Morphology of Blasia pusilla

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State University of Iowa

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MORPHOLOGY OF BLASIA PUSILLA.

by

Marguerite B. Rohret

A Thesis
submitted to the Faculty of the Graduate College,
University of Iowa, in partial fulfillment
of the requirements for the degree of
Master of Science.

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Iowa City

1916.
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Morphology of *Blasia pusilla*.

*Blasia pusilla* is a temperate zone liverwort of wide distribution. Schiffner (23) says it is found on moist clay ground in Europe even to the most northern point, also in America and Australia.

The species *Blasia pusilla* L. belongs to the Jungermanniales, (appendix 1), which includes about 135 genera and over 3500 species. This order of Hepatics is divided into the two sections Jungermanniaceae *Acrogynae* and Jungermanniaceae *Anacrogynae*. In the Acrogynous group the apical cell is given over to the formation of the archegonia, which are terminal, while in the Anacrogynous group, to which *Blasia* belongs, the archegonia are formed on the dorsal side of the thallus from segments cut off from the apical cell, so that apical growth is not hindered.

The sub-family Codonioideae includes eight genera of widely divergent variations. Here belong Pellia, Calycularia, Treubia, Fossombronia, Noteroclada, Petalophyllum, Simodon, and *Blasia*. The genus *Blasia* according to Schiffner (23) includes only one species *B. pusilla*. He mentions *Blasia javonica* but says it does not belong here.

Material and Methods.

The material for this study was collected near Cou Falls, on the Iowa City-Cedar Rapids Interurban. The plants were found growing about one-fourth mile southwest of the station, in a depression on the north-sloping bank of the creek. It has been found abundantly here and also in Muscatine County at Wildcat Den where it grows on dripping rocks. Conditions seem favorable for its more common growth in eastern Iowa but it has not been
reported except from these two localities.

The plants were collected in the summer of 1913, the spring of 1914 and the spring and summer of 1915. Large sods of the thalli were carried in wet paper into the laboratory and the material fixed before it had dried. Most of the material was fixed in chromo-acetic acid which proved very satisfactory, made according to the following formula:

<table>
<thead>
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<th>Ingredient</th>
<th>Quantity</th>
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<tr>
<td>Chromic-anhydride crystals</td>
<td>10 g.</td>
</tr>
<tr>
<td>Glacial acetic acid</td>
<td>10 cc.</td>
</tr>
<tr>
<td>Water (distilled)</td>
<td>1000 cc.</td>
</tr>
</tbody>
</table>

For external study material was preserved in copper-salt solution prepared as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
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<tbody>
<tr>
<td>Camphor 20 g. dissolved in 50 cc. of 95% alcohol</td>
<td></td>
</tr>
<tr>
<td>Glacial acetate acid</td>
<td>100 cc.</td>
</tr>
<tr>
<td>Copper acetate</td>
<td>30 g.</td>
</tr>
<tr>
<td>Copper chloride (CuCl₂)</td>
<td>30 g.</td>
</tr>
<tr>
<td>Distilled water</td>
<td>15 liters</td>
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</tbody>
</table>

For gross observation 1% formalin material was used and for other studies, especially the germinating gemmae, the plants were put into glycerin.

As the thalli are soft and delicate they were sectioned satisfactorily in 45° paraffin. Serial sections 10 microns thick were cut longitudinally, both vertical and parallel to the thallus and also transversely. Several stains were tried; Haidenhain's iron alum-haematoxylin; Delafield's haematoxylin; safranin, analin oil and gentian violet; but the best results were obtained by using safranin, and gentian violet with just a trace of orange G.
CHAPTER I.

Historical.

First mention of the genus Blasia was made by Micheli Nov. Pl. Gen. 1729. Linnaeus recognized the genus and added the specific name pusilla in his Species Plantarum 1753 p. 1138. In 1759 Schmidel wrote his "Dissertatio de Blasia". Hooker 1816 called the plant Jungermannia blasia but as this classification is much too broad it is not used today. Gottsche (28) 1828 published an account of the germination of the spores of Blasia pusilla. Later Gronland published his investigations of spore germination in the leafy Jungermanniae, including Blasia in his discussion. In 1833, Nees von Esenbeck (42) made some investigations on vegetative propagation and erroneously stated that the bud-receptacles (cupules) of Blasia are closed when young and open at the top at a later period. An incorrect figure of Hedwig's had probably given rise to this error. Hofmeister (30) included in his work on The Higher Cryptogamia, a short sketch of vegetative reproduction in Blasia, but some of his views are probably as faulty as those of Nees von Esenbeck (42).

The most comprehensive study of Blasia pusilla was the classical work of Leitgeb (35) 1874. His work was mainly on the general characters of the thallus, and on germa formation. The development of the gemmae was treated in detail, following closely the work previously done by Hofmeister. He also figured a few antheridia, several archegonia, and stages in the development of the sporophyte. Further work on the species was not reported until 1913 when W. E. Woodburn published his paper on the spermatogenesis of Blasia pusilla. This short but very excellent
paper includes the cytology of the spermogenous tissue and
development of the sperms from the mitotic divisions in the
spermogenous tissue to the mature form.

Acknowledgements

The writer wishes to express her appreciation to
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Staff for valuable suggestions.
CHAPTER II.

The Habitat of Blasia.

The Blasia bed at Cou Falls occupies a hollow in the creek bank sloping to the north and shaded from direct sunlight. The soil, a heavy yellow clay, was very sticky and soggy due to the great amount of water which seeped down from the overhanging forested slopes. The plant was so abundant that it gave the slope a bluish-green appearance.

Considerable Anthoceros was found here sending up its sporophytes between the branching thalli of Blasia. There was some difficulty in separating the two forms in vegetative condition, but the Blasia plants could be distinguished by their dichotomous branching and distinct midrib, while Anthoceros showed a more nearly circular thallus without a midrib, and with a convoluted margin. Conocephalus was also found in abundance around the edges of the depression as well as higher up on the bank, where the soil was not so moist. Very little Marchantia was found, but conditions probably were not favorable for its growth. Woodburn says, "Blasia requires a much more constant supply of moisture than do the leafy liverworts, but not so much as do the Marchantiales". Several common mosses as Mnium and Atrichum associated themselves with the Liverworts, but they did not form a very conspicuous part of the vegetation on this slope. In general, Hepatics grow in places free from disturbance, frequently on the north or east slopes where moisture is reasonably certain, and where transpiration is not excessive.
The Thallus.

Blasia pusilla has a flattened ribbon-like thallus, lying prostrate and firmly anchored to the sub-stratum by rhizoids for about three fourths of its length. The apical regions are free and grow somewhat inclined although the plants almost always point down the slope. The plant is characterized by dichotomous branching and has a broad midrib extending throughout its entire length on the underside. Along the midrib the thallus lobes are inserted horizontally and laterally. They resemble leaves but are termed thallus lobes, not being separated from the midrib and from each other.

We can see that Blasia is distinctly transitional between thallose and foliose forms of Hepatics. Among the simplest Jungermanniales are Aneura and Metzgeria. The former has a fleshy branched thallus with its broad midrib never sharply defined, and sex organs arising from short lateral branches; the latter has a membraneous, linear thallus dichotomously branched, with sharply defined midrib, and sex organs on reduced ventral branches.

Pellia epiphylla, somewhat similar to Blasia, has a thallus about 10 mm. wide expanded at the lobed apex with a broad mostly indistinct midrib. The antheridia are formed behind the archegonial inflorescence. Pellia Neesiana, more nearly like Blasia, has a narrow thallus of almost uniform width, less lobed than Pellia epiphylla. This form might easily be mistaken for Blasia. Petalophyllum with its short basal cylindrical stalk-like portion, has a fan-like expansion simple or forked with erect leaf appendages. The archegonia are formed in groups on the sides of the dorsal surface of the midrib, surrounded by protecting scales.
From this transitional zone we pass forward to the other extreme where we find the leafy Fossombronia and Haplomitrium. Fossombronia with its fragile creeping stem, simple or dichotomously branched, shows leaves in two rows inserted obliquely on the stem. The archegonia and antheridia form on the dorsal surface of the stem near the leaf insertion. Haplomitrium, a step farther advanced, has erect stems arising from a fleshy rhizome-like basal portion. The leaves are arranged radially more or less regularly in three rows. This arrangement is decidedly different from the other Hepatics, which have their leaves arranged dorsi-ventrally. The archegonial inflorescence on the upper part of the stem is without an involucre.

Although the thallose forms are successful in their own restricted habitats, they cannot compete with the foliose forms in more favored regions. Thalloid forms are in danger of being crowded out by the overgrowth of surrounding thalli, or covered by the washing of soil. They may also be more accessible to insects and snails. In erect and semi-erect growth competition is not so great and more plants can thrive in a given area. Again leaves inserted obliquely or transversely to the stem provide protection for the growing point, which is not possible when the leaves are parallel to the stem. Another important factor influencing plant growth is light. Prostrate plants are unable to raise themselves into a position where light is favorable, if crowded, while erect leafy forms can rise above the small neighboring plants and expose a greater photosynthetic surface to the light.
Structure of the Thallus.

Blasia has a relatively simple thallus. In cross section it shows wing-like extensions projecting out from the midrib which is found on the underside. The tissue is for the most part composed of uniform cells, with thin walls. Chloroplasts are numerous in all the cells throughout the thallus with possibly a few more in the top layer. No air chambers or pores were found. The midrib which is slightly depressed on the dorsal surface, and bowed out on the ventral side is eight to twelve cells in thickness. From the midrib toward the point of lobe insertion the thallus narrows gradually to the margin of the wings, which are one cell thick (fig. 2).

The only differentiation in the structure of the thallus tissue was first noticed in cross sections, where groups of cells varying from 9-36 in number, stained more deeply than the surrounding tissue (fig. 3). This differentiation suggested a strand of cells set apart for some special purpose, probably to function in conduction.

Conducting tissue has been reported in three of the Anacrogynous Jungermanniales, and nowhere else in the Liverworts. Sir William Hooker 1816 discovered the strands in Jungermannia now Pallavicinia sinnuata and Leitgeb (35) describes the cells of this strand in Symphyogyna and states that Blyttia (Pallavicinia) and Umbraculum (Hymenophyton) have similar strands.

The elongate cells forming these strands seem very much like those described for Symphyogyna. In fresh young plants they can barely be distinguished but in the old dead thalli they stand out on the surface as white threads (fig. 1). This would indicate
that the cell walls are more resistant in the strand than in the surrounding tissue and the few experiments tried only serve to emphasize this fact. Upon the decay of the spongy thallus tissue these strands still hold their shape and can easily be picked from the soil surface. Drying has the same effect, entirely destroying the soft portion but leaving the threads unaffected.

A weak eosin solution was used to test the conducting power of these cells, but the experiments were not wholly satisfactory as the whole thallus took the stain. There was a marked difference in degree, in which the strands stained as they became much darker than the surrounding cells. But even this would seem to indicate that more of the fluid was retained in the strands than in the remainder of the thallus.

Generally, only two strands were found in a single thallus but the number varies from two to five, depending on the amount of branching. They are found laterally in the thickened midrib of Blasia about equidistant between the dorsal and ventral surfaces. Where the thallus branched the strand divided giving off branches to each newly formed division. The angles of the cell walls were quite sharp in the transverse section but other markings were not found here.

In the longitudinal section (fig. 4) a greater difference was noticeable. The conducting cells, averaging the same in width as those of the thallus, had a length three to five times greater, tapering to a point at each end. Cross walls sometimes run obliquely through these long tubes. The most striking characteristic was the peculiar markings of the cell walls. The pits or depressions arranged irregularly along the walls are thin at the center and bordered by heavy darkly staining
thickenings, giving the external appearance shown in (fig. 5). These thickenings show at fairly regular intervals along the wall in the prepared sections. Where the strands join the spongy tissue on either side, only the inside walls bear the markings. The strands undoubtedly serve in a mechanical capacity, being provided with such strong walls, but it is doubtful if this is their most important function. It does not seem consistent, that a thalloid liverwort, attached by rhizoids for three fourths its length, would need such strengthening as the strands might give, however it is possible in the case of Blasia pusilla, that the resistant cells aid in giving body to the thallus upon which are found the gemmae receptacles and large sporophytes. Gottsche found that in Symphyogyna they had no connection with the "receptacles" on which the sexual organs were seated.

These strand cells do not show nuclei, but simply a disintegrated substance, probably protoplasm, as it took the stain as readily and to about the same degree as the protoplasm in the surrounding cells.

In testing the plants in concentrated sulphuric acid, the thallus was found to melt away quite readily in from one to three hours, leaving the strands seemingly unaffected by the acid. At first the tissues of the thallus swelled considerably but soon broke down and the residue assumed the consistency of jelly.

The strands, freed from the acid, were stained and mounted in balsam. They did not break down during the process but remained rigid and resistant. The mounts showed the identical markings seen in the prepared longitudinal sections.

As most liverworts thrive only in moist habitats, the whole surface, if close enough to the sub-stratum might absorb
all the water needed or the thallus might be provided with rhizoids which perform the same function. With an increase in specialization in these forms, as erect branches or parts raised above the thallus surface, it would seem almost necessary to have some sort of conducting system, more or less complex.

Chick and Tansley (46) say the following in regard to the three liverworts having conducting tissue: "The three genera Pallavicinia, Steph., Symphyogyna, Nees et Mont., and Hymenophyton, Steph., differ in well-marked characters connected with the position and investment of the sporogonium, and it is perhaps most probable that the striking character they have in common—"the possession of an axial strand"—has developed independently in each genus. The strand cells are formed, as might be expected, by longitudinal division of the inner cells cut off from the segment of the apical cell and are differentiated very closely to the apex".

The Growth of the Thallus.

The growth of the thallus proceeds by means of a wedge-shaped apical cell (fig. 6). This type seems characteristic of the dichotomously branching forms, for the cell can be divided into two segments alike in size and shape and like the original apical cell. As each segment cuts off segments from its inner face the two apical cells are pushed farther apart, and the dichotomous branching results. Leitgeb (35) says, "The growth of the shoot results through the division of the "vertex cell", which from a four sided segment, cutting off to right and left and dorsal and ventral sides. We find the same method of growth in the segments of Aneura and Pellia and the leaf-building segments of Fossombronia and Frullania. The segments cut off from
the right and left sides of the apical cell, develop the side leaves, while those cut from the dorsal and ventral sides take part in developing the branches. Those on the ventral side form hair papillae and scales." Some from the dorsal side form the sex organs.

Ventral Differentiations.

The two-celled mucilage hairs, found on both sides of the thallus, originate from a superficial cell which pushes out from the surface. This cell divides once, the basal cell retaining its nucleus and chloroplasts the outer one breaking down into a mucilaginous substance, which stains very deeply. These hairs usually turn inward toward the apical cell, and form a protection for the growing point and for the younger sex organs which are found near the apex. The mucilage hairs do not seem to be deciduous, for old ones are found far back on the thallus after the growing shoot has elongated and formed new hairs at its tip.

The ventral side of the thallus develops smooth, unicellular, colorless rhizoids. These hair-like structures are merely outpushings of the epidermal cells along the midrib (fig. 8), which function both as anchorage organs and water absorbers. They are often so numerous that they form thick mats along the midrib, and the plants can be lifted from the soil only with difficulty.

The under leaves are scale-like appendages called amphigastria. They are usually several cells in thickness at the center and one cell at the margin. These scales have denticulate margins in contrast to the entire margin of the thallus (fig. 9). They are easily detached and may give rise to new plants. No
doubt the amphigastria are rudiments of the ventral row of leaves commonly found in the leafy liverworts, and may assist in holding water.

We have a final ventral differentiation in the leaf auricles. These appendages begin as plates of cells pushed out from the lower epidermis of the thallus. Their marked incurring produces a hollow, globular structure which becomes filled with Nostoc. As the cells are pushed out a mucilage papilla is formed at the outer margin which gradually curves inward (fig. 11). Another mucilage papilla pushes out from an epidermal cell into the hollow already formed. After the formation of the leaf auricle, it is infected with Nostoc which finds entrance at the point where the mucilage hair touches the thallus. In the young stages we find an aperture here but later the auricle is completely closed (fig. 12). Seen from the top of the thallus the Nostoc Colonies appear as tiny black spots embedded in the tissue.

At the time Schmidel (44) studied Blasia there was some uncertainty as to what the Nostoc might be. Schmidel in his "Dissertatio de Blasia" considered the auricles as antheridia and the individual cells as sperms. Quoting from his paper we have the following: "Paullo post ortum ex luteo amoene viridescunt (globuli), pellucidi sunt et gemmularum instar splendent absque dubio propter succorum, quos continent, tenuitatem; sensin vero profunduis sew intensius virescunt. Pleniorem dein maturitatem adepti in nigrorem vergunt et opaci fiunt: in quibusdam exemplaribus aliqui ex obscure viridis colore intense nigrescunt. ( VII.). Globulos igitur si consideramus, eorumque situm, contenta, durationem et reliqua supra descripta perpendimus, talia in iis deprehendimus attributa, quae organis masculinis vel penitus, vel omnium
maxime competunt (XVIII.)."

Bischoff (1835) called the Nostoc colonies antheridia but a few years later Nee von Esenbeck found the real antheridia and called the Nostoc "Keimkörnerknötzchen". Hofmeister (30) held that the organs were reproductive buds basing his idea on their analogy with what he called "the undoubted buds of Anthoceros" developing in the same manner. He says, "It is well known that numerous reproductive buds are formed on the under side of the stem of Blasia. The contents of one of the inner cells of the tissue of the stem, (which cells are only separated from the under side by a single cellular layer become transformed into a cell occupying the whole cavity of the mother-cell. This daughter cell changes into a roundish body, composed of small cubical cells which contain numerous very small chlorophyll bodies of a dark bluish-green color. The cellular layer of the under surface of the stem which covers the reproductive buds becomes swollen to a hemispherical shape by the increase in size of the latter. I have not seen these reproductive buds develop into young plants".

Corda (18) figures the germination of the Nostoc cells and calls them new plants of Blasia. These erroneous ideas were not corrected until Leitgeb's work was published 1874. He gave a good description of the structure and origin of the peculiar chambers, but failed to show the fully developed auricle. Coker (16) says, "By pressing out the Nostoc he (Leitgeb) found that the colony was penetrated by clear cells, which he correctly deduces to be branches of the Blasia thallus that have arisen from the slime-secreting hair that was present in the young stages. There grows up from the floor of the chamber a tree-like structure with a single trunk (fig. 13), and from the repeated ramifications of
this tree the whole colony becomes interwoven with cells which doubtless serve to abstract nourishment from the algae. This whole ramifying structure has in all probability come, as Leitgeb thought, from the subsequent growth of the slime-secreting cell. In other cases of such symbiotic relationships, as Anthoceros, there are, likewise, cells growing in from the host plant; but in all such cases, so far as I know, these outgrowths originate, not from a common base, but separately and at many points. The striking arrangement of Blasia seems to be confined to it alone".

The host plant cells no doubt take nourishment from the colonies of algae and they may also serve as water reservoirs as do the mucilage hairs. That Nostoc is absolutely necessary to the growth of Blasia has not been ascertained, but it is true that small colonies are found in the young thalli very soon after the germination of the gemmae.

The dorsal differentiations include the sex organs, the calyptra, and the cupules, in which the asexual reproductive bodies are produced.
Chapter III.

The Antheridium.

Blasia is dioecious, the plants bearing antheridia being much more slender and more deeply lobed than those bearing archegonia.

The male plants are 10 to 20 mm. long and 1 to 2 mm. broad. They bear 10 to 35 antheridia which are formed in two rows one on either side of the thick part of the thallus. At first, the antheridia are naked on the thallus but gradually they are covered by an over-growth of thallus tissue.

As early as May 5th, small thalli were found having 2 to 6 antheridia. By June 1st, the number had reached 12, and by July 15th they had increased to between 20 and 35. The antheridia do not mature at the same time owing to their method of development. After the dorsal segment is cut from the apical cell, this segment proceeds to develop into an antheridium, and apical growth continues unhindered. This process is repeated until many antheridia are produced, and nearly all stages of development can be found on the thallus.

The antheridium begins as a papilla (fig. 14), formed from the dorsal segment of the apical cell. After the first transverse wall is laid down the lower cell forms the stalk while the upper cell or antheridial initial again divides transversely. This two-celled antheridium now divides vertically, or at right angles to the first wall, so at this stage it shows four cells either in longitudinal or transverse section (fig. 16). The next division cuts off cells around the periphery to form the wall. The enclosed (fig. 17) spermatogenesis tissue divides very rapidly forming
many cubical cells, each with a large nucleus occupying nearly half the cell (fig. 20). This nucleus stains very deeply while the cytoplasm being finely granular takes a medium stain. The mature oval antheridium is attached by a short stalk to the bottom of a small pocket, formed by an overgrowth of thallus (fig. 22). When the sperms are mature the antheridial wall breaks down, seemingly gelatinizes, and allows the sperms to escape. The introduction of water into the antheridial pocket probably aids in breaking down the wall and releasing the sperms. The sperms are exceedingly small and mature in great numbers. As they have been fully described by Woodburn (51) in his study of the cytology of spermogenous tissue, and formation of sperms in Blasia pusilla, it will not be necessary to trace their development in this paper.
CHAPTER IV.

The Archegonium.

The female plant is much shorter and more bulky than the male plant being about 10 to 15 mm. long and 3 to 5 mm. broad. It is not so deeply lobed along the margin but has a cup-like involucre of lobes at the apex surrounding the group of archegonia. Archegonia were first found about the first week of June, so it seems probable that their development is longer delayed than that of the antheridia. The archegonial initial is similar to that of the antheridium except that it is a trifle smaller (fig. 23). After the first transverse division there is a marked divergence in the development. The second division of the archegonium is obliquely vertical cutting off a wall from the outer cell (fig. 24). Later two more curved walls are laid down cutting out a triangular central cell. A transverse wall cuts off a lid from the top and the primary central cell divides again forming the venter and mother-cell of the neck canal series (fig. 26). The last division in the venter gives rise to a large egg and a relatively small ventral canal cell above it. The neck canal row and its surrounding jacket develop simultaneously, the former arising from the primary neck canal cell (fig. 27), and the latter from divisions in the lid cell.

The egg may be fertilized while the archegonium is at the apex of the thallus, but very soon it becomes imbedded in the center of the midrib, with an overgrowth of thallus completely enclosing it. Often ten or twelve archegonia are found on a single thallus but most of them are not fertilized, their content showing very dark brown.
The antheridia and archegonia being formed on separate plants, fertilization presents a problem. The sperms must have a watery medium through which they can be carried. Probably the most satisfactory mode of sperm transfer would be through the splashing of raindrops on the thallus.

While the archegonia are numerous, usually but one sporophyte is formed on each plant. In a few broad thalli, two sporophytes were found one on each branch.
CHAPTER V.

The Sporophyte.

Young sporophytes were first seen early in August. They appeared as little, hard swellings in the midrib half way between the apex of the thallus and the base. After fertilization, which occurs about the middle of July, the thallus grows completely over the archegonium enclosing it in a cavity. The archegonial neck gelatinizes (fig. 31), but the venter enlarges and thickens, forming a protective calyptra about eight cells in thickness.

The gametospore, now a globular mass, enlarges and fills the entire venter cavity. The subsequent divisions of the gametospore must take place rather rapidly for all the stages found were collected during the earlier part of August. The first division of the embryo is transverse and cuts off the lower third of the gametospore (fig. 32), which part eventually forms the foot of the sporophyte. Another transverse wall divides the epibasal cell into two parts the lower cell not quite so large as the upper one. The middle cell of the three is the stalk initial and the upper one launches the sporangium (fig. 33). Division is rather long delayed in the two lower cells but takes place at once in the top portion. The earlier divisions are vertical, cutting out three elongate cells, while the latter ones are transverse. For a short time they occur regularly, but after the cutting off of the amphithecium by periclinal walls (fig. 34), the divisions in the endothecium are more irregular. Probably not more than half the capsule tissue gives rise to spores, the remainder being used in capsule walls, elaters and other sterile parts (fig. 36).

The capsule covering is generally several cells in
thickness, but the inner layers, thin-walled and delicate, soon break down their content probably furnishing spore nutriment. The cells of the single outer layer are nodulose and thick walled, giving the capsule a roughened exterior. The wall cells are uniform in size, except at the base where they curve under forming a collar around the stalk. Here the cells are flattened and rectangular in shape (fig. 54). At the base of the sporangium is a pad of sterile tissue, four to six cells in thickness. This sterile part is not an elatrophore, such as we find in Aneura and Pellia, although sometimes a few elaters are found attached to it (fig. 54).

The lower cell of the embryo divides but few times, so that the resulting cells are quite large. The first-divisions are vertical and those of the second series transverse. The foot is not always uniform in size and shape; often it narrows to a point about one-half the width of the stalk, and barely 1 mm. in length (fig. 61); again it may be elliptical or globular with a distinct neck connecting it with the stalk (figs. 58-60). While it is seen that the foot is small in comparison to the size of the capsule, it is so firmly imbedded in the gametophyte that it holds the sporophyte erect. For a long time the foot is the only means of connection between the sporophyte and gametophyte and must function in transferring food and water to the former.

In the middle cell of the pro-embryo divisions occur more rapidly than in the foot forming a cyclindrical stalk 16 cells in diameter. The rapid growth of the stalk after pushing the capsule through the calyptra is not due to cell division but to the elongation of the cells already established. These cells do not grow in width but increase from five to eight times their original
length. By this means the sporangium is pushed one to two cm.
above the thallus so that spore dispersal is favored (figs. 56-57).

After the final divisions in the endothecium, the spore-
mother-cells and the elaters are differentiated. They break apart
and seem to float in a semi-fluid in the sporangium. The spore-
mother-cells are large and present a variety of shapes. Miss
McCormick says of Symphyogyna aspera (38), "The sporogenous cells
are irregular in shape, and bear every indication that they were
plasmolyzed in the fixation or imbedding". Farmer (26) in
discussing Pallavicinia decipiens says, "The spore-mother-cell
becomes tetrahedrally lobed and the cell-walls, at their inner
angles, grow into the cell-cavity towards the nucleus". He also
says of Pellia epiphylla, "As regards the spore-mother-cell, it
conforms to the type characteristic of the Jungermannia series
of Hepatics. At first more or less irregularly spherical, it soon
becomes four-lobed, and these lobes increase in size, chiefly
owing to radial extension, so that the spore-mother-cell ultimately
comes to consist of four large sacs whose cavities communicate
with each other by means of a small central space common to them
all". In Blasia the lobing of the spore-mother-cells was very
noticeable in their earlier stages. Very few mitotic figures
were seen and these only in the sporogenous cells before
reduction (figs. 37-44). Farmer has already noted that at the
time of reduction, the spore-mother-cells can only be fixed with
great difficulty, so this probably accounts for the lack of
figures. Le Clerc Du Sablon investigated the development of the
sporophyte of Frullania dilata and with that species he compared
Scapania compacta, Pellia epiphylla, Aneura pinguis, Targonia
hypophylla and Sphaerocarpus terrestris. He noted that there is
an early differentiation between elaters and spore producing tissue, and that the elater is the equivalent of a row of mother cells. The spore-mother-cells and elaters of Blasia have no definite arrangement in the capsule and are so mixed together that it is difficult to imagine the elaters being multicellular in origin. As the elaters elongate their nuclei assume an elongate shape also. The granular content of these cells collects in masses along the wall. No doubt they furnish nourishment to the young sporogenous cells for, at this stage, they are rich in granules and oil; no signs of which are found at a later period.

At maturity the elaters are 25 mm. (250 microns) long and .01 mm. (10 microns) in diameter. The general form is spindle-like, tapering at each end, with two spiral bands running the entire length. Some variation was shown in several sporangia, the elaters ranging from the short, thick, regularly branched type (fig. 48), to the long Y-shaped form (fig. 59). Their hygroscopic movements on being moistened and dried, lead one to think that the elaters function in spore-dispersal.

The Spores.

When shed the yellowish-brown spores are very often irregular in shape and vary from .03 mm. (30 microns) to .04 mm. (40 microns) in diameter. These one-celled granular bodies contain many bright green plastids.

If kept in a moist chamber, three or four days after shedding these spores will have rounded out and enlarged to almost twice their original size. No distinct spines show on the exine although the surface is slightly roughened in reticulate markings. Spore germination has been fully described by Leitgeb (35).
At first the calyptra containing the young sporophyte occupies a very small space at the basal part of the thallus cavity, but growth continues until, by the latter part of August, the sporophyte fills the entire cavity. About this time it passes into a resting condition, remaining so until early spring of the following year. By April tenth sporophytes were found breaking through the calyptra and pushing out of the torn thalli, the capsules showing bright green, and the stalks only a little paler in color (figs. 62-63).

Up to the time of emergence of the sporophyte from the calyptra it lies in the midrib parallel to the plane of the thallus. With the elongation of the stalk the lower part becomes curved and the mature fruit grows erect, at right angles to the thallus.

The capsule dehisces regularly by four longitudinal slits extending from its apex to the collar at the base (fig. 55). These four flaps turn back and downward, leaving the mass of spores and elaters unprotected and ready for dispersal.
CHAPTER VI.

Cupules. Vegetative Propagation.

Asexual or vegetative reproduction in Blasia pusilla is accomplished in two different ways. The amphigastria or under-leaves may become detached from the lower surface of the thallus and give rise to new plants. These scales are loosely attached, easily removed and well prepared to launch new thalli. The second method is by means of asexual bodies called gemmae, which grow in special receptacles on the thallus and upon being expelled give rise to new plants.

The development of the cupule in which these gemmae are formed is extremely interesting. The initial of the cupule is a dorsal segment of the apical cell and the mature cupule is located rather near the apex of the plant. By repeated divisions vertical to the plane of the thallus, the dorsal segment gives rise to a compact cluster of cells just back of the growing point (fig. 64). Activity appears then to be retarded in this region and increased in the surrounding cells for they soon bulge up around the compact region forming a rim (fig. 65). Cell division is more rapid in the posterior part of the depression.

The development of the cupule of Blasia follows closely the first few stages in the development of the Marchantia cupule as given by Barnes and Land (1). Here is the same compact tissue whose cells fail to divide thus allowing the surrounding cells to outgrow them. According to Barnes and Land (1), "In Marchantia the upgrowth of cells at the rim of the depression begins on the posterior margin but later extends completely around the depression, so that at maturity the cup is circular
and of almost equal height on all sides. "The origin of the
cupule of Lunularia has been shown to be the same as that of
Marchantia, except that the development of the rim takes place
only on the posterior side of the gemmiparous region, which is
also more extensive. In some cases late in the development, a
slight anterior elevation continues the line of the posterior
rim and so suggests the circular cup of Marchantia. The
superficial origin of the gemmae is thus perfectly clear".

At the point where the posterior part of the Blasia cupule
begins to increase all resemblance to Marchantia ceases. The
tissue resulting from the accelerated growth in Blasia, covers
the depression completely leaving only a small opening at the
anterior end (fig. 66). Because of this method of growth the
resulting cavity is elongate and flask-shaped. Papillate cells
are now found pushing out from all sides of the cavity and are
soon cut off by transverse walls. These are differentiated either
into mucilage hairs, similar to those on the thallus, or into the
initials of the gemmae. Further division of the gemma initials
is carried on first by transverse walls and later by vertical
walls, so that the mature gemma is composed of a mass of from
four to twelve cells, resembling the antheridium in its younger
stages (fig. 67).

When the first gemmae are mature, accelerated growth in the
margin cells of the walls about the opening, forces the edges
upward forming a chimney-like tube at the anterior end of the
cavity (fig. 68). This tube attains a length of 1 to 2 mm.
and varies from 2 to 4 cells in thickness. At the apex the edges
flare outward slightly, giving the tube a bell-shaped opening.

Most of the cupules were found on antheridial plants,
although in several instances they were found on archegonial plants, where the archegonia had not been fertilized. The cupules appear later in the life cycle than do the sex organs. Leitgeb (35) held that they were antheridial pockets for in one instance he found a half grown antheridium at the posterior end of the cupule. He tried to find other stages but was not successful. Cavers (11) thought the gemma receptacles were modified archegonial receptacles since archegonia were sometimes found in them.

The writer is inclined to think that the cupules are especially formed for gemma production and are not modified sex organ receptacles. It is true that the development of thallus tissue is parallel to the development of the sex-organ covering, but if these cupules were degenerate antheridial receptacles it seems that the tissue development would cease when it had enclosed the depression, instead of elongating to form the long neck-like extension.

Leitgeb (35) says, "Gemmae grow into male plants and those bearing flasks". The writer is not prepared to dispute this idea, until further investigation has been made, but is doubtful if such is the case. The occurrence of flasks on the archegonial plants would probably be the best argument against his theory. In cultures which he made, gemmae developed no further than a vegetative body about six cells long and two to four cells wide, in which instance it would be impossible to tell whether the plants were male or female.

The Gemmae

The multicellular gemmae are ovoid in form about .14 mm. at the greatest diameter. They are held in the receptacle upon
upon hyaline stalks, one cell in thickness, and sometimes twice
the length of the gemma.

Throughout the period of gemma development the mucilage
papillae have been secreting a slimy substance which is poured
out into the flask cavity. The mature gemmae, breaking from their
stalks, become imbedded in this viscid substance and are ready
for expulsion from the flask. Just how this is accomplished has
not been fully proven. Hofmeister (30) says, "The escape of the
buds is doubtless caused by the pressure which the numerous
rapidly growing young buds necessarily exert upon the mucilaginous
contents of their receptacle, which contents are thereby in
constant motion toward the opening in the neck". Beside the
pressure of the growing gemmae it is probable that the entrance of
water into the flask causes the swelling of the mucilage forcing
it from the flask neck. This conclusion is supported by the
observation of drops of the exuded mucilage standing at the tops
of the necks, especially when the atmosphere was moist, or when
the dew was still upon the plants. After the expulsion of the
mucilage drop with its load of gemmae, they can easily be scattered.

It is probable that insects or snails might be responsible
for distribution of some of the gemmae through contact with these
slime globules filled with mature brood bodies. But doubtless
water splashing on the plant is the more efficient agency for
gemma dispersal as the slime dissolves quickly in water.

These little asexual bodies grow very rapidly and produce
juvenile plants one to two mm. long in a few days. Their growth
is extremely interesting and takes place while they are still
sticking to the dorsal side of the old thallus. Leitgeb (35) was
probably referring to these new plants, which are sometimes
star-shaped in their earlier stages, when he described the "sternschuppen" of Blasia. Goebel (27) says the following in regard to the asexual reproduction of Blasia. "Blasia has two kinds of gemmae: the one is a nearly spherical cell-mass produced in a flask-like receptacle with a long neck; the other is a gemma-scale at the base of which there is to be seen at a very early period of development the cell from which the new thallus proceeds,—this gemma-scale arises upon the upper side of the thallus, especially upon shoots which bear neither sexual organs nor receptacles for gemmae. These gemma-scales require investigation especially in their biological relationships". No trace of these scale-like appendages showed on the dorsal surface of the specimens studied. In only one case were the gemmae found germinating in the flask, and in this instance only a single protuberance was pushed out at the side. This flask was an old thallus and the gemmae probably had been developed the fall before. This is an exception to the usual procedure however, for the gemmae are expelled at maturity, while young buds are forming at the base of the flask. Conditions for germination are not likely to be favorable when the brood-buds are tightly crowded together in the flask and surrounded by the viscid gelatinous substance produced by the mucilage papillae.

When gemmae are placed in a favorable situation, growth proceeds by means of the end cell (fig. 71) which develops into the regular wedge-shape apical cell already described for this plant. In the earlier stages of the thallus, the apical cell builds up a broad flat stem and the leaf-like lobes appear on opposite sides of this expanded portion. In very early stages the plant looks like a leafy liverwort having distinctly separated
lobes set on the stem-like midrib apparently like leaves (fig. 81). The lobes must increase in bulk laterally for in the mature thallus they are closely set together forming a more nearly thalloid plant. At the apex of the young plant, the lobes form a rosette around the growing point. This arrangement is advantageous affording protection for the bud.

Nostoc appears in the plant very soon after the gemmae germinate. Often two or three distinct colonies may be formed on plants .25 mm. in length. It is possible that the Nostoc finds entrance into the flask and adheres to the gemmae before they are shed. Rhizoids develop early on these little plants soon becoming long and much entangled.

It would seem that the young plants could not long thrive perched on the dorsal surface of the thallus but they do grow for a time probably upon nourishment stored in the gemma which persists at the base of each new plant. As the old thalli die these new shoots are allowed to rest on the soil where they mature into vigorous well-developed plants. Further study will probably throw light on the question as to whether these plants are fertile or sterile. Material kept in the laboratory did not prove very satisfactory for this study as conditions were not favorable for plant growth. The branches of the thallus had a tendency to grow erect and spindling, with much smaller and widely separated lobes.

Advantages of Asexually Reproduction.

Cavers (11) says, "It seems probable that in both Blasia and Cavicularia we have an example of the replacement of spore production by asexual reproduction. Blasia is found more often with gemma flasks than with fruits". In recent observations of
Blasia, fruits were found quite as abundant as flasks. This problem will make an interesting study in connection with seasonal changes and the variations in environmental factors operating during these seasons. Evans (24) has found in species of Metzgeria that gemmae are not likely to appear when the plant is growing luxuriantly.

However, it is the writer's theory that vegetative reproduction is a safeguard in tiding the plant over unfavorable periods. In times of stress for the plant sexual reproduction would be a much longer and more uncertain mode of propagation, than that of asexual gemmae. Sex organs are formed in the summer but spores are not shed until the following spring, while gemmae may be fully developed and shed during most months of one growing season.

In the second place it seems likely that gemmae are better prepared to produce a plant body quickly, than are the spores, being so much larger and so abundantly supplied with food. Macvicar (36) says, "When a plant cannot obtain its normal amount of nourishment and especially moisture, it will be smaller and weaker than the type, the stems being shorter and the leaves frequently deformed. Fruit is not uncommon in this form. The other deviation is when the plant has a deficiency of light. Under this condition it is generally green or pale green, the stems are elongate and thin, the leaves distant and smaller, and if it be a thallose species the branches have a tendency to grow erect. In such plants fruit rarely occurs but gemmae are often abundant". In this case also it would seem that gemma production is more abundant under unfavorable conditions.
SUMMARY.

1. Blasia pusilla is a relatively simple liverwort having a dorsi-ventral thallus with laterally inserted leaf-like lobes.

2. The growth of the thallus proceeds by means of the wedge-shaped apical cell, characteristic of the dichotomously branched forms.

3. The thallus shows distinct strands of thick-walled cells functioning as mechanical and conducting tissue.

4. The conducting strand is composed of elongate cells, tapering to a point at each end, and having pits scattered irregularly in the thick walls.

5. Mucilage hairs are found on both sides of the thallus massed at the apex for the protection of the growing region.

6. Rhizoids and scale-like amphigastria are found on the ventral surface of the thalli.

7. The leaf auricles also found on the ventral surface are filled with Nostoc colonies.

8. Blasia is dioecious, the antheridial plants being more slender and more deeply lobed than the archegonial plants.

9. Antheridia are found in two rows one on either side of the midrib.

10. Ten or twelve archegonia are formed near the apex of the plant, the group surrounded by the upstanding side leaves.

11. Both archegonia and antheridia arise from dorsal
segments of the apical cell, and the initials are similar.

12. Both archegonia and antheridia develop according to the regular Jungermannia type.

13. Mature sex organs are imbedded in the thallus being completely covered by the overgrowth of vegetative tissue.

14. The division of the gametospore is transverse cutting off a lower and smaller cell which becomes the foot initial.

15. The second division of the embryo divides the epibasal cell into stalk and capsule initials.

16. Only about half the tissue of the capsule gives rise to spores, the other portion forming elaters, capsule wall, and the sterile part at the base of the sporangium.

17. The unicellular spores are granular, containing many bright green plastids.

18. The elaters have two spiral bands running their entire length, and are sometimes branched.

19. Vegetative reproductive bodies, or gemmae, are developed in cupules on the dorsal surface of the thallus.

20. These cupules have long tube-like necks from which the gemmae are forced by the swelling of mucilage in the base of the flask.

21. The gemmae of Blasia are multicellular, each cell containing a large nucleus and many oil globules.

22. The gametophyte of Blasia pusilla occupies an
intermediate position between the thallose and foliose forms of liverworts.

23. The sporophyte of Blasia is not as highly specialized as that of Aneura or Pellia, since it does not possess an elatrophore. It is peculiar, however, in that it has a sterile portion at the base of the sporangium and a thickening of the capsule wall around this portion.

24. This study shows that the cupules of Blasia, which are the most complex of the liverworts, are comparable to the simpler ones of Marchantia and Lunularia.
Phylogeny of the Anacrogynae (After Cavers).

Acrogynae

Haplomitrium
Calobryum
Fossombronica
Podomitrium
Umbraculum

Treubia
cavicularia
Blasia
calycularia
Noteroclada
Petallophyllum Metzgeria

Pellia
calycularia
Pellia line

Symphyogyna

Aneura
Makinoa
Morckia

Sphaerocarpales
Marchantiales

Pellia line
Aneura line
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30. Hofmeister, W., Germination, Development and Fructification of the Higher Cryptogamia. 1851. Translated by Curry. 1862.


44. Schmeidel., Dissertatio de Blasia. 1759.


Abbreviations.

c. s. Conducting strands.
ap. c. Apical cell.
s. l. Side leaves.
amp. Amphigastria.
r. Rhizoid.
ep. Epidermis.
l. a. Leaf auricles.
m. p. Mucilage papilla.
n. Nostoc.
an. i. Antheridial initial.
y. an. Young antheridium.
s. t. Spermatogenous tissue.
an. w. Antheridial wall.
th. Thallus.
s. Sperms.
ar. i. Archegonial initial.
y. ar. Young archegonium.
o. ar. Old archegonium.
e. Egg.
v. Ventral canal cell.
n. c. Neck canal cells.
cal. Calyptra.
g. Gametospore.
emb. Embryo.
cap. Capsule.
s. i. Stalk initial.
f. i. Foot initial.
amph. Amphithecium.
end. Endothecium.
sp. t. Sporogenous tissue.
cap. w. Capsule wall.
sp. m. c. Spore mother cell.
el. Elater.
sp. Spore.
t. Tetrad.
st. t. Sterile tissue.
stk. Stalk.
t. c. Thallus cavity.
y. spfte. Young sporophyte.
y. cup. Young cupule.
gem. Gemma.
cup. n. Cupule neck.
Explanation of Plates.

Figure 1 was drawn X6. Figures 9, 10, 22, 54, 58-61 were made with Spencer 16 mm. objective and Spencer ocular 8; figures 8, 26, 28-30, 71 and 72 with Spencer 4 mm. objective and ocular 8; figures 62 and 63 with Bausch and Lomb 1 ½ inch objective and Spencer ocular 8; figure 55 with Bausch and Lomb binocular 55 mm. objective and ocular 10; figures 74-81 with Bausch and Lomb binocular 24 mm. objective and ocular 10.

The following figures were drawn with Spencer camera lucida. Figures 2, 3, 4 and 12 were made with Spencer 16 mm. objective and ocular 8; figures 5, 37-44 with Spencer 2 mm. objective and ocular 8; figures 68, 69 and 70 with Bausch and Lomb 1 inch objective and Spencer ocular 4; figures 6, 7, 11, 13-21, 23-25, 27, 31-36, 45-53, 56, 57, 64-67, and 73 with Spencer 4 mm. objective and ocular 8.
Plate I.

Fig. 1. Thallus showing thread-like strands of conducting tissue.
Plate II.

Fig. 2. Transverse section of thallus.

Fig. 3. Transverse section of conducting strands.
Plate III.

Fig. 4. Longitudinal section of conducting strand.

Fig. 5. Cell of conducting strand showing external markings.
Plate IV.

Fig. 6. Longitudinal section through apical cell parallel to the plane of the thallus.

Fig. 7. Longitudinal section through the apical cell vertical to the plane of the thallus.
Plate V.

Fig. 8. Longitudinal section of rhizoid.

Fig. 9. Dorsal view of an amphigastria.

Fig. 10. Transverse section through an amphigastria.
Plate VI.

Fig. 11. Section of a young auricle containing a mucilage papilla.

Fig. 12. Section of an older auricle with aperture completely closed.

Fig. 13. Section of an auricle containing the branching tree-like structure of Blasia.
Plate VII.

Fig. 14. Section through apex of the thallus showing antheridial initial an older antheridium and an apical cell.

Fig. 15. Antheridium showing division of stalk cell.

Fig. 16. An older antheridium.
Plate VIII.

Fig. 17. An antheridium showing six spermatogenesis cells and the antheridium wall.

Figs. 18-19-20. Older stages in the development of the antheridium.
Plate IX.

Fig. 21. Mature antheridium and sperms.

Fig. 22. Antheridial pocket.
Plate X.

Fig. 23. Archegonia initial.

Fig. 24. An archegonium with one curved wall laid down.

Fig. 25. A slightly older archegonium.
Plate XI.

Fig. 26. Archegonium showing venter cell and primary neck canal cell.

Fig. 27. An older archegonium with six neck canal cells.

Fig. 28. Archegonium with canal cells completely broken down.

Fig. 29. Cross section of archegonium neck.

Fig. 30. Cross section of venter.
Plate XII.

Fig. 31. One-celled embryo.

Fig. 32. Embryo with foot initial cut off.
Plate XIII.

Fig. 33. Embryo showing foot and stalk initial, also first divisions in the sporangium. Calyptra has become massive.
Plate XIV.

Fig. 34. Embryo inside the heavy calyptra, showing the separation of the endothecium from the amphithecium.
Plate XV.

Fig. 35. Sporangium showing wall enclosing the sporogenous tissue.
Plate XVI.

Fig. 36. Portion of sporangium older than fig. 35 showing the increase in sporogenous cells and their irregularity.
Plate XVII.

Fig. 37. Sporogenous cells.


Fig. 44. Daughter cells.
Plate XVIII.

Fig. 45. Spore mother cells and elaters separated and floating in the sporangium.

Fig. 46. Spore mother cells and elaters at a later stage.
Plate XIX.

Fig. 47. Mature elater with two spiral bands.

Figs. 48-49. Branched elaters.

Figs. 50-51. Spore mother cells showing lobing.

Fig. 52. Tetrads breaking apart.

Fig. 53. Mature spore with roughened exine.
Plate XX.

Fig. 54. Mature sporophyte showing sterile pad at its base, also collar of rectangular cells in capsule wall.

Fig. 55. Capsule dehiscing by four longitudinal slits.
Plate XXI.

Fig. 56. Stalk cells.

Fig. 57. Stalk cells after their elongation.

Figs. 58-59-60-61. Variation in the foot of the Blasia sporophyte.
Plate XXII.

Fig. 62. Young sporophyte at posterior part of the thallus cavity.

Fig. 63. Mature sporophyte almost filling the cavity.
Mature Sporophytes (nat. size).
Plate XXIII.

Fig. 64. Compact tissue marking beginning of cupule.

Fig. 65. A later stage showing accelerated growth at posterior edge of depression.
Plate XXIV.

Fig. 66. An older flask with posterior flap covering depression. Young gemmae developing on the floor of the cupule.

Fig. 67. Portion of older cupule with gemmae mature and raised on long stalks.
Plate XXV.

Fig. 68. Cupule showing the uppushing of the margin cells around the opening.

Fig. 69. Developing neck at the anterior end of the flask-shaped cupule.
Plate XXVI.

Fig. 70. Mature flask with gemmae being pushed out the neck by the swelling of the mucilage.
Plate XXVII.

Fig. 71. Mature gemmae as shed from the flask.

Fig. 72. Gemmae germinating.

Fig. 73. Section through a gemma producing a new plant.
Plate XXVIII.

Fig. 74. Gemma beginning to germinate.

Figs. 75-76-77-78-79-80-81. Stages in the development of the juvenile plants.
Appendix.
Tabular View of the Families of the Jungermanniales.

Bryophyta.

Class I. Musci.

Class II. Hepaticae.

Order I. Sphaerocarpales.

Fam. 1. Sphaerocarpaceae.

Order II. Marchantiales.

Fam. 2. Ricciaceae.

Fam. 3. Marchantiaceae.

Order III. Jungermanniales.

Fam. 4. Jungermanniaceae anacrogynae.

Sub. fam. 1. Metzgerioideae.

Sub. fam. 2. Dilaenoidae.

Sub. fam. 3. Codonioideae. (See page ii).

Sub. fam. 4. Haplogonioideae.

Fam. 5. Jungermanniaceae acrogynae.

Sub. fam. 1. Lophozioideae.

Sub. fam. 2. Cephalozioideae.

Sub. fam. 3. Ptilidioideae.

Sub. fam. 4. Scapanioideae.

Sub. fam. 5. Raduloideae.

Sub. fam. 6. Pleurozioideae.

Sub. fam. 7. Madlothecoideae.

Sub. fam. 8. Jubuloideae.

Order IV. Anthocerotales.

Fam. 6. Anthocerotaceae.
Genera and Species in Sub-family Codonioideae.

Genus 1. Pellia.
   Species 1. epiphylla L.
   "  2. endiviaefolia.
   "  3. Neesiana.

Genus 2. Blasia.
   Species 1. pusilla

Genus 3. Calycularia.
   Species 1. crispula.
   "  2. laxa.
   "  3. radiculosa.

   Species 1. porphyrorhiza.

Genus 5. Treubia.
   Species 1. insignis.

Genus 6. Petalophyllum.
   Species 1. Ralfsii.
      One Algerian species.
      Two Australian species.

Genus 7. Fossombronia.
   Species 26 most widely distributed.
      "  Dumortieri.
      "  Angulosa.
      "  cristata.

Genus 8. Limodon.
   Species 1. incurvus.
Blasia pusilla. L.

Hepaticae.

Order. Jungermanniales.

Family. Jungermanniaceae anacrogynae.

Sub-family. Codonioideae.

Genus. Blasia.

Species. pusilla L. (1753).
Statistische Übersicht.

Bis ende Juli 1893.

Die Gattungen und Arten verteilen sich folgendermassen auf die oben charakteristerten Familien.

Auf der ganzen Erde.

<table>
<thead>
<tr>
<th>Gattungen</th>
<th>Arten</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ricciaceae</td>
<td>4</td>
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<tr>
<td>2. Marchantiaceae</td>
<td>22</td>
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<tr>
<td>3. Jungermanniaceae anakrog.</td>
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</tr>
<tr>
<td>4. Jungermanniaceae akrog.</td>
<td>116</td>
</tr>
<tr>
<td>5. Anthocerotaceae</td>
<td>3</td>
</tr>
</tbody>
</table>

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Die fossilen Formen 40 Arten, sich auf 10 Gattungen verteilen.