Acta Palaeobotanica 39(1): 5–14, 1999

FOSSIL *TRAPA* L. OF CHINA. 1. A NEW LOCALITY FROM THE MIOCENE OF THE LIANG HE COAL MINE, WEST YUNNAN

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ABSTRACT. Fossil fruits from a new locality from the Miocene of the Liang He Open-cast Mine are characterised and described as a new species of the genus *Trapa* L., *T. chengsenii* Wójcicki, Song & Wang, sp. nov. The newly described species does not correspond in any significant way to previously known fossil or extant members of the genus *Trapa*. However, greatest similarity is found with fossil fruits known from Tertiary aged localities in China and Siberia and also with certain extant taxa distributed in the Far East and India. *T. chengsenii* sp. nov. fills gaps in the morphological variation exhibited between certain 'tetracornis' and 'bicornis' morphotypes of the genus, contributing to knowledge of the evolution of *Trapa*. In addition, a review of the fossil evidence of *Trapa* from China is briefly presented.

KEY WORDS: *Trapa*, taxonomy, morphology, fossil fruits, distribution, China

INTRODUCTION

Sites bearing fossil *Trapa* L. fruits from China have been reported in several papers representing constituents of several different fossil floras. Historically, Depape (1932) appears to be the first author who reported, briefly discussed and figured *Trapa* remains from China. However, the drawings of fragments of eleven fruits given in this paper are too schematic for more detailed interpretation to be undertaken on these materials. More recently Liu et al. (1996), based partially on the informally contained in the *Catalogue of the Chinese megafossil plants from the Cretaceous and Cenozoic* by Tao (1991), catalogued and mapped the occurrences of *Trapa* megafossils previously reported from China, amongst many other taxa. This information has been supplemented by new information subsequently and is included here as Fig. 1, showing the distribution of known fossil *Trapa* localities in China.

Fossil fruits assigned to *Trapa* from China are known from Eocene to Pleistocene aged sediments (cf. Tao & Xiong 1986; Tao 1992; Liu et al. 1996). These have been previously determined as *Trapa* sp. (e.g. Tao & Kong 1973, Li & Guo 1982, Tao & Xiong 1986, Chen et al. 1986, He & Tao 1997), *T. natans* L. (Fossil... 1978), and *T. borealis* Heer (Zhang 1976). On the basis of material from China, two new and apparently endemic taxa have also been described: *T. natans* var. *minor* Depape (1932) and *T. protojaponica* Tao & Chen (1983). A further six new species have been introduced in a short abstract by Tao (1963) for fossil *Trapa* from the Mio/Pliocene of the Yuxi Basin in Yunnan. These species are *T. chienii*, *T. hui* = *T. huiana* on the original labels, *T. portentosa*, *T. platycarpa*, *T. megacarpa*, *T. calocarpa*. In accordance to the ICBN, these species have not been validly published and clearly warrant detailed description and taxonomic procedures being undertaken.

In a single middle Miocene site in the north-eastern part of China Zhang (1976) documented fossil fruits determined as *T. borealis* Heer of a fossil morphotype placed in the distinct genus *Hemitrapa* Miki (cf. Heer 1869, Okutsu 1939, Miki 1952a, b, Budantzev 1960, Tanai 1961, Gregor 1978, Mai 1985). This morphotype is also known from the Miocene of Alaska, Miocene and Pliocene of Japan, and from the Miocene of Russia and Europe, with the Chinese occurrence expanding this previous range.

Based on existing publications, one can ex-

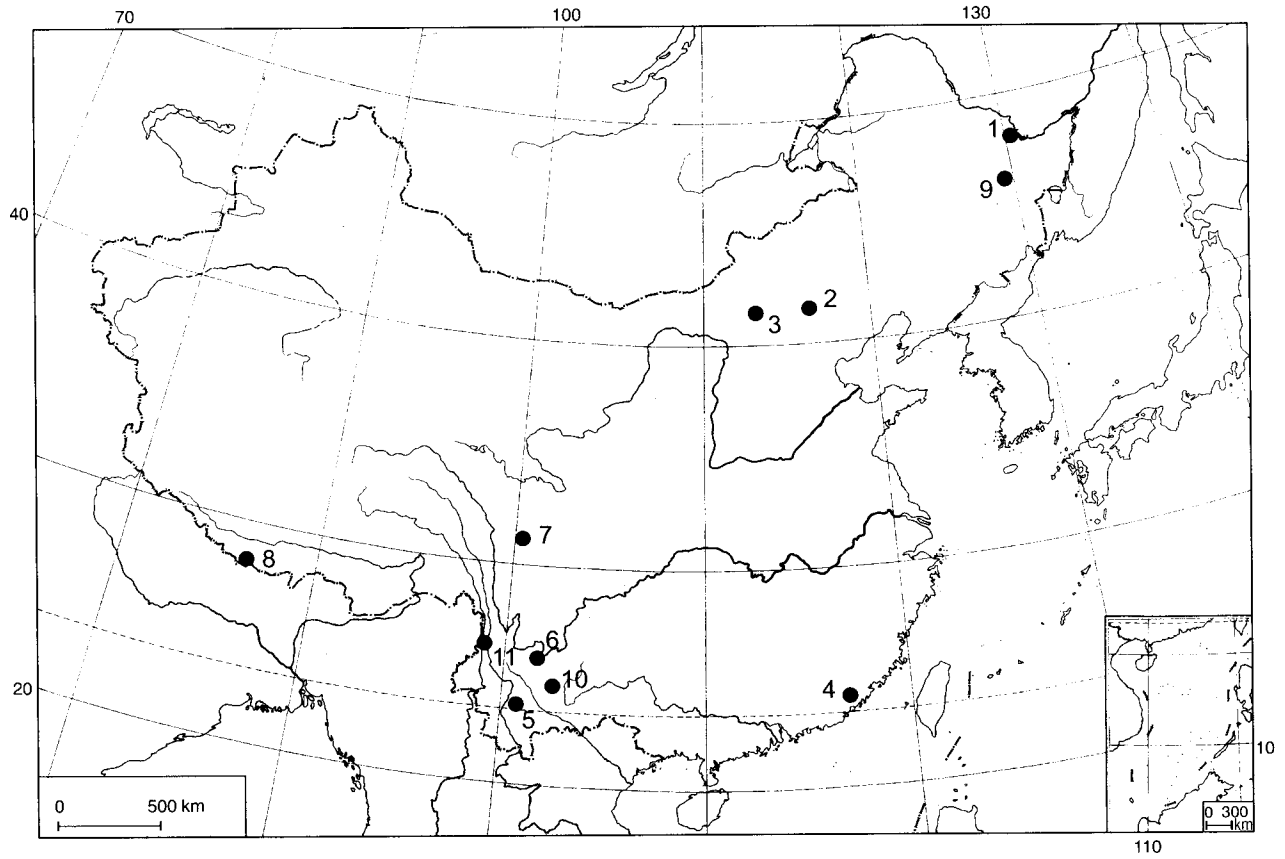

Fig. 1. Distribution of known fossil *Trapa* L. localities in China. **1–8** – localities mapped by Liu et al. (1996; here are also given individual site details); **9** – Yilan Coal Mine, Heilongjiang, Eocene (He & Tao 1997); **10** – Yu Xi Basin, Yunnan, Miocene/Pliocene (Tao 1963); **11** – Liang He Coal Mine, Yunnan – a new locality

pect that *Trapa* occurred in China earlier than in Europe, with He and Tao (1997) in particular documenting its occurrence as far back as the "early Eocene". Unfortunately, the fossil fruit figured in this paper is not informative enough for detailed analysis to be undertaken, and the original material was not available during the course of the present studies. Furthermore, it is difficult to follow the authors' opinion concerning this fossil as on the figure it is determined as *Trapa* sp., but in their table it is cited as *T. borealis*. Importantly, this fossil is very different from what has been described by Heer (1869) under this specific name, making this specific determination unlikely. However, in general morphology the fossil fruit resembles probably one of the oldest known and recognisable fossil fruits of the genus *Trapa* as described by Berry (1913) from the Lower Eocene at Peryear, Tennessee (*T. wilcoxensis*).

The enigmatic species *T. paulula* (Bell.) Brown has been identified from China in a paper by Liu et al. (1996). Originally this species was described on the basis of sterile fossil material (cf. Brown 1962) and as such, the reported occurrences of the species by Guo (1979, 1986) from the two Eocene localities in China, must be excluded. Its placement to the genus *Trapa* as it is defined presently is disputable and it is here considered to belong to one of the extinct genera *Querexia* Kryshtofovich or *Trapago* McIver & Basinger, both of which are commonly placed in the Trapaceae (see Samylina 1988, Golovneva 1991, Stockey & Rothwell 1997).

During field work by members of the Department of Palaeobotany, Institute of Botany, Chinese Academy of Sciences, Beijing on March 1998 in Miocene sediments from the Liang He brown coal open-cast mine, West Yunnan, specimens of fruit of *Trapa* were found. The fossils consist of many well preserved coalified fruits. These are sometimes preserved as impressions/compression with some coalified material present. Variation in specimen orientation within the sediment has caused differences in the primary compression direction. This variation has en-

abled a more precise characterisation of this morphotype to be made. A careful examination of these fruits strongly suggests that they belong to a single morphotype and they are considered to represent a single extinct species, as described and characterised below. The *Trapa* bearing sediments have been found to contain no other well preserved or identifiable macroflora.

CHARACTERIZATION OF THE LOCALITY

The new locality bearing fossil *Trapa* is at the of Liang He brown coal open-cast mine in Lianghe county, Yunnan Province, S. China (98°2′E, 24°8′N) (Fig. 1). Coalified compressions of the *Trapa* fruits occur in grey marls, which are situated above the coal seam. No detailed data is available concerning the precise stratigraphy of this locality although according to the account presented in the *Regional Geology of the Yunnan Province* (1990), the strata with fossil *Trapa* are considered to belong entirely to the Mengwang Formation of the Middle/Late Miocene. Specimens are deposited in the National Museum of Plant Evolution of China, Beijing.

DESCRIPTION

Trapa chengsenii Wojcicki, Song & Wang, **sp. nov.**

Holotype. National Museum of Plant Evolution of China, Xiangshan, Beijing 100093, coll. S. Song, C. S. Li, Y. & S. J. Wang & L. Q. Chen 1998, CBP-LH98-1a (Fig. 2A & 3A)

Paratypes. Palaeobotanical Museum of the Institute of Botany, Chinese Academy of Sciences, Beijing, CBP-LH-98-1b–j (Fig. 2B–F, H–K, 3B–F, H–K, 4A–F, H, I & 5A–F, H, I); Palaeobotanical Museum of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, KRAM-P No. 232/1 & 232/2 (Fig. 2G, 3G, 4G & 5G), 232/3–9; Forschungsinstitut Senckenberg, Palaeobotanik, Frankfurt/Main, Germany SM.B. 16826.

Locus typicus. China, West Yunnan, the Liang He brown coal open-cast mine. Numerous coalified compressions of *Trapa* fruits were found in layers overlying the coal.

Stratum typicum. Grey marl mainly with coalified *Trapa* fruits.

Type horizon. Mengwang Formation (Middle/Late Miocene)

Derivatio nominis. The new specific epithet commemorates eminent Chinese palaeobotanist Prof. Dr. Cheng Sen Li from the Institute of Botany, Chinese Academy of Sciences, Beijing.

Diagnosis and Description. Fruits of medium size, with two massive extended horns triangular in outline; length of fruit 15–25 mm (including neck), width of fruit at the surface of the upper horns 22–38 mm, length/width ratio of fruit 0.55–0.70; upper surface of fruit depressed with a well developed neck, both finely ribbed; height of neck 2–4 mm, width 3–5 mm; the neck usually does not protrude from the upper horns; apical aperture up to ca 5 mm, rounded, a ring of upward pointing hairs closing the apical aperture usually visible; corona lacking; upper horns 7–13 mm long, usually upward pointing (inclination 50°–60°), rarely patent, narrowly triangular in outline, probably at least slightly subulate bearing damaged or sometime ± complete thin spines up to at least ca 8 mm long with retrorse barbs (harpoons), horns with well developed transversal callosity at the base; the presence of mat areas excluded; lower horns reduced to solid tubercles, rounded or truncate, sometime probably slightly depressed, 3–5 mm long, mostly downward pointing, probably with small cavity at the base, located usually asymmetrically slightly above the middle of body of the fruit or/and in ca 1/3 from its base; between the upper and lower horns are present well developed, solid, truncate or rounded tubercles, 2–4 mm long; lower part of the body of the fruit obtriangular in outline, its surface covered with a few protruding longitudinal ribs; base of the fruit gradually narrows, sometime rounded; basal ring relatively small, in most cases not visible; scar small, usually ca 1.0–1.5 mm in diameter.

DISCUSSION

Trapa chengsenii is characterized by several features, namely; the relatively long body of the fruit, the long and slightly subulate upper horns, the reduced but massive and rounded

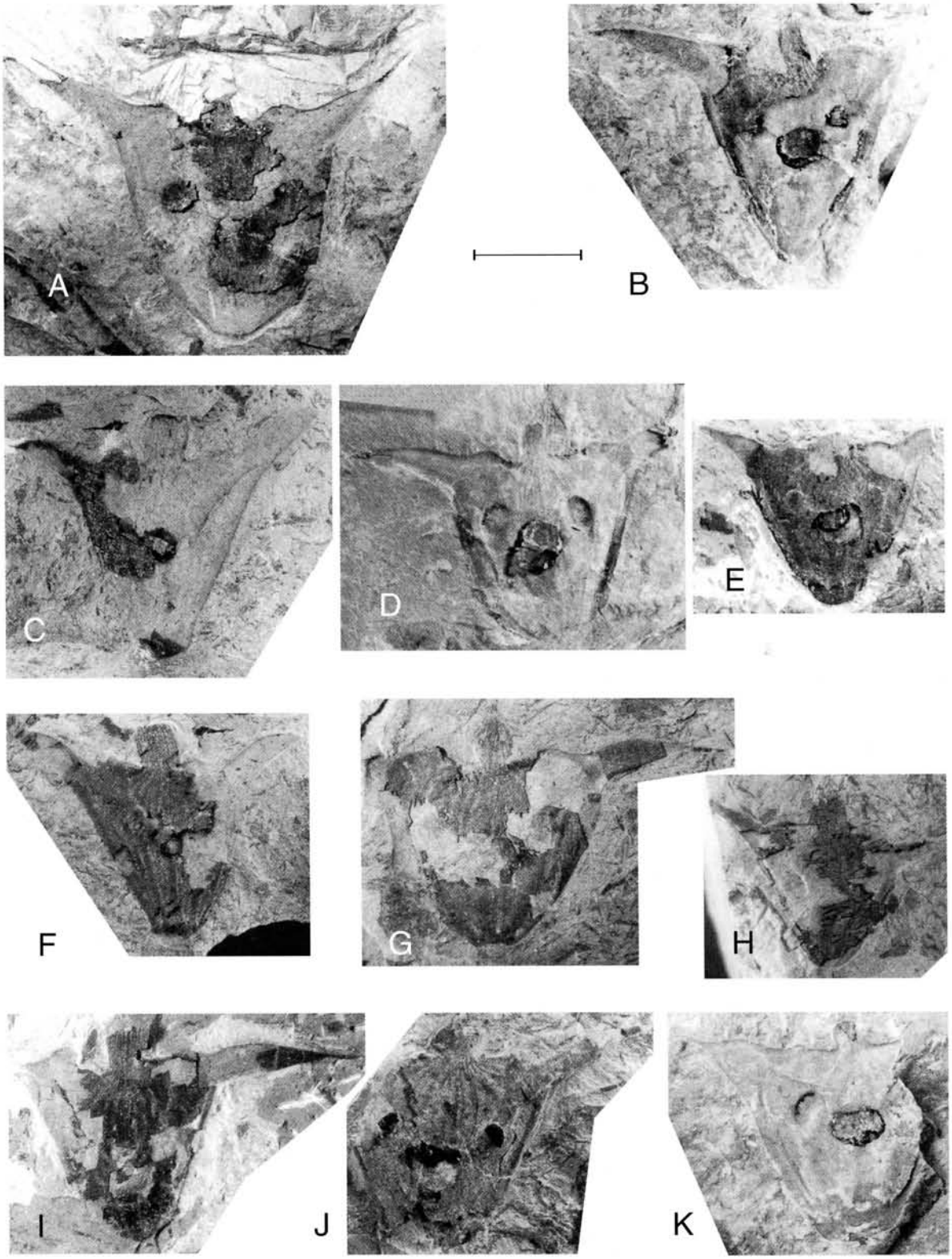

Fig. 2. Fossil fruits of *Trapa chengsenii* Wójcicki, Song & Wang, sp. nov. **A** – holotype (CBP–LH98-1a); **B–K** paratypes (A–F, H–K in the Palaeobotanical Museum of the Institute of Botany, Chinese Academy of Sciences, Beijing, Nos. CBP–LH98-1b–j; G – in KRAM-P No. 232/1). Scale bar 1 cm

or truncate tubercle-like lower horns, well developed tubercles between the upper and lower horns, and a relatively long neck lacking a corona. Many well preserved coalified fruits and differences in orientation of the specimens within the sediment (e.g. Figs 2–5) have enabled a more detailed and precise characterisation of the fruit morphology to be made.

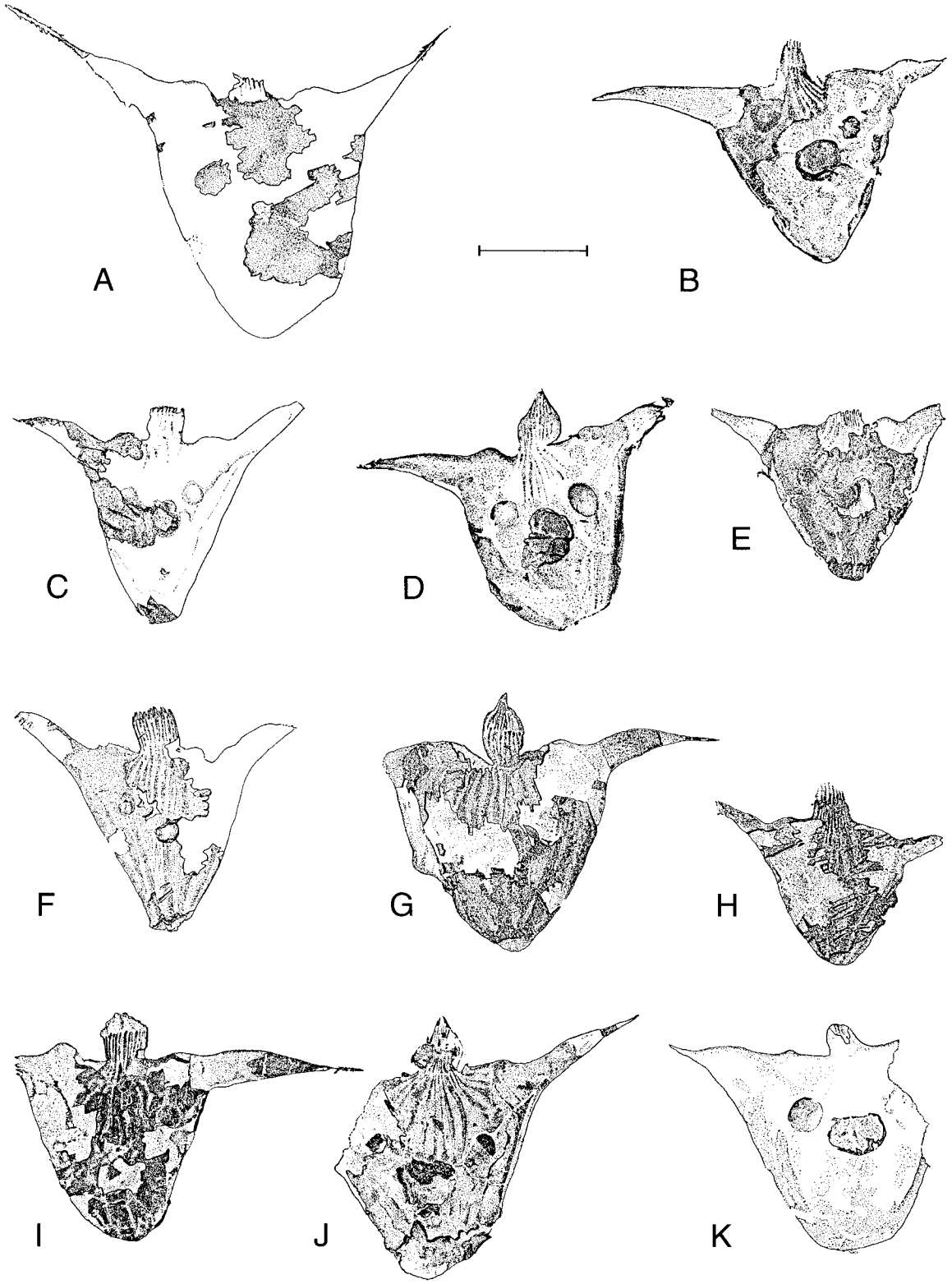

Fig. 3. Drawings of fossil fruits of *T. chengsenii* Wójcicki, Song & Wang, sp. nov. **A–K** – see Fig. 2. Scale bar 1 cm

On the whole, the fruits are not too variable and the general morphotype seems to be comparatively well stabilised, with a greater differentiation restricted to qualitative characters. Small differences in shape, inclination of the upper horns and differences in the relative position of the lower horns are probably caused by taphonomic factors such as deformation by compression and fossilisation. Such uniform variation has been observed in other

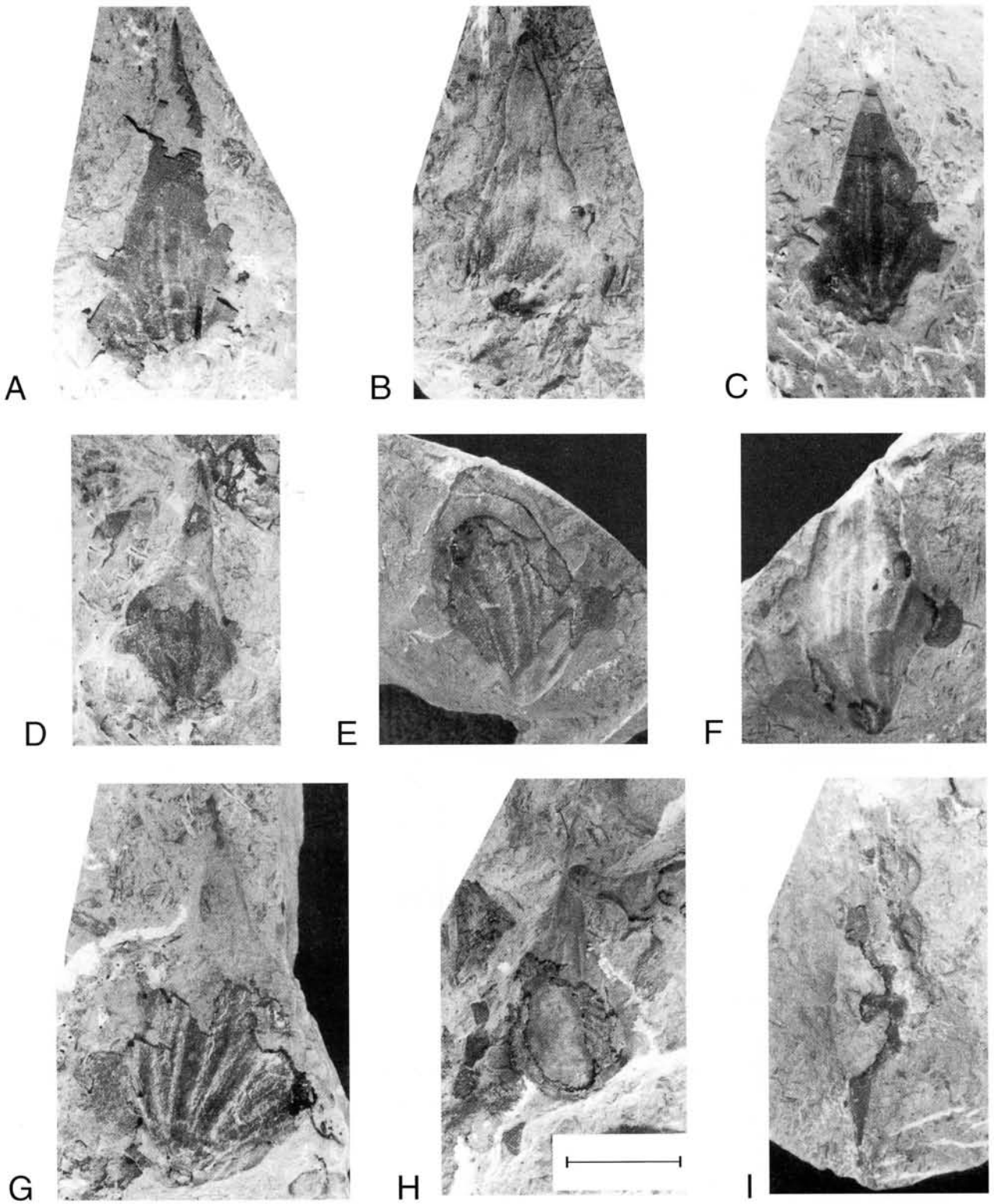

Fig. 4. Fossil fruits of *T. chengsenii* Wójcicki, Song & Wang, sp. nov. **A–I** paratypes (A–F, H, I in the Palaeobotanical Museum of the Institute of Botany, Chinese Academy of Sciences, Beijing, Nos. CBP–LH98-1k–r; G – in KRAM-P No. 232/2). E and F – part and counterpart. Scale bar 1 cm

fossil *Trapa* fruits collected from other sites (e.g. Imanishi & Hase 1972, Kovar 1979, Wójcicki & Bajzáth 1997, Wójcicki & Zastawniak 1998).

In gross morphology the fossil fruits collected from the Liang He coal mine do not resemble previously described species of *Trapa,* either fossils species (e.g. Puri 1948, Miki

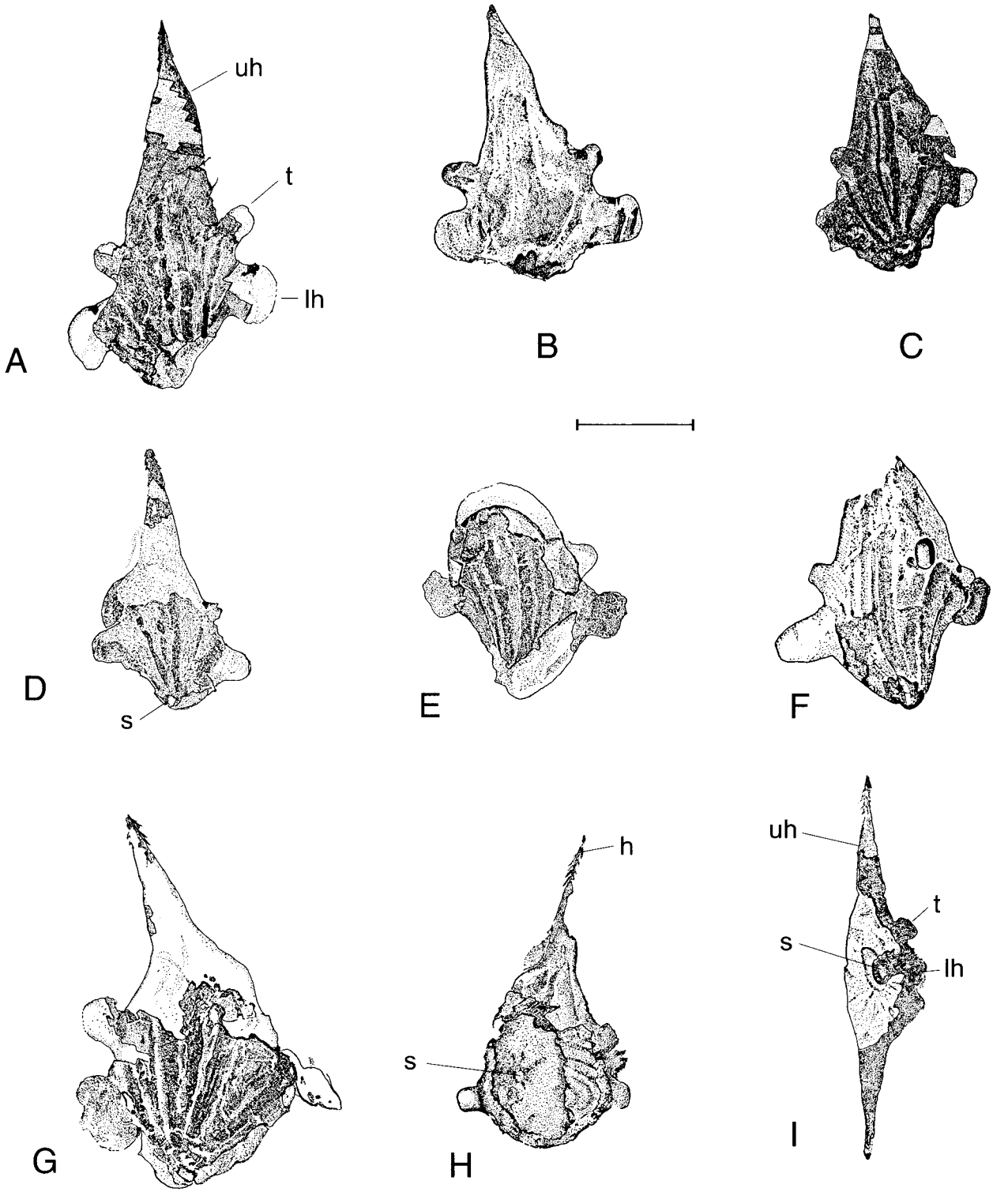

Fig. 5. Drawings of fossil fruits of *T. chengsenii* Wójcicki, Song & Wang, sp. nov. **A–I** see Fig. 4. h – harpoon, lh – lower horn, s – scar, t – tubercle, uh – upper horn. Scale bar 1 cm

1952b, Szafer 1954, Imanishi 1969, Imanishi & Hase 1972, Imanishi & Miyahara 1972, Kovar 1979, Suzuki 1980, Kadono 1987, Mai 1985, Kovar-Eder 1988), or extant species (e.g. Nakano 1914, Flerov 1926, Vassilev 1949, Janković 1958, Li & Chang 1977, Xiong et al. 1985). Slight similarity of *T. chengsenii* is to be found only with a few fossil and extant taxa (morphotypes) as described below.

The fruits of *T. chengsenii* are closest in

general morphology to the fossil fruits from the Mula Formation (Plio/Pleistocene) of Litang County, China, which have been determined as *Trapa* sp. (Chen et al. 1986). Similarities are observed especially in the general shape and size of the fruits as well as having relatively long spread or slightly upward pointing upper horns which are at least slightly subulate. However, several differences are present, allowing the two to be reliably separated from one another. Differences include the specimens of *Trapa chengsenii* having a comparatively longer and wider neck, possessing lower horns which are characteristically reduced, having comparatively large tubercles between the upper and lower horns. In addition to this, the specimens illustrated by Chen et al. (1986) have a small basal ring which is thick and well pronounced from the lower part of the fruit body. From the figures and brief comments given by Chen et al. (1986) it is, however, not clear whether the lower horns of these fruits are developed (it is mentioned in the text that some of the samples are 'bicornis' and other 'tetracornis', but the material figured is not specified properly). Original specimens from this investigation were not available during the course of the present study and this material clearly warrants detailed re-investigation.

Amongst other fossil members of the genus *Trapa*., *T. chengsenii* has shares certain similarities with the extinct 'bicornis' species *T. palibinii*, as described by Budantzev (1960) from the Tertiary deposits of the southern Baykal coast, Siberia. The fruit of this species possesses a relatively long body and it probably has pronounced tubercles between the upper and lower horns. However, distinction occur in the body of *T. palibinii* having fruits which are narrower, the neck is short to sub-sessile, and the lower horns are probably completely reduced.

In some respect the fruits of *T. chengsenii* bear resemblance to the fossil fruits described as *T. heeri* Fritsch, occurring in the Pannonian of Rohrbach, Austria, and documented by Kovar (1979). Similarity comes through the general shape of the body of fruit and is augmented by a characteristic finely ribbed and relatively long neck lacking a corona, and also the relative position of the lower horns.

In general morphology the newly described species compares well to the extant 'bicornis' taxon *T. bispinosa*, as originally defined by Roxburgh (1819) and described from the Coast of Coromandel, India (not from China as suggested by Nakano 1914). However, in the latter the neck is lacking or sub-sessile, the upper horns are thinner and spread horizontally while the lower horns are normally almost completely reduced.

T. chengsenii evidently presents an intermediate morphotype between 'bicornis' and 'tetracornis' morphotypes. This species fills a gap in the variation observed between the four-horn "*Trapa natans*-like" morphotype with a relatively long and narrow body of the fruit, and the squat 'bicornis' morphotype in which the lower horns are sometime completely reduced and possessing relatively short and wide bodied fruit. This 'bicornis' morphotype is characteristic of *T. bispinosa* Roxb., *T. japonica* Flerov and related taxa of more enigmatic status [e.g. *T. bicornis* Osb. var. *bispinosa* (Roxb.) T. Xiong and var. *taivanensis* (Nakai) T. Xiong, *T. litvinovii* V. Vassil., *T. pseudincisa* Nakai, *T. komarovii* V. Vassil., and *T. korshinskyi* V. Vassil.] which are confined to the Far East and India. The extinct species *T. chengsenii* contributes meaningfully to the distribution of these formerly discrete morphotypes, and forms a more complete picture of the evolutionary diversification of this important and interesting genus.

ACKNOWLEDGMENTS

We wish to express our thanks to Professor C.S. Li, Dr. S.J. Wang, Ms. Yu Tiao and Ms. L. Q. Chen for they valuable help during field work and collection of the material, and to Dr. Jason Hilton, (Cardiff, UK), for valuable suggestions and linguistic changes to the manuscript. Also, we thank Jacek Wieser MSc, Kraków, for his drawings. The first author is grateful to the Curators and Keepers of the herbaria B, BM, G, KRAM, LE, MW, PE, S, W, WH, WU for kindly allowing him to study comparative extant material in their collections and to Dr. Yasuro Kadono, Japan, and Dr. James G. Thiyagaraj, India, for kind donation of reference material from their countries. This work was supported in part by the State Committee for Scientific Research (grant 6 P04D 034 15) to the first author and by SFPPAS 9713 to the second.

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