

ment and generally nothing remains. The lobes of the maxillæ (fig. 2 *c*) have lost all their numerous setæ found in the male (fig. 1 *d*) and in immature specimens, and the bifid outer lobe has been shortened. Besides, all these mouth-parts have the muscles considerably or much reduced; but the muscles to the mandibular palps, still shaped as in the males, have been preserved. The hypopharynx has been very reduced (fig. 2 *e*), being only about half as large as in the male (fig. 1 *f*). The maxillipeds are still more interesting; in the female with brood (fig. 2 *d*) the four distal joints have been reduced in size, especially the lobes are much shorter and have lost all the setæ found in other specimens (fig. 1 *e*); the lobe from second joint has lost its distal setæ, but the two proximal joints with the epipod are, on the contrary, expanded to such a degree that their joint surface is between twice and three times larger than in the male of the same size; some of the muscles in the palp have been reduced in size and all are lighter in aspect, while the musculature moving the expanded proximal portions is well developed. As in *Cymothoidæ* the first joint of the female maxillipeds has a thin free ciliated plate directed backwards; the second joint is shorter than in the male, but much expanded outwards, and the free outer margin furnished with long plumose setæ not found in the other sex. We can therefore not say that the mouth-parts as a whole have been reduced in adult females; the proximal half of the maxillipeds has, on the contrary, been developed as a special instrument for producing a current of water through the marsupium, while the distal half of the maxillipeds and the outer mouth-parts, the mandibular palps excepted, have been strongly reduced, and are even unfit for use. The direction of the current must, of course, be observed in living animals; judging from various reasons, I am, however, convinced that it goes from behind forward.

The genera in which the females with brood have the mouth-parts metamorphosed are enumerated above. The alterations are essentially as in *Cymodoce*, but it must be men-

tioned that in *Cerceis* and especially in *Dynamene* (*Næsa*) *bidentata* (Mont.) I find the differences between mouth-parts in adult females (figs. 4*a*–4*e*) and other specimens (figs. 3*a*–3*d*) still more astonishing. In both genera more than the proximal half of the lower outer surface of the female mandibles is so completely fused with the skeleton of the head that even a suture cannot be detected when the mandible with the adjoining firm portion of the head is taken out and examined under the microscope, while the outer margin itself of the mandible protrudes above the skeleton mentioned and is indicated on figs. 4*a* and 4*c* by dotted lines. Furthermore, the distal half of the mandible has not only lost every vestige of an incisive dark-coloured part, lacinia and molar process, but it shows a very different shape (figs. 4*a* and 4*b* as compared with fig. 3*a*), being distally rounded, with fine and short hairs at the margin. Maxillulæ and maxillæ have not only lost all setæ or spines, but have been much reduced in size (figs. 4*c* and 4*d* as compared with figs. 3*b* and 3*c*). The maxillipeds (fig. 4*e*) have the expansions from epipod and from first and second joints much larger than in *Cymodoce*, while the lobe from second joint has been strongly reduced in size, the joints of the palp somewhat reduced but yet with some short setæ on the lobes.

It is easy without dissection to perceive whether the maxillipeds of an egg-bearing female belonging to this family have been altered or have preserved their normal size and shape. The question whether the mouth-parts have been metamorphosed can generally be decided without difficulty by looking at the end of the mandibles, whether they are very dark or yellowish. But an anomaly must be mentioned here. Of ten females with marsupium of *Cymodoce pilosa* (M.-Edw.) eight had all their mouth-parts altered as described above, but in two specimens the curious feature was observed that the maxillipeds and maxillæ had been completely metamorphosed; while the alterations in the two anterior pairs of appendages were less complete. In one of these specimens the end of the mandibles had kept their dark colour and the

outer lobe of both maxillulæ their spines, while lacinia mobilis, etc., had disappeared; in the other specimen only a little of the dark colour on the end of the mandibles and the spines on one of the maxillulæ were preserved.

Giard and Bonnier have shown that in the Bopyrinæ the females have the first joint with its epipod and second joint of the maxillipeds strongly expanded and adapted for producing a current of water. Schiödte and Meinert pointed out that in the Æginæ (*Æga*, *Rocinela*) the marsupial plates cover the entrance to the mouth, so that egg-bearing females cannot take any nourishment; females with marsupium have never been found on fishes, but are not uncommonly captured with dredge or trawl. In 1890 the present author showed that in the Æginæ and in all other Cymothoidæ, sens. lat. (*Cirolana*, *Corallana*, *Æga*, *Nerocila*, *Cymothoa*, etc.) the adult females have the two proximal joints—with the epipod—of the maxillipeds strongly expanded and evidently adapted for the same purpose as the corresponding part in female Bopyrinæ, but in no form any real reduction of the other mouth-parts was observed. In several genera of Sphæromidæ we have a similar expansion of the proximal half of the maxillipeds, but their distal half and all the other mouth-parts are reduced in a most peculiar way, and so strongly that the animals cannot take any food at all. Such metamorphosis of the mouth-parts in females carrying brood is, as far as I know, without parallel, not only among other Arthropods, but among animals of every other series.

Finally, there is the question as to the systematic value and biological bearings of this metamorphosis. In Limnoriinæ, Plakarthriinæ, and probably in all platybranchiate Sphærominæ (I have examined females with brood of representatives for the four sections constituting this group) the mouth-parts are similar in both sexes; in all these animals the end of abdomen has either a rather shallow notch (*Plakarthrium*) or a notch not visible from above (*Campecopea*) or, generally, no notch. The hemibranchiate Sphærominæ are naturally divided into two sections, Sphæromini and Cymodocini; in

Sphæromini the females have no notch at the end of abdomen and the mouth-parts normal as in the males, while in Cymodocini the same sex has a distinct, most frequently bilobed notch at the end of abdomen, and the mouth-parts metamorphosed; it may be added that no other distinguishing character between the two sections could be discovered. In the eubranchiata Sphærominæ the case is more difficult. In this group the end of abdomen is a little emarginate in one genus, *Cassidinopsis* (n. gen.), in all other genera furnished with a notch of very different shape; in some of the genera the female mouth-parts are normal, in others highly metamorphosed. Nevertheless, there is evidently a connection between the presence of metamorphosis of the mouth-parts and the development of the abdominal notch. In the female *Dynamene bidentata* (Mont.), and especially in another species of the same genus, a species constituting a transition stage to *Næsicopea* (Stebb.), the mouth-parts are metamorphosed and the abdominal notch very deep and looking much upwards (it is, besides, widened at the bottom and very constricted in the distal part); in *Cerceis* (M.-Edw.) the notch is rather deep and turned upwards; in *Paracerceis* (n. gen.) moderately large and deep and turned backwards, but the end of abdomen is somewhat produced. In both these genera the mouth-parts are metamorphosed. In *Scutuloidea* (Chilt.) the notch is less deep than in the preceding genera, in *Cassidinopsis emarginata* (Guér.) only a rather slight emargination is found; in both these genera the mouth-parts are normal; in a female of *Amphoroidea falcifer* (Thoms) with the marsupium well developed, but without brood, the mouth-parts are normal and the notch as in *Scutuloidea*. Difficulties are found in *Cymodocella* (Pfeff.) and *Dynamenella* (n. gen.); in the former genus the notch is very well, though peculiarly, developed, and the mouth-parts normal; in *Dynamenella* the female notch is about as in *Paracerceis*, but the mouth-parts seem to be normal. For want of material I cannot further prosecute this topic, but in spite of the difficulties mentioned it can be stated that in the

genera with the notch rather feebly or very feebly developed the mouth-parts are normal, in the genera with the notch rather deep or very deep and looking upwards the mouth-parts are metamorphosed, while in a few genera with the notch looking essentially backwards and at least of moderate depth the mouth-parts vary as to the feature in question. Considering the whole family, we arrive at the result that in all forms with the abdominal notch shallow or wanting in the females the mouth-parts are not metamorphosed; in the large majority of forms with the notch well developed, and in all forms having either a rather deep or very deep notch looking essentially upwards, or a notch divided by a mesial process, the mouth-parts are metamorphosed; while only at most two genera with the notch well developed remain as being—at least for the present—apparent exceptions from the rule. Some remarks on the significance of the notch and on the remarkable connection between the shape of the end of the abdomen and the development of the mouth-parts in egg-bearing females are set forth in Chapter V.

IV. SEXUAL DIFFERENCES.

In most genera the adult males are larger, sometimes even much larger, than the females, in some nearly of the same size; in *Cassidinidea ovalis* (Say) I have found the ovigerous females larger than an adult male. Of *Plakarthrium typicum* (Chilt.) I have seen several specimens of very different sizes from the same locality; among the smaller specimens I found an adult male and a female with the marsupium complete, while a considerably larger specimen had rudimentary marsupial lamellæ.

The adult males of all genera, *Dynamene* (*Næsa*) (Leach) and *Ancinella* (n. gen.) excepted, possess an oblong or very elongate, generally narrow, flat stylus, the "appendix masculina," proceeding from the inner margin—either near its base or sometimes at the end—of the endopod of plp.²; ¹

¹ On the following pages some abbreviations are generally used, viz. plp.¹, plp.², plp.⁵, for first to fifth pairs of pleopods, endp. for endopod, exp. for exopod, urp. for uropods.

this stylus is in reality (compare my paper on the "Asellota," 1905) the second joint of that endopod. On endp. of plp.¹ no trace of an auxiliary stylus is found; in *Campecopea hirsuta* (Mont.) I found a short process, not marked off by articulation, proceeding from endp. of plp.³ near its end, while the appendix on plp.² is exceedingly long, and originates at the base of endp. Of three European species of *Dynamene* (*Næsa*) (Leach) I have inspected in all several adult males, but in none of them an appendix masculina was found, and the inner margin of the endopod of plp.² is simple, not thickened. In adult males of *Ancinella profunda* (n. gen., n. sp.) no appendix masculina is found, but the inner margin of endp. of plp.² is considerably thickened, with a longitudinal groove on the inner side of this thickening; in the female this margin is of normal inconsiderable thickness without any groove.

At least in the sub-family Sphærominæ, the appendix masculina does not appear before the animals are nearly full-grown, but it is easy by another character to distinguish males even when not half-grown from immature females. As is known, the males have two processes close together on the seventh thoracic sternite; these processes, which are tubes containing the terminal portion of the ducts from the genital organs, are sometimes rather short (*Tecticeps*), sometimes rather long (*Dynamene*), very long (*Cymodoce pilosa*), or even exceedingly long (*Dynamenella bermudensis*); they are found in all genera. Of *Cymodoce pilosa* (M.-Edw.) I collected at Siracusa a rich material consisting of both sexes in very different size and age; an unusually small adult male measures 10.7 mm., the largest male 15 mm. in length, but in numerous immature males measuring from 9.7 to 13.7 mm. no vestige of the appendices on endp. of plp.² can be found, while the processes at seventh thoracic sternite are shorter than in the adults, but yet very distinct. The marsupial lamellæ are mentioned above. The length of flagellum of antennulæ and antennæ in the two sexes has not been specially examined, but at least sometimes differences are well marked.

In several genera, viz. *Sphæroma* (Bosc), *Cymodocella* (Pfeff.), *Scutuloidea* (Chilt.), *Amphoroidea* (M.-Edw.), *Cassidinopsis* (n. gen.), *Cassidinidea* (n. gen.), *Leptosphæroma* (Hilg.), *Limnoria* (Leach), and *Plakarthritis* (Chilt.), there are at most rather slight sexual differences in shape of thorax, abdomen, thoracic legs or uropoda; but in some of them the males are larger than the females. In other genera, as *Isocladus* (Miers), *Zuzara* (Leach), *Cymodoce* (Leach), *Cilicæa* (Leach), *Ciliacæopsis* (n. gen.), *Bregmocerella* (Hasw.) *Dynamene* (Leach), *Paracerceis* (n. gen.), adult specimens of the two sexes differ exceedingly from each other in various respects; the males are distinguished by processes on sixth or seventh thoracic segments or on the first portion of abdomen, shape of uropoda, frequently shape of the end of abdomen, etc., in *Bregmocerella* even processes on the head. Leach established some genera on adult males, referring the majority of females and young specimens to *Sphæroma* or *Dynamene*, the latter of which was established exclusively on such specimens. Similar confusion is still found in papers published in the last six years. In 1873 Hesse stated the species of *Sphæroma* are female of *Cymodoce*, *Dynamene* females of *Næsa*. As to the European forms of *Dynamene* it is quite correct (exotic forms referred to *Dynamene* cannot remain in this genus), but regarding *Sphæroma* the case is more complicated; among the European forms referred to the latter genus, those without terminal notch are well-founded species—with males and females—of *Sphæroma* itself, while those possessing an abdominal notch are females or young males of *Cymodoce* or other genera. Miers has correctly referred females and males of some exotic species of *Cymodoce*, but he did not undertake a special study of the family. It is scarcely necessary to give here a detailed account of the sexual differences alluded to in these genera; the notes in the systematic chapters may be sufficient. But one thing must be added. At Sicily I collected a rich material of three species of *Cymodoce*; while the adult males were not difficult to separate, it was only after a