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Research paper

Nelumbo fossils from the Miocene deposits of Dobrzyń nad Wisłą, Central Poland

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ABSTRACT

The classification of the Zingiberaceae infructescence of *Amomum europaeum* Kownas from a classic Miocene locality in Dobrzyń nad Wisłą (Central Poland) is revised. Superficially, *A. europaeum* resembles recent *Amomum* and *Etlingera* infructescences in shape and size. However, no other features link *A. europaeum* to Zingiberaceae. A re-examination of all visible structures reveals that these *A. europaeum* remains represent the horizontally-flattened receptacle ('gynobase') of *Nelumbo* (Nelumbonaceae). Miocene paleoclimatic and paleoecological conditions in Dobrzyń were similar to those of modern *Nelumbo* habitats, which supports the new interpretation.
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1. Introduction

On the left bank of the Vistula River (Fig. 1), close to the town of Dobrzyń nad Wisłą (Dobrzyń), an outcrop of middle Miocene (Zastawniak et al., 1996; Piwocki et al., 2004) coal, clay and sand appears on a 50-metre-high riparian cliff (Banach, 1977). Researchers have described many plant remains from this locality, including nine taxa of fossil wood, 58 taxa of leaf imprints and carpological remains (Lilpop, 1924, 1929; Kownas, 1951, 1956) and many new species. Kownas (1959) referred four taxa to the Zingiberaceae Martinov: *Rhizocaulon zingiberoides* Kownas, *Rhizocaulon saportae* Kownas, *Spirematospermum wetzleri* (Heer) Chandler and *Amomum europaeum* Kownas. The classification of the first three of these taxa in Zingiberaceae is still controversial (Friedrich and Koch, 1970; Kvaček and Wilde, 2006; Fischer et al., 2009; Kunzmann, 2012). Furthermore, the identification of *A. europaeum* is doubted, as these are the only known remains of this tropical genus in Europe and verification of the original material is long overdue.

This study presents a reinvestigation of these *Amomum europaeum* remains that can now be linked to the Nelumbonaceae Achille Richard and assigned to the fossil species *Nelumbo protospeciosa* Saporta. In addition, the systematics of European Cenozoic Zingiberaceae remains is further clarified.

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1.1. Geology

Despite the fact that the natural outcrops in the Dobrzyń nad Wisłą have long been of interest to researchers, this has not resulted in a comprehensive geological elaboration. Kownas (1956) only provides a schematic lithological profile and indicates a fossiliferous dark clay layer. There are now two differing opinions on the lithostratigraphic assignment of the clays in Dobrzyń nad Wisłą. Based on their lithology, Piwocki et al. (2004) included these deposits in the Pawłowice Formation. However, some researchers highlight paleobotanical evidence that suggests (Zastawniak et al., 1996; Mai, 2001) the deposits exposed in this location belong to a younger lithostratigraphic unit and represent the Poznań Formation.

The sediments exposed in Dobrzyń nad Wisłą accumulated in floodplain and deltaic environments (Leciejewicz, 1996). Leciejewicz's (1996) sedimentological work and Grabowska's (1996) micropaleobotanical research indicate fresh-water conditions. However, Piwocki et al. (2004) described traces of sea urchin burrows in certain silty–sandy deposits near Dobrzyń nad Wisłą, which indicate a periodic marine influence.

2. Materials and methods

The specimens described in this study are part of the Stefan Kownas collection that was given to the Warsaw PAS Museum of the Earth in the early 1960s. He collected these specimens along a few kilometres of river cliff bank between the river port of Dobrzyń nad Wisłą and Bachorzewo (Fig. 1).

Fig. 1. Location of the Dobrzyń nad Wisłą, Central Poland.

The PAS Museum of the Earth in Warsaw stores two specimens described as *Amomum europaeum* (represented both as parts and counterparts): Nos. MZ VII/9/29bis A and MZ VII/9/29bis B (Plate I, 1–4; Plate II, 1, 3). These specimens are well-preserved and do not differ in appearance from those described by Kownas (1959: pl. I, 1; pl. II, 2).

Comparative studies are based on material from the herbarium of the Museum of the Earth and specimens are photographed with a Nikon digital camera.

3. Results

3.1. Taxonomy

Family: Nelumbonaceae A. Richard.
Genus: *Nelumbo* Adanson, 1763 (*Nelumbium* A. L. Jussieu, 1789 — ort. var.)
Nelumbo protospeciosa Saporta.
1891 *Nelumbium proto-speciosum* Saporta — Saporta, p. 17–18, pl. 1, 2–3; pl. 4, 1–2.
1959 *Amomum europaeum* Kownas — Kownas, p. 463–465, pl. 1, 1, pl. 2, 1.
1974 *Nelumbo protospeciosa* Saporta — Dorofeev, p. 88, pl. 33, 6.

Specimens: MZ VII/9/29bis A (Plate I, 1) and MZ VII/9/29bis B (Plate I, 4).

3.1.1. Description

Specimen MZ VII/9/29bis A (Plate I, 1) shows a coalified, vertically-flattened 98 mm long and 93 mm wide receptacle with 23 distinct 12–16 mm diameter cavities filled with sediment. These cavities are arranged in two concentric circles around a single cavity in the centre of the receptacle.

In specimen, MZ VII/9/29bis B (Plate I, 4) the basal part of the receptacle is visible; it is preserved as an 85 mm long and 83 mm wide impression that shows vascular bundles radially arranged around an eccentric peduncle mould.

3.1.2. Remarks

The first remains of *Nelumbo* from European Cenozoic were described by Ettingshausen (1855). He established *Nelumbo buchii* using Eocene leaf impressions from Monte Promina in north-western Herzegovina (see also Jungwirth, 2003). However, de Saporta (1891) (who had described an Oligocene flora in Manosque, France) was the first to describe leaves and an unripe receptacle. He established the species *Nelumbo protospeciosa* (*Nelumbium proto-speciosum*). In Mai's (1995) opinion, *Nelumbo* Adanson remains in Eurasia from the Paleocene to the Miocene are represented only by *N. buchii*. The Monte Promina and Manosque species may be conspecific; however, the question has not yet been properly resolved. In this study, the Dobrzyń remains are referred to as *N. protospeciosa*.

4. Discussion

Kownas (1959) described *Amomum europaeum* as a flattened infructescence, closely related to the modern *Amomum polycarpum* Schumann. He characterized these remains in his original description[1] as follows: "The whole specimen is more or less circular, 10 cm in diameter, well visible on two sides of the breakage. The lower part shown in Table II Fig. 1 is the basal part of the whole infructescence with the well-visible casing, the destroyed base being an oblique aperture. The base, over 1 cm in diameter, is in eccentric position to the infructescence. Presumably so because of slanting pressing. Leaves of the infructescence casing, with parallel venation, spread from the base radiantly. Table I Fig. 1 shows the upper part of the breakage with the whole infructescence as seen from the basal part. In this specimen every single fruit, 23 altogether, can be seen clearly.

The fruits are nearly circular with an average diameter of 1.5 cm surrounded by a destroyed layer of small leaves of the coating, which were growing up between the particular fruits. The surface of the fruits shows distinct parallel ribs spreading radiantly from short peduncles." (Kownas, 1959, p. 468).

4.1. The European fossil record of the Zingiberaceae family

Few fossil representatives of Zingiberaceae in Europe have been verified: several species of seeds of *Alpinia* Roxburgh (Mai and Walther, 1985; Mai, 1999, 2000) and leaves of *Zingiberoideophyllum liblarense* Kräusel and Weyland showing the typical zingiberaceous architecture (Kvaček and Wilde, 2006; Kunzmann, 2012). In Europe, fossil infructescences of *Amomum* Roxburgh have only been found at Dobrzyń nad Wisłą. In recent years, researchers have reinvestigated many remains considered to belong to Zingiberaceae and reconsidered their affiliation with this family (i.e., Kvaček and Wilde, 2006). For example, Fischer et al. (2009) suggested that *Z. liblarense*, *Rhizocaulon zingiberoides* and *Spirematospermum wetzleri* remains may belong to a single species, *S. wetzleri*, which represents a new fossil subfamily of the Musaceae. Furthermore, *Musophyllum polonicum* and *Rhizocaulon saportae* from Dobrzyń nad Wisłą may represent different organs of the *S. wetzleri* plant (Fischer et al., 2009). Although Kunzmann (2012) questioned the above taxonomic assignment, he presented evidence that *Z. liblarense* belongs to Zingiberaceae.

The order Zingiberales Grisebach currently includes eight families, 92 genera and 2151 species (Stevens, 2001). Fifty-three genera and 1200 species have been identified in the ginger family (the largest in this order) that is subdivided into four tribes: Hedychieae Horaninow, Alpinieae Achille Richard, Zingibereae Meisner and Globbeae Meisner

[1] Kownas (1959) gave this original English summary at the end of his paper.

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