Acta Palaeobotanica 49(2): 279–286, 2009

'*Phoenix szaferi*' (palm fruitbodies) reinterpreted as traces of wood-boring teredinid bivalves from the Lower Oligocene (Rupelian) of the Tatra Mountains, Poland

ANDRZEJ RADWAŃSKI

Institute of Geology, University of Warsaw, Al. Żwirki i Wigury 93; PL-02-089 Warszawa, Poland;
e-mail: u.radwanska@uw.edu.pl

Received 06 January 2009; accepted for publication 17 October 2009

ABSTRACT. The variably sized, peculiarly shaped, bulbous sandy bodies contained in coalified driftwood from the Lower Oligocene (Rupelian) of the Tatra Mountains in Poland, and originally described as fruitbodies of a new palm species, then established as *Phoenix szaferi* by Bąkowski in 1967 are reinterpreted as a maze of internal moulds of siphonal tubes of the wood-boring bivalve mollusks of the family Teredinidae Rafinesque. The original interpretation is objected both from the structural as well as the anatomical point of view, while the compatibility of the structures with the present-day and fossil products of the life activity of teredinid bivalves is challenged. Consequently, the taxon *Phoenix szaferi* is rejected from the Kingdom of Plants, having been transferred to that of Animals, where it falls into the category of ichnotaxa of no taxonomical priority.

KEY WORDS: teredinid bivalves, alleged *Phoenix* palm, driftwood, Lower Oligocene, Tatra Mountains, Poland

INTRODUCTION

This report had long been intended to represent a sequel to an outstanding account, by Głazek and Zastawniak (1999), of the terrestrial plant remains from the Palaeogene of the Tatra Mountains in Poland. Precisely, to supplement the critical information then supplied by the present author, and acknowledged in that account (Głazek & Zastawniak op. cit.). Generally, the matter concerns a reinterpretation of some peculiar structures described by Bąkowski (1967) as fruitbodies of a palm, *Phoenix szaferi*. The whereabouts of their finding are given by Głazek and Zastawniak (1999), who located it in the upper part within the shaly sequence of the Zakopane Formation (Huty Formation in Slovakia).

For the clarity of the subject, it is to remind that since the discovery by Kuźniar (1910) of *Nipadites burtini* Brongniart, the fruits (nuts) of the tropical palm *Nipa* in the 'Nummulitic Eocene', a fame has rapidly spread of palms growing along the shores of the Tatra Mountains being then the 'Tatra Island' surrounded by a Palaeogene sea. This has repeatedly been reported/referenced in many publications, both of academic, and of popular standard, as a spectacular case of tropical elements in the Eocene flora of Poland (e.g. Szafer 1949, Szafer & Kostyniuk 1952). Under such circumstances, it is not strange that the report by Bąkowski (1967) has commonly been credited (e.g. Mai 1995), and even once accepted as a PhD. Thesis in the Faculty of Biology, University of Warsaw.

The serious doubts about the nature of that finding have appeared when Głazek and Zastawniak (1999) critically analysed the data they concisely summarized in their report. Firstly, it was Dr. Volker Wilde (Forschungsinstitut Senckenberg in Frankfurt a.M.) who had objected the palm nature of the finding, and claimed its bivalve woodboring nature, having been fully accepted by the present author who indicated its teredinid provenience (see Głazek & Zastawniak op. cit.).

As concerns the age of the discussed finding, having been long regarded as Eocene, it must also be objected. The newer records from the Zakopane Formation, both of the absolute age of 30.7±1.5 my dated by a fission-track method in tuffite-borne zircons, as well as the biostratigraphic dating by dinoflagellate cysts, clearly indicate a Lower Oligocene age (Głazek & Zastawniak 1999), that is the Rupelian Stage according to the International Standard Geochronologic Scale (Gradstein et al. 2004).

Finally, it is to indicate that the two other findings in the Zakopane Formation, briefly reported by Frankiewicz (1975) as large accumulations of *Phoenix* remains, have also been studied by the present author. These are apparently the driftwoods, some having been densely bored by non-teredinid bivalves, and all prepared for a separate publication (Radwański & Frankiewicz 2009). Escaping from precise identification is a similar driftwood bored by bivalves, from the Oligocene of the Outer Carpathians, deliberated by Lipiarski (1985) as a *Phoenix* fruitbody, more or less identical with that one described by Bąkowski (1967). Unfortunately, all these findings have nothing in common with any palms!

THE DISCUSSED SPECIMEN

The original specimen, upon which Bąkowski (1967) established a separate species "*Phoenix szaferi*" is contained in a small, almost quadrangular (21 cm at margin) slab of slaty sandstone replete with pieces of driftwood making up a 'log jam', and all having been coalified and tightly compressed. The two wood pieces in that maze are adorned with bulbous sand bodies, variable in size, and interpreted by Bąkowski (op.cit.) as one fruitbody of the new palm species.

The personally analysed slab, property of the Museum of the Earth, Polish Academy of Sciences in Warsaw, is kept there under the Catalogue Number MZ VII/24/1. Its present-day state does not differ significantly from that as reported by Bąkowski (1967, pls 1–3 and pl. 4, figs 1, 2), except of some fragile chips

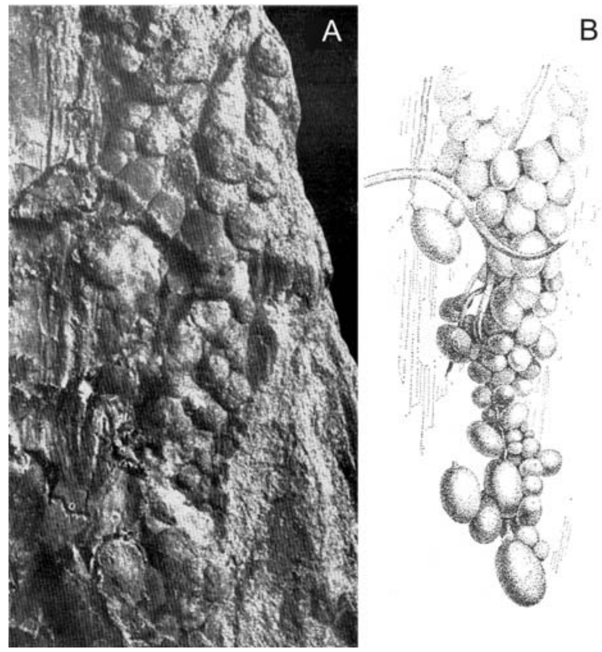


Fig. 1. Original illustration of *Pheonix szaferi* by Bąkowski (1967). **A** – Main part of the finding, 0.5 of natural size; **B** – Sketched 'reconstruction' of that finding

of vitreous coal being peeled-off. It is thus thought that satisfactory for its presentation would be the essential part of original illustrations (Fig. 1).

To elucidate a new interpretation of the bulbous structures in that sandstone slab, the two pathways of evidence are taken into account:

(1) To demonstrate why the finding cannot be a fruitbody of the palm *Phoenix*,

(2) To indicate with what the finding is compatible.

PHOENIX SZAFERI: NOT A PALM

The two features do involve a conviction that what has hitherto been regarded as *Phoenix szaferi* is neither a palm fruitbody nor other part of any plant at all.

Firstly, the analysed bulbous bodies are composed of fine-grained structureless sand, lacking any trace of the peel externally, and any seed internally. This suggests, at first insight, that bulbs can be neither fruits ('wild dates') nor their pits (stones). Secondly, the bulbs transect the pieces of coalified wood, and are not contained between them. This definitely indicates that the sandy bulbs have originated by filling the sand into the hollows in the wood pieces, and thus have nothing in common with any fruitbodies or other plant tissues. Nonetheless,

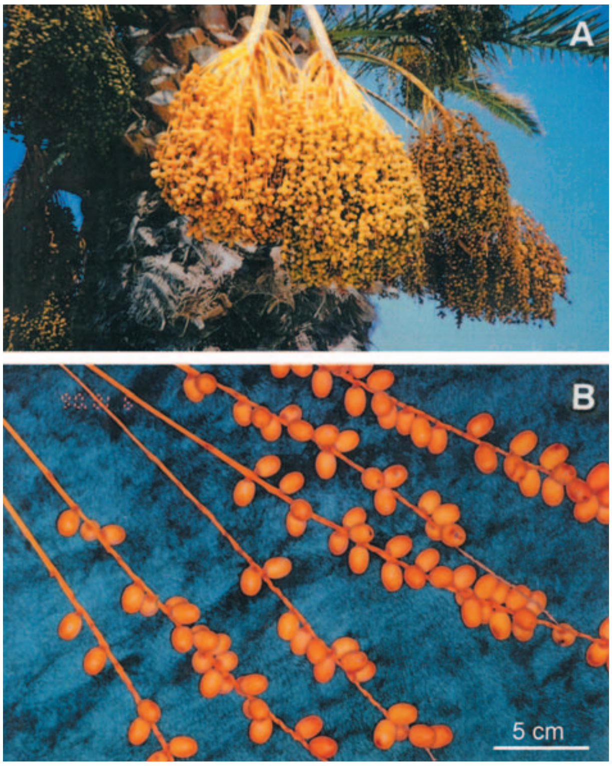


Fig. 2. Comparative images of the present-day canary palm, *Phoenix canariensis* cult., from the Island of Crete, Greece: **A** – Several almost ripe fructifications on the palm; **B** – Isolated sprays with date-like fruits

their attribution to the palm *Phoenix* was a very abortive attempt also from anatomical reasons.

To demonstrate this, it would be indicated that the fruitbodies of all present-day species of *Phoenix* are the immense clusters (up to 1m in diameter) kept on the main frond that tends to be wooden (Fig. 2.A).

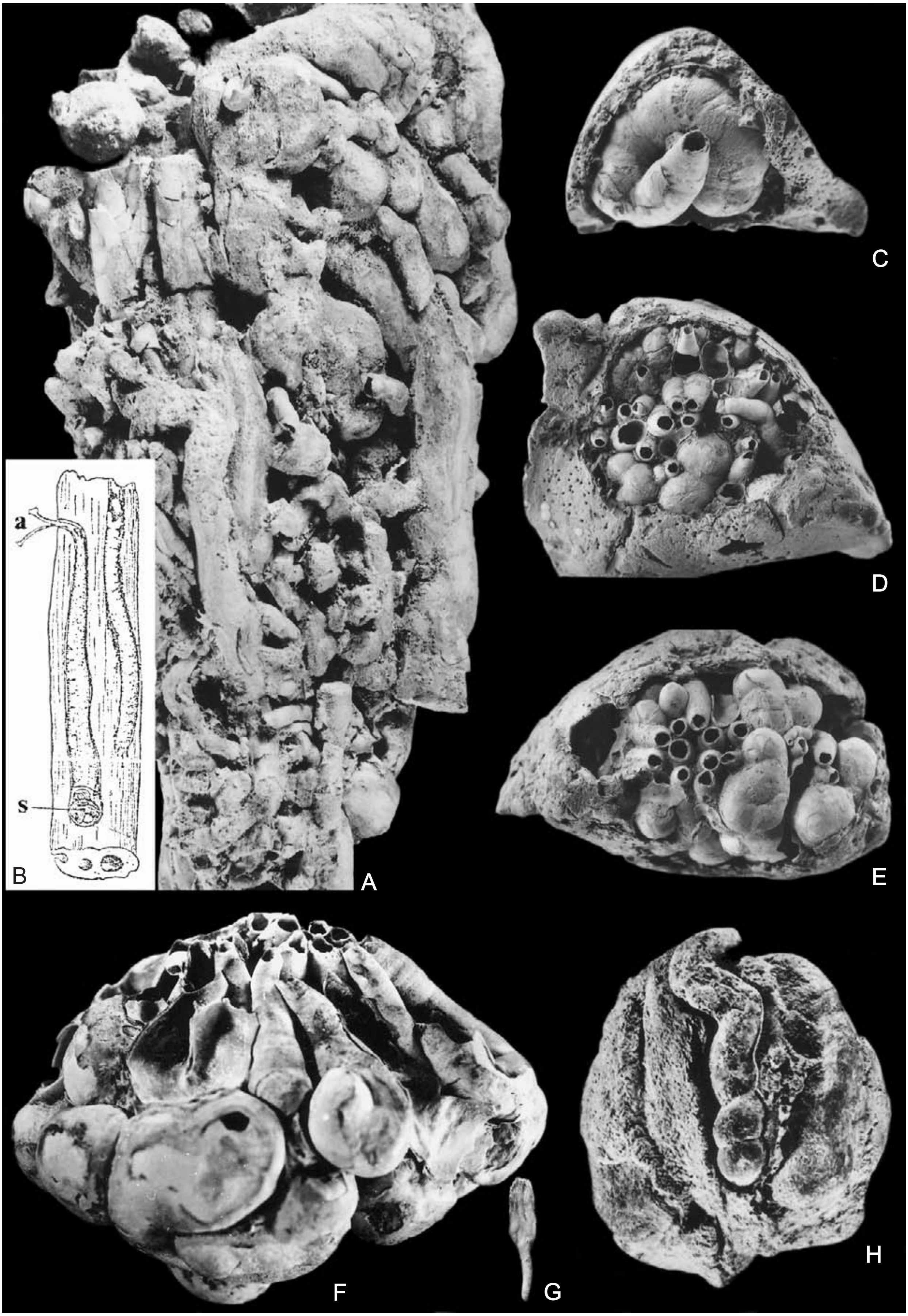
This supports a dense bunch of sprays, everyone of which bears the equal-sized date-like fruits arranged more or less alternately lengthwise (Fig. 2.B). When ripe, they fall out from the sprays, leaving them naked at the cluster. Under such circumstances, there is no chance any cluster or its part, the fruit-bearing sprays including, could get out freely of the palm tree (unless, under present-day conditions, having been cut off by the gardener), to be transported to the sea basin, and finally deposited in the sedimentary sequence.

'*PHOENIX SZAFERI*': REINTERPRETATION

The structure of the discussed '*Phoenix szaferi*' specimens is fully compatible with what is commonly known in the literature (e.g., Röder 1977, pl. 5, fig. 21, Radwański 1977, pl. 6a) as fossilized infill of siphonal tubes of wood-boring bivalves of the family Teredinidae Rafinesque 1815 (see Cox et al. 1969, p. N725).

Among the present-day members of that family (see Roch 1940, Moll 1942), the most common are those of the genus *Teredo* Linnaeus 1758, particularly of the species *T. navalis* L. which are vernacularly named the shipworms, as having been responsible in former centuries for damages of sailing ships, harbour wood-constructions, wharf pilings, and waterdams. These bivalves are adopted to live exclusively in the wood, either at the shore, or freely floating over the sea (driftwood, floating nuts), in which they drill quite elongated borings, lined with a calcareous (calcitic) tube (siphonoplax) to protect siphons extendible to the exterior of a wood (Fig. 3.B). The main part of the body is wrapped by a reduced, almost spherical aragonitic shell which is contained in a more or less bulbous chamber at the anterior end of the tube (see *s* in Figs 3.B and 3.F,H). In smaller, but elongated pieces of wood, the teredinids tend to bore parallelly one alongside the other, whereas in larger timber logs they bore at random, to riddle the log densely into a maze of borings. When the wood becomes coalified, both the aragonitic shell and the calcitic tube are leached out, and then the emptied borings are filled with the ambient sediment, and lithified. Consequently, preservable in the fossil state there usually remain lithified internal moulds (casts) of the tubes, which counterpart almost ideally the primary shape of each tube. Such very eco-taphonomic pathway is just exemplified by the discussed '*Phoenix szaferi*' specimens from the Oligocene of the Tatra Mountains, and by the comparative specimens from the Miocene of the Holy Cross Mountains, Central Poland (see Fig. 3.A).

For understanding the morphological diversity of fossil teredinid-infested driftwood, some ecologic features of the present-day forms would be indicated, also of those boring in floating nuts. The latter ones are spectacularly exemplified (see Fig. 3.C–F) by the species *Teredo* (*Uperotus*) *clava* Gmelin 1791 (see Cox et al. 1969, p. N730), which lives exclusively (see Moll 1942, Roch 1961) in floating nuts of a Moluccan palm, *Carapa moluccensis* Lamarck, and is stranded frequently upon Malayan and Indian shores. Firstly, ecologically controlled is the shape and length of the tubes, which both vary


a
s
B
A
C
D
E
F
G
H

in a broad spectrum. The shape depends on the space available to be bored (see Fig. 3.C), on the presence of simultaneously growing specimens (see Fig. 3.D–F) and, partly at least, on the structure and hardness of the wood. When the spat is over-populated upon a piece of wood, or a floating nut, the teredinids create the dwarf-sized (stunted) stenomorphic individuals. In result, within a fossil maze, there occur both large- and dwarf-sized borings, all of which being left by the fully-grown (adult) specimens, as exemplified by the studied and comparative specimens (see Figs 1.A, and 3.A).

The stenomorphy of the tubes may easily be ascertained when the needed space is limited by the size of a floating nut, the teredinids are boring in (Fig. 3.C,H). When the palm nuts are over-populated by teredinids, the tubes become not only steno-, but also xenomorphic, having been located amongst the coevally, or almost coevally, growing neighbours (Fig. 3.F). In a floating walnut (Fig. 3.H), available was only the shell, along which one teredinid bored, and thereby the internal mould of its tube adheres tightly to the fossilized kernel.

In elongated timber logs, the total length of the teredinid boring and, thus, of the tube may attain half a meter, or even slightly more. Consequently, neither the shape nor the size of the tube are species distinctive (Radwański 1977), and taxonomically significant (Roch 1940, 1961, Moll 1942: and all subsequent authors) remain solely the paddle-shaped pallets (Fig. 3.G) which are plugging in pairs each boring's aperture when the siphons withdraw (cf. *a* in Fig. 3.B).

The siphonal tubes become geotropically oriented, with their apertures upwards and bulbous chambers downwards, either in a piece of wood (see Roch 1940, pl. 1, figs 1a,b) or in a nut (Fig. 3.F), when these are stabily settled (anchored) at time of boring. Such certainly was a case of the specimen discussed, in which the bulbous chambers dominate over the elongated parts of the tubes (see Fig. 1.A).

The over-population of a wood by the present-day teredinids results in its dense honeycombing, or in the complete filling of the limited space by tubes (Fig. 3.F) so that the wood tissue becomes scarcely preserved. Under harsh water conditions, such objects disintegrate easily, and isolated tubes may float freely, having been drifted a reasonable distance over the sea (Massari & Savazzi 1981).

To conclude, the two specimens classified by Bąkowski (1967) as one fruitbody of '*Phoenix szaferi*' are really the maze of internal moulds of siphonal tubes of bivalves of the family Teredinidae, preserved in two separate pieces of driftwood, these bivalves have bored into; the teredinid-infested wood pieces are settled amongst the other, non-infested ones to form a coalified 'log jam' altogether; the elongated ridges (Fig. 1.A), classified by Bąkowski (1967) as other parts of that palm (spatha, leaf fragments), are nothing else but the growth rings in wood pieces, exposed in their longitudinal sections.

DRIFTWOOD IN THE CARPATHIAN FLYSCH

The presence of coalified wood pieces, those with the discussed teredinid tubes including, appears to be quite common in several locations confined to one stratigraphic horizon within the Zakopane Formation (Głazek & Zastawniak 1999), a member of the Podhale Flysch in the Inner Carpathians.

In the Lower Oligocene coeval flysch sequence of the Outer Carpathians, the coalified

←

Fig. 3. Fossil and present-day siphonal tubes of wood-boring bivalves of the family Teredinidae Rafinesque 1815. **A** – Internal moulds of siphonal tubes of the teredinids that riddled a driftwood, nat. size; Middle Miocene, the Pińczów Limestones at Pińczów, Holy Cross Mountains, Central Poland (taken from: Radwański 1977, pl. 6a); **B** – a sketch of the present-day *Teredo* (*Teredo*) *navalis* L., boring in a piece of wood, half-sectioned: **s** – shell, **a** – siphons, extended (redrawn from: Feliksiak et al. 1950, fig. 247); **C–F** – Present-day specimens of *Teredo* (*Uperotus*) *clava* Gmelin, living in floating nuts of the moluccan palm, *Carapa moluccensis* Lam., stranded upon a beach near Madras, India (**C–E** – Specimens due to courtesy of the British Museum of Natural History, London), all magn. × 1.5; **C** – Singly growing, spirally-coiled specimen; the siphonal tube is hand-exposed; **D, E** – Mass-aggregated specimens boring from two opposite sides of the nut; in result, both the apertures and the bulbous shell chambers are visible; siphonal tubes are hand-exposed; **F** – Mass-aggregated specimens which riddled completely the nut interior, to fill it with the maze of tubes arranged into a bunch; the nutshell has been hand-removed; **G** – Isolated pallet, plugging the tube, × 3; **H** – Internal mould of siphonal tube of the boring along the shell of the walnut, *Juglans globosa* Ludwig: the nutshell has been lost and thereby the tube mould adheres firmly to the lithified kernel, magn. × 2; Middle Miocene, Děvinská Nová Ves (Neudorf an der March), Vienna Basin, Slovakia (taken from: Radwański 1977, pl. 6b; see also Boucot 1990, fig. 300B)

driftwood was reported from the Krosno Beds by Dżułyński and Ślączka (1959) and Lipiarski (1985). On the other hand, the two specimens of silicified coniferous wood from the Menilite Beds (the "Kliwa Sandstones") were recognized by Rajchel and Uchman (1988) to bear numerous borings of terrestrial insects, precisely of the larvae of some beetles and wasp-like hymenopterans, and thus being an extreme rarity, both from entomologic and ichnologic point of view. Carbonized detritus of terrestrial plants is frequently met in many locations of the Menilite-Krosno Series (e.g. Bieńkowska-Wasiluk & Radwański 2009, fig. 1C).

The Lower Oligocene (Rupelian) age of all the terrestrial-plant-bearing flysch sequences both in the Inner as well as in the Outer Carpathians, may thus suggest a panregional dynamic noise on the adjacent land. The dynamic events upon the land or along its shores (?change of weather conditions, violent wind- or rainfalls, ?abrasive/transgressive pulse), are thus thought to have been responsible for an intense damage of floral communities and a supply of their material to the flysch basin. On the other way, the action of sea currents must also be taken into account, as already claimed long ago by Szafer (1949) for the fruits of *Nipa*, the palm of the Indo-Malayan provenience, supposedly drifted to the Tatra seashores.

CASUAL MISIDENTIFICATIONS

The case of '*Phoenix szaferi*' is not very exceptional within a broad spectrum of misidentifications of the animal-borne fossils as plants. To exemplify, a spectacular case may be reminded of the putative fruits of the Araliaceae, widely reported from the Tertiary, as precisely studied by Łańcucka-Środoniowa (1964) who evidenced their true nature as coprolites of the lepidopteran caterpillars.

Misidentification of animal remains as plants is particularly not uncommon in records from older epochs of the geologic past (Kenrick & al. 1999). Amongst widely known fossils this is well exemplified by the holotype of the old-Palaeozoic (Ordovician) putative rhodophyte alga *Solenopora*, the name of which was introduced by Dybowski (1878), but which has recently been recognized by Riding (2004) as a chaetetid sponge. Nonetheless, when the holotype of *Solenopora* and its allies are transferred by Riding (2004) to the Kingdom of Animals, many Jurassic and younger species remain in the Kingdom of Plants. This simply means, that there exist both the *Solenopora* animals, and the *Solenopora* plants, and their generic names are useful and nomenclatural valid in both Kingdoms (Radwański 2009).

As concerns the teredinid tubes misidentified as quite different fossils, an almost unbelievable case comes from the Late Cretaceous (latest Maastrichtian) greensand of Bochotnica near Kazimierz-on-Vistula, Central Poland. A piece of rock (wood imprint) with a few teredinid tubes tighted together has been described by the eminent palaeoherpetologist, Friedrich von Huene (1941) as a fragment of the jaw containing elongated roots of teeth, classified as a new genus and species of the mosasaurid; the true nature of the finding was recognized but forty years later, by Pożaryska and Pugaczewska (1981).

A FINAL REMARK

Curiously, when the taxon '*Phoenix szaferi*' is rejected from the botanical nomenclature, as having been transferred from the Kingdom of Plants to that of Animals, its name, according to the ICZN rule (Ride et al. 1999, Articles 2.1 and 10.5) remains valid, and falls into the realm of ichnotaxonomy. Within this realm, however, it has no priority, having been an objective younger synonym of the ichnogenus *Teredolites* Leymerie 1842, and ichnospecies *Teredolites clavatus* Leymerie, which embraces various fossil traces of the life activity of teredinid bivalves (Simon et al. 1984). This practically means its no utility also for the zoological nomenclature.

ACKNOWLEDGEMENTS

Cordial gratitudes are offered to Professor Dr. Ewa Zastawniak (Władysław Szafer Institute of Botany of the Polish Academy of Sciences, Kraków) and Professor Dr. Jerzy Głazek (Adam Mickiewicz University, Poznań) for their friendliness and advice when they inspired me, and seriously insisted to report not only by a verbal personal information upon the subject herein displayed.

Special thanks are to the British Museum of Natural History (London) for making easy access to some teredinid specimens compared (see Fig. 3.C–E).

Professor Dr. Dieter Hans Mai (Museum für Naturkunde, Berlin) and an anonymous reviewer have kindly supplied some comments which contributed to the quality of this report.

REFERENCES

BĄKOWSKI Z. 1967. *Phoenix Szaferi* sp.nov. from the Podhale Region and An outline of the history of the genus *Phoenix* L. Prace Muzeum Ziemi, 10: 169–213.

BIEŃKOWSKA M. & RADWAŃSKI A. 2009. A new occurrence of sharks in the Menilite Formation (Lower Oligocene) from the Outer (Flysch) Carpathians of Poland. Acta Geol. Polon., 59(2): 235–243.

BOUCOT A.J. 1990. Evolutionary Paleobiology of Behavior and Coevolution. Elsevier, Amsterdam.

COX L.R. et al. 1969. Mollusca 6 (Bivalvia): N491–N952. In: Moore R.C. & Teichert C. (eds), Treatise on Invertebrate Paleontology, Part N, 2. The Geological Society of America and The University of Kansas; Boulder, Colorado and Lawrence, Kansas.

DYBOWSKI W. 1878. Die Chaetetiden der ostbaltischen Silur-Formation. Verh. Russ.-Kaiserl. Mineral. Ges. St. Petersburg, Series 2, 14 (for 1877): 1–134.

DŻUŁYŃSKI S. & ŚLĄCZKA, A. 1959. Directional structures and sedimentation of the Krosno beds (Carpathian flysch). Rocz. Pol. Tow. Geol., 28(3): 205–260.

FELIKSIAK S., MICHAJŁOW W., RAABE Z. & STRAWIŃSKI K. 1950. Zoologia. PZWS, Warszawa.

FRANKIEWICZ J.K. 1975. Znaleziska eoceńskiej flory we fliszu podhalańskim grzbietu gubałowskiego (summary: Findings of Eocene flora in the Podhale Flysh deposits from Gubałówka ridge). Sprawozdania z Posiedzeń Komisji Naukowych, Polska Akademia Nauk, Oddział w Krakowie, 18(1): 173–175.

GŁAZEK J. & ZASTAWNIAK E. 1999. Terrestrial plant fossils in the transgressive Palaeogene littoral/flysch sequence of the Tatra Mountains (Central Carpathians). Acta Palaeobot., Suppl., 2: 293–301.

GRADSTEIN F., OGG J. & SMITH A. 2004. A Geologic Time Scale 2004. Cambridge Press, Cambridge.

von HUENE F. 1941. Ein obercretacischer Saurierrest aus Polen. Zentralbl. Mineral. Geol. Paläont., Abt. B, Jahrgang 1941: 85–91.

KENRICK P., KVAČEK Z. & BENGTSON S. 1999. Semblant land plants from the Middle Ordovician of the Prague Basin reinterpreted as animals. Palaeontology, 42(6): 991–002.

KUŹNIAR W. 1910. Eocen Tatr i Podhala (Das Eozän der Tatra und des Podhale). Spraw. Kom. Fizjogr. Akad. Um., 44(4): 26–76.

LEYMERIE M.A. 1842. Suite du mémoire sur le terrain Crétacé du Département de l'Aube. Mém. Soc. Géol. France, 2: 1–34.

LINNAEUS C. 1758. Systema naturae. Holmiae.

LIPIARSKI I. 1985. New locality of fossil plant fructification of the genus *Phoenix* L. in the Krosno Beds (Oligocene) near Zatwarnica, Polish Eastern Flysch Carpathians. Proceeding reports of the 13th Congress of the Carpatho-Balkan Geological Association, Poland – Cracow, September 5–10 1985. Additionally received reports: 9–12. Geological Institute.

ŁAŃCUCKA-ŚRODONIOWA M. 1964. Tertiary coprolites imitating fruits of the Araliaceae. Acta Soc. Bot. Pol., 33(2): 469–473.

MAI D.H. 1995. Tertiäre Vegetationsgeschichte Europas. Gustav Fischer Verlag, Jena, Stuttgart, New York.

MASSARI F. & SAVAZZI E. 1981. Driftwood transportation of exotic pebbles in the Upper Cretaceous Scaglia Rossa veneta (Mt. Loffa, Southern Alps) suggested by teredinid tubes. N. Jahrb. Geol. Paläont., Monatshefte, 5: 311–320.

MOLL F. 1942. Die fossilen Terediniden und ihre Beziehung zu den rezenten Arten. Palaeontographica, A, 94: 134–153. Stuttgart.

POŻARYSKA K. & PUGACZEWSKA H. 1981. Bivalve nature of Huene's dinosaur *Succinodon*. Acta Palaeont. Pol., 26(1): 27–34.

RADWAŃSKI A. 1977. Present-day types of trace in the Neogene sequence; their problems of nomenclature and preservation. In: Crimes T.P & Harper J.C. (eds), Trace Fossils 2. Geol. Jour. Spec. Iss., 9: 227–264.

RADWAŃSKI A. 2009. 'Beetroot Stones' of the Holy Cross Mountains: pink-to-red coloured Oxfordian red algae *Solenopora*. Acta Geol. Pol., (in preparation).

RADWAŃSKI A. & FRANKIEWICZ J.K. 2009. Driftwood riddled by wood-boring bivalves in the Podhale flysch (Inner Carpathians, Poland). [in preparation].

RAJCHEL J. & UCHMAN A. 1998. Insect borings in Oligocene wood, Kliwa Sandstones, Outer Carpathians, Poland. Ann. Soc. Geol. Pol., 68(2/3): 219–224.

RIDE W.D.L. (Chairman), COGGER H.G., DUPUIS C., KRAUS O., MINELLI A., Thompson F.C. & TUBBS P.K. 1999. International Code of Zoological Nomenclature (Fourth Edition). Natural History Museum, London.

RIDING R. 2004. *Solenopora* is a chaetetid sponge, not an alga. Palaeontology, 47(1): 117–122.

ROCH F. 1940. Die Terediniden des Mittelmeeres. Thalassia, 4(3): 1–147.

ROCH F. 1961. Die Terediniden der Sunda-Inseln und Neu-Guineas. Beaufortia, 9(95) : 7–48.

RÖDER H. 1977. Zur Beziehung zwischen Konstruktion und Substrat bei mechanisch bohrenden Bohrmuscheln (Pholadidae, Teredinidae). Senckenbergiana Maritima, 9(3/4): 105–213.

SIMON R., KELLY A. & BROMLEY R.G. 1984. Ichnological nomenclature of clavate borings. Palaeontology, 27(4): 793–807.

SZAFER W. 1949. Zarys geografii roślin. Appelbergs Boktryckeri, Uppsala.

SZAFER W. & KOSTYNIUK M. 1952. Zarys paleobotaniki. PWN, Warszawa.