Annales Societatis Geologorum Poloniae (2019), vol. 89: 307–316 doi: https://doi.org/10.14241/asgp.2019.13

SPHENOPSID AND FERN REMAINS FROM THE UPPER TRIASSIC OF KRASIEJÓW (SW POLAND)

Grzegorz PACYNA

Jagiellonian University in Kraków, Faculty of Biology, Institute of Botany, Department of Taxonomy, Phytogeography and Palaeobotany, Gronostajowa 3, 30-387 Kraków, Poland;
e-mail: grzegorz.pacyna@uj.edu.pl; ORCID identifier 0000-0003-4365-3549

Pacyna, G., 2019. Sphenopsid and fern remains from the Upper Triassic of Krasiejów (SW Poland). *Annales Societatis Geologorum Poloniae*, 89: 307–316.

Abstract: Hydrophilic elements, such as sphenopsids and ferns, are rare in the flora of the Krasiejów site and they are poorly preserved. One sphenopsid species, *Neocalamites merianii*, was recognised. It is preserved as impressions, flattened casts, moulds and isolated leaves. So far, only one small fern specimen, determined as *Sphenopteris* sp., has been found. These elements probably were transported to the site of deposition and did not grow where they were buried.

Key words: Fossil plants, *Neocalamites*, *Sphenopteris*, Germanic Basin.

Manuscript received 21 February 2019, accepted 11 August 2019

INTRODUCTION

Recent discoveries of Upper Triassic outcrops in Silesia (southwestern Poland) have yielded not only rich vertebrate material, but also new plant fossils (Dzik and Sulej, 2007; Pacyna, 2014). Plant macrofossils rarely are found in the Upper Triassic of Poland (Reymanówna, 1986; Pacyna, 2014; Pacyna *et al.*, 2017; Kustatscher *et al.*, 2018) and hence are poorly known; such discoveries open new opportunities for study of them. Krasiejów was the first Polish Triassic site with the bones of large land vertebrates described and it is still one of the most important (Sues and Fraser, 2010; Lucas, 2018). It is a window on ecosystem evolution at the beginning of the dominance of the dinosaurs. The discovery and description of *Silesaurus* give a new impetus for research on the origin of the dinosaurs and their diversification in the Triassic (Fraser and Sues, 2010; Langer *et al.*, 2010; Agnolín and Rozadilla, 2018; Baron, 2019).

The fossil assemblage identified at the Krasiejów locality (Fig. 1) is abundant in specimens, is among the most taxonomically diverse ones in the Polish Triassic and is one of the richest in the European Triassic (Dzik and Sulej, 2007; Lucas *et al.*, 2007, Sues and Fraser, 2010). The invertebrate fauna consists of conchostracans (Olempska, 2004), bivalves (Skawina, 2010, 2013; Skawina and Dzik, 2011), crustaceans and insects (Dzik and Sulej, 2007; Dzik, 2008; Qvarnström *et al.*, 2019). The numerous vertebrates include fish (Dzik and Sulej, 2007; Antczak and Bodzioch, 2018a), temnospondyls (Sulej, 2002, 2007; Sulej and Majer, 2005; Barycka; 2007; Konietzko-Meier and Wawro, 2007; Konietzko-Meier and Klein, 2013; Konietzko-Meier and Sander, 2013; Konietzko-Meier *et al.*, 2013, 2014; Gruntmejer *et al.*, 2016; Fortuny *et al.*, 2017; Antczak and Bodzioch, 2018b; Konietzko-Meier *et al.*, 2018; Teschner *et al.*, 2018), a gliding archosauromorph (Dzik and Sulej, 2016), phytosaur (Butler *et al.*, 2014), a rauisuchian (Sulej, 2005; Brusatte *et al.*, 2009), an aetosaur (Sulej, 2010; Desojo *et al.*, 2013) and a dinosauromorph (Dzik, 2003; Dzik and Sulej, 2007; Fostowicz-Frelik and Sulej, 2009; Piechowski and Dzik, 2010; Piechowski *et al.*, 2014, 2018). The precise ages and stratigraphical positions of the bone-bearing levels, the vertebrate taxonomy and the taphonomy of this locality are still debated vigorously and reasonable, but conflicting solutions to these issues have been proposed (Bilan, 1975; Dzik, 2001; Szulc, 2005; Lucas *et al.*, 2007; Gruszka and Zieliński, 2008; Bodzioch and Kowal-Linka, 2012; Lucas, 2015; Racki and Szulc, 2015; Szulc *et al.*, 2015a, b, 2017; Jewuła *et al.*, 2019).

The macroflora of this site has not yet been properly described but was mentioned only on a preliminary basis (Dzik and Sulej, 2007; Pacyna, 2014). It is the subject of one of the ongoing research projects of the present author. The plant assemblage is dominated by conifer remains and other groups are subordinate. Pteridophytic remains are scarce in the Krasiejów biota and to date have not been determined; the description of them is the purpose of this paper. Only rare sphenopsid and fern remains are present. They are poorly preserved, like most plant fossils from the Krasiejów locality, but they hold important data for studies of the palaeoecology, taphonomy and age of the assemblage. The implications of these new data are discussed in this paper. Numerous charophyte oogonia have been described from the lower bone-bearing horizon (Zatoń and Piechota, 2003; Zatoń *et al.*, 2005). Palynomorphs are absent at this locality (Dzik and Sulej, 2007) and so palynological biostratigraphy cannot be applied.

GEOLOGICAL SETTING

In the late Triassic, the Upper Silesia region formed the southeastern part of the Germanic Basin. Uplands surrounding this area to the south and east provided siliciclastic material, which was deposited in fluvial, floodplain, and playa environments across the basin (Jewuła *et al.*, 2019). One of the places where such sediments were commercially exploited is the now abandoned Krasiejów Quarry (Bilan, 1975). Geological setting of the Krasiejów site is well documented on the basis of sediments visible in the outcrop and shallow borehole (Szulc, 2005, fig. 2). The rock sequence at Krasiejów is dominated by variegated mudstones and siltstones. The sediments are reddish in colour, with grey planar or spotty intercalations. The dominant facies type are the alluvial deposits, formed on gently sloping sandflats to mudflats with small, ephemeral lacustrine basins (Szulc, 2005; Jewuła *et al.*, 2019). About 6 metres below the top of the section, the lower bone-bearing horizon, ca. 1 m thick, occurs (Fig. 2). It contains well preserved, but mostly disarticulated skeletons of various aquatic, semi-aquatic and land vertebrates (Dzik and Sulej, 2007) and in only one part of the outcrop plant macrofossils, which are poorly preserved as iron-stained impressions.

The age of the Krasiejów assemblage was proposed originally by Dzik (2001) and Dzik and Sulej (2007) as late Carnian, on the basis of tetrapod biochronology and the correlation of strata. According to them, the Krasiejów strata correlate with the Drawno Beds of the Polish Lowland and the Lehrberg Schichten (now the Steigerwald Formation) in Germany. This age proposal was confirmed later by Lucas (Lucas *et al.*, 2007; Lucas, 2015, 2018), also on the basis of tetrapod biochronology, and by Pacyna (2014) on the basis of correlation of the macrofossil plant assemblages with the German part of the Germanic Basin. This age determination was questioned by Szulc and collaborators (Szulc, 2005; Szulc *et al.*, 2015a, b; Jewuła *et al.*, 2019), on the basis of integrated stratigraphy, facies analysis and event geology. They proposed a Norian age for the assemblage and referred it to the basal part of the Patoka Member of the formation that they defined as the Grabowa Formation. The Grabowa Variegated Mudstone-Carbonate Formation (Szulc *et al.*, 2015a) is a thick succession of variegated mudstone to claystone deposits, reaching up to ca. 400 m with a carbonate admixture and with calcareous breccias in the upper part. This formation is a lateral equivalent of German Wesser and Arnstadt formations (Szulc *et al.*, 2015a; Jewuła *et al.*, 2019). The Patoka Marly Mudstone-Sandstone Member is the thickest member of this formation (up to ca. 300 m), composed of variegated, mostly red to brownish, marly, massive mudstones, with numerous horizons of limestone-claystone conglomerates.

An absolute age, based on detrital zircon analysis, could settle the question of age for the Upper Silesian bone-beds (Kowal-Linka *et al.*, 2019). However, the ages of the stage boundaries in the Upper Triassic are still a matter of debate. Also, owing to problems in correlating the non-marine Upper Triassic strata, an age determination for the Krasiejów assemblage awaits further research.

MATERIAL AND METHODS

The plant fossils described here were collected during field work at the Krasiejów locality, which was organized and conducted by J. Dzik and T. Sulej (Institute of Paleobiology, Polish Academy of Sciences) during the 2000–2002 field seasons. The specimens the author and D. Zdebska excavated are stored in the Institute of Botany of the Jagiellonian University (Fossil Plants Collection of Herbarium Universitatis Iagellonicae Cracoviensis, collection number KRA-PALEO 102). Specimens found by other members of the excavation team are stored in the Institute of Paleobiology (Collection ZPAL Ab III) and were available for study. The specimens were collected under an excavation permit granted to the Institute of Paleobiology, Polish Academy of Sciences, before the Krasiejów locality was placed under special protection as a Trias Geological Documentary Site (Wojewoda Opolski, 2003).

Plant fossils were found in only one place within the lower fossil-bearing horizon (Figs 1, 2). They formed a dense accumulation in an area covering about 3 m^2. Beside plant debris, only the well-preserved remains of the crustacean *Opolanka decorosa* Dzik are encountered in this accumulation. The plant remains are fragmented, consisting of conifer and sphenopsid shoot fragments, up to about 10 cm long, very rarely longer, completely mixed and showing no discernible direction of transport. Even more poorly preserved and rare plant remains were dispersed in a radius of 2–3 m around the main concentration; bivalve fossils and some vertebrate remains were also present there, especially isolated vertebrae of *Metoposaurus krasiejowensis* Sulej. The plant fossils are preserved mainly as iron-stained impressions, completely devoid of any organic remains. Larger sphenopsid shoot fragments are preserved as somewhat flattened casts.

The plant remains were carefully dissected using needles, examined under a Technival 2 stereoscopic microscope and photographed with a Nikon NIKKOR AF-s DX Micro NIKKOR 85 mm f/3.5G ED VR Camera.

SYSTEMATIC PALAEONTOLOGY

The suprageneric classification follows Cronquist *et al.* (1966), Kenrick and Crane (1997), Taylor *et al.* (2009) and PPG I (2016). For the nomenclatural treatment, the *International Code of Nomenclature for Algae, Fungi and Plants* (Shenzhen Code, 2017) and the *International Code of Phylogenetic Nomenclature* (Cantino *et al.*, 2007) were used.

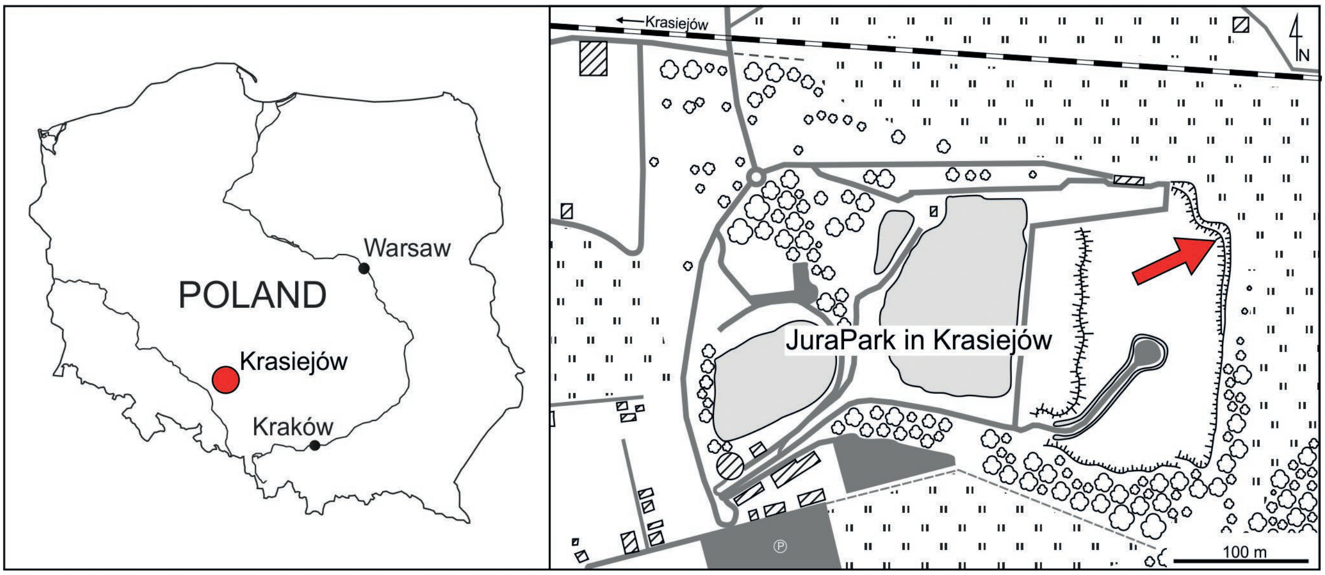

Fig. 1. Location of the Krasiejów locality on a map of Poland and drawing showing actual state of outcrop with JuraPark infrastructure (place, from which plant fossils were collected, is marked by red arrow).

Class EQUISETOPSIDA Agardh, 1825

Order EQUISETALES de Candolle ex von Berchtold & Presl, 1820

Family *incertae sedis*

Genus *Neocalamites* Halle, 1908 emend. Bomfleur *et al*., 2013

Type species: *Neocalamites lehmannianus* (Goeppert, 1846) Weber, 1968; Upper Silesia, Dobiercice; Upper Triassic.

Neocalamites merianii (Brongniart, 1828) Halle, 1908
Fig. 3A–I

Selected synonyms:

* 1828––1837 *Equisetum merianii* n. sp. – Brongniart, p. 115, pl. 12, fig. 13.

1864 *Calamites merianii* (Brongniart) Schenk – Schenk, pp. 71–74, pl. 7, fig. 3, pl. 8, fig. l a, b.

1908 *Neocalamites merianii* (Brongniart) Halle – Halle, p. 6.

1958 *Neocalamites merianii* (Brongniart) Halle – Kräusel, p. 82, pl. 6, fig. 36, pl. 7, figs 38–41, pl. 8, figs 42–43.

1959 *Neocalamites merianii* (Brongniart) Halle – Kräusel, p. 6, pl. 1, figs 1–7, pl. 2, figs 8–14, text-fig. 1.

1995 *Neocalamites merianii* (Brongniart) Halle – Kelber and Hansch, p. 48, figs 94, 96, 98–107

2008 *Neocalamites merianii* (Brongniart) Halle – Pott *et al*., pp. 188, 190, pls 3, 4.

2014 *Neocalamites merianii* (Brongniart) Halle – Barbacka *et al*., p. 286–287, pl. 1, figs 4–8.

2015 *Neocalamites merianii* (Brongniart) Halle – Kelber, pp. 57–58, 67–70, fig. 5.5, 5.15, 5.16

2018 *Neocalamites merianii* (Brongniart) Halle – Pott *et al*., p. 7, text-fig. 2D–F, pl. 1, figs 9, 10.

Material: ZPAL Ab III/3216, 3217, 3222, KRA–PALEO 102/36, 102/37, 102/38, 102/106, 102/115–133 – shoot fragments, 102/134–140 – isolated leaves.

Description: Shoot fragments preserved fragmentarily as flattened casts and moulds, 5 mm to at least 26 mm wide, distinctly ribbed longitudinally (Fig. 3A–F). Ribs 0.75–4 mm wide depending on shoot width. On broadest shoots, protruding bands 0.5–0.8 mm wide lying between ribs (these are vestiges of vascular bundles exposed on the external shoot ribs from beneath; Fig. 3A). Nodes only rarely preserved, poorly visible (Fig. 3B). No visible traces of leaf scars, leaf sheath or branch scars in nodes. Nodes not expanded. Two nodes not visible on any shoot fragments, so internode length not measurable. Longest preserved shoot fragment without node 95 mm long, 20 mm wide (hence, internodes on average-sized shoots could be at least that long). Leaves found only as isolated, fragmented specimens, without bases or apices preserved, 10–27 mm long, 1.0–1.5 mm wide, neither narrowing or expanding along leaf length (Fig. 3G–I). No traces indicating fusing of leaves in a sheath. Leaf vascular bundle remnants are not traceable on a leaf surface.

Remarks: The genus *Neocalamites* was proposed by Halle (1908) to accommodate several early Mesozoic equisetophyte species that previously had been erroneously assigned to *Schizoneura*. The genus *Schizoneura* is characterised by leaf sheaths that split into several strap-shaped leaf-sheath segments in mature stems. In contrast, *Neocalamites* has long, linear, narrow, single-veined leaves

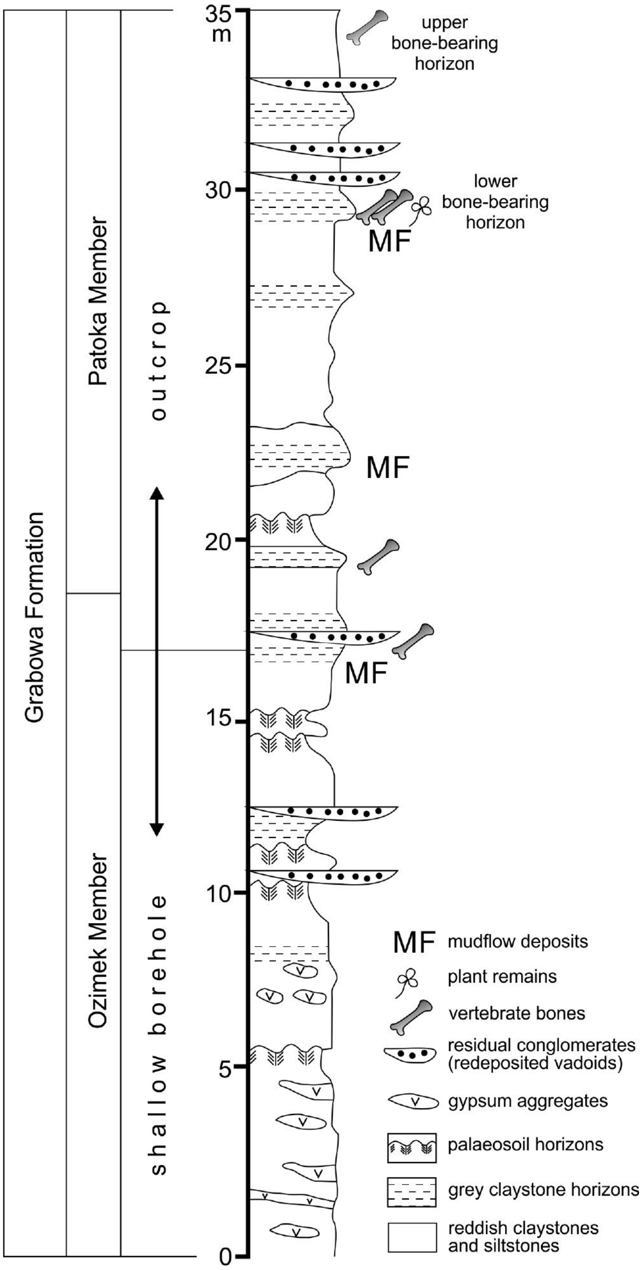

Fig. 2. Simplified lithological column of the Krasiejów succession (after Szulc, 2005, fig. 2 and Szulc *et al*., 2015b, fig. 3, modified), lower (source of plant remains) and upper bone-bearing horizons are indicated.

whose bases may be separate, overlapping or even connate. Modern ideas about these genera were extensively discussed by Bomfleur *et al*. (2013), who also proposed a very precise, emended diagnosis for *Neocalamites*, which is followed here.

Neocalamites merianii (Brongniart) Halle was described first by Brongniart (1828) as *Equisetum merianii*, on the basis of material from the Carnian of the Neuewelt locality in Switzerland. Kräusel (1958, 1959) described and illustrated numerous well-preserved specimens. Pott *et al*. (2008, 2018) gave a detailed description of the species, based on rich material from Lunz (Austria). The material described here corresponds well with the specimens reported by Kräusel (1958, 1959), Kelber and Hansch (1995), Pott *et al.* (2008, 2018), Barbacka *et al.* (2014) and Kelber (2015). In *N. merianii*, unlike in extant sphenopsid species, the number of vascular bundles is not equal to the number of ribs visible on the shoot surface (Kustatscher and Van Konijnenburg-Van Cittert, 2008; Barbacka *et al.*, 2014). The shoot surface was covered with wide ribs, and about ten vascular bundles were beneath each rib. The vascular bundles are visibly exposed on the external shoot ribs from below. Among the *Neocalamites* species, external shoot surfaces in connection with vascular bundles are preserved especially frequently in *N. merianii* (Kelber and Hansch, 1995; Kelber, 2015). Probably the cortical tissue decayed quickly, but the more resistant vascular bundles persisted longer and appeared on its surface. This interesting mode of preservation of fossil sphenopsids as exemplified by this species was described and well-illustrated by Kräusel (1958, 1959), Kelber and Hansch (1995; fig. 105), Kustatscher and Van Konijnenburg-Van Cittert (2008), Pott *et al.* (2008, 2018) and Kelber (2015), and for other *Neocalamites* species by Jarzynka and Pacyna (2015).

The specimens described here could be referred to *Neocalamites merianii* in view of their shoot dimensions, rather the large internode length (internodes are short in contemporary *Equisetites arenaceus*), the lack of a leaf sheath, the presence of slender, linear, unfused leaves (contrary to genus *Schizoneura*, see above), and also the special mode of preservation (external ribs and vascular bundles visible) typical for this species (compare Pott *et al.*, 2008, 2018). *Neocalamites suberosus* is characterised by wide leaves with broadened leaf bases. *N. carrerei* has whorls of very narrow leaves (Bomfleur *et al*., 2013). *N. lehmannianus* have leaves that usually are entirely free to their bases, but in this species coarse ribbing on external surface of shoots has not been described (for detailed discussion see Jarzynka and Pacyna, 2015). In this species, the density of vascular bundles per 1 cm of shoot width is smaller than in *N. merianii* (Barbacka *et al.*, 2014). In *N. grojecensis* external cortical surface of shoots has coarse ribbing, but external ribs are on average narrower than in *N. merianii* (Jarzynka and Pacyna, 2015).

Reproductive structures of *Neocalamites* are not often found (Bomfleur *et al*., 2013). Specimens in organic connection to their stems are rare. Most of the specimens discovered only occur with sterile shoots. However, on the basis of well preserved and properly documented specimens, it is assumed that *Neocalamites* produced compact strobili consisting of successive whorls of peltate sporangiophores, each sporangiophore bearing six or more sporangia (Kon'no, 1962; Brea and Artabe, 1999; Escapa and Cúneo, 2006; Pott *et al*., 2008, 2018; Zan *et al.*, 2012).

Because of problems in recognising reproductive structures and evidence that *Neocalamites*-type stems had secondary growth (Kelber and Hansch, 1995), the systematic position of this genus is unclear. *Neocalamites* stems probably could grow several metres high (Holt, 1947); such huge plants are unknown in the modern *Equisetum* lineage. Secondary growth and free leaves, similar to those in calamitaleans, could indicate that this form is a vestige of that group. Recently, Elgorriaga *et al.* (2018) provided the first comprehensive phylogenetic analysis of Equisetales, with

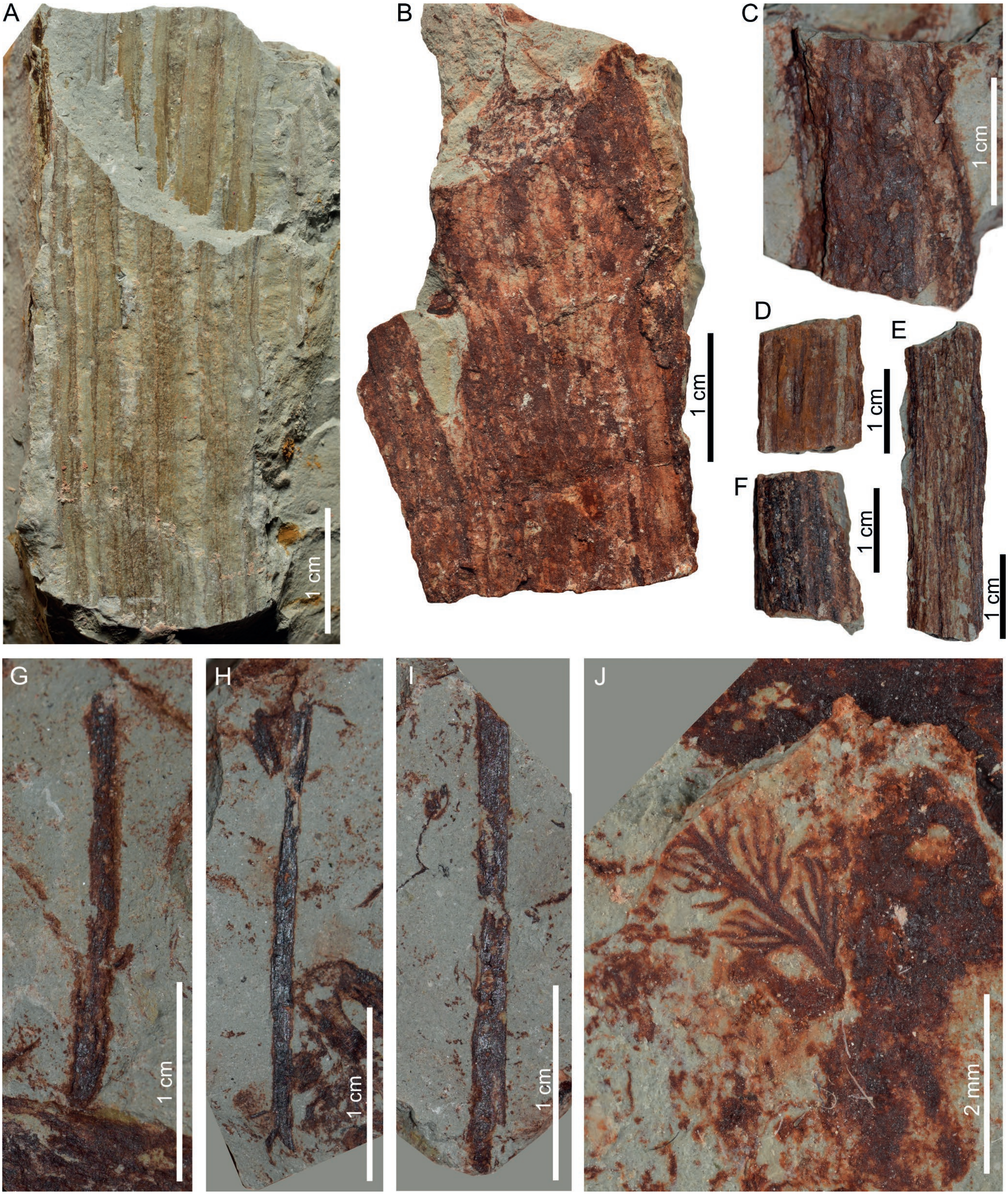

Fig. 3. Sphenopsid and fern remains from Krasiejów. **A–I**. *Neocalamites merianii*; A –flattened cast, protruding bands lying between ribs well visible, KRA–PALEO 102/36B; B – flattened cast, somewhat distorted, node visible as horizontal band at lower part of specimen, KRA–PALEO 102/106; C–F – somewhat flattened casts (C – KRA–PALEO 102/123, D – KRA–PALEO 102/128, E – KRA–PALEO 102/119, KRA–PALEO 102/120); G–I – leaves (G – KRA–PALEO 102/134, H – KRA–PALEO 102/140, I – KRA–PALEO 102/138). **J**. *Sphenopteris* sp., leaf fragment, KRA–PALEO 102/3.

special emphasis on the origin of the genus *Equisetum.* They recovered Equisetaceae plus *Neocalamites* as a sister to the Calamitaceae, plus a clade of Angaran and Gondwanan sphenophytes, with the four groups forming a clade that is sister to the Archaeocalamitaceae. According to them, *Neocalamites* is a sister to the Equisetaceae, but they concluded that *Neocalamites* appears to have a mosaic of equisetalean features not present in any other clade, supporting the idea that it was part of a distinct natural group. Probably this group forms an evolutionary bridge between the Archaeocalamitaceae and the Equisetaceae.

Distribution: *Neocalamites merianii* is common in the Triassic (especially Ladinian–Carnian, mainly southern Germany and the Neuewelt, Switzerland and Lunz, Austria localities) and less common in Early Jurassic floras of Europe (Kräusel, 1958, 1959; Kelber and Hansch, 1995; Pott *et al.*, 2008). In Poland, it was noted previously only once, from the upper Ladinian and Hettangian strata of the Holy Cross Mountains region (Barbacka *et al.*, 2014).

Class POLYPODIOPSIDA Cronquist *et al*., 1966

Order and family *incertae sedis*

Genus *Sphenopteris* (Brongniart, 1822) Sternberg, 1825

Type species: *Sphenopteris elegans* (Brongniart, 1822) Sternberg, 1825; Lower Silesia, Wałbrzych; Carboniferous, Namurian A.

Sphenopteris sp.
Fig. 3J

Material: KRA–PALEO 102/3 – small leaf fragment.

Description: Penultimate and ultimate fragments of compound leaf (Fig. 3J). Penultimate fragment 4 mm long, 2.5 mm wide, dividing into five ultimate pinnules alternately arranged. Ultimate pinnules 2 mm long, 1 mm wide, probably ovate in shape, constricted toward axis. Lamina poorly preserved, mainly dichotomizing veins visible, dividing three times within lamina. Ultimate pinnule margins not preserved. Pinnules arise from main penultimate segment axis at acute angles (about 5°).

Remarks: This specimen probably is a second-order pinna, dividing into pinnules of the third order or pinnula dividing into segments. The present author could not determine the extent to which the neighbouring pinnules were fused together, if at all, owing to the poor preservation of the specimen. The shape and type of venation are compatible with the genus *Sphenopteris*.

The author has at his disposal only one small, sterile leaf fragment, therefore its closer affinity within any group of ferns could not be resolved. The morphological genus name *Sphenopteris* was used strictly for its determination. This genus is characterized by pinnules usually decurrent, constricted at the base, oval in outline and almost entire margined, lobed or variously toothed. The midvein is straight and produces forking secondary veins that depart at a steep angle and extend toward the margin. Genus *Sphenopteris* was used for fern foliage from the Palaeozoic and Mesozoic eras and its affinity could not be settled with certainty (Taylor *et al*., 2009). The specimen from Krasiejów has pinnule shape and venation typical for that genus.

Species determination for such small plant fragment is always difficult or impossible. The most similar species is *Sphenopteris schoenleiniana* (Brongniart, 1835; Presl in Sternberg, 1838) known from the upper Anisian (Van Konijnenburg-Van Cittert *et al*., 2006), Ladinian (Mader, 1990; Kustatscher and Van Konijnenburg-Van Cittert, 2011) and Carnian (Kelber and Hansch, 1995). Pinna shape and venation are similar, but the dimensions are smaller in the Krasiejów specimen (Schenk, 1864; Schoenlein and Schenk, 1865; Kelber and Hansch, 1995; Van Konijnenburg-Van Cittert *et al*., 2006; Kustatscher and Van Konijnenburg-Van Cittert, 2011). Another similar species is *Coniopteris lunzensis* (Carnian, Lunz, Austria; Pott *et al*., 2018), which has similar pinna shape and venation in the central part of the primary pinna. However, the apical portion of a pinna in this species has linear pinnules with pointed apices arranged at very acute angles. The pinna dimensions are also larger in this species. Species *Todites linnaeifolius* (also Carnian, Lunz, Austria; Pott *et al*., 2018) has similar pinna shape, but typical neuropterid venation in contrast to sphenopterid in Krasiejów specimen. There are other somewhat similar but weakly known species referred to genus *Sphenopteris* from the Triassic of Europe, e.g., *Sphenopteris myriophyllum* Brongniart, 1828, *Sphenopteris oppositifolia* Presl in Sternberg, 1838, *Sphenopteris clavata* Presl in Sternberg 1838, *Sphenopteris kirchneri* Goeppert, 1841, *Sphenopteris braunii* Goeppert, 1841, *Sphenopteris patentissima* Goeppert, 1841 and *Sphenopteris birsina* Heer, 1877 (Sternberg, 1820–1838; Brongniart, 1828–1837; Goeppert, 1841; Heer, 1877). They were discussed througly by Kustatscher and Van Konijnenburg-Van Cittert (2011) in comparison with *Sphenopteris schoenleiniana*. These species established in the 19th century as a rule were briefly described, poorly illustrated by means of drawings, and have not been revised after the original description. It is not possible to compare such a small specimen as that from Krasiejów with other species in any detail because of the small number of features visible. The specimen from Krasiejów could be referred to almost all of them with equal probability.

DISCUSSION

In the Krasiejów flora, hygrophilous elements, such as cryptogamous plants, are infrequent and are poorly preserved. Ferns are extremely rare – only one specimen was found. Sphenophytes are not numerous, and disarticulated leaves are found separately. This may mean that these elements were transported to the deposition site and did not grow where they were buried. Transportation did not favour the preservation of fragile plant organs such as fern leaves and caused disarticulation (sphenopsid leaves separated from shoots). The transport may have been long-distance or high-energy.

Climatic conditions may have made ferns rare in the sedimentary basin. Sphenophytes and ferns are dependent on molecular water and thus connected with water bodies, even seasonal ones; they can grow around large or small ones or along rivers, permanent or seasonal. Sphenophytes and ferns are rarer than gymnosperms in the flora, especially rarer than the conifers, among which easily transportable and durable seeds predominate. The taphonomy of the sphenophytes and ferns from Krasiejów is in good agreement with the environmental models for this locality proposed by Bodzioch and Kowal-Linka (2012) and Jewuła *et al.* (2019).

The plants described here are poor indicators of age. *Neocalamites merianii* is known from the Middle Triassic to Lower Jurassic (Kräusel, 1958), but is best known from and most characteristic for the Ladinian (e.g., Thale flora; Kustatscher and Van Konijnenburg-Van Cittert, 2008) and especially the Carnian floras (Lunz, Austria, and Neuewelt, Switzerland; Kräusel, 1959; Kelber, 1998, 2005; Pott *et al.*, 2008, 2018; Franz *et al.*, 2019). This may indicate a Carnian age for the Krasiejów assemblage (see also Pacyna, 2014 and Kustatscher *et al.*, 2018 for other arguments for Carnian age of Krasiejów plants). If the rocks exposed in the Krasiejów outcrop are indeed Norian in age, as postulated by Szulc and collaborators (Szulc, 2005; Szulc *et al.*, 2015a, b; Jewuła *et al.*, 2019), redeposition of the fossils could have been a factor here. Redeposition of plant microfossils (spores and pollen) is a well-known phenomenon in palaeobotany (Taylor *et al.*, 2009). However, palynomorphs are absent at the Krasiejów locality. Petrified, silicified or calcified plant macrofossils, especially of woody stems could be redeposited (Florjan and Worobiec, 2016). However, redeposited plant compressions or impressions have not been described so far. The plant remains from Krasiejów are preserved as impressions. Plant organs (shoots, leaves, seeds) were transported before burial, but they were not redeposited as individual elements. They are too fragile to have been redeposited and preserved in a taxonomically identifiable form. Redeposition, if this was the case, must have been on a large scale, e.g., caused by intense synsedimentary tectonics involving the transportation of a huge volume of rock containing plant matter.

Acknowledgments

I sincerely thank J. Dzik and T. Sulej (Institute of Paleobiology, Polish Academy of Sciences, Warsaw) for allowing me to collect plant specimens at the Krasiejów locality and for giving me access to their collection of fossil plants from Krasiejów for this research. I thank D. Zdebska (Institute of Botany, Jagiellonian University, Cracow) for discussions and help with problems during the preparation of this article. I thank journal referees Mihai Popa (Faculty of Geology and Geophysics, University of Bucharest, Bucharest), Christian Pott (LWL-Museum für Naturkunde, Münster) and Joachim Szulc (Institute of Geological Sciences, Jagiellonian University, Cracow) for their helpful comments and suggestions. M. Jacobs and F. Simpson (School of the Environment, University of Windsor, Windsor) skilfully corrected the language. M. Szewczyk took photos of some specimens, A. Sojka prepared the figures. The project was financed by funds from the Polish National Science Centre (Grant No. DEC-2017/01/X/ST10/01867).

REFERENCES

Agardh, C. A., 1825. *Classes plantarum*. Literis Berlingianis, Lund, 22 pp.

Agnolín, F. L. & Rozadilla, S., 2018. Phylogenetic reassessment of *Pisanosaurus mertii* Casamiquela, 1967, a basal dinosauriform from the Late Triassic of Argentina. *Journal of Systematic Palaeontology*, 16: 853–879.

Antczak, M. & Bodzioch, A., 2018a. Diversity of fish scales in Late Triassic deposits of Krasiejów (SW Poland). *Paleontological Research*, 22: 91–100.

Antczak, M. & Bodzioch, A., 2018b. Ornamentation of dermal bones of *Metoposaurus krasiejowensis* and its ecological implications. *PeerJ*, 6, e5267.

Barbacka, M., Pacyna, G., Feldman-Olszewska, A., Ziaja, J. & Bodor, E., 2014. Triassic-Jurassic flora of Poland; floristical support of climatic changes. *Acta Geologica Polonica*, 64: 281–309.

Baron, M. G., 2019. *Pisanosaurus mertii* and the Triassic ornithischian crisis: could phylogeny offer a solution? *Historical Biology*, 31: 967–981.

Barycka, E., 2007. Morphology and ontogeny of the humerus of the Triassic temnospondyl amphibian *Metoposaurus diagnosticus*. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 243: 351–361.

Berchtold, F. & Presl, J. C., 1820. *O Prirozenosti Rostlin, aneb Rostlinar*. Krala Wiljma Endersa, Prague, 322 pp.

Bilan, W., 1975. The Rhaetic profile in Krasiejów near Opole. *Zeszyty Akademii Górniczo-Hutniczej, Geologia*, 1: 13–19. [In Polish, with English summary.]

Bodzioch, A. & Kowal-Linka, M., 2012. Unraveling the origin of the Late Triassic multitaxic bone accumulation at Krasiejów (S Poland) by diagenetic analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 346–347: 25–36.

Bomfleur, B., Escapa, I. H., Serbet, R., Taylor, E. L. & Taylor, T. N., 2013. A reappraisal of *Neocalamites* and *Schizoneura* (fossil Equisetales) based on material from the Triassic of East Antarctica. *Alcheringa*, 37: 349–365.

Brea, M. & Artabe, A. E., 1999. Apocalamitaceae (Sphenophyta) triásicas de la Formación Paramillo, Agua de la Zorra, provincia de Mendoza, Argentina. *Ameghiniana*, 36: 389–400.

Brongniart, A., 1822. Sur la classification et la distribution des végétaux fossiles en général, et sur ceux des terrains de sédiment supérieur en particulier. *Mémoires du Muséum d'Histoire Naturelle*, 8: 203–240.

Brongniart, A., 1828–1837. *Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans les diverses couches du globe*. G. Dufour et Ed. d'Ocagne (Vol. I), Crochard et Compie (Vol. II), Paris, Vol. I, 488 pp., Vol. II, 72 pp., Atlas: 166+30 plates.

Brusatte, S. L., Butler, R. J., Sulej, T. & Niedźwiedzki, G., 2009. The taxonomy and anatomy of rauisuchian archosaurs from the Late Triassic of Germany and Poland. *Acta Palaeontologica Polonica*, 54: 221–230.

Butler, R. J., Rauhut, O. W. M., Stocker, M. R. & Bronowicz, R., 2014. Redescription of the phytosaurs *Paleorhinus* ('*Francosuchus*') *angustifrons* and *Ebrachosuchus neukami* from Germany, with implications for Late Triassic biochronology. *Zoological Journal of the Linnean Society*, 170: 155–208.

Cantino, P. D., Doyle, J. A., Graham, S. W., Judd, W. S., Olmstead, R. G., Soltis, D. E., Soltis, P. S. & Donoghue, M. J., 2007. Towards a phylogenetic nomenclature of Tracheophyta. *Taxon*, 56: 822–846.

Cronquist, A., Takhtajan, A. & Zimmermann, W., 1966. On the higher taxa of Embryobionta. *Taxon*, 15: 129–134.

Desojo, J. B., Heckert, A. B., Martz, J. W., Parker, W. G., Schoch, R. R., Small, B. J. & Sulej, T., 2013. Aetosauria: a clade of armoured pseudosuchians from the Upper Triassic continental beds. In: Nesbitt, S. J., Desojo, J. B. & Irmis, R. B. (eds), *Anatomy, Phylogeny and Palaeobiology of Early Archosaurs and their Kin. Geological Society, London, Special Publications*, 379: 203–239.

Dzik, J., 2001. A new *Paleorhinus* fauna in the early Late Triassic of Poland. *Journal of Vertebrate Paleontology*, 21: 625–627.

Dzik, J., 2003. A beaked herbivorous archosaur with dinosaur affinities from the early Late Triassic of Poland. *Journal of Vertebrate Paleontology*, 23: 556–574.

Dzik, J., 2008. Gill structure and relationships of the Triassic cycloid crustaceans. *Journal of Morphology*, 269: 1501–1519.

Dzik, J. & Sulej, T., 2007. A review of the early late Triassic Krasiejów biota from Silesia, Poland. *Palaeontologia Polonica*, 64: 1–27.

Dzik, J. & Sulej, T., 2016. An early Late Triassic long-necked reptile with a bony pectoral shield and gracile appendages. *Acta Palaeontologica Polonica*, 61: 805–823.

Elgorriaga, A., Escapa, I. H., Rothwell, G. W., Tomescu, A. M. & Cúneo, N. R., 2018. Origin of *Equisetum*: Evolution of horsetails (Equisetales) within the major euphyllophyte clade Sphenopsida. *American Journal of Botany*, 105: 1286–1303.

Escapa, I. H. & Cúneo, N. R., 2006. Primer registro de *Neocalamites* (Halle) Vladimirovicz en el Pérmico de Gondwana. *Ameghiniana*, 43: 85–92.

Florjan, S. & Worobiec, G., 2016. *Skamieniałości roślinne*. *Zarys tafonomii roślin*. Instytut Botaniki im. W. Szafera, Polskiej Akademii Nauk, Kraków, 220 pp. [In Polish.]

Fostowicz-Frelik, Ł. & Sulej, T., 2009. Bone histology of *Silesaurus opolensis* Dzik, 2003 from the Late Triassic of Poland. *Lethaia*, 43: 137–148.

Fortuny, J., Marcé-Nogué, J. & Konietzko-Meier, D., 2017. Feeding biomechanics of Late Triassic metoposaurids (Amphibia: Temnospondyli): a 3D finite element analysis approach. *Journal of Anatomy*, 230: 752–765.

Franz, M., Kustatscher, E., Heunisch, C., Niegel, S. & Röhling, H. G., 2019. The Schilfsandstein and its flora; arguments for a humid mid-Carnian episode? *Journal of the Geological Society*, 176: 133–148.

Fraser, N. C. & Sues, H. D., 2010. The beginning of the 'Age of Dinosaurs': a brief overview of terrestrial biotic changes during the Triassic. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, 101: 189–200.

Goeppert, H., 1841. *Die Gattungen der fossilen Pflanzen, verglichen mit denen der Jetztwelt und durch Abbildungen erläutert*. Henry & Cohen, Bonn, 120 pp.

Goeppert, H., 1846. Ueber die fossile Flora der mittleren Juraschichten in Oberschlesien. *Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Cultur im Jahre 1845*, 139–149.

Gruntmejer, K., Konietzko-Meier, D. & Bodzioch, A., 2016. Cranial bone histology of *Metoposaurus krasiejowensis* (Amphibia, Temnospondyli) from the Late Triassic of Poland. *PeerJ*, 4, e2685.

Gruszka, B. & Zieliński, T., 2008. Evidence for a very low-energy fluvial system: a case study from the dinosaur bearing Upper Triassic rocks of Southern Poland. *Geological Quarterly*, 52: 239–252.

Halle, T. G., 1908. Zur Kenntnis der Mesozoischen Equisetales Schwedens. *Kungliga Svenska Vetenskapsakademiens Handlingar*, 43: 1–38.

Heer, O., 1877. *Flora fossilis Helvetiae*. Wurster & Co., Zurich, 182 pp.

Holt, E. L., 1947. Upright trunks of *Neocalamites* from the Upper Triassic of western Colorado. *The Journal of Geology*, 55: 511–513.

International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code), 2017. https://www.iapt-taxon.org/nomen/main.php [22.01.2019].

Jarzynka, A. & Pacyna, G., 2015. Fossil flora of Middle Jurassic Grojec clays (southern Poland). Raciborski's original material reinvestigated and supplemented. I. Sphenophytes. *Acta Palaeobotanica*, 55: 149–181.

Jewuła, K., Matysik, M., Paszkowski, M. & Szulc, J., 2019. The late Triassic development of playa, gilgai floodplain, and fluvial environments from Upper Silesia, southern Poland. *Sedimentary Geology*, 379: 25–45.

Kelber K.-P., 1998. Phytostratigraphische Aspekte der Makrofloren des süddeutschen Keupers. *Documenta Naturae*, 117: 89–115.

Kelber K.-P., 2005. Makroflora (Die Keuperfloren). In: Beutler, G., Hauschke, N., Nitsch, E. & Vath, U. (eds), Deutsche Stratigraphische Kommission, Stratigraphie von Deutschland IV - Keuper. *Courier Forschungsinstitut Senckenberg*, 253: 32–41.

Kelber, K.-P., 2015. Die Makroflora des Lettenkeupers. In: Hagdorn, H., Schoch, R. & Schweigert, G. (eds), *Palaeodiversity, Special Issue: Der Lettenkeuper – ein Fenster in die Zeit vor den Dinosauriern*, pp. 51–100.

Kelber, K.-P. & Hansch, W., 1995. Keuperpflanzen. Die Enträtselung einer über 200 Millionen Jahre alten Flora. *Museo*, 11: 1–157.

Kenrick, P. & Crane, P. R., 1997. *The Origin and Early Diversification of Land Plants. A Cladistic Study*. Smithsonian Institute Press, Washington, D.C., 441 pp.

Konietzko-Meier, D., Bodzioch, A. & Sander, P. M., 2013. Histological characteristics of the vertebral intercentra of *Metoposaurus diagnosticus* (Temnospondyli) from the Upper Triassic of Krasiejów (Upper Silesia, Poland). *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, 103: 237–250.

Konietzko-Meier, D., Danto, M. & Gądek, K., 2014. The microstructural variability of the intercentra among temnospondyl amphibians. *Biological Journal of the Linnean Society*, 112: 747–764.

Konietzko-Meier, D., Gruntmejer, K., Marcé-Nogué, J., Bodzioch, A. & Fortuny, J., 2018. Merging cranial histology and 3D-computational biomechanics: a review of the feeding ecology of a Late Triassic temnospondyl amphibian. *PeerJ*, 6, e4426.

Konietzko-Meier, D. & Klein, N., 2013. Unique growth pattern of *Metoposaurus diagnosticus krasiejowensis* (Amphibia, Temnospondyli) from the Upper Triassic of Krasiejów, Poland. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 370: 145–157.

Konietzko-Meier, D. & Sander P. M., 2013. Long bone histology of *Metoposaurus diagnosticus* (Temnospondyli) from the Late Triassic of Krasiejów (Poland) and its paleobiological implications. *Journal of Vertebrate Paleontology*, 33: 1003–1018.

Konietzko-Meier, D. & Wawro, K., 2007. Variation in tooth rows distribution in *Metoposaurus diagnosticus krasiejowensis* (Temnospondyli) from Late Triassic of Krasiejów (Silesia, south−western Poland). *Acta Palaeontologica Polonica*, 52: 213–215.

Kon'no, E., 1962. Some species of *Neocalamites* and *Equisetites* in Japan and Korea. *The Science Reports of the Tohoku University, Second Series, Geology, Special Volume*, 5: 21–48.

Kowal-Linka, M., Krzemińska, E. & Czupyt, Z., 2019. The youngest detrital zircons from the Upper Triassic Lipie Śląskie (Lisowice) continental deposits (Poland): Implications for the maximum depositional age of the Lisowice bone-bearing horizon. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 514: 487–501.

Kräusel, R., 1958. Die Juraflora von Sassendorf bei Bamberg. I. Sporenpflanzen. *Senckenbergiana lethaea*, 39: 67–103.

Kräusel, R., 1959. Die Keuperflora von Neuewelt bei Basel. III. Equisetaceen. *Schweizerischen Palaontologischen Abhandlungen*, 77: 5–19.

Kustatscher, E., Ash, S. R., Karasev, E., Pott, C., Vajda, V., Yu, J. & McLoughlin, S., 2018. Flora of the Late Triassic. In: Tanner, L. H. (ed.), *The Late Triassic World*. Springer, Cham, pp. 545–622.

Kustatscher, E. & Van Konijnenburg-Van Cittert, J. H. A., 2008. Lycophytes and horsetails from the Triassic flora of Thale (Germany). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 250: 65–77.

Kustatscher, E. & Van Konijnenburg-Van Cittert, J. H. A., 2011. The ferns of the Middle Triassic flora from Thale (Germany). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 261: 209–248.

Langer, M. C., Ezcurra, M. D., Bittencourt, J. S. & Novas, F. E., 2010. The origin and early evolution of dinosaurs. *Biological Reviews*, 85: 55–110.

Lucas, S. G., 2015. Age and correlation of Late Triassic tetrapods from southern Poland. *Annales Societatis Geologorum Poloniae*, 85: 627–635.

Lucas, S. G., 2018. Late Triassic terrestrial tetrapods: Biostratigraphy, biochronology and biotic events. In: Tanner L. H. (ed.), *The Late Triassic World*. Springer, Cham, pp. 351–405.

Lucas, S. G., Speilmann, J. A. & Hunt, A. P., 2007. Biochronological significance of Late Triassic tetrapods from Krasiejow, Poland. *New Mexico Museum of Natural History and Science Bulletin*, 41: 248–258.

Mader, D., 1990. *Palaeoecology of the Flora in Buntsandstein and Keuper in the Triassic of Middle Europe. Volume 2. Keuper and Index*. Gustav Fischer Verlag, Stuttgart, New York, pp. 937–1582.

Olempska, E., 2004. Late Triassic spinicaudatan crustaceans from southwestern Poland. *Acta Palaeontologica Polonica*, 49: 429–442.

Pacyna, G., 2014. Plant remains from the Polish Triassic. Present knowledge and future prospects. *Acta Palaeobotanica*, 54: 3–33.

Pacyna, G., Barbacka, M., Zdebska, D., Ziaja, J., Fijałkowska-Mader, A., Bóka, K. & Sulej, T., 2017. A new conifer from the Upper Triassic of southern Poland linking the advanced voltzialean type of ovuliferous scale with *Brachyphyllum-Pagiophyllum*-like leaves. *Review of Palaeobotany and Palynology*, 245: 28–54.

Piechowski, R. & Dzik, J., 2010. The axial skeleton of *Silesaurus opolensis*. *Journal of Vertebrate Paleontology*, 30: 1127–1141.

Piechowski, R., Niedźwiedzki, G. & Tałanda, M., 2018. Unexpected bird-like features and high intraspecific variation in the braincase of the Triassic relative of dinosaurs. *Historical Biology*, 1–17.

Piechowski, R., Tałanda, M. & Dzik, J., 2014. Population variability and ontogeny of the Late Triassic dinosauriform *Silesaurus opolensis*. *Journal of Vertebrate Paleontology*, 34: 1383–1393.

Pott, C., Bouchal, J. M., Choo, T., Yousif, R. & Bomfleur, B., 2018. Ferns and fern allies from the Carnian (Upper Triassic) of Lunz am See, Lower Austria: A melting pot of Mesozoic fern vegetation. *Palaeontographica Abteilung B*, 297: 1–101.

Pott, C., Kerp, H. & Krings, M., 2008. Sphenophytes from the Carnian (Upper Triassic) of Lunz am See (Lower Austria). *Jahrbuch der Geologischen Bundesanstalt*, 148: 183–199.

PPG I, 2016. A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution,* 54: 563–603.

Qvarnström, M., Wernström, J. V., Piechowski, R., Tałanda, M., Ahlberg, P. E. & Niedźwiedzki, G., 2019. Beetle-bearing coprolites possibly reveal the diet of a Late Triassic dinosauriform. *Royal Society Open Science*, 6 (3), 181042.

Racki, G. & Szulc, J., 2015. The bone-bearing Upper Triassic of Upper Silesia, southern Poland: integrated stratigraphy, facies and events – introductory remarks. *Annales Societatis Geologorum Poloniae*, 85: 553–555.

Reymanówna, M., 1986. Macroflora. Classes Pteridophyta and Spermatophyta. In: Malinowska, L. (ed.), *Geology of Poland. Volume III. Atlas of Guide and Characteristic Fossils. Part 2a. Mesozoic. Triassic*. Wydawnictwa Geologiczne, Warszawa, pp. 184–186.

Schenk, A., 1864. Beiträge zur Flora des Keupers und der rhaetischen Formation. *Berichte der naturforschenden Gesellschaft zu Bamberg*, 7: 51–142.

Schoenlein, J. T. & Schenk, A., 1865. *Abbildungen von fossilen Pflanzen aus dem Keuper Frankens*. Kreidel, Wiesbaden, pp. 22.

Skawina, A., 2010. Experimental decay of gills in freshwater bivalves as a key to understanding their preservation in Late Triassic lacustrine deposits. *Palaios*, 25: 215–220.

Skawina, A., 2013. Population dynamics and taphonomy of the Late Triassic (Carnian) freshwater bivalves from Krasiejów

(Poland). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 379: 68–80.

Skawina, A. & Dzik, J., 2011. Umbonal musculature and relationships of the Late Triassic filibranch unionoid bivalves. *Zoological Journal of the Linnean Society*, 163: 863–883.

Sues, H.-D. & Fraser N. C., 2010. *Triassic Life on Land. The Great Transition*. Columbia University Press, New York, 236 pp.

Sulej, T., 2002. Species discrimination in the Late Triassic labyrinthodont *Metoposaurus*. *Acta Palaeontologica Polonica*, 47: 535–546.

Sulej, T., 2005. A new rauisuchian reptile (Diapsida: Archosauria) from the Late Triassic of Poland. *Journal of Vertebrate Paleontology*, 25: 78–86.

Sulej, T., 2007. Osteology, variability, and evolution of *Metoposaurus*, a temnospondyl from the Late Triassic of Poland. *Palaeontologia Polonica*, 64: 29–139.

Sulej, T., 2010. The skull of an early Late Triassic aetosaur and the evolution of the stagonolepidid archosaurian reptiles. *Zoological Journal of the Linnean Society*, 158: 860–881.

Sulej, T. & Majer, D., 2005. The temnospondyl amphibian *Cyclotosaurus* from the Late Triassic of Poland. *Palaeontology*, 48: 157–170.

Sternberg, K. M., 1820–1838. *Versuch einer geognostisch botanischen Darstellung der Flora der Vorwelt*. Fr. Fleischer, Leipzig und Prag, 220 pp.

Szulc, J., 2005. Sedimentary environments of the vertebrate-bearing Norian deposits from Krasiejów, Upper Silesia (Poland). *Hallesches Jahrbuch für Geowissenschaften, Reihe B, Beiheft*, 19: 161–170.

Szulc, J., Racki, G. & Bodzioch, A., 2017. Comment on "An early Late Triassic long-necked reptile with a bony pectoral shield and gracile appendages" by Jerzy Dzik and Tomasz Sulej. *Acta Palaeontologica Polonica*, 62: 287–288.

Szulc, J., Racki, G. & Jewuła, K., 2015a. Key aspects of the stratigraphy of the Upper Silesian middle Keuper, southern Poland. *Annales Societatis Geologorum Poloniae*, 85: 557–586.

Szulc, J., Racki, G., Jewuła, K. & Środoń, J., 2015b. How many Upper Triassic bone-bearing levels are there in Upper Silesia (southern Poland)? A critical overview of stratigraphy and facies. *Annales Societatis Geologorum Poloniae*, 85: 587–626.

Taylor, T. N., Taylor, E. L. & Krings, M., 2009. *Paleobotany, The Biology and Evolution of Fossil Plants, Second Edition*. Academic Press, Amsterdam, 1230 pp.

Teschner, E. M., Sander, P. M. & Konietzko-Meier, D., 2018. Variability of growth pattern observed in *Metoposaurus krasiejowensis* humeri and its biological meaning. *Journal of Iberian Geology*, 44: 99–111.

Weber, R., 1968. Die fossile Flora der Rhät-lias-Übergangsschichten von Bayreuth (Oberfranken) unter besonderer Berücksichtigung der Coenologie. *Erlanger Geologische Abhandlungen*, 72: 1–73.

Wojewoda Opolski, 2003. Rozporządzenie 0151/P/1/2003 Wojewody Opolskiego z dnia 20 stycznia 2003 r. w sprawie uznania za stanowisko dokumentacyjne. *Dziennik Urzędowy Województwa Opolskiego,* nr 3, poz. 94. [In Polish.]

Van Konijnenburg-Van Cittert, J. H., Kustatscher, E. & Wachtler, M., 2006. Middle Triassic (Anisian) ferns from Kühwiesenkopf (Monte Prá della Vacca), Dolomites, Northern Italy. *Palaeontology*, 49: 943–968.

Zan, S., Axsmith, B. J., Escapa, I., Fraser, N. C., Liu, F. X. & Xing, D. H., 2012. A new *Neocalamites* (Sphenophyta) with prickles and attached cones from the Upper Triassic of China. *Palaeoworld*, 21: 75–80.

Zatoń, M. & Piechota, A., 2003. Carnian (Late Triassic) charophyte flora of the *Paleorhinus* biochron at Krasiejów (SW Poland). *Freiberger Forschungshefte C*, 499: 43–53.

Zatoń, M., Piechota, A. & Sienkiewicz, E., 2005. Late Triassic charophytes around the bone-bearing bed at Krasiejów (SW Poland) – palaeoecological and environmental remarks. *Acta Geologica Polonica*, 55: 283–293.