Psilotum: Morphology, Anatomy, Reproduction and Phylogeny

The common name of *Psilotum nudum* is **Whisk Fern**

Salient Features of *Psilotum*:

i. The sporophytes are dichotomously branched with an underground rhizome and upright branches.
ii. The upright branches are leafless.
ii. Rhizoids present instead of roots.
iv. Stem have a relatively simple vascular cylinder.
v. The sporangia are borne in groups (trilocular) and form synangia.
vi. Spores produced are all alike (homosporous).
vii. The development of gametophyte is exosporic and form monoecious subterranian gametophyte.
viii. The development of embryo is exoscopic.

Sporophyte:

The plant body of Psilotum is sporophytic branched rhizome system and dichotomously branched, slender, upright, green aerial systems that bears small appendages and synangia (singular: synangium).

Fig.7.10: Habit

Aerial Stem:

Any one of the rhizome tips may turn upward and undergo several dichotomies to give rise to a green aerial shoot (Fig. 7.11 A). The aerial shoots are slender, generally erect but may be

pendent in epiphytes (*P. flaccidum*). They are perennial and become shrubby by repeated dichotomies and sometimes attain a height up to one meter.

The aerial axis may be cylindrical at base, furrowed in the upper parts, but somewhat flattened with three longitudinal ridges at the top. The basal part of the aerial axes is smooth but the distal part bears small, scaly appendages and synangia (Fig. 7.11 B, C).

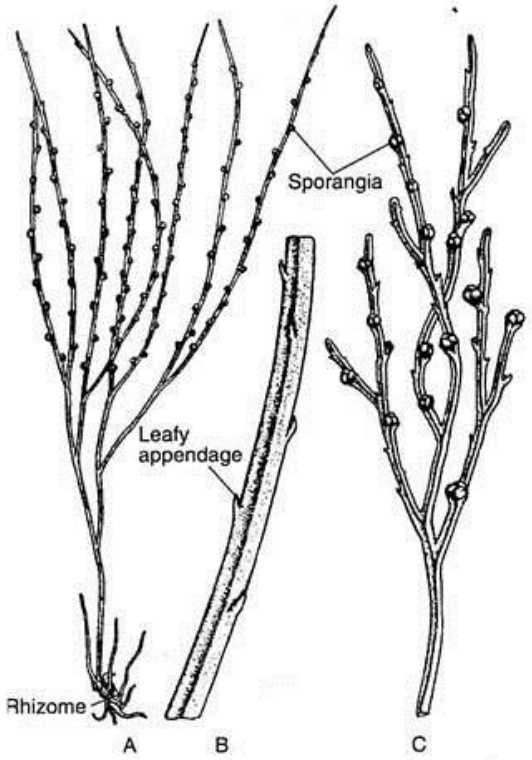


Fig. 7.11 : *Psilotum nudum* : A. A sporophyte plant, B. An enlarged part of stem showing scaly appendage, C. A fertile twig

The aerial stems are photosynthetic and the general appearance is xerophytic although the plants grow in very moist environment.

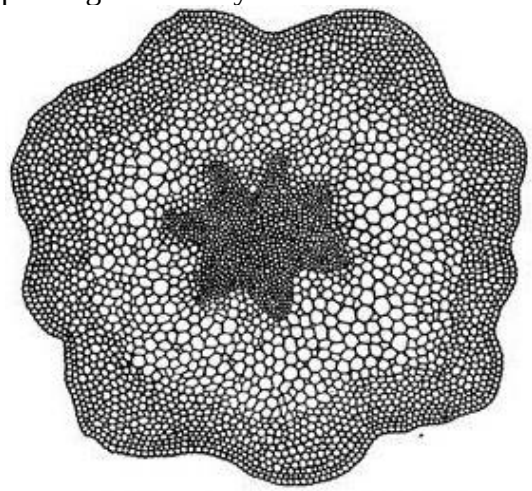


Fig. 7.12 : T.S. of stem of *Psilotum nudum*

In T.S., the aerial system is covered by an epidermis, followed by extensive cortical areas, single-layered endodermis and stele. The stele is siphonostelic in the basal part which becomes actinostelic in the younger branches (Fig. 7.12 and 7.13).

The epidermis is single-layered, in which the outer tangential cell walls are heavily cutinised and covered by a layer of cuticle. The epidermis is broken regularly by stomata (Fig. 7.12). The stomata of Psilotum do not have subsidiary cells.

The cortex is extensive and is divisible into three regions (Fig. 7.13). The outer portion (chlorenchymatous) directly beneath the epidermis consists of elongated, lobed chlorophyllous cells with intercellular spaces. This region is two- to five-layered thick and the cells are full of chloroplastids and starch grains.

Internal to this zone, there is a middle cortex of 4 to 5 layers of vertically elongated thick-walled sclerenchymatous cells without intercellular spaces. The walls of these cells apparently become lignified in the lower portion of the aerial stem.

These tissues provide mechanical support to the plant. Further inwards, there is a broader zone of parenchymatous cells (the inner cortex), the cell walls of which become thinner and thinner towards the centre. These cells are without intercellular space but contain more starch grains.

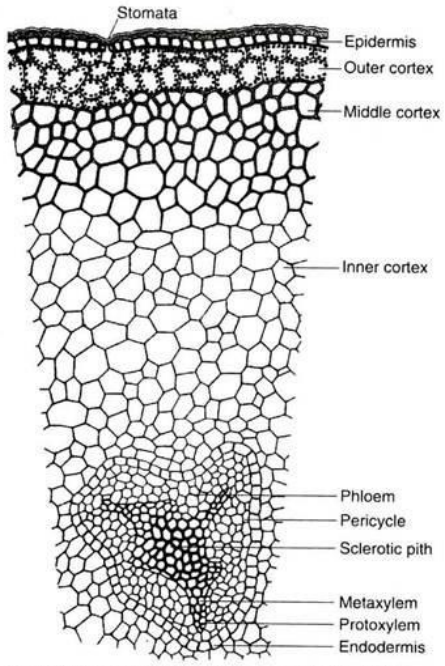


Fig. 7.13 : An enlarged view of a segment of T.S. of *Psilotum nudum* stem

The cortical tissue is bounded inwardly by a single-layered endodermis whose vertically elongated cells have a conspicuous casparian bands on the radial and end walls.

The centre of the stem is occupied by a ridged or flattened cylinder of primary xylem with protoxylem elements at the tip of each ridge. This cylinder may have as many as ten ridges near the transition region from rhizome to aerial stem. Fewer ridges are present in the more distal parts of the aerial stem.

A single-layered parenchymatous pericycle is present just below the endodermal layer. The phloem is internal to the pericycle and located between the ridges of the xylem.

At the extreme base, the stem is protostelic (actinostelic). In the middle portion the stele is siphonostelic as the centre of the xylem is occupied by a patch of elongated sclerenchymatous cells (sclerotic pith).

Rhizome:

The basal subterranean branched rhizome is generally hidden beneath the soil or humus. It bears numerous rhizoids, instead of roots, which perform the functions of absorption and anchorage.

In T. S., the rhizome reveals an outermost epidermis, cortex, endodermis, pericycle and stele (Fig. 7.14 A). The epidermis is indistinct and gives rise to 2-celled rhizoid. The cortex is extensive, parenchymatous and differentiated into outer, middle and inner layers.

The outer cortical layer is characterised by the presence of intracellular endophytic mycorrhiza. The cells of middle cortex are large with starch grains, while the cells of the inner cortex are often dark brown in colour because of the presence of phlobaphene (an oxidative product of tannins).

The stele is protostelic (haplostele or actinostele) and is surrounded by a well-defined endodermal layer with conspicuous casparian bands on the radial walls.

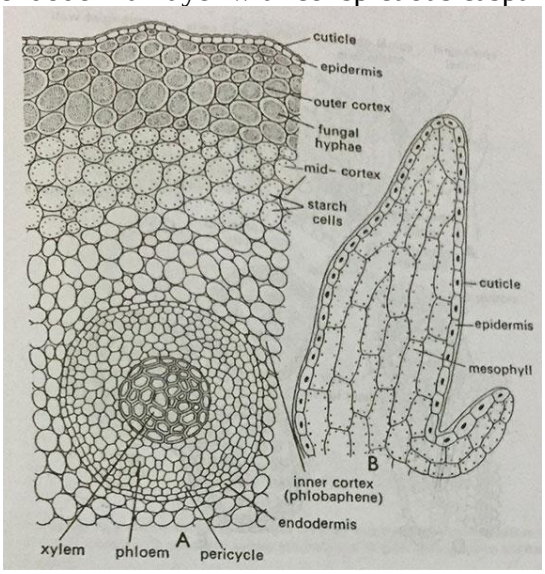


Fig.7.14: *Psilotum nudum*. A, portion of a transverse section of a rhizome showing mycorrhizal fungus; B, L.S. of leaf.

Appendages:

These are small scale-like structures (Fig. 7.14 B) helically arranged on the upper part of the aerialsystem. Internally, the appendage is composed of parenchymatous photosynthetic cells, bounded by a single-layered cutinised epidermis. There is no stomata in the appendages.

There is no vascular trace in the appendages of *P. nudum*, although minute leaf traces originate from stele in *P. flaccidum* which fade out in cortex.

Reproduction in *Psilotum*:

The *Psilotum* reproduces vegetatively as well as by spores.

i. Vegetative Reproduction:

The sporophyte as well as gametophyte of *Psilotum nudum* propagate vegetatively through the production of Gemmae. They are small, multicellular and ovoid structures developing on surface of rhizome (in sporophytic plant body) or prothallus (in the gametophyte).

After detachment from the parent body, gemmae of sporophyte may germinate to form a subterranean shoot.

ii. Reproduction by Spores:

Spore-Producing Structure:

At maturity, many of the dichotomously branched aerial shoots become fertile and produce trilocular sporangia known as synangia (Fig. 7.11C & 7.16A, B). The mature synangium is generally a three-lobed structure (Fig. 7.17A) and each lobe of the synangium corresponds to a sporangium.

The synangia located at the tip of very short axis, measuring 1-2 mm in diameter and closely associated with a forked, foliar appendage (Fig. 7.1 7B). At maturity, the synangium exhibits loculicidal dehiscence.

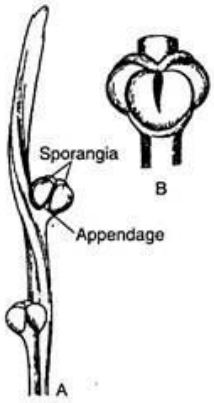


Fig. 7.16 : *Psilotum nudum* : A. A part of fertile axis bearing sporangia with bifid appendages, B. A trilocular synangia showing dehiscence

Gametophyte:

The mature gametophyte shows a striking similarity with a piece of sporophytic rhizome (Fig. 7.18A). It grows as saprophyte with an associated fungus.

Spores germinate exosporically to form the gametophyte. The mature gametophytes are brown, cylindrical, subterranean, radially symmetrical and usually dichotomously branched,

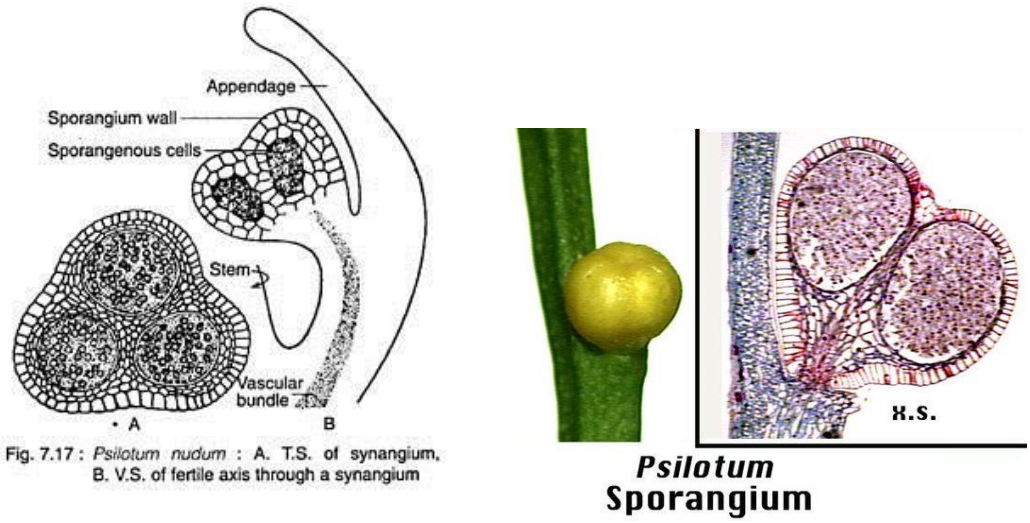


Fig. 7.17 : *Psilotum nudum* : A. T.S. of synangium, B. V.S. of fertile axis through a synangium

but may sometimes become irregular. The surface of the gametophyte is covered by long unicellular, brownish rhizoids. The gametophyte grows by means of apical meristem (Fig. 7.18A).

In T.S., the gametophyte reveals cutinized peripheral cells which encloses many-layered thin-walled parenchymatous cells (Fig. 7.1 8C). Many of the internal parenchyma cells are filled with the hyphi of a symbiotic fungus. It has been observed that in the gametophyte of tetraploid P. nudum, the centre is occupied by xylem with annular, scalariform and reticulate tracheids, surrounded by phloem and an endo- dermis.

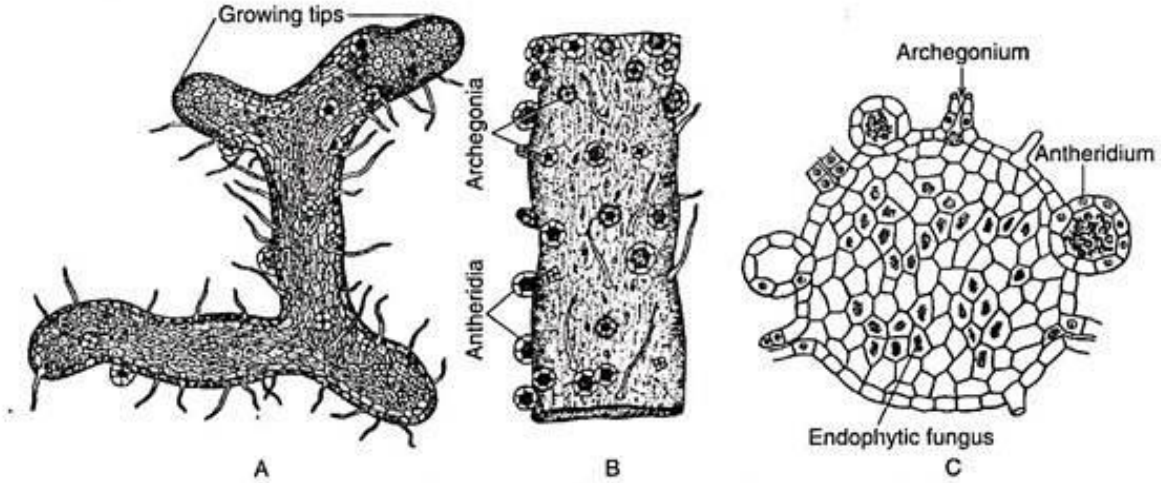


Fig. 7.18 : *Psilotum nudum* : A. A gametophyte, B. An enlarged portion of the gametophyte showing sex organs and rhizoids, C. T.S. of gametophyte

Thus, *Psilotum* is the only plant in the plant kingdom where the vascular tissues develop in the gametophytic generation. The external resemblance of the sporophytic rhizome and gametophyte, coupled with the presence of vascular tissue in the gametophyte, supported the homologous theory on the origin of alternation of generations.

Sex Organs:

The gametophytes of *Psilotum* are monoecious (i.e., homothallic). Sex organs i.e., antheridia and archegania, are superficial and scattered over the surface of the gametophyte. Generally, antheridia are more in number than archegonia.

Antheridium:

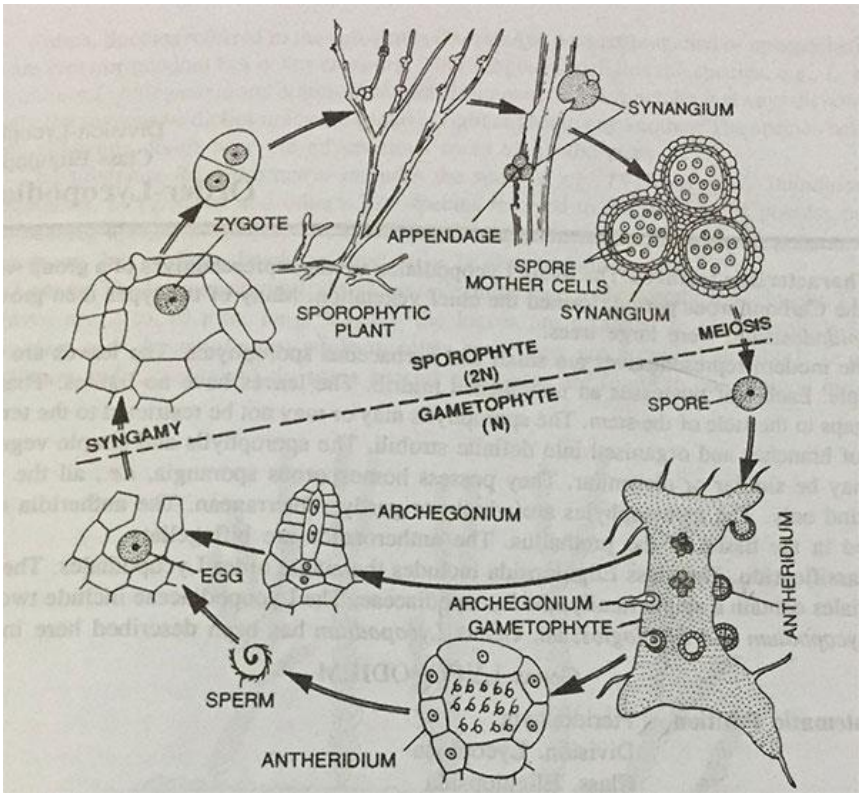
The antheridium projects above surface of the prothallus as a minute protuberance. Each androcyte eventually becomes a spirally-coiled, multiflagellate antherozoid and escapes by the disintegration of the opercular cell.

Archegonium:

The archegonium is also developed from a single superficial cell (archegonial initial) of the prothallus. There is a long projecting neck arranged in four vertical rows of cells with four to six cells in each row. The primary venter cell divides transversely to produce a large egg and a small ventral canal cell.

Fertilisation:

At maturity, the cell wall of the lower tier of neck cells becomes thick walled and cutinized. The apical tier, however, breaks away in presence of water and the mucilagenous contents of the neck cells are released. Thus, a free passage is formed for the entry of the antherozoids. Fertilisation is accomplished by the union of a multiflagellate sperm and egg, resulting in the formation of a diploid zygote.



Embryo (New Sporophyte):

The diploid zygote is the mother cell of the sporophytic generation. It shows exoscopic mode of embryo development. In this type of embryogeny the shoot forming apical cell is directed outward (towards the neck of the archegonium). The foot anchors the young sporophyte securely to the gametophyte and absorbs nutrients until the sporophyte becomes pysiologically independent.

Affinity with Rhyniopsida:

Psilotum and *Tmesipteris* resemble the earliest known Silurian-Devonian vascular plants . Rhyniopsida — in the following characteristic features:

1. The sporophytes are dichotomously branched with subterranean rhizome and upright branches.
2. Absence of roots and sporophytic generation bears rhizoids.
3. The branches are leafless e.g. *Psilotum.*
4. Sporangia multilayered, in rare instance are terminal.
5. Terminal branch shows protostelic configuration.

References:

http://www.comfsm.fm/~dleeling/svp/psilotum_nudum.html
http://botanystudies.com/detailed-study-of-psilotum-nudum-whisk-fern/
http://www.biologydiscussion.com/botany/pteridophyta/psilotum-features-reproduction-and-phylogeny/46152

Suggested Readings:

1) Vasishta, Pg 51-67
2) Singh, Pandey and Jain, Pg 45-55