AMERICAN MUSEUM NOVITATES

Number 227 — Published by THE AMERICAN MUSEUM OF NATURAL HISTORY New York City — Oct. 11, 1926

56.2...P(114:74.7)

A NEW SPECIMEN OF *PROTOBALANUS*, SUPPOSED PALEOZOIC BARNACLE

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In a recent number of American Museum Novitates (No. 197, Nov. 21, 1925) I published the result of a re-examination of the type (then the only known example) of the peculiar fossil *Protobalanus hamiltonensis* from the Devonian (Hamilton Group, Marcellus shales) at Avon, New York, first described in 1888 by Hall and Clarke in the 'Natural History of New York,' Paleont., VII, p. 209, Pl. XXXVI, fig. 23. What gave this fossil its especial interest was a strong superficial resemblance to an acorn barnacle, making it one of the chief arguments in support of the belief in the existence of the acorn barnacles in the Paleozoic, as opposed to the theory of Darwin and the majority of later authorities that they originated during the Mesozoic, appearing first in the Cretaceous.

A second and more complete specimen of *Protobalanus* (Cat. No. 22866, A. M. N. H.) has now been discovered. Before proceeding to its description, it may be stated that, although leaving unsettled the question of what the animal was, it seems to put an end to the probability that *Protobalanus* was a cirriped at all, and to exclude all possibility that it was an ancestor of or in any way related to the modern acorn barnacles (*Balanus* and allied forms).

The new specimen (Figure 1) is in the same slab of calcareous shale that contains the original one, but lies in the matrix in an inverted position (with the convex or dorsal surface downward instead of upward as in the type). Having occasion to examine again the slab containing the type, I observed in a minute crevice near one edge a plication suggesting those on the plates of *Protobalanus*. That it was well concealed is attested to by the fact that such experienced paleontologists as John M. Clarke, R. P. Whitfield, and perhaps also James Hall had examined the slab and doubtless looked for additional specimens, as I had previously done myself without success. The specimen was skillfully uncovered by Mr. E. J. Foyles of the Paleontology department of the Museum and proved to be complete as regards the median dorsal region, which was missing in the type specimen, showing with a fair degree of clearness the

number and arrangement of the plates on that part of the carapace, and giving no indication of any opening there, certainly of none large enough for the protrusion of the cirri of a barnacle, that region being occupied by a median series of plates instead of paired valves as would be the case in a barnacle. Unfortunately, except for indicating that *Protobalanus* was not a barnacle it accomplishes little toward clearing up the deep mystery of what it was, and leaves it an example of a highly specialized

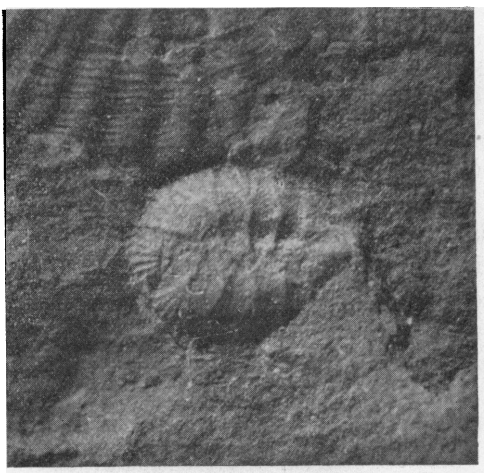

Fig. 1. *Protobalanus hamiltonensis* Hall and Clarke. (Cat. No. 22866, A. M. N. H.). × 9.

animal with calcareous plates which ought to make fossilization comparatively easy, but which has no known ancestors and no known descendents. The following description is based on both the old and new specimens.

Protobalanus hamiltonensis, Hall and Clarke

Protobalanus hamiltonensis HALL AND CLARKE, 1888, 'Nat. Hist. of New York,' Paleont., VII, p. 209, Pl. XXXVI, fig. 23; WHITFIELD, 1889, Bull. Amer. Mus. Nat. Hist., II, p. 66, Pl. XIII, fig. 22; WITHERS, 1915, Geol. Mag., (N. S. decade VI), II, p. 114, Fig. 1; PILSBRY, 1916, Bull. 93, U. S. Nat. Mus., p. 11; VAN NAME, 1925, Amer. Mus. Novitates, No. 197, p. 1, Figs. 1 and 2.

The specimens each consist of the dorsal carapace, which apparently covered the whole or nearly the whole of the animal. Its elevation is that of a low dome, somewhat depressed in the median or apical region which, however, may not have been the case during life. When seen from above it is ovate, broadly rounded in front and narrow behind. It is composed of a total of seventeen thin calcareous plates which, however,

do not cover the entire surface but leave spaces that appear to have been occupied by a smooth, somewhat flexible membrane. The plates comprise a marginal or parietal series of twelve plates (one anterior median, one posterior and five pairs of laterals) whose broad outer ends are contiguous and form the oval outer border of the carapace, but whose inner ends are narrow and not in contact. The median line is occupied by a series of five small somewhat square plates placed corner to corner and extending between the anterior and posterior plates of the parietal series. The tips of the lateral plates do not reach the median plates.

The plates are very thin. An examination of the broken edges of them with strong illumination and considerable magnification did not reveal evidence of tubes or pores in their substance. All the parietal plates exhibit low, radially disposed ridges of rounded cross-section separated by narrow furrrows; these are distinct at the outer margin where they occasion indentations or scalloping of the margin, and converge toward the inner narrow end, but become obsolete and disappear before reaching the latter. Lines of growth are not distinguishable.

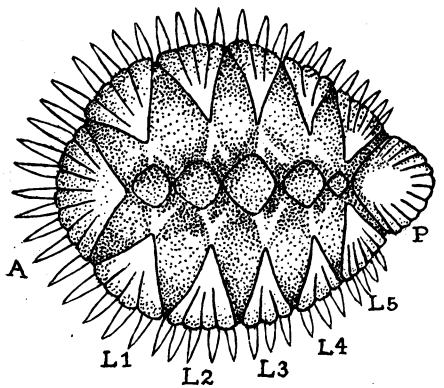

Fig. 2. Restoration of *Protobalanus*, dorsal view. × 12.
A, anterior median plate; P, posterior median plate: L1, L2, etc., lateral plates.

Owing to the thinness of the plates and the low elevation of their ridges, the latter are not always easy to count accurately and may not always be constant in different specimens or even on opposite sides of the body of the same individual. Their number is, however, about as follows: anterior median plate 8; first laterals 4; second laterals 4; third laterals 3 or 4; fourth laterals 3; fifth laterals 6; posterior median 12. The interior median plates appear to have been smooth or possibly finely radially striated.

The marginal or parietal plates are nearly triangular in outline (the base curved and forming part of the outer border of the carapace) except the posterior one, which is more convex in the curvature of its base and whose upper surface has a convexity of its own (independent of that of the rest of the carapace) culminating in a blunt elevation on the median anterior part of the plate. The plates seem to have been well calcified, for when treated with acid they give indication of containing more calcareous matter than does the rock in which the fossil is imbedded. I have not been able to find evidence of any openings in the carapace.

That the membrane filling in the intervals between the plates was somewhat flexible, though probably tough and strong, can be judged by the general depression of the apical region (including the median plates) of the specimen, and by the existence of ridges (transverse or nearly so) that connect the apices of the lateral plates of each pair with the corners of the median plate lying between them, the membrane apparently having yielded less to the depressing force because of being under greater tension or better supported along those lines. Less distinct ridges running obliquely from these transverse ridges toward the median plate next posterior are also discernible in some of the intervals.

The specimens lie imbedded in a small slab of dark gray, fine-grained calcareous shale, which contains also many other small fossils, chiefly brachiopods and mollusks. The surface of the matrix about the margin of the carapace in both specimens of *Protobalanus* exhibits short, radiating, depressed lines extending out for a distance of about one-eighth the width of the carapace in some places, but generally not so far. In number and position they correspond roughly but not exactly to the furrows and indentations in the scalloped edges of the plates. They are not distinguishable about the posterior end of the body. Their explanation has been a puzzle. That given by Hall and Clarke that the radially striated area represented a "marginal portion of the plates" is not tenable. The lines are on the surface of the surrounding matrix, entirely outside the margin of the carapace. Neither can we now accept the explanation of them that I gave in my former article (1925, p. 4) that they were impressed by the grooved basal part of the fossil, the latter having been shifted before it was finally buried. This might plausibly apply to the first specimen, but the fact that the second specimen, buried in an inverted position, is also surrounded by the radiating lines, effectively disposes of this explanation, for it is impossible to see how any shifting of the inverted specimen could produce them. In view of this, and after re-examining the type in the light of the information the new specimen affords, I think that they are the impressions of actual processes or appendages which appear to have been of flattened form, probably tapering to a point at the end. How wide these processes or appendages were, and whether they rise from the edge of the carapace or are the tips of structures projecting from beneath the edge of it, I have not been able to determine satisfactorily, but if we accept the former view, it seems possible that their bases may have been overlapped by one or more rows of small, very thin scales, though the indications on which this conjecture is based are very slight and obscure, and I have also failed to find sufficient indication that they supported a marginal belt of more or less soft flexible character about the edge of the carapace, although that may have been their function.

Size of the specimens: the type is 4.5 mm. long by 3.5 mm. wide; the second specimen is smaller, length 3.6 mm., width 2.8 mm.

Locality.—Avon, New York, Marcellus Shales, Hamilton Group, Middle Devonian.

As stated above, the material does not make it clear what kind of an animal *Protobalanus* was. Its broad depressed form indicates rather sedentary habits and is a specialization that would enable it to seek protection in narrow crevices and help it in clinging to rocks or other surfaces where exposed to the action of waves or water currents, or

perhaps for living as an external parasite on some larger organism. I am unable to place it in the Mollusca in spite of a superficial resemblance to the chitons, since there are only five (or seven, counting both anterior and posterior marginals) plates in the median series instead of eight as chitons should have. The radiating spines or processes about the margin of the body also stand in the way of such a disposition of it. Assignment to the Arthropoda or possibly even to the Annulata would be little more than a guess. If it belongs in the former phylum we might suspect it to be a larval form. Its small size would lend support to such a view, but on the other hand its apparently well clacified and externally ornamented plates suggest an adult animal.

Though any relationship between *Protobalanus* and the Cirripedia seems extremely doubtful, there are a few points of resemblance between it and another peculiar Paleozoic fossil which has been placed in the Cirripedia. This is *Pollicipes signatus* Aurivillius, 1892, from the Lower Ludlow (Upper Silurian) of Gotland, Sweden, which is likewise dealt with by Withers (1915, p. 117, Fig. 3, after Aurivillius) and made by him the type of a new genus (*Hercolepas*) as it clearly does not belong in *Pollicipes*, though Withers calls it an "undoubted cirripede." The only known specimen has a series of radially grooved triangular lateral plates which overlap an inner series of plates sculptured with minute punctæ. The margin of the carapace bears two or three rows of minute scale-like plates and a fringe of apparently movably articulated spines. I cannot consider the resemblance to *Protobalanus* anything more than superficial and accidental, so that I feel obliged to leave the problem of the relationships of *Protobalanus* unsolved.

In conclusion I wish to express my thanks to Dr. Chester A. Reeds and Mr. Edward J. Foyles of the Department of Invertebrate Paleontology of The American Museum of Natural History for the opportunity of studying this material and for assistance in various ways.

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