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Tertiary coprolites imitating fruits of the *Araliaceae*

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The *Araliaceae* are an old family, which most probably appeared in the Cretaceous and were already extensively distributed in the older Tertiary. In the territory of Europe, they found especially favourable conditions for their development in the Miocene and Pliocene.

The first descriptions of fossil remains identified as belonging to this family concerned their leaves. Later on the endocarps, being excellently preserved in the fossil state, began to attract closer attention and they became the base of a separate taxonomy, which developed especially as regards the genus *Aralia*. Morphological differences occurring in the structure of the endocarps enabled the distinction of as many as 20 species of this genus among the Tertiary floras of Eurasia. In the fossil state the endocarps preserve very well and details of their structure (delicate parallel striation of the surface) are visible even if the specimens are much damaged.

Descriptions of whole compound fruits of the genus *Aralia* are also to be found in palaeobotanical literature. C. and E. M. Reid were the first to report them in 1915 from the Dutch Pliocene (Swalmen) under the name *Aralia racemosa* L. (?). Numerous remains of a similar structure were later on described from the Pliocene at Krościenko as fruits of *Aralia* sp. (Szafer, 1947, Table XII, Figs. 21, 22), from the Pliocene at Mizerna as fruits of *Araliaceae* (Szafer, 1954, Table XIII, Figs. 21, 22), and from the Miocene at Stare Gliwice as fruits of *Aralia* aff. *chinensis* L. (Szafer, 1961, Table XXI, Figs. 1—3).

The correctness of the determination of the specimen from Swalmen (Reid 1915, Table XIV, Fig. 26) arouses, however, reservations already partly expressed by the authors themselves, who wrote that the specific differentiae were not distinctly marked. F. Kirchheimer, (1958), expressed the opinion that the appartenance of this specimen to the genus *Aralia* was not certain and could be maintained only after the inner structure had been examined. In fact, neither the specific nor the generic features of the specimen from Swalmen seem to have been properly documented. It is true that this specimen resembles the fruit of *Aralia*, but it is sexfid, while the compound fruits of this genus are pentafid as a rule and sexfid ones occur quite exceptionally. Moreover,

Plate I

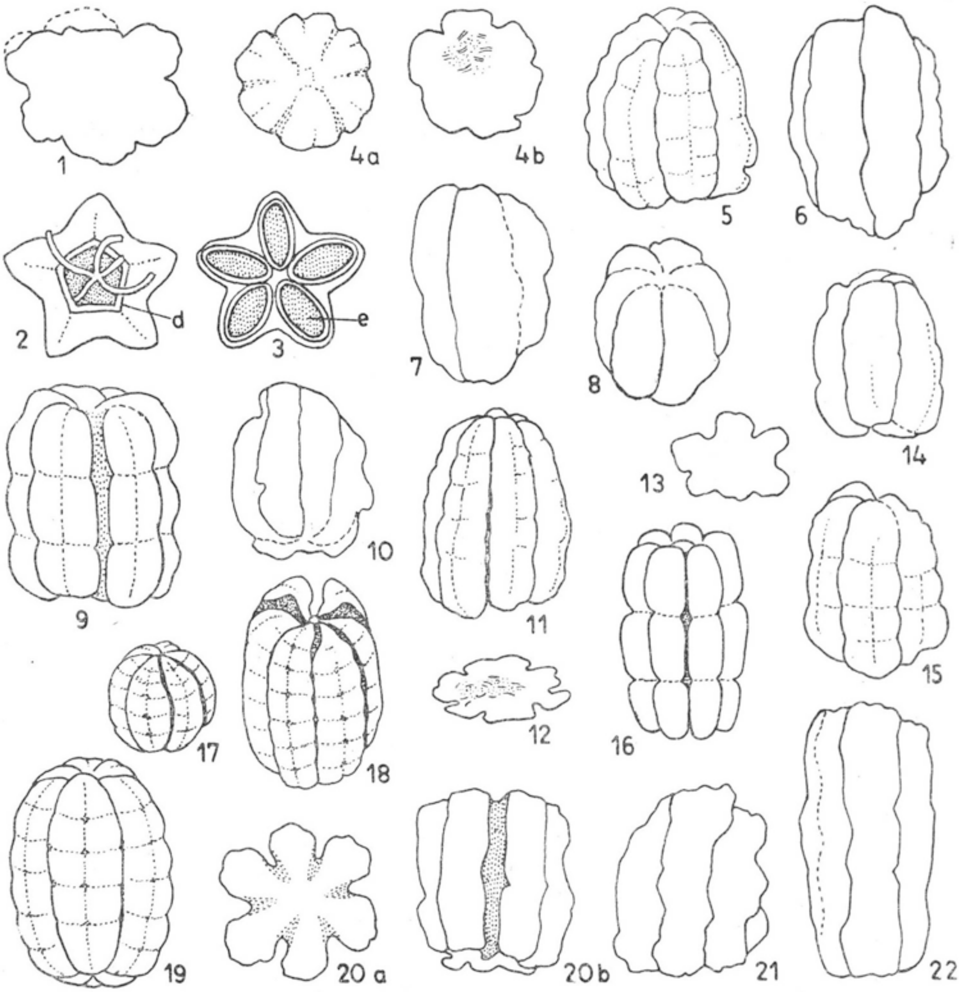

Fig. 1—22. Tertiary and recent coprolites of caterpillars and recent fruits of the genus *Aralia* (enlarged about 10 times)

1. *Aralia racemosa* ? Fruit (Swalmen; Reid, 1915). 2, 3. *Aralia racemosa* L. (recent specimen), fruit seen from above and in cross-section (d = receptacle, e = endocarp). 4, 5. *Aralia* sp. Fruits (Krościenko; Szafer 1947). 4*a* — Fruit seen from above; 4b — The same in cross-section. 6. Order ? Fruit (Reuver; Reid, 1915). 7, 8. *Araliaceae*, Fruits (Mizerna; Szafer, 1954). 9—12. *Aralia* aff. *chinensis* L. (Stare Gliwice; Szafer, 1961: photographs of specimens Nos. 9 and 12 hitherto unpublished). 13, 14. *Carpolithus* sp. (Hampshire; Chandler, 1961). 15. Specimen reported as a contamination of *Zelkova Keaki* seeds deriving from Yokohama (Chandler, 1961). 16. *Carpolithes* sp. 1, placenta ? (Hordle; Chandler, 1926). 17—19. Coprolites of caterpillars (Taniyagi-Higashiei; Miki, 1937). 20—22. Excrements of caterpillars of butterflies feeding on needless of pine (Kapuściński, 1955): 20*a*, b — *Lymantria monacha* L., 21 — *Lymantria dispar* L., 22 — *Hyloicus pinastri* L.

in the upper part of the remnant no traces are visible of the border of the large receptacle, which is so characteristic of the *Aralia* fruits and some other genera of the family *Araliaceae* (cp. Plate I, Fig. 2). It should be added that the fruits under discussion have a fleshy exocarp, in which there are sticking five laterally compressed and easily divisible endocarps, so that the chance for the compound fruits in the fossil state being preserved as a whole is comparatively a small one although it cannot be completely excluded (cp. Menzel, 1913, Table 1, Fig. 19; Reid, 1915, Table 14, Figs. 28—30; Mädler, 1939, p. 134; Szafer, 1961, Table 21, Figs. 4 and 5, as well as Dorofieyev, 1963, Table 44, Figs. 4 and 5).

A survey of the rich fossil material from Krościenko and Stare Gliwice provided for the present author facilities to learn to know accurately the inner and outer structure of the remains regarded to be compound fruits of the genus *Aralia*.

Most of these remains (20 specimens from Krościenko and 16 specimens from Stare Gliwice) show an analogous scheme of structure, the differences in size being quite considerable: length 1.0—3.5 mm, width 1.0—3.0 mm. They are usually slightly elongated, sexfid as a rule, and provided with six deep, longitudinal grooves. The convex surfaces that are between the grooves are lustrously black, irregularly wrinkled and show the tendency to divide into shorter segments. On the examined specimens there is never to be seen a trace of a stem having been implanted or that of a receptacle and on the cross-sections there is never a trace of endocarps. Inside, they are filled with a wholly uniform and tightly compressed mass of brown colour, which also indicates that these remains cannot be connected with any sort of fruits.

Similar doubts are being aroused by the specimen from Reuver (Reid, 1915, Table XIV, Fig. 31), reported as a fruit of a more closely unknown genus, the Oligocene remains from Headon Beds (Chandler, 1961, Plate 20, Figs. 154—156), described as *Carpolithes* sp., and the specimen that is a contamination of the *Zelkova Keaki* fruits deriving from the Botanical Gardens in Yokohama (Reid 1915; Chandler, 1926; Chandler, 1961, Plate 30, Fig. 157). A fairly similar structure can also be traced in the specimen of *Carpolithes* sp. from the Eocene from Hordle (Chandler, 1926, Table VII, Figs. 11a, b), which shows, however, deeper longitidinal furrows and more distinct transversal narrowings than the specimen from Reuver. Miss M. E. J. Chandler emphasizes (l.c. p. 44) that this specimen can be neither a fruit nor a seed because it is wholly filled inside.

All the discussed remains have been copied from the original publications and juxtaposed in a more or less equal enlargement (cp. Plate I).

Remains of a similar form and structure as those described above were reported by S. Miki (1937, Fig. 10, P) from the Pliocene of Stegodon Beds in Japan and determined as excrements of caterpillars. The resemblance is striking, especially when we consider that the coprolites of the caterpillars of butterflies are distinguihed by a considerable regularity of construction at various dimensions, a tendency to segmentation, and, above all, by an amorphous inner structure.

According to S. Kapuściński (1955, as well as kindly imparted personal information) the excrements of caterpillars of some species of butterflies are deeply longitudinally grooved and show in cross-section a characteristic form of a sexcogged wheel (Plate I, Fig. 20a). This relates to the presence of six protruding lamellae on the inner wall of the rectum in caterpillars. If there occur, besides that, still more minute lamellae the coprolite may show additional shallower furrows on its surface. Some excrements are marked with distinct narrowings. It is worth while to add that the morphological structure of the excrements of caterpillars is greatly varied and characteristic of the particular species of butterflies.

The above described features of the morphological structure of caterpillar excrements of some butterflies are easily discernable in the fossil remains presented in Plate I. The excrements of caterpillars feeding on needles of pine (*Lymantria monacha*, *L. dispar*, and *Hyloicus pinastri*) drawn for comparison are pronouncedly angular because they are overfilled with small fragments of comparatively fresh needles (Plate I, Figs. 20—22). Fossil remains generally have a rather smooth surface covered with a shining, mineralized coating that preserved them from dissolution. Confusedly composed, highly carbonized organic fragments are sometimes visible in cross-sections (Plate I, Figs. 4b, 12). A maceration of fossil remains with nitric acid results in a fine plant chaff. Under the microscope there can be distinguished in it as if fragments of leaves of which the ribs only have been preserved (the leading tissue is visible).

In the fossil material tabulated in Plate I. there appear several types of coprolites distinguished by a different depth of the longitudinal grooves, the presence of additional furrows between the six main grooves, the number of transversal narrowing and the "sculpture" of the surface. This differentiation in the morphology of the Tertiary coprolites points to the diversity of the world of butterflies at that time.

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Trzeciorzędowe koprolity opisywane jako owoce Araliaceae

Streszczenie

Rośliny należące do rodziny *Araliaceae* opisywane są we florach kopalnych na podstawie liści, pojedynczych endokarpów oraz całych owoców złożonych. Owoce te u rodzaju *Aralia* oraz wielu innych rodzajów rodziny *Araliaceae* mają niewielką szansę zachowania się w całości, gdyż ich 5 endokarpów ściśniętych bocznie i otoczonych mięsistym egzokarpem ulega łatwo rozdzieleniu.

Znaczna część szczątków trzeciorzędowych, określanych jako owoce rodziny *Araliaceae*, a w szczególności rodzaju *Aralia* (*A. racemosa* L., *A.* aff. *chinensis* L., *A.* sp.), ma nieco odmienny i charakterystyczny wygląd, a budowę wewnętrzną całkowicie amorficzną. Są to koprolity gąsienic motyli, które po raz pierwszy zostały podane z pliocenu japońskiego. Do utworów tego typu należą również szczątki opisane jako *Carpolithes* sp. z oligocenu i eocenu Anglii.

W materiale trzeciorzędowych koprolitów można wydzielić kilka typów morfologicznych, związanych z gąsienicami różnych gatunków motyli.