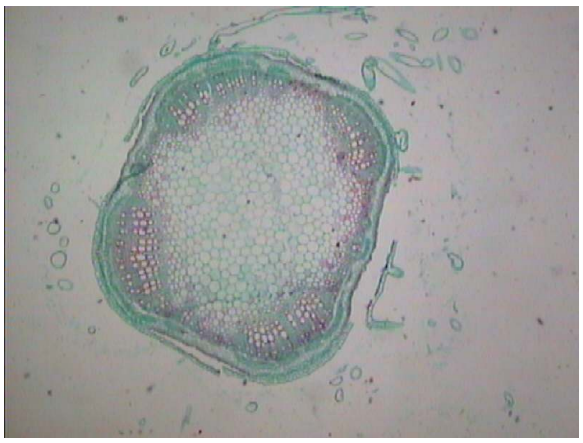


Figure (3.10.6): Leaf transverse sections of *S. spinosa*. A.- Leaf (x 100); B – Intercostal region; C – Midrib region (B, C x 400).

A.



B.

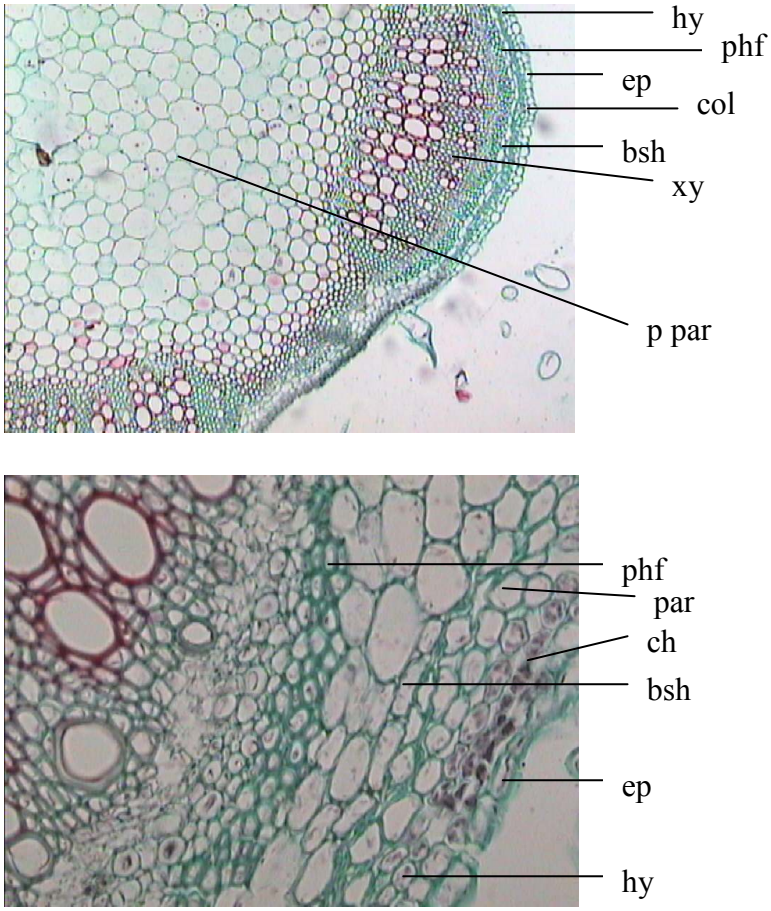


Figure (3.10.7): Stem transverse sections of *S. spinosa*. A- Stem section (x 40); B – Stem (x 100); C – Stem (x 400).

3.11. *Stachys aegyptiaca* Pers.

3.11.1. EPIDERMAL CHARACTERS

3.11.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular elongated with straight thick beaded walls (110 – 95 –82 μm long; 28 – 25 – 20 μm wide), few of the cells are polygonal; with cellulosic cell walls. **Cuticle** longitudinally striated. **Stomata**, absent. **Trichomes**: are glandular and nonglandular.

Nonglandular: are one form, numerous, multicellular, multiseriate branched, with thin cellulosic warty walls (Figure 3.11.1 A; Table 3.1).

Glandular: are two forms and very rare.

a. stalk unicellular, head unicellular, round in shape.

b. stalk bicellular, head unicellular round in shape.

Lower epidermis: Cells rectangular, elongated with slightly thick straight cellulosic, beaded anticlinal walls, 105 – 55 –42 μm long, 35 – 26 – 15 μm wide, **cuticle** smooth. **Stomata**, absent. **Trichomes:** similar to those of the upper epidermis (Figure 3.11.1 B; Table 3.1).

3.11.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with straight, cellulosic and hemicellulosic thin beaded anticlinal walls, 45 – 33.1 – 15 μm long, 28 – 19.1 – 12 μm wide; cells covered with thin smooth **cuticle**. **Stomata**: absent. **Trichomes:** very dense, 300/mm^2, commonly nonglandulars, occasionally, glandular trichomes both are similar to those existing in the midrib region epidermis (Figure 3.11.2 A; Table 3.2).

Lower epidermis: Cells are polygonal with thin straight cellulosic beaded anticlinal walls, 75 – 35 – 22 μm long, 25 – 17 – 15 μm wide. **Cuticle** smooth. **Stomata**, few diacytic (50/mm^2) ovate or circulate.

Trichomes: glandular and nonglandular intermixed are similar to those of the upper epidermis of midrib region (Figure 3.11.2 B).

3.11.1.3. Stem epidermis

Cells rectangular elongated, 105.2 – 100 –85 μm long; 35 – 25 – 12 μm wide, with thick, straight cellulosic beaded walls. **Cuticle:** striated longitudinally. **Stomata**: absent. **Trichomes:** very dense, nonglandular, 300/mm^2 with one form and few glandular trichomes (Figure 3.11.3 A,B,C,D; Table 3.3).

Nonglandular: are multicellular, multiseriate, branched with thick warty walls, branches with acute apex (Figure 3.11.3 C, D).

Glandular: are two forms.

a. stalk unicellular and heads unicellular round shape (Figure 3.11.3 B).
b. stalk, bicellular and head unicellular rounded in shape.

3.11.2.1. INTERNAL STRUCTURES
3.11.2.1. Leaf, Midrib Region

Upper epidermis: Cells tabular, with thick outer wall and thin radial walls and both are cellulosic; cuticle thick. **Ground tissue:** consists of several layers of lamellar collenchyma under the upper and lower epidermis. **Vascular tissue:** represented by one arched vascular bundle. Primary xylem elements (vessels and tracheids) are large and polygonal in the outline with lignified walls and they arranged in radial rows. Primary phloem elements showing a small groups of sieve elements and companion cells with thin unlignified walls (Figure 3.11.4 A,B; Table 3.5).

Lower epidermis: Similar in characters to those of the upper epidermis of the midrib region (Figure 3.11.4 A; Table 3.5).

3.11.2.2. Leaf, Intercostal Region

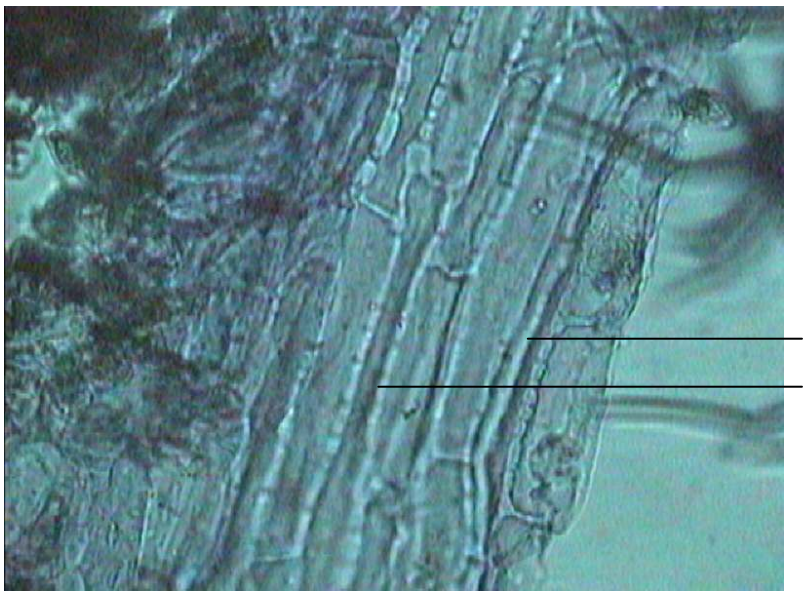
Upper epidermis: Similar in the characters to those of the upper epidermis of the midrib region. **Messophyll:** consists of two or three layers of palisade type cells with large intercellular spaces, contain chloroplasts, followed by spongy type cells 2 or 3 layers containing chloroplasts and with conspicuous intercellular spaces (Figure 3.11.5 C; Table 3.6).

3.11.2.3. Stem

The transverse section is quadrangular in out line exhibiting some glandular and nonglandular trichomes (Figure 3.11.5 A,B,C; Table 3.7).

Epidermis: Cells are rounded small with outer walls, the outer walls are thicker than the radial walls and both walls are cellulosic cuticle thick. **Cortex:** It consist of one layer forming continuous ring of hypodermal tabular cells devoided of chloroplasts or starch with thin walls, followed by lamellar collenchyma 2 – 4 layers at stem angles or chlorenchyma tissue with rounded cells contains chloroplasts and having a conspicuous intercellular spaces are quite clear as (3 or 4 layers) in between angles. The bundle sheath with large cells forming one layer and devoid of starch. **Vascular tissue:** consists of primary xylem and primary phloem as several vascular bundles connected with several layers of fibers forming a continuous cylinder. Secondary xylem and phloem occurred forming a continuous cylinder. Outer phloem fibers as small groups of thick lignified polygonal cells. Primary phloem elements, sieve tube elements and companion cells with unlignified cell walls. Primary xylem consists of metaxylem with large vessels and protoxylem with small vessels. Vessels are few and forming a radial rows. **Medulla (pith):** consist of polygonal homogenousparanchymatous cells with thick cellulosic walls, large intercellular spaces (Figure 3.11.5 A,B,C; Table 3.7).

A.



B.

Figure (3.11.1): Leaf, midrib region of *Stachys aegyptiaca*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

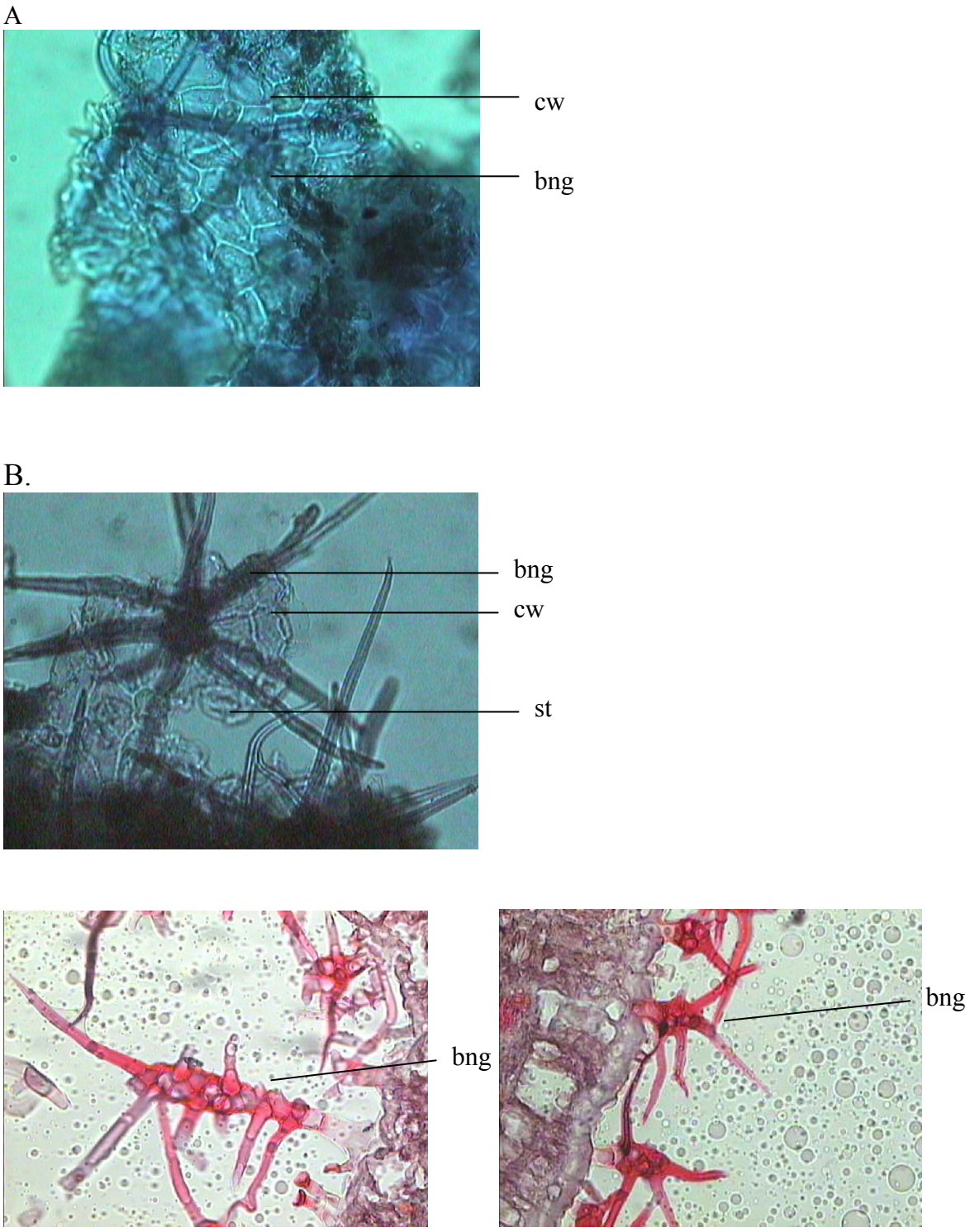
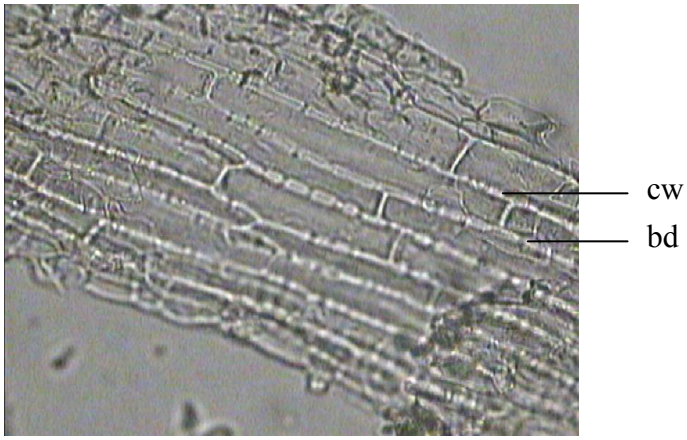
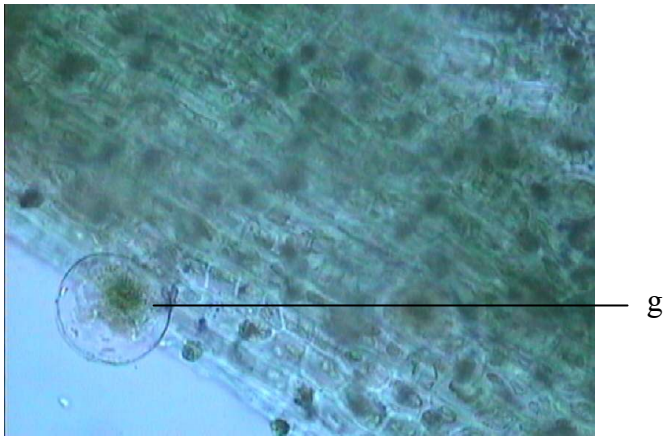


Figure (3.11.2): A – D Leaf, intercostal region of *Stachys aegyptiaca*. A – Upper epidermis; B – Lower epidermis; C, D – Lower epidermis showing multicellular multiseriated branched nonglandular trichomes (A – D x 400).

A.



B.

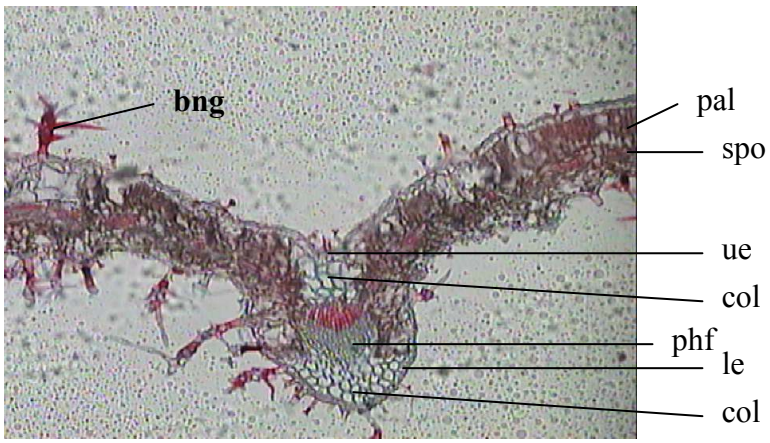


C.

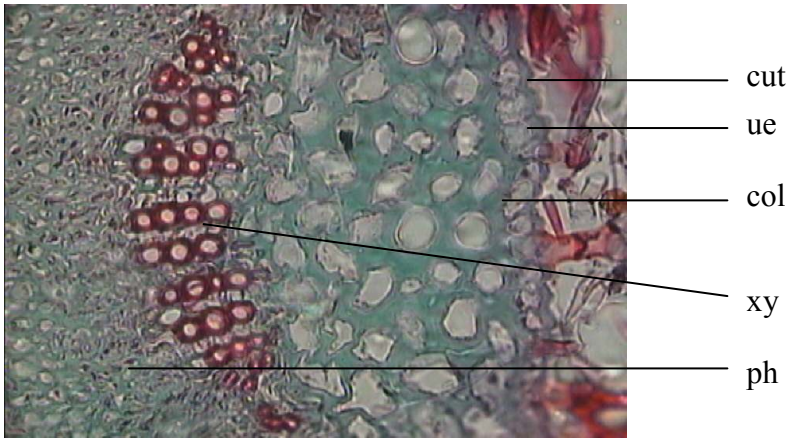
D

Figure (3.11.3): A – D Stem epidermis of *S. aegyptiaca*. A, B – Stem epidermis; C, D – Multicellular multiseriate branched nonglandular trichomes (A – D x 400).

A.



B.



C.

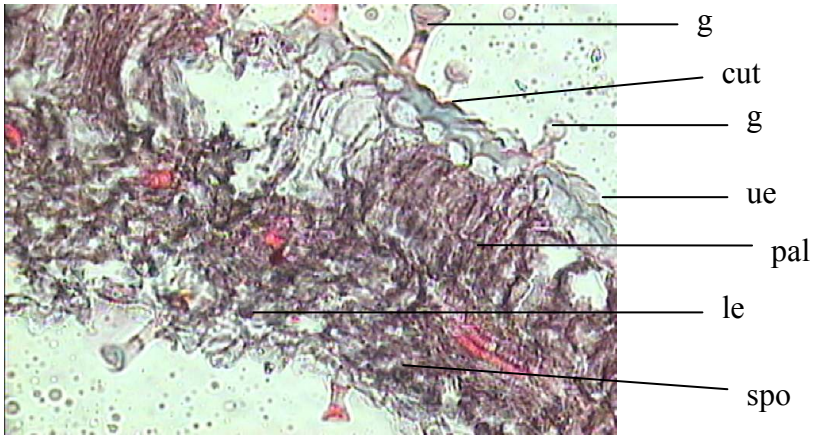
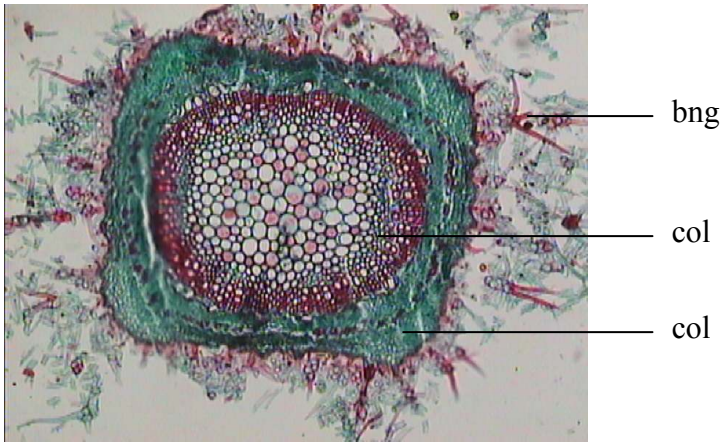
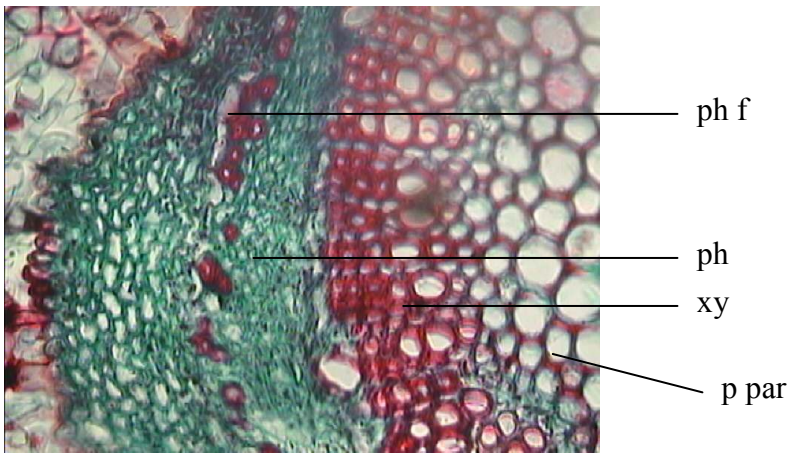


Figure (3.11.4): Leaf transverse sections of *S. aegyptiaca*. A – Midrib and intercostal region (x 100); B – Midrib region; C – Intercostal region (B, C x 400).

A.



B.



C.

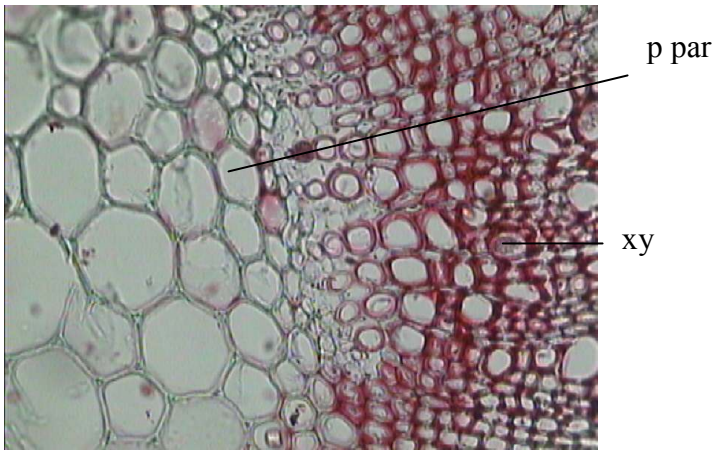


Figure (3.11.5): Stem transverse sections of *S. aegyptiaca*. A – Stem (x 100); B, C – Stem (x 400).

3.12. *Stachys schimperi* Vatke.

3.12.1. EPIDERMAL CHARACTERS

3.12..1.1. Leaf, Midrib Region

Upper epidermis: Cells rectangular or polygonal elongated with thin cellulosic, straight beaded anticlinal walls, 16.5 – 13.3 – 8.5 μm wide, 65.1 – 53 – 13.5 μm long. **Cuticle** longitudinally striated. **Stomata,** are absent. **Trichomes** are glandular and nonglandular intermixed (Figure 3.12.1 A; Table 3.1).

Nonglandular: multicelular, multiseriate branched, with thick warty walls. Branches have acute apex and cellulosic walls (Figure 3.12.1 A - D; Table 3.1).

Glandular: have three forms

a. stalk, bicellular, long unbranched head unicellular, rounded.

b. stalk, multicellular (3 cells) long unbranched, head unicellular, rounded.

c. stalk, multicellular, multiseriate (3-4 cells), one branch having a unicellular, glandular head (Figure 3.12.1 D).

Lower epidermis: Cells rectangular or polygonal elongated with thin straight cellulosic beaded anticlinal walls, 55.5 – 13.4 – 8.9 μm long, 25.5 – 13.1 – 12.5 μm wide. **Cuticle:** longitudinally striated. **Stomata** are absent. **Trichomes** are similar to those of the upper epidermis of the same region (Figure 3.12.1 B,C,D; Table 3.1).

3.12..1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with slightly sinuous anticlinal walls, walls are cellulosic and hemicellulosic, thin, beaded, 35 – 15 – 12.5 μm long, 25 – 20 – 17.5 μm wide. **Cuticle** is striated. **Stomata**: numerous, 150/mm^2, mostly diacytic, occasionally anisocytic or anomocytic, ovate or circulate. **Trichomes**: nonglandular and

glandular trichomes are present, both are similar to those presented at the midrib region (Figure 3.12.2 A,B,C; Table 3.2).

Lower epidermis: Cells are polygonal with thin (2.5 μm) cellulosic straight beaded anticlinal wall. **Cuticle** striated. **Stomata**, numerous, 250/mm^2, mostly diacytic and anisocytic occasionally anomocytic, ovate and circulate. **Trichomes**: are similar to those of the upper epidermis of the midrib region (Figure 3.12.3 A,B,C; Table 3.2).

3.12.1.3. Stem Epidermis

Epidermis: Cells are polygonal with thin, cellulosic, straight beaded anticlinal walls, 35.5 – 18.5 –15.5 μm long, 32 – 20 – 18.5 μm wide. **Cuticle** is smooth. **Stomata** are numerous, 300/mm^2 mostly anomocytic and occasionally anisocytic, rarely diacytic ovate or circulate 25 – 15 – 10 μm long, 20 – 18 – 13.5 μm wide. **Trichomes** are similar to those of the leaf midrib region (Figure 3.12.4 A,B,C; Table 3.3).

3.12.2. INTERNAL STRUCTURES

3.12.2.1. Leaf, Midrib Region

Upper epidermis: Cuticle is thick, cells are tabular, small size, with thick outer walls and thin radial walls. **Messophyll:** It consists of 2 or 3 layers of lamellar collenchyma tissue below the upper and lower epidermis. Parenchyma tissue, 2 – 4 layers on both sides of the vascular bundles. One large vascular bundle which is arched in the outline; xylem elements are , polygonal with thick lignified cell walls, phloem elements with thin, unlignified cell walls, followed by groups of irregular outer phloem fibers with thick unlignified cell walls (Figure 3.12.5 A,C,D; Table 3.5)..

Lower epidermis: one layer of tabular cells with thick outer walls and thin inner walls; cuticle is thick (Figure 3.12.5 A,C,D; Table 3.5).

3.12.2.2. Leaf, Intercostal Region

Upper epidermis: Cuticle is thick and cells are tabular with thick outer walls and thin inner walls, both are cellulosic. **Messophyll:** Differentiated to palisade and spongy tissue, palisade tissue consists of 3 - 5 layers, cells contain chloroplasts. Spongy tissue consists of 2 or 3 layers of irregular chlorenchymatous cells. Both kinds of tissues with large intercellular spaces (Figure 3.12.5 B; Table 3.6).

Lower epidermis: similar in characters to those of the upper epidermis (Figure 3.12.5 B; Table 3.6).

3.12.2.3. Stem

The stem is round angled in the transverse section.

Epidermal cells: One layer of tubular small cells with thick outer walls, thin radial walls, both cellulosic; cuticle is thick. **Cortex:** It consist of 3 or 4 layers of irregular chlorenchyma tissue with thin cellulosic walls and conspicuous intercellular spaces contain chloroplasts, four main small groups of lamellar collenchyma at the stem angles. The bundle sheath observed as a continuous ring of one rectangular cell with thin unlignified cell walls, devoid of chlorophyll or starch. **Vascular tissue*:*** Consist of several vascular bundles connected by well developed fibers forming a continuous cylinder. Outer phloem fibers in small groups with thick lignified walls. The primary phloem elements are with thin cellulosic walls. The primary xylem well developed with several vessels with thick lignified cell walls one layer, vascular cambium clear. **Medulla Pith:** is wide and consists of large polygonal paranchymatous homogenous cells, with thick cellulosic walls, having a conspicuous intercellular spaces (Figure 3.12.6 A,B,C,D; Table 3.7).

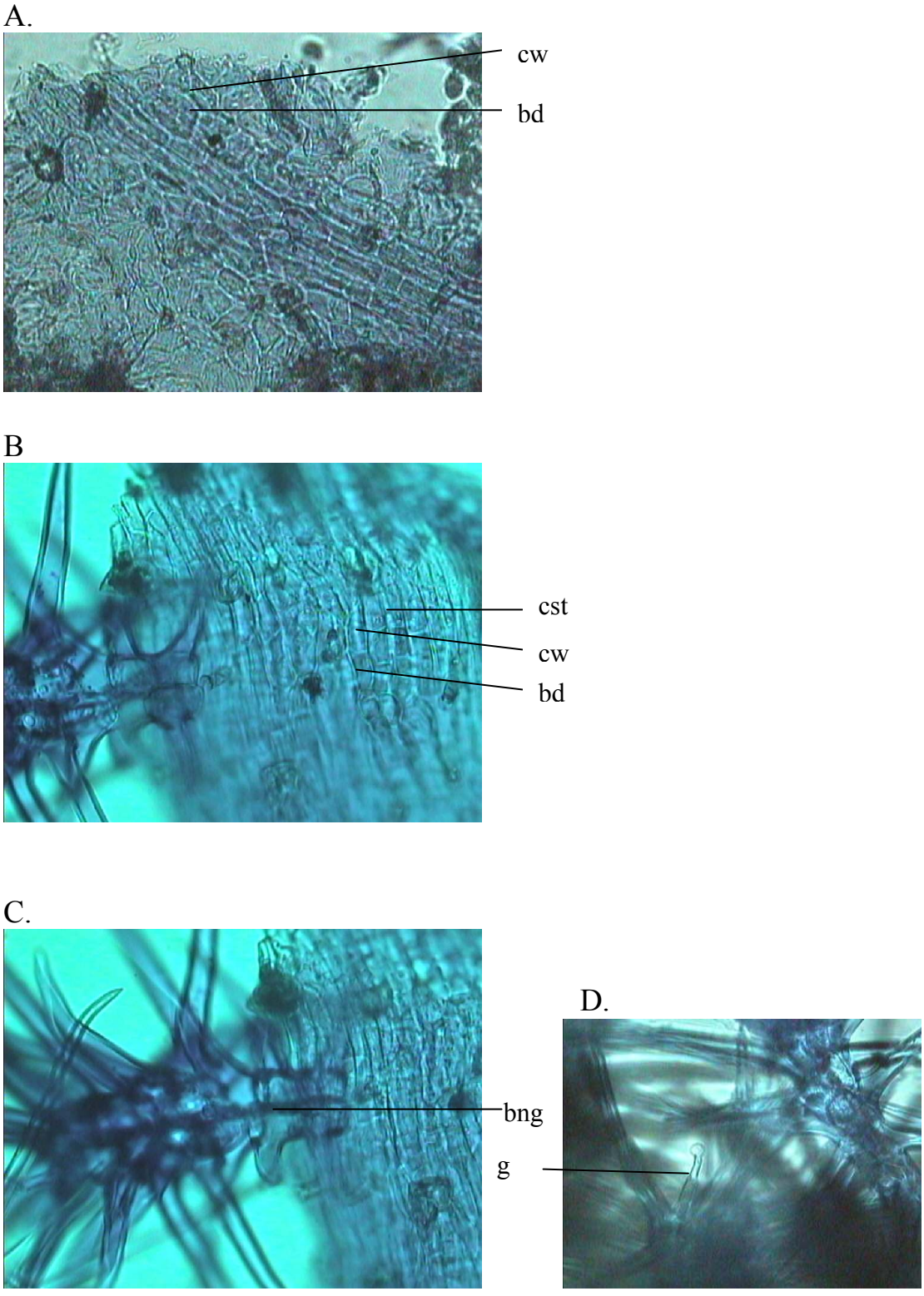
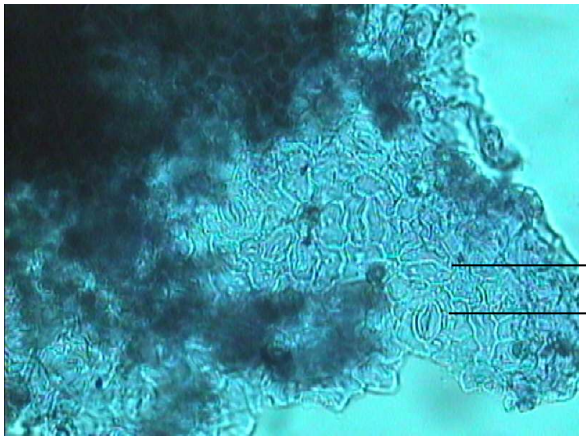
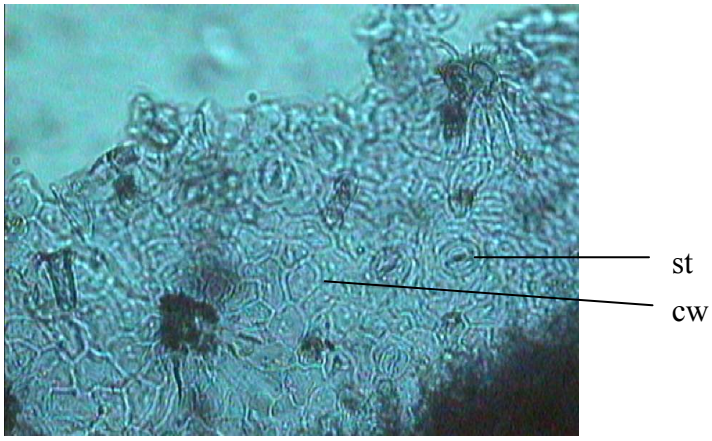


Figure (3.12.1) Leaf, midrib region of *Stachys schimperi*. A – Upper epidermis; B, C – Lower epidermis; D – Midrib showing glandular multicellular multiseriate branched trichomes (A – D x 400).

A.



B.



C.

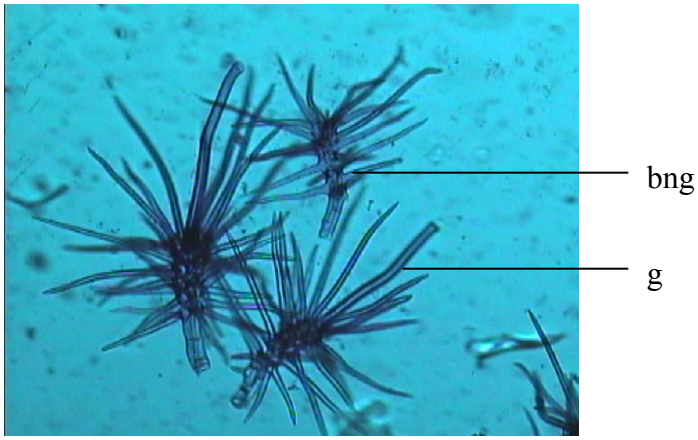
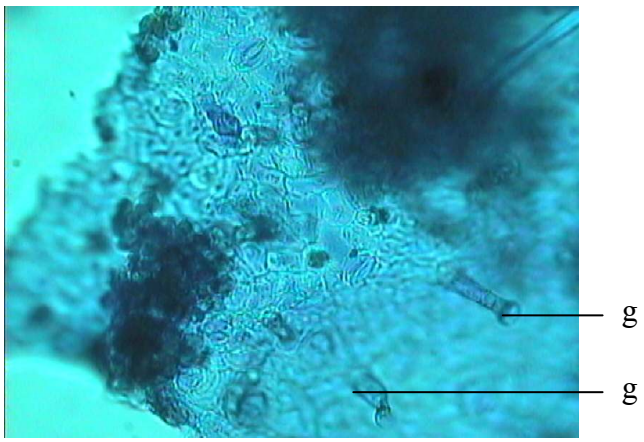
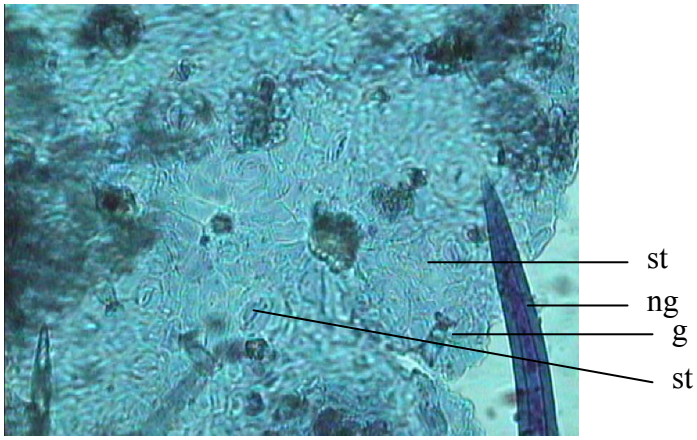


Figure (3.12.2): Leaf, intercostal region of *S. schimperi*. A,B – Upper epidermis (x 400); C – Branched nonglandular trichomes on the upper epidermis of intercostal region (x 100).

A.



B.



C.

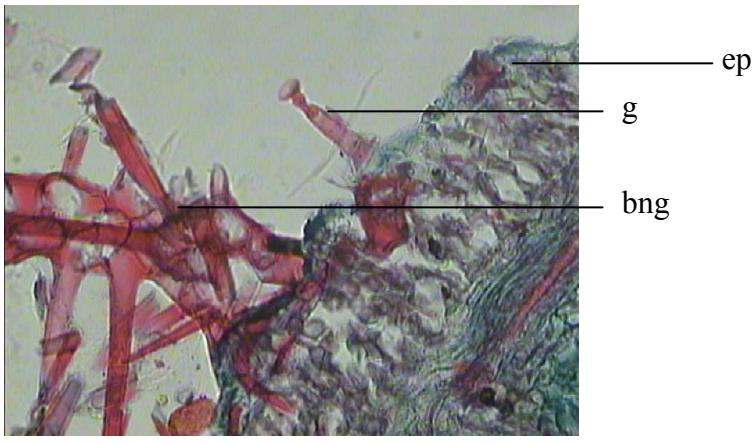
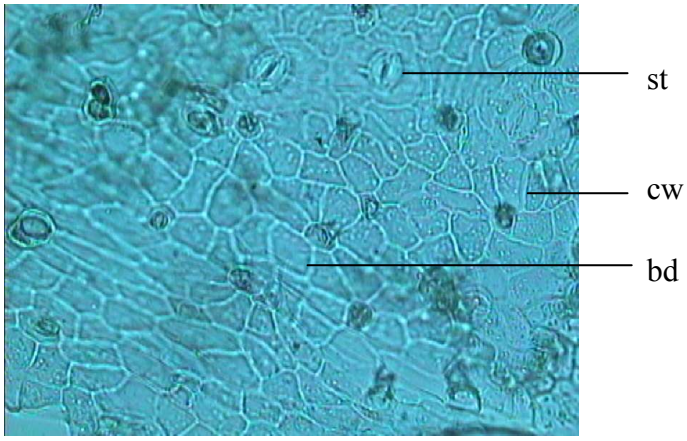


Figure (3.12.3): Leaf intercostal region of *S. schimperi*. A, B Lower epidermis; C – Transverse section of the intercostal region showing the trichomes (A – C x 400).

A.



B.

C.

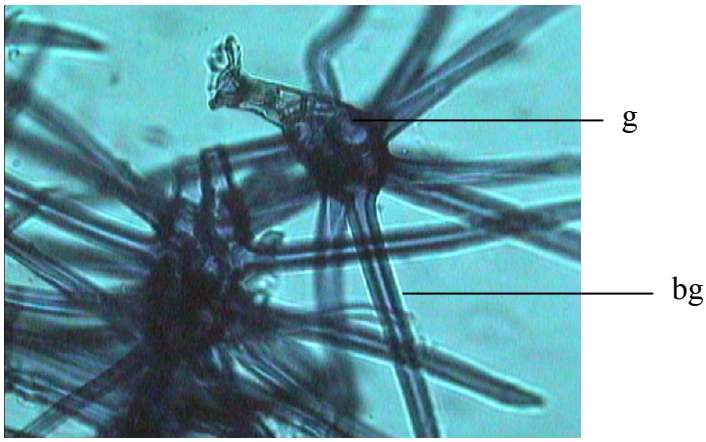
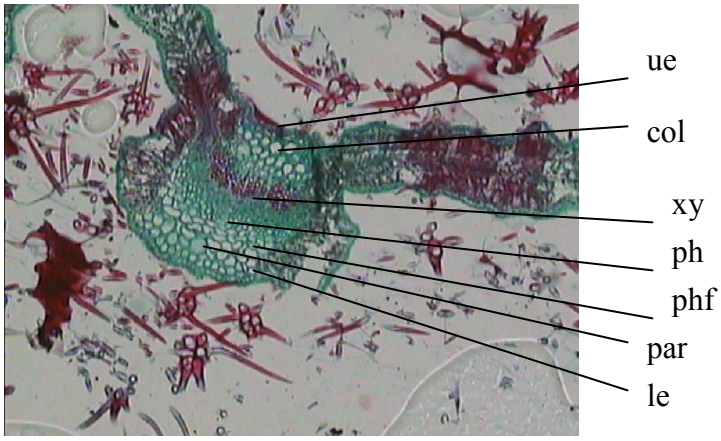
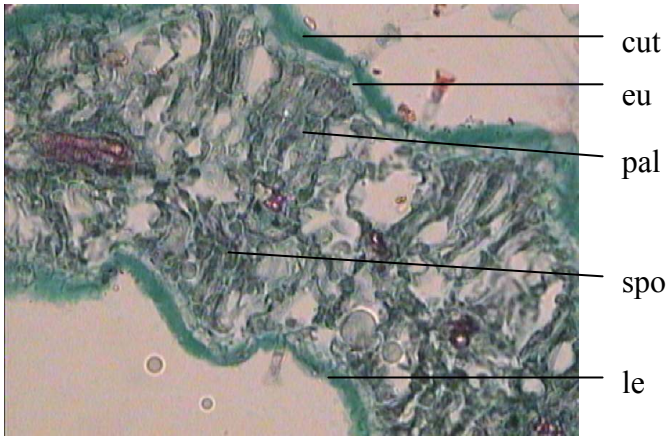


Figure (3.12.4): Stem epidermis of *S. schimperi*. A – Stem epidermis; B, C – Trichomes of stem epidermis (A – C x 400).

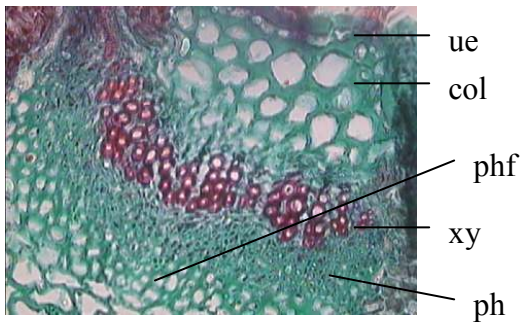
A.



B.



D.



C.

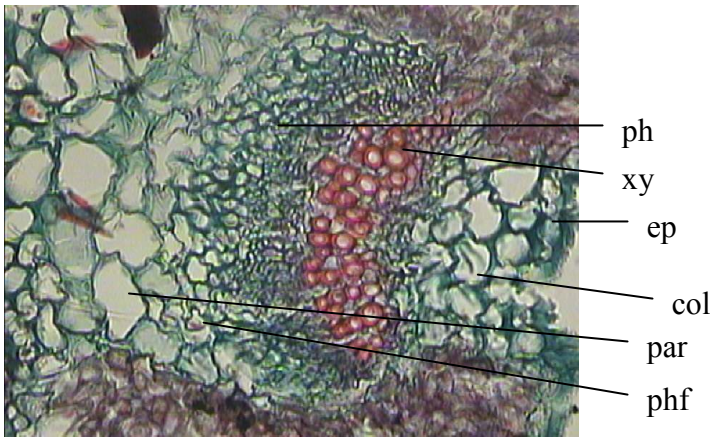
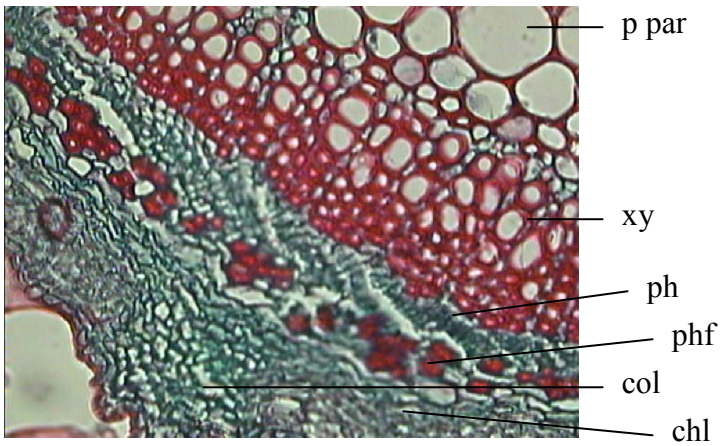
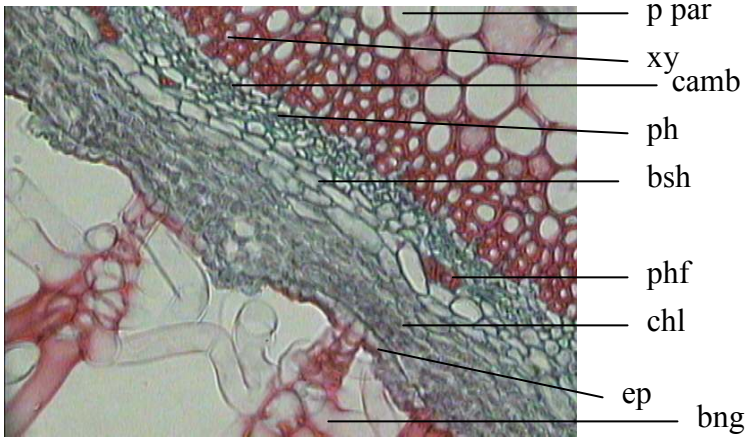


Figure (3.12.5) Leaf transverse sections of *S. schimperi*. A – Leaf (x 100); B – Leaf, intercostal region; C, D – Leaf midrib region (B - D x 400).

A.



B.



C.

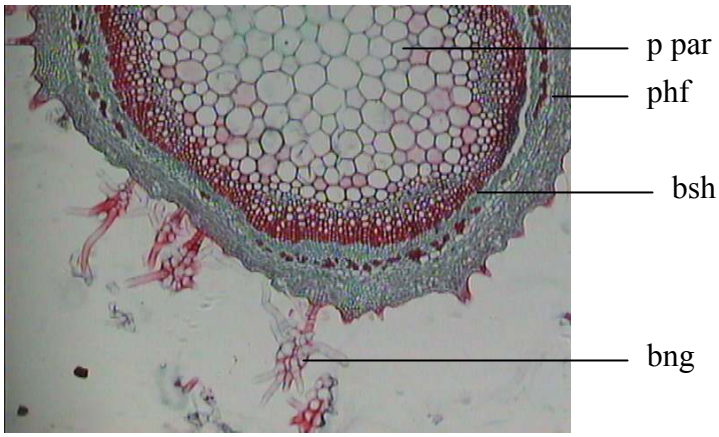


Figure (3.12.6): A – C Stem transverse sections of *S. schimperi*. (A, B x 400); (C x 100).

3.13. *Stachys yemensis* Hedge

3.13.1. EPIDERMAL CHARACTERS

3.13.1.1. Leaf, Midrib Region

Upper epidermis: Cells rectangular elongated with thin straight, anticlinal, cellulosic wall, 45.3 – 32 – 25.5 μm long, 25.2 – 15.8 – 21 μm wide, exhibiting beading. **Cuticle** is smooth. **Stomata** is absent. **Trichomes** are numerous, nonglandular, one form: multicellular, multiseriate, branched, branches, with thick warty cellulosic walls and with acute apex, and glandular trichomes where not observed (Figure 3.13.1 A; Table 3.1).

Lower epidermis: Similar to those of the upper epidermis (Figure 3.13.1 B; Table 3.1).

3.13.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal, 77 – 55 –20 μm long; 55 – 35 –15 μm wide with thin straight cellulosic beaded anticlinal wall. **Cuticle** is smooth. **Stomata** are absent. **Trichomes** are numerous, glandular and nonglandular, 300/mm^2 intermixed.

Nonglandular: are one form; multicelluar, multiseriated, branched branches with thick cellulosic warty cell walls wide lumina and acute apex (Figure 3.13.2 A; Table 3.2).

Glandular: are one form very rare, stalk unicellular, head unicellular and round.

Lower epidermis: Cells are polygonal with thin straight cellulosic beaded anticlinal walls (53 – 42 – 21 μm long; 45 – 22 – 18.8 μm wide). **Cuticle** is smooth. **Stomata** are very few diacytic 50/mm^2. **Trichomes** are numerous, 400/mm^2.

Nonglandular: one form multicelluar, multiseriate, branched and branches with thick warty cell walls, wide lumina and acute apex.

Glandular: are absent (Figure 3.13.2 B; Table 3.2).

3.13.1.3. Stem Epidermis:

Cells are polygonal with thin straight cellulosic beaded anticlinal walls, 35 – 23 – 15 μm long; 15 – 10.3 – 7.5 μm wide. **Cuticle** is longitudinally striated. **Stomata** are numerous 150/mm^2 anomocytic mostly, occasionally diacytic, ovate. **Trichomes** are glandular and nonglandular, similar to those of the upper epidermises of the leaf intercostal region (Figure 3.13.3 A; Table 3.3).

3.13.2. INTERNAL STRUCTURE

3.13.2.1. Leaf, Midrib Region

Upper epidermis: Cuticle is thick, cells are tabular large with cellulosic cell walls; outer walls are thick, inner walls are thin. **Cuticle** is thick. **Ground tissue*:*** it consists of 3 layers of lamellar collenchyma tissue below the upper and lower epidermises followed by 2 – 4 layer of paranchymatous tissue both with thick cellulosic walls. The parenchyma tissue surrounding the vascular bundle. **Vascular tissue*:*** consists of one arched vascular bundle. Primary phloem elements (sieve tube and companiom cells) with thick cellulosic walls. A group of outer phloem fibers with thick cellulosic walls were observed. Xylem elements are polygonal with wide lumina and lignified cell walls; arranged in rows. Bundle sheath is absent.

Lower epidermis: Cells rounded in outline, small with thin outer and inner walls, both cellulosic. **Cuticle** is thick (Figure 3.13.4 A,B; Table 3.5).

3.13.2.2. Leaf, Intercostal Region

Upper epidermis: Cells tabular large, with thick outer walls and thin inner walls, thick **cuticle.** **Messophyll*:*** The ground tissue of the intercostal region consists of palisade and spongy tissue; palisade tissue consists of 2 layers of palisade type cells contains chloroplasts, and with large intercellular spaces, spongy tissue 3 or 4 layers of small rounded chlorenchymatous cells both with large intercellular spaces (Figure 3.13.4 A, C; Table 3.6)..

Lower epidermis: Cells tabular, small, with thick outer walls, ***cuticle*** **is** thin (Figure 3.13.4 C; Table 3.6)**.**

3.13.2.3. Stem

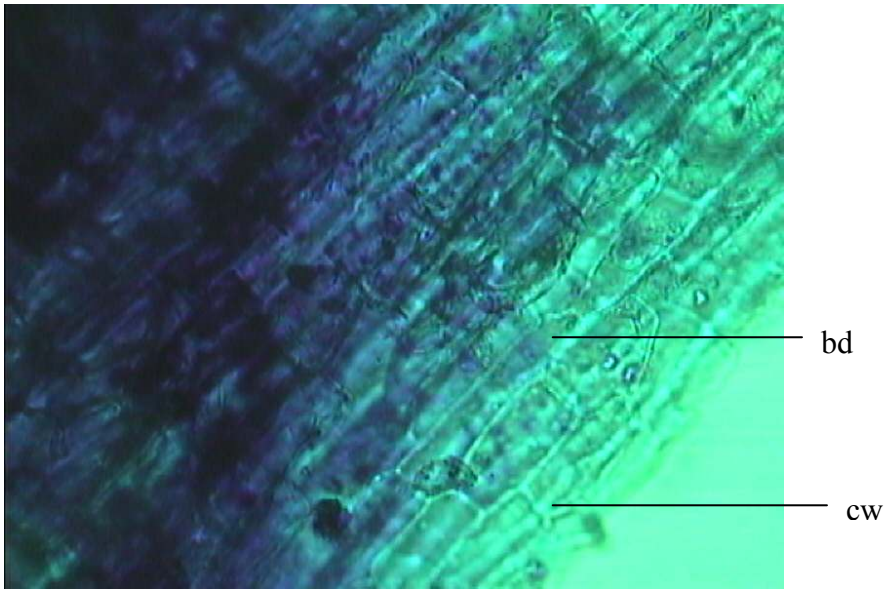
The transverse section is rounded exhibiting some glandular and nonglandular trichomes (Figure 3.13.5 A – D; Table 3.7)..

Epidermis: Cuticle is thick, cells are tabular, with thick outer walls and thin inner walls both cellulosic. **Cortex:** consist of 1 or 2 layers of large hypodermal cells palisade shape with thin cellulosic walls (may be water-storage parenchyma). Three to four layers of lamellar chollenchyma devoided of chloroplasts and several layer of parenchyma, devoid of chloroplasts with conspicuous intercellular spaces. A ring of one layer of bundle sheath which is rectangular cells, devoided of chloroplasts or starch. **Vascular tissue:** Consist of several large vascular bundles connected by several layers of fibers forming a continuous cylinder. Small groups of outer phloem fibers with thick lignified cell walls intermixed with other fibers with unlignified walls. Primary phloem elements with thin cellulosic walls. Vascular cambium is one layer. Primary xylem elements well developed and consist of metaxylem and protoxylem. Vessels and other xylem elements with thick lignified cell walls secondary growth of secondary xylem and phloem were

observed forming a continuous cylinder. The vascular bundles forming a continuous cylinder.

Pith (Medulla): it consists of paranchymatous polygonal homogenous cells with thin cellulosic cell walls and large intercellular spaces (Figure 3.13.5 A – D; Table 3.7).

A.



B.

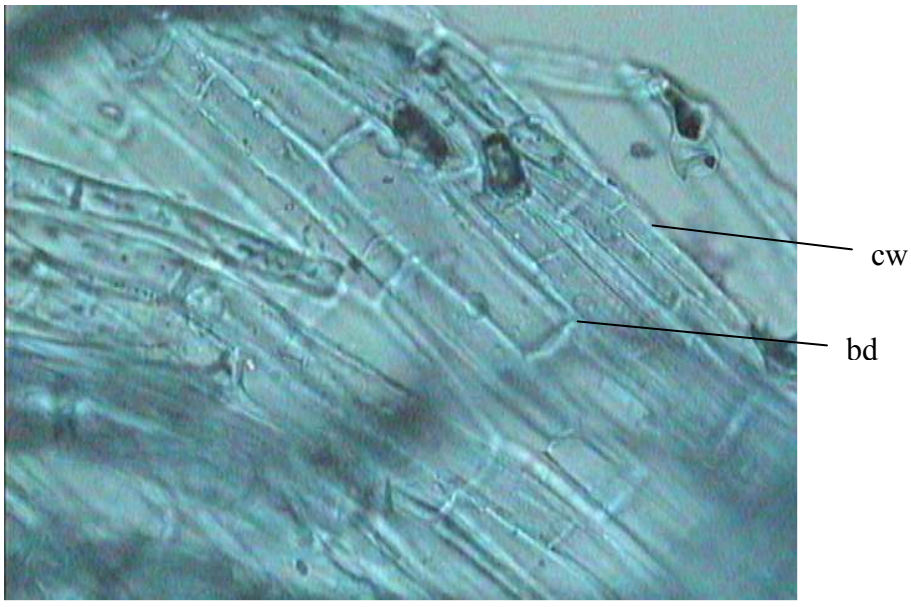
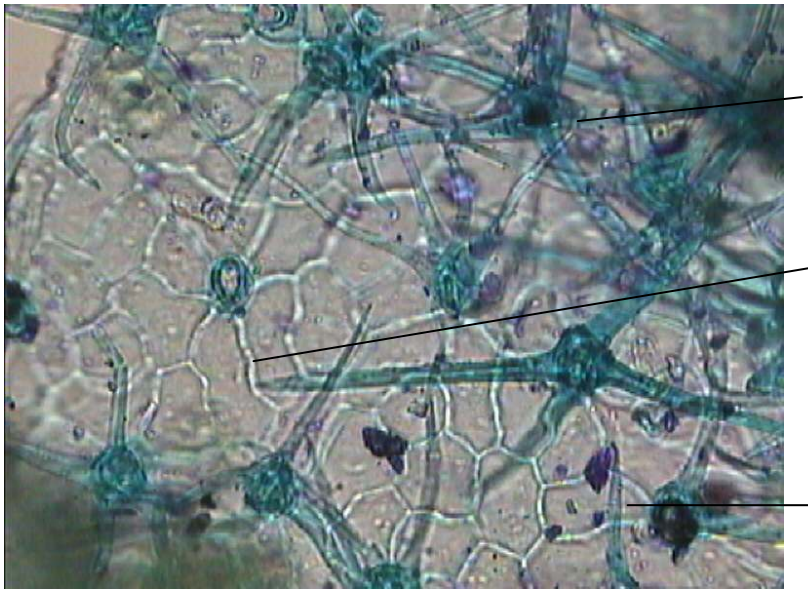


Figure (3.13.1): Leaf, midrib region of *Stachys yemensis*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.



B.

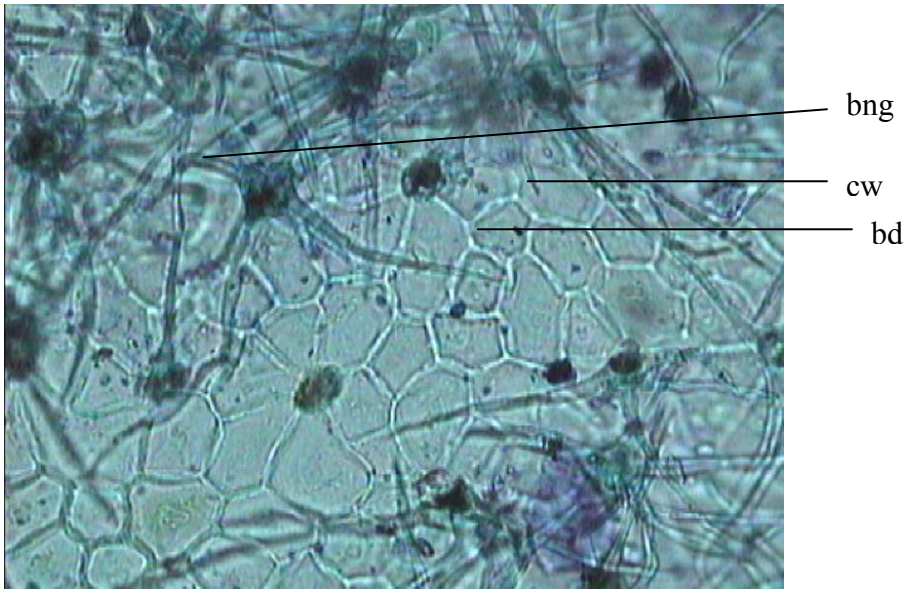


Figure (3.13.2): Leaf intercostal region of *S. yemensis*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.

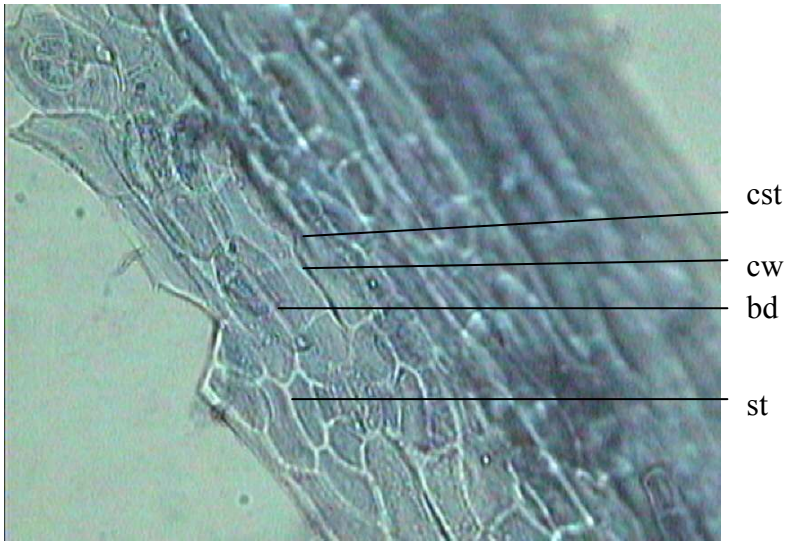
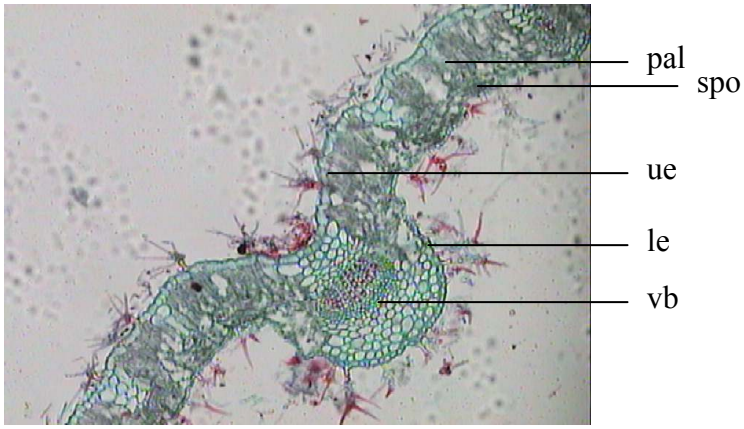
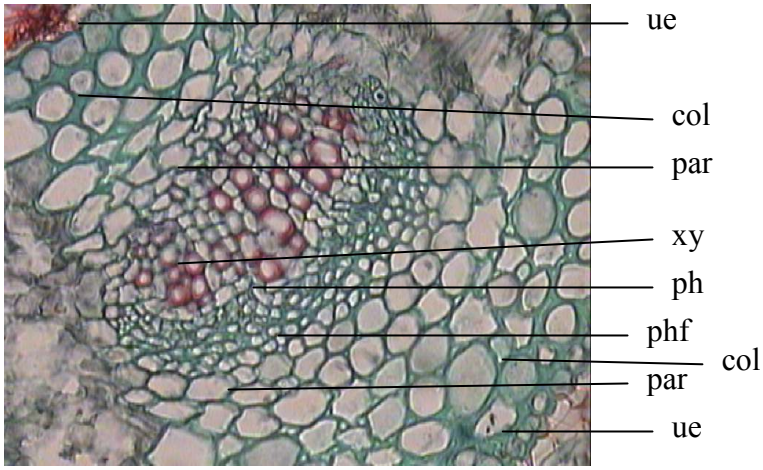


Figure (3.13.3): A – Stem epidermis of *S. yemensis* (x 400).

A.



B.



C.

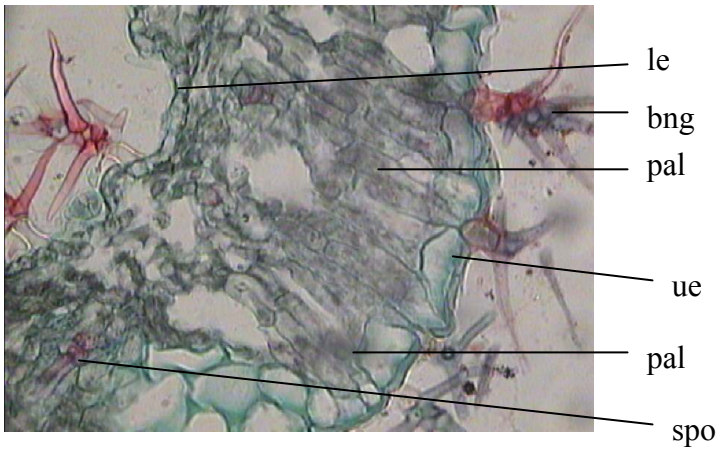
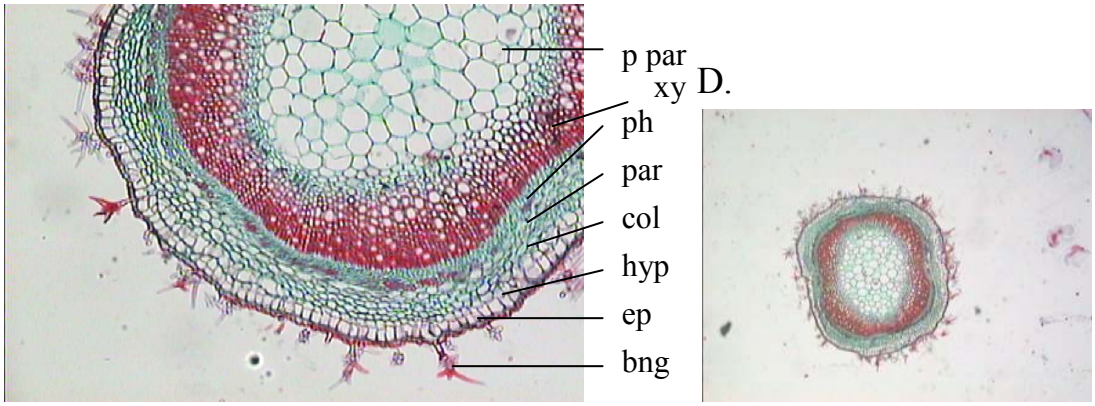
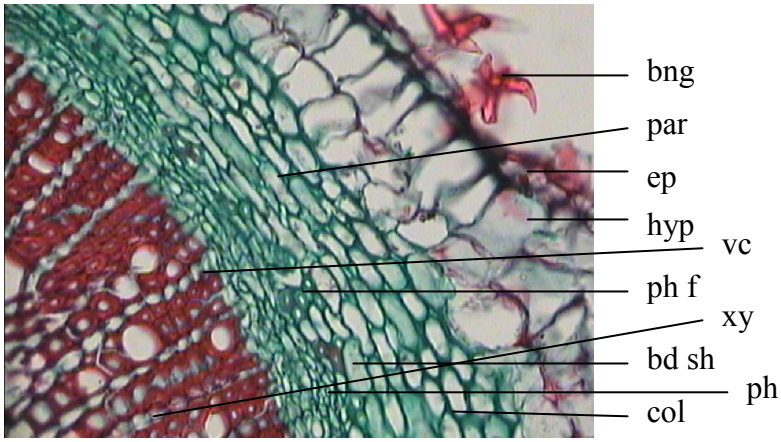


Figure (3.13.4): Leaf transverse sections of *S. yemensis*. A – Leaf midrib and intercostal region (x 100); B – Midrib region; C – Intercostal region (B, C x 400).

A.



B.



C.

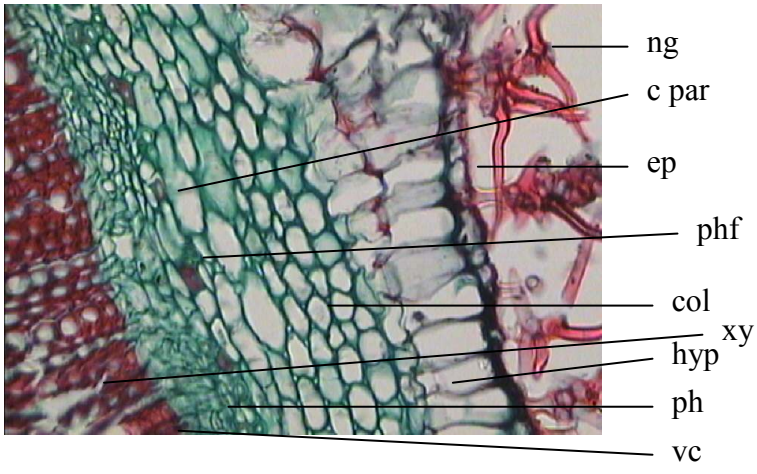


Figure (3.13.5): A – D, Stem transverse sections of Stachys yemensis. A – Stem (x 100); B, C, – Stem (x 400); D – Stem (x 40).

3.14. *Thymus decussatus* Benth.

3.14.1. EPIDERMAL CHARACTERS

3.14.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular or polygonal elongated with thin cellulosic, straight beaded anticlinal walls, 45.2 – 33 – 25 μm long, 15 – 12.5 – 10.5 μm wide. **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular (Figure 3.14.1 A; Table 3.1).

Nonglandular: are three forms.

a. unicellular, unbranched with thin warty walls.

b. bicellular, uniseriate unbranched with thin warty walls.

c. multicellular (3 – 7 cells), uniseriate with thin warty walls.

Nonglandular trichomes all with wide lumina and acute apex.

Glandular: with two forms

a. stalk unicellular, head unicellular rounded.

b. stalk unicellular, head multicellular (8-12).

Lower epidermis: Cells similar in their characters to those of the upper epidermis (Figure 3.14.1 B,C; Table 3.1).

3.14.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin sinuous cellulosic beaded anticlinal walls 37.1 -31.25 – 27 μm long, 18 – 15 – 11 μm wide. **Cuticle** is smooth. **Stomata** mostly ovate, diacytic rarely anomocytic, 150/mm^2. **Trichomes** are glandular and nonglandular intermixed (Figure 3.14.2 A,B; Table 3.2).

Nonglandular: occur in three forms.

a. unicellular, unbranched with thin warty walls, wide lumina and acute apex (Figure 3.14.2 A,B).

b. bicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex (Figure 3.14.2 A,B).

c. muticellular (3 - 7 cells) uniseriate unbranched, with thin warty walls wide lumina and acute apex (Figure 3.14.2 A,B).

The unicellular form is distributed at leaf margin while the other two forms are distributed at leaf intercostal region.

Glandular: are two forms.

a. stalk unicellular and head unicellular rounded.

b. stalk unicellular and head multicellular (8-12 cells) with spherical shape and distinguished brown colour (Figure 3.14.2 C).

Lower epidermis: Cells are polygonal with thin slightly sinuous cellulosic beaded anticlinal walls, 35 – 25.2 – 13.5 μm long, 32 – 28 – 13.4 μm wide. **Cuticle** is smooth. **Stomata** are diacytic and anomocytic, 250/mm^2. **Trichomes** are glandular and nonglandular similar to those of the upper epidermis of the intercostal region (Figure 3.14.2 C; Table 3.2).

3.14.1.3. Stem

Epidermis: Cells are rectangular or polygonal with thin cellulosic straight beaded anticlinal walls, 34.5– 28.5 – 25 μm long, 30 – 21.7 – 15.3 μm wide. **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes**: glandular and nonglandular intermixed similar to those of the lamina intercostal region of the leaf (Figure 3.14.3 A, B; Table 3.3).

3.14.2. INTERNAL STRUCTURE

3.14.2.1. Leaf, Midrib Region

Upper epidermis: Cells are tabular with thick outer walls and thin inner walls; both cellulosic. **Cuticle** is thick. **Ground tissue:** The ground tissue in midrib region consists of two layers of paranchymatous tissue of palisade shaped cells with thin cellulosic cell walls, containing

chloroplasts collenchyma tissue were not observed. **Vascular tissue:** represented by one large rounded vascular bundle, surrounded by single layer of bundle sheath cells with thin unlignified walls. The vascular bundle consist of xylem elements having vessels with wide lumina, lignified thick walls and arranged in rows. The phloem elements in 6-8 groups of sieve tubes and companion cells with thin unlignified cell walls. The phloem is completely covered with a large group of outer phloem fibers with thick slightly lignified cell walls which reaches to the lower epidermis (Figure 3.14.4 A; Table 3.5).

Lower epidermis: Characters are similar to those of the upper epidermis (Figure 3.14.4 A; Table 3.5).

3.14.2.2. Leaf, Intercostal Region

Upper epidermis: Cells are in rectangular to tabular shape, with thick outer walls and thin inner walls. Cuticle is thick, all walls are cellulosic. **Messophyll:** It is differentiated to palisade and spongy tissue. Palisade tissue consists of 2 layers of elongated palisade type cells with many chloroplasts and with large intercellular spaces which continued through midrib region. Spongy tissue consists of 5 – 8 layers of irregular shape parenchyma with thin cellulosic walls and large intercellular spaces (Figure 3.14.4 B, C; Table 3.6)..

Lower epidermis: Characters are similar to those of the upper epidermis of the intercostal region (Figure 3.14.4 B, C; Table 3.6).

3.14.2.3. Stem

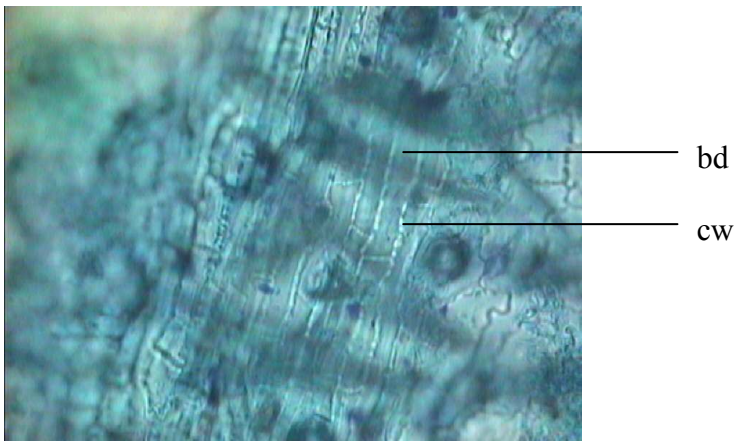
Epidermis: Cells are rectangular with slightly thick outer walls (2.5 μm) and the inner walls are thin and both are cellulosic. Cuticle is thick. **Cortex:** It consist of one layer of hypodermis; and 2 – 3 layers of paranchymatous tissue with irregular shaped cells and thin cellulosic walls 2 – 4 layers of lamellar collenchyma at stem angles, bundle sheath is one layer with is large rectangular shape cells with thin, walls,

devoided of chloroplasts or starch. **Vascular tissue:** Outer phloem fibers are in small groups of cells outside the primary phloem, both with thin unlignified walls and cells slightly crushed so it give irregular shape.

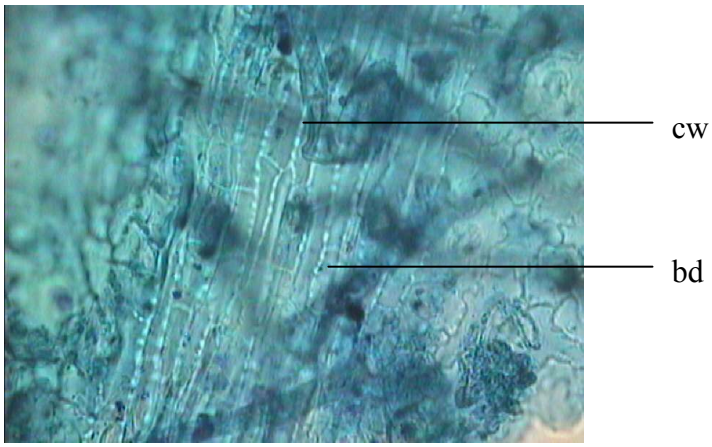
Primary xylem consists of protoxylem and metaxylem, tracheary elements well developed, cells with lignified cell walls; both xylem and phloem forming a continuous cylinder of several vascular bundles connected with xylem parenchyma tissue. Vascular cambium very clear as a continuous ring of 3 layers, with rectangular, elongated cells. Secondary growth of secondary xylem and phloem is observed and forming a continuous cylinder with lignified elements. Vessels scattered with wide lumina.

Medulla (**Pith):** it consists of homogenous paranchymatous cells with irregularly shapes and with thin cellulosic walls. In old stem, cells in the center of the pith torn apart and the stem becomes hollow (Figure 3.14.5 A, C; Table 3.7).

A.



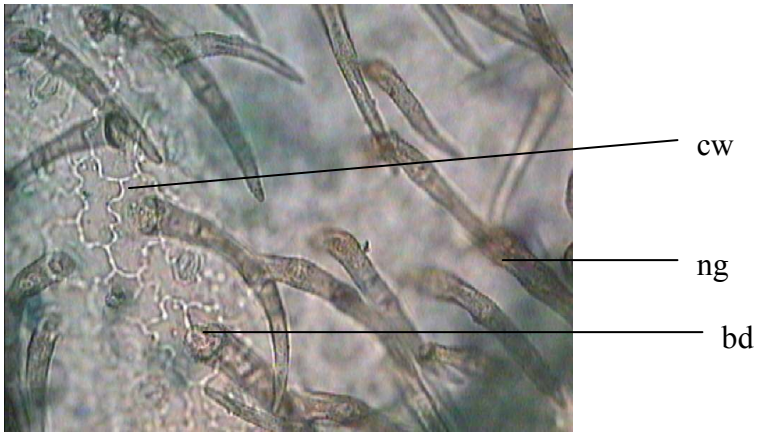
B.



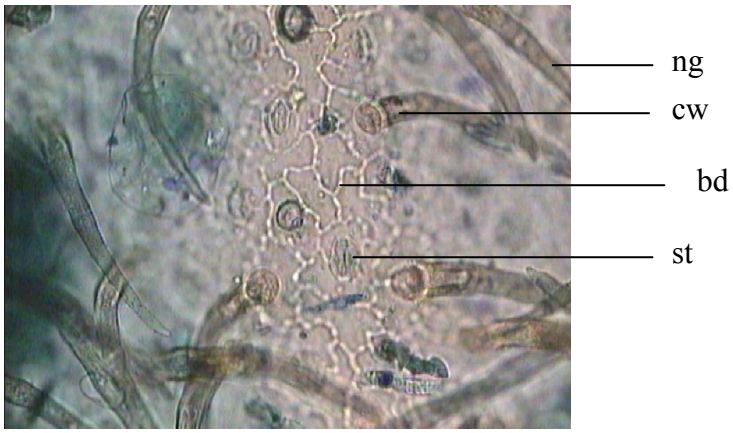
C.

Figure (3.14.1). Leaf, midrib region of *T. decussatus*. A – Upper epidermis; B – Lower epidermis; C – Glandular trichomes of the midrib region, upper epidermis (A – C x 400).

A.



B.



C.

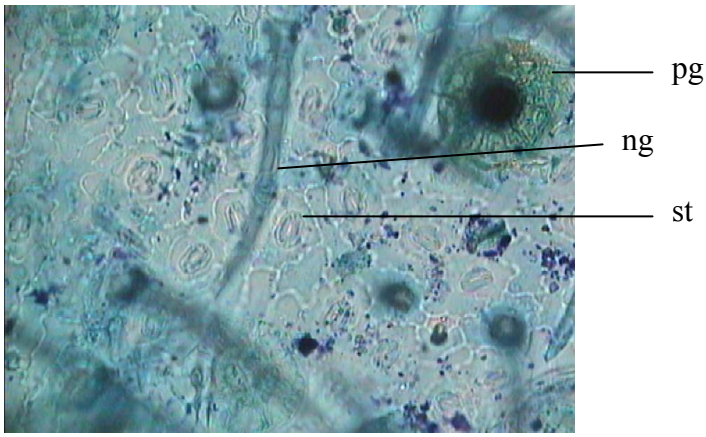
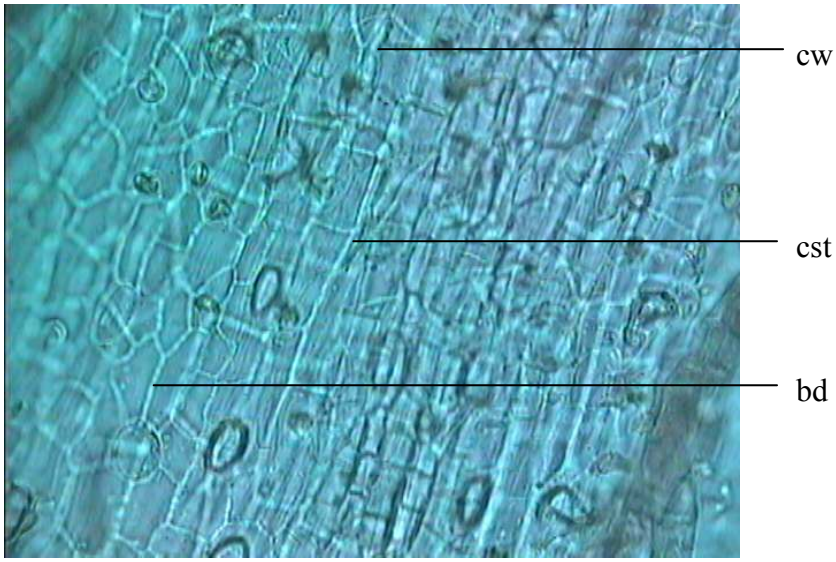


Figure (3.14.2): Leaf intercostal region of *T. decussatus*. A, B – Upper epidermis; C – Lower epidermis (A – C x 400)

A.



B.

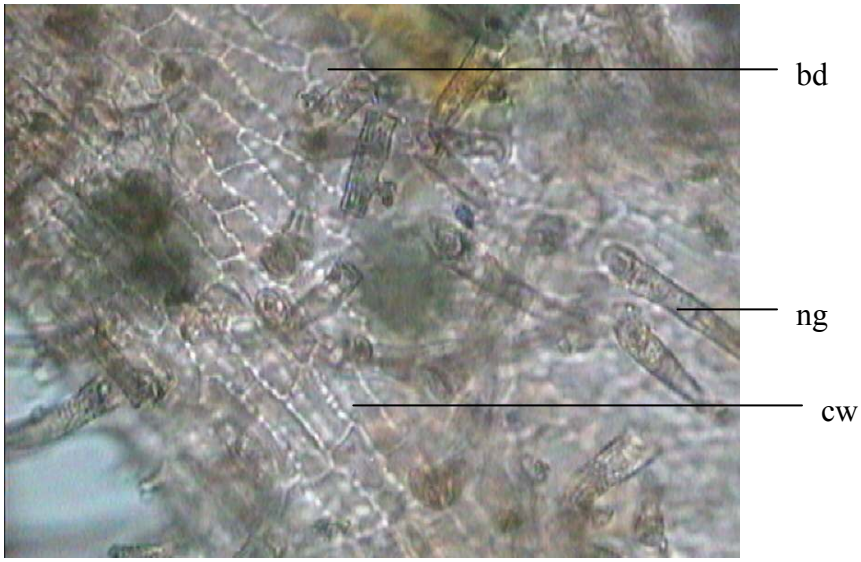


Figure (3.14.3). A, B Stem epidermis of *T. decussatus* (A, B x 400).

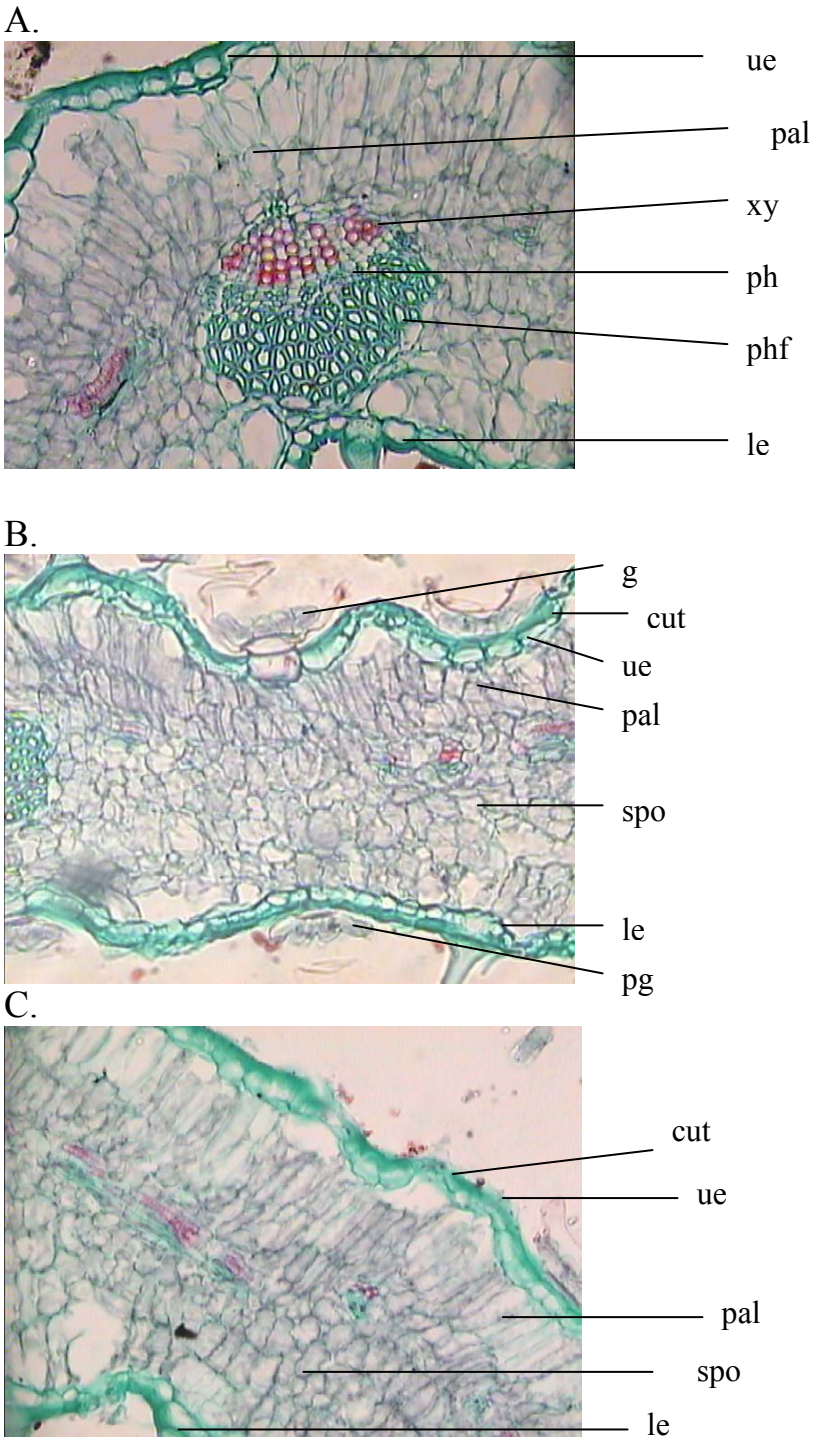
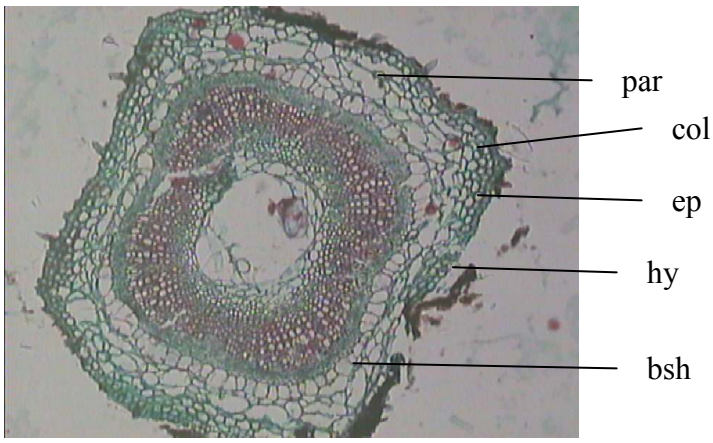
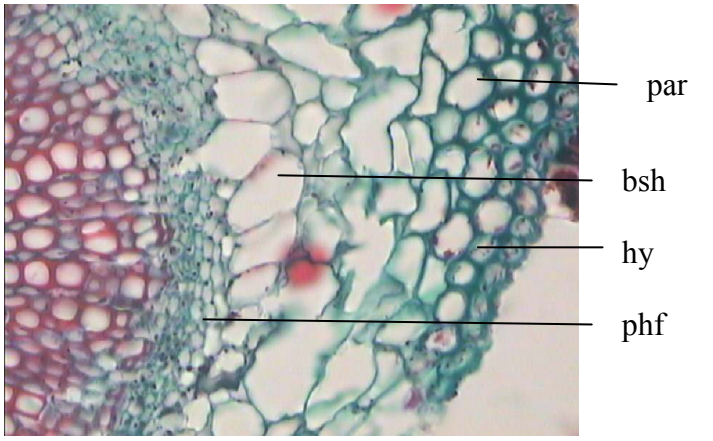


Figure (3.14.4). Leaf transverse sections of *T. decussatus*. A – Leaf midrib region; B, C – Leaf intercostal region (A – C x 400)

A.



B.



C.

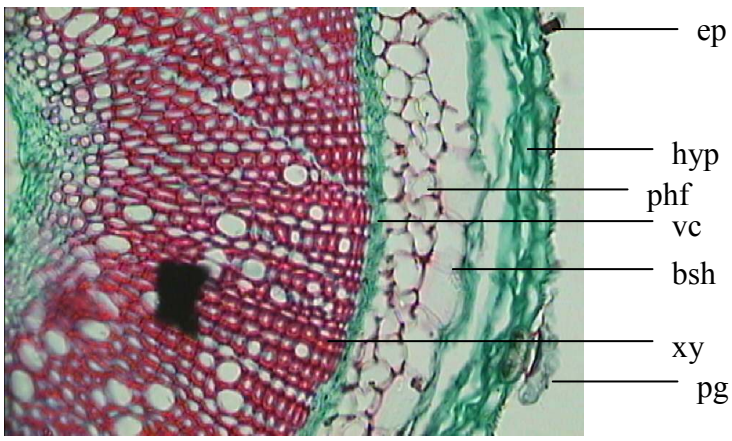


Figure (3.14.5): A – C Stem transverse sections of *T. decussatus*. A – Stem (x100), B, C – Stem (x 400).

3.15. *Thymus aff. vulgaris*

3.15.1. EPIDERMAL CHARACTERS

3.15.1.1. Leaf, Midrib Region

Upper epidermis: Cells are rectangular and some polygonal elongated with thin straight cellulosic beaded anticlinal walls, 50 – 45.3 – 25 μm long, 25 – 12.5 – 8.5 μm wide. **Cuticle:** is longitudinally striated. **Stomata** are absent. **Trichomes**: nonglandular and glandular intermixed (Figure 3.15.1 A, C; Table 3.1).

Nonglandular: three forms;

a. unicellular, unbranched with thin warty walls (Figure 3.15.1 C).

b. bicellular, uniseriate unbranched with thin warty walls (Figure 3.15.1 C).

c. multicellular (3 – 7 cells), uniseriate unbranched with thin warty walls.

All with wide lumina and acute apex (Figure 3.15.1 C).

Glandular: are numerous having two forms:

a. stalk unicellular, head unicellular and with spherical shape.

b. stalks unicellular, heads multicellular (4 – 8 cells) with spherical shape.

Lower epidermis: Epidermal cells are polygonal with thin straight beaded anticlinal walls, 35.5 – 15.1 – 10.5 μm long, 25.5 – 15.5 – 10.5 μm wide. **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes** are glandular and nonglandular, similar to those of the upper epidermis (Figure 3.15.1 B,C; Table 3.1).

3.15.1.2. Leaf, Intercostal Region

Upper epidermis: Cells are polygonal with thin straight cellulosic beaded anticlinal walls, 33.4 – 22.1 – 13 μm long, 23 – 12.5 – 10.5 μm wide. **Cuticle** is smooth. **Stomata** are numerous, 150/mm^2, mostly diacytic, rarely anomocytic both ovate. **Trichomes** are glandular and nonglandulars (Figure 3.15.2 A; Table 3.2).

Nonglandular: are similar to those existing at the midrib upper epidermis.

Glandular: are two forms.

a. stalk unicellular head unicellular, round (Figure 3.15.2 A).

b. stalk unicellular, head multicellular round (Figure 3.15.2 B).

Heads show yellow to brownish colour which gave negative test with Sudan-3 which indicated that is not a pure oils but it could be flavonoles.

Lower epidermis: Cells are polygonal with straight slightly thick, cellulosic beaded anticlinal, walls 43.5 – 35.1 – 25.2 μm long, 25.5 – 15 – 12.5 μm wide. **Cuticle** is longitudinally straight. **Stomata** are numerous, 150/mm^2, mostly diacytic rarely anomocytic, ovate. **Trichomes**: non glandular and glandular (Figure 3.15.2 B; Table 3.2).

Nonglandular: are few distributed on leaf margin which are three forms

a. unicellular, unbranched with thin warty walls.

b. bicellular, uniseriate unbranched with thin warty walls, wide lumina and acute apex.

c. multicellular uniseriate unbranched with thin warty walls.

All the forms distributed at the base of the leaf margin are similar to those that exist on the midrib region upper epidermis.

Glandular: with two forms.

a. stalks unicellular and heads are unicellular, round to spherical shape (Figure 3.15.2 B).

b. stalks unicellular and heads are multicellular (4 – 8 cells) round which distributed mostly at the base of the leaf margin (Figure 3.15.2 B; Table 3.2).

3.15.1.3. Stem Epidermis

Cells are rectangular or polygonal with thin straight cellulosic beaded anticlinal walls, 35.5 – 22.1 – 13.5 μm long, 25.5 – 12.5 – 10.8 μm wide. **Cuticle** is longitudinally striated. **Stomata** are absent. **Trichomes**: Nonglandular are numerous and intermixed with one form of glandular trichomes (Figure 3.15.3 A, B; Table 3.3).

Nonglandular: three forms.

a. unicellular unbranched with thin warty walls, wide lumina and acute apex (Figure 3.15.3 B).
b. bicellular uniseriate unbranched with thin warty walls wide lamina and acute apex.
c. multicellular (3 - 7 cells) long uniseriate with thin warty walls, could be found at stem angles.

All the trichomes heading towards the stem apex direction.

Glandular: are one form, stalk unicellular, heads are multicellular (4 – 8 cells) with spherical shape.

3.15.2. INTERNAL STRUCTURE

3.15.2.1. Leaf, Midrib Region

Upper epidermis: Cuticle is thick, cells are large tabular with cellulosic walls, outer walls are thick and inner walls are thin. **Ground tissue:** tissue of the midrib consists of 2-4 layers of lamellar collenchyma tissue immediately below the upper epidermis. **Vascular tissue**: consists of one large vascular bundle, round in the outline, primary xylem elements are polygonal with wide lumina, thick lignified cell walls, they arranged in rows; bundle sheath is one layer; primary phloem are small groups. Groups of (4 - 5 layers) of outer phloem fiber are found with thick lignified cell walls surrounding the primary phloem elements. Paranchyma tissue, 2 – 4 layers slightly crushed, cells with cellulosic cell

walls. One layer of lamellar chollenchyma with slightly thick cell walls occur below the lower epidermis (Figure 3.15.4 A,B; Table 3.5).

Lower epidermis: Characters are similar to those of the upper epidermis of the midrib region (Figure 3.15.4 A,B; Table 3.5).

3.15.2.2. Leaf, Intercostal Region

Upper epidermis: Cuticle is thick. Cells are rectangular with thick cellulosic outer walls and thin inner walls. **Messophyll:** It is differentiated into palisade and spongy tissue; palisade tissue consists of, 2 or 3 layers of large palisade type cells containing chloroplasts and with many intercellular spaces. Spongy tissue consists of 2 or 3 layers of irregular slightly round chlorenchymatous cells with large intercellular spaces (Figure 3.15.4 A,B; Table 3.6).

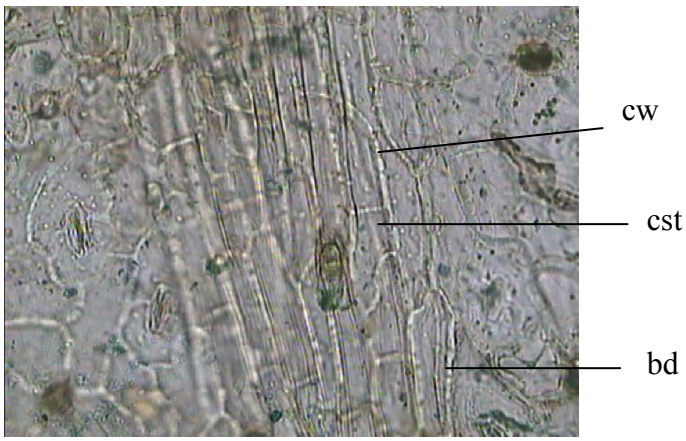
Lower epidermis: Characters are similar to those of the upper epidermis of the intercostal region (Figure 3.15.4 A,B; Table 3.6).

3.15.2.3. STEM:

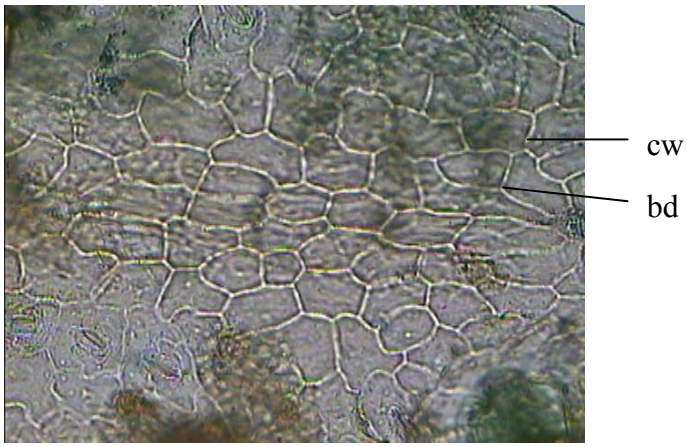
Epidermis: Cells are tubular or round with thick outer walls, and the inner are thin; cuticle is thick. **Cortex:** It consist of one layer of hypodermal cells. Groups of 2 or 3 layers of lamellar colenchyma tissue occur at stem angles. The parenchyma tissue showing irregular cells, 2 or 3 layers with large intercellular spaces. A continuous layer of bundle sheath with large cells, devoided of starch or chloroplasts was observed. **Vascular tissue:** Consists of primary phloem elements, 3 – 4 groups with unlignified cell walls forming a continuous ring by the connecting fibers. Vessels few and in radial rows. Primary xylem well developed as a continuous cylinder with trachery elements having thick lignified pitted walls. The metaxylem with wide vessel and protoxylem with narrow vessels. Vascular cambium is clear (one layer). Secondary growth of secondary xylem and phloem are observed forming a continuous cylinder. **Medulla (Pith)):** It consists of large round paranchymatous to polygonal

homogenous cells with thin cellulosic cell walls and with conspicuous intercellular spaces. Medulla becomes hollow at the center (Figure 3.15.5 A,B; Table 3.7).

A.



B.



C.

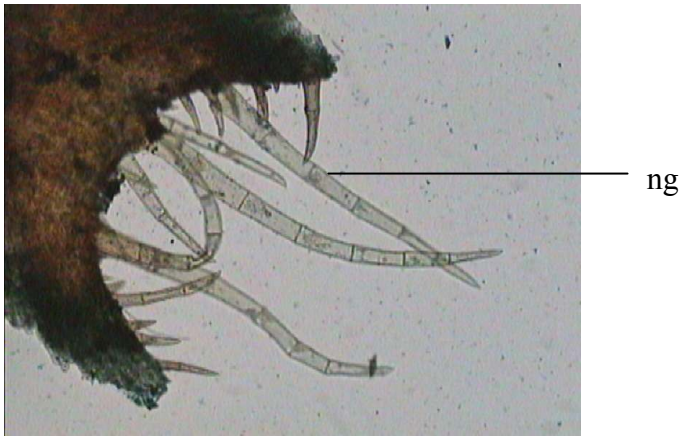
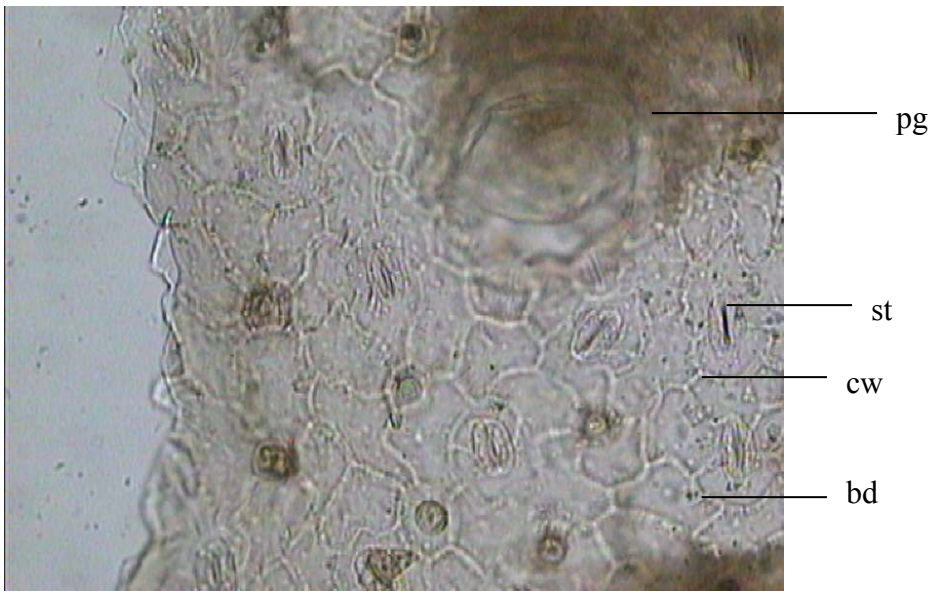


Figure (3.15.1): Leaf midrib region of *Thymus aff. vulgaris*. A – Upper epidermis; B – Lower epidermis; C – Nonglandular trichomes of the midrib region (A – C x 400).

A.



B.

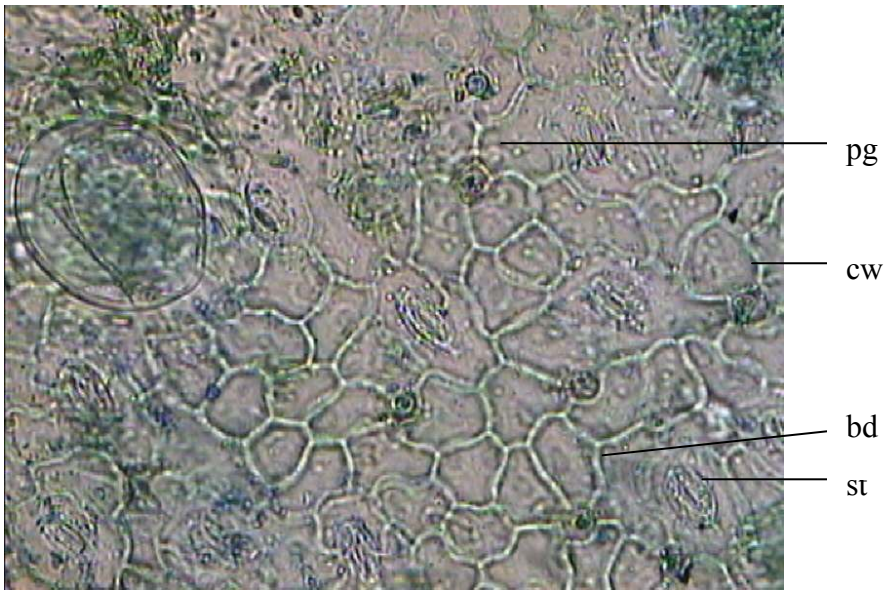
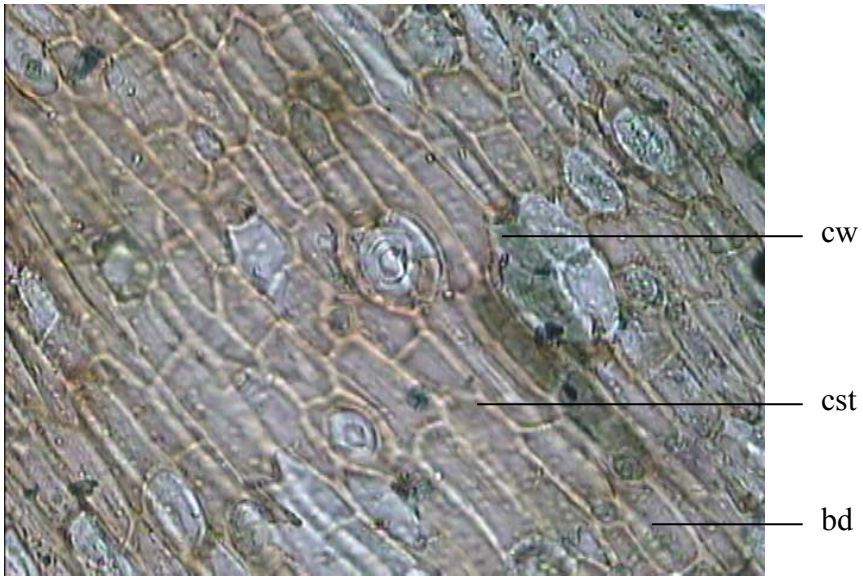


Figure (3.15.2): Leaf intercostal region of *T. aff. vulgaris*. A – Upper epidermis; B – Lower epidermis (A, B x 400).

A.



B.

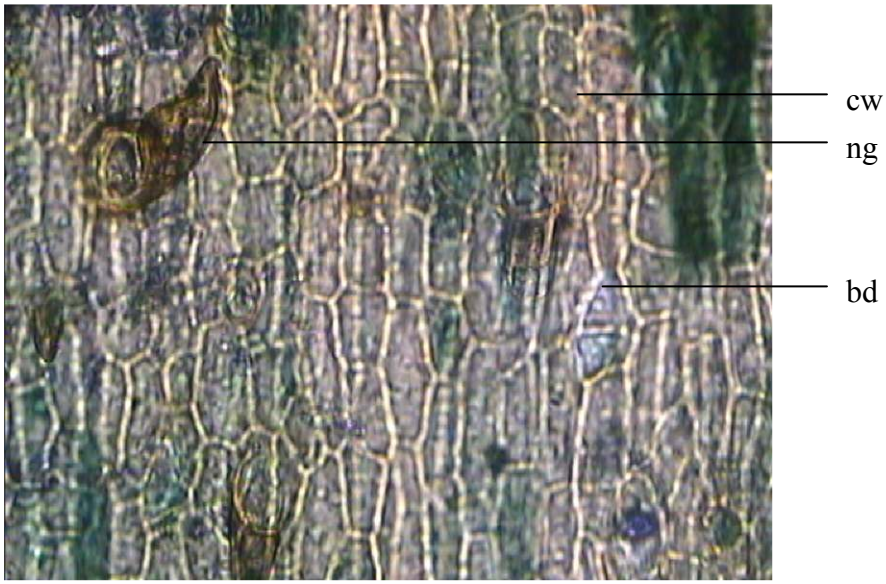
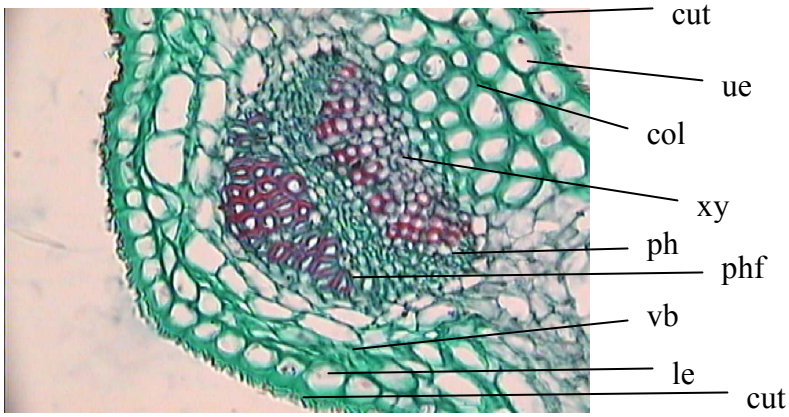


Figure (3.15.3): A, B Stem epidermis of *T. aff. Vulgaris* (x 400).

A.

B.



C.

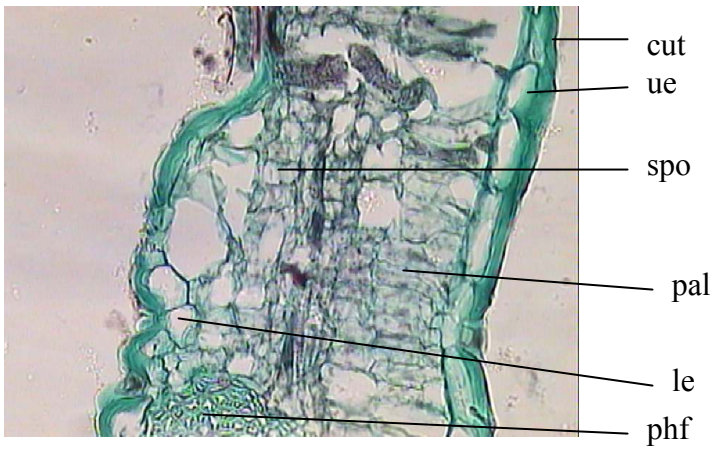
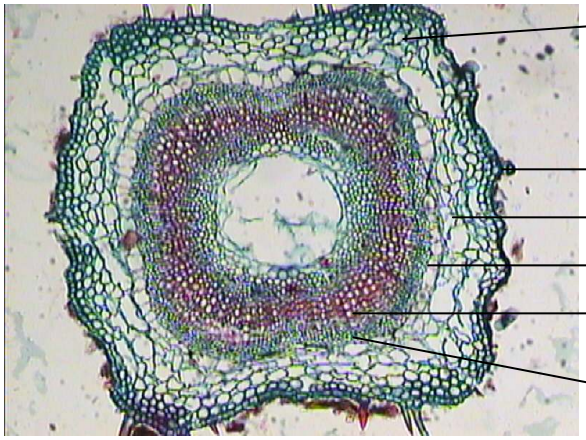
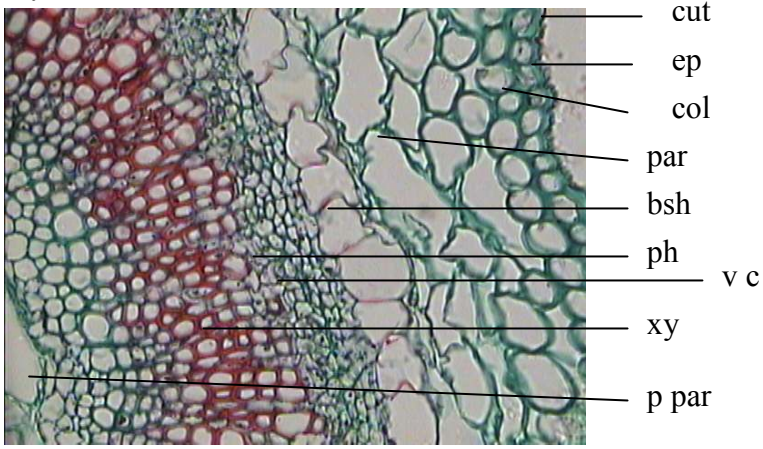


Figure (3.15.4): Leaf transverse section of *T. aff. vulgaris*. A – Leaf (x 100); B – Midrib region; C – Intercostal region (B, C x 400).

A.



B.



C.

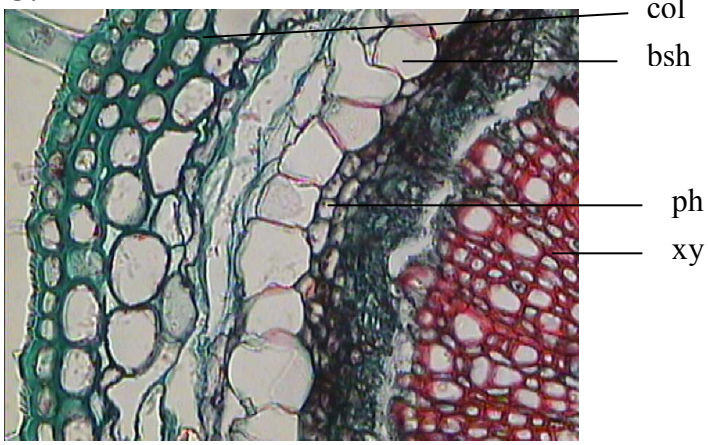


Figure (3.15.5): A – C Stem transverse sections of *T. aff. vulgaris*. (A x 100); (B, C x 400).

3.16 Pollen grain characters

3.16.1. *Marrubium vulgare L.:*

Most of the pollen grains have yellow colour and their general shape is circular with 6 colpi; exine is smooth reticulate perforate surface. The pollen grains are with polar length about 47.5 ± 2 μm and equatorial length 38.75 ± 3 μm (Figure 3.16. A, B; Table 3.8).

3.16.2. *Micromeria biflora* Benth.*:*

The pollen grains have a distinguished brown colour, very small with circular shape; exine is reticulate almost with smooth tecta reticulate surface, and 6 zono-colpate, with polar length, 8.3 ± 2 μm, and equatorial length, 5.5 ± 3 μm (Figure 3.16. C; Table 3.8).

3.16.3. *Mentha microphylla* Koch.*:*

Most of the pollen grains have yellow to brown colour, with circular shape; exine is reticulate with perforated to granulate surface, with 6 zonocolpate. The grains are with polar length, 26.8 ± 1 μm, and equatorial length, 21.87 ± 2 μm (Figure 3.16. D; Table 3.8).

3.16.4. *Nepeta deflersiana* Schweinf.*:*

The pollen grains are triangular shape with yellow colour, exine is reticulate perforated having a distinguish 3 zono-colpi with polar length, 25.5 ± 2 μm, and equatorial length, 15 ± 3 μm (Figure 3.16. E; Table 3.8).

3.16.5. *Nepeta septemecrenata L.:*

The pollen grains are circular with yellow colour and 6 zono-colpate, exine is reticulate. The polar length 29.16 ± 3 μm, and equatorial length 30.7 ± 2 μm (Figure 3.16. F; Table 3.8).

3.16.6. *Otostegia fruticosa var fruticosa* (Forssk.) Brig.*:*

The pollen grains have yellow to brown colour, with circular to ovate shapes, with 6 zono-colpate, exine is tecta reticulate perforate with

rough surface, polar length, 33.5 ± 2 μm, and equatorial length, 32.5 ± 3 μm (Figure 3.16. F; Table 3.8).

3.16.7. *Otostegia fruticosa var schimperi (Boiss.) Tackh.:*

The pollen grains have yellow colour, circular to ovate shape with 3 distinctive zonocolpate, exine with perforated surface structure, the polar length, 31.5 ± 2 μm, and equatorial length, 28.6 ± 2 μm (Figure 3.16. H, I; Table 3.8).

3.16.8. *Salvia aegyptiaca L.:*

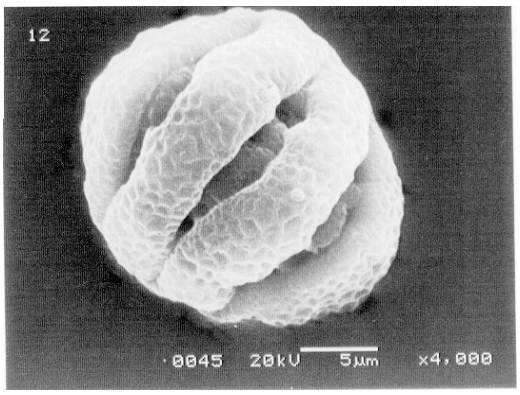
Pollen grains are yellow to brown colour, with circular to slightly ovate shape having the disc form with 6 zonocolpate, surface structure mega reticulate with polar length, 36.3 ± 2 μm, and equatorial length 30.3 ± 2 μm (Figure 3.16. J, K; Table 3.8).

3.16.9. *Salvia deserti* Decne.*:*

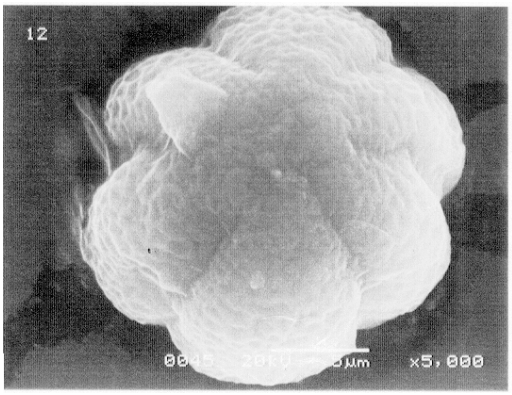
Pollen grains are yellow colour, with circular slightly ovate shape having the disc form with 6 zono colpate, surface structure of the exine is semi-perforated to reticulate, with polar length, 36.5 ± 2 μm, and equatorial length, 22 ± 2 μm (Figure 3.16.1 L; Table 3.8).

3.16.10. *Salvia spinosa L.:*

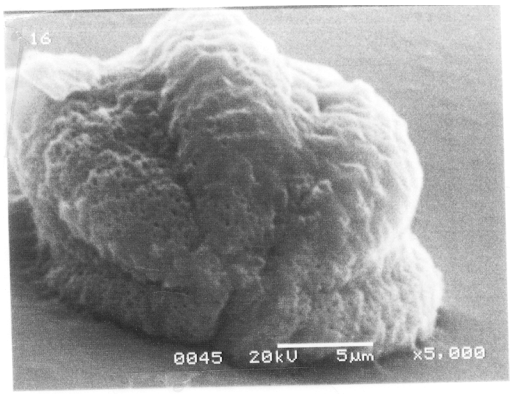
The pollen grains, yellow to brown colour circular to ovate shape as a disc form with 6 zono colpate, having semi-perforated to reticulate surface structure of the exine, with polar length, 43.3 ± 2 μm, and equatorial length 27.5 ± 3 μm (Figure 3.16. M, N; Table 3.8).



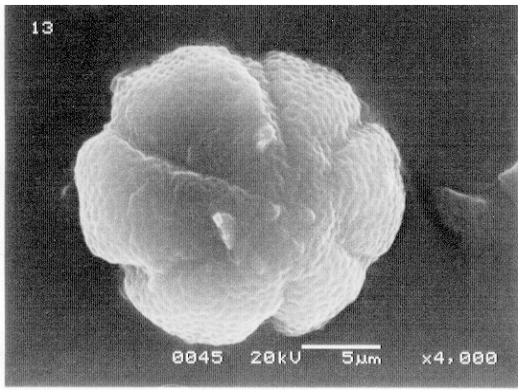
A.



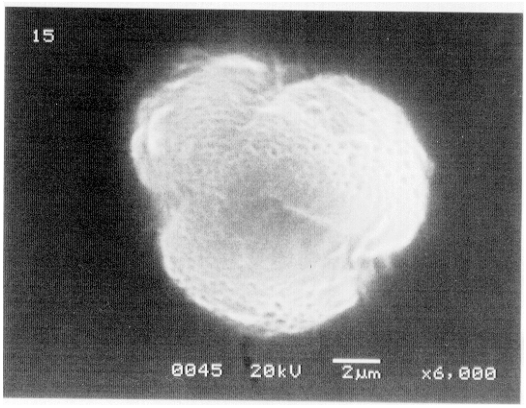
B.



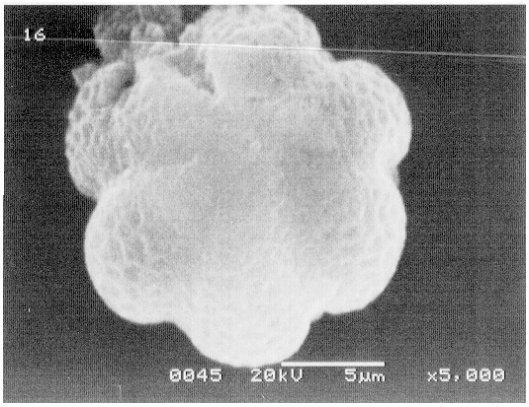
C.



D.

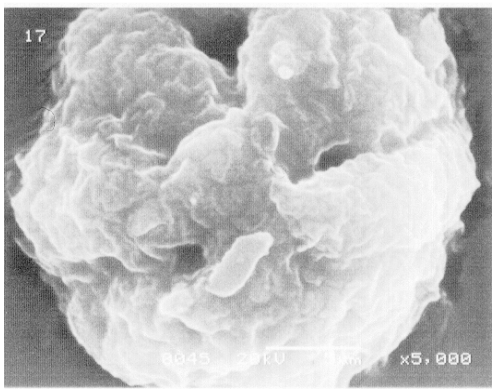


E.

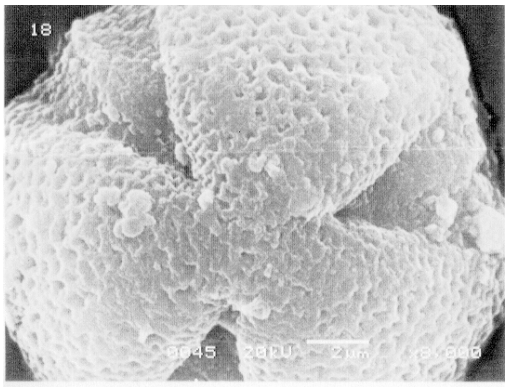


F.

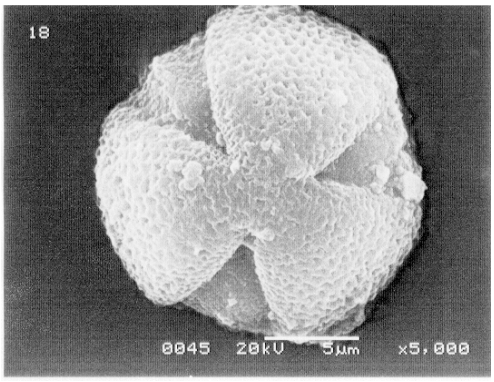
Figure (3.16) A – N SEM photographs of the pollen grains of some Lamiaceae species. A, B – *Marrubium vulgare;* C – *Micromeria biflora;* D – *Mentha microphylla;* E – *Nepeta deflersiana;* F – *Nepeta septemecrenata.*



G.

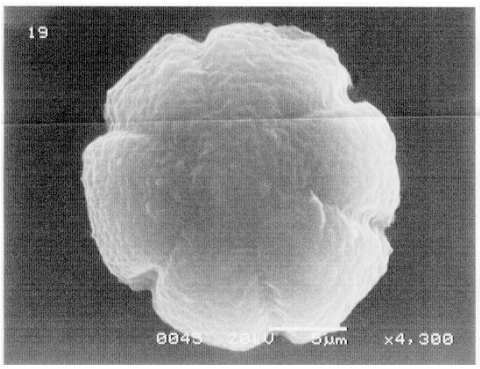


H.

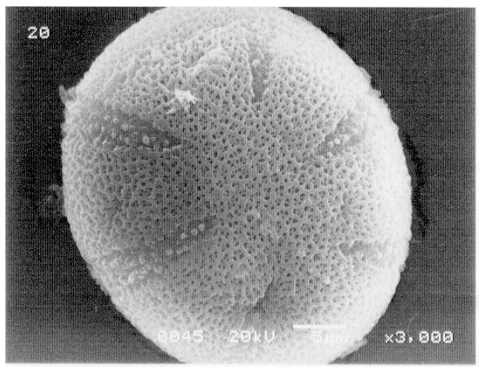


I.

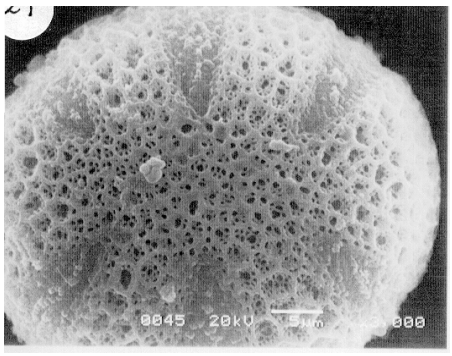
J.



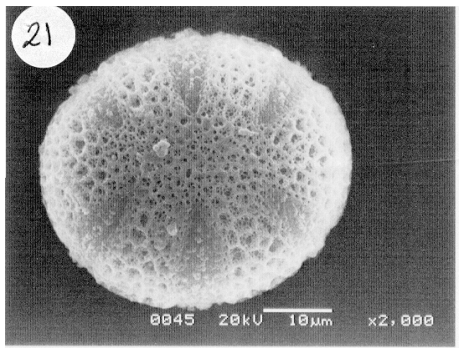
K.



L.



M.



N.

Figure 3.16 (continued): G – *Otostegia fruticosa* var: *fruticosa;* H, I – *Otostegia furiticosa* var: *Schimperi;* J, K – *Salvia aegyptiaca;* L – *Salvia deserti;* M, N – *Salvia spinosa.*

Table (3.1) The Epidermal characters of Leaves, Midrib (Costal Region):

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Marrubium vulgare	Upper	Polygonal elongated.	Thin straight, anticlinal walls beaded.	Striated	Absent	1. Unicellular (papilose) 2. Bicellular 3. Multicellular (3), uniseriate, unbranched with thick warty walls.	1. Stalk, Unicellular, unbranched with head unicellular. 2. Stalk unicellular head bicellular. 3. Stalk unicellular, head multicellular (4 – 16).
	Lower	Polygonal elongated	Thin, straight anticlinal walls beaded	Striated	Absent	Similar	Similar
Micromeria biflora	Upper	Rectangular elongated	Thin straight anticlinal beaded	Longitudinally Striated	Absent	1. Unicellular (papilose) 2. bicellular, 3. multicellular (3 – 8), uniseriate unbranched with thin warty walls.	1. Stalk unicellular, head unicellular.
	Lower	Rectangular elongated	Thin sinous anticlinal walls beaded	Similar	Absent	Similar	Similar
Mentha microphylla	Upper	Rectangular elongated	Thin straight walls beaded.	Striated irregularly	Absent	1. unicellular 2. bicellular 3. multicellular (3 – 8), uniseriate unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular.
	Lower	Similar	Thin straight beaded.	Similar	Absent	Similar	Similar
Nepeta deflersiana	Upper	Rectangular polygonal or elongated	Thin straight anticlinal walls beaded.	Smooth	Absent	1. Unicellular 2. Bicellular 3. Multicellular (3-7) with thin warty cell walls.	1. stalk unicellular, unbranched head unicellular or bicellular. 2. stalk is bicellular, unbranched head is unicellular or bicellular. 3. Stalk is multicellular (3 cells) unbranched head is unicellular, bicellular or multicellular.
	Lower	Similar	Thin straight anticlinal walls beaded.	Striated	Absent	Similar	Similar

Table (3.1) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Nepeta septemecrenata	Upper	Polygonal elongated	Thin straight anticlinal walls	Striated longitudinally	Absent	1. unicellular 2. bicellular 3. Multicellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular. 2. Stalk bicellular, unbranched, head unicellular round shape.
	Lower	Polygonal elongated	Thin straight anticlinal walls	Striated longitudinally	Absent	Similar	1. Stalk unicellular, head unicellular. 2. Stalk bicellular, unbranched, head unicellular. 3. Stalk unicellular head multicellular (4 – 8).
Otostegia fruticosa var. fruticosa	Upper	Polygonal elongated	Thin, straight anticlinal walls beaded.	Smooth	Absent	1. Unicellular 2. bicellular, uniseriate, unbranched,with thick warty walls.	1. Stalk unicellular, head unicellular, 2. Stalk unicellular head bicellular 3. Stalk unicellular head multicellular (4-8).
	Lower	Polygonal elongated	Thin, anticlinal beaded	Smooth	Absent	Similar	Similar
Otostegia fruticosa var-schimperi	Upper	Rectangular elongated	Thin straight anticlinal, beaded	Longitudinally striated	Absent	1. unicellular 2. bicellular 3. multicellular, uniseriate, unbranched with thick warty walls.	1. Stalk unicellular and head unicellular. 2. Stalk unicellular and head multicellular. 3 or 4 with spherical shape.
	Lower	Rectangular elongated	Thin, straight anticlinal beaded	Longitudinally striated	Absent	Similar	Similar
Salvia aegyptiaca	Upper	Polygonal elongated.	Thin straight anticlinal beaded.	Smooth	Absent	1. Unicellular 2. bicellular 3. multicellular uniseriate, unbranched with thick warty walls.	1. Stalk unicellular, head unicellular 2. Stalk unicellular head multicellular (4 – 8)
	Lower	Polygonal elongated	Similar	Striated	Absent	Similar	Similar

Table (3.1) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Salvia deserti	Upper	Polygonal elongated	Thin straight anticlinal walls, beaded	Longitudinally striated.	Absent.	1. Unicellular 2. bicellular 3. multi-cellular, uniseriate, un-branched with thin warty cell walls.	1. Stalk unicellular head unicellular, round shape. 2. Stalk unicellular, head multicellular (4-8) with spherical shape.
	Lower	Polygonal elongated	Thin, straight anticlinal beaded.	Longitudinally striated.	Absent.	Similar	Similar
Salvia spinosa	Upper	Polygonal elongated	Thin straight anticlinal walls	Striated longitudinally	Absent	1. unicellular 2. bicellular 3. multicellular, with thin warty walls.	1.Stalk unicellular, head Unicellular. 2. Stalk unicellular, head bi-cellular. 3. Stalk unicellular, head multi-cellular (4 – 8).
	Lower	Polygonal elongated	Thin straight anticlinal beaded	Smooth	Absent	Similar	Similar
Stachys aegyptiaca	Upper	Rectangular elongated	Thick straight beaded	Striated longitudinally.	Absent	Multicellular, multiseriate branched.	1. Stalk unicellular, head unicellular rounded. 2. stalk bicellular head unicellular round shape.
	Lower	Rectangular elongated	Slightly thick, straight beaded.	Smooth	Absent.	Similar	Similar
Stachys schimperi	Upper	Rectangular or polygonal elongated	Thin, straight anticlinal walls beaded	Striated longitudinally.	Absent	Multicellular, multiseriate, branched.	1. Stalk bicellular, head unicellular. 2. Stalk multicellular (3 cells), head unicellular. 3. stalk multicellular, multiseriate, branched with one branch having a unicellular glandular head.
	Lower	Rectangular or polygonal elongated	Similar	Striated longitudinally.	Absent	Similar	Similar

Table (3.1) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Stachys yemensis	Upper	Rectangular, elongated	Thin straight anticlinal walls beaded.	Smooth	Absent	Multicellular, multiseriate branched.	Not observed
	Lower	Rectangular, elongated	Thin beaded straight.	Smooth	Absent	Similar	Not observed
Thymus decussatus:	Upper	Rectangular or polygonal elongated.	Thin, with straight anticlinal walls. beaded	Longitudinally striated	Absent	1. Unicellular 2. bicellular 3. multicellular, uniseriate, unbranched with thin warty walls.	1. Stalk unicellular, head unicellular rounded less distribution. 2. Stalk unicellular, head multi-cellular (8-12).
	Lower	Rectangular or polygonal elongated.	Thin, straight anticlinal beaded.	Longitudinally striated	Absent	Similar	Similar
Thymus aff. vulgaris	Upper	Rectangular or polygonal elongated	Thin, straight anticlinal beaded	Striated longitudinally	Absent.	1. unicellular, 2. bicellular, 3. multicellular 3-7, long with thin warty walls.	1. Stalk unicellular, head unicellular cell. 2. Stalk unicellular, head multi-cellular (4-8) cell.
	Lower	Polygonal	Similar	Similar	Absent	Similar	Similar

Table (3.2) The Epidermal characters of Leaves, Intercostal Region:

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Marrubium vulgare.	Upper	Polygonal	Slightly thick Straight anticlinal beaded.	Striated	Diacytic 300/mm^2	1. Unicellular (papillose) 2. Bicellular, 3. Multicellular (3), uniseriate, unbranched with thick warty cell walls.	1. Stalk unicellular, unbranched with head unicellular. 2. Stalk unicellular, head bicelluar. 3. Stalk unicellular, head multicellular (4 – 16).
	Lower	Polygonal	Slightly thick sinuous anticlinalbeaded.	Striated	Diacytic 300/mm^2	Similar	Similar
Micromeria biflora	Upper	Isodiametric	Slightly thick sinuous, anticlinal walls, beaded	Striated	rare diacytic	1. unicellular (papillose) 2. bicellular, 3. multicellular, uniseriate unbranched with thin warty cell walls, some with hooked apex.	1. Stalk unicellular, un-branched head unicellular 2. Stalk unicellular, un-branched head multicellular (4-12) cells
	Lower	Similar	Similar	Smooth	Numerous diacytic anisocytic 400/mm^2.	Similar	Similar
Mentha microphylla	Upper	Polygonal	Thin, straight anticlinal.	Smooth	Few diacytic aninocytic 50/mm^2	1. multicellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, un-branched head unicellular. 2. Stalk unicellular unbranched head multicellular with spherical shape (4-12) cells.
	Lower	Polygonal	Similar	Smooth	Few diacytic 50/mm^2	Similar	Similar

Table (3.2) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Nepeta deflersiana	Upper	Polygonal	Thin sinuous anticlinal walls beaded	Smooth	Anisocytic, anomocytic diacytic 150/mm^2	1. unicellular un-branched with thin warty walls. 2. bicellular uniseriate un-branched with thin warty walls. 3. multi cellular (3-7) uniseriate un-branched with thin warty walls.	1. stalk is unicellular unbranched, head is unicellular. 2. stalk is bicellular unbranched head is unicellular or bicellular. 3. Stalk multicellular (3 or 4) unbranched, head unicellular, bicellular and multicellular (3) ovate shape.
	Lower	Polygonal	Thin sinuous anticlinal, beaded	Smooth	Anisocytic, anomocytic diacytic 200/mm^2.	Similar	Similar
Nepeta septemecrenata	Upper	Polygonal	Thin sinuous anticlinal	Smooth	Anisocytic, Anomocytic Diacytic 150/mm^2	1. Unicellular, 2. Bicellular, 3. Multicellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular with large spherical shape. 2. Stalk bi-cellular, head unicellular round shape. 3. Stalk unicellular, head multicellular (3-4) with large spherical shape
	Lower	Polygonal	Thin sinuous anticlinal	Smooth	Anisocytic, Diacytic, Anomocytic 250/mm^2	Similar	Similar
Otostegia fruticosa var: fruticosa	Upper	Polygonal	Thin slightly sinuous anticlinal walls beaded	Smooth	Daicytic, Anomocytic, Anisocytic, 150/mm^2	1. unicellular, 2. bicellular, uniseriate unbranched with thick warty cell walls. Wide base cell and acute apex.	Stalk unicellular, head is unicellular, bicellular and multi cellular (3 or 4), all with spherical shape.
	Lower	Polygonal	Thin slightly sinuous anticlinal walls beaded	Smooth	Diacytic Anomocytic, Anisocytic, 200/mm^2	Similar	Similar

Table (3.2) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Otostegia fruticosa: var: schimperi	Upper	Polygonal	Thin slightly sinuous walls, beaded.	Smooth	Diacytic, Anisocytic 150/mm^2.	1. Unicellular, 2. Bicellular 3. Multicellular unbranched with thick warty walls, wide lumina and acute apex.	1. Stalk unicellular and head unicellular rounded. 2. Stalk unicellular head multicellular rounded (3 or 4) with spherical shape.
	Lower	Polygonal	Thin slightly sinuous anticlinal walls, beaded.	Similar	Anomocytic Anisocytic 250/mm^2.	Similar	Similar
Salvia aegyptiaca:	Upper	Polygonal	Thin with slightly sinuous anticlinal walls beaded.	Smooth	Diacytic, Anisocytic 200/mm^2.	1. unicellular, 2. bicellular, 3. multicelular , uniseriate with thick warty cell walls.	1. Stalk unicellular, head unicellular 2. Stalk unicellular head multicellular (4-8).
	Lower	Polygonal	Similar	Smooth	Diacytic, Anisocytic, 600/mm^2.	Similar	Similar
Salvia deserti	Upper	Polygonal	Thin straight anticlinal, beaded	Striated.	Diacytic, 150/mm^2	1. unicellular 2. bi-cellular 3. multi-cellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular head unicellular 2. stalk unicellular, head multicellular (4-8).
	Lower	Polygonal	Similar	Striated	Diacytic, 500/mm^2	Similar	Similar

Table (3.2) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Salvia spinosa	Upper	Polygonal	Thin sinuous anticlinal, beaded	Smooth	Diacytic, 100/mm^2	1. Unicellular 2. Bicellular 3. Multicellular, uniseriate, unbranched, with thin warty cell walls.	1. Stalk unicellular, head unicellular rounded. 2. Stalk unicellular, head bicellular.
	Lower	Polygonal	Thin, sinuous anticlinal walls, beaded	Smooth	Diacytic, 450/mm^2	Similar	1 Stalk unicellular, head unicellular. 2 Stalk unicellular, head bicellular. 3. Stalk unicellular, head multicellular (4-8).
Stachys aegyptiaca	Upper	Polygonal	Thin straight anticlinal beaded	Smooth	Absent	Multicellular, multiseriate branched	1. Stalk unicellular long, head unicellular rounded. 2. Stalk bicellular, head unicellular rounded.
	Lower	Polygonal	Similar	Smooth	Diacytic 50/mm^2	Similar	Similar
Stachys Schimperi	Upper	Polygonal	Thin, slightly sinuous anticlinal.	Striated	Diacytic, Anomocytic, Anisocytic, 150/mm^2	Multicellular, multiseriate branched.	1. Stalk bicellular, head unicellular rounded. 2. Stalk multicellular (3 cells), head unicellular rounded 3. Stalk multicellular, multiseriate, branched with one branch having a unicellular glandular head.
	Lower	Polygonal	Similar	Striated	Diacytic. Anomocytic, Anisocytic. 250/mm^2	Similar	Similar

Table (3.2) ***(continued)***

Species	CHARACTERS						
	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
						Non Glandular	Glandular
Stachys yemensis	Upper	Polygonal	Thin straight anticlinal beaded.	Smooth	Absent	Multicellular, multiseriate branched	Stalk unicellular, head unicellular rounded, very rare.
	Lower	Polygonal	Similar	Smooth	Diacytic, 50/mm^2	Similar	Absent
Thymus decussatus	Upper	Polygonal	Thin sinuous anticlinal beaded.	Smooth	Diacytic, anomocytic. 150/mm^2	1. Unicellular 2. bicellular 3. multicellular (3-7), uniseriate, unbranched with slightly thick warty walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head multicellular (8-12).
	Lower	Polygonal	Thin, with sinuous beaded	Smooth	Diacytic, anomocytic. 250/mm^2	Similar	Similar
Thymus aff. vulgaris	Upper	Polygonal	Thin, straight anticlinal beaded	Smooth	Diacytic, anomocytic. 150/mm^2	1. unicellular 2. bicellular 3. multicellular (3-7), uniseriate unbranched with thin warty walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head multi-cellular (4 – 8) with spherical shape.
	Lower	Polygonal	Slightly thick, straight anticlinal beaded.	Striated	Similar	Similar	Similar

Table (3.3) The Epidermal characters of the Stem.

Species	CHARACTERS					
	Cell Shape	Cell Wall	Cuticle	Stomata	Trichomes	
					Non Glandular	Glandular
Marrubium vulgare	Polygonal elongated	Thin celluloesic straight anticlinal beaded	Smooth.	Few 50/mm^2 diacytic and anisocytic.	1. Unicellular 2. Bicellular 3. Multicellular (3-5), uniseriate unbranched, with thick warty walls.	1. Stalk unicellular, unbranched, head unicellular, 2. Stalk unicellular, head bicellular 3. Stalk unicellular head multicellular (4-16).
Micromeria biflora	Polygonal and rectangular elongated.	Thick straight anticlinal walls beaded.	Longitudinally striated.	Numerous, diacytic, anisocytic, (200/mm^2) absent from the stem angles.	1. Unicellular (papillose) 2. bicellular 3. multicellular, uniseriate, unbranched with thick warty cell walls.	1. Stalk unicellular, un-branched, head unicellular round shaped 2. Stalk unicellular, un-branched, head multi-cellular with spherical shape and orange color (4 – 16).
Mentha microphylla	Polygonal	Thin straight beaded.	Striated	Few, diacytic 50/mm$^{2.}$	1. Unicellular 2. bi-cellular 3. multi-cellular, uniseriate, un-branched with thin warty walls.	1. Stalk unicellular, unbranched, head unicellular 2. Stalk unicellular, head multicellular (4-8).
Nepeta deflersiana	Polygonal almost rectangular elongated	Thin, straight anticlinal beaded	Smooth	Anomocytic, anisocytic, diacytic 100/mm^2.	1. Bi-cellular, uniseriate unbranched with thin warty walls. 2. Multi-cellular, 3-7 cells uniseriate, un-branched with thin warty walls.	1. Stalk unicellular, head is unicellular or bicellular. 2. Stalk bi-cellular, head unicellular or bi-cellular. 3. Stalk multi-cellular, head unicellular, bi-cellular or multi-cellular (3 or 4)cells.
Nepeta septemecrenata	Polygonal or rectangular elongated.	Thin, straight anticlinal beaded.	Longitudinally striated.	Anomocytic, Anisocytic and Diacytic 100/mm^2.	1. Unicellular 2. Bicellular 3. Multicellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular some with large spherical form. 2. Stalk bi-cellular, head unicellular rounded in shape 3. Stalk is unicellular uniseriate, unbranched head multicellular (4-8)

Table (3.3) ***(continued)***

Species	CHARACTERS					
	Cell Shape	**Cell Wall**	**Cuticle**	**Stomata**	**Trichomes**	
					Non Glandular	**Glandular**
Otostegia fruticosa var. fruticosa	Polygonal	Thin, straight anticlinal, beaded.	Smooth	Anomocytic, Diacytic 150/mm^2.	1. Unicellular 2. bi-cellular, uniseriate, un-branched, both with thick warty cell walls wide base cell.	1. Stalk unicellular, head unicellular, bicellular and multicellular. 2. Stalk unicellular, head bicellular 3. Stalk multicellular (3 or 4)
Otostegia fruticosa: var: schimperi	Rectangular elongated	Slightly thick straight anticlinal, beaded	Striated	Absent	1. unicellular 2. bicellular 3. multicellular, uniseriate, unbranched with thick warty cell walls.	1. Stalk unicellular and head unicellular with spherical shape. 2. Stalk unicellular, head multicellular with spherical shape.
Salvia aegyptiaca	Polygonal elongated, polygonal, rounded in between the angles.	Thin straight anticlinal, beaded	Striated	Diacytic, anisocytic absent from the stem angles. 300/mm^2	1. Unicellular 2. bi-cellular 3. multicellular uniseriate, unbranched with thick warty cell walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head multicellular (4 – 8).
Salvia deserti	Polygonal elongated at stem angles and polygonal in between the angles.	Thin, straight anticlinal walls, beaded.	Striated at stem angles and smooth in between stem angles.	Diacytic, anisocytic, absent at stem angles. 250/mm^2	1. unicellular 2. bicellular 3. multicellular, uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular head unicellular rounded shape. 2. Stalk unicellular head multicellular (4 – 8).
Salvia spinosa	Polygonal to rounded and polygonal elongated at stem angles.	Thin straight anticlinal beaded.	Striated at the angles and smooth in between stem angles.	Diacytic, anisocytic absent from the stem angles. 250/mm^2	1. unicellular 2. bicellular, uniseriate, unbranched with thick warty cell walls.	1.Stalk unicellular, head unicellular. 2. Stalk unicellular, head bi-cellular. 3. Stalk unicellular, head multicellular (4 – 8).
Stachys aegyptiaca	Rectangular elongated.	Thick, straight, beaded.	Striated longitudinally.	Absent	Multicellular, multiseriate branched	1. Stalk unicellular, head unicellular rounded. 2. Stalk bicellular head unicellular rounded.

Table (3.3) ***(continued)***

Species	CHARACTERS					
	Cell Shape	**Cell Wall**	**Cuticle**	**Stomata**	**Trichomes**	
					Non Glandular	**Glandular**
Stachys schimperi	Polygonal	Thin, straight anticlinal.	Smooth	Anomocytic, anisocytic diacytic 300/mm^2.	Multicellular, multiseriate, branched	1. Stalk bicellular, head unicellular, rounded. 2. Stalk multicellular 3 cells unbranched head unicellular 3. Stalk multicellular multiseriate branched, one branch with unicellular head.
Stachys yemensis	Polygonal	Thin, straight anticlinal beaded	Longitudinally striated.	Anomocytic and diacytic 150/mm^2	Multicellular, multiseriate branched	Stalk unicellular head unicellular rounded
Thymus decussatus	Rectangular or polygonal.	Thin, straight, anticlinal, beaded.	Striated longitudinally	Absent	1. unicellular, 2. bicellular 3. multicellular (3-7), uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head multicellular (8-12) with spherical shape.
Thymus aff. vulgaris	Rectangular or polygonal.	Thin, straight, anticlinal, beaded.	Striated longitudinally	Absent.	1. unicellular, 2. bicellular 3. multicellular (3-7), uniseriate, unbranched with thin warty cell walls.	Stalk unicellular, head multi-cellular (4-8), with spherical shape.

Table (3.4): Epidermal Character of the floral parts.

Species	CHARACTERS						TRICHOMES	
	Floral parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Marrubium vulgare	**Calyx:**	Abaxial surface:	Polygonal.	Thin, sinuous anticlinal, beaded.	Striated	Numerous diacytic anisocytic 200/mm^2	1. unicellular 2. bicellular, 3. multicellular (3-8) cells with thick warty walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head bicellular. 3. Stalk unicellular, head multicellular (3 – 16). 4. Stalk multicellular (3 – 4), head unicellular rounded.
		Adaxial surface:	Polygonal.	Thin, sinuous anticlinal, beaded.	Striated	Numerous diacytic, anisocytic 200/mm^2	Similar	Similar
	Corolla:	Abaxial surface:	Isodiametric elongated	Thin, sinuous anticlinal, beaded.	Smooth	Similar	Similar	Similar
		Adaxial surface::	Similar	Thin, sinuous anticlinal, beaded.	Smooth	Similar	Similar	Similar .

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Pars	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Micromeria **biflora**	***Calyx:***	Abaxial surface:	Isodiametric and polygonal elongated at Calyx veins, beaded.	Thin sinuous anticline walls.	Striated	Rare diacytic.	1. unicellular 2. bicellular 3. multicellular (3-8) with thick warty walls.	1. Stalk unicellular and head unicellular rounded. 2. Stalk unicellular head multicellular (4-8) with spherical form.
		Adaxial surface:	Similar	Thin sinuous anticline walls.	Striated	Absent.	Similar	Similar
		Abaxial surface:	Polygonal at the corolla veins, isodiametric in between.	Thin sinuous, beaded.	Striated	Absent.	Similar	1. Stalk unicellular, head unicellular round shape. 2. Stalk unicellular and head multicellular (4 – 8) with round spherical shape.
	Corolla:	Adaxial surface::	Polygonal elongated at the corolla veins isodiametric in between.	Thin, sinuous beaded.	Striated	Rare diacytic.	Similar	Similar

Table (3.4): (continued).

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Mentha microphylla	**Calyx**	Abaxial surface	isodiametric	Thin, straight anticlinal walls at Calyx veins and sinuous in between Calyx veins, beaded.	Striated, striations	Not observed.	1. unicellular 2. bicellular 3. multicellular with thin warty walls and acute apex.	1. Stalk unicellular and head multi-cellular (4-12) with spherical shape. 2. Stalk unicellular, head unicellular
		Adaxial surface	Similar	Similar	Similar	Similar	Similar	Similar
	Corolla	Abaxial surface	Similar	Thin sinuous anticlinal walls, beaded	Striated,	Not observed.	Similar	Similar
		Adaxial surface	Similar	Similar	Striated	Not observed.	Similar	Similar

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Nepeta deflersiana	***Calyx:***	Abaxial surface	Polygonal at Calyx veins, isodimetric in between Calyx veins.	Thin sinuous anticlinal walls.	Smooth or slightly striated.	Anomocytic, diacytic. 50/mm^2	1. Unicellular 2. bicellular 3. multicellular (3-6), uniseriate unbranched with thin warty walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head bicellular. 3. Stalk bicellular head unicellular. 4. Stalk bicellular, head bicellular 5. Stalk multicellular (3 or 4), head multicelular (1 - 4) ovate.
		Adaxial surface	Similar	Thin sinuous anticlinal walls.	Smooth or slightly striated.	Similar	Similar	Similar
		Abaxial surface	Similar	Thin, sinuous. anticlinal walls	Striated longitudinally	Absent	1. Multicellular (3-6), uniseriate, unbranched, with thin warty walls.	Similar
		Adaxial surface	Polygonal	Thin, sinuous anticlinal walls.	Smooth	Absent	Similar	Similar
	Corolla:							

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Nepeta septemecrenata	***Calyx:***	Abaxial surface	Isodiametric	Thin, sinuous anticlinal walls, beaded.	Striated	Few diacytic, anomocytic 50/mm^2.	1. unicellular 2. bicellular, 3. multicellular (3-5). uniseriate with thin warty walls.	1. Stalk, unicellular, head unicellular. 2. Stalk, bicellular, head unicellular. 3. Stalk, bicellular, head bicellular 4. Stalk, unicellular head multicellular (4 - 8) with spherical form
		Adaxial surface	Similar	Thin, sinuous anticlinal walls, beaded	Striated	Few diacytic anomocytic 50/mm^2.	Similar	Similar .
		Abaxial surface	Polygonal		Smooth	Few diacytic, anomocytic 50/mm^2.	Similar	Similar
	Corolla:	Adaxial surface	Similar	Thin, sinuous anticlinal walls beaded. Similar	Smooth	Similar	Similar	Similar

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
		Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Non Glandular	Glandular
Otostegia fruticosa var. fruticosa	***Calyx:***	Abaxial surface	Isodiametric	Thin, sinuous anticlinal walls beaded	Smooth	Absent	1. unicellular 2. bicellular 3. multicellular uniseriate, unbranched with thin warty cell walls.	1. Stalk unicellular, head unicellular 2. Stalk unicellular, head multicellular (3 or 4).
		Adaxial surface	Similar	Similar	Similar	Absent	Similar	Similar
		Abaxial surface	Isodiametric	Thin sinuous anticlinal walls, beaded.	Smooth	Absent	Similar	Similar
		Adaxial surface	Similar		Similar	Absent	Similar	Similar
	Corolla			Thin, sinuous anticlinal walls, beaded.				

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Otostegia fruticosa var: schimperi	**Calyx:**	Abaxial surface	Polygonal elongated	Thin, sinous anticlinal walls beaded.	Smooth	Absent	1. unicellular 2. bicellular 3. multicellular, uniseriate with thick warty walls wide Lumina and acute apex.	1. Stalk, unicellular, head unicellular. 2. Stalk, unicellular, head bicellular. 3. Stalk, bicellular, head unicellular. 4. Stalk, unicellular, head multicellular (3 or 4 cells)
		Adaxial surface	Polygonal elongated	Thin, sinuous anticlinal walls beaded.	Smooth	Absent	Similar	Similar
	Corolla:	Abaxial surface	Polygonal elongated	Thin, sinuous anticlinal beaded.	Striated	Rare diacytic Anisocytic 50/mm^2	1. unicellular 2. bicellular 3. multicellular, uniseriate, unbranched with thick warty walls.	1. Stalk, unicellular, and head unicellular rounded, small. 2. Stalk unicellular and head multicellular (3 or 4), rounded, large.
		Adaxial surface	Similar.	Similar	Smooth	Absent	Similar	Similar

Table (3.4): (continuted).

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Salvia aegyptiaca	***Calyx:***	Abaxial surface:	Isodiametric	Thin, sinuous anticlinal, beaded	Smooth	Absent	1. unicellular 2. bicellular 3. multicellular or (3-7) cells, uniseriate, un-branched, with thick warty walls.	1. Stalk unicellular, head unicellular. 2. Stalk unicellular, head multi-cellular (4-8) cells.
		Adaxial surface:	Similar	Thin, sinuous anticlinal,beaded	Smooth	Absent	Similar	Similar
		Abaxial surface:	Isodiametric	Thin, sinuous anticlinal walls, beaded.	Smooth	Absent	Similar	Similar
	Corolla:	Adaxial surface:	Similar	Thin sinuous anticlinal walls, beaded.	Smooth	Absent	Similar	Similar

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Parts	**Epidermis**	**Cell Shape**	**Cell Wall**	**Cuticle**	**Stomata**	**Non Glandular**	**Glandular**
Salvia deserti	***Calyx.***	Abaxial surface	Polygonal at veins and isodiametric in between veins.	Thin straight anticlinal at Calyx veins sinuous in between Calyx veins, beaded.	Smooth	Absent	Numerous 1. unicellular 2. bicellular 3. multicellular 3-6, with thin warty walls.	Numerous 1. Stalk unicellular, head unicellular. 2. Stalk bicellular head unicellular. 3. Stalk unicellular, head multi-cellular (4-8).
		Adaxial surface	Similar	Similar	Smooth	Absent	Similar	Similar
	Corolla	Abaxial surface	Polygonal at corolla veins and isodimetric in between corolla veins	Thin, anticlinal straight at corolla veins and sinuous in between corolla veins	Smooth	Absent	Similar	Similar
		Adaxial surface	Polygonal walls at corolla veins and isodimetric in between corolla veins.	Similar	Smooth	Absent	Similar	Similar

Table (3.4): (continued)

Species	CHARACTERS						TRICHOMES	
	Floral Parts	Epidermis	Cell Shape	Cell Wall	Cuticle	Stomata	Non Glandular	Glandular
Salvia spinosa	***Calyx:***	Abaxial surface	Isodiametric elongated beaded.	Thin, with sinuous anticlinal walls	Smooth	Absent	1. unicellular 2. bicellular 3. multicellular unbranched with thin warty walls.	Stalk unicellular and head unicellular.
		Adaxial surface	Similar	Similar	Smooth	Diacytic 150/mm^2	Similar	Similar
		Abaxial surface	Isodiametric beaded.	Thin, with sinuous anticlinal walls	Smooth	Absent	Similar	Similar
	Corolla:	Adaxial surface	Isodiametric elongated beaded.	Thin, with sinuous anticlinal walls	Smooth	Few, diacytic 50/mm^2.	Similar	Similar

Table (3.5): Internal structure of leaf, lamina, midrib region.

Species	STRUCTURE		
	Epidermis		Ground Tissue
	Upper	Lower	
Marrubium vulgare	One layer of tabular cells thick cutinized outer walls cuticle thick	Similar	2 or 3 Layer of lamellar collenchymas. 3-6 layers of large parenchyma cells. One vascular bundle large arched.
Micromeria biflora:	One layer of large round cells Thick outer walls cuticle thick	Small rounded Thick outer walls Cuticle thick	small group of parenchyma tissue. One small vascular bundle rounded Groups of slightly lignified outer phloem fibers. bundle sheath lamellar collenchyma
Mentha microphylla	One layer of tabular cells thick outer walls cuticle thick	Similar	1 or 2 layers of lamellar collenchymas cells. 2-4 layers of parenchyma cells with conspicuous intercellular spaces. One large arched shape vascular bundle. Groups of outer phloem fibers, slightly lignified.
Nepeta deflersiana:	One layer of tabular cells thin outer walls cuticle thin	Similar	One lamellar collenchymas. 2 – 4 layers of parenchymatous cells. one vascular bundle arched Bundle sheath 1 layer. Primary xylem. Primary phloem A group of outer phloem fibers.
Nepeta Septemecrenata:	One layer of tabular cells thick outer walls cuticle thick	Similar	one layer of lamellar collenchyma. 2-6 parenchyma tissue. vascular bundle one rounded. procambium primary xylem and phloem. groups of outer phloem fibers

Table (3.5): ***(continued)***

Species	STRUCTURE		
	Epidermis		Ground Tissue
	Upper	Lower	
Otostegia fruticosa vav: fruticosa	One layer of tabular cells thick outer walls cuticle thick	Similar	One layer of lamerllar collenchyma. 10-13 layers of parenchyma tissue. One large boat shape vascular bundle Primary xylem Primary phloem Outer phloem fibers (groups).
Otostegia fruticosa vav: schimperi	One layer of large round cells Thin outer walls Cuticle thin	One layer large round cells Thick outer walls Cuticle thick	1 group of lamellar collenchyma tissue. 3 or 4 layers of parenchyma tissue. One large vascular bundle arched. Primary xylem Primary phloem. Group of outer phloem fibers
Salvia aegyptiaca	One layer of round cells Thick outer walls Cuticle thick	Similar	One layer of lamellar collenchyma. 4 or 5 layers of parenchyma tissue. Round shape vascular bundle. Primary xylem. Primary phloem. Small group of outer phloem fibers.
Salvia desserti	One layer of tabular to rounded cells Thick outer walls Cuticle thick	Similar	One layer of lamellar collenchyma. 3 or 4 layers of parenchyma cells One small arched shape vascular bundle.
Salvia spinosa	One layer of cells around Thick outer walls Cuticle thick	Similar	Lamellar collenchymas one layer 6-12 layers of parenchyma tissue. One large vascular bundle arched as a boat shape.
Stachys aegyptiaca	One layer of tabular cells Thick outer walls Cuticle thick	Similar	Lamellar collenchyma One vascular bundle arched Primary xylem Primary phloem 4 – 6 lamellar collenchyma tissue.

Table (3.5): ***(continued)***

Species	STRUCTURE		
	Epidermis		Ground Tissue
	Upper	Lower	
Stachys shimperi	One layer of tabular cells Thick outer walls Cuticle thick	Similar	2 or 3 lamellar collenchyma tissue 2-4 parenchyma tissue One vascular bundle arched. One layer of lamellar collenchyma.
Stachys yemensis	One large tabular cells Thick outer walls Cuticle thick	One layer of small tabular cells Thin outer walls Cuticle thick	3 layers of lamellar collenchyma tissue 2-4 layers of parenchyma tissue. One vascular Bundle arched Primary phloem Primary xylem Group of outer phloem fibres Lamellar cholenchyma (1 or 2)..
Thymus decussatus	One layer of tabular small cells Thick outer walls Cuticle thick	Similar	Parenchyma tissue (palisade shape). One large round shape vascular bundle Single ring of bundle sheath Xylem and phloem elements. Group of outer phloem fibers lignified.
Thymus aff. vulgaris	One layer of tabular cells Thick outer walls Cuticle thick	Similar	Lamellar collenchyma tissue Single ring of bundle sheath. Vascular Bundle rounded Primary xylem Primary phloem Parenchyma tissue Group of outer phloem fibers lignified. Lamellar collenchyma

Table (3.6): Internal structure of leaf, lamina, intercostal region.

Species	STRUCTURE		
	Epidermis		Mesophyll
	Upper	Lower	
Marrubium vulgare	1. Cuticle thin 2. Cells tabular small 3. Outer walls thick	Similar	2 or 3 layer of palisade type cells 3 or 4 layers of rounded spongy type cells with large intercellular spaces.
Micromeria biflora	1. Tabular large cells 2. thick outer walls 3. cuticle thick	1. Tabular cells 2. thick outer walls 3. cuticle thick	2 layer of palisade type cells 3 or 4 layers of sponge type cells with large intercellular spaces.
Mentha microphylla	1. Cuticle thick 2. Cells tabular 3. Outer walls thick	Similar	2 layer of palisade type cells 3 or 4 layers of spongy type cells with large intercellular spaces.
Nepeta deflersiana	1. Cuticle thin 2. one layer tabular cells 3. Outer walls thin	Similar	3-4 layers of palisade type cells. 5-7 sponge type cells both with conspicuous intercellular spaces.
Nepeta Septemecrenata	1. Cuticle thin 2. one layer tabular cells 3. Outer walls slightly thick	Similar	2 or 3 layers of palisade type tissue 3 or 4 layers of spongy type cells with conspicuous intercellular spaces.
Otostegia fruticosa var: fruticosa	1. Cuticle thick 2. one layer tabular cells 3. Outer walls thick	Similar	2 or 3 palisade type cells 3 or 4 spongy type cells
Otostegia fruticosa var: schimperi	1. Cuticle thin 2. Cells tabular 3. Outer walls thick	Similar	One layer of palisade cells 3 or 6 spongy cells large intercellular spaces
Salvia aegyptiaca	1. Cuticle thick 2. Cells big tabular 3. Outer walls thick	1. Cuticle thick 2. Small tabular 3. Outer walls thick	4 – 7 layers of palisade type cells with large intercellular spaces.
Salvia deserti	1. Cuticle thick 2. one layer tabular large 3. Outer walls thick	1. Cuticle thin 2. cells tabular small 3. Outer walls thin	2 layers of palisade type cells 3 or 4 spongy type cells with large intercellular spaces.

Table (3.6): (continued)

Species	STRUCTURE		
	Epidermis		Mesophyll
	Upper	Lower	
Salvia spinosa	1. Cuticle thick 2. round cells 3. Outer walls thick	1. small rounded 2. thin outer walls 3. Cuticle thin	4 - 6 layers of short palisade type cells with large intercellular spaces.
Stachys aegyptiaco	1. Cuticle thick 2. Cells tabular 3. Outer walls thick	Similar	2 or 3 layers of palisade type tissue with large intercellular spaces. 3 or 4 spongy type tissue with conspicuous intercellular spaces.
Stachys shimperi	1. Cuticle thick 2. Cells tabular 3. Outer walls thick	Similar	3 - 5 layers of palisade type tissue 2 or 3 spongy type tissue both with large intercellular spaces.
Stachys yemensis	1. Cuticle thick 2. Cells tabular large 3. Outer walls thick	1. Cuticle thin 2. cells tabular small 3. Outer walls thick	2 layers of palisade type tissue 3 or 4-sponge type tissue both with large intercellular spaces.
Thymus decussatus	1. Cuticle thick 2. Cells tabular 3. Outer walls thick	Similar	2 or 3 layers of palisade type cells 5 - 8 layers of spongy type cells both with large intercellular spaces.
Thymus aff. vulgaris	1. Cuticle thick 2. Cells tabular 3. Outer walls thick	Similar	2 or 3 layers of palisade type cells 2 or 3 layers of spongy type cells both with large intercellular spaces.

Table (3.7): The internal structure of the stem.

Species	STRUCTURE			
	Epidermis	**Cortex**	**Vascular Tissue**	**Pith (Medulla)**
Marrubium vulgare	one layer tabular thick outer walls cuticle thin.	hypodermis present lamellar collenchymas in the stem corners. chlorenchyma parenchyma bundle sheath	Discontinuous cylinder strands of vascular cambium Primary xylem primary phloem 4 main vascular bundles at stem angles Groups of outer phloem fibers (arc shape)	1. Polygonal paranchymatous homogenous with conspicuous intercellular spaces. 2. Contain solitary crystals.
Micromeria biflora	One layer tabular thick outer walls slightly thick inner walls cuticle thick	lamellar collenchymas at stem angles chlorenchyma tissue. bundle sheath	Discontinuous cylinder primary phloem vascular cambium Primary xylem 4 main vascular bundles at stem angles small groups of slightly lignified outer phloem fibres	1. polygonal homogenous parenchymatoes tissue with thick cell walls conspicuous intercellular spaces
Mentha microphylla	one layer tabular thin outer walls cuticle thin.	Hypodermis present lamellar collenchymas at stem angles chlorenchyma tissues bundle sheath	Discontinuous cylinder primary phloem Primary xylem 4 main vascular bundles at stem angles small groups of 2 outer phloem fibres	Rounded homogenous parenchymatous tissue with large intercellular space
Nepeta deflersiana	one layer tabular thick outer walls cuticle thin.	Hypodermis present chlorenchyma tissue bundle sheath	continuous cylinder with secondary growth	polygonal homogenous parenchymatous tissue with slightly thick walls and conspicuous inter cellular spaces.
Nepeta septemecrenata	one layer tabular thick outer walls cuticle thin.	Lamella colenchyma chlorenchyma tissue bundle sheath	Discontinuous cylinder Primary xylem primary phloem 4 main vascular bundles at stem angles Groups of outer phloem fibers (arc shape)	polygonal parenchymatous homogenous, thin celluloesic walls conspicuous intercellular spaces

Table (3.7): ***(continued)***

Species	STRUCTURE			
	Epidermis	**Cortex**	**Vascular Tissue**	**Pith (Medulla)**
Otostegia fructicosa var. fruticosa	one layer tabular thick outer walls cuticle thick.	lamellar collenchyma at stem angles. chlorenchyma tissue between angles. parenchyma tissue bundle sheath. hypodermis not observed	discontinuous cylinder 4 main vascular bundles at stem angles primary phloem primary xylem outer phloem fibers (arc shape)	thin walls parenchyma cells homogenous, polygonal to rounded conspicuous intercellular spaces.
Otostegia fruticosa var: schimperi	one layer of small round cells outer thick cell walls cuticle thick.	lamellar collenchymas tissue at stem angles. chlorenchymas. bundle sheath hypodermal not observed	continuous cylinder primary phloem primary xylem	Polygonal parenchymatous cells homogenous, thin cell walls conspicuous intercellular spaces.
Salvia aegyptiaca	one layer of round cells thick outer walls cuticle thick	lamellar collenchyma at the stem angles. chlorenchyma in between stem angles bundle sheath hypodermis not observed	4 main vascular bundles at stem angles primary phloem primary xylem groups of outer phloem fibers (arc shape)	Polygonal parenchyma tissue homogenous, thin cell walls large intercellular spaces.
Salvia deserti	One layer of small tabular cells outer thick cuticle thick	lamellar collenchymas at stem angles. chlorenchymas tissue in between angles parenchyma tissue in between stem angles bundle sheath hypodermal not observed	4 main vascular bundles at stem angles primary phloem primary xylem groups of outer phloem fibers (arc shape)	Polygonal parenchyma homogenous, thick unlignified cell walls large intercellular spaces.
Salvia spinosa	one layer of tabular cells, outer thick cuticle thick	hypodermis is present lamellar collenchymas at stem angles chlorenchyma tissue in between stem angles parenchyma tissue in between stem angles bundle sheath	primary phloem vascular cambium primary xylem 4 main vascular bundles at stem angles groups of outer phloem fibers (arc shape)	Polygonal to round shaped, homogenous parenchyma, large intercellular spaces, thin cell walls

Table (3.7): ***(continued)***

Species	STRUCTURE			
	Epidermis	**Cortex**	**Vascular Tissuee**	**Medulla (Pith)**
Stachys aegyptiaca	one layer rounded small outer thick walls cuticle thick.	lamellar collenchyma at stem angles chlorenchyma. bundle sheath.	primary phloem. primary xylem continuous cylinder groups of outer phloem fibers lignified.	polygonal homogenous parenchyma thick cell walls with large intercellular spaces.
Stachys schimperi	one layer of tabular small cells thick outer walls cuticle thick.	lamellar collenchyma at stem angles. chlorenchyma tissue. bundle sheath	primary phloem vascular cambium primary xylem continuous cylinder small groups of outer phloem fibers with lignified walls	polygonal homogenous parenchyma slightly thick cell walls large intercellular spaces.
Stachys yemensis	one layer of tabular small cells outer thick walls cuticle thick.	Hypodermis (water storage) lamellar collenchyma parenchyma bundle sheath.	primary phloem. vascular cambium primary xylem continuous cylinder (with secondary growth). Small groups of lignified outer phloem fibers.	Polygonal homogenous parenchyma cells with thin cell walls large intercellular spaces.
Thymus decussatus	one layer of rectangular or round small cells slightly thick outer walls cuticle thick.	Hypodermis present lamellar collenchyma parenchyma tissue bundle sheath	lamellar collenchyma vascular cambium 3 layers. primary xylem primary phloem continuous cylinder.	Parenchymatous tissue homogenous, irregular Thin cell walls becomes hollow in old stems.
Thymus aff vulgaris	one layer of tubular to rounded cells thick outer walls cuticle thick	Hypodermis present lamellar collenchyma parenchyma tissue bundle sheath	primary phloem (groups) vascular cambium (1 layer). primary xylem continuous cylinder.	Parenchyma tissue homogenous polygonal Thin cell walls becomes hollow in old stems.

Table (3.8) Morphological characters of pollen grains of some Lamiaceae species (using LM).

Species	Size of the pollen (pollar/ equatorial) using LM	Shape	Tectum Surface	Number, Type of the Colpi
1. Marrubium vulgare	47.5 ± 2 x 38 ± 3	Circular	Smooth reticulate perforate	6-zonocolpate
2. Micromeria biflora	8.3 ± 3 x 5.5 ± 3	Circular	Smooth tecta reticulate	6-zonocolpate
3. Mentha microphylla	26.8 ± 1 x 21.87 ± 2	Circular	Reticulate perforate	6-zonocolpate
4. Nepeta deflersiana	25.2 ± 2 x 15 ± 3	Triangle	Reticulate perforate	3-zonocolpate
5. Nepeta septemecrenata	29.16 ± 3 x 30.7 ± 2	Circular	Reticulate	6-zonocolpate
6. Otostegia fruticosa var *fruticosa*	33.5 ± 2 x 32.5 ± 3	Circular to ovate	Tecta reticulate perforate	6-zonocolpate
7. Otostegia fruticosa var *schimperi*	31.5 ± 2 x 28.6 ± 2	Circular to ovate	Perforated	3-zonocolpate
8. Salvia aegyptiaca	36.3 ± 2 x 30.3 ± 2	Circular to ovate	Mega reticulate	6-zonocolpate
9. Salvia Deserti	36.5 ± 2 x 22 ± 2	Circular to ovate	Semi perforate to reticulate	6-zonocolpate
10. Salvia spinosa	34.3 ± 2 x 27.5 ± 3	Circular to ovate	Semi perforate to reticulate	6-zonocolpate

Table (3.9) Distribution of trichomes in the species under study: L = leaves (Midrib, Intercostal, upper and lower epidermis), S = stem, F = Floral parts (calyx and corolla). +: present, - absent; uni = unicellular, Bi = bicellular, mult = multicelular, Mult Br = multicellular branched, st1 = stalk unicellular, st2 = stalk bicellular, st3 = stalk multicellular.

Type 1 = Stalk 1 – 3 cells, head 1 cell (capitate 1,2) Type 2 = Stalk 1 – 8 cells, head 2 – 4 cells (capitate 3).

Type 3 = stalk 1 cell, head 4 – 16 (peltate) Type 4 = Stalk multicellular, branched, head 1 cell

SPECIES		TRICHOMES													
		Nonglandular				Glandular									
		Unbranched			Branched	Unbranched								Branched	
		Type 1			Type 2	Type 1			Type 2			Type 3		Type 4	
						head 1 Capitate 1, 2			head 2 - 4 Capitate 3			Peltate		Head 1	
		Uni	Bi	Mult	Mult Br	St 1	St 2	St 3-5	St 1	St 2	St 3-4	Head 4-8 St 1	Heads 8-16 St 1	Stalk Multi. Br	
Marrubium vulgare	L	+ pap	+	+	-	+	-	-	+	-	-	+	+	-	-
	S	+	+	+	-	+	-	-	+	-	-	+	+	-	-
	F	+	+	+	-	+	-	+	+	-	-	+	+	-	-
Micromeria biflora	L	+ pap	+	+	-	+	-	-	-	-	-	+	+	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	+	-	-
	F	+	+	+	-	+	-	-	-	-	-	+	-	-	-
M. microphylla	L	+	+	+	-	+	-	-	-	-	-	+	+	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	F	+	+	+	-	+	+	-	-	-	-	+	-	-	-
Nepeta deflersiana	L	+	+	+	-	+	+	+	-	-	+	-	-	-	-
	S	-	+	+	-	+	+	+	+	+	+	-	-	-	-
	F	+	+	+	-	+	+	-	+	+	+	-	-	-	-

Table 3.9 (continued)

SPECIES		TRICHOMES													
		Nonglandular				Glandular									
		Unbranched			Branched	Unbranched								Branched	
		Type 1			Type 2	Type 1			Type 2			Type 3		Type 4	
						head 1 Capitate 1, 2			head 2 - 4 Capitate 3			Peltate		Head 1	
		Uni	Bi	Mult	Mult Br	St 1	St 2	St 3-5	St 1	St 2	St 3-4	Head 4-8 St 1	Heads 8-16 St 1	Stalk Multi. Br	
N. septemecrenata	L	+	+	+	-	+	+	-	-	-	-	+	+	-	-
	S	+	+	+	-	+	+	-	-	-	-	-	+	-	-
	F	+	+	+	-	+	+	-	-	-	-	+	-	-	-
O. fruticosa var fruticosa	L	+	+	-	-	+	-	-	+	-	-	+	-	-	-
	S	+	+	-	-	+	-	-	+	-	-	+	-	-	-
	F	+	+	+	-	+	-	-	+	-	-	+	-	-	-
O. fruticosa var schimperi	L	+	+	+	-	+	-	-	+	-	-	+	-	-	-
	S	+	+	+	-	+	-	-	-	-	-	-	-	-	-
	F	+	+	+	-	+	+	-	+	-	-	+	-	-	-
Salvia aegyptiaca	L	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	F	+	+	+	-	+	-	-	-	-	-	+	-	-	-
S. deserti	L	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	F	+	+	+	-	+	+	-	-	-	-	+	-	-	-
S. spinosa	L	+	+	+	-	+	-	-	+	-	-	+	-	-	-
	S	+	+	-	-	+	-	-	+	-	-	+	-	-	-
	F	+	+	+	-	+	-	-	-	-	-	-	-	-	-

Table 3.9 (continued)

SPECIES		TRICHOMES													
		Nonglandular				Glandular									
		Unbranched			Branched	Unbranched								Branched	
		Type 1			Type 2	Type 1			Type 2			Type 3		Type 4	
						head 1 Capitate 1, 2			head 2 - 4 Capitate 3			Peltate		Head 1	
		Uni	Bi	Mult	Mult Br	St 1	St 2	St 3-5	St 1	St 2	St 3-4	Head 4-8 St 1	Heads 8-16 St 1	Stalk Multi. Br	
Stachys aegyptiaca	L	-	-	-	+	+	+	-	-	-	-	-	-	-	-
	S	-	-	-	+	+	+	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. schimperi	L	-	-	-	+	+	+	+	-	-	-	-	-	-	+
	S	-	-	-	+	+	+	+	-	-	-	-	-	-	+
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. yemensis	L	-	-	-	+	+	-	-	-	-	-	-	-	-	-
	S	-	-	-	+	+	-	-	-	-	-	-	-	-	-
	F	-	-	-	-		-	-	-	-	-	-	-	-	-
Thymus decassutus	L	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	+	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. aff. vulgaris	L	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	S	+	+	+	-	+	-	-	-	-	-	+	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table (3.10) Distribution of stomata in species under study: di = diacytic, ani = anisocytic, ano = anomocytic, L = leaves (midrib and intercostals, upper and lower) S = stem, F = flower parts, calyx, (corolla, adaxial and abxial).

Species		Stomata types			
		di	di ani	di ani ano	di ano
Marrubium vulgare	L	+			
	S	+	+		
	F		+		
Micromeria biflora	L	+	+		
	S		+		
	F	+			
Mentha microphylla	L	+			
	S	+			
	F				
Nepeta deflersiana	L			+	
	S			+	
	F				+
Nepeta septemecrenata	L			+	
	S			+	
	F		+		+
Otostegia fruticosa var fruticosa	L			+	
	S				+
	F				+
Otostegia fruitcosa var schimperi	L		+		
	S				
	F		+		
Salvia aegyptiaca	L	+			
	S		+		
	F				
Salvia deserti	L	+			
	S		+		
	F				
Salvia spinosa	L	+			
	S		+		
	F	+			
Stachys aegyptiaca	L	+			
	S				
	F				
Stachys schimperi	L			+	
	S			+	
	F				
Stachys yemensis	L	+			
	S				+
	F				
Thymus decussatus	L				+
	S				
	F				
Thymus aff vulgaris	L				+
	S				
	F				

4.0 DISCUSSION

The anatomical characters of leaves, stems and floral parts (epidermal and internal structures) of 15 species (Table 2.1) of the subfamily Stachyoideae were studied and summarized in Tables 3.1 – 3.9 and 3.10 and showed the following common anatomical characters.

4.1. EPIDERMAL CHARACTERS OF VEGETATIVE PARTS (Leaf and Stem)

4.1.1 Cuticle:

All the species under study were characterized by smooth or striated, thick or thin cuticle. This finding is in agreement with Bokhary and Hedge (1979).

4.1.2. Epidermal Cells:

The epidermal cells of both leaf epidermises (upper and lower) were almost similar in their anatomical characters, but the epidermal cells of the lower epidermis are smaller and more variable in cell shape. Generally both epidermises have polygonal cells with sinuous or slightly sinuous anticlinal cell walls. Epidermal cells of the midribs and other veins of the leaves, and floral parts are elongated four times longer than their width and arranged in more or less parallel rows (Tables 3.1, 3.4).

Epidermal cells of stems are rectangular or polygonal elongated, , with straight anticlinal cell walls (especially on stem angles) (Tables 3.3). These results are in general agreement with those reported by Metcalfe and Chalk (1950) after Buch (1926), Inamdar and Bhatt (1972), Bokhary and Hedge (1977) and Azizian and Cutler (1982).

4.1.3. Stomata

Stomata are of three kinds: diacytic, anomocytic and anisocytic which are characteristic of the Lamiaceae (Metcalfe and Chalk, 1950; Cantino, 1990; Ezer, 1997; Bosabalidis and Kokkini, 1997) Table 3.10 show the distribution of stomata in the species under study.

The stomata are often present on both leaf epidermises of the intercostal regions (amphiostomatic), but more frequent on lower epidermis, in most species under study, or rare on the upper epidermis of the intercostal region e.g. *Micromeria biflora* (Figure 3.2.2A), *Stachys aegyptiaca* (Figure 3.11.3A) and *Stachys yemensis* (Figure 3.13.2A, B) (Tables 3.2). Stomata are absent on both midrib epidermis in all species under investigation (Tables 3.1). These findings are in general agreement with those reported by Metcalfe and Chalk (1950) and Azizian and Cutler (1982).

Stomata are commonly diacytic or anisocytic or anomocytic or intermixed. Results on Table 3.10 indicate diacytic stomata occur in the vegetative parts, mainly in the leaves and with anisocytic stomata on the stems in *Marrubium vulgare* (Figure 3.1.2 A, B; Table 3.2, 3.3), *Micromeria biflora* (Figure 3.2.3 B; Table 3.2, 3.3), *Mentha microphylla* (Figure 3.3.2 A; Table 3.2, 3.3), diacytic stomata occur in *Salvia aegyptiaca* (Figure 3.8.2A, B, C), *Salvia spinosa* (Figure 310.2 A; Table 3.2.) and *Salvia deserti* (Figure 3.9.2 A, B; Table 3.2) *Stachys aegyptiaca* leaf (Figure 3.11.2 A,B) and *Stachys yemensis* leaf (Figure 3.13.2A,B).

Diacytic stomata, anisocytic and anomocytic stomata intermixed occur more frequently in *Nepeta deflersiana* (Figure 3.4.2 A, B), *N. septemecrenata* (Figure 3.5.2A, B, C), *Otostegia fruticosa var fruticosa* (Figure 3.6.2 A, B) and *Stachys schimperi* (Figure 3.12.2A, B). Some other species have diacytic stomata and anomocytic stomata, which were observed in *Stachys yemensis* (Figure 3.13.4 A, B), *Thymus decussatus* (Figure 3.14.2 A, B), *T. aff. vulgaris* (Figure 3.15.2 A, B, C) (Tables 3.2, 3.10).

Number of stomata per unit area ranges from 600 – 50/mm^2, rare or absent, the highest number actually was in all *Salvia* species, *S. aegyptiaca, S. deserti* and *S. spinosa*, 600 – 500 and 450/mm^2,

respectively which is quite similar to those of *Salvia* species, studied by Bokhary and Hedge (1977) and Elena et al. (1993) on leaves of *Salvia officinalis* L. and *Salvia tomentosa*, Mill.

4.1.4. Trichomes:

4.1.4.1. Nonglandular trichomes are present on both surfaces of leaves and stem epidermis of most species under study, (Tables 3.1, 3.2, 3.3, and 3.9) in two types:

Type 1: uniseriate unbranched with three major forms.

Form 1. unicellular unbranched with varying length and with thin to thickened cell walls, and wide basal cell or seated on pedestals of several epidermal cells with thin to thickened cellulosic cell wall. Some papillose were found in *Marrubium vulgare* (Figure 3.1.2 B), *Micromeria biflora* (Figure 3.2.2 A, B), these results are in agreement with those mentioned by Etienne (1919).

Form 2. Bicellular trichomes with short basal or wide and long terminal cells.

Form 3. Multicellular trichomes with 3 – 8 cells long with wide basal cell and long terminal cell with acute or hooked apex and with thin to thickened cellulosic cell walls.

These forms (1, 2 and 3) were characteristic of all the species under study which agreed with the findings of Buch (1926) and Metcalfe and Chalk (1950), with the exception of the absence of these types in all *Stachys* species: (*S. aegyptiaca, S. schimperi* and *S. yemensis*). Nonglandular trichomes type 1 (forms 1, 2 and 3) are unbranched and occur in various morphology, being common and are characteristic of the family Lamiaceae (Metcalfe and Chalk, 1950). They have recently been mentioned by several authors e.g. Bokhary and Hedge (1977), Doaigey and Gawad (1985); Elena et al. (1993); in some *Salvia* species; Azizia and Cutler (1982) in the genera *Phlomis* L. and *Ermostachys* bunge,

Fischer (1985) in *Coleus blumei leaves*, Doaigey et al. (1985), Cantino (1990) in some Lamiaceae species; Doaigey (1992); Elena et al. (1993); Bosablidis and Kokkini (1997); Bini-malec et al (1997) in some *Thymus* species. Ezer et al. (1998) in *Ballota nigra*, Gavalas et al (1998) in some *Mentha* species, Ascensao et al. (1999) in *Plectranthus ornatus*. Generally they have little diagnostic significance, and the form, length and density of the nonglandular trichomes may be of some taxonomic importance.

Type 2: Multicellular, multiseriate, branched or tufted trichomes: which occurred in one form in the leaf and stem epidermis of *Stachys aegyptiaca* (Figure 3.11.2 A, B, 3.11.3 C, D), *Stachys yemensis* (Figure 3.13.2 A, B)*, Stachys schimperi* (Figure 3.12.3 C). This type was not observed in the leaves or stems epidermises of the other species under study; on the contrary, Metcalfe and Chalk (1950) mentioned their existence in *Stachys* and other species as *Ballota*, *Marrubium, Mentha, Nepeta,* and *Teucrium*. . These results are in agreement with those reported by Azizian and Cutler (1982) on the leaf epidermis of *Eremostachys macrophylla* and *Phlomis pungens*. Cantino (1990) found type 2 nonglandular trichomes in 16 percent of the genera Lamiaceae, Ezer et al. (1998) in *Ballota nigra* leaves. A few of this type was also mentioned by Gavalas et al (1998) in some *Mentha* species and *M. x villoso nervata*.

4.1.4.2. Glandular trichomes:

Several types of trichomes occur in various forms in all the species studied. These are very important feature of the family Lamiaceae in general (Metcalfe and Chalk, 1950). According to the number of cells per gland, the shape, length and number of stalk cells and the degree of

which the stalk base sinks in the epidermis, four types of glandular trichomes were found:

Type 1.

a) – short glandular trichomes with unicellular stalk up to 2 – 10 μm long and with 1 celled head (capitate 1). This form is more common and largely distributed on the leaves and stems of all the species under study (Tables 3.1, 3.3 and 3.9).

b) – Long glandular trichomes with 2 or 3 to 5 celled stalk and 1 celled head (capitate 2) are quite common in certain species e.g. leaves and stems of *Nepeta deflersiana* (Figure 3.4.1 2, 3), *Nepeta septemecrenata* (Figure 3.5.4 B), *Stachys aegyptiaca* (Figure 3.11.4 C) and *Stachys schimperi,* (Figure 3.12.4 B, 3.12.3 A; Tables 3.1, 3.3 and 3.9).

Type 2.

Long glandular trichomes with 1 - 3 or 4 celled stalk and 2 - 4 celled head (capitate 3) are quite common in *Marrubium vulgare* (Figure 3.1.6 B), *Nepeta deflersiana* (Figure 3.4.1.3 A,B,C,D), *Otostegia fruticosa* var: *fruticosa* (Figure 3.6.1, 2, 3 C) and *O. fruticosa var: schimperi* (Figure 3.7) and *Salvia spinosa* (Figure 3.10.2 B).

Types 3.

Short glandular trichomes with unicellular stalk and multicellular spherical head small or large (peltate) (4 -8 cells). This type is quite common on both leaf and stems epidermises of almost all the species under study except *Stachys* species (*S. aegyptiaca, S. schimperi, S. yemensis*, and *Nepeta deflersiana)* glandular trichomes (type 3) having heads with 8 – 16 cells are quite common in *Marrubium vulgare* (Figure 3.1.6 D), *Micromeria biflora* (Figure 3.2.3 A), *Nepeta septemecrenata* (Figure 3.2.3 B)

and *Thymus decussatus* (Figure 3.14.2 C). These results confirmed those reported by Metcalfe and Chalk (1950). Kissler (1958) who named those glandular trichomes with one or two celled stalk and 8 – 16 celled heads as terpene secreting trichomes, or by Solereder (1909) as intequmentary trichomes. These three types of glandular trichomes have been also reported on *Salvia* species, (Bokhary and Hedge 1977), Doaigey and Gawad (1984), Doaigey et al. (1985) and Elena et al. (1993). Cantino (1990) recorded several forms of peltate and capitate trichomes on the vegetative parts of some Lamiaceae species, Doaigey (1991) confirmed the existence of these trichomes on *Otostegia* species. Gavalas et al. (1998) and Ascensao et al. (1999) confirmed the presence of several forms of these glandular trichomes in *Mentha* leaves.

Type 4.

Glandular branched trichomes with one branch having unicellular head; recorded in *Stachys schimperi*, leaves and stems, (Figure 3.12.4C); stalk is varying in its length and position among the other nonglandular branches which were characteristic in the vegetative parts of *Stachys aegyptiaca* (Figure 3.11.3 C, D), *S. schimperi* (Figure 3.12.4 C) and *S. yemensis* (Figure 3.13.3 A, B) (Table 3.1, 3.2 and 3.3). These branched glandular trichomes (Type 4) have rarely been recorded in the Lamiaceae, though; Bokhary and Hedge (1971) found this form of trichomes on the vegetative parts of *Meiandra* and reported it as being unusual in the family. Such trichomes were found on the leaf of *Phlomis pungens* by Bech (1963). Azizian (1980) found them to be common on most of species of *Phlomis* which grow in dry habitat (*Phlomis* section phlomis) and he named them, compound glandular trichomes. Branched glandular trichomes are also

reported in *Hyptis* by Rudall (1980); in *Lavandulla, L. stricta* and *L. coronopifolia* by Doaigey (1992).

4.2. Epidermal Characters of Floral Parts:

The epidermal characters of floral parts (calyx and corolla) of 10 species under study are summarized in Tables 3.4, the distribution of the trichomes in Table 3.9 and the distribution of stomata in Table 3.10: *Marrubium vulgare, Micromeria biflora, Mentha microphylla, Nepeta deflersiana, N. decussatus, Otostegia fruticosa var: fruticosa, O. fruticosa var: schimperi, Salvia aegyptiaca, S. spinosa and S. deserti*.

4.2.1. Cuticle

All the species under study were characterized by smooth or striat cuticle; longitudinal striations occur on the calyx and corolla adaxial and abaxial surfaces in *Micromeria biflora* and *Mentha microphylla* and slightly striated in *Nepeta septemecrenata;* striations more clear at the calyx and corolla veins. Corolla with striate cuticle were found in *Salvia deserti* and *Otostegia fruticosa var schimperi,* striations on calyx were found in *Marrubium vulgare* (Table 3.4)

4.2.2. Epidermal Cells

All species commonly have isodiametric to elongated epidermal cells with thin sinuous anticline walls on the abaxial and adaxial surfaces of both the calyx and corolla. Elongated cells arranged in parallel rows were common on the veins of the floral parts of the abaxial and adaxial surfaces or at the bases of these parts (Table 3.4).

4.2.3. Stomata

Floral parts have the same general types of stomata found in the leaves and stems, stomata were present in less numbers and distribution. Diacytic stomata observed in *Salvia spinosa* 150/mm^2 (calyx). Diacytic and anisocytic stomata were found in the floral parts of *Marrubium vulgare* (200/mm^2) (Figure 3.1.5)*, Nepeta septemecrenata* (Figure 3.5.5

A), and Otostegia *fruticosa* var*: schimperi* (50/mm^2) (Figure 3.7.4 A, B). Diacytic stomata and anomocytic types were found in *Nepeta deflersiana*, Figure 3.4.5, *Otostegia fruticosa var: fruticosa* (50/mm^2) (Figure 3.6.5 B) Otherwise, stomata were rare (50/mm^2), diacytic in *Micromeria biflora* and not observed in floral parts of the other species studied.

4.2.4. Trichomes

Trichomes are present on the floral parts either sparse or abundant. The nonglandular trichomes (Type 1) of the three major unbranched forms as indicated before (1, 2, 3 forms) (Table 3.4, 3.10) with wide lumina and acute apex exist in all the floral parts of the species under study with higher density and variety of lengths.

Nonglandular multicellular branched or tufted trichomes Type 2, were not observed in the floral parts of all species under study.

Glandular trichomes. Type (1) (capitate 1 or capitate 2) are present in the floral parts of all species *Marrubium vulgare, Micromeria biflora, Mentha microphylla, Nepeta deflersiana, N. septemecrenata, Otostegia fruticosa var schimperi, O. fruticosa var: fruticosa, Salvia aegyptiaca, S. spinosa* and *S. deserti*. Type (2) (capitate 3) exist in calyx and corolla of *Marrubium vulgare, Nepeta deflersiana*. Type (3) peltate (3 or 4 cells) glandular trichomes exist on the calyx and corolla of most of the species under study, e.g. *Marrubium vulgare* (Figure 3.1.5)*, Micromeria biflora* (Figure 3.2.1) and *Mentha microphylla* (Figure 3.4.4) and *Nepeta septemecrenata* (Figure 3.4), *Otostegia fruticosa* var *fruticosa, O.* var *schimperi.* Type (3) with 4 – 8 celled heads were found in *Salvia aegyptiaca and Salvia deserti*.

Type (4) glandular trichomes branched are absent from calyx and corolla of all the species under study.

4.3. INTERNAL STRUCTURE

4.3.1. Leaf Internal Characters:

4.3.1.1. Midrib:

The internal structure of the leaf are summarized in Tables 3.5, 3.6 and show the following:

Epidermis: A single layer of upper and lower epidermis are observed, both tabular to round cells, with thick outer walls and thick cuticle in all species with exception of *Otostegia fruticosa* var. *fruticosa* and *Stachys yemensis* where the outer cell walls are thin and with thin cuticle. This result is confirmed by Fahmy (1997) on the leaves of some *Salvia* species.

Messophyll: One to 3 layers of lamellar chollenchyma, are found on the upper in most of the species under study or on the lower side of the midrib, with thick unlignified cell walls e.g., in *Micromeria biflora* (Figure 3.2.7 A, B); or on both sides of the midrib e.g.. *Stachys aegyptiaca* (Figure 3.11.4 A,B); *Stachys schimperi* (Figure 3.1.2.5 A,C,D); *Stachys yemensis* (Figure 3.13.5 A,B); *Thymus* aff. *vulgaris* (Figure 3.15.4 B) results are in agreement with Holm, (1911); Metcalfe and Chalk (1950) on some Lamiacea species and Doaigey and Gawad (1984) on *Salvia* species.

Parenchyma is well developed in the midrib region and is a common characteristic for all the species under study, surrounding the vascular tissue, mostly with conspicuous intercellular spaces ; which agrees with the findings of Holm (1911) and Metcalfe and Chalk (1950), on some Lamiaceae species; Fisher (1985) on *Coleus blumei* leaves, and Doaigy and Gawad (1984) on the *Salvia* species.

Vascular tissue occurs as one main, arched or round vascular bundle in all of the species under study with well developed xylem and phloem elements (Metcalfe and Chalk, 1950).

Outer phloem fibers occurred with three general forms; either with lignified cell walls in *Thymus decussatus* (Figure 3.14.4 A, B) and *Thymus aff. vulgaris* (Figure 3.15.4 A, B) or slightly lignified outer phloem fibers in *Micromeria biflora* (Figure 3.2.7 B) and *Mentha microphylla* (Figure 3.3. 6 A, B). This result is in accordance with what was found in *Micromeria* (Etienne, 1930), or thick outer unlignified phloem fibers observed in *Nepeta deflersiana* (Figure 3.4.6 A, B), *N. septemecrenata* (Figure 3.5.5 A), *Otostegia fruticosa* var: *fruticosa* (Figure 3.6.7 A, B), *O. fruticosa* var: *schimperi* (Figure 3.7.6 A, B) and outer phloem fibres were not observed in leaf transverse sections of the rest of the species under study. The existence of sclerenchyma tissue in the leaf section is in agreement with Metcalfe and Chalk (1950) in some Lamiaceae species, in particular those showing xerophytic features.

4.4.1.2. Intercostal Region: Internal structures were listed in Table (3.6) and show that messophyll composed of 2 or 3 palisade type cells, and spongy type cells is characteristic for all the species under study or one layer of long palisade cells and 2 – 4 spongy type cells e.g. in *Micromeria biflora* (Figure 3.2.7 A), *Mentha microphylla* (Figure 3.3.6 A, B,C), *Otostegia var schimperi* (Figures 3.7.6 A,B), which was confirmed by Metcalfe and Chalk (1950) after Etienne (1930) in *Salvia* species. On the contrary, Bokhary and Hedge (1977) and Doaigy and Gawad (1984) confirmed the existence of short palisade cells only in some *Salvia* species, palisade type without any spongy tissue was found in *Salvia aegyptiaca* (Figure 3.8.6 A,B,C) and *Salvia spinosa* (Figure 3.10.6 A,B,C). The two parenchyma spongy and palisade layers are with conspicuous to large intercellular spaces which is similar to that described by Fisher (1985) in *Coleus blumei* (Lamiaceae) leaves.

4.3.2. Stem Internal Structure:

Stem internal characters are listed in Table (3.7), in cross section the stem is usually distinctly quadrangular or slightly round as in *Nepeta deflersiana* (Figure 3.4.8 D) and *Stachys yemensis* (Figure 3.13.6 D) which agreed with Lemesle (1928).

Epidermis: In all the species studied, stem has a single epidermal layer with thin to thick cuticle, cells mostly tabular to round with thick outer cell walls and thin inner walls, which agreed with Etienne (1930).

Cortex: One layer of hypodermal cells are found in *Marrubium vulgare* (Figure 3.1.8 B), *Mentha microphylla* (Figure 3.3.7), *Nepeta deflersiana* (Figure 3.4.7), *Salvia spinosa* (Figure 3.10.7 C) *Stachys aegyptiaca, Stachys yemensis,* (Figure 3.13.1 A, B, C); (which is considered as sub-epidermal layer of palisade shape water storage parenchyma); *Thymus decussates* (Figure 3.14.5 B, C) and *Thymus aff. vulgare* (Figure 3.15.5 A, B).

There is always a group of well defined lamellar collenchyma cells in the stem angles in most of the species under study e.g. *Nepeta septemecrenata, Nepeta deflersiana, Stachys schimperi* and *Thymus decussatus* and *T. aff. vulgaris* which agreed with Lemesle (1928), Metcalfe and Chalk (1950) and Doaigey and Gawad (1984).

Cortex consists of 1 – 5 layers of chlorenchyma tissue followed by parenchyma tissue devoid of chloroplasts; large and round, with thin cellulosic walls, and conspicuous intercellular spaces in the species *Marrubium vulgare* (Figure 3.1.8 A, B); in between stem angles or cortex as one type layers of parenchyma tissue in between stem angles with conspicuous intercellular spaces in *Stachys yemensis, Thymus aff. vulgaris* and *Thymus decussatus* which is in agreement with Metcalfe and Chalk (1950) in *Dysophylls verticillata* Benth., cortex .

Bundle sheath: The parenchyma tissue tends to be one layer of large tabular cells forming a ring of bundle sheath which is devoided of starch or chloroplasts, with thin cellulosic cell walls covering the vascular tissue. In general bundle sheath existed in

the cortex of the species. *Thymus aff. vulgaris* and *Thymus decussatus*, with large cells not suberized walls, which agree with Lemesle (1928) or small with thin walls in the other species under study as it is mentioned by Metcalfe and Chalk (1950) in some Lamiaceae species.

Outer phloem fibers: have three main forms:

a. As small groups of outer phloem fibers forming an arc shape opposite to the angles of the stem above the 4 main vascular bundles forming a discontinuous ring of fibres with unlignified walls observed in *Marrubium vulgare* (Figure 3.1.8 A) *Micromeria biflora* (Figure 3.2.8), *Mentha microphylla* (Figure 3.3.7 A) *Nepeta septemecrenata* (Figure 3.5.7 A, B), *Otostegia fruticosa var fruticosa* (Figure 3.6.6 A, B) and all *Salvia* species under study which agreed with Solereder (1914).

b. as small groups or strands with lignified thick walls as in *Stachys aegyptiaca* (Figure 3.11.6 A, B), *S. schimperi* (Figure 3.12.6 A, B, C), *S. yemensis* (Figure 3.13.6 A, B, C).

c. absent from species as in *Nepeta deflersiana, Thymus aff. vulgaris* and *T. decussatus.*

Vascular tissue: Have two main forms.

Either as four main large vascular bundles opposite the stem angles was recorded in *Marrubium vulgare, Micromeria biflora, Mentha microphylla, Nepeta septemecrenata, O. fruticosa var: fruticosa, Salvia aegyptiaca, S. deserti, S. spinosa* which agreed with Lemesle (1928) or as a full cylinder as in *N. deflersiana, O. fruticosa* var*: schimperi, Stachys aegyptiaca, Stachys schimperi, Stachys yemensis, T. decussatas* and *T. vulgaris* which have been reported by Etienne (1930).

Phloem:

a. either as large four main groups opposite vascular tissue as in the species of *Marrubium vulgare, Micromeria biflora, Mentha microphylla, N. septemecrenata, O. fruticosa* var. *fruticosa, O. fruticosa* var. *schimperi* and *Salvia* species which agreed with Solereder (1914).

b. or small and crushed e.g. *N. deflersiana*, *Thymus decussatus* and *Thymus aff vulgaris* which is in agreement with Ezer et al. (1998) on some *Thymus* species.

Xylem: as four main large groups at the stem angles reported in *Marrubium vulgare, Micromeria biflora, Mentha microphylla, Nepeta septemecrenata, Otostegia fruticosa* var: *fruticosa* and all *Salvia* species Lemesle (1926) or as a full cylinder in *N. deflersiana, Stachys yemensis, T. decussatus* and *T. aff. vulgaris* which agreed with Etienne (1930).

Pith: is homogenous as a polygonal to round cells with thin or slightly thick cellulosic cell walls and with conspicuous intercellular spaces in all the specie under study which is in agreement with Etienne (1930)

Pith parenchyma becomes hollow in stems of *Thymus decussatus* (Figure 3.14.5 A) and *Thymus aff. vulgaris* (Figure 3.15.5 A).

Large parenchymatous cells and some crystals idioblasts were observed in the pith region of *Marrubium vulgare* (Figure 3.1.9, 10) which in agreement with Metcalfe and Chalk (1950) and Ezer, et al. (1998).

4.4. Pollen Grains:

The pollen morphological characters of 10 species are summarized in Table 3.8 and showed the following observations: Size of the pollen grains is quite similar in all the species studied. The smallest ones are the pollen of *Micromeria biflora, Nepeta deflersiana* and *Mentha microphylla* (8.3 ± 3.5 x 5.5 ± 2 μm, 25.2 ± 2 x 20 ± 3 μm, 26.8 ± 1 x 21.87 ± 2 μm respectively), and each one of these species is related to a different genus. The shape of pollen is useless for the identification since it varies considerably within one species. Variation in shape is also caused by the choice of extraction methods and embedding media. The three-dimensional view for each pollen grain often makes it difficult to

observe using the light microscope. Thus pollen grains need to be described by using their outline shapes of polar and equatorial views. Photographs in Figure 3.16 (A – N), show some examples of polar and equatorial views taken by the aid of SEM and indicate that pollen of the species under study look circular to ovate on a polar and equatorial view except those of *Nepeta deflersiana* having triangular shape. The fine structure of the exine of pollen is quite uniform for almost all species under study as it is smooth reticulate to reticulate perforate except that of the pollen of *Micromeria biflora* (Figure 3.16 C) and *Otostegia fruticosa* var fruticosa (Figure 3.16, F; Table 3.8) where it looks slightly different than the rest, it has tecta reticulate perforate (with large perforations). In *Salvia* species the exine of the pollen is uniform as a semitecta reticulate (with small lumina) and could be described as reticulate perforate, especially in *Salvia deserti* (Figure 1.16.4) and *S. spinosa* (Figure 3.16. M, N) while in *Salvia aegyptiaca,* (Figure 3.16 J, K) the exine shows mega reticulate.

The number and type of colpi of the pollen in species under study are 6-zono colpate type and this is in accordance with Moore and Webb (1978) except the pollen of the species *Nepeta deflersiana* (Figure 3.16 E) and *Otostegia fruticosa var. schimperi* (Figure 3.16 H, I) where they have 3-zonocolpate on a polar view (Table 3.8).

4.5 Comparative Analysis of the Species Under Study

4.5.1 *Marrubium vulgare*

No anatomical description on *Marrubium vulgare* exist except the general anatomical characters of stem and leaves of the genus, which were mentioned by Metcalfe and Chalk (1950), Al Yahya (1990) and Ezer et al. (1998). The present studies on vegetative (leaves, stems) and floral parts of *M. vulgare* (Figures 3.1.1, 3.1.9; Tables 3.1, 3.10) show. The presence of nonglandular trichomes type 1 of varying lengths, (some papillose) 1 – 3 cells long on the leaves; 1 – 3- 5 cells long on the stems and 1 – 3 – 8 cells long on the floral parts of this species. Glandular trichomes unbranched type 1 (capitate 1) are numerous in the vegetative parts, while those with long stalk, 1 – 4 cells long (capitate 2, 3) and peltate were found only on the floral parts. Stomata: diacytic and anisocytic, numerous (300 – 200/mm^2), on both vegetative and floral parts.

Leaf midrib region; with lamellar collenchyma, one main vascular bundle; surround by wide parenchyma tissue and the messophyll differentiated into palisade (2 or 3) and spongy (3 or 4) tissues.

Stem cortex with one layer of hypodermal cells; several layers of collenchyma in stem angles; a discontinuous cylinder of bundle sheath, 4 main large vascular bundles at stem angles, xylem and phloem in the main four vascular bundles, forming a discontinuous cylinder in the stem, connected with fibres and secondary vascular or bundles in between stem angles, the outer phloem fibres as groups of unlignified walls forming an arc shape on the main vascular bundles. Secondary growth exists.

A thin walled pith parenchyma tissue, mostly contains solitary crystals. Few crystals were observed in stem and corolla epidermal cells.

These characters are in general agreement of those of the family Lamiaceae, mentioned by Metcalfe and Chalk (1950), Al Yahya (1990).

and Ezer et al. (1998). Although there are no branched non glandular trichomes on the leaves, stems or floral parts of *M. vulgare* which is mentioned by Metcalfe and Chalk, (1950).

4.5.2. *Micromeria biflora*

The general anatomical description on *Micromeria biflora* was mentioned by Metcalfe and Chalk (1950). The present studies on the vegetative (leaves, stems) and floral parts (Figures 3.2.1 – 3.2.8; Tables 3.1 – 3.10) show: The presence of nonglandular trichome type 1 of varying lengths, (some papillose) and glandular trichomes unbranched type 1 capitate 1 and type 3 peltate with heads 4 – 8 – 16 cells; stomata numerous (400/mm^2) diacytic and anisocytic, mostly on the lower leaf surface.

Leaf midrib, with one main round vascular bundle surrounded by a bundle sheath; large groups of thick walls, phloem fibres, one layer of lamellar collenchyma tissue. Leaf intercostal region consists of palisade and spongy tissues.

Stem cortex consists of chlorenchyma tissue and lamellar collenchyma (in stem angles), bundle sheath.

Four main vascular bundles at stem angles with phloem and xylem elements forming a discontinuous cylinder. Outer phloem fibres with slightly lignified thick cell walls. Pith parenchyma tissue with thick cell walls.

These characters are in general agreement with those of the family Lamiaceae mentioned by Metcalfe and Chalk (1950).

4.5.3. Mentha microphylla

The genus *Mentha* is taxonomically complex. In addition to much phenotypic plasticity and genetic variability, most of the species are capable of hybridization with each other (Halliday and Beadle, 1972).

The present anatomical studies on the leaves, stems and floral parts (Figures 3.3.2, 3.3.7, Tables 3.1, 3.10) indicated that this specie, has some anatomical characters e.g. trichomes, numerous, mostly (type 1) unicellular, bicellular, multicellular, unbranched. Glandular trichomes, numerous (type 1 capitate 1 and type 3 peltate) on the vegetative and floral parts. Stomata a few 50/mm^2, diacytic.

Leaf midrib region with one main vascular bundle arched surrounded by parenchyma tissue; groups of outer phloem fibers; messophyll differentiated into palisade and spongy tissue.

Stem cortex; consists of hypodermal layer lamellar collenchyma at stem angles; 3 or 5 layers of chlorenchyma tissue; single ring of bundle sheath; xylem and phloem in four main vascular bundles, forming a discontinuous cylinder in the stem.

Pith consists of homogenous parenchyma tissue. These characters are also in general agreement of those of the family Lamiaceae mentioned by Metcalfe and Chalk (1950) and Gavalas et al. (1998) on *Mentha x villoso-nervata* and *M. longifolia* and *M. spicata* who confirmed the existence of glandular and nonglandular trichomes; and Mucciarelli and Sacco (1999) in *M. requrieni* Benth and the existence of peltate and capitate in peppermint (*Mentha* x *piperita* L.) leaves by Maffei et al. (1989) and Turner et al. (2000), so it could be suggested that those characters are a general or common characters of the genus *Mentha*.

4.5.4. *Nepeta* species (*N. deflersiana, N. septemecrenata*)

The present anatomical studies on the leaves, stems and floral parts of the two species (Figures 3.4.1, 3.4.7, 3.5.1, 3.5.7, Tables 3.1, 3.10) indicated that the two species have some anatomical characters in common, e.g. presence of nonglandular trichomes, unicellular, bicellular and multicellular unbranched (Type 1). Stomata mostly anisocytic, and

anomocytic rarely diacytic (50 – 250/mm^2). Glandular trichomes, capitate 1 and capitate 2 (Type 1) are present in both species (Table 3.9).

Leaf midrib with lamellar chollenchyma parenchyma tissue one main vascular bundle small groups of outer phloem fibers messophyll differentiated to palisade and spongy tissues in both species; stem cortex; shows chlorenchyma tissue single ring of bundle sheath homogenous pith with unlignified paranchymatous tissue.

Characters are in general agreement with those of the family Lamiaceae, mentioned by Metcalfe and Chalk (1950), Doaigey et al (1985) on *Nepeta septemecrenata* and *N. deflersiana*, and Kolalite (1998) on *N. cataria* and *N. catari* var*: vitriodora*. These characters are also common characters of the genus, *Nepeta*.

In spite of these previous common anatomical characters of the species some anatomical differences were found; glandular trichomes Type 2 capitate 3 were found in *Nepeta deflersiana*; and not found in *N. septemecrenata* although it was observed by Doaigey et al. (1985) on *N. deflersiana* and *N. septemecrenata* species also the glandular trichomes type 3 peltate found in *N. septemecrenata* vegetative and floral parts and not found in *N. deflersiana* also the outer phloem fibres as small groups of unlignified cells forming an arc shape in *N. septemecrenata*.

4.5.5. *Otostegia* species (*O. fruticosa* var. *fruticosa, O. fruticosa* var. *schimperi*).

The present anatomical studies on the plant materials of leaves and stems of the two species (Figures 3.6.1, 3.6.7, 3.7.1, 3.7.7, Tables 3.1, 3.10), indicates that the two varieties have some anatomical characters in common, e.g. presence of glandular and nonglandular trichomes unbranched. Stomata: diacytic, anisocytic and anomocytic with almost similar frequency in both species as it is 250 – 150/mm^2 in *O. fruticosa*

var. *schimperi* and 200 – 150/mm^2 in *O. fruticosa* var *fruticosa*, on the lower and upper surface respectively.

Leaf midrib have lamellar collenchyma; several layers of parenchyma tissue; one large main vascular bundle; a small group of outer phloem fibers; messophyll differentiated into palisade and spongy tissues.

Stem cortex; with several layers of lamellar collenchyma at stem angles, chlorenchyma tissue between angles, bundle sheath; strands of outer phloem fibers forming an arc shape.

Four main groups of vascular bundles with pith thin walled homogenous parenchyma. These characters are also in general agreement of those on the family Lamiaceae, mentioned by Metcalfe and Chalk (1950) and Doaigey et al. (1985) and Doaigey (1991) on the same species. Although Doaigey et al. (1991) observed some nonglandular trichomes exhibiting few branches in *Otostegia fruticosa* var*: schimperi*.

This result showed that the *O. fruticosa* var. *fruticosa* and *O. fruticosa* var. *schimperi* are closely related to each other and it could be suggested that these characters are common of the genus *Otostegia*.

4.5.6 *Salvia* species (*S. aegyptiaca, S. deserti, S. spinosa*)

The present anatomical studies of leaf, stems and floral parts of the three species (Figures 3.8.1, 3.8.7, 3.9.1, 3.9.7, 3. 10.1, 3.10.7 and Tables 3.1, 3.10) indicated that all the three species have some anatomical characters in common, e.g. nonglandular trichomes (Type 1), unicellular bicellular and multicellular; glandular trichomes (capitate 1) peltate, (Type 3)stalk unicellular, head multicellular (4 – 8 cells). Stomata; mostly diacytic on the leaf and with anisocytic on the stem, numerous on the lower intercostal region ranging from 600/mm^2 in *Salvia aegyptiaca*, 500/mm2 *Salvia deserti*, 450/mm^2 *Salvia spinosa*.

Leaf midrib shows lamellar chollenchyma, one main vascular bundle arched, presence of parenchyma tissue several layers in the midrib region. Messophyll consist of palisade type cells only in *S. aegyptiaca* and *S. spinosa*. Stem cortex; shows a lamellar collenchyma at the stem angles, several layers of chlorenchyma tissue, a group of outer phloem fibers arc shape; xylem and phloem in four main vascular bundles forming a discontinuous cylinder in the stem; thick to thin walled unlignified homogenous pith. These characters are also in general agreement of those of the family Lamiaceae, mentioned by Holm (1911), Metcalfe and Chalk (1950); Bokhary and Hedge (1977), Elena et al. (1993), Doaigey and Gawad (1984) and Doaigey et al. (1985). This could be suggested as common characters of the genus Salvia.

In spite of these previous common anatomical characters, the species have some anatomical differences exist e.g. glandular trichomes capitate 2 in the floral parts of *Salvia deserti* and capitate 3 in the vegetative parts of *Salvia spinosa* only.

The messophyll consists of palisade type tissue only in *Salvia spinosa* and *S. aegyptiaca*.

Results emphasize the slight differences in the *Salvia* species, *Salvia spinosa*, shows type 2 glandular trichomes (capitate 3) on the leaves and stems, *Salvia spinosa* has non peltate glandular trichomes on the floral parts, *Salvia spinosa* and *S. aegyptiaca* have palisade type cells only. These results show that *Salvia spinosa* is more distinguished than the rest.

4.5.7. *Stachys* species (*S. aegyptiaca, S. schimperi, S. yemensis*)

The present anatomical studies on limited plant materials of leaves and stems of the three species (Figures 3.11.1, 3.11.6; 3.12.1; 3.12.5; 3.13.6 and Tables 3.1, 3.10) indicated that all species have some anatomical characters in common: presence of multicellular, multiseriate

branched nonglandular trichomes; stomata mostly diacytic type; lamellar collenchyma in leaf midrib region; messophyll differentiated into palisade and spongy tissue; one layer of hypodermal cells (water storage tissue); several layers of collencyma in stem angles; a continuous cylinder of bundle sheath; groups of outer phloem fibers with thick lignified cell walls; xylem and phloem in main four vascular bundles forming a continuous cylinder in the stem and one vascular bundle in the leaf midrib region.

These characters are also in general agreement with those of the family Lamiaceae, mentioned by Metcalfe and Chalk (1950) and Doaigey et al. (1985) on *Stachys aegyptiaca* and Azizian and Cutler (1982) on some Lamiaceae species (*Phlomis* L. and *Eremostachys* bunge), and could be suggested as common characters of the genus *Stachys*.

In spite of these previous common anatomical characters of the species, some anatomical differences were found; different frequency in the occurrence of stomata, since it is 250 – 150/mm^2 in *Stachys schimperi* while it is 50/mm^2 in *S. aegyptiaca* and *S. yemensis*. Glandular trichomes with unicellular stalk and unicellular or bicellular heads were found in *S. aegyptiaca, S. yemensis* while glandular trichomes with bicellular stalks and unicellular heads were found in *S. schimperi* and *S. aegyptiaca*. On the other hand, glandular trichomes with multicellular unbranched stalk and glandular trichomes with multicellular, branched stalks and unicellular heads were observed in *S. schimperi*.

This result shows that *S. aegyptiaca* and *S. yemensis* are closely related to each other, rather than *S. schimperi* which are more distinguished.

4.5.8. *Thymus* (*T. decussatus, Thymus aff. vulgaris*)

The present anatomical studies on limited plant materials of leaves and stems of the two species (Figures 3.14.1, 3.14.5; 3.15.1;; 3.15.6 and

Tables 3.1, 3.10) indicated that both species have some anatomical characters in common, presence of nonglandular trichomes, unbranched, unicellular, bicellular, multicellular and glandular trichomes of two general forms, a) capitate 1, stalk unicellular, head unicellular, b) peltate, stalk unicellular, head multicellular, (4, 8, 12 cells); stomata mostly diacytic, rarely anomocytic observed on the leaves, one vascular bundle covered with well developed groups of outer phloem fibers lignified or slightly lignified, in the leaf midrib region; the messophyll differentiated into palisade and spongy tissue.

Stem cortex; having a hypodermal layer, lamellar collenchyma several layers of parenchyma tissue; a continuous cylinder of bundle sheath. Vascular tissue as a continuous cylinder with clear vascular cambium in both species. Pith parenchyma tends to be hollow in the stem center of both species. These characters are also in general agreement with those of the family Lamiaceae, mentioned by Metcalfe and Chalk (1950), Christodoulkis and Bazos (1990) on *Thymus capitatus* and Bini-Maleci et al. (1997) on *Thymus striatus* Vahl and *Thymus striatus* var. *ophioliticus lacaita*.

In spite of these previous common anatomical characters of the species some anatomical differences were found; different frequency in the occurrence of stomata since it is 250/mm^2 on the lower surface in *Thymus decussatus*, while it is 150/mm^2 in *T. aff. vulgaris*; Messophyll consists of 5 – 8 layers of spongy type cells, in *T. decussatus*, while it is 2 or 3 in *T. aff. vulgaris*. In general these two species are closely related to each other.

5.0 CONCLUSION

The aim of this study is to give a comprehensive account of the anatomical characters of stems, leaves, floral parts and pollen grains of some members of the subfamily Stachyoideae (Lamiaceae) that is growing naturally in the Kingdom of Saudi Arabia. According to the results in this work which is summarized in Tables 3.1 – 3.10 indicated that the 15 species of the subfamily Stachyoideae are closely related in their anatomical characters and with general agreement of those mentioned by Metcalfe and Chalk (1950) as common anatomical characters of the family Lamiaceae.

In spite of the general similarity the anatomical characters of these species of the subfamily Stachyoideae under investigation; they can be divided into two groups with the reference to the types of their trichomes:

Group 1. This group includes 11 species: *Marrubium vulgare; Micromeria biflora; Mentha microphylla; Nepeta deflersiana* and *N. septemecrenata; Otostegia fruticosa var: fruticosa and var: schimperi; Salvia aegyptiaca, S. deserti* and *S. spinosa* and *Thymus decussatus* and *T. aff. vulgaris*. These species are characterized by the presence of nonglandular, unbranched trichomes, either unicellular, bicellular or multicellular uniseriate and glandular unbranched trichomes (capitate 1, 2) and peltate (4 – 8 – 16) celled heads; stomata, 50 – 600/mm^2; outer phloem fibres are small or large with unlignified cells walls; vascular tissue in continuous or discontinuous cylinder.

This group can be divided into two subgroups with reference to the types of glandular trichomes: Subgroup 1 includes (7 species); *Marrubium vulgare; Micromeria biflora; Mentha microphylla; Nepeta deflersiana* and *N. septemecrenata; Thymus decussatus* and *T. aff. vulgari*s which are characterized by peltate glandular trichomes with 4 –

16 celled heads. Subgroup 2 includes 4 species *Otostegia fruticosa var: fruticosa and var: schimperi* and *Salvia* species (*S. aegyptiaca, S. deserti* and *S. spinosa*) which are characterized by the presence of peltate glandular trichomes with 4-8 celled heads.

Group 2. This group contains the 3 species of *Stachys* (*S. aegyptiaca, S. schimperi* and *S. yemensis*) and characterized by branched multicellular multiseriate nonglandular trichomes, unbranched glandular trichomes (capitate 1, 2) and branched glandular trichomes with unicellular head. Stomata 50-200/mm^2, vascular tissue in continuous cylinder having lignified cell walls.

The suggested grouping of the 14 species of the subfamily *Stachyoideae* into two groups is in general agreement with the classification of this subfamily into tribes by Briquet (1897) where *Stachys* species (group 2) may be considered as tribe *Stachyeae* and the rest of the species (group 1 with the two subgroups) as tribes *Marrubieae* and *Salvieae*. However, dividing these species into two groups may agree with Cantino, et al. (1992) where they put the genera of these species in two different tribes (Lamioideae and Nepetoideae).

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Appendix 1.1 The genera and species of the family Lamiaceae reported in the flora of Saudi Arabia by Chaudhary, (2002).

Genera	**Species**
1. *Ajuga* L.	*A. Arabica* *A. chamaepitys spp. Tridacylites* *A. bracteosa*
2. *Teucrium* L.	*T. polium* *T. leudocladum* *T. popovii* *T. hijazicum* *T. yemense* *T. oliverianum*
3. *Scutellaria* L.	*S. rubicunda* *S. arabica*
4. *Lavandula* L.	*L. atripicifolia* *L. dentate* *L. coron opifolia* *L. pubescens* *L. citiodora*
5. *Thuspeinana* durund	*T. persica*
6. *Marrubium* L.	*M. vulgare*
7. *Nepeta* L.	*N. deflersiana* *N. sheilae*
8. *Lallemantia* Fisch and C.A. Meyer	*L. royleana*
9. *Phlomis* L.	*P. brachyodon*
10. *Leucas* Burm. Ex. R. Br.	*L. inflate* *L. martinicensis* *L. alba* *L. glabrata* *L. neuflizeana* *L. urticifolia*
11. *Lamim* L.	*L. album* *L. amplexicaule* *L. ehrenbergii*
12. *Otostegia* Benth	*O. fruticosa*
13. *Ballota* L.	*B. undulate* *B. adenophora*
14. *Stachys* L.	*S. yemensis* *S. aegyptiaca* *S. schimperi*

Appendix 1.1 (continued)

Genera	**Species**
15. *Salvia* L.	*S. spinosa* *S. deserti* *S. aegyptiaca* *S. tingitana* *S. paleastina* *S. tanigera* *S. merjamie* *S. schimperi*
16. *Meriandra* Benth	*M. benghalensis*
17. *Saturegia* L.	*S. nabateorum*
18. *Micromeria* Benth	*M. abyssinica* *M. imbricate*
19. *Origanum* L.	*O. syriacum* *O. majorana* *O. vulgari*
20. *Thymus* L.	*T. decussatus* *T. bovei*
21. *Mentha*	*M. citrate* *M. longifolia* *M. citrate*
22. *Basilicum*	*B. polystachyon*
23. *Plectranthus* L.	*P. arabicus* *P. asivensis* *P. barbatus* *P. cylindraceus* *P. tenuiflorus* *P. lanaginosus*
24. *Endostemon* N. E Br.	*E. tenuiflorus* *E. tereticautis*
25. *Ocimum*	*O. ameriacanum* *O. florskolei* *O. tenuiflorum* *O. serpyllfolium* *O. filamentosum* *O. obovatum*
26. *Orthosiphon* Benth	*O. thymiflorus* *O. pallidus*

Appendix (1.2) Classfication of Lamiaceae (Bentham, 1876)

Tribes	**Subtribes**
Ocimoideae	*Eucimieae*
Nepeteae	
Stachydeae	*Scutellarieae* *Lamieae*
Ajugoideae	*Murrubieae*
Monardeae	
Satureineae	*Melissieae*
Lavanduleae	
Mentheae	

Appendix (1.3) Classification of Lamiaceae (Briquet, 1897).

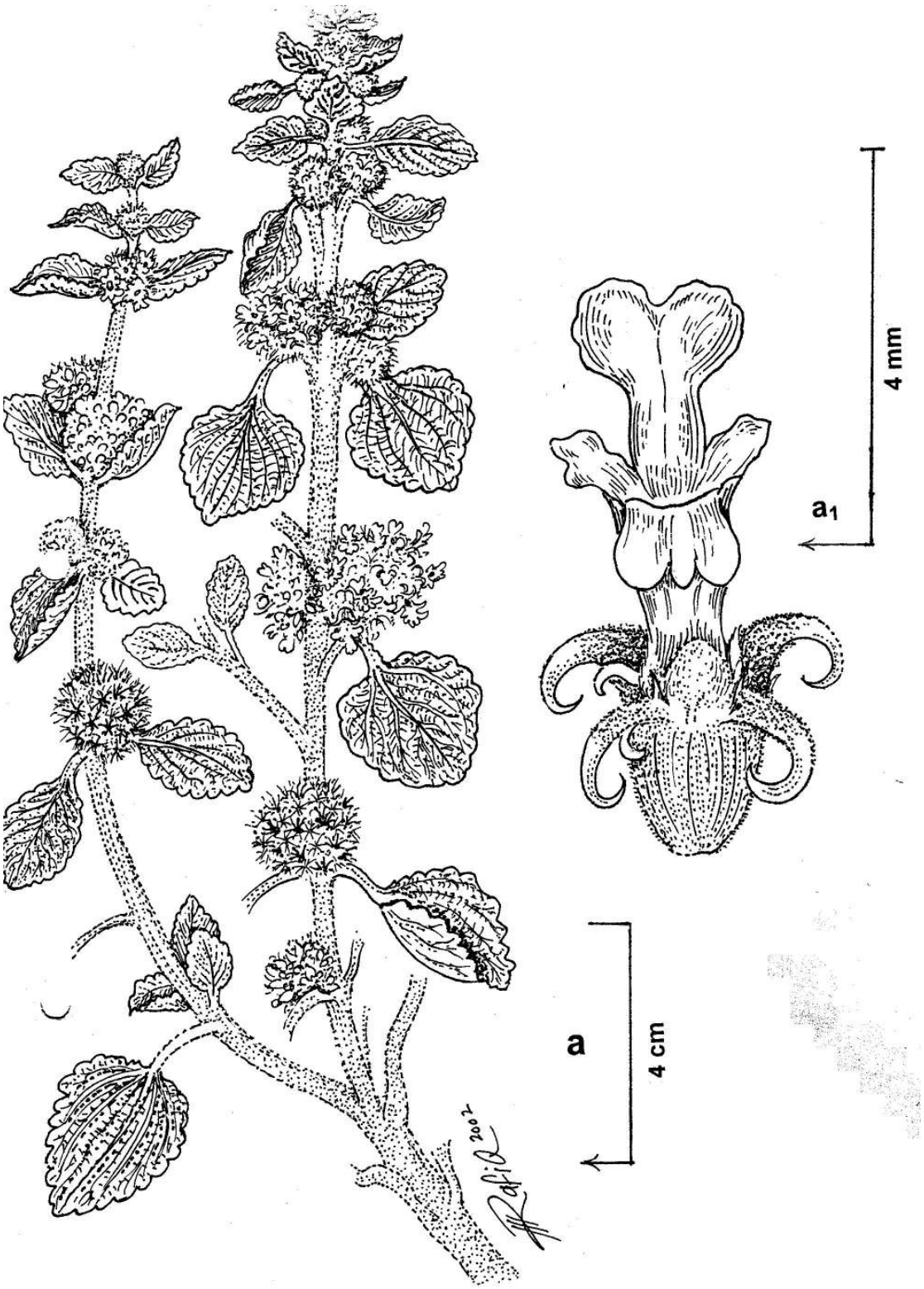
Subfamily	Tribe	Subtribe
Ajugoideae	*Ajugeae*	*Ajugeae*
Scutellrioideae	*Scutellariae*	
Stachyoideae	*Stachyeae* *Marrubieae* *Salvieae* *Satureae*	 *Thymineae* *Menthineae* *Melissineae*
Ocimoideae	*Ocimeae*	*Moshosmineae* *Plectranthineae*
Lavanduloideae		

Appendix (1.4) Classification of subfamily Stachyoideae to 8 tribes with 37 genera and species. (Thonner, 1962).

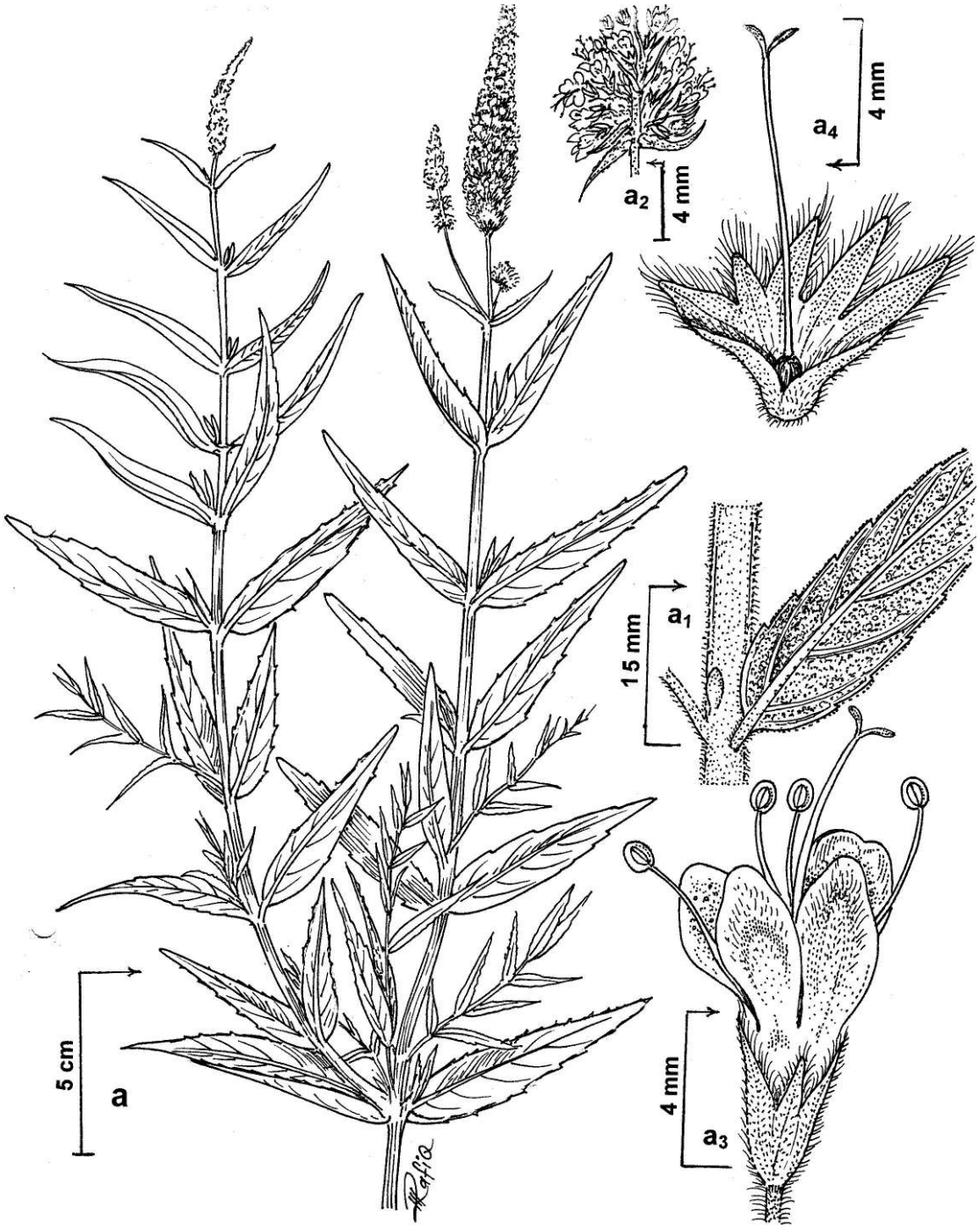
Subfamily	Tribe	Genera
1. *Ajugoideae*	*Rosmarinear* *Ajugeae*	*Rosmarinus* L. *Teucrium* L. *Ajuga* L.
2. *Parasioideae*		*Parsium* L.
3. *Scutellarioideae*		*Scutellaria* L.
4. *Lavanduloideae*		*Lavandula* L.
5. *Ocimoideae*	*Ocimeae*	*Ocimum* L.
6. *Stachyoideae*	1. *Hormineae*	1. *Sphacele* Benth.
	2. *Meriandreae*	2. *Meriandra* Benth
	3. *Salvieae*	3. *Salvia* L.
	4. *Pogostemoneae*	4. *Elsholtzia willd.* 5. *Pogostemon Desf.* 6. *Tetradenia* Benth
	5. *Nepetaei*	7. *Cedronella Monech.* 8. *Nepeta* L.
	6. *Marrubieae*	9. *Acrotome* Benth. 10. *Marrubium* L. 11. *Sideritis* L.
	7. *Stachyeae* Sub tribe*: Brunellinae*	 12. *Cleonia* L. 13. *Brunella* L.
	Sub tribe*: Lamiaceae*	14. *Leonotis Pers.* 15. *Phlomis* L. 16. *Leucas R. Br.* 17. *Renschia Vatke* 18. *Moluccella* L. 19. *Leonurus* L. 20. *Lamium* L. 21 *Achyrospermum wall* 22. *anisomeles R. Br.* 23. *Otosteia Benh.* 24. *Ballota* L. 25. *Stachys* L.
	8. *Satureieae* Sub tribe*: Mellissinae*	26. *Ziziphora* L. 27. *Melissa* L. 28. *Saccocalyx Coss.* 29. *Satureie* L.
	Subtribe*: Hyssopinae*	30. *Hyssopus* L.
	Sub tribe*: Thyminae*	31. *Majorana Moench* 32. *Coridothymus* Reich b. fiL. 33. *Thymus* L. 34. *Origanum* L.
	Sub tribe*: Menthinae*	35. *Lycopus* L. 36. *Preclia* Opiz. 37. *Mentha* L.

Appendix (1.5) Classification of Lamiaceae (Cantino et al., 1992).

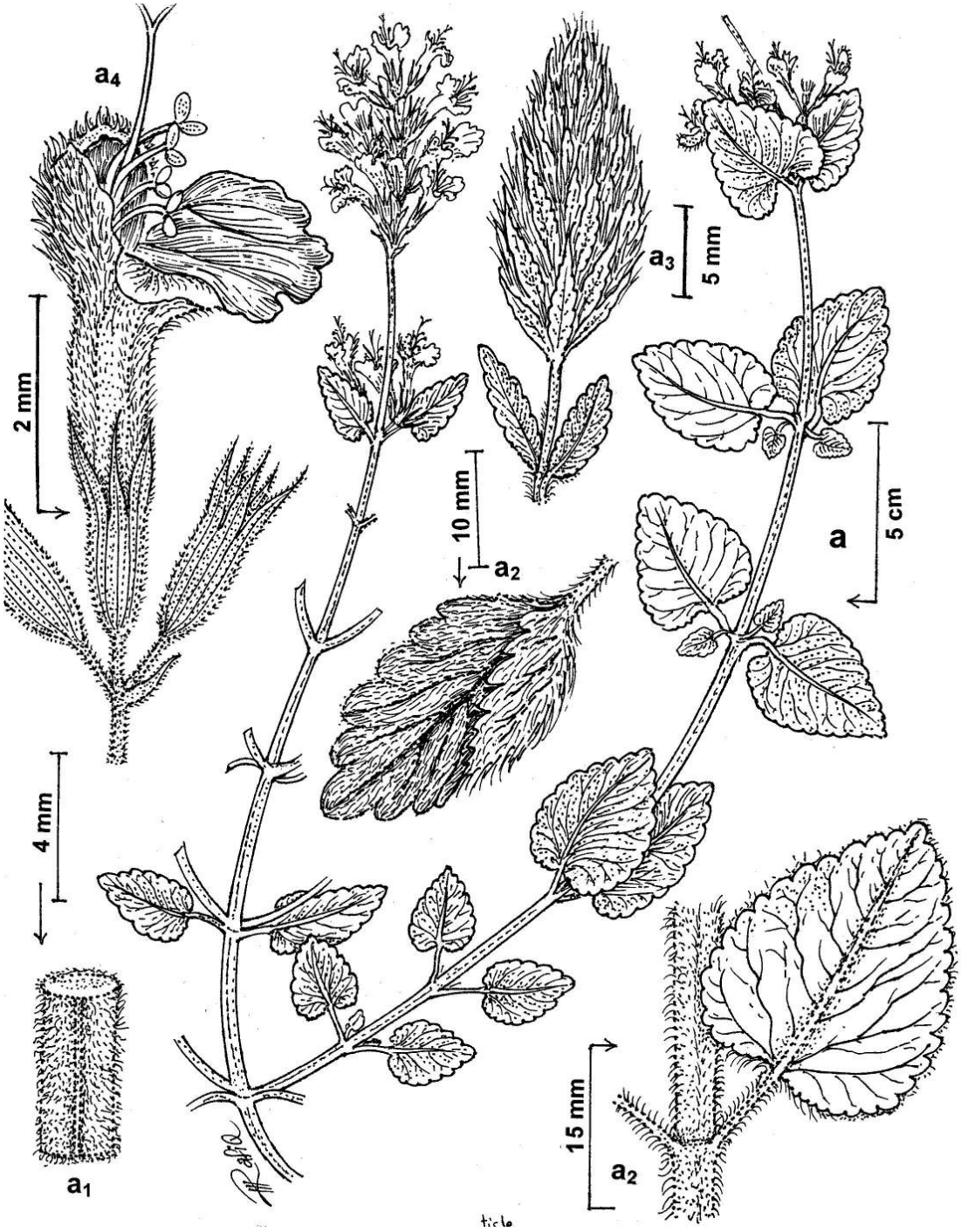
Sub-family	Tribe
1. Teucriodeae	
2. Scutellarioideae	Westrinqieae Chioanthea
3. Lamioideae	Mentheae
4. Pogostemonoideae	Ocimeae
5. Prostantheroideae	Eisholtzieae
6. Nepetoideae	Lavandulaeae
7. Viticoideae	



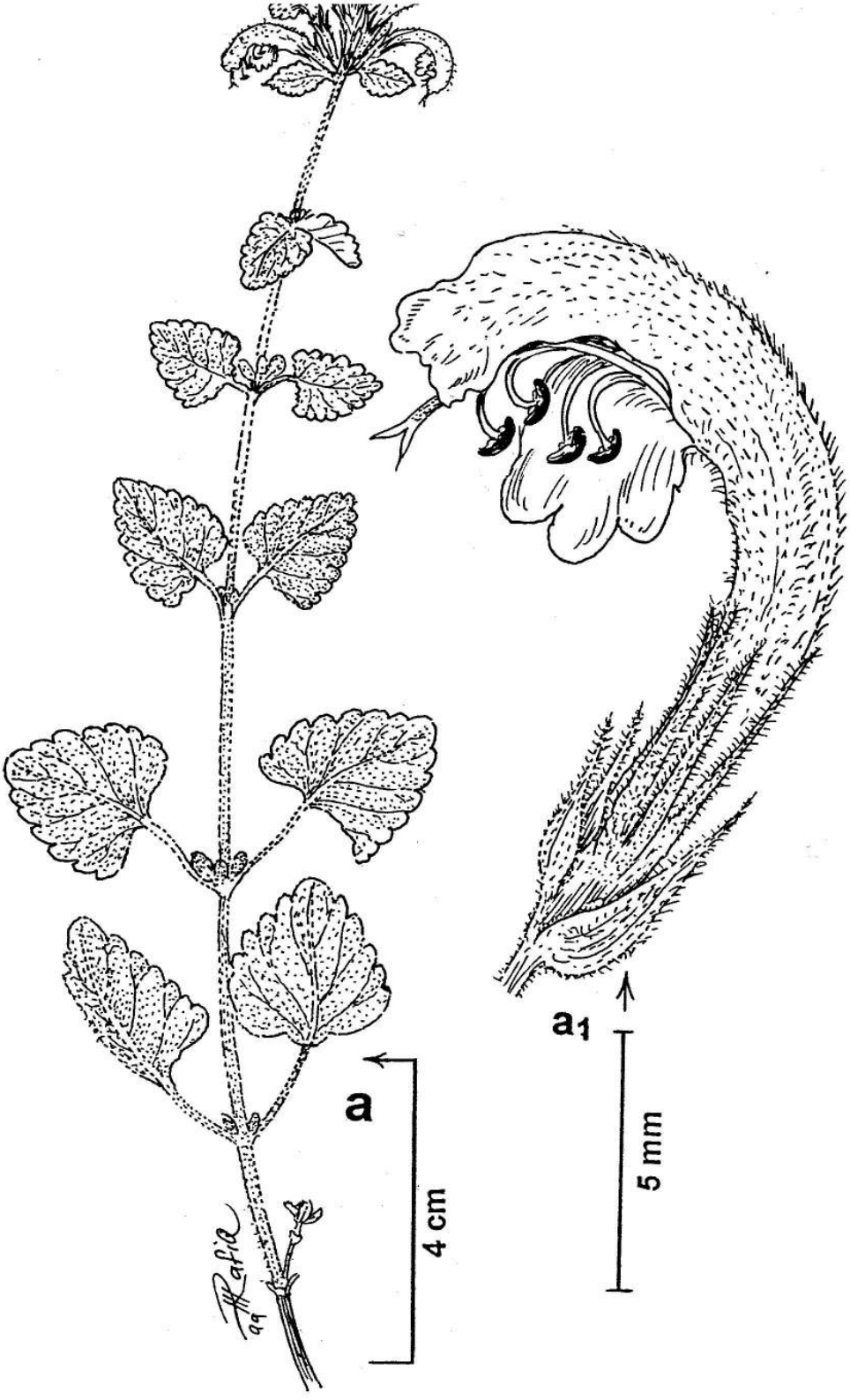
Appendix B.1 *Marubium vulgari* L. (a habit; a_1 flower).
(Chaudhary, 2002)



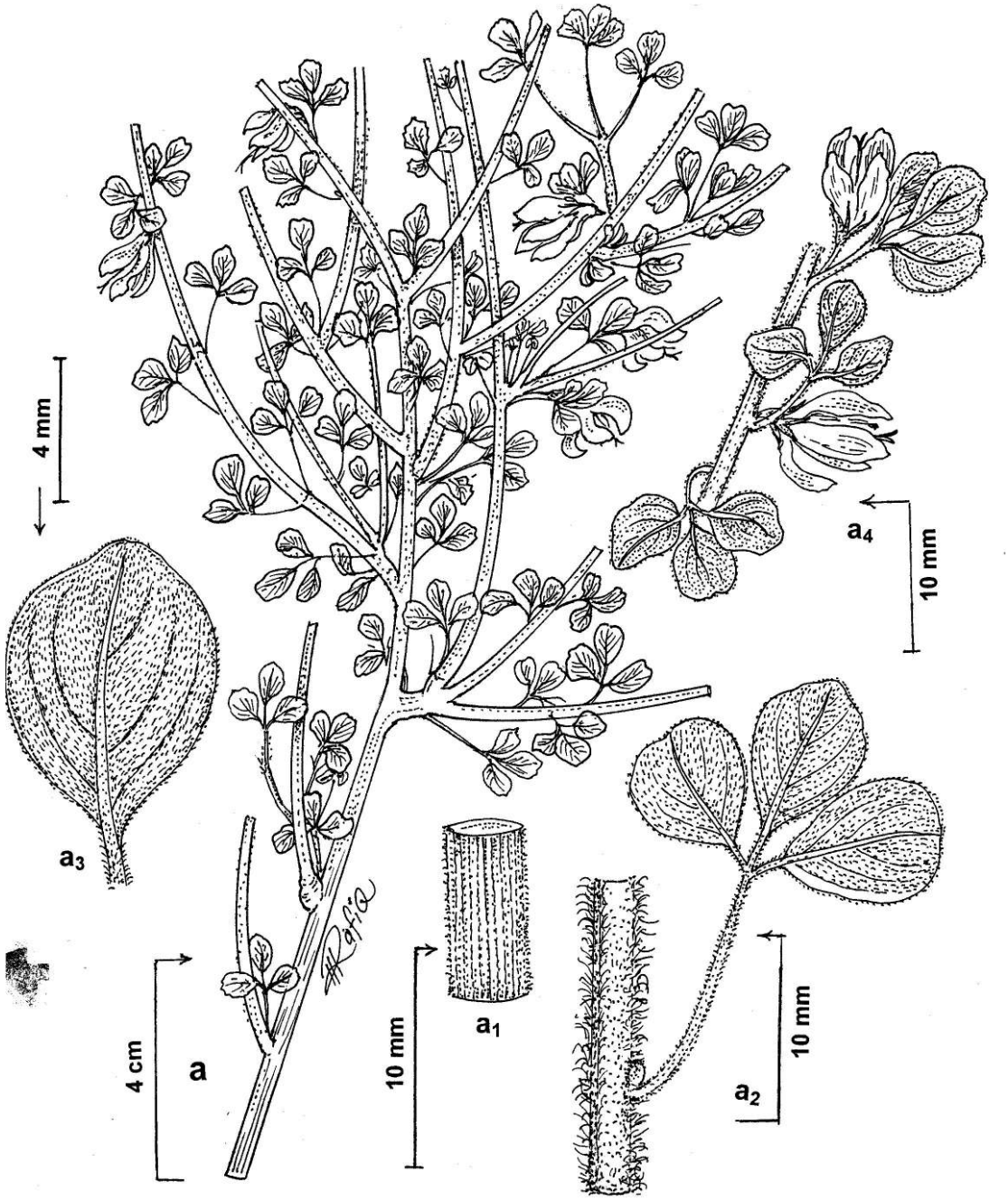
Appendix B.2 *Mentha microphylla*. (a: habit, a_1: branch, a_2: pat of inflorescencse, a_3: flower, a_4: corolla). (K.S. Herbarium)



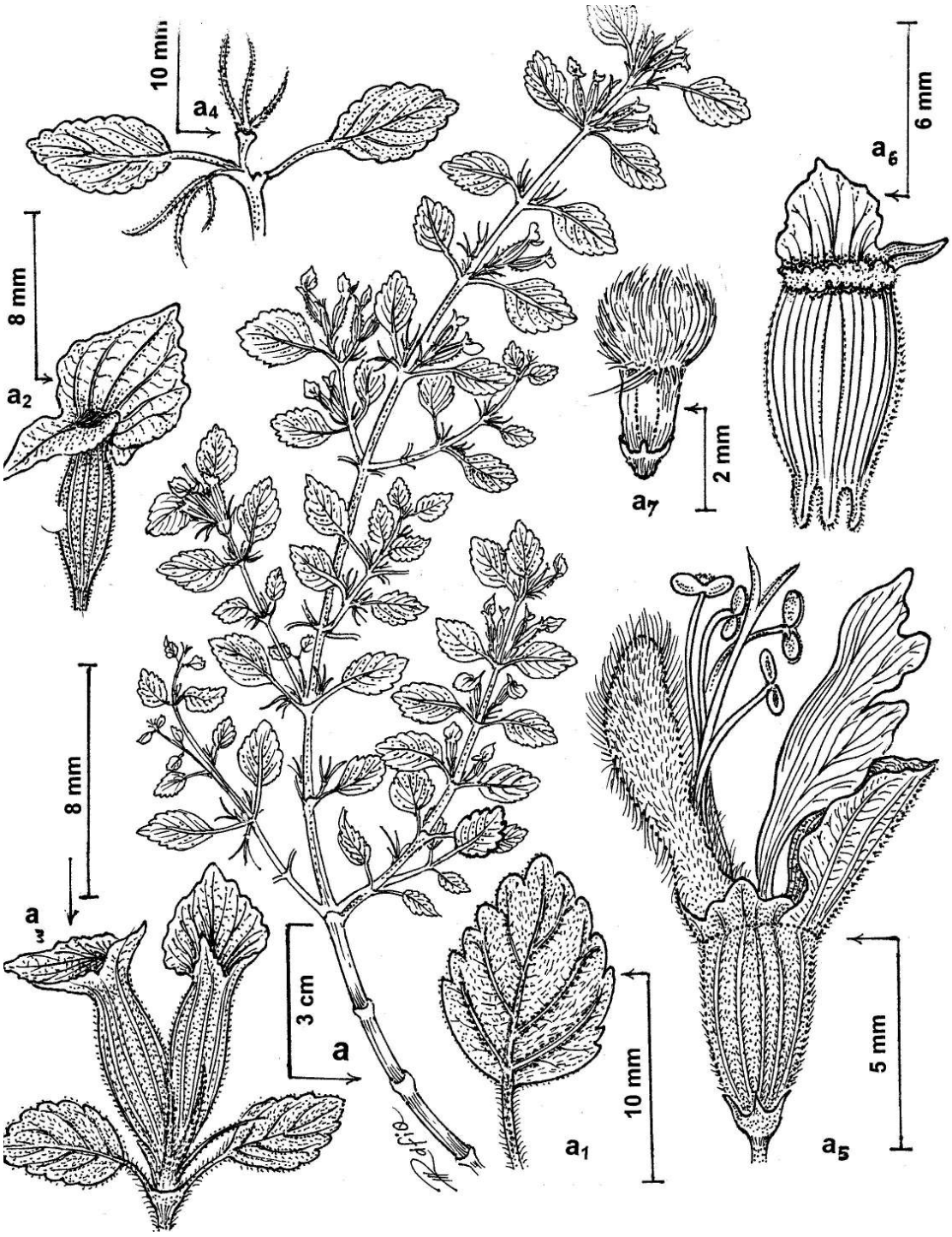
Appendix B 3. *Nepeta deflersiana* L. (a, a1, a2 and a3: habit, a4: part of vertical).



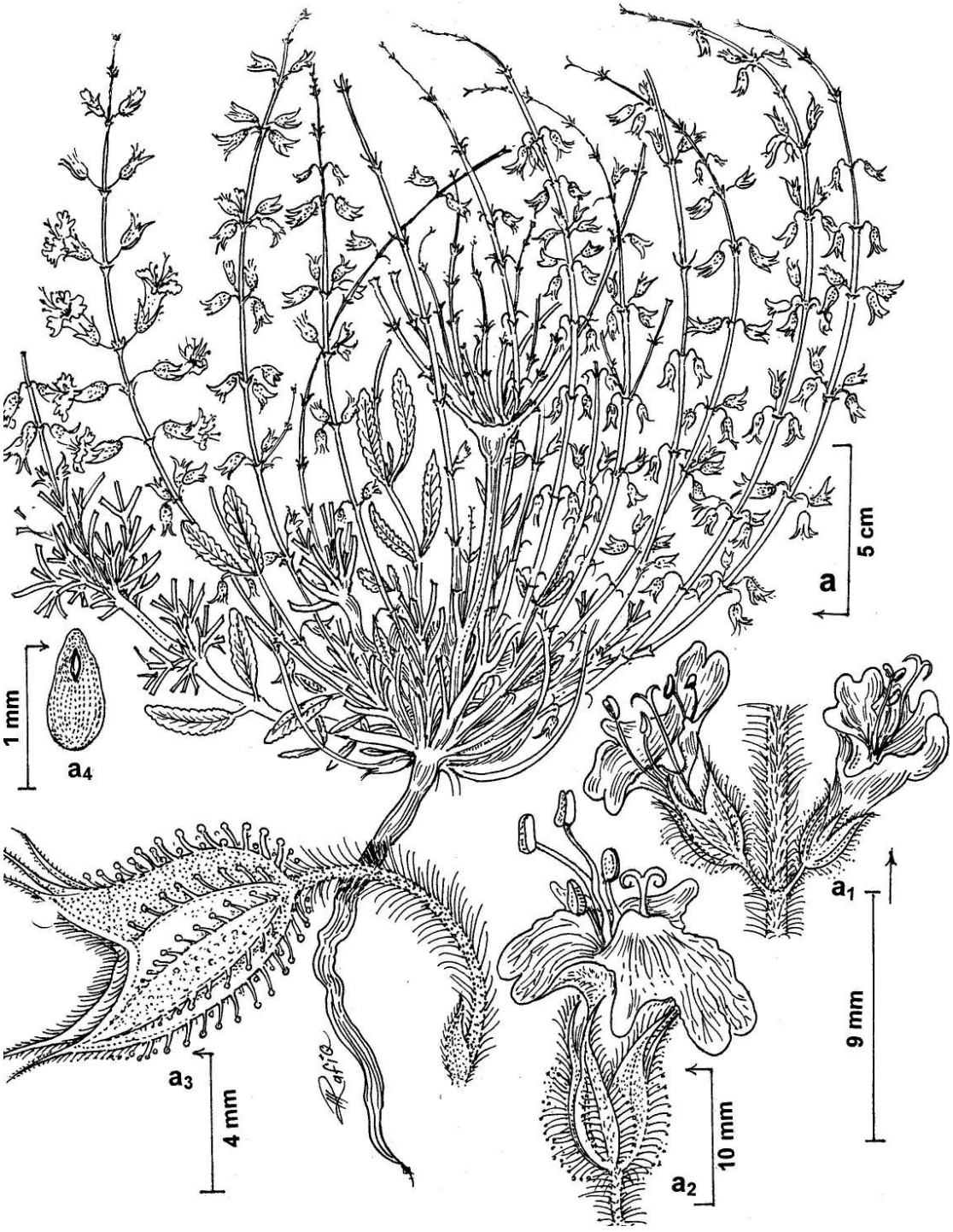
Appendix B 4. *Nepeta septemecrenata*. (a: branch, a_1: flower).



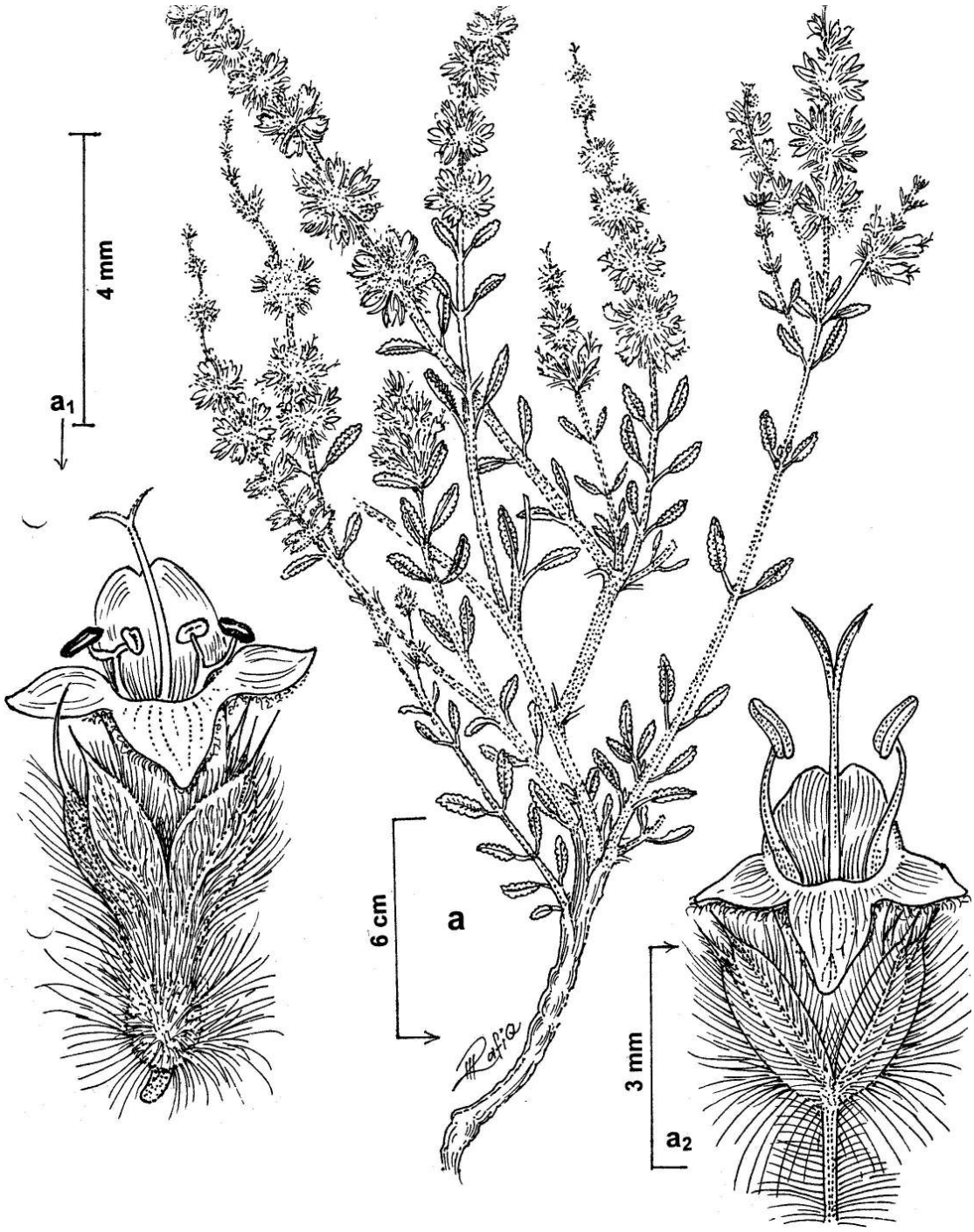
Appendix B 5. *Otostegia fructicosa* ssp. *fruticosa* (a, a1, a_2: branch, a_3: leaf, a_4: flower).



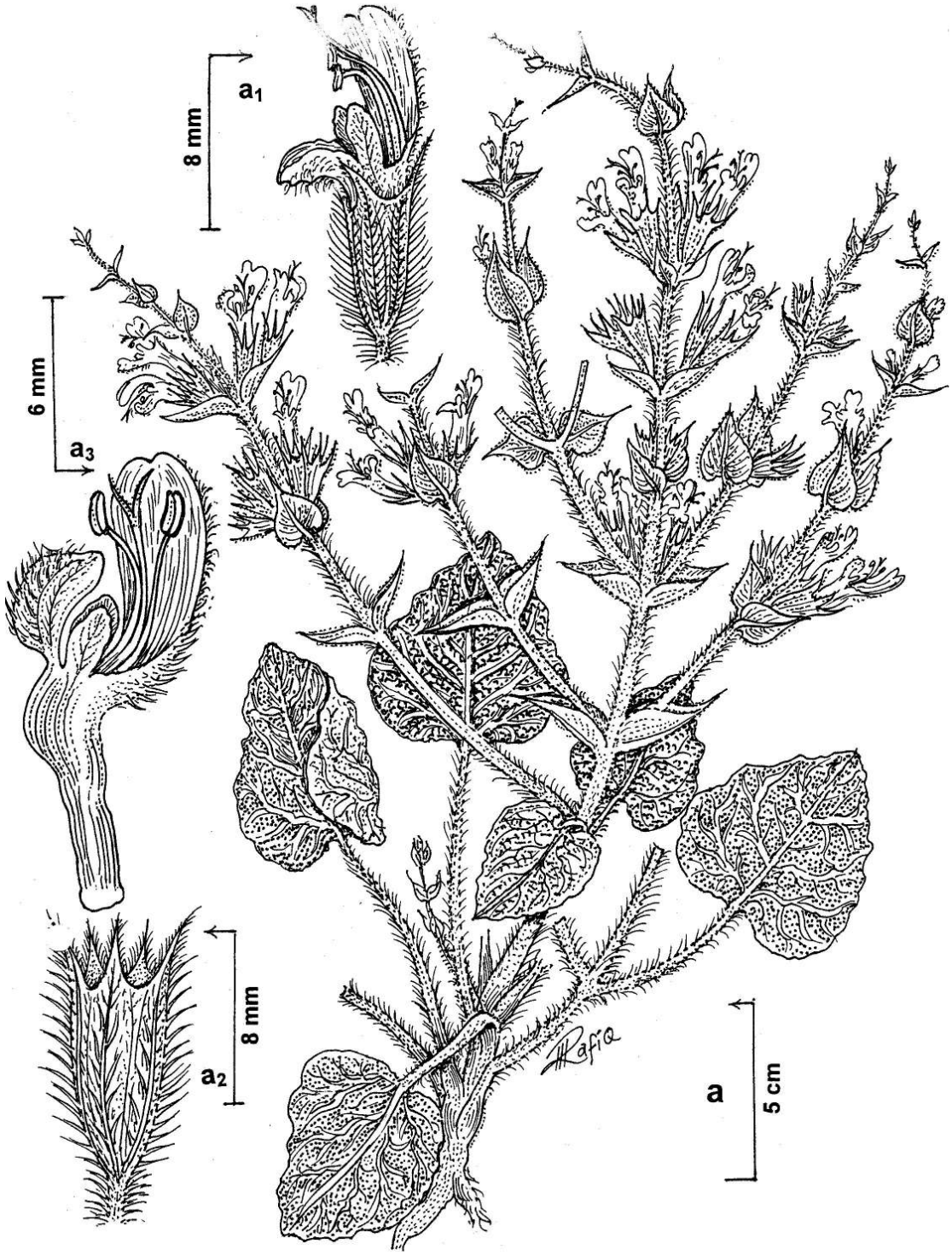
Appendix B 6. *Otostegia fruticosa schweinf* ssp *schimperi*. (a: branch, a_1: leaf, a_2: flower, a_3: flower, a_4: , a_5, a_6, a_7: flower ssp. schimperi).



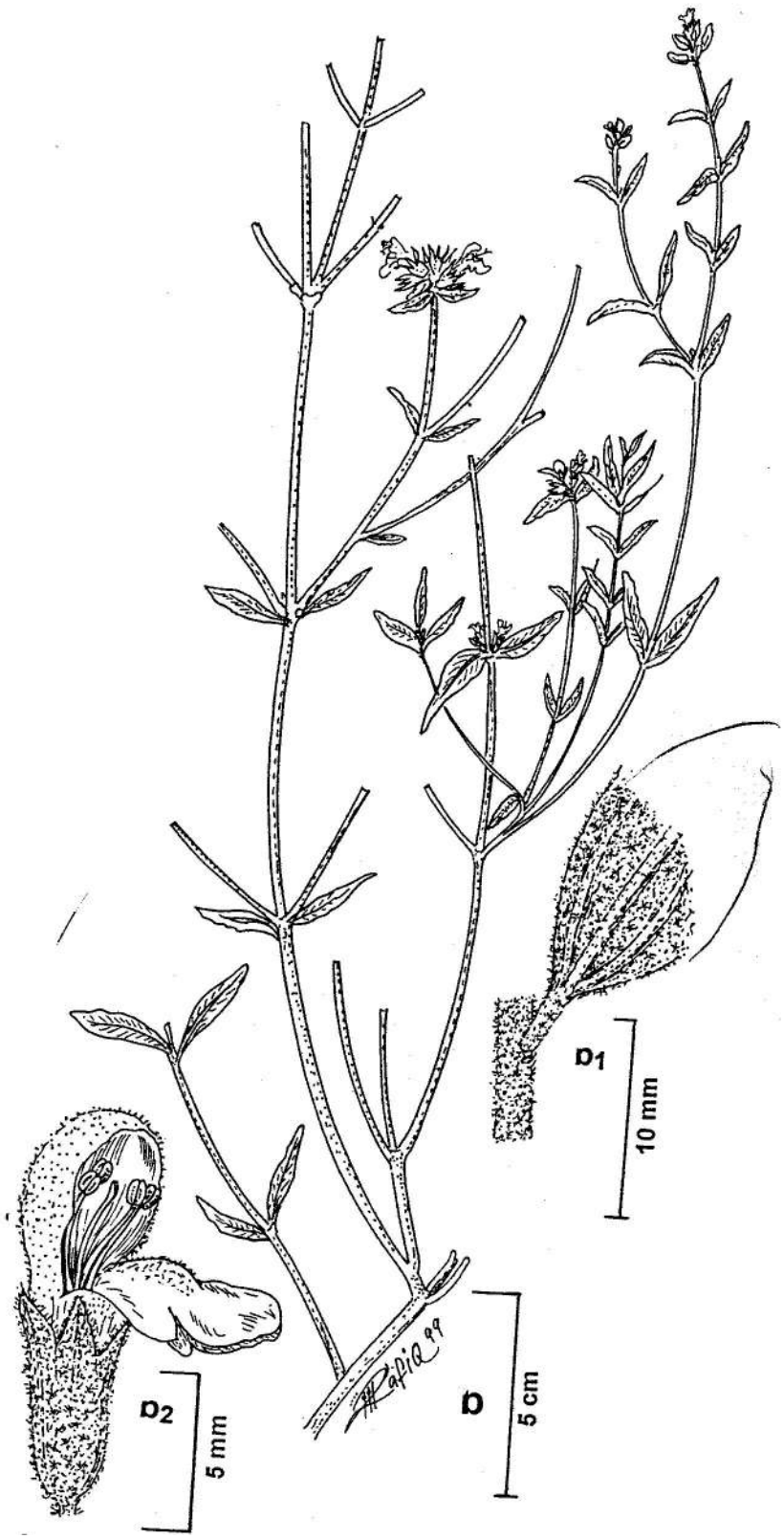
Appendix B 7. *Salvia aegyptiaca* L. (a: habit, a_1: part of inflorescence, a_2: flower, a_3: caylex, a_4: nutlet).



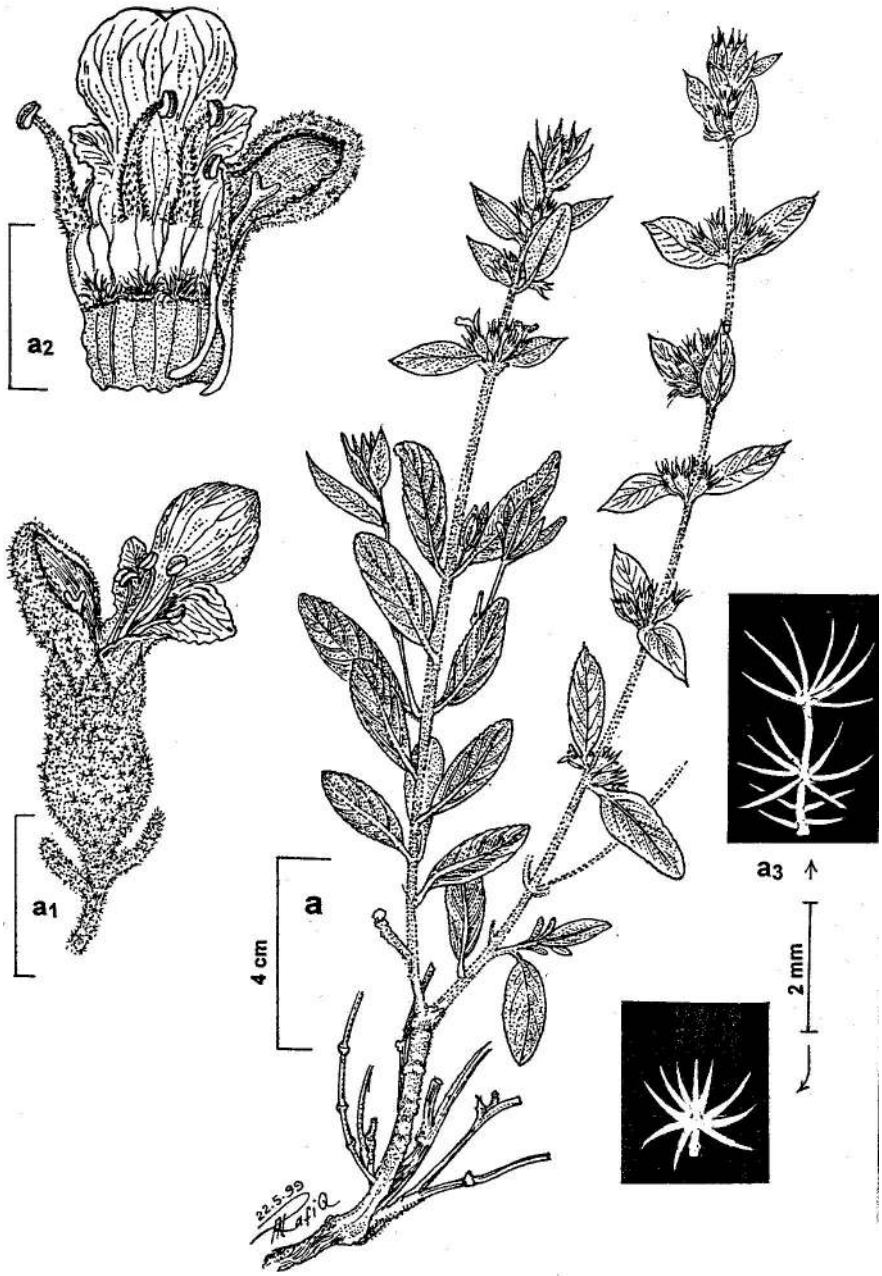
Appendix B 8. *Salvia deserta* Decne. (a: habit, a_1 and a_2: flowers)



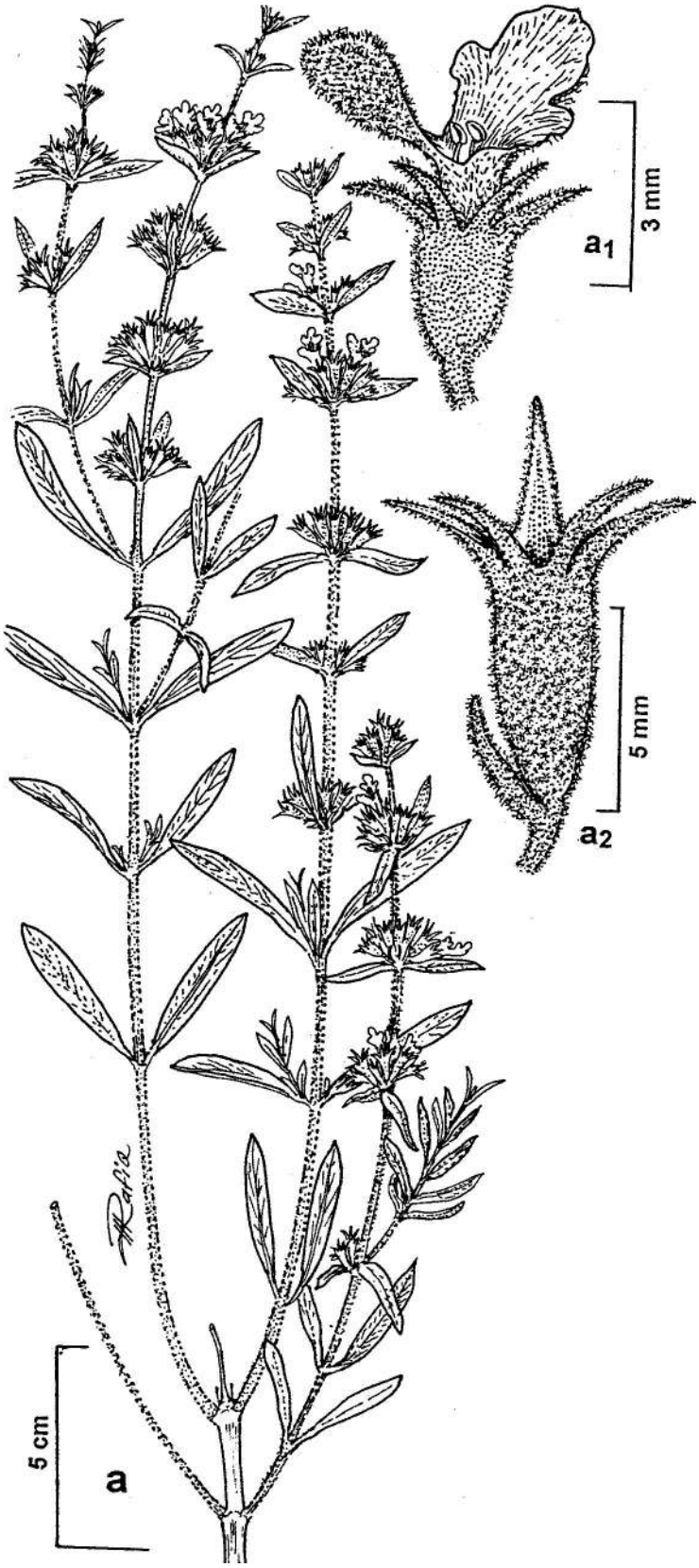
Appendix B 9. *Salvia spinosa* L. (a: habit, a_1: flowers, a_2: calyx, a_3: corolla).



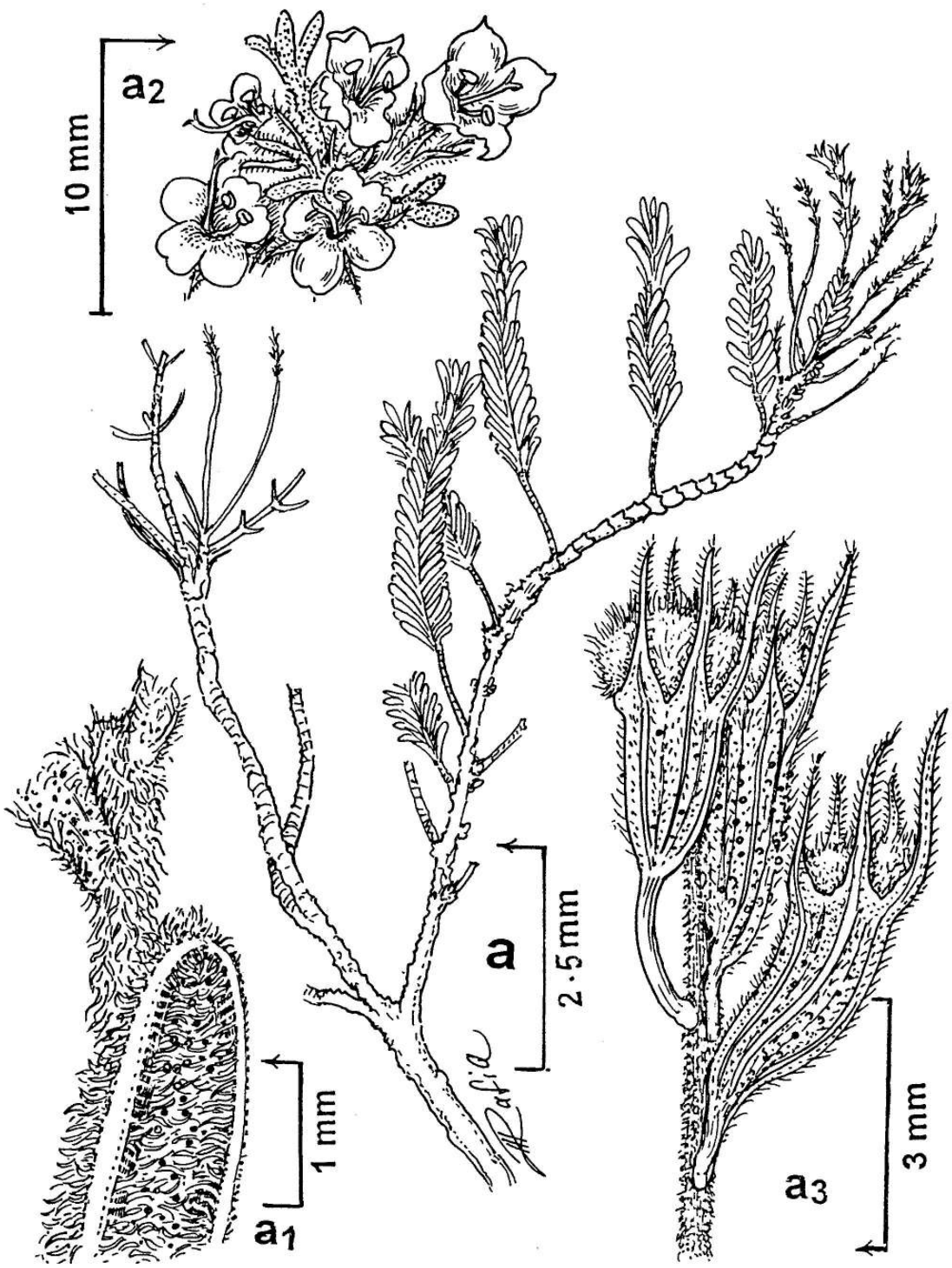
Appendix B 10. *Stachys aegyptiaca*. (a: branch, a_1: part of a leaf and stem, b_2: flower).



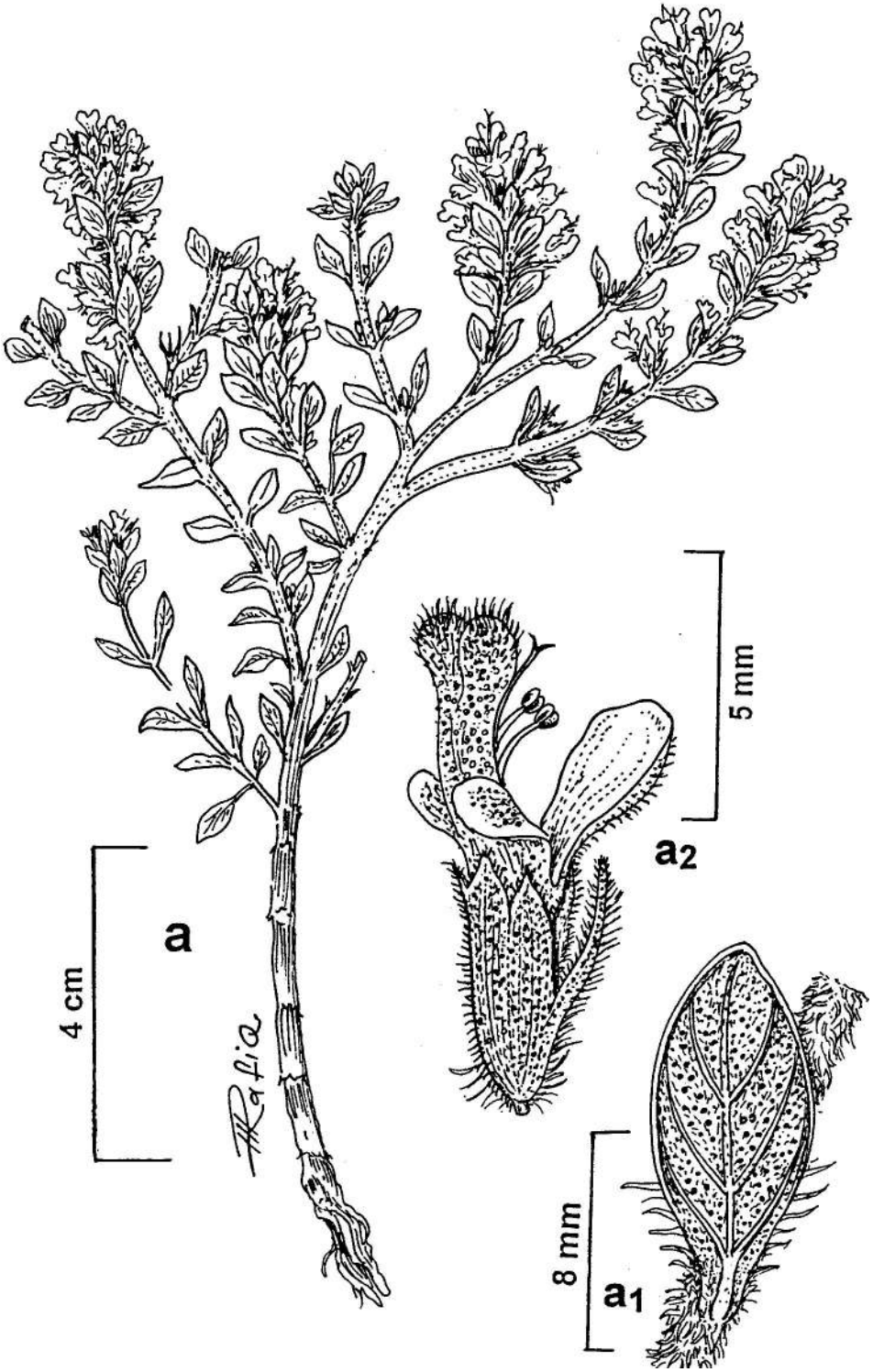
Appendix B 11. *Stachys schimperi* Vatke. (a: habit, a_1: flower, a_2: corolla cut open, a_3: hairs).



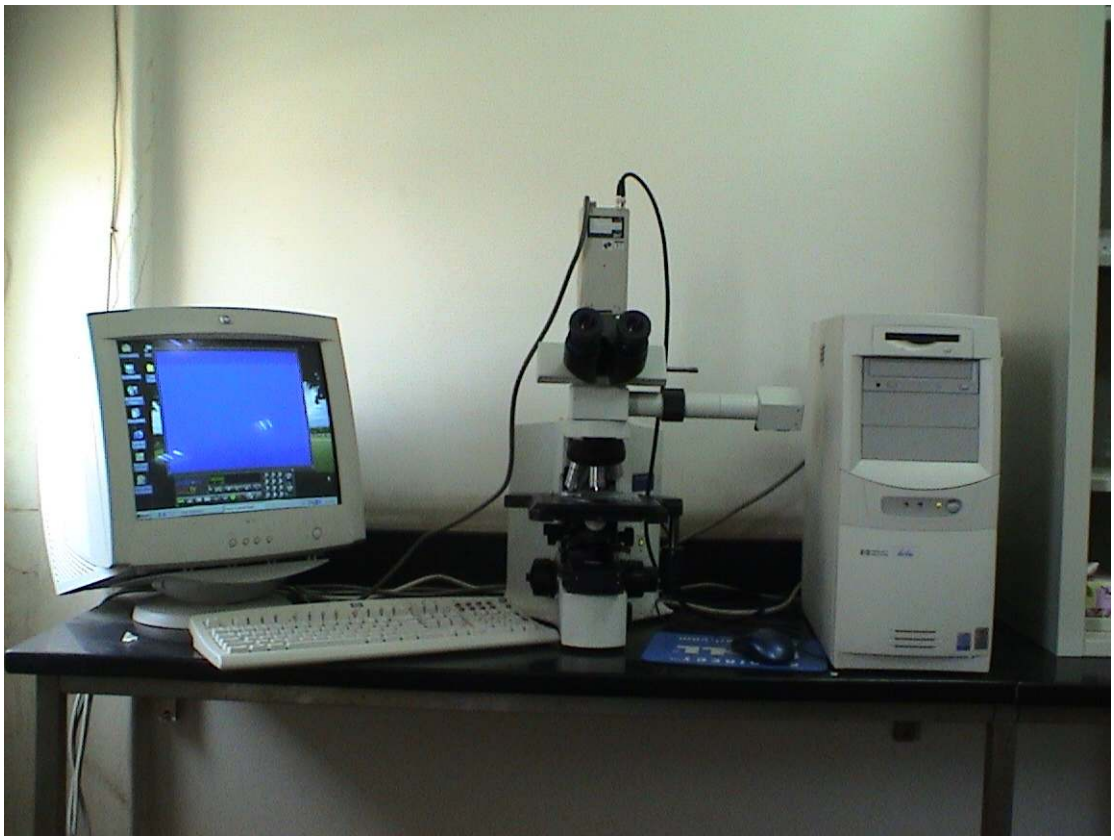
Appendix B 12. *Stachys yemensis* Hedge. (a: habit, a_1: flower, a_2: calyx).



Appendix B 13. *Thymus decussates* Benth. (a: branches, a_1: part of a branch and leaf, a_2: flowers, a_3: calyces).



Appendix B 14. *Thymus* off. *vulgaris*. (a: branch, a_1:leaf, a_2: flower).



Appendix C 1 Light Microscope, Olympus BX41TF with camera video TK – C1381EG, instrument used for photographing epidermal and internal characters of the species under study.