FOSSIL FRUITS OF *TRAPA* AND REMAINS OF OTHER FRESH-WATER PLANTS FROM THE PLEISTOCENE OF KASHMIR*

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THE aquatic element in the Karewa flora comprises leaf fragments of *Nelumbo nucifera* (Puri, 1950), fruits of *Trapa*, fragments of *Ceratophyllum*, *Myriophyllum*, *Naias*, *Typha*, *Sparganium* and bits of leaves comparable to grasses, reeds and sedges. Wodehouse (1935) has recorded pollen grains of the Gramineæ (genus not determined) from some shales collected by De Terra from the region.

Remains of *Trapa* and fragments of leaves comparable to *Typha* and *Sparganium* have been found from almost all the localities. The other aquatic plants recorded seem to have had restricted distribution in the past and have been collected only from one or two localities.

Trapa Linn.

Well preserved fruits of two species of *Trapa* are found in thousands in the Karewa beds in all localities except Liddarmarg. Prof. Sahni collected several blocks of rocks from Botapathri in the Ningal valley at 9,500 ft., out of which he figures two fruits and a small spine with barbs (Sahni, 1938). The author has also figured three fruits from his own collections (Puri, 1947). It is interesting to note that up till now only detached fruits have been found, and in spite of careful search in the field I have not succeeded in finding any fruit in organic connection with stem or leaves.

In addition to fruits, spicular ends of long spines have been found in small pieces, lying broken and detached near fruits. In some specimens (Figs. 3 and 4) these occur in organic connection with fruits.

Fruit of *Trapa* is a characteristic large bony nut of obovoid or compressed turbinate shape, having two or four angles, bearing long spines. The number of angles and spines distinguish the different species.

Fruits with 4 angles bearing spines..... ..... *T. natans.*

Fruits with 2 angles bearing spines..... .....*T. bispinosa.*

* Contribution from the Birbal Sahni Institute of Palæobotany, Lucknow. The author wishes to record grateful acknowledgement of kind help received from the late Prof. Birbal Sahni in the preparation of the first draft of this paper.

Trapa natans Linn.

(Figs. 2–4)

Fossil fruits photographed here are rhomboidal in shape, with an average size of $1{\cdot}3'' \times 1{\cdot}6''$. They are four angled; the angles being ovate in shape with sharply pointed apices, each carrying a spine. These spines bear at their ends a number of barbs which are downwardly directed (Figs. 3 and 4) and being delicate are not preserved in all cases. Several barbed spines occur detached in clays along with fruits (Fig. 5). The number of the barbs on a spicular end varies from 6 to 7. These are broken in complete fruits but in detached specimens barbs are intact and well preserved. In the centre of the fruit there is a circular scar which probably represents the point of attachment of the fruit to the stalk. The size of this scar is about $0{\cdot}3'' \times 0{\cdot}3''$. A small aperture, which probably is the scar of the vascular supply of the fruit, is present in the centre of this circular area (Fig. 3).

Occurrence .. *Laredura* at 6,000 ft.,
Dangarpur at 6,300 ft.,
Nagbal at 6,500 ft.,
Botapathri at 9,500 ft., and
Gogajipathri at 8,800 ft.

Number of specimens .. Several thousands.

Collections .. Type specimens and others are preserved in the Birbal Sahni Institute of Palæobotany, Lucknow.

Fossil fruits generally resemble modern fruits of *Trapa natans* Linn. in all details except in breadth, which according to Hooker (1879) is $\frac{3}{4}''$ only in modern fruits. I have seen fruits of this species larger than the fossils and there seems little doubt that fossils belong to *Trapa natans*. Hooker's description was probably based on fruits in connection with stem, which are usually smaller than full grown detached fruits.

Trapa bispinosa Roxb.

(Figs. 1 and 6–9)

Fruits are obovoid in shape, with lower ends more or less convex or slightly flat. These are two angled, both angles bearing spines. The position of the spines may slightly vary in different specimens. The variety of shapes exhibited by fossils may be due to differential pressure to which fruits were subjected at the time of fossilisation. In the centre of the flat upper line there is a raised area (Figs. 7–9) which may be probably the stigmatic disc.

Occurrence .. Laredura at 6,000 ft.,
Dangarpur at 6,300 ft.,
Nagbal at 6,500 ft.,
Botapathri at 9,500 ft., and
Gogajipathri at 8,800 ft.

Number of specimens .. Several thousands.

Collections .. Type specimens L. 868 and L. 869 figured in Photos 7 and 8 are from my own collections, which are deposited at the Botany Museum of the Khalsa College, Amritsar. Other specimens are preserved in the Birbal Sahni Institute of Palæobotany, Lucknow.

The big block in Photograph 1 was collected by Prof. Sahni and is preserved at Lucknow.

The specimens agree with modern fruits of *Trapa bispinosa* Roxb. (Fig. 9) in shape, 2 angles and general appearance.

Modern Distribution of *Trapa*

There are 3 modern species, *T. natans*, *T. bispinosa* and *T. bicornis*, which are confined to the continents of Europe and Asia. Of these *Trapa natans* has a scattered distribution in the Northern Hemisphere, occurring in fresh water lakes and ponds of France, Switzerland, Italy, Hungary, Austria, Central Europe, Macedonia, Russia, North Persia, Chinese Turkestan, Java, etc. It has now also become naturalized in New England and New York in the U.S.A. It is generally believed that the distribution area of this species is contracting since the Post-glacial times as is evidenced by its past and present distribution in the countries of Europe.*

In India, it occurs commonly in large or small bodies of fresh water up to the altitude of 5,500 ft. It has not been seen above the elevation of 5,200 ft. in the Kashmir Valley. *Trapa bispinosa* is distributed in south-eastern and southern Asia. This species is less common in Kashmir lakes than *Trapa natans*.

Past Distribution of the Genus *Trapa*

The earliest known records of *Trapa* are from the Cretaceous of North America, from where Berry (1914) reports two species, *Trapa microphylla* Lesq. and *Trapa*? *cuneata* Knowlt.

Several species of fruits have been described from the Eocene. Of these Brown and Houldsworth (1939) describe *T.*? *microphylla* Lesq. from Burns Ranch, Montana, Canada. In a review of the fossil flora of Alaska, Knowlton (1894) records fruits of *Trapa borealis* Heer from Port Graham. From the Eocene rocks of Monte Bolca in Italy Goppert (1857) records *Trapa arethusæ* Ung. *Trapa protonatans* Endo was described from the Upper Eocene Formations of South Manchuria by Endo (1934). Berry (1914) states that "the oldest recognisable fruits are a large bicornute form from the Eocene of Canada and Alaska and *Trapa wilcoxensis* Berry found in the Wilcxo flora."

* On my continental tour in 1948 I discussed the question with Prof. C. Malmstroem and Dr. O. H. Selling of Sweden, who showed me much evidence produced in Sweden that agrees with the general statement made here. I take this opportunity to thank them for their kind hospitality and ungrudging help in various ways to make my tour successful.

From the Oligocene of Saxony *Trapa credneri* has been described by Schenk.

Five species are reported from the Miocene, of which *Trapa americana* Knowlt. was described by Brown (1937) from North America. *T. silesiaca* Gopp. and *T. teumeri* Menzel were described by Gothan and Sapper from Miocene rocks of Niederlausitz. Kryshtofovich (1920) recorded *Trapa yokoyamai* Nathorst from the postmiocene of Kayakusa, Japan.

Trapa prenatans Dorf. is known from the Pliocene deposits of America (Dorf, 1936). This species is closely allied to modern *T. natans*, which at the present time does not occur in America except in cultivation.

The Pleistocene records of the genus are numerous. *Trapa incisa* S. et. Z. was described by Miki (1927) from Stegodon beds near Higashiei, Japan. He also records *Trapa macropoda* Miki and *T. bicerata* Miki from the Pleistocene deposits of this country.

Principi (1938) records *Trapa natans* from the glacial and postglacial deposits of Scandinavia, British Islands, Germany, Holland, France and Russia. Another species *T. muzzanensis* is recorded by the same author from Russia.

In the Interglacial and Postglacial deposits of Europe *Trapa natans* has been recorded from many countries. This species seems to have flourished at very high latitudes during the Preglacial times and its absence from these regions today has been variously interpreted. All, however, tend to emphasise on changes in the climate since the Pleistocene to explain this.

Trapa together with lilies, *Typha, Myriophyllum, Ceratophyllum* described in the following pages forms a shallow water community in the Dal and Wular lakes today. In these lakes organic matter of the mud seems to be very high, while in lakes at higher altitudes in which these plants are not present today the lake bottom seems to contain scanty organic matter. This may be one of the reasons for the absence of *Trapa, Typha* and other plants in lakes situated at altitudes higher than 5,200 ft. in the valley. Pearsall (1921) and Misra (1938) have clearly demonstrated correlation between the amount of organic matter in lake mud and the distribution and succession of aquatic communities both in shallow and deep waters and an association like the one found from the Karewas thrives in English lakes today in highly organic muds.

Typha or Sparganium

(Figs. 10–12)

Elongated fragments of leaves represented in photographs 10–12, show parallel venation. It is extremely difficult to assign such specimens to any genus with certainty and these have therefore, been identified provisionally.

Occurrence	..	Laredura, 6,000 ft., Dangarpur, 6,500 ft., Gogajipathri, 8,800 ft., Ningal Nullah, 9,000 ft., Liddarmarg, 10,600 ft.
Number of specimens	..	More than 50.
Collections	..	The specimens form a part of my own collections and are preserved in the Birbal Sahni Institute of Palæobotany, Lucknow.

Modern species of *Typha* and *Sparganium* are found in Kashmir lakes at or below the altitude of 5,200 ft. They are also found along fresh water ponds, lakes and marshy places throughout India.

The fossil history of these genera is doubtful, although many specimens from the Tertiary and Pleistocene deposits of the Northern Hemisphere are known.

RANUNCULACEÆ

This family has a very scanty representation in the Karewa floras both as regards the number of specimens as well as the genera and

FIG. 24

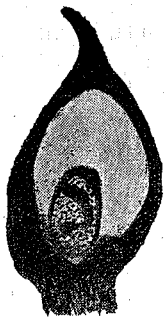

FIG. 25

FIG. 24. Fossil achenial fruit of *Clematis* shown in Photo 22.
FIG. 25. Fossil achene of *Ranunculus* shown in Photo 23.

species belonging to it. Two specimens of achenial fruits belonging to two different genera are the only finds in the entire collection.

Ranunculus

(Figs. 23 and 24)

The specimen measures 0·3″ in length and is 0·16″ broad in the middle. It has an ovate shape with a small style and a beaked stigma. The skin of the ovary is not preserved, but a small central mass, which in all probability may be a small ovule is left near the base of the ovary. This ovule-shaped body is 0·1″ long and seems to be attached at the base of the ovary. Style and stigma attain a length of 0·08″. The style is straight and ends in a small curved beaked stigma.

Occurrence	..	Laredura at 6,000 ft.,
Number of specimens	..	Only one.
Type Specimen	..	L. 290.
Collection	..	The specimen belongs to Dr. Stewart's collection of 1935, and is preserved in the Botany Museum of the Gordon College, Rawalpindi.

The specimen compares favourably in size, shape, and general appearance with achenial fruits of *Ranunculus*, but further identification of the species is not possible.

Clematis Sp.

(Figs. 21, 22 and 25)

The specimen described here is again an achenial fruit, measuring about 1·1″ in length. It consists of a small fruit with a persistent feathery style. The ovary is more or less oblong in shape. It is smooth, measuring 0·29″ in length. A bit of the black organic matter was scratched with a neelde to study it for cuticular details, but it did not yield any results. The ovary at its top passes into a long, fairly thick feathery style, measuring about 0·9″.

Occurrence	..	Laredura at 6,000 ft.
Number of specimens	..	One only.
Type specimen	..	L. 181.
Collection	..	The specimen is included in Dr. Stewarts collection and is preserved in the Botany Museum of the Gordon College, Rawalpindi.

The specimen from its characteristic shape resembles the achenial fruit of *Clematis*. It is difficult to determine the species from such a single, detached and rather badly preserved specimen. It may, however, be mentioned that several species of *Clematis*, e.g., *Clematis montana* Buch-Ham., *C. gouriana* Roxb. and *C. grata* Wall. grow today in Kashmir in the vicinity of the lake.

CERATOPHYLLACEÆ

This family of herbaceous water plants is represented in the Karewa flora by a number of specimens that favourably compare in general appearance with branches and leaves of *Ceratophyllum* (Figs. 16–19).

The specimens are bits of leaves lying scattered in the fashion of a narrow ribbon-like thallus. One specimen (Fig. 18) consists of long branched filaments which run close to one another and seem to diverge from a basal point. These flat ribbons are somewhat narrower than in the other two specimens and may not be of the same species.

A piece of fresh *Ceratophyllum demersum* when left in a watch glass for a week in laboratory dried and assumed appearance comparable to fossils (Fig. 19).

Occurrence	..	Laredura at 6,000 ft., and Dangarpur at 6,300 ft.
Number of specimens	..	Ten.
Type specimen	..	Loc. 1 D. 45; L158.
Collections	..	The type specimen L. 158 is from Dr. Stewart's collection and is preserved in the Botany Museum of Gordon College, Rawalpindi. Specimen No. Loc. 1. D. 45. comes from De Terra's collection of 1932 and is preserved in the Botany Museum of Lucknow University.

The specimens have been compared provisionally with *Ceratophyllum demersum* L. This species at present grows throughout India in fresh water lakes and other bodies of still water. It flourishes in the Dal, Wullar and Manasbal lakes at an altitude of 5,200 ft. in the Kashmir Valley.

HOLARRHAGACEÆ

This family is represented in the Karewa floras by a few bits of branches bearing leaves, which have been provisionally identified as belonging to the genus *Myriophyllum*. The fossil specimens do not show any surface features, which could be employed for comparison with living species of *Myriophyllum*, but on account of a great similarity in form and in the absence of any other better identification, the specimens are provisionally identified and described here as *Myriophyllum* sp. (Figs. 13–15, and 20).

The specimens show a central axis, bearing elongated leaf-like structures, that compare favourably with modern species of *Myriophyllum*. Several of them are found in Kashmir Lakes and fresh water lakes and ponds throughout India. Fossil records of these are known from the Tertiary and Pleistocene rocks of America, Europe and Asia, but on account of the uncertainty with which these have been identified I am not inclined to give more details of their fossil distribution.

SUMMARY

Fossil fruits of two species of *Trapa* and remains of *Ceratophyllum, Myriophyllum, Typha, Sparganium, Clematis* and *Ranunculus* are figured and described from the Karewa deposits of Kashmir. Modern and past distribution of these, so far known, is given and it is stated that distribution of *Trapa* is now restricting itself in Europe. Remains of a few species of this genus are recorded from the Tertiary rocks of America, where it no longer occurs today.

The significance of the occurrence of water plants in the Karewa flora has already been discussed (Puri, 1943, 1947, 1950) and it may be stated that they support the idea of the Pleistocene uplift of the Himalayas and indicate the extent to which the Karewa lake occupied the Kashmir Valley during the Pleistocene.

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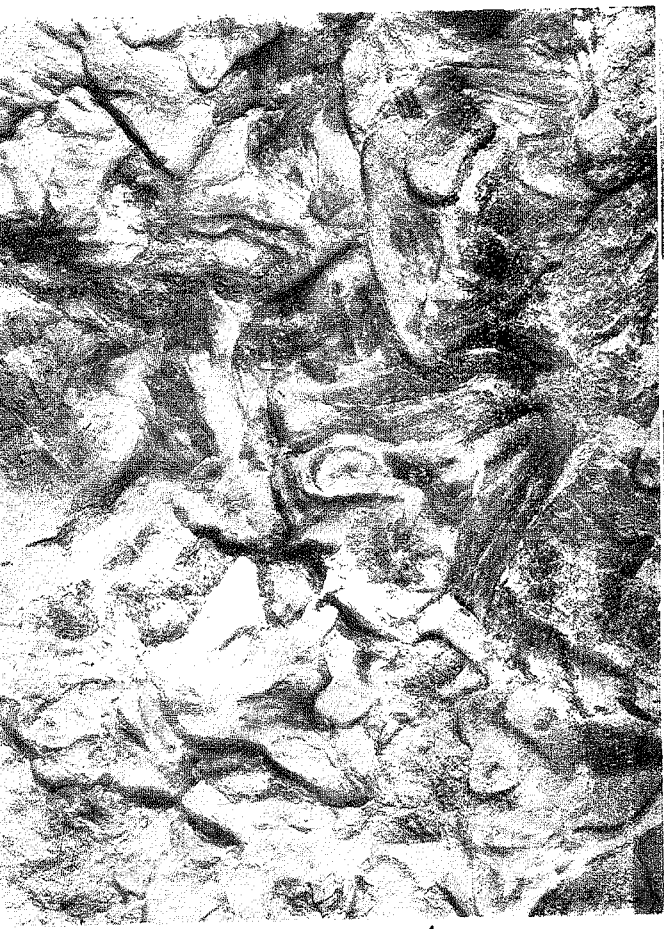

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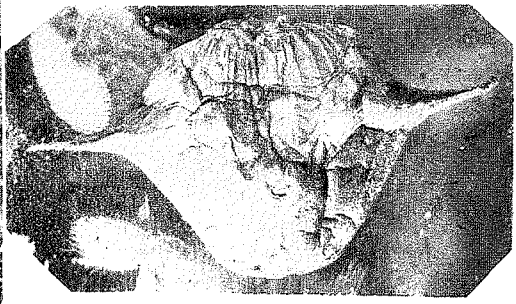

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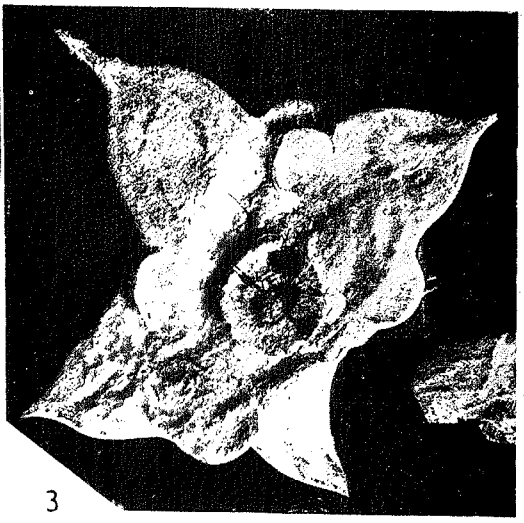
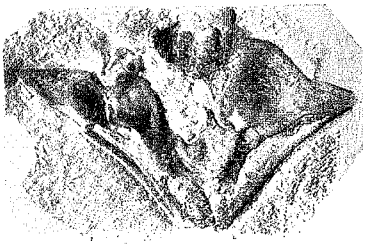


3

×Ca. 1½

6



8

×Ca. 3

4 7

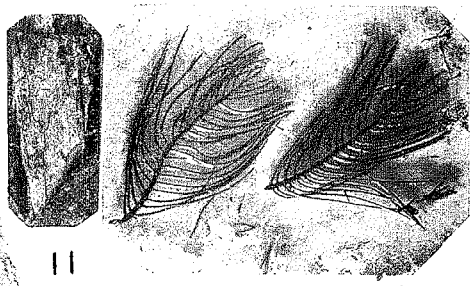
10

19

16

23 x Ca.5

13



11

20

14 x Ca.5

12

15

22
x Ca.5

18

17

21

EXPLANATION TO PLATES

PLATE VII

FIG. 1. Block of clay with impressions of fruits of *Trapa*, Sahni collection, Dangarpur, Kashmir.

FIG. 2. Fossil fruit of *Trapa natans*, Puri collection, Laredura, Kashmir.

FIG. 3. Fossil fruit of *Trapa natans*, Puri collection, Dangarpur, Kashmir.

FIG. 4. Fossil fruit of *Trapa natans*, Puri collection, Dangarpur, Kashmir.

FIG. 5. Detached barbed spines of fruit of *Trapa*, Puri collection, Laredura, Kashmir.

FIG. 6. Fossil fruits of *Trapa bispinosa*, Puri collection, Botapathri, Kashmir.

FIG. 7. Fossil fruit of *Trapa bispinosa*, Puri collection, Laredura, Kashmir.

FIG. 8. Fossil fruit of *Trapa bispinosa*, Puri collection, Laredura, Kashmir.

FIG. 9. Living fruit of *Trapa bispinosa*, from a pond in Lucknow.

FIG. 10. Leaf fragment, *Typha* or *Sparganium*, De Terra collection, Liddarmarg, Kashmir.

PLATE VIII

FIG. 11. Leaf fragment, *Typha* or *Sparganium*, Sahni collection, Dangarpur, Kashmir.

FIG. 12. Leaf fragment, *Typha* or *Sparganium*, Stewart collection, Ningal Nulla, Kashmir.

FIG. 13. A bit of stem with leaves of *Myriophyllum* sp., Stewart collection, Laredura, Kashmir.

FIG. 14. A bit of stem with leaves of *Myriophyllum* sp., Stewart collection, Laredura, Kashmir.

FIG. 15. A bit of stem with leaves of *Myriophyllum* sp. Puri collection, Laredura, Kashmir.

FIG. 16. Fossil leaf fragments of *Ceratophyllum* sp., De Terra collection, Liddarmarg, Kashmir.

FIG. 17. Fossil leaf fragments of *Ceratophyllum* sp., Stewart collection, Laredura, Kashmir.

FIG. 18. Fossil leaf fragments of *Ceratophyllum* sp., Stewart collection, Dangarpur, Kashmir.

FIG. 19. Living leaf fragment of *Ceratophyllum demersum*, from Lucknow University Botanical Gardens.

FIG. 20. A bit of stem with leaves of living *Myriophyllum* sp. from Lucknow University, Botanical Gardens.

FIG. 21. Fossil achenial fruit of *Clematis*, Stewart collection, Laredura, Kashmir.

FIG. 22. Fossil achenical fruit of *Clematis* enlarged to show feathery style.

FIG. 23. Fossil achene of *Ranunculus* sp., Stewart collection, Laredura, Kashmir.