Acta Palaeobot. 38(1): 167–174, 1998

TRAPA SRODONIANA, A NEW FOSSIL SPECIES FROM THE PLIOCENE OF BEŁCHATÓW (MIDDLE POLAND)

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ABSTRACT. The fossil nuts of *Trapa* from the Pliocene sediments of the Bełchatów brown-coal mine (Middle Poland) determined earlier as *Trapa silesiaca* Goeppert are described here as a fossil species new to science, *Trapa srodoniana* sp. nov. The newly described species corresponds in significant ways to some living taxa of the *Trapa* genus distributed in the Far East, especially *T. tuberculifera* V. N. Vassil. Palaeophytocoenological analysis of the fossil flora of the Bełchatów VIb profile, where the new species of *Trapa* was found, suggests that the layers examined in the clayey-sandy complex overlying the coal is of Pliocene age, i.e. younger than was previously supposed. Fossil fruits of cf. *Ranunculus sceleratoides* Nikitin and cf. *Rumex* sp. represent taxa new to the fossil flora of Bełchatów.

KEY WORDS: *Trapa*, carpology, taxonomy, fossil flora, palaeophytocoenoses, Pliocene, Poland, Europe

INTRODUCTION

Traces of the presence of fossil remains of *Trapa* L. were found in the material collected during an investigation carried out in the Bełchatów Brown Coal Open-cast Mine, Middle Poland (Fig. 1) by workers of the Department of Palaeobotany of the W. Szafer Institute of Botany, Polish Academy of Sciences in Cracow (Stuchlik et al. 1990).

They were found in several of the layers examined in the clayey-sandy complex overlying the coal, especially in its part above Paratonstein TS-2. This complex constitutes the highest part of the whole Tertiary profile of Bełchatów. On the basis of a palaeobotanical study its age was determined to be Upper Miocene–Lower Pliocene. Some remains of Pannonian fauna were also found in this complex (MN zone 9–10; Stuchlik et al. 1990).

The best-preserved complete nuts of *Trapa* were found in profile VIb. Because of their general shape the nuts were previously determined as *Trapa silesiaca* Goeppert (Stuchlik et al. 1990, Pl. 14), a fossil species described from the Upper Miocene flora at Sośnica (Goeppert 1855). It appeared, however, in the course of critical studies of the fossil remains of *Trapa* from the European Tertiary, carried out by the first author, that the nuts of *Trapa* from profile VIb in an open pit at Belchatów represented a quite different species, new both to the Tertiary and science.

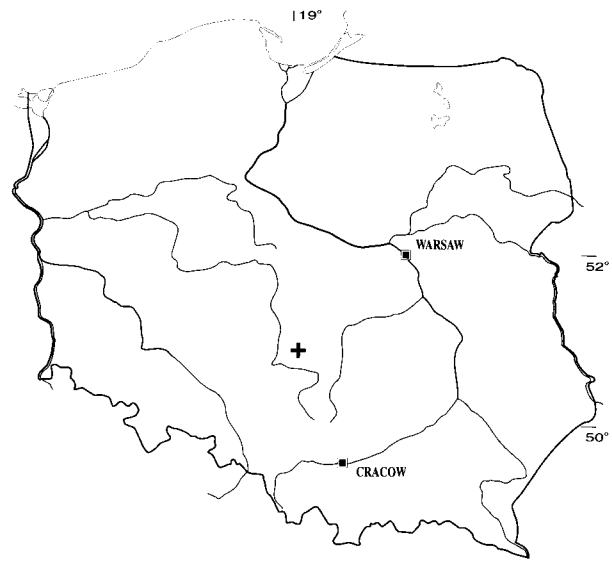

Fig. 1. Location of the Bełchatów Brown Coal Open-cast Mine in Poland

During the study of the fossil flora of the Bełchatów palaeobotanical profile VIb, nine complete *Trapa* nuts and some fragments were found (coll. J. Kurdziel 1984) in the es-

carpment of a southern slope at an altitude of 140 m, between borings 23G-1 and 27G-1 (see Stuchlik et al. 1990). This fossil material is stored at the Museum of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow (KRAM-P 191/449, 450, 488, 776).

Only the nuts preserved whole were the subject of detailed morphological-comparative studies. The remaining findings, consisting of small parts of *Trapa* fruits, most frequently the ends of barbed spines (harpoons), were inadequate for taxonomic examination. It is impossible to determine them to species level but they could represent the same species.

During the course of long-term studies of the Bełchatów sediments other botanical findings were also investigated. The composition of the orictocoenosis of the Bełchatów palaeobotanical profile VIb was established on the basis of leaf impressions and numerous fossil remains of fruits and seeds obtained by flushing a layer of grey clays and coaly sands (Stuchlik et al. 1990, Table *s.n.*). The carpological remains were identified by M. Łańcucka-Środoniowa and leaf impressions by E. Zastawniak. The composition of the taxa identified allowed for correction of previous suggestions concerning the age of the profile investigated.

ORICTOCOENOSIS OF BEŁCHATÓW VIb WITH *TRAPA SRODONIANA*

Presented below is a complete list of the taxa from the Bełchatów palaeobotanical profile VIb, verified on the basis of the stock-book of the Museum of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences in Cracow:

Abies sp. (needles), Alismataceae (fruits), *Alnus cecropiaefolia* (Ett.) Berger (leaves), *A. ducalis* (Gaudin) Knobloch (leaves), *Alnus* sp. (leaves), cf. *Alnus* sp. (fruits), cf. *Arceuthobium* sp. (shoots), *Batrachium* sp. (fruits), *Betula longisquamosa* Mädler (fruits), *Boehmeria* sp. (fruits), *Caldesia* sp. (fruits), *Carex* sp. div. (fruits), *Carpinus grandis* Unger (leaves), *C. betulus* L. type (fruits), *Carya* sp. (nut), cf. *Cladium* sp. (fruits), Coniferae indet. (seeds), Cupressaceae (shoot), Cyperaceae (fruits), *Decodon globosus* (E. M. Reid) Nikitin (seeds), *D. sibiricus* Dorof. (seeds), *Dulichium arundinaceum* (L.) Britton *fossilis* Mai (fruits), *D. marginatum* (C. & E. M. Reid) Dorofeev (fruits), *D. vespiforme* C. & E. M. Reid (fruits), *Eoeuryale brasenioides* Miki (seeds, spines), Ericaceae (fruits), *Fagus decurrens* C. & E. M. Reid (fruits), *F.* cf. *microcarpa* Miki emend. Uemura (seeds), *F. silesiaca* Walther & Zastawniak (leaves), cf. *Gleditsia* (spines), *Hypericum tertiaerum* Nikitin (seeds), cf. *Juncus* (fruits), Leguminosae (fruits), *Liquidambar europaea* A. Br. (leaves), cf. *Liquidambar* sp. (seeds), *Ludwigia palustris* (seeds), cf. *Magnolia* (seeds), *Microdiptera menzelii* (C. & E. M. Reid) Mai (seeds), Musci, *Myrica lignita* (Unger) Saporta (leaves), cf. *Myrica* (fruits), *Nyssa ornithobroma* Unger (fruits), cf. *Ostrya* sp. (fruits), *Paliurus sibiricus* Dorefeev (= *P.* cf. *ramosissimus* Poir.) (fruits), *Parrotia pristina* (Ett.) Stur (leaves), *Phyllanthus* sp. (seeds), *Pinus leitzii* Kirchh. (leaf fascicle, needles), *P. palaeostrobus* Ett. (leaf fasciculi), *Pinus* sp. (needles), *Pirus* vel *Malus* (seeds), *Platanus leucophylla* (Unger) Knobloch (leaves), *Poliothyrsis lutetianoides* (Szafer) Mai (seeds), *Populus balsamoides* Goeppert (leaves), *Populus* sp. (leaves), cf. *Potentilla* sp. (aff. *supina* L. – fruits), *Proserpinaca reticulata* C. & E. M. Reid (fruits), *Pterocarya paradisiaca* (Unger) Iljinsk. (leaves), *Quercus gigas* Goeppert (leaves), *Q. pseudocastanea* Goeppert (leaves), *Quercus* sp. (fruits), cf. *Ranunculus sceleratoides* Nikitin (fruits; species new to the fossil flora of Bełchatów), *Ranunculus* vel *Batrachium* (fruits), Rosaceae (spines), *Rubus* cf. *laticostatus* Kirchh. (fruits), *Rubus* sp. (fruits), cf. *Rumex* sp. (fruit; taxon new to the fossil flora of Bełchatów), *Sagittaria* sp. (fruits), *Salix* sp. (leaves), *Saururus bilobatus* (Nikitin) Mai (fruits and seeds), *Scirpus* cf. *sylvaticus* (fruits), *Sparganium* cf. *camenzianum* Kirchh. (fruits), *Staphylea pinnata* L. *fossilis* Dubois (seeds), *Stewartia beckerana* (Ludwig) Kirchh. (fruits), *Swida gorbunovii* Dorof. (fruits), *Taiwania paracrytomerioides* Kilpper (needles), *Taxodium dubium* (Brongn.) Unger (shoots, seeds), *Tilia* sp. (fruit), *Trapa srodoniana* sp. nov. (fruits), *Ulmus* sp. (leaves), cf. *Urtica* (fruits), *Weigela oraviensis* Łańc.-Środ. (seeds), *Viola* sp. (seeds), *Viscum miquelii* (Geyler & Kinkelin) Czeczott (leaves), *Viscum* sp. (leaves, pseudoberries), *Zelkova ungeri* Kovats (fruits); in addition zoocecidia, coprolites of insects, fungal sclerotia, buds, scales, knots and *Antherites*.

AGE OF FOSSIL FLORA OF BEŁCHATÓW VIb WITH *TRAPA SRODONIANA*

All the tree and shrub taxa in the list above are components of the so-called Mixed Mesophytic Forest, typical of the Upper Miocene and Pliocene of Central Europe (Mai 1995). They belong to the Arcto-Tertiary element of a temperate nature, dominant in the Neogenic fossil floras of this part of Europe. In the material under study this element is represented by fossil species of deciduous trees and shrubs of the genera *Quercus, Carpinus, Fagus, Betula, Liquidambar, Magnolia, Ostrya, Parrotia, Prunus, Pterocarya, Tilia, Ulmus* and *Zelkova*, with a small admixture of coniferous trees *Abies, Pinus* and Cupressaceae. According to Mai (1995), such a composition is characteristic of the fossil floras of the Reuver Floristic Complex from the Upper Pliocene of Central Europe. These floras have a relatively poor taxonomic composition and, above all, the proportion of more thermophilous relict genera of the palaeotropical element is rather small or totally absent. The palaeotropical element, abundantly represented in the Lower and Middle Miocene of Europe, becomes increasingly scarce in the younger horizons of the Neogene until it disappears completely in the Upper Pliocene (Mai 1995; Planderova et al. 1993). As no palaeotropical taxa have been found in the fossil flora of Bełchatów VIb (Table 1) and the taxonomic composition is almost identical with that given by Mai (1995) for the Upper Pliocene, it may be assumed that the Bełchatów palaeobotanical profile VIb is probably of Upper Pliocene age, and so, of

Table 1. Vertical distribution of genera of the Bełchatów VIb orictocoenosis based on the van der Burgh (1994) method

Canopy (a)	**Understorey (b)**	**Shrubs (c)**	**Herbs (d)**
		ARCTOTERTIARY	
Abies	Cupressaceae p.p.	*Arceuthobium*	Alismataceae
Alnus	*Liquidambar*	Cupressaceae p.p.	*Batrachium*
Betula	*Magnolia*	Ericaceae	*Boehmeria*
Carpinus	*Nyssa*	*Myrica*	*Caldesia*
Carya	*Parrotia*	*Paliurus*	*Carex*
Coniferae	*Pirus* vel *Malus*	*Phyllanthus*	*Cladium*
Fagus	*Poliothyrsis*	Rosaceae	*Cyperaceae*
Gleditsia	*Salix*	*Rubus*	*Decodon*
Ostrya		*Staphylea*	*Dulichium*
Pinus		*Stewartia*	*Eoeuryale*
Platanus		*Swida*	*Hypericum*
Populus		*Weigela*	*Juncus*
Pterocarya		*Viscum*	*Ludwigia*
Quercus			*Microdiptera*
Taiwania			*Potentilla*
Taxodium			*Proserpinaca*
Tilia			*Ranunculus*
Ulmus			*Rumex*
Zelkova			*Sagittaria*
			Saururus
			Scirpus
			Sparganium
			Trapa
			Urtica
			Viola
19	8	13	25
		PALAEOTROPICAL	
0	0	0	0

the same age as the XIVth spore-pollen zone, distinguished by Ziembińska-Tworzydło in the Neogene of the Polish Lowland (Piwocki & Ziembińska 1995). In the pollen spectrum (*Faguspollenties* phase) this zone is characterized by the presence of pollen grains of beech and then by the dominance of the Arcto-Tertiary element in which the cool, so-called "Quaternary taxa" prevail; in addition the thermophilous taxa of the palaeotropical element are absent or few in number and, if present, they occur mainly in the shrub layer. In Ziembińska-Tworzydło's opinion (Piwocki & Ziembińska 1995), palynological profiles of that age are known from the Bełchatów region.

Moreover, the composition of the different growth forms of the Bełchatów VIb orictocoenosis (Fig. 2) is similar to those illustrated by the graphs of the Upper Pliocene (Reuver) or even Lower Pleistocene (Tiglian) floras (see van der Burgh 1994, fig. 3). The taxonomic composition of the Bełchatów VIb profile is, however, typical of the Pliocene.

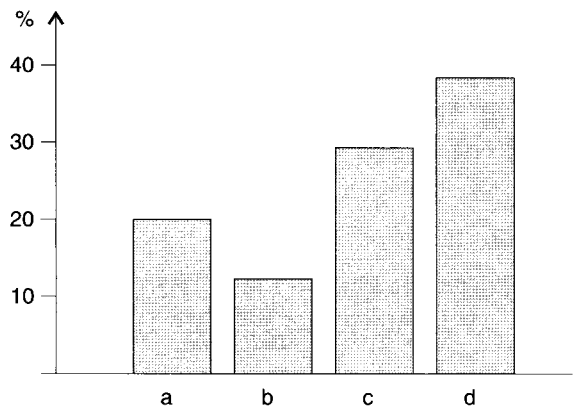

Fig. 2. Histogram showing percentage representation of different growth forms of Arcto-Tertiary taxa in the Bełchatów VIb orictocoenosis [after van der Burgh's (1994) method]; **a** – canopy trees, **b** – understorey trees, **c** – shrubs, **d** – herbs

As mentioned above, the age of the whole clayey-sandy complex which, among other horizons, comprises the Bełchatów VIb profile, was determined previously to be Upper Miocene-Lower Pliocene (Stuchlik et al. 1990). The finding of remains of the Pannonian fauna in this complex was an important indicator. The dating of the fossil flora from Bełchatów profile VIb, situated above the horizon containing the fossil fauna, permits us to shift the upper age boundary of the whole complex upwards.

PLANT COMMUNITIES OF THE PLIOCENE OF BEŁCHATÓW

In the period when sediments containing the fossil flora were being deposited in the Bełchatów profile VIb, mixed or deciduous mesophytic beech-oak-hornbeam forest was the dominant plant community; it was composed of fossil species belonging to the above-mentioned genera of trees and shrubs (see p. 00). In addition to forest of this type, marsh forest must also have been represented in the plant cover to a small extent, since such characteristic components of it as *Taxodium* and *Nyssa* (trees), and *Proserpinaca* (herbs), were found. Numerous herb remains provide evidence that, apart from the stands of more or less dense forest, other plant communities were also present. On the banks of stagnant pools and streams reed-and-sedge-swamp communities were a source of fruits and/or seeds belonging to such genera as *Carex, Cladium, Dulichium, Ludwigia, Microdiptera, Ranunculus, Saururus, Schoenoplectus, Scirpus* and *Sparganium* all of which were found. The habitat of these plants was eutrophic, permanently or for a greater part of the year inundated (Mai 1995). In addition to the taxa given above, some remains of plants characteristic of communities with floating leaves, occurring in shallow fresh water were found as well. In the material under study these are Alismataceae, *Batrachium, Caldesia, Eoeuryale* and *Sagittaria. Trapa srodoniana* sp. nov. would have been growing in such a community.

DESCRIPTION OF A NEW FOSSIL *TRAPA* SPECIES

***Trapa srodoniana* Wójcicki, sp. nov.**

1990. *Trapa silesiaca* Goeppert; Stuchlik et al., Pl. 14.

Holotype. Palaeobotanical Museum of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow (KRAM-P), coll. J. Kurdziel 1984. KRAM-P 191/449a (Fig. 3).

Isotypes. Palaeobotanical Museum of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow (KRAM-P), coll. J. Kurdziel 1984. KRAM-P 191/449 and 191/776 (Fig. 3).

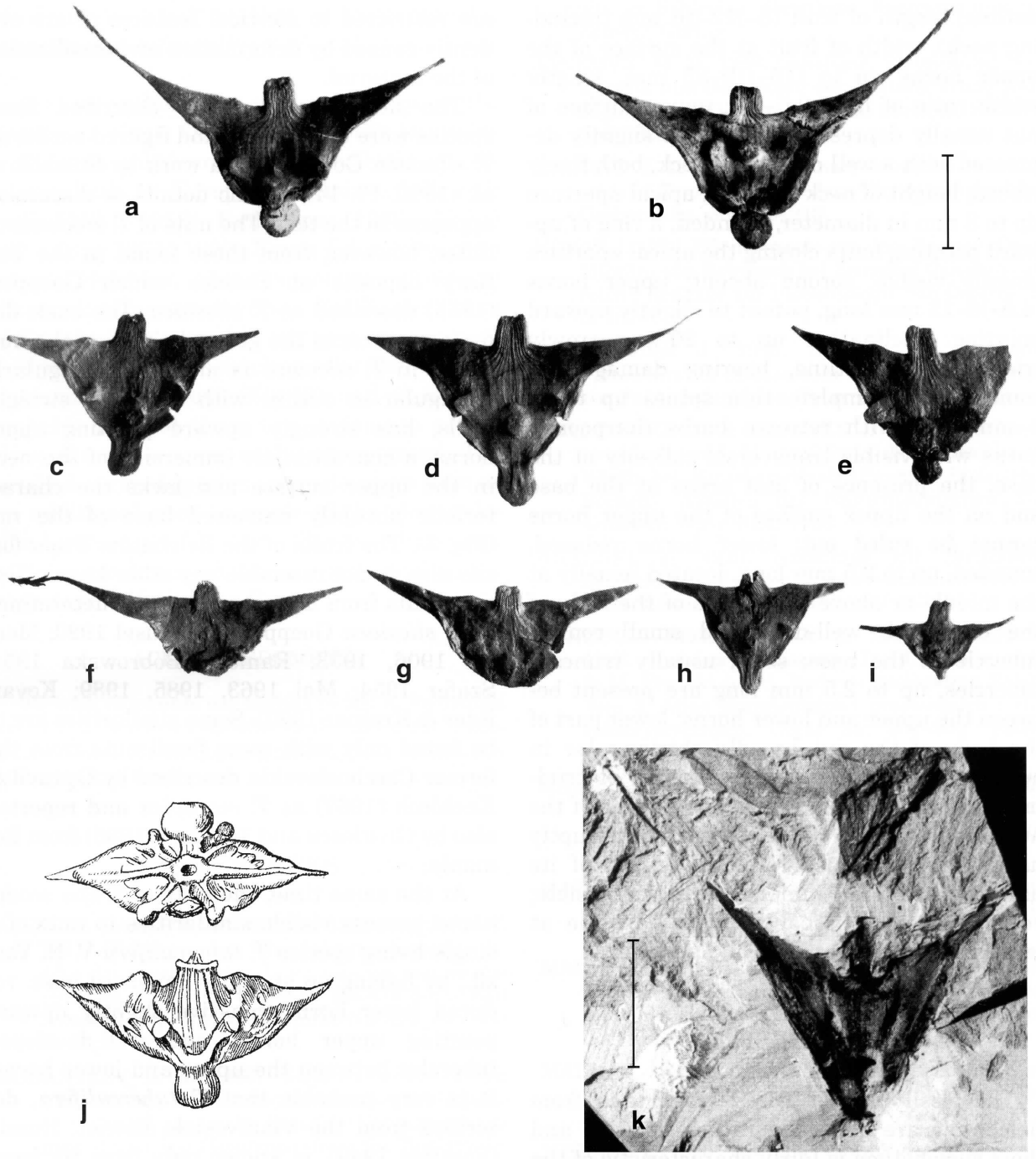

Fig. 3. a–i – *Trapa srodoniana* Wójcicki, sp. nov: a & b – holotype, both sides of the nut (KRAM-P 191/449a); c & d – isotypes (KRAM-P 191/449a); **j** – *Trapa tuberculifera* V. Vasil. (from Vasilev 1949); **k** – *Trapa silesiaca* Goeppert, neotype (from Łańcucka Środoniowa & Zastawniak 1996). Scale bar 1 cm to a–i and k. a–i – phot. A. Pachoński, k – phot. M. Małachowska-Kleiber.

Locus typicus. Bełchatów Brown Coal Open-cast Mine, Middle Poland.

Stratum typicum. Clays within the range of a clayey-sandy complex above Paratonstein TS-2.

Type horizon. Pliocene.

Derivatio nominis. The new specific epithet commemorates two eminent Polish palaeobotanists Prof. Dr. Maria Łańcucka-Środoniowa (1913–1995) and Prof. Dr. Andrzej Środoń[1] (1908–).

Diagnosis. Fruits of medium size, with two massive extended horns, broadly triangular in

[1] For biographies see Stuchlik (1988), Zastawniak (1993a, b, 1995) and Mirek et al. (1995)

outline; length of fruit (8–)12–16 mm (including neck), width of fruit at the surface of the upper horns up to (16–)19–33 mm, length/width ratio of fruit 0.5–0.8; upper surface of nut usually depressed or at least slightly depressed with a well developed neck, both finely ribbed; height of neck 2–4 mm; apical aperture up to 3 mm in diameter, rounded, a ring of upward pointing hairs closing the apical aperture usually visible; corona absent; upper horns (4.5–)6–13 mm long, patent to slightly upward pointing (inclination up to 20°), narrowly triangular in outline, bearing damaged or sometimes ± complete thin spines up to ca 5 mm long with retrorse barbs (harpoons), horns with visible transversal callosity at the base; the presence of mat areas at the base and on the upper surface of the upper horns cannot be ruled out; lower horns reduced, rounded, up to 2.5 mm long, located usually at the middle or above the centre of the body of the nut, with well-developed small conical tubercle at the base; solid, usually truncate tubercles, up to 2.5 mm long are present between the upper and lower horns; lower part of the body of the nut broadly obtriangular in outline, its surface covered with five protruding longitudinal ribs (visible on one side of the nut); base of nut characteristically abruptly narrowed, sometimes rounded, length of its narrow part up to 4 mm; basal ring not visible; very small scar probably covered by the at least slightly elongated basal appendix.

DISCUSSION

The fossil nuts of *Trapa srodoniana* from Bełchatów are generally rather uniform and their morphotype is fairly characteristic of the whole population (Fig. 3). The variability observed suggests that at least some of the fossil nuts represent immature forms but they should not be interpreted as taxonomically distinct since all the qualitative characters are well developed, even on the smallest nuts. Stabilization of the morphotype within one locality, both of fossil and living *Trapa* nuts, is reported from different parts of the distribution of the genus (e.g. Nakano 1914; Janković 1958; Kovar 1979; Staszkiewicz & Wójcicki 1979, 1981; Kadono 1987; Tzvelev 1993; Wójcicki & Bajzáth 1997). Some of the more pronounced differences observed in the nuts are restricted to metrical features or are evidently caused by deformation and fossilization of the material.

The nuts of the newly described fossil species were determined and figured earlier as *T. silesiaca* Goeppert in a work by Stuchlik et al. (1990, Pl. 14), but no details or discussion appeares in the text. The nuts of *T. srodoniana* differ, however, from those found in the Tertiary deposits at Sośnica which Goeppert (1855) described as *T. silesiaca*. The basic difference concerns the general shape of the nut, which in *T. silesiaca* is much more regularly triangular in outline with relatively straight walls, has strongly upward pointing upper horns, a characteristic immersion of the neck in the upper surface and lacks the characteristic abruptly narrowed base of the nut (Fig. 3). The fruits of the Bełchatów *Trapa* fossils also do not resemble any other known Tertiary nuts from European deposits determined as *T. silesiaca* Goepp. (eg. Kräusel 1920; Menzel 1906, 1933; Raniecka-Bobrowska 1954; Szafer 1954; Mai 1963, 1985, 1989; Kovar-Eder & Krainer 1990). Some similarities are to be found only with some fossil nuts from the former Czechoslovakia described by Opravil & Knobloch (1967) as *T. moravica* and reported also by Givulescu and Ţicleanu (1986) from Romania.

At the same time, the nuts of *Trapa srodoniana* possess visible similarities to nuts of a single living species *T. tuberculifera* V. N. Vassil., by having an abruptly narrowed base, reduced lower horns, massive slightly upward pointing upper horns, and well-developed tubercles between the upper and lower horns. It is very probable that *T. tuberculifera*, described from the Vladivostok district, Russia (Vassilev 1949), is known only from its *locus classicus* or from a few localities in Manchuria.

In general shape, and especially in the character of the upper horns, the newly described species resembles also two other living species, *T. komarovii* V. N. Vassil. and *T. korshinskii* V. N. Vassil. [excluding many of their synonyms given by Vassilev (1949); the two species should be critically re-egzamined taxonomically and probably synonymized] distributed in northern China (mainly in Manchuria) and Japan. The nuts of *T. srodoniana* resemble also those of a morphotype of the rather variable *T. japonica* Fler. (Flerov 1926) and recently Tzvelev (1993) proposed reducing the status

of *T. tuberculifera* to that of a variety [*T. japonica* var. *tuberculifera* (V. N. Vassil.) Tzvelev].

It is interesting that the morphotype of the Bełchatów *Trapa* fossils has not been found before and is unknown from other Tertiary sediments, both in Europe and Asia (cf. Fritsch 1885; Miki 1952; Budantzev 1960; Negru 1979; Mai 1985, 1995; Kovar-Eder 1988, and other). However, the taxonomical problems concerning the contemporary Far Eastern taxa of *Trapa* which resemble our new species have still to be solved. Their close relation to *T. srodoniana* is apparent (Fig. 3) and it is very probable that all these taxa belong to a very close, if not the same, evolutionary group. The newly described species seems to serve then as an additional good example of the close relation between the Tertiary (Pliocene) European and Asiatic floras, which survived in relatively high degree in the Far East.

ACKNOWLEDGMENTS

We wish to express our thanks to Mr. A. Pachoński and Ms. M. Małachowska-Kleiber for taking the photographs and to Mr. A. Copping for linguistic verification of the English text.

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