TERTIARY PLANTS FROM NORTH AMERICA

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1. A *NIPA* FRUIT FROM THE EOCENE OF TEXAS

BECAUSE of the limited range of palms of the genus *Nipa* in the recent epoch, any occurrence of them in the fossil state in the western hemisphere is of interest to students of ancient floras. At present *Nipa* occurs only in the East Indies and adjacent lands, but its former occurrence in northern latitudes is attested by discoveries in Eocene rocks of Europe and northern Africa. In the London Clay Flora *Nipa* fruits are the most common fossils (REID & CHANDLER, 1933). During the middle part of the Eocene epoch, the plant apparently thrived along the shores of the ancient Tethys Sea that extended over parts of northern Africa, southern Europe, and south-eastern Asia during Eocene and Oligocene times.

Nipa was first mentioned in North America by Berry who in 1914 described a supposed fruit from the Wilcox group of Mississippi. Two years later (1916) he described an additional specimen from an unrecorded locality in Tennessee. Then Ball (1931) listed without description or figures a *Nipa* from the Fayette formation of Texas. Reid and Chandler have questioned the identity of the specimens figured by Berry on grounds that the photographs fail to reveal the characteristic angularity of the fruits, and they conclude that the occurrence of Nipas in North America lacks proof. These doubts are justified on the basis of the evidence heretofore available, but the specimen recently found in Texas and described in the following paragraphs shows the essential features of a detached *Nipa* fruit and demonstrates the existence of the genus in the North American Eocene. Along with the necessary angularity, our specimen shows the terminal umbo and the striated surface. Furthermore, the late Prof. B. Sahni examined the specimen and positively identified it as a *Nipa* fruit.

The specimen, shown here on Plate 1, Fig. 7, was found by Mr. W. E. Humphrey in the Weches greensand of the Claiborne group of the Middle Eocene of Texas. The locality, a well-known one for fossil marine organisms, is along the Colorado river, one-half mile upstream from the highway bridge at Smithville, in Bastrop County. The Weches greensand is a marine deposit that is generally devoid of plants, and the discovery in it of any kind of land vegetation was unexpected. However, in its natural habitat today, *Nipa* grows along tidewater, so the presence of the fruits in marine deposits is easy to explain. *Nipa* fruits can be carried far by ocean currents, so it is impossible to guess where the specimen under consideration might have grown. The possibilities are that it grew somewhere along the ancient Mississippi embayment, because preservation seems to be too complete for it to have been transported a distance equal to the present width of the Atlantic Ocean, or even more than a few hundred miles.

The fruit from *Texas* has been obliquely flattened at an angle of about 45 degrees from the vertical. Before flattening, the empty space in the interior had become filled with glauconitic sand which prevented complete collapse. As preserved it is 4·5 cm. thick and 10 by 11 cm. in lateral dimensions. Three well-defined ridges delimit surface facets and converge toward the apex where there is a distinct umbo. Two of the ridges form a nearly straight line across the top surface, and the third divides one of the halves thus produced into two angles of about 60 and 120 degrees each. On living *Nipa* fruits, the number of ridges varies from two to six, depending upon size of the individual and its position within the cluster. The basal part of the specimen is not well preserved and the overall length has been altered by flattening. Apparently it was originally about 9 cm. long and 6 or 8 cm. broad. In size and form it is close to some of the fruits from Belgium figured by Seward and Arber (1903). The coarse striations on the top surface converge toward the umbo. These result from the fibrous composition of the husk.

The umbo shows some peculiarities that are believed to have resulted from pressure on the tissues. It stands out as a short, blunt stalk that, before the specimen was identified, was thought to be an attachment stalk. It is about 3 mm. high, and its nearly flat surface measures about 10 by 16 mm. The three surface ribs flatten out at about 6 mm. from the umbo, and in the intervening space there is a shallow encircling crease that accentuates the prominence of the umbo. This crease is obviously due to the warping of the tissues immediately around the umbo during flattening. The surface of the crease shows no marks that could be interpreted as trace bundles, or other scars that would inevitably be present were the umbo an attachment stalk, and the crease the place of attachment of bracts or other organs.

Having no abscission layers, *Nipa* fruits break away from the clusters with ragged bases. Structural details of the base of the fossil specimen are not clear, but on the rounded surface where the fibrous outer husk does not overlap the inner part completely, there is a large slightly protruding body which may be the seed or a sand-filled cast of the seed cavity.

Most fossil fruits resembling those of the living *Nipa* palm are assigned to *Nipadites burtini*. The specific name was coined by Brongniart. Because such fruits show no, or at most few, characters whereby species may be differentiated, this name was used by Seward and Arber for the Belgian fruits, and was retained by Reid and Chandler for all of the specimens from the London Clay. Kräusel (1923) described *Nipadites borneensis* from the Eocene of central Borneo, which closely resembles *N. burtini*. The Texas specimen, however, is referred to Brongniart's species.

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2. FOSSIL CAPSULE VALVES OF *KOELREUTERIA* FROM THE JOHN DAY SERIES OF OREGON

Several genera of plants that at present are restricted to eastern Asia are known to have extended into North America during the Tertiary period. Some of these are *Ginkgo*, *Metasequoia*, *Cercidiphyllum*, and *Ailanthus*, all of which will still thrive in North America if transplanted into regions where the rainfall is adequate and the winter temperatures are not too low. *Koelreuteria* (Sapindaceae) is another eastern Asiatic genus of which fossil remains have been found in Alaska and Colorado (HOLLICK, 1936; EDWARDS, 1927; BROWN, 1934). Until recently it had not been found elsewhere in the American Tertiary, so its discovery in Oregon in association with other oriental genera is a matter of some interest.

The capsule valves under consideration were found during the summer of 1949 in a road cut in the extreme western edge of Section 21, Range 20 E, Township 7 S, Wheeler County. The place is less than a quarter of a mile west of the ranchhouse of the Knox Ranch. The fossiliferous rock at this place is a light-grey, thinly laminated shale that weathers to a cream colour, and consists mainly of reworked water-deposited volcanic ash. The plant bed lies several hundred feet above the Clarno formation of Eocene age but below the main part of the Columbia basalt. It is, therefore, in the

John Day series, and hence Oligocene. Although it appears to be in the upper part of the John Day, the section was not measured and the position was not determined with precision. Although plant remains are fairly abundant at this locality, they are not as numerous as at places in the Clarno.

Only a small collection of plants was made but it is sufficient to indicate approximate contemporaneity with the Bridge Creek flora (KNOWLTON, 1902; CHANEY, 1925, 1927). The following have been identified:

Metasequoia sp. (cf. *M. langsdorfii* or *M. heerii*). Leafy branchlets and seeds. This is the most abundant plant at this locality.

Pinus sp. Seed resembling living *P. monticola.*

Pinus sp. Seed resembling living *P. contorta.*

Cercidiphyllum crenatum (Unger) Brown. Foliage.

Prunus sp. Small fruit.

Koelreuteria oregonensis sp. nov. Capsule valves.

Carpinus grandis Unger. Foliage.

Alnus carpinoides Lesq. Foliage.

Betula heteromorpha Knowl. Foliage.

Populus? sp. Foliage.

Fish fragments.

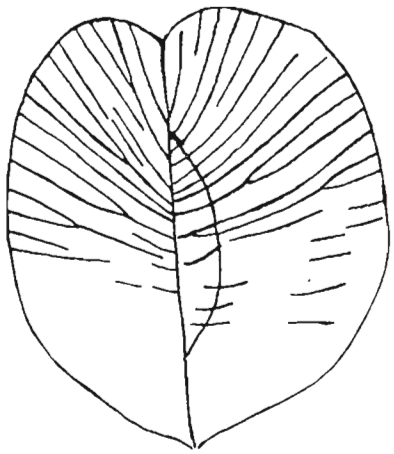
The assortment of capsule valves consists of five specimens. Two of these are counterparts of one valve (PLATE 1, FIGS. 1, 3) and the others are single halves. One is complete (PLATE 1, FIG. 2) and shows the whole margin. In shape the valves vary from nearly circular to broadly oval, and measure about 25 mm. in the longest dimension. When first found, these objects were mistaken for *Ptelea* samaras, objects that are fairly common in the western Tertiary. However, close inspection showed their obvious resemblance to the capsule valves of *Koelreuteria.*

The *Koelreuteria* fruit is a capsule made up of three thin, nearly membranaceous valves. The valves separate completely upon dehiscence, but remain attached for some time at the apex of the flower stalk. In *K. integrifolia* and *K. bipinnata* the individual valves are circular or broadly ovate and rounded basally and apically, but in *K. paniculata* they are obcuneate. Hu and Chaney (1940, PLATE 38, FIG. 2) figure a specimen of *K. integrifolia* in the herbarium of the Fan Memorial Institute that is almost identical as far as size and shape are concerned with fruits of *K. bipinnata* from Kweichau and in the collection of the United States National Herbarium (PLATE 1, FIGS. 4, 6). Capsule valves of *K. integrifolia* from Kaingsu and Kwangsi in the National Herbarium and the Arnold Arboretum collections are broadly ovate, and measure about 29 × 39 mm. in length and breadth. The only apparent difference between the two species is shape, and this is probably so variable that it is not a dependable means of separation.

Because of the convexity of the outer surface, the valves of *Koelreuteria* invariably show some distortion as a result of flattening. There is usually a crease along the midrib, and one side often becomes folded over the other at the apex. There is usually some splitting along the margin. These irregularities are of some value in distinguishing the valves in the fossil condition from the circular winged fruits of *Ulmus, Ptelea, Abronia,* and others with which they might be confused.

The seeds of *Koelreuteria* are borne on three placental wings that extend inward from the ventral surfaces of the valves and meet in the centre. They have never been found attached in the fossil fruits. In a compression of an individual valve the wing may be preserved as a slightly thickened carbonaceous mass located near the centre. Upon casual observation this may be mistaken for a seed although it usually lies slightly to one side of the midrib (PLATE 1, FIGS. 1, 3, 4). In symmetrically winged fruits such as those of *Ptelea* or *Abronia* the seed is bisected by the midline.

The veins of the *Koelreuteria* capsule valve form a network within the tissue. The system consists of a rather weak midvein that extends from the base to the apex, a set of fairly prominent but slightly tortuous lateral veins, and smaller connecting veinlets. In the central region the lateral veins pass to the margin at right angles to the midrib, but they slope at the base, and in the upper part they are deflected forward as much as 45 degrees or more. Some of the veins depart opposite each other, and in fossil specimens pairs of opposite or nearly opposite veins present the appearance of extending completely across the face of the valve. They cross the thickened mass representing the flattened placental wing



TEXT-FIG. 1 — *Koelreuteria oregonensis* sp. nov. Tracing of specimen shown in Plate 1, Fig. 3, to show the venation pattern and the position of the placental wing. Cross veins not shown. (Slightly enlarged)

(TEXT-FIG. 1), thus creating a pattern that is unique and different from that shown by *Ptelea* and similar fruits where the lateral veins arise at the margins of the seed body. The characteristic course of the veins is well shown by Hu and Chaney (1940, PLATE 38, FIG. 1) in *K. miointegrifolia*.

In North America the capsule valves of *Koelreuteria* have been found in two localities in Colorado.[1] *K. viridifluminis* is from the Green river formation near De Beque (BROWN, 1934), and *K. alleni* was found many years ago in the lake beds at Florissant. The latter, however, was not correctly identified until Edwards (1927) recognized its affinities. *K. alleni* had previously been assigned to *Ophioglossum* and *Salvinia* by Lesquereux, *Tmesipteris* by Hollick, *Phyllites* by Florin, and *Carpolithes* and *Brachyruscus* by Cockerell. Brown suggests that *K. alleni* and *K. viridifluminis* are the same but does not formally synonymize them. Hu and Chaney state that the Florissant fruits differ from those of *K. miointegrifolia* only in size, the former being only one-half as large. On the basis of this comparison the Florissant fruits are similar to those from Oregon, but the question of identity cannot be settled until the Florissant material becomes better known. The description of *K. miointegrifolia* by Hu and Chaney could be applied directly to the Oregon specimens with allowance made only for the size difference.

Although the distribution of *Koelreuteria* during the Tertiary was wider than at present, lack of familiarity with the genus on the part of palaeobotanists in some instances has caused it to pass unnoticed in ancient floras. It is quite likely that some objects identified as *Ulmus* fruits are *Koelreuteria* capsule valves. A modern instance of an apparent mistaken identity is in the work of Weyland (1937) on the Tertiary flora of the Rhineland, in which he has identified fossils as *Abronia* that unquestionably belong to *Koelreuteria*. In his well-illustrated account, one of his specimens (TEXT-FIG. 17) bears every resemblance to a capsule valve of *Koelreuteria* drawn with the apex downward. The tip on one side of the midrib extends beyond the other, an inequality that results from flattening and which is often noticeable in herbarium specimens of living species. His figure represents the dorsal view of the valve, and shows the venation system but not the placental wing on the ventral side. In his Fig. 18 the area interpreted as the seed is in reality the flattened placental wing. This figure is similar to our Fig. 2 on Plate 1. (Weyland's two specimens are reproduced photographically in Figs. 2 and 3 on his Plate XI.) Weyland refers the Rhineland fruits to *Abronia* on the basis of Laurent's description and figures (1904-5) of *A. bronni* from the Pliocene of France. Laurent's fruits are obviously not *Koelreuteria*, and their reference to *Abronia* is improbable.

Abronia, with about a dozen species, is restricted to the western United States and northern Mexico where it inhabits dry water courses. Its winged fruits are broadly oval (PLATE 1, FIG. 5) with a spindle-shaped seed in the centre. In addition to the encircling wing, there is a smaller median wing that in the photograph is shown pressed against the larger one at one side of the seed. There is no possibility, in well-preserved specimens at least, of confusing this third wing of the *Abronia* samara with the placental wing of *Koelreuteria* because it is present in addition to the seed. The lateral veins are fewer than in *Koelreuteria*, and they arise at the margin of the seed body. Also, there

1. For nomenclatorial changes and two additional localities in the Middle Eocene, see Brown, 1946, *Jour. Washington Acad. Sci.* **36**: 351.

is a distinct marginal vein that completely encircles the fruit. Not being subject to distortion from direct pressure from above, and in showing several distinctive characters of its own, the fossil remains of *Abronia* should not be difficult to distinguish from *Koelreuteria* if preservation is adequate to justify generic assignments of any kind.

Aside from the appearance of the fossils themselves, there are other reasons for believing that *Abronia* is not likely to be present among the plants from the Rhineland Tertiary that are described by Weyland. As stated, the living species of *Abronia* are desert plants, and the plants associated with this genus in fossiliferous deposits should also reflect desert conditions. But instead, Weyland found in the Rhineland flora such examples as *Ailanthus*, *Acer*, *Paliurus*, *Catalpa*, *Englehardtia*, and several legumes. Then in a subsequent account (1938) he adds magnolias and laurels to the list, none of which occupy habitats similar to that of *Abronia*. In addition to representing an environment different from that indicated by the examples cited above, *Abronia* is a low-growing herb, the type of plant that seldom finds its way into the fossil record. The fact that it sometimes grows in dry water courses might occasionally account for the presence of the fruits in flood deposits, but in such events the accompanying fossil plants should represent surface debris of the kind that is usually picked up and transported by cloudbursts in desert areas. The plants enumerated by both Laurent from France and by Weyland from the Rhineland are not what one would expect to find in deposits formed under such circumstances. The only conclusion that seems logical is that Weyland's Rhineland fruits belong to *Koelreuteria*, and that the fruits from the French Pliocene are probably neither *Koelreuteria* nor *Abronia*.[2]

Although Hu and Chaney claim that *Koelreuteria miointegrifolia* resembles *K. alleni*, none of the published figures of the latter bears any close resemblance to the Oregon form. Furthermore, the Oregon capsule valve is different from the Green River shale form, *K. viridiffuminis*, so the only available course is to assign a new name to it. *Koelreuteria oregonensis* sp. nov. is proposed. Its formal diagnosis is as follows:

Capsule valves circular to broadly oval, up to 27 mm. in length, similar to living K. bipinnata, but smaller.

Horizon — John Day Series, Oligocene.

Locality — Western edge of Section 21, R 20 E, T 7S, Wheeler County, Oregon.

Aside from merely establishing a new locality for *Koelreuteria* in the North American Tertiary, the discovery of the capsule valves in Oregon shows that during the middle part of this period, this genus was a member of the so-called "redwood association" that Chaney (1925, 1927) described as part of the Bridge Creek flora. Recent discoveries indicate that the supposed redwoods in the Bridge Creek and other mid-Tertiary floras of Oregon belong, at least in large part, to *Metasequoia*. Thus we find in the John Day series the two eastern Asiatic genera, *Koelreuteria* and *Metasequoia*, occurring together.

Acknowledgement is made to Drs. A. C. Smith of the United States National Herbarium and C. E. Kobuski of the Arnold Arboretum for loans of herbarium material of three species of *Koelreuteria*.

2. In a later paper (*Palaeontographica*, **85**B, 130, 1948) Dr. Weyland established the genus *Pteleaecarpum* for the Rhineland fruits.

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EXPLANATION OF PLATE 1

(All the figures are of natural size)

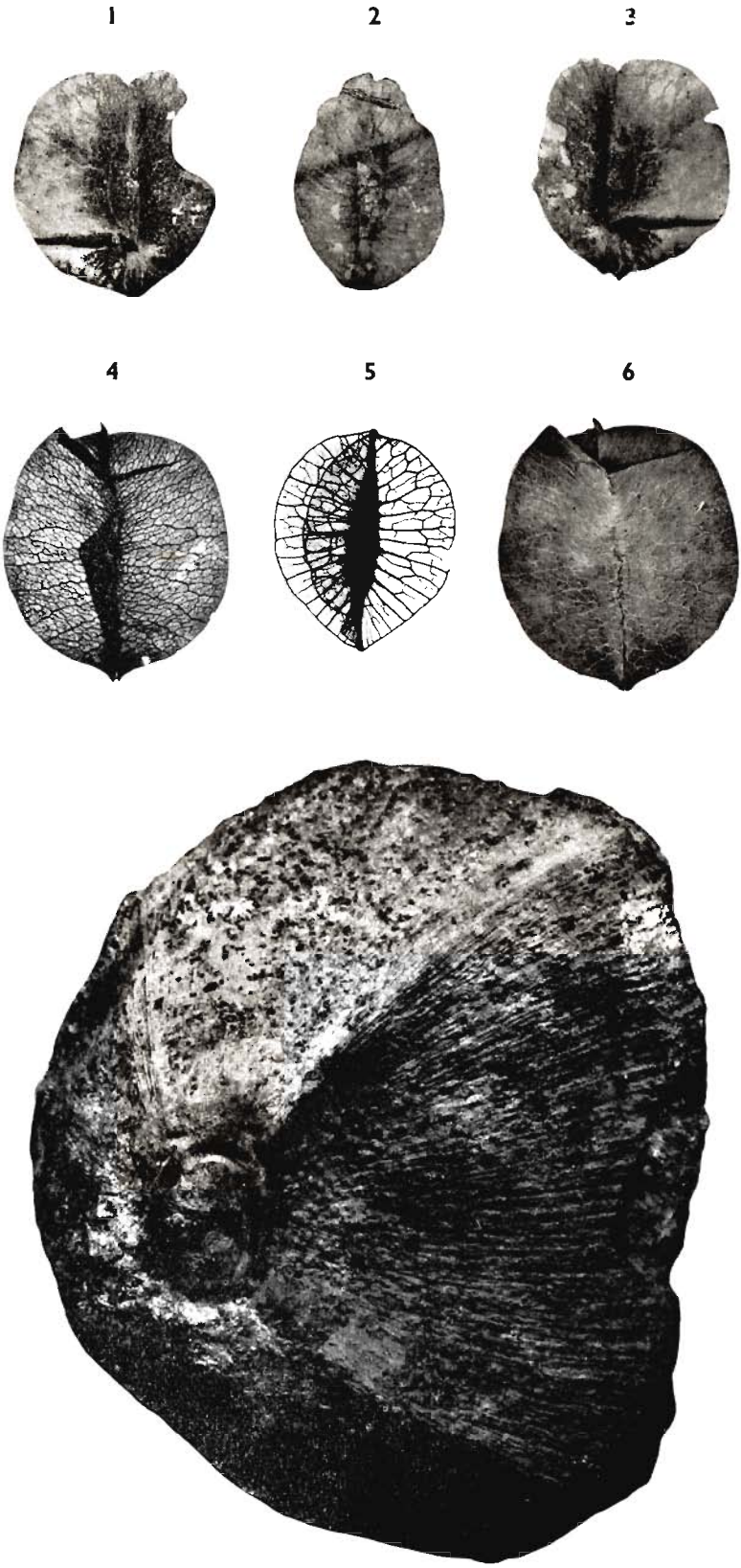
1, 3. Counterparts of one capsule valve of *Koelreuteria oregonensis* sp. nov.

2. Single complete capsule valve of *K. oregonensis* sp. nov.

4, 6. Single capsule valve of *K. bipinnata* from Kweichau. Fig. 4 by transmitted light to show the placental wing; Fig. 6 by reflected light.

5. *Abronia macroptera*. Complete fruit showing the centrally located seed, the venation, and the third wing with its own set of veins. Shown for comparison with capsule valves of *Koelreuteria*.

7. *Nipadites burtini* Brongn Weches greensand. Texas.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