CORYSTOSPERMAL PTERIDOSPERM IN THE LIASSIC CONTINENTAL DEPOSITS OF ROMANIA

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Abstract: In the present paper two Coryspermoral taxa are presented, Thinnfeldia speciosa (ETTINGSHAUSEN) and P. rhomboidalis (ETTINGSHAUSEN) DOUDENKO 1974. Thinnfeldia speciosa was recorded by the author only at Anina, a fossil – the locality of Lagerstatten, in the Fosoi Paleoibotanical Site of Special Scientific Interest (Banat region), where it partly generated a lens-shaped coa seam, of Hettangian age (included within the Thaumatopteris schenkii Assemblage Zone). The diagnosis of this genus and species has been emended, and the name of Thinnfeldia being kept. The cuticle of T. speciosa is presented here for the first time. Pachypteris rhomboidalis is Sinemurian dated, demonstrated until now as belonging to the Nilsonia orientalis Assemblage Zone.

Key words: Pteridospers, Coryspermoralae, Thinnfeldia speciosa, Pachypteris rhomboidalis, Liassic, Hettangian, Sinemurian continental deposits, Anina, Holbav, Cristian, Romania.

Introduction

The Liassic continental deposits from Romania bear a rich terrestrial compressive flora in which pteridospers belonging to the Orders Caytoniales and Coryspermoralae have a special place from taxonomic, systematic, paleoecological (paleoego-graphical or in the strict sense, related to the paleobiotope) and stratigraphic points of view. The Liassic continental deposits of Romania are dated Hettangian – Sinemurian, being represented by alluvial, fluvial, flood plain and subsidiary by lacustrine or deltaic deposits. These continental deposits occur in the South Carpathians, belonging to the Gotic (Reșița basin) and to the Danubian (Sirești, Presacina and Cerna basins) units, facially resembling to the Cresten facies. The flora is especially compressive but permineralized florules have been either recorded, such as at Holbav silicified wood assemblage (in study). The Bihoț unit (Apușeni Mountains) has Liassic continental deposits also, with some significant florules, but they are not discussed in the present paper, having other types of pteridospers. Stratigraphically, the Hettangian stage is indicated by taxa belonging to the Thaumatopteris schenkii Assemblage Zone (Popa, 1997 by Popa, in Stănciuc et al., 1997) and the deposits of this age are not widespread in Romania. They were recorded by the author in the central part of the Reșița Basin on the basis of the index taxon and in the Sirești basin on the basis of associated taxa. The Sinemurian stage is characterized by the Nilsonia orientalis Assemblage zone (Semaka, 1965), being well represented chrono-stratigraphically in both units and making the majority of the continental Liassic deposits in Romania.

Material and methods

The two species have been studied in samples collected by the author especially in situ, directly from the litologic sequences, with the stratigraphic and sedimentologic control and also by other geologists collecting from the mining dumps in various localities. The studied samples are sandstone fragments with vegetal compressions, that means especially leaves, axes of all types (rhizomes, stems, branches), roots and reproductive structures.

The methods used are field and laboratory methods. Field methods include collecting plant fossil, implying the initial record of the studied outcrop’s lithology (Popa, 1997a). The layers are described, numbered and sampled palaeontologically, palynologically and sedimentologically, for a careful recording of all types of information. In the laboratory, the material is usually studied macro- and microscopically, with the cuticular analysis, when the material permits this. The fragments were macerated with various Schultze reagents, mounted on biological slides, studied (MC7 research microscope) and photographed in transmitted light (Olympus 52 microscope). The non-macerated material was studied and photographed with binocular lens (Zeiss made) or with a usual camera (Praktica camera with rings and a wide-angle Pentacon objective).

Pachypteris, Thinnfeldia, Komlopteris – taxonomical aspects

The Coryspermal pteridospers present a large morphological leaf variation, being taxonomically a delicate group. Pachypteris, Thinnfeldia, Komlopteris, Dicrodium, Cycadopteris, Lomatopteris are only a few of very related morphologically genera, with large transitional morphotypes, their relationships being until now not entirely cleared.

The Pachypteris BRONNIART genus has a long history in the field of Taxonomy, here briefly presented. It was defined by Bronniart (1828-1836) on badly preserved material, some years before Eltinghausen (1852) established the Thinnfeldia genus on very well preserved material in Anina (Banat region, Romania).

For a series of species, Doledenko (1971) demonstrated Thinnfeldia to be a junior synonym for the Pachypteris genus, although previous authors, such as Andrae (1855) and Natherst (1880), had intuited the synonymy. The success of Eltinghausen's denomination was explained for by the high preservation of the material and its figuration. This state of preservation is a general feature for the remains collected from the area (Popa, 1994). A long series of authors have reported Pachypteris since its definiton, with many species and with a broad occurrence, with a large stratigraphic range, while Thinnfeldia has been used rarely and traditionally by the German authors. Important papers emending the diagnosis and refining the knowledge on the genus have been written during the 20th century, such as Antevs (1914), Thomas (1954), Harris (1964), Dobudenko (1969, 1971, 1974) and Barbacca (1994b).

Later, while the knowledge on the anatomy of this...
type of foliage advanced, *Pachypteris* was split into a new genus named *Kamptopterus* by Barbacka (1994b), on the basis of leaf morphology (pinnate, long pinnules with entire margins in *Kamptopterus* vs. bipinnate leaves, with generally small pinnules in *Pachypteris*) and cuticular anatomy (stomata arrangement and structure). M. Barbacka also retained the genus *Thinifeldia*.

*Pachypteris* is characterised macroscopically by mono- or bipinnate leaves, with pinnules ranging from rounded, elliptic to lanceolate, very variable in shape. Microscopically, *Pachypteris* is generally hypostomatic, having a haploclinal type of stomata with irregular subsidiary cells. The stomata are scattered on the whole surface of the lower epidermis, excepting the midrib, which is more or less prominent (Dolüdenko, 1974; Barbacka, 1993, 1994).

Phylum Gymnospermophyta
Class Pteridospermopsida
Order Corystospermales
Family Incertae sedis
Genus *Thinifeldia* (ETTINGSHAUSEN) emend.

Emended diagnosis. Pinnate leaves, with stout, non-ornamented rachis, opposed or sub-opposed, large pinnules with elongate shape, narrow base, entire margin and rounded apex, obliquely inserted to the rachis. The venation ariehopterid, the midrib clear and the secondary veins simple or rarely divided dichotomously, well represented on the abaxial epidermal surface by parallel rows of elongated parenchimatus cells. Leaves with thick cuticles, hypostomatic, rarely amphystomatic, with stomata confined to the areas between the secondary veins and subsidiary cells in slightly bowl-shaped collars. Type species: *Thinifeldia speciosa* (ETTINGSHAUSEN) (Fig. 6).

**Fig. 6 - Thinifeldia speciosa**, original illustration of Ettingshausen (1852).
The stomata have guard cells slightly cutinised, sunken under the subsidiary cells, being rarely preserved during the maceration with the Schiltze Reagent. The subsidiary cells are rectangular or trapezoid in shape, forming a continuous collar around the ostiole. They are also slightly depressionary towards the ostiole, their external contour being higher than the internal boundary. A stoma usually has 4-6 subsidiary cells. The topographic distribution of the stomata is on the whole surface between the secondary veins, with the exception of the midrib that lacks stomata. The stomatal density is very high, the distribution of the stomata is random, their axes being not parallel.

On the leaf rachis, the parenchymatous cells are elongated, with parallel stomata among them. The parenchymatous cells are longitudinally distributed, the stomata axes having the same orientation (Slide 110, P41/C2/S6/E16/F1 pinnule fragment no. 6, in the neotype).

From the mentioned area of collecting (points P41/C2 and P41/C2), leaves of T. speciosa are associated with a rich root, stem and bilaterally divided branch material, corystosperm reproductive material, the so-called berets, also being recorded (Point P41/C2/S6). They probably belong to the same species, taking into consideration that T. speciosa is the only corystosperm in the area.

The preservation of the material is quite remarkable. In the field, the pinnules can be extracted on their entire length by hand, being black, almost transparent or slightly opaque, brown in colour in the daylight.

Systematic position. The same species of leaf was identified by Ettingshausen (1852) as Thinnefeldia speciosa. The figuration of his type series without doubt indicates the identity between the collected material and that of Ettingshausen’s material. This species, T. speciosa, has not been discussed taxonomically until now, due to the lack of fossil materials. Now, describing it, the denomination of Thinnefeldia seems to have more sustainability, although it has a “transitional” position between Pachypteris and Komlopteris and is closer to the latter (Table 1).

Taxonomically, the species closest to T. speciosa is Komlopteris nordenskioldii BARBACKA. This differs from T. speciosa by the less elongated, decurrent pinnules, strongly marked secondary veins, by the stomatal distribution on the midrib and by the inner ornamentation of the subsidiary cells.

The boundary lines between the three genera are somehow delicately set. One point of view would be to keep all the three genera separated, considering the presented differences; another point of view would be the extension into synonymy of the all three genera under the umbrella of the older denomination of Pachypteris (BRONGIART). This situation has to be cleared in a future study that will take into consideration also the reproductive structures of T. speciosa and eventually its reconstruction.

For the moment, keeping Thinnefeldia (ETTINGSHAUSEN) as a separate genus seems to be indicated.

Occurrence. The studied material has been collected from the Banat region, South Carpathians (Anina Mountains), within the locality of Anina, Romania. Ettingshausen (1852) collected the paleobotanical material from the Thinnefeld pit, in Anina, close to the old part of the locality (Steierdorf), being cited by later authors with the same occurrence. The remains presented here have been collected since 1993 by the author from the southern end of the Ponor quarry (also close to the Steierdorf old part of town of Anina). This area represents the paleobotanical preserved site (SSSI - Special Site of Scientific Interest - Popa, 1994), points P40/C2 and P41/C2 being the collecting points (the points 40 and 41 in the author’s field notebook no. 2).

Phytostratigraphy. Stratigraphically, the remains occur within the basal succession of the Valea Terezei Member, belonging to the Steierdorf Formation (Bucur, 1985), a sequence that outcropped by the mentioned points in the field notebook. The basal succession is characterised by an assemblage with Thaumatopteris schencki, Thaumatopteris sp., Dictyoxyphillum nervosum, typical small size Nilsonia sp., Podozanites cf. paucinervis, Pagiophyllum sp., rare Sagenopteris sp. and many other taxa, assemblage that belongs in the author’s view to the Assemblage Zone with Thaumatopteris schencki, indicative of the Hettangian stage. This association changes in the proximity of the refractory clay stratigraphic level, where the boom of Nilsonia orientalis was recorded, indicating the Sinemurian.

Within point P41/C2, in layer S6, the accumulation of leaf material being locally so dense that the bed was named by the author “the pizza with plant bed”. The density of the leaf material decreases northwards (towards point P40/C2), where it is associated more intimately with conifers (Pagiophyllum sp., Podozanites cf. paucinervis). This association is the reason for the increase in the coal bed’s (Seam no. 5 = S5) thickness, under Layer no. 6, within point
<table>
<thead>
<tr>
<th>Type species</th>
<th>Pachypteris</th>
<th>Thinfeldia</th>
<th>Komlopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>Bi- or monopinnate</td>
<td>Monopinnate</td>
<td>Monopinnate</td>
</tr>
<tr>
<td>Pinnules</td>
<td>Small, various margins, often dissected</td>
<td>Large, entire margins, very elongated</td>
<td>Large, entire margins</td>
</tr>
<tr>
<td>Pinnule insertion</td>
<td>Decurrent</td>
<td>With entire base, non-decurrent</td>
<td>Decurrent</td>
</tr>
<tr>
<td>Epidermis</td>
<td>Hypostomatic</td>
<td>Hypostomatic, rarely amphyostomatic</td>
<td>Amphyostomatic</td>
</tr>
<tr>
<td>Secondary veins</td>
<td>Not always represented</td>
<td>Well represented in the majority of the leaves, rarely slightly represented</td>
<td>Well represented</td>
</tr>
<tr>
<td>Stomatal distribution</td>
<td>On the whole abaxial surface, excepting the midrib, or only between secondary veins</td>
<td>On the whole abaxial surface, excepting the midrib and only between secondary veins</td>
<td>On the whole abaxial surface, on the midrib and only between secondary veins</td>
</tr>
<tr>
<td>Subsidiary cells</td>
<td>Various shapes, even with papillae, flattened</td>
<td>Rectangular or trapezoidal, slightly bowl shaped</td>
<td>Various shapes, with an inner line, bowl shaped</td>
</tr>
</tbody>
</table>

Table 1. Comparion between Pachypteris, Thinfeldia and Komlopters genera

P41/C2, this layer being thinner.

Paleoecology. As deduced from the sedimentary structures, the paleoecology of T. speciosa is characterized by a wet, marsh biotope, where this plant lived together with the taxa mentioned. This species is a local co-generator of coal seam no. 5, being the only generator in the area of point P41/C2, while in point P40/C2 is associated with cheirolepidae and inverte sedis conifers and other taxa. The taxon is recorded stratigraphically first in layer no. 4, in both points, and has a boom in layer no. 6, especially in Point P41/C2, where it generates the so called “pizza with plants”, in the roof of layer no.5 that is a coal seam. Both layers no. 4 and 6 (lithic sandstones) represent actually paleosols, containing thick roots (some of them dispersed radially, for better stability) and stems in growing position or parallel to the lamination. Probably a phenomenon of competition occurred between T. speciosa and the mentioned conifers, within the swamp area (layer no. 5) and before (layer no. 4) and after (layer no. 6) its closing.

Type series. The holotype was lost, probably during World War II. The Neotype is on sample P41/C2/S6/E16, leaf fragment no. 1, slides no. 100 to 110. The paratypes occur on the same sample, leaf fragments no. 2, with slides no. 111-112 and leaf fragment no. 3, with slides no. 113-116.

Stratum typicum. Layer no. 6, Point no. 41 in the Popsa field notebook no. 2, southern sector of the Ponor quarry, within the Ponor Paleobotanical reserve.

Repository. University of Bucharest, Laboratory of Paleontology, Department of Geology and Paleontology, within Popsa collection.

Genus Pachypteris (BRONGNIART) BARBACKA 1994

Pachypteris rhomboidalis (ETTINGSHAUSEN) DOLUDENKO 1974

Plate I, Figs. 3-4, Pl. II, Fig. 6, Text-Fig. 4

1852 - Thinfeldia rhomboidalis ETTINGSHAUSEN, p. 2-4, Pl. I, Figs. 4-7.
1855 - Pachypteris thinfeldi ANDRAE, p. 43-44, Pl. 11, Fig. 6, Pl. 12, Figs. 7-9.
1857 - Thinfeldia rhomboidalis SCHENK, Pl. 27, Figs. 1-8.
1873 - Thinfeldia rhomboidalis SAPORTA, p. 343-346, P. 43, Fig. 1-2, 4-8.
1880 - Pachypteris rhomboidalis NATHORST, p. 80, 84.
1902 - Thinfeldia rhomboidalis MOLLER, p. 4, 6, 13, 14, 24, 25, Pl. II, Fig. 18
1914 - Thinfeldia rhomboidalis ANTEVS, p. 27, P. 2, Fig. 5, Pl. 4, Fig. 4, 6.
1922 - Pachypteris rhomboidalis KRASSER, p. 365-366.
1971 - Pachypteris rhomboidalis DOLUDENKO, p. 103, Pl. 12, fig. 1-6.
1974 - Pachypteris rhomboidalis DOLUDENKO, p. 13, Pl. 1, Figs. 1-6.
1968 - Thinfeldia rhomboidalis WEBER, p. 53-55, Pl. 8, Fig. 83, Pl. 9, Fig. 84-92, Pl. 10, Fig. 94-101
1969 - Thinfeldia rhomboidalis HUMML, p. 396.
1991 - Thinfeldia rhomboidalis BARBACKA, p. 258.
1994 - Pachypteris rhomboidalis BARBACKA, p. 7, Pl. 1, Fig. 3, Pl. 5, Figs. 3, 5.

Lots of citations of the taxon have been found, being not listed.

Description. The leaf is pinnate, with a stout rachis, 0.7-1 mm wide. The rachis is not ornamented, having the same position as the pinnules level. Pinnules are attached in an opposed or slightly sub-opposed position (Fig. 4). Their shape is typically rhomboid, with a narrow base (1.5-2 mm
wide), with the acrosopic margin almost parallel to the rachis, entire margin and rounded apex, having a constant shape. A midrib is slightly defined, with secondary veins undivided. The substance of the lamina is thick.

Fig. 4

Fig. 4 – *Pachypteris rhomboidalis*, sample G75, leaf fragment no. 3, Cristian.

The leaf is hypostomatic, with the upper cuticle thicker than the lower one. On the upper cuticle, the parenchymatous cells are usually square, triangular or irregular in shape, frequently with irregular anticlinal walls. The midrib is slightly expressed epidermally on the upper cuticle, but with no secondary veins. The midrib has rows of parallel, slightly elongated cells. The stomata are very rare on the upper epidermis, stiptical. The lower cuticle also has parenchymatous cells irregular in shape, with the midrib expressed concurrently with the upper cuticle, very pale. The stomata have an elongated ostiole, with guard cells rarely preserved during the Schultze Reagent maceration. The subsidiary cells form a wide ring of 3-5 cells irregular in shape, disposed without any depression with regard to the ostiole. The stomata are randomly distributed on the whole surface of the pinnule, excepting the midrib and a narrow zone close to the pinnule’s margin. The margin has 7-12 rows of elongated cells.

Remarks. The species has been defined by Ettingshausen (1852) as *Thinmfeldia rhomboidalis*. Andrae (1855)(Fig. 5) and Dolodenko (1974) emended the diagnosis of the species on material collected also from Anina, given by A. Badaluta to V. Vachrameev, attributing the species to the *Pachypteris* genus.

Occurrence. Ettingshausen collected his material from Anina. Dolodenko (1974) and Barbacka (1991, 1994) described or figured the species from the same occurrence. The material studied and presented here was collected by two geologists, E. Grădinaru and C. Dragoi, from the localities of Holbav and Cristian, near Bragov town and given to the author to study. This material was collected from barren gangue dumps, close to some old mines. The species was also figured in the paper of Dragostan & Popa (1997), with no description, with the indication of the sample’s inventory code. It was cited or described by previous authors in other localities. In Holbav, the species was recorded in Valea Lăcă coalfield and in Cristian it was collected from the Fabricii Valley. In Romania, *P. rhomboidalis* was cited in Anina especially. In the world, the occurrence is very wide.

Phytostratigraphy. The samples contain the taxon collected from Cristian, include a rich flora of pteridosperms, cycads and cycadoids. On one sample, *P. rhomboidalis* is associated with *Nilosia orientalis*, the marker for Sinemurian.

Conclusions. The genus *Thinmfeldia* has been cleared and completed taxonomically on material having the same occurrence as the original material of Ettingshausen, having as type species *T. speciosa*. Stratigraphic, paleoecologic and occurrence data have been presented with regard to the mentioned species and also to the *Pachypteris rhomboidalis* species.

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Captions of Plates

Plate 8. I
Fig. 1 - *Thinnsfeldia speciosa*, Neotype, within a dense leaf accumulation.
Fig. 2 - *Thinnsfeldia speciosa*, Paratype, P40/C2/S6/E51, long leaf.
Fig. 3 - *Pachypteris rhomboidalis*, sample G45.
Fig. 4 - *Pachypteris rhomboidalis*, sample G

Plate 8. II
Fig. 1 - *Thinnsfeldia speciosa*, Neotype, upper epidermis, showing midrib (m) and usual epidermal cells. Slide 10x.
Fig. 2 - *Thinnsfeldia speciosa*, Neotype, rachis epidermis. Slide 110.
Fig. 3, 4 - *Thinnsfeldia speciosa*, lower epidermis showing midrib (m) and secondary veins (nII0. Slide 10x.
Fig. 5 - *Thinnsfeldia speciosa*, lower epidermis, terminal intervein area with stomata. Slide 148.
Fig. 6 - *Pachypteris rhomboidalis*, lower epidermis. Slide 70.