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The borings of Teredinidae in fossil wood of *Taxodium Distichum* Gothan, 1906

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Abstract: The borings of *Teredinidae* in fossil wood of *Taxodium distichum* Gothan, 1906. Photographs of borings in fossil wood (*Taxodium distichum* Gothan, Miocene, Roztocze, Poland) were taken. The texture of the borings surface was analyzed. Moreover, photographs were taken of the surface texture of borings in makore wood (*Tieghemella heckelii* Pierre) from Africa after *Teredinidae* and after different species of insects in Scotch pine (*Pinus sylvestris* L.) for comparative purposes. The photographs were compared. The suspected wood borings in the studied fossil wood of *T. distichum* were made by mollusc (*Teredinidae*).

Keywords: fossil wood, *Teredinidae, Taxodium distichum*

INTRODUCTION

The wood borings originate from remnants of numerous animal species such as Insecta: Isoptera, Coleoptera (Cerambycidae, Anobiidae, Bostychidae, Ipidae, Curculionidae), Hymenoptera (Siricidae, Xiphydriidae, Formicidae) in terrestrial environment or Molsusca (Bivalvia: Teredinidae and Pholadidae) and Isopoda found in sea water. Those species not only find shelter in wood but also nourish on it.

The wood boring can occur either with or without fungal decay of wood. Frequently, borings can also be found in fossils or carbonated wood.

Such wood borings led many researchers to determine types of organisms that caused them, while the wood was still retaining its original properties.

The results of those examinations are either of general nature [Kłusek 2006] or more precise to varying degrees [Madziara-Borusewicz 1970, Rajchel and Uchman 1998].

The most abundant fossil wood in Poland are the remains of *Taxodium distichum* Gothan (Miocene), which are found in Roztocze (south-east of Poland). Recently, those fossilia have been subjected to thorough research [Heflik 1996, Kłusek 2006]. A paper by Kłusek [2006] also signalled the "borings formed due to the activity of wood-eating insects" in fossil wood of *T. taxodii*.

Those facts urged the authors to analyze whether the cause of the damage was wood boring by insects or by Teredinidae (Bivalvia). Teredinidae (Teredo sp., Bankia sp., Nausitora sp.) are a highly specialized bivalve mollusk that drills into wood. Which is significant as Teredinidae are considered an element of marine fauna from the Cretaceous [Finlay and Marwick 1940, Haubold and Daber 1989] or even earlier [Bieda 1966].

MATERIALS

The fossil wood of *Taxodium distichum* Gothan, 1906 from Frampol (Miocene, Roztocze, SE Poland) was used in the research. Its weight was 362 g and the maximum dimensions were 164 x 73 x 25 mm. A natural crack in fossil wood sample exposed the interior of the boring, revealing the surface texture of wood boring wall. The tunnel cross-section is round with a diameter of 9mm (Fig. 1).

For comparative purposes, several wood samples were used, including contemporary wood of Scotch pine (*Pinus sylvestris* L.) damaged by various modern species of wood boring insects and contemporary makore wood (*Tieghemella heckelii* Pierre, Sapotaceae) from

Africa, damaged by *Teredinidae*. The tunnel cross-section is round with a diameter of 4 mm (Fig. 3).

The shape of the cross section of Teredinidae borings is round, with a diameter of Y mm. Samples of *P. sylvestris* wood were split to show the interior of insect borings. Tunnels in Scotch pine were bored by: old house borer larvae (*Hylotrupes bajulus* L., Coleoptera, Cerambycidae) – oval cross-section 4 x 8 and 18 mm, larvae of *Anobium pertinax* L. (Coleoptera, Anobidae) – round cross section with diameter 3–4 mm, and larva Siricidae (Hymenoptera) – round cross section with diameter 8mm.

Photographs of surface texture of wood boring wall were taken using a camera LUMIX with Leica DC Vario-Elmarit 1:2.8/4.5–108 lens with a light shining in an oblique direction. The surface texture of wood boring wall, which is visible in the pictures, was then compared.

Figure 1. The boring in fossil wood of Taxodium distichum Gothan, 1906

RESULTS

The surface texture of wood boring wall in fossil *T. taxodii* wood is shown in the Fig. 2 and 3. The surface texture of boring wall in makore wood is shown in the Fig. 4.

Figure 2. and 3. The surface texture of wood boring wall in fossil wood of Taxodium distichum Gothan under different lighting


Figure 4. The surface texture of wood boring wall of Teredinidae in makore wood (*Tieghemella heckelii* Pierre)

The surface texture of wood boring walls of wood-eating insects has been presented in the subsequent photographs: Fig. 5 – larvae of *H. bajulus*, Fig. 6 – larvae of *A. pertinax*, Fig. 7 – larva of Siricidae.


Figure 5. The surface texture of wood boring wall of old house borer (*Hylotrupes bajulus* L.) in Scotch pine wood (*Pinus sylvestris* L.)

Surface texture types of wood boring walls can be divided into 2 groups which result from the wood boring method. Insect larvae drill wood with mandibulae. The traces of the wood boring insects' mandibulae are very numerous and small in relation to the diameter of the tunnel. The surface texture of wood borings walls is therefore rough. Depending on age, population density, wood type and environment, adults size of Teredinidae ranges from a few millimetres to one meter. The shells of Teredinidae are wood-boring instruments. Having small teeth on the valves, the insects use their shells as a rasp. In Teredo sp. adults, the shell is triangular and consists of two parts – the anterior and posterior lobes that are similar in size. Teredinidae drive a tooth into the front of the shell and rub the wood with the front surface of the shell, which is very rough. The front part of the shell grinds the walls of the tunnel. Teredinidae shells leave grinding marks on the walls of the boring. These grinding marks (Fig. 2, 3 and 4) are relatively larger than those of the mandibulae of insects' larvae (Fig. 5, 6, 7).

Figure 6. The surface texture of wood boring wall of *Anobium punctatum* L. in Scotch pine wood (*Pinus sylvestris* L.)

Figure 7. The surface texture of wood boring wall of Siricidae in Scotch pine wood (*Pinus sylvestris* L.)

The surface textures of wood boring wall in fossil *T. taxodii* wood and contemporary makore wood (*T. heckelii*) are similar. The oval abrasions on the surface of the tunnel walls are similar in diameter size of the tunnels. In the case of H. bajulus (Fig. 5), A. pertinax (Fig. 6), Siricidae (Fig. 7) is completely different. On the surface of the boring walls there are many microscopic traces of the mandibulae of insects larvae. The surface texture of tunnel walls is completely different than in Fig. 2 and 3.

DISCUSSION

With respect to the anatomical structure of *T. taxodii* wood corresponds to the living bald cypress tree (*Taxodium distichnum* (L.) Rich.) [Kłusek 2006]. Bald cypress is a dominant species of many coastal forested wetlands [Allen et al. 1996].

Modern bald cypresses grow in waterlogged or temporarily flooded stands in warm and humid climatic regions and are the dominant species of coastal forested wetlands. The habitat conditions in Roztocze area were presumably similar when the ancient trees grew there [Kłusek (2006]. Adequate water resources in the case of the Roztocze trees were doubtless connected with the waterlogged nature of their stands [Kłusek 2006]. *T. taxodii* was similarly a dominant species in forest on temporarily flooded stands. The wood of T. taxodii was often taken into seawater by floods, just like bald cypresses today. Larvae of Teredinidae inhabited such wood. Some modern Teredinidae species exhibit periodic resistance to seawater salinity [Becker, 1958]. The shape and size of tunnels of Tredinidae are very different compared to Pholadidae (Bivalvia, Mollusca) or other animals that make wood borings in sea water [Becker, 1958, Krajewski et Witomski, 2016], while some Isopoda (*Sphaeroma hookeri* Leach) in seawater can make depressions similar to the borings of cambiophagic insects [Becker, 1961].

Naturally, insects could also drill tunnels in T. taxodii wood. The wood of T. distichnum provides good living conditions to insects, including the old house borer (*Hylotrupes bajulus* L., Coleoptera, Cerambycidae) [Dominik 1977], which was carried to the United States (Becker1970, Dominik et. Starzyk, 2004). The borings in fossil wood are described as tunnels of insects as most often only fragments of samples are available. Under these conditions, fragments of fossil wood with tunnels of very young Teredinidae can thus be marked, for example, as Anoobidae, and the old ones as Siricidae. Insect remains are rather rare, except for inclusions in amber and asphalt masses. Under favourable conditions the colour of body coatings may also be fixed. *Eosilphites decoratus* (Coleoptera, Siphidae) (Tertiary, middle Eocene from brown coal lignites at Geiseltal bei Halle in eastern Germany) is a textbook example [Daber et Helms 1988]. Unfortunately, the remains of Miocene xylphagic insects from Roztocze in Poland are not available. We must, therefore, determine the taxonomic affiliation of the animal on the basis of borings in wood. Under these conditions, mistakes are common. An example of changes in the view on insects that caused wood borings from Tertiary was described by Madziara-Borusewicz [1970].

Individual species of xylophagic insects make wood borings of different sizes, different cross-sections and in some cases also a characteristic shape. The wood borings of insects are filled with small scobs and excrement, most often of characteristic shape. The shapes and size of the outlet holes on the wood surface are very helpful in determining the insect species which damaged the wood. However, determining insect species based on wood borings is quite difficult, although included in textbooks [Dominik et Starzyk, 2004, Krajewski et Witomski, 2016]. They are rare in pieces of fossil wood.

Round sections of tunnels are found in many species of wood borings insects, for example: Coleoptera (Anobiidae, Bostrichidae, Ipidae, Curculionidae and in the final sections some Cerambycidae, e.g. *Corymbia sp*. and *Monochamus sp*.) and Hymenoptera (Siricidae and Xiphydridae). The surface texture of wood boring walls, however, is completely different than in Teredinidae, as shown in Fig. 4, 5 and 6. The borings in fossil wood from Poland are attributed to Sirex sp. (Hymenoptera, Siricidae) and Anobium sp. (Coleoptera) Anobiidae [Rajchel and Uchman 1998] or in the case of carbonic wood Familae of Lymexylonidae, Buprestidae and Ipidae [Madziara-Borusewicz 1970] without analyzing the texture of the wall surface of such a tunnel. The designations of the long sections of wood borings in the paper of Madziara-Borusewicz [1970] most likely present the truth. The designations of wood borings in the paper of Rajchel and Uchman [1998] leave doubts. The tunnels of wood boring insects in carbonic wood are often containing small, compacted scobs. Madziara-Borusewicz [1970] also noticed this.

Wood borings of Teredinidae are empty [Becker 1958] except for a short section in front of the animal. This phenomenon was already described in German encyclopaedias in the 18th century [Krajewski et Matejak, 2002]. During the animal's life, the wall surfaces of Teredinidae tunnels are covered with a layer of calcium carbonate [Becker 1958]. However, the calcium carbonate layer may deteriorate as a result of putrefaction after the animal's death. Unfortunately, the shells and pallets in modern wood often do not remain fixed. Of course, in the process of fossilization, tunnels can be filled with mineral material or small scobs can also be fossilized. If the surface texture of wood boring wall is inaccessible to view or the interior of the tunnel is filled with mineral substance, it is difficult to determine whether wood borings are left of insects or Teredinidae. When the texture of the walls is visible, it is simple to determine whether they are wood borings left by insects or by Teredinidae.

CONCLUSIONS

The wood boring in the studied fossil wood of *T. distichum* was made by Teredinidae. Studying the surface texture of tunnel walls in fossil wood seems to be an effective way to distinguish wood borings of Teredinidae from those of xylophagic insects.

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Streszczenie: *Tunele Teredinidae w skamieniałym drewnie Taxodium distichum Gothan, 1906.* Wykonano zdjęcia faktury powierzchni ściany tuneli wydrążonych przez *Teredinidae* w kopalnym drewnie *Taxodium distichum* z Frampola (Miocen, Roztocze, SE Polska). Dla celów porównawczych sfotografowano tekstury powierzchni ściany tuneli w drewnie makore (*Tieghemella heckelii* Pierre) z Afryki, pozostałe w sośnie zwyczajnej (*Pinus sylvestris* L.) po żerowaniu *Teredinidae* i innych gatunkach owadów. Na podstawie porównania fotografii stwierdzono, że tunel w badanym drewnie kopalnym *T. distichum* został wydrążony przez Teredinidae.

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