

ON THE FOSSIL PHYLLOPOD GENERA, DIPELTIS AND
PROTOCARIS, OF THE FAMILY APODIDÆ.

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THE GENUS *Dipeltis* was established by Professor A. S. Packard in 1885 on a specimen in the collection of Mr. R. D. Lacey, "not satisfactorily preserved, so that its exact relations are not readily determined though it will be recognizable as a *Cyclus*-like form." In the following year the same author gave a more extended description, with a figure of the type and a restoration of the dorsal side of the animal. Recently, better preserved specimens of *D. diplodiscus* have been found at Morris, Illinois—one by Mr. J. C. Carr, and another, a nearly perfect individual, by Mr. L. E. Daniels. All these fossils may be only sheddings, since they are more or less cracked along the median ridge of the head shield and the two large thoracic segments. An excellent specimen representing a new species, which preserves the cercopoda and probably impressions of the anterior limbs, was found some years ago by Mr. J. C. Carr.

It is now certain that *Dipeltis* has no direct relationship with *Cyclus*, nor is it a Niphosuran, as supposed by Packard; also that the restoration by the latter author is quite faulty, and further that the family Dipeltidæ must be abandoned. The reason for these changes is that *Dipeltis* is closely related to *Apus*, as will be readily seen in Plate LVIII, figs. 2-6.

Genus DIPELTIS, Packard (emend).

Generic characters.—Head shield subovate or subtriangular, nearly smooth with two submarginal ocelli, and a pair of close-set eyes anterior to the middle. Lateral angles acute in the adolescent stage, becoming less so with maturity. Head shield not extended in one piece over the abdomen, as in other Apodidæ, but followed by two very large thoracic segments, which at maturity have the lateral portions much extended posteriorly, but less so in young specimens. Abdomen with from six to nine segments. The telson, or anal segment (seventh in *D. carri*, tenth in *D. diplodiscus*), is more or less wide, and bears laterally two slender cercopoda, or cirri.

Type.—*D. diplodiscus*, Packard.

Dipeltis differs conspicuously from *Apus* and *Lepidurus* in its narrower head shield followed by two large thoracic segments. If these three parts in *Dipeltis* were united into one, there would result a cephalon in general form very much like that of *Lepidurus*. The small number of abdominal segments is another conspicuous difference as compared with the recent genera.

At first sight, *Dipeltis* might not be regarded as a member of the Apodida, because of the two peculiar, and disproportionately large, segments back of the cephalon. The presence, however, of long cercopoda and a wide anal segment, the position of the eyes, and the *Apus*-like head shield are all characters of this family. The few and wide abdominal segments are not unlike those of *Lepidurus*. On the other hand, the very suggestive theory may be advanced that the cephalon and the two large body segments of *Dipeltis* may represent a mature condition of a stage in the development of *Limulus*, since the cephalothorax of this genus is composed of seven segments, five belonging to the head and two to the thorax. Against this view the fact may be urged that no pre-Carboniferous members of the Hemiaspida, ancestors of *Limulus*, show any near relationship to *Dipeltis*. The abdomen of the latter has from seven to ten segments, and the anal piece with its two long cercopoda is in complete harmony with the Apodida and wholly unlike *Limulus*.

The nature of the waters in which *Dipeltis* lived was marine. These animal remains are found in nodules, associated with *Prestwichia*, *Eurypterus*, malacostracous, schizopod, and decapod crustaceans, arachnids, insects, *Ariculopecten*, and *Solnomya*, and numerous ferns. This evidence indicates that the waters in which the rocks of Mazon Creek were deposited were neither fresh nor brackish, but marine (probably estuarine), and into these the plants and insects have been blown or washed from the not far distant land.

DIPELTIS DIPLODISCUS, Packard.

(Plate LVIII, figs. 2-5.)

Dipeltis diplodiscus, PACKARD, Amer. Nat., 1885, p. 293; Mem. Nat. Acad. Sci., III. Pt. 2, p. 145, pl. v, figs. 2, 2a.

Head shield twice or more than twice as broad as long. In the adolescent stage, it is somewhat drawn out posteriorly at the sides, but these extensions disappear with maturity. Upon the head shield there is a more or less sharply elevated median carina, which is also present on the two large thoracic segments. On each side of this ridge, immediately within the anterior edge, are situated two small shallow pits, which are interpreted as ocelli, and posterior to these are two faintly preserved eye spots. Cephalon nearly smooth with faint ridges, as shown in Fig. 3.

The thorax has two, smooth, disproportionately large, unconsolidated segments, both of which at maturity are greatly excavated posteriorly. These two segments are followed by nine smaller abdominal ones, each of which bears medially a parallel series of linear ridges. These ridges are most prominent posteriorly, and terminate on the lateral extensions of the ninth segment. The tenth, or anal segment, is imperfect. It is grooved medially, and probably had two slender lateral cercopoda, as in *D. carri*.

Length of smallest specimen, not including the cercopoda, 11 mm.; greatest width, 8 mm. Length of largest specimen, which lacks the small abdominal segments, 23 mm.; width across the large anterior segments, 19 mm.

Formation and locality.—In Lower Coal Measure nodules, near Morris, Illinois. Three specimens are known: One, the type, is in the collection of Mr. R. D. Lacoë; another was found by Mr. J. C. Carr, and a third, the most perfect example, by Mr. L. E. Daniels. Specimen No. 25713, U.S.N.M.

DIPLODISCUS CARRI, new species.

(Plate LVIII, fig. 6.)

This species is associated with *D. diplodiscus*. It differs in being considerably narrower, and in having but seven small abdominal segments, three less than in the latter form. Moreover, the segments are broader, and posteriorly do not taper so rapidly, as in *D. diplodiscus*. The anal segment, as far as can be seen, is very wide, deeply grooved, and bears two long, slender cercopoda. These are marked by widely separated transverse lines.

The specimen exposes the dorsal side, but is crushed in along the center through the two large thoracic segments and the head shield. The drawing shows the detail as observed, but the ventral structure can not be made out beyond the fact that the head bears a series of diverging furrows, probably corresponding to five pairs of limbs.

Greatest length not including the cercopoda, 17 mm.; greatest width, 9 mm.

Formation and locality.—A single specimen of this species was found by Mr. J. C. Carr, near Morris, Illinois. The writer takes pleasure in naming the species after its discoverer, in recognition of his intelligent and persistent efforts for many years to unearth the fossil treasures of Mazon Creek.

PROTOCARIS, Walcott.

(Plate LVIII, fig. 1.)

Protocaris, WALCOTT, Bull. U. S. Geol. Surv., No. 10, 1884, p. 50, pl. x, fig. 1;
Ibid., No. 30, 1886, p. 147, pl. xv, fig. 1.

Generic characters.—Carapace large, smooth, subquadrangular in outline, posteriorly much extended over the abdomen, slightly excavated medially along the anterior margin and more deeply posteriorly; mar-

gins somewhat thickened; just within the anterior margin, two large nearly circular depressions appear to be present, which may represent eyes. Abdomen tapering slightly, with thirty short, equally broad segments back of the carapace, and a wide anal segment. Cercopoda not long and comparatively thick.

Type.—*P. marshii*, Walcott. (No. 15400 U.S.N.M.)

The writer is unable to add much to the structure of *Protocaris* as worked out by Mr. Walcott. The obverse and reverse sides of the only specimen show that the abdomen continued beneath the cephalon, as in *Apus*. Therefore many more than thirty segments were present in *P. marshii*. The cercopoda are shorter and thicker than in *Apus* or *Lepidurus*. That eyes are present is not certain, but faint markings exist as indicated in Fig. 1. Theoretically it is probable that eyes are present on the dorsal surface and near the anterior margin of *Protocaris*. The reasons for this are: (1) In the development of trilobites the eyes are known to pass from the ventral to the dorsal side; (2) the ontogeny of *Apus* shows a similar transposition; (3) in the Lower Cambrian nearly all trilobites associated with *Protocaris* have eyes on the dorsal surface; (4) *Protocaris* is clearly one of the Apodidæ, and in this family the eyes are never much removed from the anterior margin. Therefore it is not to be expected that at the very base of the Cambrian the eyes of *Protocaris* would have traveled much back of the anterior margin; (5) in *Dipeltis* of the Carboniferous the eyes are situated as in recent species of the Apodidæ.

Protocaris is a synthetic type, as might be expected of animals occurring at the base of the known fossil-bearing strata. Regarding this fossil, Walcott stated that "this is probably the oldest Phyllopod crustacean known, and that this animal is *Apus*-like." The numerously segmented abdomen, the presence of cercopoda and a wide anal segment, or telson, and the posterior extension of the carapace over the abdomen clearly indicate that *Protocaris* is nearly related to the Apodidæ. On the other hand, the subquadrangular shield of this genus is quite unlike that in any member of the Apodidæ, and its anterior excavated margin recalls certain Ceratiocaridæ, as *Ceratiocaris*, *Dithyrocaris*, and *Argas*. *Protocaris* differs, however, from these *Phyllocarida* in its *Apus*-like abdomen.

Since writing the above it has been learned that Clarke and Bernard have reached similar conclusions. The former states:

Another very early univalved species, not unlike *Nebalia*, but wonderfully similar to the living Phyllopod *Apus*, is the *Protocaris marshii*, Walcott. * * * The single example of *Protocaris* known, has probably been subjected to some horizontal distortion in the shale, giving the carapace a disproportionate size with reference to *Apus*, possibly also serving to obliterate any external evidence of ocular nodes which may have existed, but the remarkable closeness in the form of the abdominal segments, the degree of segmentation, and the single strong pair of caudal processes, render it highly probable that in *Protocaris*, we have to do with an apudiform phyllopod rather than with a nebalioïd phyllocarid.¹

¹ On the structure of the carapace in the Devonian crustacean *Phinocaris*, by J. M. Clarke, Amer. Nat., 1893, p. 799.

Bernard writes "that animals closely resembling *Apus* were extant in earliest times we now know for certain * * * from the remarkable Cambrian *Protocaris marshii*, which apparently possessed the same peculiar characters of the posterior segmentation as *Apus*, and which I should like to call *Apus marshii*."¹

The fauna in which *Protocaris* occurs in Georgia, Vermont, is entirely marine, and is associated with characteristic Lower Cambrian trilobites and brachiopods.

GEOLOGICAL HISTORY OF THE APODIDÆ.

Living Apodidæ, although rare, are, however, widely distributed over the continents, generally in fresh-water ponds and pools. Three or four days suffice to develop the nauplius from the egg, which may have lain buried in mud from the previous season.

Fossil Apodidæ are occasionally discovered in fresh-water Tertiary deposits, and before the true systematic position of *Dipeltis* and *Protocaris* was known, no members of this family were believed to exist earlier than the Triassic. Salter² mentions a true *Apus* from the Triassic of Europe. Zittel, in his *Handbuch der Palæontologie*, says that Prestwich described *Apus dubius* from the Coal Measures of England. From Doctor Charles E. Beecher, the writer learns that "*A. dubius* seems to be an abdominal segment or plate of some eurypterid." In *Dipeltis* the family is represented in the Upper Carboniferous, and, although the carapace of *Protocaris* is not entirely *Apus*-like, there is not much doubt that the genus belongs in the Apodidæ. The history of the family therefore, extends throughout the time represented by the entire known fossil-bearing rocks, as *Protocaris* occurs at the base of the Lower Cambrian.

Since the Apodidæ are generally believed to be of late introduction geologically, the family has been regarded as a highly specialized group, by Salter and Packard. The latter writes:

In conclusion, therefore, we consider the Phyllopods as a whole, especially the Apodidæ and Branchipodæ, to be a comparatively recent, highly specialized group, which were developed under exceptional biological conditions in bodies of fresh water, and which, as in *Apus*, show that this branch of the Crustacean genealogical tree has culminated. The irrelative repetition of the segments and appendages (in *Apus*) gives evidence that the type, so far from being ancestral, is one comparatively modern, specialized, and fully worked out.³

In his studies of the Apodidæ, Bernard also recognizes the imperfection of the geological history of the family, but for reasons given, mainly anatomical, concludes that "*Apus* is a very ancient form in spite of the deficiency in its own geological record."⁴ In a later paper,⁵ he states that *Protocaris marshii* might be called *Apus marshii*, thus recognizing the great geological age of the Apodidæ.

Protocaris and *Dipeltis* inhabited marine waters, while all recent species are denizens of fresh waters, generally of ponds and pools.

¹ Quart. Jour. Geol. Soc. Lond., L, 1891, p. 413.

² Quart. Jour. Geol. Soc. Lond., XIX, 1863, pp. 87-92.

³ Twelfth Ann. Rept. U. S. Geol. Surv. Terr., Pt. 1, 1883, p. 419.

⁴ The Apodidæ. A morphological study. Nature series, 1892, p. 182.

⁵ Quart. Jour. Geol. Soc. Lond., L, 1894, p. 413.

CLASSIFICATION.

Family APODIDÆ, Burmeister (emend after Packard).

“Head and body in front broad and flat, shovel-shaped or subquadrate; carapace broad and flat [usually followed by a cylindrical body or rarely by two large thoracic segments]; the body cylindrical, few or numerous segments extending beyond the carapace; antennæ small, second pair minute, sometimes wanting; labrum large, broad, flat; feet numerous, usually 63 pairs; with a large coxal, maxilla-like basal lobe forming gnathites; beyond five subjointed endites; the 2-4 endites in first pair of feet very long and slender, especially the fifth; gill pear-shaped or bottle-shaped; flabellum triangular, simple; the fifth endite of the first pair of legs is sometimes nearly as long as the body, the eleventh pair bearing egg sacs, and in the male having the genital outlet. Behind the eleventh pair two of the abdominal segments bear each six pairs of appendages, there being many more appendages than segments to the abdomen, while a variable number at the end are without appendages. Telson cylindrical, either short or ending (in *Lepidurus*) in a long paddle-like outgrowth. A pair of [short or] long filiform [or stout] jointed caudal appendages. Larva a nauplius.” Cambrian to Recent.

APODINÆ, new subfamily.

Characters of the family as given, omitting the two thoracic segments of the Dipeltinæ. Habitat: Marine and fresh waters. Cambrian to Recent.

Carapace subquadrangular. *Protocaris*.

“Telson ending in a long paddle-shaped outgrowth. *Lepidurus*.

Telson short, cylindrical, simple. *Apus*” (Packard).

DIPELTINÆ, new subfamily.

Like Apodinæ, but with a narrow head shield and two large, free, thoracic segments. Telson apparently not drawn out. Ventral appendages unknown. Habitat: Marine waters. Upper Carboniferous. *Dipeltis*.

EXPLANATION OF PLATE.

PLATE LVIII.

Protocaris marshii, Walcott.

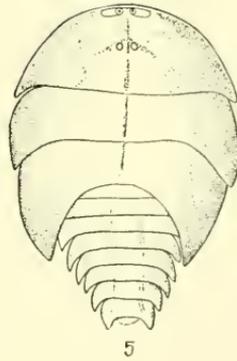
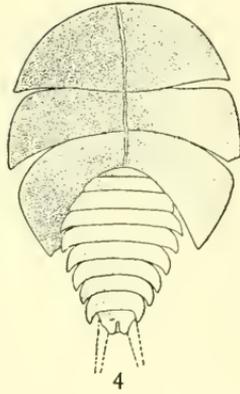
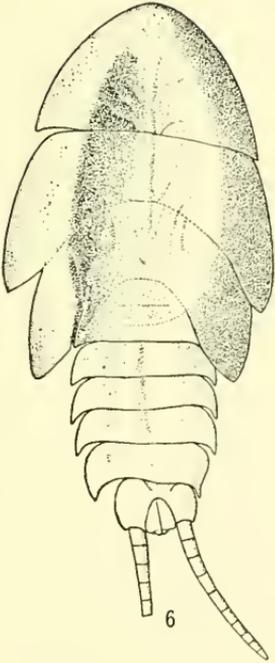
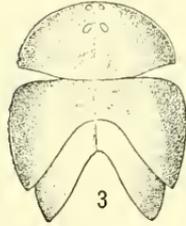
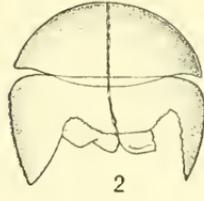
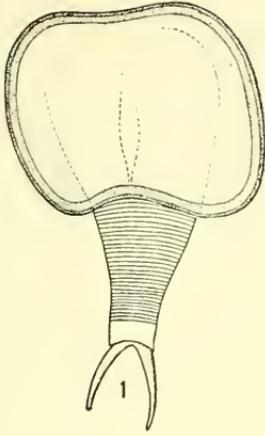
Fig. 1. Lower Cambrian; Swanton, Vt. Natural size.

Dipeltis diplodiscus, Packard.

2. Lower Coal Measures; Morris, Ill. View of the type specimen preserving the head shield, the first and portions of the second thoracic segments. Natural size. Lacoe Collection.
3. Specimen showing the complete head shield and the two large segments. Natural size.
- 4, 5. Reverse and obverse, respectively, of a small, nearly entire specimen. Enlarged three times.

Dipeltis carri, new species.

6. Lower Coal Measures; Morris, Ill. The central depression in this specimen is due to crushing. Enlarged three times.



FOSSIL PHYLLOPODS.

FOR EXPLANATION OF PLATE SEE PAGE 676.

