NOTES

ON

A SPECIES OF BARNACLE (DICHELASPIS) PARASITIC ON THE GILLS OF EDIBLE CRABS.

BY

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In the summer of 1900 Prof. H. V. Wilson, at that time director of the Beaufort Laboratory, suggested that, in view of the economic importance of the edible crabs, a fuller knowledge of the life histories of the ectoparasites of these forms was desirable. The following notes on one of the most interesting of such parasites are the outcome of an investigation carried on during parts of that and the following summer.

It is a pleasure to express my thanks to Professor Wilson for many helpful suggestions.

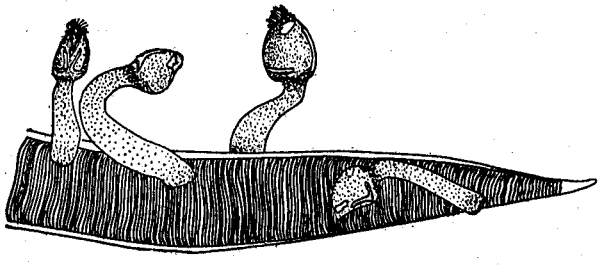

FIG. 1.—*Dichelaspis mulleri* attached to a gill of *Callinectes sapidus*. × 2.

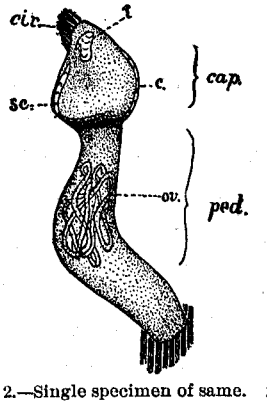

FIG. 2.—Single specimen of same. × 4.

OCCURRENCE AND HABIT OF ADULT.

A large number of the common edible crabs, or blue crabs (*Callinectes sapidus* [Ordway] Rathbun), of Beaufort, N. C., are found to be infested with a small lepadide barnacle, ectoparasitic on the gills (fig. 1). This form was first observed at Beaufort by Mr. T. G. Pearson. To ascertain somewhat definitely the proportion of crabs containing this parasite, record was made of 180 mature crabs examined during August and the first half of September, and barnacles were found in 128, or in 71 per cent. These crabs were taken just as they were brought into the laboratory, no selection being made except that soft crabs and evidently young crabs were disregarded. The barnacles were much more abundant later than earlier in the summer.

The sexes were found to be unequally burdened; the percentage for males infested was only 56, while for females it reached 89 per cent. It was also easily seen that the average number of barnacles in infested females was considerably above the corresponding average for males. A possible explanation of this difference is that

females when with eggs must be much less vigorous in their movements, because of the burden, but especially because of the necessity of having some care for the eggs. The consequently slower respiratory current would then afford better opportunity for barnacles in the free-swimming cypris stage to attach, as they are by chance sucked in and driven through the branchial chamber, or, if the cypris seeks out its host, the less active crabs will, again, be the easiest to find and to obtain attachment in.

The females also bore more of the *Balanus* barnacles on their shells; and it was further found that about four-fifths of those crabs on which the *Balanus* was seen would also contain *Dichelaspis*. It was rare to find a female crab with *Balanus* that had not also *Dichelaspis*. This fact is quite useful to one who is in search of the latter; promising crabs can be selected at a glance, even before capture. After ascertaining the above percentages, the collectors were asked to bring in only such crabs as carried *Balanus* barnacles.

It is to be presumed that these gill parasites are thrown off with the cuticle of the gill in the molt of the crab, and that the frequent molts of young crabs would prevent the barnacles on their gills from becoming conspicuous either in size or in numbers. It would then be expected, as indeed it is observed, that this *Dichelaspis* is not found in young or in soft crabs.

While one usually finds in an infested individual from two or three to eight or ten *Dichelaspis*, the number varies from one to as many as can be crowded into the branchial chambers—500 to 1,000, or perhaps more. In one instance observed the gill chambers had been filled to overflowing, and one or two barnacles were found attached without to a maxilliped.

This species of *Dichelaspis* is not peculiar to *Callinectes* as a host; both the edible stone crab (*Menippe mercenaria* Stimson) and the spider crab (*Libinia canaliculata* Say) contain it, but with less frequency. It is probably present in other large crustacea, lobsters as well as crabs, of other regions of the coast.

No organic connection between the barnacle and its host is found; and, while histological study of the parasite has not been made, no signs of degeneration are noted, except as to the extent of the calcified area of the valves of the capitulum; as will be seen later, too, the mouth parts are well developed. The barnacle is, therefore, to be regarded as a space parasite, which has become adapted to this habitat because of the peculiar advantages it offers—protection, frequent transportation, and the supply of a continual current of water, from which small organisms can be gathered for food. The branchial chamber of the crab is, indeed, a particularly favorable place for life, and is made use of by various forms. Vorticellid colonies and acinetid protozoa, polyzoa—ectoproctous and endoproctous—nemerteans, etc., are found with greater or less frequency. The considerable variation in the size and shape of the calcified plates to be noted later (see figs. 4 and 5) has probably no other significance than that it accompanies the degeneration of the plates, resulting from the fact that their function of protection is now performed by the carapace of the host. The relation of the calcified areas (*t. sc. c.*) to the whole valves (*T. S. C.*) is shown by the somewhat diagrammatic sketch (fig. 3) in which the outlines of the valves and the lines of growth are added, though in nature they are seen only under the microscope.

A barnacle removed from its host, with no piece of gill left attached will live for a considerable time with rather infrequent changes of water. One thus kept for 23

days in a flat dish molted twice and at the end seemed quite healthy. The water was changed six times.

Those crabs whose gills are heavily burdened with *Dichelaspis* have less vitality; their movements are sluggish and they are the first to die when brought into the laboratory. This reduction of vitality is not an evidence of real parasitism, but may be explained by the fact that when the cirripeds are present in large numbers much of the gill surface is occupied, gill lamellæ are fastened together, and the respiratory current retarded by them, and the barnacles have the first chance at the water. The health of the host being thus impaired, much harm results indirectly to it, in that it is rendered less able to contend with its enemies or to escape their attacks.

The following is an explanation of terms used in the description:

The *capitulum* incloses the body, and is supported upon the stalk or *peduncle*.

The juncture of the capitulum with the peduncle is regarded as the *base* of the capitulum; the angle opposite this juncture is the *apex*.

Upper means away from; *lower* toward the base.

The *rostral angle* or *umbone* is indicated by the point of union of the two segments of the scutum.

The *occludent* margin of the capitulum extends from the rostral angle to the apex.

All of the carina, except its basal portion, takes part in the *carinal* margin, which is thus approximately at right angles to the base. A tergum, therefore, has, roughly, four sides—upper, carinal, lower, and occludent.

The term *plates* or *valves* (*terga, scuta, carina*) applies to the calcified portions of the valves.

DESCRIPTION.

Darwin (1851–1854) gives this diagnosis of the genus *Dichelaspis:*

Valves 5, generally appearing like 7, from each scutum, being divided into two distinct segments, united at the rostral angle; carina generally extending up between the terga, terminating downward in an embedded disk or fork or cup. Mandible, with three or four teeth; maxillæ notched, with the lower part of the edge generally not prominent; anterior ramus of the second cirrus not thicker than the posterior ramus, nor very thickly clothed with spines; caudal appendages uniarticulate, spinose.

As will be seen from the description given below, the cirriped under consideration belongs to this genus. While the carina, which terminates downward in a fork, usually reaches only to or barely beyond the lower edges of the terga, there is considerable variation in the size and shape of the plates. To this barnacle I have given the name *Dichelaspis mülleri.** After a description of the species there will follow a comparison of *D. mülleri* with other species of the same genus.

Dichelaspis mülleri.

Capitulum barely longer than broad; basal segment of scutum parallel to lower margin of capitulum, narrower than occludent segment and about five-sixths as long; tergum divided very unequally by a notch; lower part of tergum about twice as wide as occludent segment of scutum; carina terminating downward in a fork; mandible with four teeth.

The capitulum is less than 1½ times as long as broad (fig. 2), generally about half as thick as long, sometimes more compressed. In two of the largest specimens the capitula were 3^{mm} in width by $4\frac{1}{2}^{mm}$ in length. Others of a much more usual shape were 3^{mm} by $3\frac{1}{2}^{mm}$. These were unusually large.

The peduncle is 1½ to 3 times as long as the capitulum, but one specimen was found with a capitulum 4^{mm} in length and peduncle 40^{mm} in length. The peduncle is translucent, except when colored by the ova, which, when present, give to a greater or less portion of the peduncle a pink color.

* Named after Fritz Muller, who says in his "Facts and Arguments for Darwin" (English translation, 1869, p. 137) that he has met with a species of *Dichelaspis* in the branchial cavity of *Lupa dicantha* (*Callinectes hastatus* formerly included under this name). He does not describe the form, which may well be identical with the Beaufort species.

The plates are small and well removed from one another. Each *scutum* (fig. 2) is composed of two segments united at the umbone by an uncalcified flexible portion; the occludent segment extends parallel and close to the occludent margin of the capitulum; is widest in the middle, where it is about half as wide as the lower part of the tergum; is narrower near the umbone, and at its upper end is always more or less pointed. The point is directed toward the notch in the tergum and reaches to or a little beyond the lower edge of that plate. Between this segment and the basal segment, which lies parallel to the base of the capitulum, is an angle varying from 70° to nearly 90°. The basal part is narrower and about five-sixths as long as occludent portion, is of a more uniform width, and, though often ending rather bluntly, is usually pointed. It may not reach quite to the points of the prongs of carina, or may overlap them as much as two-thirds their length. One scutum was found with a third narrower segment between the other two and directed toward the upper end of the carina.

Each *tergum* bears a notch on the occludent margin (figs. 2, 4, and 5). If the notch is measured from its apex to the tip of the smaller, occludent portion of the plate, its depth is generally about one-sixth (though it may be one-third) the length of the tergum or less. The lower end of the tergum is in width usually one-half (one-third to three-fourths) the length of the plate; generally it has a smooth outline, though sometimes a little jagged or with a notch. The carinal margin is usually slightly concave; this side, too, sometimes bears more or less of a notch. The upper end is blunt and rounded. Length of tergum two-thirds that of scutum, or one-third that of capitulum. That the two terga of the same individual are not necessarily just alike is shown by figs. 4 and 5; in each figure the dotted line represents the tergum of one side, the continuous line that of the other side, of one barnacle.

FIG. 3.—Diagrammatic sketch of valves.

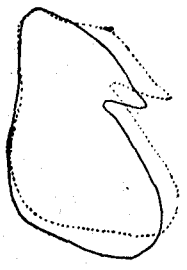

FIG. 4.—Outlines of the two terga of an individual. × 30.

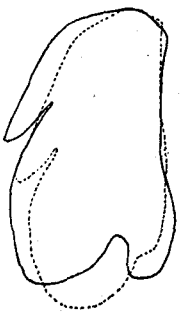

FIG. 5.—Same of another individual. × 30.

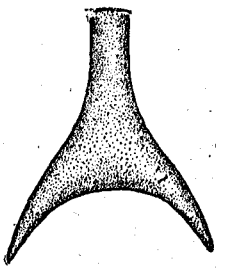

FIG. 6.—Lower part of a carina. × 30.

The *carina* (figs. 2 and 6), terminating downward in a fork, is much widened at the base of the widely separated and pointed prongs. Above the fork the carina is of very nearly uniform width. It ends bluntly, reaching to or barely beyond the lower edges of the terga; in a few cases it extends up between the terga as much as halfway. Within it is convex.

The mouth-parts are well developed. On the *labrum* are two rows of short teeth, set closely together in the middle; the *palpi* are about equal in size to the first maxillæ, and are clothed on and near the inner edge with bristles. The *mandibles* (fig. 7) have four teeth—the lower angle appears as a fifth tooth—the second being farther removed from the first than from the fourth; the lower three teeth are a little less sharp than the first; on the inferior angle are two or three very short teeth and as many stout spines; below it are a number of closely crowded slender spines; the mandible is hairy near the end and bears little tufts of hairs on its outer margin. The *second maxilla* has four spines above the notch (one is small), two slender spines in the notch, and nine or ten below (fig. 8).

The *cirri* of the first pair are removed from those of the second pair and are about half as long. Their rami are equal in length and are thickly clothed with spines. The rami of the second cirrus are of equal thickness and little shorter than those of the sixth. The *caudal appendages*, which are nearly as long as the pedicels of the sixth cirrus, are narrow and of very nearly uniform width throughout. They taper a very little at the end where is borne a tuft of 15 or 20 bristles, the longest of which are a little longer than the appendages. Sometimes other spines are found near the end.

As seems to be the case in most species of the genus, the *penis* is very large, reaching in *D. mülleri* to or beyond the second cirrus. It tapers to a point and has a tuft of short bristles on the end. On each side are scattered bristles in three rows.

COMPARISON WITH OTHER SPECIES OF DICHELASPIS.

Darwin (1851–54) gives five species under this genus, and says of their distribution:

> Eastern and western warmer oceans in the Northern Hemisphere, attached to Crustacea, sea-snakes, etc.; attached to crabs at Madeira and off Borneo; to sea-snakes in the Indian Ocean. The individuals of all the species appear to be rare.

Since Darwin four species have been added to the genus: *D. darwinii* de Filippi ('61 and '61*a*), very abundant on the gills of *Palinurus vulgaris* in the Mediterranean; *D. neptuni* (MacDonald) Hoek (MacD. '69 and Hoek '83), on the gills and respiratory appendages of "*Neptunus pelagicus*, one of the swimming crabs occurring in great plenty at Moreton Bay, Australia";* *D. aymonini* Lessona and Tapparone-Canefri ('74), found on the gills of *Machrochira kaemferi* sent from Japan by Cav. Aymonin,

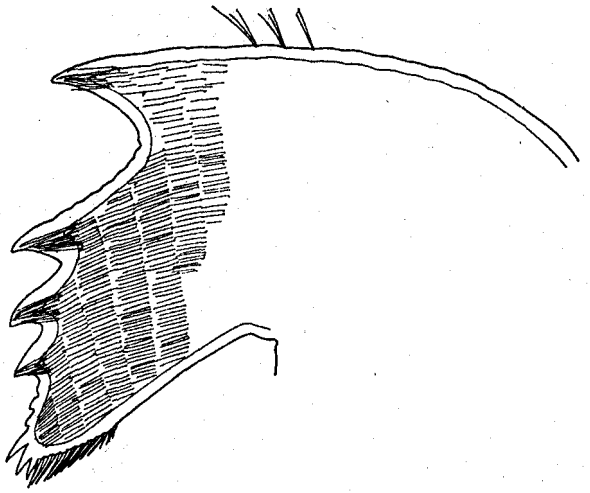

FIG. 7.—Mandible. × 239.

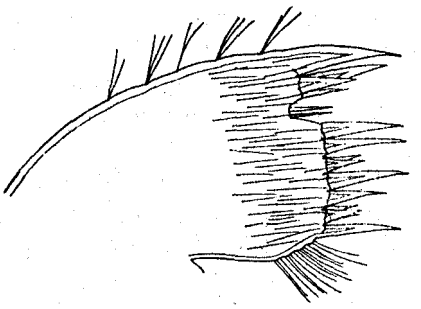

FIG. 8.—Second maxilla. × 239.

then living at Yokohama; finally, *D. sessilis* Hoek ('83), collected by the *Challenger* expedition in the Atlantic near the Azores, attached to a spine of an Echinid from 1,000 fathoms.

I reproduce in part a table for the identification of species, given by Dr. P. P. C. Hoek ('83, p. 48):

1. Carina terminating in a disk ..... *D. warwickii, D. grayii, D. pellucida*
2. Carina terminating in a fork ..... *D. neptuni, D. aymonini, D. darwinii, D. lowei*
3. Carina terminating in a cup ..... *D. orthogonia, D. sessilis*

(2) is further subdivided:

I. Basal segment of scutum directed toward centrum of capitulum ..... *D. neptuni*
II. Basal segment of scutum parallel to lower margin of capitulum.
  (*a*) Capitulum almost as long as broad [*intended for* almost as broad as long?].
    α. Tergum triangular ..... *D. aymonini*
    β. Tergum divided by a deep notch ..... *D. darwinii*
  (*b*) Capitulum more than 1½ times as long as broad ..... *D. lowei*

Thus the form of the carina, the direction of the basal segment of the scutum, and the shape of the tergum, with other points of difference, exclude this barnacle from

*MacDonald describes this form as somewhat between *Lepas* and *Dichelaspis* and gives it the name *Paradolepas neptuni*; but Hoek refers it to the genus *Dichelaspis*.

all of the above species except *D. darwinii* and *D. lowei*.* While *D. mülleri* resembles *D. lowei* in many points, it differs from it chiefly in these important respects:

(1) In shape: The capitulum of *D. lowei* is 1½ times as long as wide, while in *D. mülleri* the length barely exceeds the width. Darwin describes the capitulum as "much compressed." In *D. mülleri* it is one-half as thick as long; little compressed as compared with *Lepas*.

(2) The segments of the posterior cirri have in *D. lowei* eight pairs of main spines; in *D. mülleri* six pairs.

(3) In size of plates: The plates of our species are much smaller and farther removed from one another.

(4) The segments of the scuta are separated by an angle of °70 to 80°, instead of by an angle of 50°.

(5) The carina of *D. mülleri* does not "extend up between three-fourths of the length of the terga" (or very rarely, at most), and the prongs, instead of being separated by an angle, as in *D. darwinii*, are united by an even curve (fig. 6). This latter point, however, may be subject to variability.

D. darwinii is described by de Filippi ('61, p. 76) as extremely common as a parasite in the branchial chamber of *Palinurus vulgaris*, and is found in or near the Bay of Naples. The external resemblance to *D. mulleri* is very close, but striking differences exist between the nauplii of *D. mulleri* and those of *D. darwinii* as figured by de Filippi ('61*a*, tav. XIII, figs. 10 and 11). I need mention only that in his figure of the older nauplius (ibid., fig. 11) the frontal horns are still bent backward parallel to the body, and the spines on the appendages are no longer than those of the just-hatched nauplius (cf. figs. 10 and 11 of *D. mulleri*). Other differences in the life of the nauplii are referred to later.

Those species of *Dichelaspis* having similar habitats to that of *D. mulleri*, and apparently occurring in considerable numbers, are *D. darwinii* on lobsters of the Mediterranean, *D. neptuni* on crabs of the Southern Pacific, and *D. aymonini* on spider-crabs of Japanese waters.

SOME OBSERVATIONS ON THE DEVELOPMENT.†

The peduncle of mature individuals is generally found to be entirely, or in part, of a pink color, this color being due to the ova seen through the translucent integument. After the eggs have passed into the branchial chamber, where they are cemented together into a somewhat saddle-shaped lamella, the external pink appearance extends to the capitulum. Some idea of the condition of the eggs can thus be gained from a glance at the barnacle.

Eggs found in the ovary, which is contained in the peduncle, are roughly spherical in shape. Before passing out of the ovary they attain a diameter of about 0.1 mm.; under a high power such an egg is faintly pink in color, appearing light yellow near the circumference.

When laid the eggs are kept in the branchial chamber, where the first segmentation stages are found. The cleavage begins as total and unequal. Eggs were observed

D. lowei Darwin. Madeira; attached to a rare brachyurous crab; very rare (Darwin, 1851-54).

† In the terminology of the following description of developmental stages, Korsheldt & Heider's text-book ('99, pp. 209-219) and Hoek's report ('84) have been followed. The figures and descriptions in the former are of *Balanus* and of different species of *Lepas*, in the latter of a species of *Lepas*.

that had undergone only the first cleavage; as compared with the ovarian egg they were elongate, narrowed somewhat, and not much pointed at the future posterior end. As the embyro nauplius within is developed the egg becomes more pointed at this end and more square-shouldered at the other.

To understand the arrangement of the nauplial appendages in the egg, fig. 10 of the nauplius as just hatched should be compared with the egg-nauplius of fig. 9. The latter figure is a ventral view of an egg nearly ready for hatching. The entire second appendage with its two rami is seen (figs. 9 and 10, II, II*a*, II*b*), but the third appendage (see fig. 10, III, etc.) is completely hidden in this view by the overlapping second. The first appendage, too, is folded behind the second so that only its proximal portion is seen (fig. 9, I). The œsophagus apparently arches

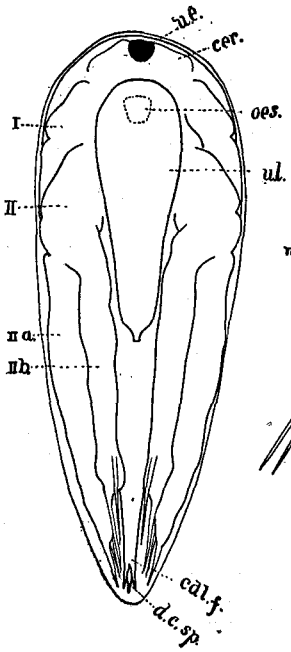

FIG. 9.—Egg nauplius. Ventral view. × 343.

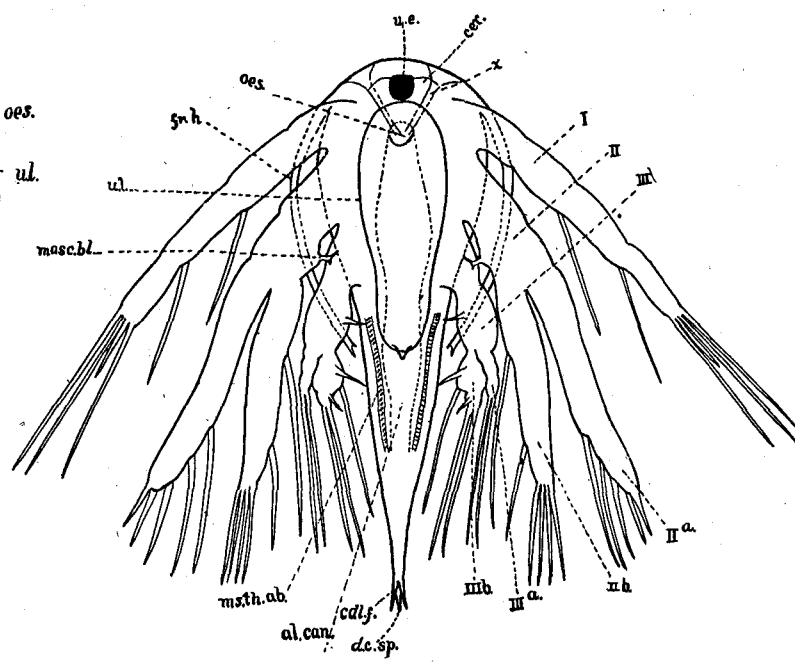

FIG. 10.—Nauplius before the first molt. Ventral view. × 343.

over ventralward, so as to open somewhat on the ventral surface of the large "upper lip" (*u.l.*), the œsophagus being seen in optical cross-section at *oes.* The large nauplius eye (*u.e.*) is closely approximated to the brain (*cer.*). At the posterior end the point of the dorso-caudal spine (*d. c. sp.*) is seen just dorsal to the caudal fork (*cdl. f.*), which terminates the thoraco-abdominal region of the body.

By selecting barnacles whose capitula are tolerably well filled with eggs, and teasing them on a slide, eggs are frequently found from which the nauplius is in the act of hatching. In several cases observed under the microscope the process was as follows: The appendages are pressed out against the shell, while the caudal end of the body is bent ventrally and anteriorly against the shell. Then while the appendages and body are pushed anteriorly as much as possible, the caudal fork slips posteriorly along the shell. These alternate movements, bracing first with the appendages, then

with the caudal part, bring pressure to bear on the anterior end of the shell and on other parts. Rupture was never observed to take place elsewhere than at the anterior end. When the shell has ruptured, with the leverage afforded on all sides, the larva is half out in a second or two; then with a single effort the shell is slipped off from the ends of the appendages and the nauplius swims freely about.

The nauplius in this stage (fig. 10) measures 0.213^{mm} in length. Of the three pairs of swimming appendages the two posterior are biramous, the rami of the third being very short. The first appendage bears 6 spines; the second, 5 and 6 on the anterior and posterior rami, respectively, besides the rudiment of the "masticatory blade" (*masc. bl.*) on the protopodite; the third bears 2 on the anterior ramus, 3 on the posterior, and 2 or 3 short spines on the protopodite and posterior ramus. The spines are straight and without branches that could be seen with the power used.

In addition to the other parts referred to in the description of the egg-nauplius, the alimentary canal (*al. can.*) can here be traced for the greater part of its course. Alongside of it are seen two stout muscles (*ms. th. ab.*) attached anteriorly and dorsally to the carapace in the region of the third appendage; posteriorly they seem to be inserted on the ventral side of the thoraco-abdominal part, and I assume them to be the means of the antero-ventral flexures of that section of the body observed in the act of hatching, and when the nauplius is kept from swimming by light pressure on the cover-glass. The parts indicated by *x* are perhaps muscles to the mouth region, but they were not so clear that muscular structure was evident. The position of the long frontal horns (*fr. h.*) bent posteriorly subparallel to the sides of the body is characteristic of this stage of the nauplius.

To obtain nauplii for study or preservation, ripe-looking barnacles may be selected and teased as described above. It was found better, however, to keep one or two dishes of water, each containing thirty or forty barnacles; the water need be changed only every two or three days. The nauplii aggregate at the surface and toward the brightest light, and can be obtained at almost any time, but, as the first molt occurs very soon, they are almost all in the second stage. De Filippi states that the nauplii of *D. darwinii* remain near the ovisacs for a long time, undergoing further development there ('61, p. 75, and '61*a*, p. 203). The first nauplii of *D. mulleri* often at least, probably as a rule, leave the branchial chamber early, undergoing the first molt outside. Washing out the gill chamber of the crab has never yielded more than a very few nauplii; when they pass from the capitulum of the parent they must be carried at once out of the crab's gill chamber.

The length of time between the hatching and the first molt was not definitely determined, but it was evidently very short—probably usually within an hour. In one case, when a barnacle was teased on a slide and nauplii in the act of hatching were found in the drop on the slide and others already free, two or three vigorous larvæ of the first stage (fig. 10) were transferred to a watch glass of water. Fifteen minutes later a nauplius was observed to have the frontal horns projecting forward, to have the appendages placed parallel to the axis of the body, and to be evidently longer than when first observed. The appendages were pressed more and more closely against the sides, and slight twitching motions of the body and appendages—apparently shrugging first one shoulder, then the other—were accompanied by a gradual lengthening of the body to 0.387^{mm}, by which time it could be seen that the

nauplius was in the act of molting. The dorso-caudal spine and the thoraco-abdominal process could be seen to evaginate as they were drawn out from the old cuticle. In a short time the appendages and body were out except for the long spines; more pronounced movements soon freeing these, the molt was completed. The nauplius in this stage, represented by fig. 11, measures, from the anterior profile of the body to

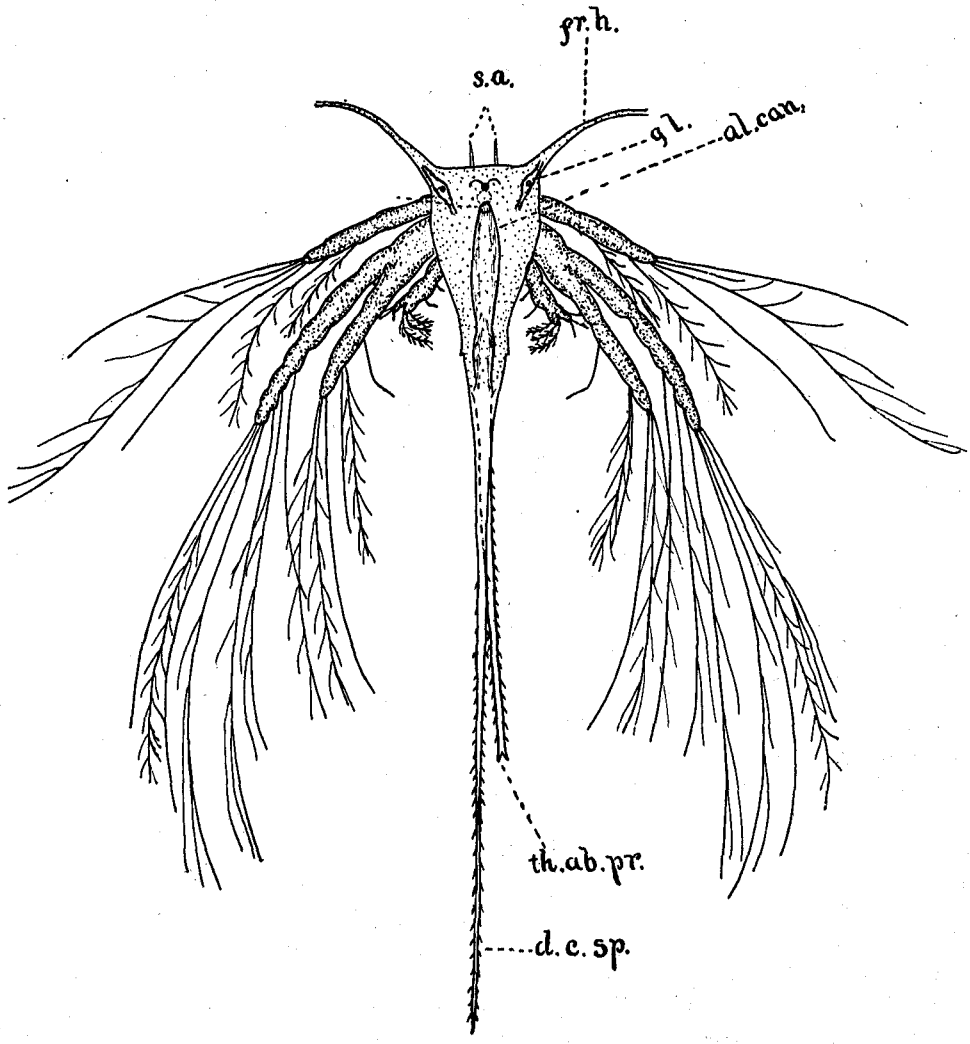

FIG. 11.—Nauplius after first molt. Dorsal view. × 140.

the end of the dorso-caudal spine, 82^{mm}, or about four times its length in the preceding stage. Occasionally a nauplius is found with the evagination of the dorso-caudal spine incomplete, so that the latter appears to become abruptly smaller at some point.

In fig. 11 the position of the "frontal horns" should be noted, as well as the presence of the sensory appendages (*s. a.*) projecting from underneath the head between the frontal horns. Most of the spines are branched; the dorso-caudal spine

(*d. c. sp.*) and the thoraco-abdominal process (*th. ab. pr.*) are barbed. The alimentary canal can be traced. At *gl* is seen the gland cell produced into the frontal horn.

Fig. 12 is a more enlarged drawing of the under surface of the body. The large "upper lip" bears a row of setæ on each side of its distal portion. At the distal end of this row there is a group of setæ about twice as long as the others. Along the axis of the lip there is a band (muscle? or gland?) which loses itself in the horseshoe-shaped dark area about the mouth region. The stout masticatory blade (*masc. bl.*) on the protopodite of the second appendage is to be observed.

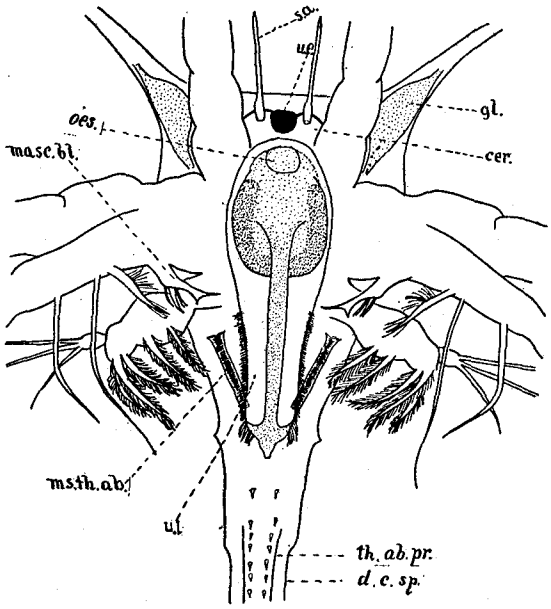

FIG. 12.—Same as fig. 11. Ventral view of body. × 280.

Fig. 13 gives a lateral view of the anal region. The alimentary canal is very much reduced in its most posterior part. The dorso-caudal spine arises just dorsal to the anus (*a*) and the thoraco-abdominal process immediately ventral. The point of insertion of the large muscle previously referred to (*ms. th. ab.*) can be seen, and just at that place there seems to be an articulation, but no observations as to the actual place of flexure were made on the living nauplius.

Several methods were tried to raise or obtain older stages of the nauplius, but with scant success. It was found that the nauplii of the smooth *Balanus* barnacle growing on the carapace of the crab could be raised to the cypris stage by keeping them in an aquarium jar of water, to which was added every day or two some sediment from another jar containing a culture of diatoms, a method suggested by Dr. Caswell Grave. The interval between the first and second molts and that between the second and third molts were, with *Balanus*, one to two days each. This and other aquarium methods were used with *Dichelaspis*, but only once was a third stage reached. In this case the aquarium was started August 22; on August 29 the nauplii were found to have undergone at least a second molt; they differed from the nauplii of the second stage little, except in size, the length having increased to 1.13^{mm} with the other proportions likewise larger.*

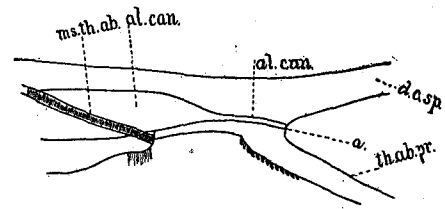

FIG. 13.—Same as fig. 11. Lateral view of posterior part of alimentary canal, etc. × 280.

* Professor de Filippi states that he failed to get the nauplii of *D. darwinii* further than the second stage of their development, and he argues from this and from other facts (form of the larva, means of locomotion, etc.) that the nauplial life is very long ('61, p. 75, and '61*a*, p. 205). But it is quite possible that further effort with Grave's method will show that the metamorphosis does not take an exceptional length of time.

In two or three crabs having a large number of barnacles of all sizes, minute white specks on the gills, when examined with a lens, proved to be attached cypris or stages between the attached cypris and the typical lepadide form.

Fig. 14 is a sketch made from an attached cypris that had been mounted in balsam; the gill had been torn from the adhering antennæ (*ant.*). The valves of the very convex and bilaterally compressed shell are continuous dorsally (*sh.*); their ventral edges are connected by the adductor muscle (*ms. ad.*) and are apposed except where the adhering antennæ are protruded in front, and posteriorly where the branchial opening, through which the thoracic feet (*th. l. I, VI*) are protruded, admits the passage of water into and out of the branchial chamber. The shell is lined by the mantle (*ml.*); anteriorly, between the mantle and the shell is seen a thick layer of loose tissue (*y*), which is perhaps a thickening of the mantle, or possibly is due to imperfect preservation; while it is not figured by Hoek or Claus (in Korsheldt & Heider) it is in all of my specimens. The dorsal infolding (*inv. d.*), separating the part that is to be the capitulum from the portion from which the peduncle is derived,

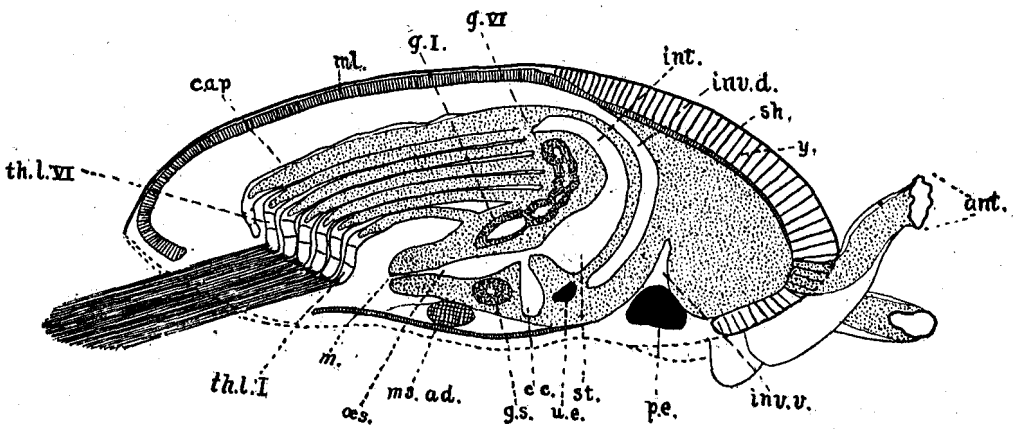

FIG. 14.—Attached cypris. Optical section, with some projections ×168. (Drawing from mounted specimen.)

is well developed. Just anterior to this is the ventral invagination (*inv. v.*), causing the peduncular portion to be bent upon itself. In this infold are the large paired eyes (*p. e.*) left behind by the withdrawal of the stalk integument, but still attached to the cuticle, and later to be thrown off (Korsheldt & Heider '99, p. 218). The unpaired nauplius eye (*u. e.*) is seen near the ventral end of the dorsal invagination, instead of anterior to the cæca as in *Lepas* (Claus's figure of the cypris of *Lepas pectinata* in K. & H. '99, p. 216). The mouth at the top of the "oral cone" leads by the œsophagus (*œs.*) into the enlarged stomach (*st.*) from which the intestine (*int.*) proceeds. Opening into the œsophagus are a pair of cæca, *cc*, (Hoek); in Claus's figure a similarly placed cavity is called the liver. Ventral to the alimentary canal is seen the chain of thoracic ganglia (*g. I* to *g. VI*) without commissures; the first is much the largest. Just above the œsophagus from this one is the supraœsophageal ganglion (*g. s.*).

Specimens in all stages of the metamorphosis from the attached cypris to the perfect lepadide adult can be found on the crab gill.

ABBREVIATIONS USED WITH FIGURES.

a .....anus.
al. can ....alimentary canal.
ant .....adhering antennæ.
c.....carina.
cc.....cæcum.
c. ap .....caudal appendage.
cap .....capitulum.
cdl. f.....caudal fork.
cer.....brain.
d. c. sp ....dorso-caudal spine.
fr. h.....frontal horn.
g. I, g. VI. ventral ganglia.
gl .....gland cell.
g. s.....supraœsophageal ganglion.
int.....intestine.
inv. d ....dorsal invagination.
inv. v ....ventral invagination.
m.....mouth.
masc. bl ..masticatory blade.
ml .....mantle.
ms. th. ab. thoraco-abdominal muscle. (?)
ms. ad ...adductor muscle.
œs .....œsophagus.
ov .....ovary.
ped .....peduncle.
p. e .....paired (cypris) eye.
s. a .....sensory appendage.
sc.....scutum.
sh.....shell.
st .....stomach.
t.....tergum.
th. ab. pr ..thoraco-abdominal process.
th. l, I–VI. thoracic limbs.
u. e .....unpaired (nauplius) eye.
u. l.....upper lip.
T, S, C ....uncalcified valves (terga, scuta, carina).
x, y .....(see pages 408 and 411, respectively.)
I, II, III..first, second, and third nauplial appendages.
IIa, IIb...anterior and posterior rami of second appendage.
IIIa, IIIb.anterior and posterior rami of third appendage.

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