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Peperomiaophylites mohgaonensis gen. et sp. nov., a new genus of dicot leaf from the Deccan Intertrappean Beds of Mohagaon Kalan of Chhindwara district, Madhya Pradesh, India

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ABSTRACT

The black, fossiliferous chert was collected from Mohgaon Kalan in the Deccan Intertrappean Beds of Chhindwara district (Lat. 22.015027 N, Long. 79.186717 E). With the help of the cellulose acetate peel technique, consecutive peels were taken. The leaf was studied from peel sections. It is a dicotyledonous, dorsiventral (bifacial) leaf with a prominent midrib. From this site of Intertrappean beds, several petrified and imprinted impressions of dicotyledonous and monocotyledonous leaves have been discovered and described by multiple authors. However, only a few leaf petrification is reported from the DIB of Mohagaon Kalan, for example- *Acanthophyllum shiblii*, *Deccanophyllum intertrappea*, *Julianiophyllum sahnii*, *Corokiophyllum mohgaonkalanites*, *Salicaceophyllum mohgaoensis*, *Dorsiventrophyllum chitaleyii*, *Aerophyllites intertrappea*, *etc*. Upon comparing the specimen with the leaves of modern families, along with the reported fossil leaves, it exhibits a remarkable resemblance to the modern genus *Peperomia* of the family Piperaceae; however, it does not show much similarity with any dicot fossil leaf that has been investigated so far from the DIB of Mohagaon Kalan. Due to some unclear identification, the assigned genus *Peperomia* is somewhat ambiguous; therefore, it is named as *Peperomiaophylites mohgaonensis* gen. et sp. nov., forming a new genus. The specific name is derived from the fossiliferous locality of Mohgaon Kalan.

Keywords: Fossil, Dicot, Leaf, Deccan Intertrappean Beds, *Peperomia*

INTRODUCTION

This paper examines the anatomy of a dicotyledonous leaf from the Deccan Intertrappean beds of Madhya Pradesh. The specimen was collected from the well-known fossiliferous locality of Mohgaon kalan in Chhindwara district (Lat.22.015027N, Long.

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79.186717E). From the Deccan Intertrappeanbeds, many authors have so far described several dicotyledonous and monocotyledonous leaves. However, only some petrified leaves are reported, for example- *Deccanophyllum intertrappea* (Sheikh & Kolhe, 1980), *Dorsiventrophyllum chitaleyii* (Mistri et al., 1995), *Julianiophyllumsahnii* (Kapgate, 1998), *Corokiophyllum mohgaonkalanites* (Narkhede and Patil, 2003), *Salicaceophyllum mohgaoensis* (Kapgate et al., 2008), *Acanthophyllum shiblii* (Ramteke D. D. and Kapgate D. K.), *Aerophyllites intertrappea* (Chitaley and Patil, 1970).

The present specimen of a dicot leaf is considered to be similar to the genus *Peperomia* of the family Piperaceae, with a few notable differences.

METHODOLOGY

This petrified leaf is a fossil that has been preserved in silicified chert. The leaf was revealed in a cross-section after the chert was broken. Taking repeated peels of the material allowed the anatomical features to be investigated. It is carried out by etching the specimen with hydrofluoric acid and then applying cellulose acetate to it. After it dries, its peel comes off along with the thin layer of cellular details of the material. By repeating this process, we obtained serial thin sections of the material. The technique is popularly known as the serial peeling technique (Darrah, 1936).

DESCRIPTION

On observation of peel sections, it is clear that this preserved leaf is a dicotyledonous dorsiventral bifacial leaf, which shows a distinct midrib at the middle of the leaf lamina. The complete leaf specimen measures 1.4 cmin length, showing the good preservation of both arms. The midrib region is 831.6 × 589 µm thick. The left arm is approximately 926.3 µm long and 300 µm thick, and is completely preserved (Plate 1; photo 2). The right arm is measured about 1034.2 µm long and 300 µm thick and is also seen in completely preserved form (Plate 1; photo 3). The left-side lamina exhibits a single large bulge, located some distance away from the midrib.

This leaf specimen shows the following anatomical characteristics:

1. **Cuticle:** A somewhat thin but significant cuticular layer is present over the upper and lower epidermis of the entire leaf.
2. **Epidermis:** It is preserved in traces. It may be made up of thin-walled parenchymatous cells. The epidermis may consist of a uniseriate or multiseriatelayer with little sinuousness. The sinuous structure of the epidermis can be assumed based on uneven or sinuous occurrences of

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cuticle. Such a structure is found chiefly on the lower side of the midrib. At the juncture of the midrib and the leaf blade, a notch is found where the space between the cuticle and the palisade layer is greater; thus, the epidermis in this area is thicker and measures about 160 µm thick. The epidermis in the lamina on the upper surface is measured to be about 90-100 µm thick. (Plate 1; photo 6). The epidermis in lamina on the lower surface is about 50-60 µm thick (plate 1; photo 4).No trichomes are observed on the upper and lower epidermis.

3. **Cortex:** In midrib, below the 2-3 layer of palisade, some thick-walled cells are followed internally made up of angular parenchymatous cells without having any intercellular spaces, it can be considered as hypodermal cells, some mass of thin walled parenchymatous cells are present around the periphery of midrib and is extended up to the phloem. In this layer, some patches of thick-walled angular parenchymatous cells occur.

4. **Mesophyll Tissue:** It is a chlorenchymatous tissue present in the leaf and may be differentiated into palisade cells and spongy cells.

5. **Palisade tissue:** The palisade layers consist of elongated chlorenchymatous cells that hang down from the epidermis and are arranged compactly. Palisade cells are part of the chlorenchymatous mesophyll tissue of a dicot leaf. It is typically elongated and compactly arranged near the surface to facilitate photosynthesis. Such cells are visible in this leaf as fully brown-coloured cells. Brown colour deposited in the cell may be the fossilized chloroplast. In the present leaf, palisade is rarely seen in a compact arrangement. It occurs mainly in a loose form. Its shape and occurrence in the leaf, at different locations, are also quite unusual. The palisades in this leaf are in the form of elongated, cuboidal and polygonal shapes, at different places. In this petrified leaf, in the upper and lower portions of the midrib and in the lamina portion near the midrib, the palisade cells are seen elongated; otherwise, elsewhere in the leaf, it is cuboidal and cubical and roughly oriented. As the epidermal layer is obscure, the border of the leaf is demarcated by palisade cells and might have been considered the outermost layer of the leaf. The palisade in the midrib is present loosely in 6 to 7 layers under the upper epidermis and 3-4 layers beneath the lower epidermis. The first few layers of palisade cells are oriented vertically, whereas the rest of the portion is oriented

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randomly. In the juncture between the midrib and lamina, the palisade cells are seen concentrically oriented toward the hollow notch. Epidermal cells in this region may be larger in shape or multiseriate. A one-third portion of the lamina toward the midrib, at some places, features a columnar and compactly arranged single layer of palisade. At the lower epidermis and closer to the midrib, the palisade cells are even seen oriented horizontally. These cells on the adaxial side, at some places, are seen forming sunken stomata. At the lower surface, the epidermal gap is visible beneath the sunken stomata. Stomata are simple and sparse on the lower surface of the lamina.

6. **Mesophyll parenchyma/chlorenchyma:** : In dicot leaves, it is usually found in the form of spongy tissues and occurs beneath the upper palisade layer. In this leaf, the mesophyll is made of thick-walled parenchymatous cells, which may or may not contain chloroplasts without having any intercellular spaces within them. More than half of the lamina is composed of this type of mesophyll parenchyma without having any palisade cells. Druses are present throughout the leaf.

7. **Stomata:** In the present leaf, stomata are amphistomatic, present on both sides of the lamina. Some stomata occur on the lower left side of the midrib. Stomatal numbers are higher on the upper surface of the leaf lamina near the midrib. Stomata are simple and sunken as well. Stomata are sparse on the lower surface. It is identified by the appearance of a gap or depression in the brown-coloured palisade layer.

8. **Midrib:** It is oval to triangular. It is bulkier and 9 to 10 times thicker than the lamina. The thin layer of cuticle covers it. The space between the cuticle and the palisade is very narrow in the midrib. The cuticle of the midrib is roughly wavy, indicating a small, sinuous epidermis. The palisade is present along all sides of the midrib. It is 3-6 layers thick in the middle of the upper side of the midrib and 2-4 layers thick in the middle of the midrib from the lower side. The Palisade layers, located toward the inside, are followed by 1-3 layers of hypodermis, consisting of thick-walled, angular, parenchymatous cells. Underneath the hypodermis, there is a large mass of cortex made of thin-walled, angular parenchyma cells. It is about 300 µm thick. The pith consists of a large number of parenchymatous cells (Figure 1; Photo 5) without intercellular spaces, and it measures about 850 × 1150 µm. The pith occupies more

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than half of the midrib.

9. **Vascular bundle:** It is located in the middle of the midrib. No Vasculature is found in the lamina. In the midrib, a single large, dilated, cup-shaped vascular bundle is present. Thus, the vascular bundle in the present leaf is concentric, collateral, siphonostelic and close. Its presence may be obscure at the upper two corners of the midrib. Centrally, there occurred a huge mass of pith made of angular parenchyma without having any intercellular spaces. It has a number of small patches of thick-walled parenchymatous or cholenchymatous cells. No confirmed bundle sheath is there.
10. **Secretory canal:** Very few secretory canals are present, and they are found only in the lamina portion. (Figure 2; photo 9)
11. **Airspaces:** some air gaps are there only in the mesophyll area of the lamina (figure2; photo 10)
12. **Trichomes:** No trichomes occur on either surface of the leaf.
13. **Special feature seen in the left lamina:** A little distance away from the midrib, there occurs a bulge or swelling in the left lamina. This bulge is composed of large, thin-walled parenchymatous cells without any intercellular spaces. Some cells at the centre are larger. (Figure 2; photo 11)

From the above description, the following essential features are confirmed:

- This leaf is a dicotyledonous, dorsiventral (bifacial) leaf that shows a distinct midrib at the middle of the leaf lamina.
- Specimen showing the good preservation of both arms.
- The left side of the lamina shows a special bulge.
- Single or multilayered epidermis
- Absence of epidermal out growth.
- Mesophyllis differentiated into palisade and mesophyll parenchyma, but it is undifferentiated in most parts of the leaf, mostly toward the marginal side.
- Air spaces are more common in undifferentiated mesophylls in the lamina.
- Presence of hypodermis.

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- A single, prominent, U or dilated convex lid covered cup-shaped midrib containing central concentric, siphonostelic amphiscribral and closed vascular bundle. The bundle sheath is absent. Stomata-like gaps occurred on both epidermises.
- From the above discussion, the specimen described is confirmed as a dicotyledonous leaf.

For identification of the specimen, the above-mentioned characters of the fossil leaf are compared with the leaves of modern families as well as reported fossil leaves.

Comparison with fossil flora

The present dicot Fossil leaf obtained from Mohagaon Kalan of Chhindwara district of Madhya Pradesh (India) is compared with many so far investigated fossil dicot leaves. The present dicot leaf differs from them in many aspects. The differences are given below.

1) *Deccanophyllum intertrappea* (Sheikh & Kolhe, 1978) - has a saucer-shaped vascular bundle, and strictly differentiated palisade and spongy cells in the leaf.

2) *Deccanophyllum Chitaley*-, no secretary canal in the leaf.

3) *Gnetalophyllum deccanii*- Leaf is triangular and saucer-shaped with ridges and furrows.

4) *Acanthophyllum*: In this leaf, the hypodermis is absent, a sclerenchymatous ring surrounds the vascular bundle, and cystoliths are present.

5) *Dorsiventrophyllum intertrappea* (Sheikh & Kolhe, 1980): leaf is isobilateral, mesophyll is undifferentiated with large cells.

6) *Dorsiventrophyllum chitaleyii* (Mistri et al, 1995) – absence of siphonous vascular bundle in leaf.

7) *Dorsiventrophyllumagasheii* (Kolhe, 1980)—Absence of sinuous epidermis in leaf.

8) *Julianiophyllummohgaonensis* (R. W. Ukey)– midrib is acutely triangular and has lateral veins; hypodermis is absent.

9) *Julianiophyllum sahnii* (Kapgate, 1984)- Absence of sinuous epidermal cells; absence of Hypodermis; Triangular Vascular bundle.

10) *Deccanophyllitites shekhii*— In this leaf.Hypodermis is absent, and prominent palisade tissues are present under the lower epidermis.

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11) *Chitaleaophyllumintertrappea* (Kokate, Pundkar, Thorat, 2014) - Triangular vascular bundle covered by a sclerenchymatous bundle sheath.

12) *Salicaceophyllum mohagaonesis* (V. D. Kapgate, 2001) - Vascular bundle midrib covered by a two to three-layered sclerenchymatous bundle sheath, outer line of Midrib in the lower portion having a rough surface with several stomata.

Comparison with modern families

The present fossil dicot leaf is compared with the leaves of tropical modern dicot families, showing xeric and succulent characters. Only differentiating characters are considered for this comparison, such as

1. Julianiaceae - There is no hypodermis. Epidermal hairs and cystoliths are present.
2. Elatinaceae-A complete parenchymatous bundle sheath surrounds the vascular bundle. The vascular bundle is small, and aerenchyma is present.
3. Anacardiaceae - 2-layered palisade and papillose epidermis.
4. Apocynaceae-Laticiferous tissues and bicolateral vascular bundle
5. Cactaceae- The stem is photosynthetic cladophyll, and leaves are modified into spines
6. Asphodelaceae- Vascular bundles are scattered throughout the mesophyll, surrounded by sclerechymafibres
7. Euphorbiaceae- From midrib to margin, the leaf is continuously tapering with lots of scattered vascular bundles.
8. Amaranthaceae- The upper part of the epidermis is always at a lower level of the lamina.
9. Acanthaceae- Single lateral vein on both sides of the lamina
10. Schisandraceae- Bundle sheath of sclerenchyma
11. Winteraceae- Parenchyma contains large intercellular spaces.

In contrast to the families discussed above, genus Peperomia of family *Piperaceae* shows a resemblance to the characters of the specimen studied in the following sense:

The leaf is bifacial. In some species, epidermal cells are large and have thin walls. Different Peperomia species show different characteristics. Some species have uniseriate epidermis, while others have multiseriate epidermis. Minimal differentiation between palisades and spongy layer. Stomata are primarily present on the abaxial side of the leaf and are sparse. Mesophyll is usually made up of large isodiametric water-storing parenchymatous cells with few chloroplasts. Mesophylls have air spaces. All these

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characters show their succulent, epiphyte and terrestrial habit and habitat. This family is prevalent during the Maastrichtian period in the Deccan Intertrappean Beds. The leaf is bifacial. In some species, epidermal cells are large and have thin walls. Different Peperomia species show different characteristics. Some species have uniseriate epidermis, while others have multiseriate epidermis. Minimal differentiation between palisades and spongy layer. Stomata are primarily present on the abaxial side of the leaf and are sparse. Mesophyll is usually made up of large isodiametric water-storing parenchymatous cells with few chloroplasts. Mesophylls have air spaces. All these characters show their succulent, epiphyte and terrestrial habit and habitat. This family is prevalent during the Maastrichtian period in the Deccan Intertrappean Beds.

Conclusion

In the present leaf, there occurs a thin layer of cuticle that covers the entire leaf. Below the cuticle,a space exists between the cuticle and the palisade. This space is fragile around the midrib so that it may consist of a small polygonal epidermal layer. In the lamina region, this space is vertically wide, consisting of a single layer of epidermis followed by 1-2 layers of thin-walled, transparent parenchymatous cells, which are sometimes referred to as the hypodermis or collectively asmultiseriate epidermis. Such a structure occurs in some species of *Peperomia*, such as *P. obtusifolia* and *P. columella*. Most of the species of Peperomia are succulent viz., *P. ferryrae*, *P. nivalis*, etc. In the midrib, a large portion of parenchymatous cells is present both outside and inside the vascular bundle, which may serve as a site for water storage. Some patches of thick-walled parenchymatous or collenchymatous cells occurred in the pith, which may be there to provide the mechanical strength to the bulky midrib. The appearance of sunken stomata again favours its succulent nature. The occurrence of bulging in Lamia (for water storage), as seen in the present leaf, is also reported in some modern species of *Peperomia*, such as *P. obtusifolia*, *P. caperata*, and *P. rotundifolia*. Most of the lamina consists of undifferentiated, thick-walled mesophyll parenchyma tissue. These thick-walled mesophyll tissues give mechanical strength to the lamina, along with the purpose of doing photosynthesis. Sclerenchymatous cells are absent or scanty in the present leaf, thus showing its similarity with some modern species of *Peperomia leaf,viz., P. dolabriformis, P. columella*, etc.

Peperomia is placed in the family Piperaceae, which is a part of the clade Magnoliids of

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Angiosperms and is assumed to have diverged after the earliest Angiosperms, but before monocots and eudicots. The *Piperaceae* likely originated around 100-120 million years ago during the early Cretaceous period. The genus Peperomia, derived from the *Piperaceae* family, is part of the succulent lineage.

Peperomia species show diversity in habit and habitat. They are in the form of aquatic, terrestrial, epiphytes, succulent, understory herbs, shrubs, and small trees. The actual habit of the present leaf exhibits numerous characteristics from different species of *Peperomia*, with some minor differences, such as the lamina being thinner than the much bulkier midrib. Obscure appearance of uni- or multiseriate epidermis, and may be others. Hence, the new genus *Peperomiaophylitesmohgaonensis* gen. et sp. nov. is created. The specific name is after the fossiliferous locality Mohgaon Kalan.

Holotype: - MAN/ Dicot Leaf/ Deposited at Department of Botany, Dr Ambedkar College, Chandrapur.

Horizon: Deccan Intertrappean beds

Locality: - Mohagaon Kalan, Madhya Pradesh, India

Age: Early Cretaceous.

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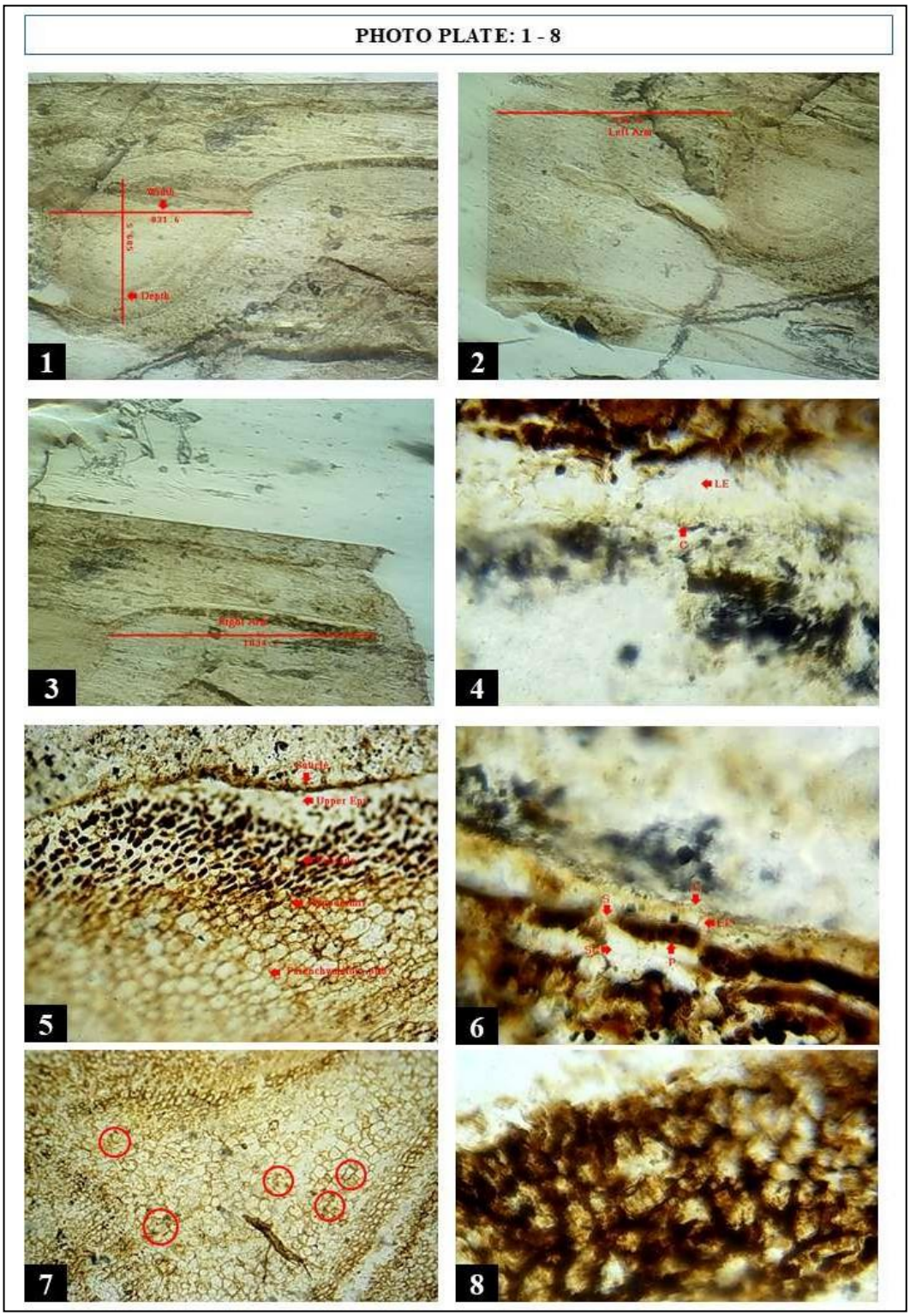

Figure: 1) Dimension of midrib; 2) Length of Left arm; 3) Length of right arm; 4) Photograph showing the Lower Epidermis (LE) and thin cuticle; 5) Parenchymatous pith region demarcated with xylem and phloem; 6)Well-preserved upper epidermis (EP) separating the thin cuticle (C) from palisade layer (P) along with the stomatal cavity (SC) below the stomata (S); 7) Mesophyll cells in the pith region (circled portion); 8) undifferentiated mass of cells in the lamina.

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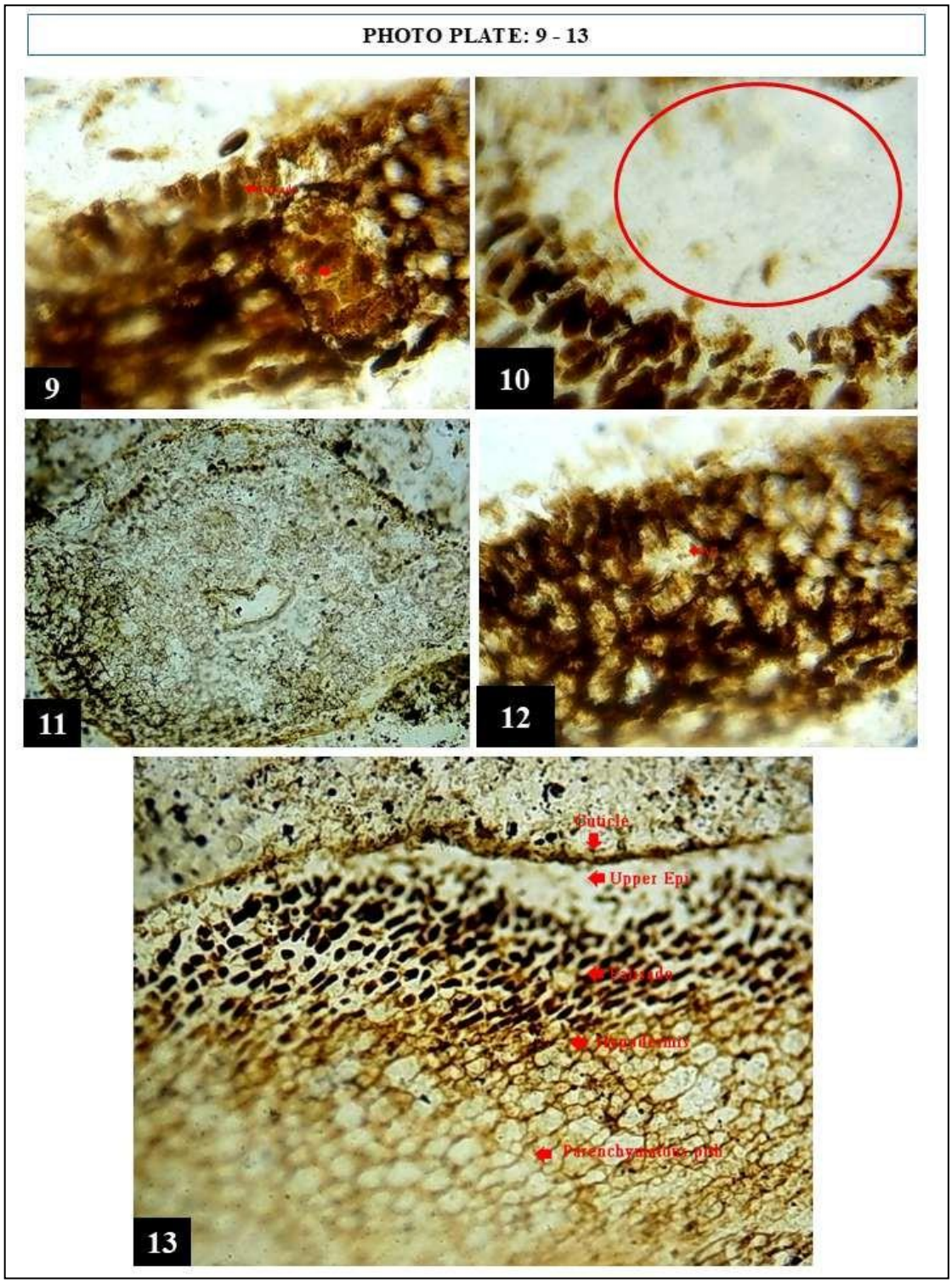

Figure: 2 - 9) Photograph showing the Secretary canal; 10) Gap between the juncture of the midrib and the lamina; 11) Bulged portion in the lamina near the midrib; 12) Small air cavity. 13) A photograph showing the palisade region separated by the upper Epidermis and cuticle on the outer side, while the hypodermis and parenchymatous pith are on the inner side.

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