

ON THE SYSTEMATIC POSITION OF *HEMITRAPA* AND SOME OTHER FOSSIL *TRAPA*

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GENERALLY speaking, the stems or leaves of aquatic plants, because of their flaccidity, are seldom preserved, while their nuts, being solid and durable, often remain fossilized. The observation of the existing *Ceratophyllum*, *Trapa* and *Trapella* shows that although they have quite different systematic positions, their nuts apparently resemble one another closely, with shapes like spindles or eggs and with single chambers and with spines or appendages. In the case of remains consisting chiefly of nuts, therefore, it is hardly possible to determine their systematic positions, unless their morphological aspects are fully examined and considered. The ancient plants of *Hemitrapa trapelloidea*, *Trapa borealis*, *Trapa Yokoyamae*, *Trapa sachalinensis* and *Trapa hokkaidoensis* have, thus, peculiarities different from those of *Trapa*, and although similarly shaped to *Trapella* of Gamopetalae in some respects, yet they can hardly be said to be of quite the same form. The conclusion, therefore, is that they all should be given the same systematic position as *Hemitrapa*, and that, together with *Trapella*, they should be included within the family of Trapellaceae. Particulars in this connection are as follows.

HEMITRAPA

In 1941, a lot of remains belonging to this genus were discovered, in the *Pinus trifolia* beds developed at Seto (Aichi Pref. in Japan) and Tajimi (Gifu Pref. in Japan) areas (TEXT-FIG. 1). Spindle-shaped, they closely resemble in appearance *Trapa borealis*, well known in the form of fossils, and yet are different from the same because there are brushes of inflected bristles on the elongated appendages of the receptacle as often seen on the horns of the nut of the existing *Trapa*. They are different, too, from *Trapella*, inasmuch as they each have a perigynous receptacle which is not placed above the ovary, along with another distinction, in that the appendages are not the secondary growths of the bract but the mere extensions of the

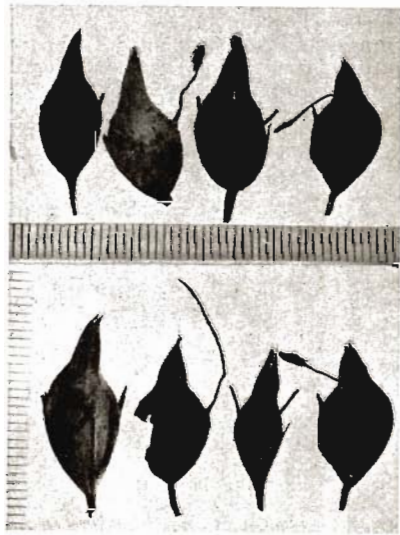
receptacle tips. Again, they can be distinguished from *Trapa* by the fact that in their case the receptacle is bowl-shaped with no horns, and that the brushy hairs are more slender, growing out of the top of the nut. Such being the case, there are no existing plants which are similar to them, for which reason the writer in 1941 referred them to a hitherto unknown genus of *Hemitrapa*.

Special Features—As compared with the existing *Trapa*, the remains of *Hemitrapa* show the following peculiarities (see TEXT-FIG. 2):

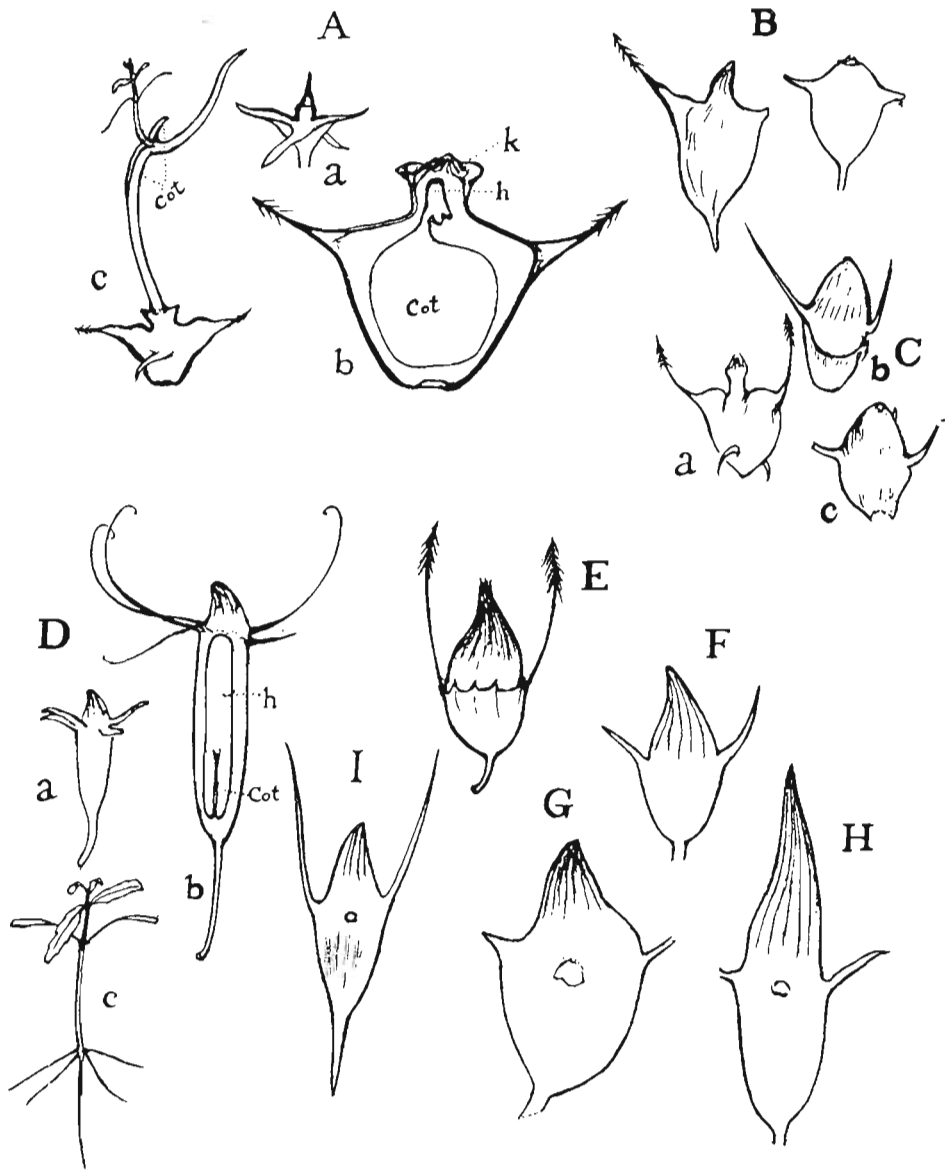
1. The part of the nut wrapped up by the receptacle is more or less of the same size as its uncovered top.

2. The brushy hairs on the top of the nut grow out of no apical crown of particular shape.

3. The appendages are in contrast to those of the existing *Trapa*, which have their right and left horns and front and rear ones



TEXT-FIG. 1 — *Hemitrapa trapelloidea* Miki (collected from Seto and Tajimi in Japan). Scales in mm.



TEXT-FIG. 2 — A, *Trapa*: a, young fruit; b, fruit showing inner structure of embryo (*cot.* cotyledon; *h*, stem part in embryo; *k*, apical crown); c, seedling. B, *Trapa silesiaca* Göpp. $\times \frac{2}{3}$ (after Menzel). C, remains of *Trapa incisa* S. & Z. $\times 1$; a, complete, b-c, incomplete, viewed from inverted direction. D, *Trapella antennifera* Glück: a, young fruit; b, fruit showing inner structure of the embryo $\times ca. 1$ (*h*, stem part in embryo, *cot.* cotyledon); c, seedling $\times \frac{1}{10}$. E, *Hemitrapa trapelloidea* Miki $\times 1$ (after Miki). F, *Hemitrapa borealis* Miki comb. n. (after Heer). G, *Hemitrapa yokoyamae* Miki comb. n. (after Nathorst). H, *Hemitrapa sacharinensis* Miki comb. n. (after Okutsu). I, *Hemitrapa hokkaidoensis* Miki comb. n. (after Okutsu).

grown on the same plane, and they are not fit for the protection of the nut.

4. The receptacle is bowl-shaped with peduncles, and the entire nut is somewhat spindle-shaped, curving somewhat like an arc.

As compared with *Trapella*, however, *Hemitrapa* has the following similarities:

1. Provided with peduncles, the entire nut is spindle-shaped but curves like an arc.

2. The nut has a well-developed receptacle, and the brushy hairs on its top grow out of no apical crown.

As stated above, the perianth is developed from the periphery of the nut, which, in comparison with *Trapa* whose perianth is placed lower, shows a more evolved form. Again, judging the embryo from the form of the nut, it can be concluded to be quite unlike that of *Trapa* which stores nourishment in a large cotyledon. This is fully proved by the fact that the part of the nut wrapped up by the receptacle is equal in size to its upper part in which the stem of embryo is contained. The conclusion, there-

former, and so on. This, therefore, makes it almost impossible to presume affinity between these two. But, as compared with *Trapella*, it has many peculiarities in common: the forms of the embryos, non-existence of apical crowns, possession of peduncles, curving of nuts, etc. For these reasons, it is clearly more appropriate to seek affinity with *Trapella* than with *Trapa*.

OTHER FOSSILS WITH SIMILAR PECULIARITIES

Of the fossils of spindle-shaped and somewhat curved nuts with peduncles and bowl-shaped receptacles, but with no particular apical crowns, the following four have hitherto been reported as belonging to the genus of *Trapa*: *Trapa borealis* Heer, *Trapa Yokoyamae* Nathorst, *Trapa sachalinensis* Okutsu and *Trapa hokkaidoensis* Okutsu. Their peculiarities, as compared with the genera of *Trapa*, *Hemitrapa* and *Trapella*, are shown in the following table:

TABLE 1

GENES AND SPECIES	APICAL CROWN	FORM OF EMBRYO, ESP. SIZE OF COTYLEDON AND STEM OF EMBRYO	FORM OF NUT	CURVING OF NUT	ANGLE FORMED BY APPENDAGES
<i>Trapa</i>	+	< Cot	Inverted egg	=	90°
<i>Trapella</i>	—	Stem >	Spindle	+	90°
<i>Hemitrapa</i>	—	=	Spindle	+	30°-40°
<i>Trapa borealis</i>	—	=	Spindle	+	30°-40°
<i>Trapa Yokoyamae</i>	—	=	Expanded egg	+	60°
<i>Trapa sachalinensis</i>	—	=	Spindle	+	50°
<i>Trapa hokkaidoensis</i>	—	=	Spindle	+	40°

fore, is that, just as in the case of *Trapella*, the form of the nut is a good reflection of a well-developed stem of the embryo. It is also noticeable that the nut of *Hemitrapa* seems to have matured with its upper part down after post-floral movement, as is often seen in many aquatic plants and those belonging to Solanaceae.

Habitat—The nut of *Hemitrapa* consists of a single chamber which does not split open. Its coat is about 1 mm. thick with no particular protection. Besides, the stem of its embryo is rather thick. All these things being the peculiarities of the aquatic plants in general, it is clear that *Hemitrapa* belongs to one of them.

Affinities—There are points of distinction between *Hemitrapa* and *Trapa*; for instance, the forms of the embryos, position of perianth, non-existence of apical crown in the

As shown above, these fossils come very near to *Trapella* and *Hemitrapa* in regard to their growth of hairs, the form and curves of the nuts and the morphological aspects of the embryos. It is true that appearances alone are not sufficient to allow us to determine whether their appendages such as spine and horns are the mere extensions of receptacles, as in the case of *Hemitrapa*, or the secondary growth of bracts as *Trapella*, but the former presumption is not impossible, because appendages do not form a right angle in each case. Thus, they have very little in common with *Trapa*, and resemble *Trapella* and *Hemitrapa* far more closely. Especially, they come nearer to *Hemitrapa* than to *Trapella* with regard to the position of their perianths, forms of their appendages and so forth. Hence, the appropriateness of classifying them as belonging to *Hemitrapa*.

Hemitrapa borealis Miki comb. n. Fig. 2 F
Syn. *Trapa borealis* Heer (1869) Taf. 8, f. 9-11
(except 11)

Nut ovate: 28 mm. high, 10 mm. wide, appendages 2.

At a glance the remains seem as deformed *Trapa incisa* S. & Z. which is inverted, as shown in Fig. 2 C (b, c), but it differs in the existence of a well-developed brushy haired part and by having peduncles, which characteristics correspond to those of *Hemitrapa*.

The species differs from *Hemitrapa trapelloidea* by having fewer robust appendages.

Hemitrapa Yokoyamae Miki comb. n. Fig. 2 G
Syn. *Trapa Yokoyamae* Nathorst (1888) Taf. 7, f. 6-8

Nut broadly ovate: 30-40 mm. high, 20 mm. wide, curved, appendages 4.

Nut differs from *Trapa* by being curved with a well-developed brushy haired part and delicate appendages.

The species may be distinguished from other species by large broad nuts.

Hemitrapa sachalinensis Miki comb. n. Fig. 2 H
Syn. *Trapa sachalinensis* Okutsu (1939) Geol. Soc. Japan 46, 328, Fig. 1

Nut longer spindle: 50-60 mm. high, 12-15 mm. broad, appendages 4.

The species may be distinguished from other species by longer nuts.

Hemitrapa hokkaidoensis Miki comb. n. Fig. 2 I
Syn. *Trapa hokkaidoensis* Okutsu (1939) Geol. Soc. Japan 46, 329, Fig. 2

Nut 45 mm. long, 10 mm. wide, appendages 4.

The nut seems as if it were a form of *Hemitrapa trapelloidea* (FIG. 1) or *Trapa silesiaca* Göpp. (FIG. 2 B) but it differs from the former by four appendages and from the latter by a well-developed apical brushy haired part, though without any apical crown.

Keys regarding *Hemitrapa*:

1. Nut with thread-like appendages
 - (a) Appendages 4, incomplete regarding terminal parts — *H. hokkaidoensis*
 - (b) Appendages numerous, the longer ones of which have brushes of inflected bristles on the top — *H. trapelloidea*
2. Nut with somewhat robust appendages
 - (a) Nut broadly ovate, 20 mm. wide — *H. Yokoyamae*

- (b) Nut spindle shaped, 10 mm. wide
 - (i) Appendages long — *H. hokkaidoensis*
 - (ii) Appendages short — *H. borealis*

DISTRIBUTION

The remains of *Hemitrapa* have been found in the early Tertiary strata of America and Asia but not in Europe (GAMS, 1927). As pointed out by Kryshstofovich, this is probably due to the fact that the temperate parts of Asia have a climate quite different from that of Europe. It is to be presumed, therefore, that this small aquatic plant did not grow in the aforesaid regions of Europe.

SYSTEMATIC POSITION

Hemitrapa has a close relation to *Trapella* as stated above. *Trapella* was classified as belonging to the family of Pedaliaceae, but in the case of Pedaliaceae there are no instances of well-developed receptacles and nut which matures upside down, besides the distinction regarding ovaries which are single chambered and placed lower. Again, as compared with the family of Acanthaceae which have closely resembling flowers and well-developed receptacles, and which in many cases grow in water or marshy places, distinctions can be noticed with respect to the absence of crystalloids, forms of pollen and methods of seed discharge. Like *Trapella* and *Hemitrapa*, *Solanum* has its fruit grown upside down, but the distinction is that it has symmetrical flowers and fewer seeds.

Thus, the existence of plentiful remains of ancient plants resembling *Trapella* proves that many such plants used to grow in abundance in remote ages. And from the viewpoint of palaeobotany, the writer deems that there are valid reasons for establishing a new family of Trapellaceae (this is also the opinion of Dr. Honda) instead of including them in the family of Pedaliaceae as Oliver does.

SUMMARY

1. *Hemitrapa* has peduncles, bowl-shaped receptacles and inconspicuous horns with no apical crown on the top of its spindle-shaped receptacles — peculiarities which *Trapella* shares but which *Trapa* does not. Yet, it is different from *Trapella*, too. There are such

remarkable distinctions as are seen in the possession of receptacles growing directly from the periphery of the nut and of appendages of mixed length, the longer ones of which are provided with brushes of inflected bristles; hence the appropriateness of establishing a new genus.

2. The four species of *Trapa borealis*, *Trapa Yokoyamae*, *Trapa sachalinensis* and *Trapa hokkaidoensis* have also nuts, of either spindle or expanded-egg shapes and with

no apical crowns; besides, they have their right and left appendages and front and rear ones grown on the same plane. These being the peculiarities of *Hemitrapa*, the writer re-classifies them as belonging to *Hemitrapa*.

3. Both *Trapella* and *Hemitrapa* belong to Trapellaceae because there existed many extinct plants with many common characteristics not corresponding to those of Pedalaceae and Acanthaceae.

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