

ARE THE PSILOPHYTALES A STARTING OR A RESULTING POINT?

BY

S. LECLERCQ.

(University of Liège, Belgium.)

The supposed phylogenetic relationships of the various groups of the *Pteridophytes* were usually represented as stemming from the *Psilophytes*, which thus are considered as a general starting point. A review of the Siluro-Devonian records shows that another possible assumption exists: that the different races of the *Pteridophytes* had an independent origin issuing from different lines probably running down separately into the algae complex.

The principle of an independent origin of the main races of the vascular plants is certainly not a new conception. It has been expressed and discussed by numerous scientists. Rejected by many, it has been admitted by a few, though positive evidence is still wanting. In that connection, the finding of the Silurian flora of Australia has been the thin end of a wedge driven into the foundation of the general monophyletic dogma. The proof of the existence of representative members of, at least, two distinctive lines, the *Psilophytes* and *Lycopside*s, gave rise to a reaction against the usual "family-tree" conception. The consequence of this reaction has been borne by the *Psilophytales*. This is well shown in recent phylogenetic diagrams. In 1944 (p. 449) Professor EMBERGER represents the *Psilophytales* as the common root of the Vascular plants. In 1948, Professor LAM regards them as the converging point of the *Pteridophytes* and *Spermaphytes*. Professor ZIMMERMAN, likewise, in 1952 (p. 462), assigns the *Psilophytes* a key-position. In 1952 (p. 83) Professor LAM, already mentioned, gives a new diagram that takes the Siluro-Devonian data into consideration: though open to doubt, the *Lycopside*s join the *Psilophytes* far back towards the Cambrian;

while the *Sphenopsides* and *Pteropsides* are still connected with them; whereas the *Coniferopsides* are related to the *Lycopside*s by means of the *Baragwanatia*. The breaking up of the "family-tree" has begun. In the same way, but in a more reactionary manner, Professor HENRY ANDREWS, in 1947 (p. 252), had already assimilated the new current of ideas which he represented in an interesting schematic diagram of the plant-kingdom. The striking characteristics of his table are that the main races remain distinct throughout, issuing separately from the algae complex, and that the *Psilophytes* have become a secondary issue. What has happened? What are the reasons that have ousted the *Psilophytes* from their keystone position? In fact, it is chiefly a matter of a new interpretation of almost the same data.

The valuable message of the *Psilophytes* seems to have been understood in too narrow a sense. The message is, at least, twofold: *first*, it concerns the limits of the group, its characterization and limitation: its bearing is restricted; *secondly*, a more general meaning concerns the positive evidence of archaic types of vascular plants, strangely simple in their habits and structure, at a very remote epoch, when the crucial phase of transmigration from sea to land was in process of completion. This enlarged signification is constructive. It overrides the limits of the *Psilophytes* themselves and affords a clue to understand the origin of all the phyla. Both meanings of the *Psilophytales* will be considered.

The *Psilophytes*.

In the present state of our knowledge, the *Psilophytales* concept is a knotty point. There is a general tendency to relate or attribute to this group any form showing simple morphology or structure which blurs its limits. Another factor which adds to our confusion stems from the fact that, for the most part, the data at our disposal are of unequal value, and do not lend themselves to comparison.

Without doubt, our best source of information is derived from the *Rhyniaceae* which have revealed, in full detail, the whole organization of "Urform" land-plants (KIDSTON and LANG 1919–1921). That is to say: erected leafless axes with terminal sporangium and simple vascular strand made of annulate tracheids.

Closely related to the *Rhyniaceae* is the genus *Psilophyton*. Unfortunately, among the numerous specimens referred to it, most of them are questionable; let us see why. Regarding the spiny axes, *Sv. Bot. Tidskr.*, 48: 2

their aspect is variable according to the diversity of form, length and orientation of the spines. Certain shoots have small, rigid, straight, scattered spines. Others have long (8–10 mm) slender, thin (0.3 mm) flexuous, closely set spiny appendages: (*P. arcticum*, HØEG 1942, p. 34, *P. wyomingense*, DORF 1933, p. 242); the bases of the spines are more or less circular, swollen, conical, "some of them with a central punctiform scar, very much like a nerve in cross section" (*P. arcticum*, HØEG 1942, p. 34); the branching system may be dichotomous or sympodial or pseudomonopodial with subequally dichotomous lateral branches, given off from the main axis, at an acute or wide angle, and repeatedly or infrequently bifurcating at either a sharp or wide angle, flattened in one plane or not. The fructification is a disputed question. Is it represented by the *associated*, terminal sporangia hanging down at ultimate naked branchlets, as reproduced by DAWSON (Fig. 1); or by the terminal spike-shaped twig with double rows of erected sporangia borne on spiny stems (Fig. 2) (CROFT and LANG 1942, p. 138)? — In the light of this, is not *Bucheria ovata* (Fig. 4) the loose spike of *Psilophyton wyomingense* as suggested by the author (E. DORF 1933, pp. 244 and 247)? *Bucheria ovata* shows a very similar construction to cf. *Psilophyton princeps*' fructification. It consists of two rows of small ovate bodies symmetrically disposed on opposite sides and fixed at the distal end of a spineless axis. The spiny stems of *P. wyomingense*, found in association with it, may have been prolonged by spineless outer branches, and the fructification of that type. But, on the other hand, in Germany, KRÄUSEL and WEYLAND (1938, p. 184), have described *P. pubescens*, which (as stated by the authors) is very close to *P. wyomingense* by the type of spines and the branching system. In any case, the fructification is of a new type. Here the lateral branches, three or four times bifurcated, end in small curved systems that turn inward, and bear small sporangia packed together and projected into the concavity (Fig. 3).

Thus, so far, three types of fructifications, obviously characteristic and different from each other, are related to the same genus. These amazing attributions rest upon the spinous nature of the axis which bears the fructification. This leads one to wonder if the spine-appendages have a systematic value and can be regarded as an evidence of relationship. This opinion is further strengthened by the anatomical structure referred to two species of *Psilophyton*. It is well known that the *Psilophyton princeps* described by DAWSON is sup-

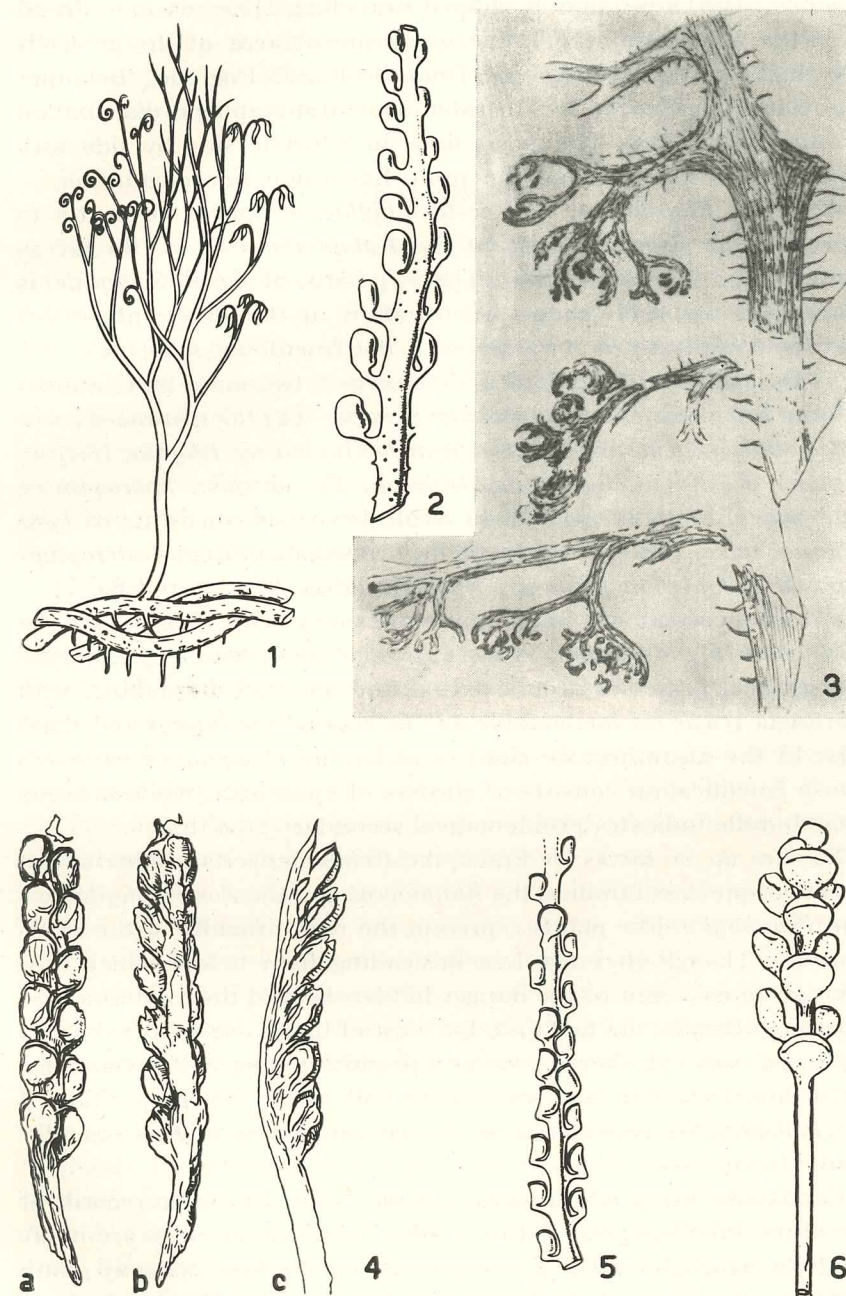
posed to present a vascular strand which conforms very closely to the simple bundle of the *Rhyniaceae*. The type of xylem found by KRÄUSEL and WEYLAND in *Psilophyton pubescens* is curious (1938, p. 186). Here, the vascular strand, though not complete, consists of regular radial series of small thick walled cells mixed with "medullary rays" of one to four cells in width. The arrangement of the cells suggests secondary development, as stated by the authors. It appears that, behind the spinous stems, different systematic types are possibly hidden, some of them belonging to *Psilophytales*, others not. Let us recall a few observations: (a) The spike-shaped fructification of cf. *Psilophyton princeps* (Fig. 2) (CROFT and LANG 1942) that is closely constructed like *Zosterophyllum*, a spineless *Psilophytales* (Fig. 5);—(b) *Psilophyton arcticum* (HØEG 1942) of which "the low cone of the spine basis appears as a diminutive leaf cushion" with, on certain occasions, a "nerve" scar inside (a structure that reminds us of the *Lycopside*);—(c) The *Psilophyton pubescens* (KRÄUSEL and WEYLAND 1938) of which the fructification and xylem structure would appear to point to the Ferns, as it will be shown later.

The foregoing facts explain the present perplexity that exists about the characterization of the genus *Psilophyton*. Hitherto, the data at our disposal have increased the complexity of the problem more than they have cleared it up.

The whole class of the *Psilophytales* suffers from troubles similar to that of the genus *Psilophyton*. However, besides the *Rhyniaceae*, there are the *Zosterophyllaceae* which, though in a less spectacular way, have given substantial information. No less than five species have been distinguished, based chiefly upon the fructification variations. The general type consists of a lax-spike with erected sporangia more or less reniform; stalked or sessile, disposed bilaterally or spirally (Figs. 5 and 6). The habit of the plant is probably tufty, with thin leafless axes infrequently dichotomously branched, with,

Figs. 1—6. — Fig. 1. *Psilophyton princeps* DAWSON (After DAWSON, ANDREWS 1947). — Fig. 2. Cf. *Psilophyton princeps*, CROFT and LANG, $\times 1$. Interpreted reconstruction after the holotype (figs. 12 and 12a, Pl. 9, CROFT and LANG 1942). Reviewed by W. H. LANG. — Fig. 3. *Psilophyton pubescens*, KRÄUSEL and WEYLAND, $\times 2$. Clusters of sporangia borne terminally on lateral branchlets repeatedly bifurcated. After KRÄUSEL and WEYLAND 1938. — Fig. 4. *Bucheria ovata* DORF, $\times 1$. Face (a), dorsal (b) and profile (c) view of the dorsiventral spike. After DORF 1933. — Fig. 5. *Zosterophyllum fertile* LECLERCQ, $\times 2$. (*Platy-zosterophyllum*.) Outline drawing of holotype in fig. 2, Pl. 1, LECLERCQ 1942; to show the sporangia in two alternating rows, most are viewed laterally more or less folded, some are bent. — Fig. 6. Reconstruction of an *Eu-zosterophyllum*, $\times 2$. Aerial shoot with spirally arranged sporangia. After WALTON 1940.

Sv. Bot. Tidskr., 48: 2



Sv. Bot. Tidskr., 48: 2

in some cases, a peculiar H-shaped branching. The vascular strand is of the *Rhyniaceae* type. The geographical area of the genus is amazingly wide. It is known from Scotland, England, Belgium, Rhineland (Germany), to Australia. The stratigraphical distribution is among the oldest. The genus lived in Silurian, side by side with *Psilophyton*'s remains and the proto-Lycopsid *Baragwanathia*.

With the *Rhyniaceae*, the *Zosterophyllaceae* appear presently to represent the strongest basis of the *Psilophytales* Class. So far as KIDSTON and LANG's definition (1917, p. 719) of the *Psilophytales* is concerned, the spike-shape fructification of the *Zosterophyllaceae* may be considered as a variation of the fructification theme.

As far as the fructifications are concerned, two main types appear to loom out of the *Psilophytales* fog; they are: (1) the sporangia borne at the end of the terminal naked branches including: *Rhynia*, *Horneophyton*, *Hicklingia*, *Cooksonia*, *Dutoitia*, *Taeniocrada*, *Sporogonites*, *Dawsonites*; and (2) specialized fertile branches consisting of loose terminal spikes with rows of erected sporangia including: *Zosterophyllum*, cf. *Psilophyton princeps*; *Bucheria* (Figs. 2, 4, 5 and 6).

For the present we shall ignore *Gosslingia breconensis* HEARD (CROFT and LANG 1942, p. 141—142) which, in spite of its psilophytic appearance, possesses a dorsiventral and alternate branching, with sporangia borne on the adaxial side or edge of the lateral and main axis. In the meantime we shall consider the *Psilophyton pubescens* whose fructification consists of clusters of sporangia, while the vascular bundle indicates problematical secondary growth.

To sum up, so far as we know, the *Psilopsides* certainly include at least two spineless families: the *Rhyniaceae* and the *Zosterophyllaceae*. The *Psilophyton*-like plants represent the real difficulty of the *Psilophytales*. Though they are less misleading than before, since they have given us a hint of the danger hidden behind their external appearance. Despite the fact that, for most of them, our final judgment has to be reserved, they represent a promising source of revelations. But I doubt whether these revelations will strengthen the position of the *Psilophytales* considered as the common root of the Vascular Plant.

Let us now make a brief survey of the Siluro-Devonian records of the other *Pteridophytes*. If the whole *Pteridophytes* class are made of phyla which have been individual from the first, we may admit that the precursors of the *Lycopsides*, *Sphenopsides*, *Pteropsides* have known the same difficulties as the *Psilophytes* in gripping the land.

Sv. Bot. Tidskr., 48: 2

So much so that their habit, fructification and internal structure may have had very much the same aspect. This, however, does not necessarily imply affinity between them, but simply primitive features of more general signification.

The Lycopsides.

Considered from a palaeobotanical point of view, the *Lycopsides* represent a fortunate issue inside the plant-kingdom. The race is followed, without break, from the Silurian up to our own days. So far, the oldest representative is the vigorous *Baragwanathia* which has differentiated leaves, nerves, spirally disposed; a well developed star-shaped xylem; sporangia distributed over the plant, and located, singly, near the base of unmodified leaves, which characterize the plant as a proto-*Lycopsides* (LANG and COOKSON 1935). The habit of the plant, its morphology, anatomy and the position of the sporangia indicate a formal separation from the *Psilophytales*.

The discovery of *Baragwanathia* is important, it widens the horizon of our conceptions in many ways: (1) it disjoins the *Lycopsides* from the contemporary *Psilophytes*; (2) within the bounds of the *Lycopsides*, it shows a high differentiated form, preceding in time simpler forms like *Drepanophycus* and *Protolpidodendron*; (3) it raises the question of a possible co-existence of more than two phyla in Silurian rocks and even earlier.

The Lower Devonian genus *Drepanophycus* combines psilophytic appearance with characteristic lepidophytic features. It has spiny leaves and two modes of branching of the axes: dichotomy and H-shaped type (CROFT and LANG 1942, p. 136; STOCKMANS 1940, p. 60). These features have been interpreted as evidence of relationship with the *Psilophytales*, until it was demonstrated that these spiny leaves are nerved, and that the fructification is made of sporangia, borne adaxially on unmodified leaves and distributed over the plant.

In this connection, it is not without interest to consider the meaning of some spiny-appendages. Spinous axes are found in varied types of plant. The *Psilophytales* and *Drepanophycus* have already been mentioned. But spines are also found scattered on a *Protoarticulate*: *Hyenia Vogtii* (HØEG 1942, p. 85), and on a *Protopteridales*: *Dawsonites Ellenae* (HØEG 1935, p. 3 and 4). The origin, nature and function of spines are no doubt different in many cases. Their glandular nature has been established for *Psilophyton princeps*; the

Sv. Bot. Tidskr., 48: 2

photosynthetic activity of the nerved spines of *Drepanophycus* is credible. Moreover, we have seen that *Psilophyton arcticum* (HØEG 1942, p. 34) has a nerve-like punctuation in some of the spine-scars, though no strand has, so far, been observed in the spine itself. In consequence of the above facts, I am not inclined, at the present stage of our knowledge, to assign a peculiar phylogenetic value to these appendages, unless their association with other characteristic features of the *Psilophytales* class could be clearly established. The spiny aspect of the *Drepanophycus* leaves is of minor importance compared with the existence of a central strand in the spiny leaves, and the position of the sporangia.

The *Lycopside*s, in Early and Middle Devonian, show an amazingly sudden influx of new forms that leads one to think that the race, at its very beginning, was already composed of a *bundle* of lines. Besides the *Drepanophycus*, the following genera may be mentioned: *Protolpidodendron* (KRÄUSEL and WEYLAND 1932) with the leaves bifurcating at the tips; *Colpodexylon* with trifurcated leaves (BANKS 1944); *Protolpidodendropsis pulchra* (HØEG 1942, p. 132) with well defined leaf-cushions surrounded by flexuous furrows; the robust plant of *Bergeria mimerensis* (HØEG 1942, p. 121) with rhombic sometimes quadratic or fanshaped leaf-like cushions; *Lepidodendron primaevum* (ROGERS) in some part being sigillarioid, in others lepidodendroid. These facts are inconsistent with a lineal descent from the *Psilophytes* which are contemporary.

The *Sphenopsida*.]

The earliest unquestionable remains of the *Sphenopsida* are represented by the well-known genera *Calamophyton* and *Hyenia*, both of Middle Devonian. Here, the point of interest lies in the degree of specialization already reached. Compared to the *Lycopside*s of the same age, these plants appear to bear, more obviously, the stamp of the race, as is established by jointed shoots; whorled dissected leaves; triangular-shaped xylem. The fertile appendages are perhaps more significant. In organization and position, they suggest the sporangiophores of the *Calamites* with which they appear homologous.

This is confirmed by the studies of Professor JOHN WALTON (1949) on *Protocalamostachys arranensis*. This Lower Carboniferous strobilus has sporangiophores divided at their distal end into four slender pedicels that curve towards the strobilar axis and each bearing a

single sporangium. The sporangia are thus borne on distinct pedicels and not attached to a peltate sporangiophore. In the same way, W. S. LACEY (1943) has demonstrated that in *Calamostachys binneyana*, the sporangiophore head is *cruciate* or divided into *four arms* and not peltate. These facts are consistent with the opinion that the *Sphenopsides* have evolved within a narrow limit of change following a clearly defined pattern. This is confirmed by the modern *Articulat*es, and is certainly not invalidated by the problematical compressions found in the Lower Devonian. In regard to the latter, two small plants have been described. In Germany, KRÄUSEL and WEYLAND (1930, p. 60) have re-examined the *Climaciophyton trifoliatum*, a small three-angled stem, not more than one mm in diameter, bearing, at short intervals, whorls of three coalescent leaf-like appendages. In the U.S.A., SCHULTER and DORF (1938) have discovered in Wyoming, the *Sphondylophyton hyenioides*, a caespitose plant of 3 cm long bearing regularly disposed whorls made of two to four leaf-like appendages, dichotomous at the base and split into truncated linear segments (5–8 mm long; 1–2 mm wide). As stated by the authors, both plants have a thalloid aspect. But regarding the Wyoming species, SCHULTER and DORF point out that the plant grew in association with a typically terrestrial flora; the habitat of which appears to have been, occasionally, flooded by fresh water.

As we know, Early Devonian indicates the persistence of shallower seas, land-locked bays, lagoon conditions peculiar to Silurian. This must be kept in mind according to *Climaciophyton* and *Sphondylophyton* that might be interpreted as early ancestors of *Sphenopsides*, in which the algoid appearance would have been retained. SCHULTER and DORF (1938, p. 33) emphasize the signification of "these two articulate elements present in Lower Devonian flora which project the history of the *Sphenopsides* much further back than was formerly the case". They consider that the past history of the race "may have been as long as that of the parallel groups of the Early Devonian: the *Psilophytes* and the *Lycopside*s".

On the other hand, specimens of *Hyenia elegans* found in Belgium have the sporangiophores prolonged with linear dissected leaf-like appendages, suggesting that the fertile organ and the leaves are homologous (LECLERCQ 1940, p. 9). This appears to dismiss the arguable feature according to which the sporangiophore of the *Proto-articulate* would represent the persistence of the original leafless fertile system of the *Psilophytales*.

In the present state of our knowledge, no positive intermediate form between *Psilophytes* and *Sphenopsides* has been found. All we know is, that, from Early and Middle Devonian to our days, the *Sphenopsides*, as a whole, remain perfectly distinct throughout. These facts lead us to suppose that the *Sphenopsides* may have run an independent course from the first.

The Pteropsides.

As in the case of the *Sphenopsides*, we know very little of the Lower Devonian *Pteropsides*; but contrary to the *Sphenopsides*, the multiplicity of their records in Middle Devonian is somewhat baffling.

The most demonstrative remains are offered by the *Protopteridium minutum* from the upper level of the Lower Devonian of Shansi (HALLE 1936, p. 16). The small plant has a main axis branched sympodially. The lateral ramifications spread out in one plane. More striking are the cuneate flattened organs borne on the main axis and smaller branches. They are modified in clusters of sporangia, on the ultimate segments. All the gradations between the pinnule-like appendages and the clusters of sporangia are found on the "frond-like" branch. This gives evidence that both organs are homologous. Moreover, a presumably pluriseriate annulus exists on the sporangia. Undoubtedly, these features point towards the Ferns, not to the *Psilophytales*.

A more conjectural fern-like plant is the *Psilophyton Goldschmidtii*. As said by the author (HALLE 1916, p. 22), the lateral ramification *spreads out in one plane showing a bilateral symmetry* which recalls the branching of a large dichotomously divided frond. Unfortunately, no fructifications, leaf-like organs, nor internal structures are so far known.

We may also mention the *Psilophyton pubescens* (KRÄUSEL and WEYLAND 1948), which appears to approach the Ferns in a more marked manner. As it has been indicated page 303, the branching is alternate and apparently in one plane; the xylem appears to have had secondary growth; while the fructification consists of clusters of sporangia borne terminally on lateral branchlets repeatedly bifurcated.

Terminal clusters of sporangia of very much the same aspect occur in two Ferns of Middle Devonian: *Dawsonites Ellenae* HØEG Sv. Bot. Tidskr., 48: 2

(1935, p. 2) from Western Norway, and *Aneurophyton Germanicum* (KRÄUSEL and WEYLAND 1926, p. 118, and 1929, p. 320) from the Rhineland. *Dawsonites Ellenae*, the simpler of the two, has fertile shoots, terminated by clusters of sporangia. The sporangia are reniform and fixed on repeatedly divided stalks. Some of the axis show a few scattered spines. The sterile shoots bear small lateral appendages that end in circinnated recurved tips. This organization presents a general resemblance to the higher differentiated *Aneurophyton germanicum*. Here, specialized fertile fronds exist. They are constructed on the same plane as the sterile frond, but instead of pinnules, small fertile clusters are inserted (KRÄUSEL and WEYLAND 1929; STOCKMANS 1948). The minute sporangia are stalked and projected into the concavity. On the other hand, the ultimate pinnules of the vegetative frond are not unlike the recurved tips of the sterile portion of *Dawsonites Ellenae*. It may be that, later, the *Psilophyton pubescens*, *Dawsonites Ellenae*, and *Aneurophyton germanicum* will come to be regarded as related members of the same line of descent.

Another interesting example of Fern-like organization is given by the *Protopteridium Thomsoni* (LANG 1926, p. 185). Though of Middle Devonian, this plant is very simple in habit. The most complete specimen is 42 cm long. From a confused mass of apparently leafless axes arises a long branch, that shows a regularly alternate branching spread in one plane, and is terminated by a fertile region. The latter has a similar alternate branching to that in the lower part. The erected fertile organs are turned towards the axis. They consist of brush-like tufts of linear sporangia, parallelly and symmetrically disposed inside the concavity. The anatomy of the axis is fairly complex. It consists of a primary xylem, with two or three irregular lobes, surrounded by a well developed secondary xylem made of scalariform and pitted tracheids and medullary rays (KRÄUSEL and WEYLAND, 1938). *Protopteridium thomsoni* curiously combines axes of *Hostimella* appearance, with a highly differentiated xylem, and a decidedly fern-like fructification. The associated features found in this species indicate the need of caution in deciding whether impression of simple appearance really represents true primitive plant.

Likewise the *Lycopside*s, the *Ferns* and *Seed-Ferns* of the Middle Devonian have evolved extensively.

We are well informed on several species of *Protopteridium* (four) and *Aneurophyton* (three). Contemporaneous with them are: *Sval-*

Sv. Bot. Tidskr., 48: 2

bardia polymorpha (HØEG 1942), a relative form of *Archaeopteris* genus of Upper Devonian; *Barinophyton* (KRÄUSEL and WEYLAND 1938, ARNOLD 1939, STOCKMANS 1948, HØEG 1942), a separate fertile shoot of large-size Fern; *Cladoxylon scoparium* (KRÄUSEL and WEYLAND 1926), a rather large polystelic Fern.

On the other hand, petrified material is not infrequently found. It has brought to light varied types of simple or elaborate organisation: the simple *Iridopteridaceae* (ARNOLD 1940) with a triangular or lobed xylem that point to the Paleozoic *Zygopteridaceae* (*Iridopteris*, *Reimannia*, *Arachnoxylon*); the *Cladoxylon* and *Asteropteris* with elongated simple or divided curved xylem strands; the *Actinopodium*, *Schizopodium*, more strongly related to the *Pteridosperms*.

If the *Ferns* and *Seed-Ferns* have the same line of descent, they presumably evolved very early in distinct directions.

The plant association of the Middle Devonian reveals an average level of differentiation much too high to have issued from the almost contemporaneous *Psilophytales*.

While the Ordovician, Silurian and Lower Devonian represent periods on innumerable attempts and failures—with a few winners!—the Middle Devonian is characterized by increasing changes within the polarized races. In Middle Devonian, “les jeux sont faits”, “the die is cast”.

If we try to visualize the past history of the *Pteridophytes* and come to any conclusion, it appears that the *Psilophytales* represent a division possibly equal in importance to that of the *Lycopside*s, *Sphenopside*s, *Pteropside*s, running parallel with them, instead of being their converging point. The chronology of the record and the stratigraphy seem to emphasize that view. If this conception were confirmed, the *Psilophytales* might be considered as a resulting point instead of a starting point. I mean, a group whose identity proper is not yet cleared up but has its own potentiality. A group which represents an ending side-line of evolution, though it may have had a flourishing time in the Early Paleozoic and a cosmopolitan geographical extension. In that way, the numerous impressions of the Lower Devonian which have not yet revealed any or very little of their internal structure or fructification represent a hopeful field for the understanding of the *Psilophytales* complex.

Other fields of research exist. For instance, the Silurian flora, which so far have only been touched upon. Regarding this the Senni *Sv. Bot. Tidskr.*, 48: 2

beds of the late Lower Old Red Sandstone are particularly promising. Another source of information by which our knowledge of the earliest vascular plants may increase, is represented by the spores abundantly spread in the Siluro-Devonian rocks. The range in size and variety of type suffices to foreshadow the rich and distinct flora which flourished in those times. Despite the fact that isolated spores or spore-masses are referred with difficulty to the mother-plant, their very presence is of major interest in a rock reputed as unfossiliferous. In this way, Professor THOMSON (1952) has pointed out the sharp difference existing in the spore flora of the Lower and Middle Devonian rocks. This is in conformity with the distinctive flora of these two geological horizons. Simple types of spores have been collected from a Coblencian bed of Münsterfeld and Daun (Germany). The spores are smooth, thin-walled, circular or elliptical, with or without triradiate markings. On the contrary, a Middle Devonian seam in Esthonia has revealed spores with a dotted appearance; short, long or hooked projections and wing differently developed.

Despite the prevailing scepticism regarding the existence of precursors of the vascular plant in Cambrian, I am inclined to admit that possibility.

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