STUDIES ON ARTHROPODA

II.

BY

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ON THE COMPARATIVE MORPHOLOGY OF THE APPENDAGES IN THE ARTHROPODA

A. CRUSTACEA

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PREFACE

In 1893, thus more than thirty years ago, the present writer published a preliminary communication: Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen und Insecten. Zoolog. Anzeiger Bd. XVI, pp. 193—198 and 201—212. 1893. (Translated in Annals and Magaz. Nat. Hist., 6. Ser., Vol. XII, pp. 417—434. 1893). It was the results of investigations conducted during several years, but frequently interrupted by more pressing undertakings. The paper contains no figures, and the text is divided into a number of paragraphs, shaped as abstracts or resumés. Many of its statements differ substantially from those of most or all earlier authors. I am glad to be able to say that many of the new results have been accepted by a number of Zoologists, some of the statements being admitted by Carcinologists, other by Entomologists or Zoologists investigating points in the structure of lower Insects or Chernetida. But in spite of the long period passed away since the publication of that article no author has attempted to follow its lines from order to order in Crustacea and Insecta. Consequently I will now begin to publish the more detailed treatise accompanied with figures and indirectly promised in 1893.

Since that year I had several times begun to draw figures to the work, and some among these have been published in a few of my carcinological papers. But I could not find the time necessary for the final task before in 1923. And the treatise proved itself to be so large that I determined to divide it into two parts, the first containing only the Crustacea; the second, which shall deal with Insects, Myriopoda, and Arachnida, may, I hope, be published in about three years; a number of figures to that second part are ready. I am sure that a number of years ago I had not been able to write the work as well as now, because the material at my disposal is at present much richer than f. inst. in the year 1900, and during the thirty-one years passed away I have widened my knowledge and experience very much. I am glad to be able to state that only a single point — and that not even of the first importance — in my preliminary paper was shown to be erroneous, viz. my suggestion that the claw of the legs in Crustacea Peracarida may be a real joint; on the other hand I can now add a good number of hitherto unnoticed facts as proofs for the general ideas of the composition of the appendages, and besides point out many other hitherto unnoticed features of morphological interest.

I may beg the Inspector of the Department of Arthropoda in our Zoological Museum, Mag. sc. William Lundbeck, to accept my sincere thanks for the liberality with which I have been allowed to use the rich collections under his care. Finally I wish to express my warm gratitude to the managing Committee of the Rask-Ørsted Fund for having allowed me the sum to defray the expenses of publication of the present paper.

INTRODUCTION

On Principles, Nomenclature, Methods, and Literature.

The contents of this chapter refer not only to the present first half, but partly to the whole work. I may begin with elucidation of the ideas on which the investigation of the mouth-parts is founded; maxillulæ, maxillæ, and maxillipeds in many Malacostraca are excellent starting points.

Principles. — Already in the resumé on the Crustacea in "Dijmphna-Togtets zoologisk-botaniske Udbytte", 1887, I wrote (p. 509) on the mouth-parts in Malacostraca: "Je prends mon point de départ des pattes-mâchoires. On y voit facilement que chaque lobe au service de la bouche est un prolongement latéral, un godet, d'un article de la patte-mâchoire. Ce lobe peut être un simple prolongement latéral, ou bien il est séparé de l'article en question par une mince membrane articulaire de manière à se présenter comme un article indépendant. . . . . Souvent on voit sans peine dans les mâchoires que le lobe est le prolongement latéral d'un article; parfois, cependant, le lobe est devenu si puissant et a pris un développement si singulier, qu'on a assez de peine à constater sa genèse. Quoi qu'il en soit, je crois qu'on peut poser en principe que les lobes doivent toujours s'être produits comme des prolongements latéraux des articles de la mâchoire. It faut donc examiner avec la plus grande exactitude possible quelles sont les pièces chitineuses qui se trouvent à la face dirigée en bas et dans le bord extérieur d'une mâchoire — dans la face dirigée vers la tête de l'animal, la chitinisation est le plus souvent assez défectueuse —; ensuite il faut tâcher de reconnaitre l'article de la mâchoire auquel est attachée la chitine de chaque lobe, pour bien déterminer, par cette voie, chaque élément de cet organe buccal qui a subi tant de transformations."

In the preliminary paper (1893) named in the preface I said in the main the same on the maxillipeds, and continued: "Ebenso müssen die Kauladen der zwei Maxillenpaare als Processe von den Seiten der einzelnen Glieder des Endopodits des Kiefers aufgefasst werden; diese Seitenprocesse werden oft in Verhältnis zu den Gliedern ausserordentlich gross, sehr verlängert, von denselben durch ein Gelenk abgesetzt, dann mitunter auch quer getheilt, und werden dadurch bei einer mehr oberflächlichen Beobachtung nur schwierig verstanden. Es ist daher nothwendig die Glieder in dem Endopodit der Maxillen an durchaus gereinigten Praeparaten zu finden, und gleichzeitig aufzusuchen, von welchem Gliede die Chitinplatten der Kauladen ausgehen. Dieses scheint mir das einzige, sichere Verfahren." The same principles must be applied at the investigation of the mouth-parts not only in Crustacea but in all Arthropoda.

Nomenclature. — In the last quotation the name "Endopodit" is used for the main stem of the appendage, while in the present paper I apply the name "sympod" to its proximal part typically consisting of three joints; to the distal joint of the sympod the endopod itself and the exopod, if existing, are attached. In 1893 I wrote also: "Wahrscheinlich bestehen die Gliedmassen der Crustaceen ursprünglich aus einem Stamm und zwei äquivalenten Ästen"; consequently I considered this interpretation as a probability, not as an absolute certainty. Today I adhere to the same view; it seems to me that numerous facts let one think that the typical appendage in Crustacea (Trilobita included) is biramous, consequently consists of sympod, endopod and exopod; the result is that epipod, præepipod, branchiæ, marsupial plates, are appendices, outgrows, of secondary nature on the two proximal joints of the sympod. But it seems to me impossible to deny the possibility that the exopod may be analogous with the epipod, and if so the primitive appendage is uniramous.

Zoologists generally use the names endopodite, exopodite, epipodite proposed by H. Milne-Edwards, but they seem to me to be unnecessarily long, and I apply endopod, exopod, epipod. The names "protopodite" or "basipodite" used by authors for the proximal unbranched portion of the appendages are discarded, as the name "sympod" is better, especially as it cannot be misunderstood. Instead of the older names for the joints in the legs of Decapoda, viz. coxopodite, basipodite, ischiopodite, etc. I use the terms: coxa, basis, ischium, merus, carpus, propodus, and dactylus. Besides I use the term præcoxa for the first joint in the typically three-jointed sympod, and the name præepipod for the external plate or appendices found on this joint in Anostraca, in many Cladocera and Ostracoda, in the anterior pairs of thoracic legs in Stomotopoda, etc. And the name præischium is proposed for the first joint of the endopod in Syncarida, Peracarida, etc. Whether the marsupial lamellæ in the females of the Peracarida may be considered as a kind of epipodial nature is difficult to decide, but it seems to be probable.

Methods. --- As to my methods of investigation a little may be said. Dissection of Entomostraca, smaller Malacostraca (Insects, etc.) by very small and narrow knives has been much used. But care must be taken that at the removal of mouth-parts not only the most proximal part of each appendage but frequently even a little of the sternal chitine of the head is taken off in order to see the quality of the insertion of first joint and to be sure that the whole appendage has been separated from the head. When the appendage is not too small, the examination of its surface in a half-dried condition under the single microscope is frequently useful in order to see lines, sutures, limits between submembranous and harder chitine. Together with appendages in the natural state specimens cleaned in caustic potash have been generally used. Ostracods with the shell removed or Copepods with their back cut open or removed are put into a solution (only 15 per cent.) of caustic potash and remain there for one or two days; then the animal or the appendage is put in glycerine with water and its nearly dissolved contents so to say pumped out. When the entire animal is cleaned in this way, the appendages are then cut off and examined separately. In many cases it is then possible to see the limits of the joints exactly, to discern the pieces of firmer chitine from the membrane between them, to discover things not visible without such præparation; as far as possible both transmitted light and light from above on the surface has been used, of course not contemporaneously. Boiling in caustic potash acts frequently too violently on the skin of Crustacea, while it can be used for Insects. When a moulded skin of a Crustacean can be obtained, it is frequently an excellent object of investigation. Specimens in which the skeleton is still well preserved but muscles and other contents half dissolved can be cleaned by manipulations of various kind in diluted glycerine, with the result that the skeleton is better preserved for study than in specimens put in potash. Instead of caustic potash a not too strong solution of "Eau de Javelle" can be used; it acts speedily, in a few minutes, but it is dangerous to apply and must be watched carefully. The microscopic preparations may be laid in glycerine, but this liquid makes sometimes the fine lines in the chitine of small appendages rather indistinct, and therefore I not unfrequently put the appendage in a saturated solution of acetate of potassium (CH_3COOK). Sections cut by microtome have not been used, and I may dissuade Zoologists from that method at the study of topics dealt with in the present paper.

In some cases, as f. inst. at the legs of *Paranebalia*, or the carpus and propodus in the legs of the Mysidæ, the study of the musculature has been most useful for the morphological judgment. But most frequently it is quite unnecessary for the aims of the present treatise, viz. recognition of chitinous elements, the joints and the lobes, in the appendages. In dealing with the literature on the Leptostraca some remarks are set forth on the musculature. (At the study of the mandibles in Insects and Myriopoda and their comparison with each other and with the mandibles in Malacostraca the musculature is of great importance.)

Literature. — The literature dealing with or at least touching morphological features and their interpretation in the appendages of Arthropoda is enormous, but yet the more general parts of our knowledge as to that topic is far behind the state of the comparative morphology of the skeleton of limbs, jaws, etc. in Vertebrates from fishes to Simiæ — it is my hope to be able to fill a part of the lacunæ of more general nature. It would be nearly impossible without doubling the size of this treatise to give a somewhat detailed account of the progress of knowledge, of the opinions of various authors as to all the questions treated here; besides I consider it to be of slight or no value to enumerate all opinions, arrange them against each other, point out their steps forwards, criticize their deficiencies, etc. In most cases I make only a small selection of the most important contributions. But care is taken to quote statements or refer to drawings of earlier authors, who have described or figured some interesting feature correctly but in opposition to the general opinion not only then prevailing, but frequently adopted down to the present time. — In the following portion of this chapter only literature dealing with types of some or all sub-classes of the class Crustacea is mentioned; while that on the other classes of Arthropoda is postponed to the second part of my work; more important papers dealing only with a single sub-class or an order of Crustacea, and of interest to the contents of my task, are quoted at each group in question.

Several works of G. O. Sars are referred to in following chapters, because on numerous figures drawn by that eminent Carcinologist features of interest are often seen, though in many cases not mentioned in his text. Sars never cultivated comparative morphology (in the stricter sense of the term) from order to order, but he is a most excellent observer, and his innumerable figures of animals of most orders of Crustacea are an inexhaustible source of information as to modifications in the shape and equipment of appendages.

Claus, C.: Neue Beiträge zur Morphologie der Crustaceen (Arbeiten zoolog. Institut Wien, Bd. VI, I. 1885) may be briefly mentioned. The paper is on the whole rather discursive with phylogenetic speculations; one of its more important topics, viz. on the paragnatha, is quoted and criticized later on. But as to other particulars, especially the branchiæ, etc., in various Decapoda and their larvæ, it contains most useful matter.

Thiele, Joh.: Betrachtungen über die Phylogenie der Crustaceenbeine. (Zeitschr. wiss. Zool. Bd. LXXXII, 1905). It is deemed necessary to mention this paper, though I must say that I have not found in it any new and correct statement on any structural feature worth notice. The author lays stress on the musculature, and muscles are conspicuous on all his 18 figures, but f. inst. on his drawing of a thoracic leg of *Paranebalia longipes* the four muscles most important as to the number of joints in the endopod are overlooked (see his fig. 2), and on his drawing (fig. 7) of a thoracic leg of *Mysis* (*Praunus*) *flexuosa* the muscle in the penultimate joint is wrong. When he says

(p. 466): "Hansen scheint durchaus mehr Glieder zu sucken, als andre Zoologen annehmen", this fact may be due to errors committed by "other Zoologists" as Boas, Claus, Giesbrecht, Thiele — nearly all German authors; it is not any fault of mine, that they did not find the existing number. Thiele's phylogenetic speculations, especially those on the derivation of the Crustacean leg from the parapodium in Annelids, may perhaps be of interest to people who cultivate that cheap and easy-going occupation to fill up the enormous gaps in our knowledge with unfruitful constructions, instead of diminishing some of the gaps by careful, critical, and frequently difficult investigations based on a broad knowledge of animals and their structure acquired during a good number of years.

Borradaile, L. A.: On the Structure and Function of the Mouth-Parts of Palæmonid Prawns. (Proc. Zool. Soc. London, April 1917). — A considerable part of the contents of this paper (f. inst. the author's study of corpus mandibulæ) is outside the topic dealt with in the present treatise, but besides he attempts to give general morphology of appendages in the sub-classes of Crustacea, not only of the mouth-parts but also of the thoracic limbs in Branchiopoda, *Nebalia*, *Anaspides;* most of his 51 figures represent entire appendages in order to show their joints. But in extremely few cases his interpretations of the parts or joints of an appendage agree completely with mine, and I find few if any instance in which his interpretation of any joint in an appendage is new and also correct. The author did not as a rule undertake an investigation of the chitinous plates or pieces of a maxillula or maxilla; generally he draws the outline of the appendage, inserting the articulations which it is nearly impossible to overlook, and then he makes much more use of speculation than of investigation; besides he examined too few forms of nearly all orders. In very few instances his paper is quoted for approval or criticism on the following pages; I find it quite superfluous to spend twenty or thirty pages on detailed critical elucidation.

Finally two hand-books must be mentioned. Dr. *W. T. Calman's* treatment of the Crustacea (1909) in Ray Lankester's A Treatise on Zoology, Part VII. Appendiculata. Third Fascicle, is very good. As to our general knowledge at the present moment of the sub-classes and orders, and as to features of secondary importance the reader is frequently referred to this careful author; I may even add that I deliberately omit many points, as to which I was unable to alter any view or add anything worth mention to Calman's statements; the reader may then look for information in his book. The classification followed is also that given in his hand-book, excepting that I add the Trilobites. — *W. Giesbrecht's* treatment of the appendages in Crustacea (1913) in Dr. Arnold Lang's "Handbuch der Morphologie" is as to the appendages rather unsatisfactory in many points. It is on the whole only a very industrious compilation of opinions prevalent before 1886, and it will be difficult to point out any new and at the same time correct view in any interpretation of any appendage.

SUB-CLASS BRANCHIOPODA

Gerstaecker, A.: Die Klassen und Ordnungen der Arthropoden. Bd. V. I. Crustacea (Erste Hälfte). 1866—1879.

Simon, E.: Étude sur les Crustacés du Sous-Ordre des Phyllopodes. Ann. Sociét. Entom. France, 6e Sér., Tome VI. 1886.

Sars, G. O.: Fauna Norvegiæ. Bd. I. Phyllocarida og Phyllopoda. 1896.

Behning, A.: Studien über die vergleichende Morphologie sowie über die temporale und Lokalvariation der Phyllopoden-Extremitäten. 1912. Internationale Revue der gesamten Hydrobiologie und Hydrographie. Bd. III. Biolog. Suppl.

The animals of this sub-class are generally considered to occupy a primitive position among Crustacea. This may be true in several respects, but in all types at least some pairs of the appendages and frequently most or all pairs present a shape which it is difficult to look upon as primitive, as they have been altered or reduced to an excessive degree. The thoracic appendages are in most cases lamellar and their joints far from easy to point out; nevertheless they present some primitive features of great importance. Animals of the order Notostraca are the best starting point for the understanding of the composition of the legs in the whole sub-class.

Order Notostraca.

(Pl. I, fig. 1).

Huxley, T. H.: Anatomy of Invertebrate Animals. 1877.
Lankester, E. Ray: Observations and Reflexions on the Appendages and on the Nervous System of *Apus cancriformis*. Quart. Journ. of Microsc. Science. Vol. XXI. New Ser., 1881.

Only two genera, *Apus* and *Lepidurus*, are known, and they are closely allied. The type examined by me is *Lepidurus productus*.

The *antennulæ* are small and simple. — The *antennæ* are wanting in this species (at least in the specimens examined by me); in *L. glacialis* they are quite small, rudimentary. Yet it may be remarked that Sars (op. cit.) described and figured (p. 79—81, Tab. XIII, fig. 21) a small postlarval stage with several pairs of legs well developed, in which the antennæ are good-sized with a long sympod divided into some joints and both rami: the exopod long and 5-jointed, the endopod very much shorter and 2-jointed. — The *mandible* has no "palp"; its incisive margin possesses a number of teeth.

The organ called *paragnatha* (Pl. I, fig. 1 a, *h*) has nothing to do with appendages; it looks as a thick, bifid lobe, and is in reality a protuberance from the lower median part of the head behind the mandibles. It may be useful to insert here some general remarks. The paragnatha are found in most Crustacea and are most frequently a broad and somewhat or deeply bifid organ, but f. inst. in parasitic Copepoda it assumes other shapes. The name paragnatha is not practical, as it might suggest the organ to be parts of a pair of appendages (see later on in the historical sketch). The name *labium* would be better in Crustacea and is used by some authors, but I prefer to name it *hypopharynx*; because it is homologous with hypopharynx in Thysanura, Orthoptera, Diptera. Furthermore the name labium is not advisable, as "labium" in Insects is quite a different thing, viz. a pair of partly coalesced appendages, in reality homologous with the maxillipeds in Amphipoda, Isopoda, etc. In *Lepidurus* (fig. 1 a) the hypopharynx (*h*) is turned much backwards so that its free anterior surface is visible from below when the mandibles have been removed. The lateral part of each half is well chitinized; its shape and the structure of its surface may be seen on the figure, which also exhibits the opening of oesophagus (*o*), and a portion of the big muscles (*m*) between the mandibles and partly uncovered by the removal of the thin skin of the mouth; besides the outer part of both maxillulæ (m^1) is seen outside the free lobes of hypopharynx.

The *maxillulæ* (fig. 1 b) are moderately large; each consists of two very distinct joints, the distal one (*2*) broad and well separated from the first joint (*1*) which seen from behind exhibits a distal firmly chitinized, oblong-triangular piece at the outer free margin, while its well chitinized proximal portion is slender and articulated to the skeleton of the head, viz. to the side of the basal part of hypopharynx; at the distal end of this slender portion is seen on the outer margin a firm, rather small triangular protuberance where the membranous skin outside the firm chitine begins. Seen from in front (fig. 1 a) the firm chitine of first joint (*1*) is rather narrow. As the maxillulæ lie close on the posterior and outer sides of hypopharynx and are connected with it by membrane, they are directed much backwards and their distal joint inwards.

The *maxillæ* (fig. 1 c) are somewhat smaller than the maxillulæ. Each consists of a proximal rather thin-skinned part and a distal well chitinized, oblong lobe with many setæ towards and at the terminal margin. From the proximal half projects forwards and a little outwards a somewhat large, oblong, tubular protuberance which contains the duct (*d*) from the maxillary gland, and the opening is seen on its obtuse end. This process looks as a kind of palp, but such an interpretation cannot be accepted, and no corresponding thing is found in any Crustacean known to me, excepting perhaps in some Cirripedia.

Maxillipeds and thoracic Legs. — For special study four pairs of appendages have been selected, viz. the maxilliped, the first, the fifth, and the tenth leg (in the female). The investigation has been undertaken on legs in their natural condition and well preserved in spirit, on legs cleaned in caustic potash or "Eau de Javelle", and on the empty well-sized skin cast off by an ecdysis. The outlines are easy enough to draw, but to discern on such very flattened limbs the limits tolerably well between the more chitinized areas and the thin-skinned parts on the anterior and posterior surfaces is partly very difficult, and much time has been spent in making the six figures. The left fifth leg (figs. 1 d and 1 e) is chosen as point of departure.

Such an appendage is frequently described as consisting of an oblong stem (a descriptive, scarcely a morphological term) with six "endites", lappets or lobes on the inner side, a plate and a pear-shaped organ on the outer margin, the latter named branchia or epipodite, the plate named "flabellum" or exopodite by different authors. There cannot be the slightest doubt that the outer pear-shaped organ is homologous with the epipod and the plate with the exopod in Leptostraca. Both originate very near each other, but in looking at the leg from in front (fig. 1 e) it is seen that a sharp and very narrow articulation, which goes across the leg, begins between their insertions, and that each among them has on the anterior side a strip of firmer chitine projecting from the stem respectively behind and in front of the transverse articulation. All the endites, the sixth excepted, are lateral, movable lobes projecting from the joints in the leg. It is seen that the part of the stem between its base and the origin of the exopod has two lobes rather distant from one another, and that both in front (fig. 1 e) and behind (fig. 1 d) its firmer chitine is divided by an obliquely transverse membrane into two main portions, each representing a joint. The first joint (*1*) is rather large, and its chitine is on the posterior side divided by a narrow oblique membrane into a very large proximal and a small distal part, but undivided on the anterior side; its lobe (l^1) which differs in some respects from the following lobes, is sometimes named "gnathobasis". The second joint (*2*) is shorter and bears the epipod (*ep*). The third joint (*3*) which bears at the base the exopod (*ex*) on the outer and the third lobe (l^3) on its inner margin, is long and firmly chitinized on the front side to the above-named narrow articulation, while on the posterior side (fig. 1 d) we see that its proximal portion between exopod and lobe is membranous, consequently its firm chitine somewhat shorter on the posterior than on the anterior side. The leg seen from behind (fig. 1 d) shows that the fourth lobe is articulated to a transverse, quite short strip of moderately stiff chitine (*4*) representing the fourth joint, while on the anterior side the joint has no firm chitine marked off, but the lobe shows a triangular base which may be a remnant of the joint itself fused with the lobe. Fifth lobe (l^5) projects both on the anterior and the posterior side from a small oblique piece (5), which on the anterior side is very oblong and very firm, on the posterior side broader and only moderately chitinized; these two pieces represent the fifth joint. Second to fifth lobe are similar in structure and equipment, while the sixth is rather different in these respects; it is on both sides united by rather narrow membrane with the whole outer margin of the plates representing the fifth joint, and I think it is not a lobe but the lobe-shaped terminal joint (*6*) of the stem; a comparison with the maxilliped, the posterior pairs of legs and the leg of *Estheria* (fig. 3 a) corroborates this interpretation. — We arrive at the result, that the sympod of the leg consists of three large and well separated joints, each with an inner lobe; the first joint, præcoxa, has no præepipod, while the second, the coxa, has a good-sized epipod, and the third, basis, a large exopod; the endopod consists of three joints, the two proximal small, very short but with very developed lobes, while the third joint is shaped as a long lobe; the exopod is a large, unjointed plate.

First leg (fig. 1 f) is more slender than the fifth; second to fifth lobe and sixth joint are much narrower, exopod and epipod smaller than in the leg described, but its chitinized and membranous parts are nearly similar. Only one small difference may be mentioned, viz. that the oblique membranous strip which on the posterior side divides the firmer chitine of the first joint into two portions, is on first leg nearly longitudinal and can therefore not give rise to incorrect counting of the joints.

The *maxilliped* (fig. 1 g) has first joint considerably longer than in fifth leg. Third to fifth lobe is extremely elongated and divided into many joints, while the sixth joint (*6*) is a quite small, oblong piece. In most other particulars the maxilliped is similar to first leg, but the chitinous pieces representing fourth and fifth joint have partly disappeared, and the epipod is considerably, the exopod very much, reduced in size.

Tenth leg (figs. 1 h and 1 i) in the female is, as well known, extremely different in aspect from the other legs. First joint and the five lobes do not exhibit important differences from those of a normal leg, but second to fifth and especially fourth and fifth joints are extremely expanded on the outer side, forming a very large, somewhat flat cup with its free margin constituting the major part of a circle; the exopod (*ex*) is a large, circular, flattened cup fixed on the proximal transverse margin of the expanded part of the stem, and in natural position the exopod forms together with the expanded part a circular box for the eggs. The epipod (*ep*) is shaped as a quite small oblong process issuing from the posterior margin of the expansion midway between the first joint of the leg and the insertion of the exopod. The sixth joint (*6*) is a triangular plate. Fig. 1 i exhibits the appendage from in front, and it is seen that each of the five proximal joints has a piece of firmer chitine, though the pieces of fifth and especially of fourth joint are quite small; fig. 1 h, representing the limb from behind, shows that third to fifth joint have a common feebly chitinized surface towards the lobes.

The legs behind the tenth pair are gradually reduced in size, but agree in the main with those of fifth pair. In the posterior pairs the terminal joint is a very large, incurved plate somewhat longer than broad and several times larger than one of the lobes.

Historical. — The appendages of various species of *Apus* or *Lepidurus* have been described and figured more or less carefully by many authors, among which Zaddach (1841), Claus

(1873 and 1885), Huxley (1877), Gerstaecker (op. cit.), Lankester (1881), G. O. Sars (in several papers and especially in Fauna Norv. 1896), Behning (1912), Borradaile (1917). Some remarks on the more important descriptions may be made, and we begin with the mouth-parts.

I have not seen any correct representation of the maxillulæ. Gerstaecker's drawing (op. cit. Taf. XXX, Fig. 2) is good, excepting as to one particular, viz. he has divided the firm chitine of first joint by a transverse suture which does not exist. But then he considers half of the hypopharynx as "Maxille des zweiten Paares"; of the maxilla he has a good figure, but unfortunately he interprets it as "rudimentäre Extremität zwischen Maxillen und erstem Beinpaar". — Lankester's description, interpretation and figures are wrong; he figures the real maxillula as consisting of a single piece, having overlooked the articulation, but interprets it as one of the two pieces constituting his maxilla, while he considers the corresponding half of the hypopharynx as the other part; the real maxilla he figures moderately well (he overlooks the glandular duct already seen by Gerstaecker), but names it maxilliped. — Claus (in 1885) makes nearly the same error as Lankester, as he considers the two halves of the hypopharynx as "Paragnathen-ähnlichen, median vereinigten Vorderlappen" of the maxillulæ (his maxillæ of first pair), while he interprets the real maxillula as "Maxillarlade"; besides he overlooks that it consists of two joints, and his fig. 2 on Taf. I is on the whole superficial. The maxillæ are correctly interpreted by him. — Sars (1896) overlooks (Tab. XII, figs. 10—12) that the maxillula is two-jointed, but he describes, figures and interprets the hypopharynx well, naming it the lower lip; his interpretation of the maxilla is also correct.

Then the thoracic legs. Huxley (1877) seems to be the first author who has extended the earlier interpretation of the elements in the legs of Decapoda to those of the Apodidæ. He writes on *Apus:* "Each appendage consists of three divisions — an endopodite, exopodite and epipodite, supported on a protopodite or basal division. The latter consists of three joints — a coxopodite produced into a strongly setose prominence . . . . a basipodite and an ischiopodite, the latter elongated internally into a lanceolate process, and bearing on its outer side two appendages", according to Huxley the pyriform epipodite or branchia and the large plate "which appears to represent the exopodite". "The endopodite consists of four joints, the two proximal ones being much the longest, and, like the penultimate giving off internally a long process. Finally, the terminal joint is claw-like and serrated on its concave edge". I have quoted most of his description because it contains new and important views, but curiously mixed up with errors. He counts three joints in the sympod (his protopodite), but names the first joint coxopodite, which is wrong, and due to the fact that he takes his starting point from the Decapoda in which the first separate joint of a walking leg is the coxa. Furthermore his basipodite, in which he did not find any inner lobe, is no joint, but probably only the anterior smaller part of the firmer chitine of first joint on its posterior surface. He says also incorrectly that both epipod and exopod originate from his third joint. Finally I cannot understand his counting of four joints in the endopod, but according to his statement on the number of lobes he must have counted the real second joint of the leg two times. It may be added that his interpretation of the parts of the egg-box is almost correct.

Lankester, who gives a detailed description (op. cit., p. 188) with figures of all appendages, has invented a curious interpretation of the legs in *Apus* and of mouth-parts and legs in various Malacostraca. F. inst. he interprets the real exopod, his "flabellum", as epipod, the fifth "endite" as the endopod and the sixth "endite", in reality the terminal joint of the endopod, as the exopodite — but as to the whole matter the reader must for the rest be referred to his paper. It may be added that Lankester's interpretations have not — as far as I know — been adopted by any Zoologist, and even its main lines will scarcely ever be followed, but a special and necessarily lengthy criticism may therefore be omitted. Only one point may be added, viz. that Lankester has seen that in the "oostegopods" the "flabellum" forms the operculum of the egg-box, and he observes the rudimentary branchia, but his interpretation of the other half of the egg-box is erroneous.

Since 1877 all authors excepting Lankester have adopted at least main points of Huxley's views on the constituting elements of the legs, but their investigations or ideas are on the whole not valuable from a morphological standpoint, as no one has attempted a real study of the skeleton of the stem. As to the literature since 1881 some remarks on the contributions by the prince among Carcinologists, G. O. Sars, may be nearly sufficient. He gives (1896) detailed descriptions of the aspect and very fine figures of the legs in *Lepidurus glacialis*, but without any study of the segmentation of the stem; the articulations are partly overlooked, and the very few indications of such divisions are partly wrong. He uses correctly the names exopod and epipod excepting at the egg-box; he says that the bottom of the box is the exopodite and the lid the epipodite, but both statements are erroneous (see above), and as his fig. 17 on Tab. XII exhibits the rudimentary real epipod, his error is incomprehensible. In some other papers Sars describes forms of *Apus* or *Lepidurus*, but without any further statements on the morphology of the legs. — Behning's discussion (1912, op. cit. p. 42) is very poor, with old errors. — Borradaile's figs. 3 (1917, op. cit.) representing a leg of *Apus*, is misleading as to several points and without any value.

Order Anostraca.

(Pl. I, fig. 2).

This order comprises three families: Branchipodidæ, Polyartemiidæ, and Thamnocephalidæ. As to the frontal appendages, antennulæ, antennæ, mandibles, maxillulæ, and maxillæ it may be sufficient to refer to Simon (1886), to Calman's hand-book, and to the detailed and excellent descriptions with figures given by Sars (1896, op. cit.) of *Branchinecta paludosa* and *Polyartemia forcipata*; all these appendages exhibit no morphological feature of special interest to be discussed here. They show relationship to those in Apodidæ, excepting the curious ramification of the antennæ in the males, and of course the puzzling "frontal appendages" not found in any other order of the Branchiopoda, but in some Copepoda.

The maxillipeds and thoracic legs are interesting and somewhat uniformly built in all genera. As type the fifth leg of *Chirocephalus Grubei* is chosen (fig. 2 a). The leg is completely lamellar without any transverse articulation; as in Apodidæ it has five lobes along the inner margin, and besides a very broad terminal lobe. The five lobes are not marked off from the stem; the first (l^1) is low but extremely broad, as broad as, or broader than, the four following lobes together. On the outer margin of the stem opposite the first lobe is seen a very large plate (*pe*) which is even broader and much higher than the lobe, and in the leg figured divided much before the middle by a deep incision, which yet does not reach the bottom or origin of the plate; the plate may also be interpreted as consisting of two plates coalesced towards their base, while the anterior rounded part of the proximal plate, seen from behind, overlaps the posterior portion of the distal plate. These plates, originating opposite to the proximal lobe, the lobe of first joint, do not exist in Apodidæ and must be interpreted as præepipods. Opposite the lobe of second joint one sees the oblong, vesicular epipod (*ep*); considerably beyond the epipod the oblong, lamellar exopod (*ex*) is articulated on a lamellar protuberance from the posterior side of the leg at its outer margin. The terminal part of the leg beyond the base of the exopod is a very large plate.

The legs of Anostraca show consequently the same parts — though excepting the exopod not marked of by articulations — as in Notostraca, and besides the præepipod; the interpretation of the elements of the legs in Apodidæ can therefore be applied without difficulty in the present order. Consequently the epipod originates from the second, the exopod from the third joint, and the distal and the inner part of the terminal plate answers to the sixth joint; of the six fused joints in the stem the three proximal belong to the sympod, the three other constitute the endopod. But the præepipod is interesting; in *Polyartemia* (Sars, op. cit. Tab. X) the two præepipods are quite independent, not coalesced towards the base, while in *Branchinecta* (Sars, Tab. VII) only a single plate exists, but compared with the lobe from first joint it is broader than that and proportionately as broad as the two præepipods together in *Polyartemia* or in *Chirocephalus Grubei*, the latter forming an intermediate stage between the structure in the two other genera. — The præepipod exists also in several Cladocera, Ostracoda, etc.

The interpretation of exopod and epipod applied here is the same as that adopted by Sars, but a strong difference between us is that he considers (p. 47) the endopod to be only the terminal plate, an untenable view when the leg is compared with those in Notostraca or Conchostraca. That the legs in Anostraca are flattened in the highest degree and without articulations may be a special and perhaps secondary modification.

Order Conchostraca.

(Pl. I, figs. 3—4).

This order is divided into two families, Limnadiidæ and Limnetidæ. The first-named family comprises several genera on the whole rather allied to each other, the other family only a single genus.

Antennulæ, mandibles, maxillulæ, and maxillæ exhibit no morphological feature which ought to be mentioned, because they are allied to the corresponding appendages in Notostraca, and besides these appendages in *Limnadia, Estheria, Cyclestheria, Limnetis,* etc. have been well figured and described by Sars in various papers. The antennæ differ strongly from those in the two preceding orders; they are large, robust, consisting of a long sympod and two rami divided into several joints. The sympod has the major part of its firmer chitine on the outer and the anterior side divided by fine transverse stripes of membrane into a number of secondary articulations, a peculiar modification which makes it impossible to determine the number of real joints; on the inner side of the sympod I found in *Estheria* thin chitine without subdivisions.

In the family Limnadiidæ the maxillipeds and thoracic legs are to a certain degree intermediate between those in Notostraca and Anostraca. Fig. 3 a exhibits the left fifth leg of *Estheria* (*Leptestheria*) *dahalacensis,* seen from behind; the extremely curious exopod (*ex*) is cut off at its base and figured separately in order not to overlap a good deal of the endopod and make the figure difficult to understand, but two dotted lines connect the margins cut through. The leg has five lobes on the inner margin, a terminal joint, an enormous exopod, a good-sized epipod, but no præepipod. The first lobe is feebly marked off, curved backwards nearly as in Apodidæ, and a fine oblique line separates the first joint from the second. The four other lobes are not marked off; the corresponding joints are confluent. On the fifth lobe is articulated a very oblong process (*t*) generally interpreted as a sensory organ; the terminal oblong joint (*6*) is marked off by a fine articulation. The exopod, which is extremely produced both backwards and forwards, possesses in the subgenus *Leptestheria* the curious securiform process overlapping in situ a part of the endopod. The fifth joint of the stem is in this species produced at the outer margin as a kind of small lobe, but that process is completely wanting in *Limnadia*, etc. From comparison with the Apodidæ it is evident that the leg in the Limnadiidæ consists of the same elements, viz. a three-jointed sympod, a three-jointed endopod, an exopod and an epipod; the differences are that in the chosen type *Leptestheria* second to fifth joint of the stem are not marked off from each other, and that among the lobes only the first is marked off. As to the interpretation it may be said here, that as to exopod and epipod it agrees with Sars (1896), but this author writes (p. 94): "The endopodite, or stem proper," which agrees badly with his nomenclature of the parts of *Branchinecta*, and he says nothing on the number of joints in that "endopodite". — It may be added that in *Cyclestheria* only the maxilliped, in the other genera also the first pair of legs have in the male the endopod transformed into a subchelate prehensile organ, figured by various authors and especially by Sars in several papers.

Limnetis brachyura is a good type for its family. Fifth thoracic leg (fig. 4 a) shows the same elements as in *Estheria*, but the leg is shorter and broader. The three proximal lobes, especially second lobe, are broad and somewhat short, while fourth and fifth lobe are long and slender; the terminal joint, which is shaped as fifth lobe, is marked off by an articulation, but no other transverse articulation or limit can be discovered on the leg. It may be remarked that second and third lobe are opposite to the origin of respectively epipod and exopod. The leg differs very considerable in outline from that in *Estheria*, but as to all essential features it belongs evidently to the same type. The maxilliped has in the male the endopod transformed into a prehensile hand, and the lobes of second and third joint of the sympod are fused, forming a single extremely broad lobe (Sars, op. cit. Tab. XX, fig. 7); according to Sars the epipod is wanting in seventh (his eighth) and the following pairs of legs.

Order Cladocera.

(Pl. I, figs. 5—6; Pl. II, figs. 1—2).

Lund, L.: Bidrag til Cladocerernes Morphologi og Systematik. Naturh. Tidsskr. 3. Række, B. VII, I. 1870.

Lilljeborg, W.: Cladocera Sueciæ. Nova Acta Reg. Societ. Sci. Upsalensis, 3. Ser. T. XIX. 1900.

This order is divided into two sub-orders, these again into tribes, each comprising one or two to four families. Such rich division indicates great differences in the structure of the animals; it may yet be stated here that the appendages of the head show no morphological feature of special interest; the antennæ are built nearly as in Conchostraca excepting that their rami have only few joints, the mandibles as in all Branchiopoda without palp, the maxillulæ are small and simple, and the maxillæ wanting.

In this order the body has only four to six pairs of legs behind the head, and in these animals it may be preferable to count the maxillipeds as the first pair of thoracic legs. In some genera the legs — excepting the last pair — are rather similar in the same animal, but in the majority they exhibit considerable or large differences when one proceeds from the first to the last pair in the same specimen. Besides the legs vary extremely in aspect in different families, as in some forms they are pediform, but in the majority lamellar, moderately to extremely broad and showing nearly every conceivable shape. They consist typically of the same elements as in the preceding orders of Branchiopoda — even the præepipod is sometimes present — but one or two or more of the parts found in Conchostraca are always either extremely reduced or wanting. It may be remarked that the epipod exists in most cases; its sacciform shape and darker colour makes it easy to discern, and its place is frequently most helpful at the interpretation of the other elements of the leg.

Historical. — It may be convenient to insert here some remarks on the papers in which the morphology of the legs is treated. In 1870 L. Lund published the above-named paper with a good number of figures of appendages on five beautiful plates. In reality he lays down the foundation to a modern morphological treatment of the legs, though he uses names of his own invention. He gives (Pl. VIII, fig. 13) a diagram of a leg, and his nomenclature (in Latin) is quoted for comparison. His "*stipes*" is the sympod, and he figures it (erroneously) without articulations, but with a "*processus maxillaris*" on the inner margin, while on its outer margin he draws "*processus saccarius*", the epipod, and "*lobus ciliatus stipites*", the præepipod. On the end of "stipes" we find "ramus interior", the endopod, divided into three joints (this number exists really in some forms), and "*ramus exterior*", the exopod, which he wrongly divides into three joints, though it is unjointed in the whole order which he also says in the text. His figures are excellent and easily studied, as he always applies the same lettering at the homologous parts of the legs. — Lilljeborg (op. cit., 1900) adopts Lund's views in his brillant big monograph with its numerous plates, and his work together with Lund's paper illustrate the legs in all genera and numerous species of the Swedish and Danish fauna. — A third paper may also be referred to, viz. the above-named treatise by Behning (1912), the major part of which deals with the comparative morphology of the legs in Cladocera. The author describes and figures the legs in numerous forms of that order and in types of the three other orders of the sub-class, but his representation furthers our morphological insight very little beyond that given by Sars, Lund, Lilljeborg; f. inst. his figures of the legs in *Evadne* and *Polyphemus* show a lesser number of joints than is stated in his text. His views as to endopod and sympod (his "Stamm") differs strongly from mine. Besides he spends several pages on phylogenetic speculations, a curious pleasure not yet abandoned by several Zoologists who evidently — as said by my late friend Dr. William Sørensen, "raise parks of phylogenetic pedigrees".

For a more special study of the legs in Cladocera the reader is referred to Lund and Lilljeborg. Here it may be sufficient to deal with three main types, exemplifying how the elements and joints found in legs of the three preceding orders may be developed, reduced, fused or lost in the present order.

Sub-Order Gymnomera. — The legs are rather or completely pediform. In *Polyphemus pediculus* the first pair (the maxillipeds) have a long sympod without epipod or præepipod (Pl. I, fig. 5 a), somewhat feebly or nearly indistinctly divided into three joints, and with a feeble lobe, in reality a low protuberance with two teeth, on the third joint; at its end is inserted the rather small, lamellar exopod (*ex*), while the endopod (*en*), which is distinctly three-jointed, is the longer part of the leg. Second and especially third pair are shorter than the first but similar in structure, excepting that the sympod has scarcely any articulation marked off, and the lobe is on second leg considerably, on third leg much, higher than in first pair and forms a masticatory process; fourth pair of legs are very reduced. — In *Podon, Evadne, Bythotrephes* one or two parts of the legs, f. inst. the exopod, are more reduced than in *Polyphemus*, but otherwise the structure is similar. In *Leptodora* the sympod is unjointed; the endopod well developed, three-jointed excepting on the reduced posterior pair; a masticatory lobe on first leg is in the highest degree rudimentary, and the exopod has disappeared (according to Behning it is "especially" in fifth pair represented by a small seta or tooth).

Sub-Order Calyptomera. — The legs are considerably or completely lamellar, and the variation in shape and development is nearly endless. A type for each of the two tribes shall be mentioned.

In *Sida crystallina* first leg (maxilliped) may serve as type (Pl. II, fig. 1 a). The sympod (*sp*) is somewhat long but without transverse articulations, but the portion answering to its first joint has on the inner side a protruding lobe, a "gnathobase" (l^1) about as long as broad and with a number of curved setæ on the end. Opposite this lobe the præepipod (*pe*) is seen as a moderately low plate with the naked margin evenly rounded; the epipod (*ep*) is of very moderate size, oblong and attached by its end. The distal two-thirds of the inner margin of the sympod is almost straight excepting towards its base, continues forward as the inner margin of the endopod, and this margin is along its entire length equipped with a close row of extremely long setæ. The endopod is somewhat small, oblong, marked off towards the inner margin from the sympod, and exhibits near that margin rudiments of a division into three joints. The exopod (*ex*) is very large, much longer than broad, but only partially and feebly marked off from the sympod by an oblique, curved line; the position of its setæ may be seen on the figure. — Second to fifth pair of legs similar to each other; they differ mainly from first leg in having the masticatory lobe considerably lower and broader, while the epipod is larger and so to say biramose. Sixth leg as usual reduced, rather altered in shape and without epipod.

As type for the other tribe, Anomopoda, *Daphnia magna* is chosen. The thoracic appendages differ very much from each other. Second pair (first legs) has the sympod, the endopod, the exopod and the epipod well developed (Pl. II, fig. 2 a). The sympod is, seen from in front, distinctly divided by a somewhat curved transverse line into two parts; the proximal part bears the epipod (*ep*) beyond its middle, while the proximal half of its outer margin is somewhat convex, which may be interpreted as a quite rudimentary development of the præepipod strongly developed in the following pair of legs; this proximal portion answers evidently to first and second joint combined in *Polyphemus*, and has no lobe on the internal margin. The distal part of the sympod is its third joint (*3*) which possesses a large, setiferous inner lobe (l^3) as broad as the length of the joint, and distinctly marked off by a suture. The endopod (*en*) is subtriangular, with a couple of small lobes, and its distal half is partly marked off by a line which does not reach the outer margin; consequently the endopod shows vestiges of being composed of three joints. The exopod (*ex*) is about as long as the sympod, rather narrow, undivided.

First appendage (maxilliped) in *Daphnia* differs extremely (Pl. I, fig. 6 a) from the leg described, and is not easily interpreted with certainty. The epipod (*ep*) is large, but it is difficult to decide where the sympod terminates and the endopod begins; it may perhaps be preferable to follow L. Lund in saying that the part of the leg bearing strong setæ on the inner margin is the endopod, and then the sympod has no vestige of any lobe on its inner margin, while the endopod is rather distinctly two-jointed, and an exopod is wanting. — In the third appendage (second leg) (Pl. II, fig. 2 b) the sympod is long with a low and densely setiferous lobe along nearly its whole inner margin; the endopod (*en*) is a small, oblong-quadrangular piece; the exopod (*ex*) is a large plate about as broad as long, the epipod (*ep*) is well developed, while the præepipod (*pe*) is a large plate which projects forwards behind the proximal half of the epipod, and has the margin pubescent; every vestige of articulations of the leg has disappeared. — The fourth appendage is not very different from the third, but the endopod has vanished; the fifth appendage is very reduced, though the exopod, which is turned outwards, and the epipod are still distinct.

General Remarks. — The exopod is sometimes wanting in a single pair or rarely even in nearly all legs; the epipod is not unfrequently wanting in some or all legs; in several forms a præepipod is distinct or large in some legs. The sympod is rarely more or less distinctly divided into the typical three joints, but in no form one finds three lobes on its inner margin; f. inst. in *Polyphemus* and in second appendage of *Daphnia* only the distal joint has a distinct or large lobe, while in *Sida* the first joint has a lobe nearly as in Conchostraca, and the more distal part of the inner margin of the sympod is undivided and setiferous; f. inst. in two pairs of legs in *Daphnia* nearly the entire inner margin of the sympod is undivided and setiferous. The endopod is in some forms, as in *Polyphemus*, divided into three well developed joints; in *Sida* this division into the three joints is only half developed in the four anterior pairs; in most cases the endopod is quite undivided and without lobes.

Summary on the Sub-Class Branchiopoda.

The antennulæ are simple, uniramous. — The antennæ have in two orders sympod, endopod and exipod well developed, but a considerable part or most of the sympod is divided by secondary articulations in such a way that primary features have disappeared; in the two other orders the antennæ are simple or — in males of Anostraca — ramified in irregular ways. — The mandibles without palp. — Maxillulæ at most two-jointed, without palp. — Maxillæ at most two-jointed, without real palp, sometimes nearly rudimentary, or wanting. Consequently at least mandibles, maxillulæ and maxillæ do not exhibit a primitive but rather a reduced structure.

The maxillipeds belong as to structure and position to the thoracic legs. The legs are nearly or completely lamellar in all forms excepting Cladocera Gymnomera. In some forms, especially in Notostraca, the sympod consists of three distinct joints; third joint bears the sometimes distinctly three-jointed endopod and the always unjointed exopod (rarely absent), while an epipod is most frequently present on second joint. In three orders, Notostraca, Anostraca and Conchostraca, the leg has five lobes on the inner side, each issuing from a separate joint or answering to a joint, while the sixth joint of the stem varies extremely in size and shape; in Cladocera reductions of different kind are common. In Anostraca and in some legs of many Cladocera the first joint of the sympod has on the outer margin a single plate, the præepipod, or two such plates.

It is seen that all the elements of Crustacean legs are present in several Branchiopoda. The two branches, endopod and exopod, look never as equivalent, excepting in the antennæ of Conchostraca and Cladocera. The legs possess two decidedly primary features, viz. the existence of the exopod, and that the sympod consists of three joints, the first of which, when marked off distinctly, is well developed and frequently longer than the next. But as far as I can see, the legs do not exhibit any other primary feature (whether epipod and præepipod are primary appendages or not can scarcely be decided), but they show innumerable adaptations of secondary nature; even the number of joints in the endopod, viz. three, is scarcely a primary feature, though it can be shown in all four orders.

SUB-CLASS COPEPODA

Order Eucopepoda.

(Pl. II, figs. 3—6).

Krøyer, H.: Karcinologiske Bidrag. Naturh. Tidsskrift, 2. Række, B. II, p. 527 (1848), p. 561 (1849).

Giesbrecht, W.: Pelagische Copepoden. Fauna und Flora des Golfes von Neapel, 19. Monogr. 1892.

Sars, G. O.: An Account of the Crustacea of Norway. Vols. IV—VIII. 1901—1921.

With, Carl: Copepoda I. Calanoida. Amphascandria. The Danish Ingolf-Expedition, Vol. III, 4. 1915.

The first sub-order, Copepoda Calanoida G. O. S., comprises on the whole the most highly and most typically developed forms of the whole order, and "the very great majority of the Calanoida are pronouncedly pelagic animals". A perusal of the 108 plates in Sars' splendid "Account" vol. IV gives the result that all genera show very considerable uniformity as to the main points in the structure of their appendages, excepting in the last pair of legs and the antennulæ in the male sex.

As most of the animals are small it is practical to investigate the constituting elements of their limbs in moderately large and sometimes in comparatively very large forms in order to be able to discern their articulations and the difference between their membranes from the firmer chitine of the joints. To begin with it is useful to put a large specimen of *Megacalanus* or *Macrocalanus* in water to hinder exsiccation, then after the removal of water between legs by blotting paper to hold the specimen between the ends of two fingers on the left hand under a simple microscope and with a minute knife in the right hand to move the more proximal part of the appendages; the result will be that three joints can be discovered with certainty in the sympods of antennæ, mandibles, maxillipeds and natatory legs. The investigation of all appendages may be undertaken in a specimen opened dorsally and then cleaned well in caustic potash; for the study of maxillulæ, maxillæ and natatory legs *Megacalanus princeps* may be recommended. The results of the investigation differ much from nearly the whole literature.

The *antennulæ* possess never an accessory flagellum; they are well developed in all free-living forms, with at most 25 joints. — It may be inserted here that in several forms the front end of the head has a pair of unjointed sensory filaments (Pl. II, fig. 3 a, from *Calanus finmarchicus*).

The *antennæ* consist of a three-jointed sympod, a two- or three-jointed endopod (*en*) and an exopod generally divided into several joints; fig. 3 b, representing the left antenna from behind of *Cal. finmarchicus*, shows the three joints (præcoxa, coxa and basis) in the sympod. The first joint (*1*) is rather small, the second much broader and longer, but yet shorter and a little more narrow than the third (*3*), which in *Calanus* (and probably in other forms) possesses a kind of minute lobe (with two setæ) near the distal end of the inner margin — on the left side of the figure. Fig. 6 a exhibits an antenna of a *Setella sp.* (a pelagic form belonging to another sub-order); in this form with the very elongated and slender sympod it was still more easy to see the articulations.

The *mandibles* consist generally of a three-jointed sympod with the two rami; the endopod is two-jointed, while the exopod most frequently has four joints. Fig. 3 c, representing the left mandible of *Cal. finmarchicus*, shows that the first joint, præcoxa, is produced inwards as "corpus mandibulæ"; the second joint, coxa (*c*), is rather small, almost twice as broad as long, well chitinized, separated from first joint by well developed membrane, and from the third very large joint, the basis (*b*), by a movable articulation.

The *maxillulæ* are very interesting. Fig. 4 a represents left maxillula from behind of *Calanella hyalina*, and in numerous other genera the maxillulæ are very similar. First joint, præcoxa (*pc*), is extremely large, with two very conspicuous inner lobes, the proximal one two or three times as long and broad as the second, but both without transverse suture or articulation at the base; the distal part of the outer margin of first joint has a protruding plate (*pe*) with a number of robust and extremely long setæ, and this plate is not marked off at the base, but the examination of a maxillula cleaned in potash shows that its posterior wall is the continuation of the wall of first joint; this plate is certainly a præepipod. Second joint is rather short, well marked off and movable; on the inner side it is produced into an oblong lobe (l^2) marked off by an articulation. Third joint is oblong and bears on the outer side the exopod (*ex*) which consists of a single joint; the endopod has one joint, in some genera two or at most three joints, but in other forms it is not marked off from the long third joint of the sympod. — The structure described shows three very interesting features: that first joint has a præepipod, that it has not one but two lobes on the inner side, finally that second joint has an inner lobe; the last-named feature is also found in Ostracoda, while the others are unique among Crustacea in the maxillulæ.

The *maxillæ* show also great similarity in most genera of the Calanoida. They must be studied on large specimens cleaned in potash; the maxillæ of *Megacalanus princeps* are an excellent object. At first sight such a maxilla (fig. 5 a) looks as a thick leg with six lobes on the inner side and no appendage on the outer margin. At a closer examination of its posterior surface it is seen that first joint (*pc*) is very large, with the outer half well chitinized, while the inner part of its posterior surface is rather membranous. Second joint (*c*) is extremely short on the outer half of the posterior surface, while on the inner half it is an oblong, chitinized plate produced into two oblong lobes, the proximal one of which besides marked off by a transverse articulation. Third joint (*b*) is on the outer half a moderately small plate a little broader than long, and on the inner side equipped with two long lobes well marked off at their base; on the outer margin the joint has a minute protuberance bearing a strong plumose seta, and I am inclined to interpret this knot (*ex*) as a rudimentary exopod (comp. the mandible in several Ostracoda). The endopod consists of five joints; the first is very long and broad with a long and strong lobe not marked off; second joint is extremely short with a moderately large lobe; the three distal joints are short and without lobes. Thus we have eight joints in the limb. It may be remarked that the three-jointed sympod with its four lobes from the two distal joints is rather similar to the same parts of the maxilla in many Decapoda (see later on).

The *maxillipeds* are similar to rather slender, simple, unbranched legs; they have frequently and at most eight joints (fig. 5 b). Second and third joints, which both are long, are by authors considered as a two-jointed sympod; the first joint, which is short (*pc*) but frequently well defined from the body and from the second joint and very easily seen, has not been taken into account by Carcinologists except Borradaile (1917). An exopod can not be traced.

The *thoracic legs* are generally described as a two-jointed sympod terminating in endopod and exopod, both typically three-jointed. Furthermore it is well known that a transverse plate unites the proximal part of the long "first" joint of the legs of the same pair, so that they are moved together. But if the entire insertion of f. inst. second pair of legs of a large form as *Megacalanus* (fig. 5 c) is investigated on the specimen, a curved, chitinized piece (*pc*) situated obliquely in front of and outside the base of the long joint mentioned (*c*) is conspicuously moved when these legs are turned forwards or backwards. This piece is surrounded by broad membranous skin excepting at the outer angle of the long joint, where it is coalesced with that joint and is continued as a very narrow strip of hard chitine along the basal posterior margin of the joint till the median plate (*pl*); this piece must consequently belong to the leg and be its first joint or rather the anterior or lateral part of that joint, because the transverse plate (*pl*), which is a firm bridge between the posterior part of the inner side of the legs — therefore it looks hollow seen from in front (fig. 5 c) — belongs in all probability to that real first joint, the præcoxa, consequently a movement between first and second joint of each leg does not exist excepting in front, as the two præcoxæ are fused in the median line and connected behind and externally with the proximal part of second joint. It seems to be impossible to interpret the whole structure and especially the movements of the arcuate piece in front of and outside the base of the joint, the coxa, in any other way.

Summary on the Calanoida. — In antennæ, mandibles, maxillulæ, maxillæ, maxillipeds and natatory legs the sympods consist typically of three joints; the endopod is most frequently five-jointed in maxillæ and maxillipeds, in the other appendages with one, two, or at most three joints. The exopod is absent in the maxillipeds, rudimentary or wanting in maxillæ, most frequently well developed in the other appendages. Epipods always wanting; præepipod generally well developed in maxillulæ, absent in the other appendages.

Harpacticoida, etc. — A perusal of the 284 plates in Sars' work on the Harpacticoida (Account, vol. V) and of the very numerous plates in his vols. VI—VIII shows endless variation in fusion and reduction of joints in the appendages as compared with their structure in most Calanoida, but it seems to be impossible to find any increase in the number of joints or any element (f. instance epipods) not present in *Calanus, Megacalanus* etc. As to reduction or fusions it may be briefly stated that all three joints in the sympod of the antennæ cannot be discerned, that the second joint in the mandibles frequently disappears and in other genera the mandibular "palp" is much more reduced, that the præepipod of the maxillulæ disappears, that the distal joints of the maxillæ are often not developed, that the maxillipeds have only few joints and of very different shape, etc. But in most or perhaps in nearly all cases it is possible to understand the structure of any appendage by comparison with the typical Calanoida. — In the semiparasitic and parasitic forms the appendages are reduced in a considerable or an extreme degree.

Historical. — The literature is vast, but only some few authors may be taken into account here. In 1848—49 Kröyer (op. cit.) described some species of *Calanus* figured by him a few years before in the work on Gaimard's voyage. In his description (in Danish) of *C. spitsbergensis* and *C. cristatus* he says (p. 534 and 548) that the basal piece — our sympod — of the antennæ consists of three joints, and that the basal part of the mandibular palp consists of two joints, the first quite small (p. 536 and 549); in two species of *Pontia* he finds the same two joints in the mandibular palp (p. 566 and 574). In my preliminary paper (1893) I said the same, but these important morphological points had been completely overlooked or at least not mentioned in the descriptions by all authors until C. With in his Ingolf-work (1915). It may be stated here that Borradaile in 1917 figured and counted the basal short joint in the mandibular palp and the small first joint in the maxillipeds, but that his counting of joints in these two appendages and in the maxilla is otherwise arbitrary and wrong.

Giesbrecht's gigantic work on pelagic Copepoda (1892) contains innumerable figures of the appendages, and is of extreme value in rendering their outline and the setæ, but as to comparative morphology of the constituting elements of their sympods it is worthless, and the text has no account of the general morphology of the limbs. His descriptions and somewhat diagrammatic figures in his treatment of the Crustacea (1913) in A. Lang: Handbuch der Morphologie, differ as to every appendage (excepting the antennulæ) from that given here; his morphological interpretations are on the whole based only on the general outline of each limb. F. inst. he counts only two joints in the sympod of the antennæ, overlooks the coxa in the mandible, the præcoxa in maxillipeds and natatory legs, etc.

In 1862 Claus set forth the view, which was generally accepted by writers, that the Copepoda possess only a single pair of maxillæ but two pairs of maxillipeds, and that the development shows that these two pairs are respectively endopods and exopods of a single pair. In 1881 Grobben based the same view on the development of *Cetochilus septentrionalis*. In 1893 I pointed out that the development showed quite the opposite, and that in Copepoda the three pairs of appendages succeeding the mandibles ought to be named maxillulæ, maxillæ and maxillipeds, quite as in Malacostraca. Some months later in the same year Giesbrecht published a paper (in Mittheil. Zool. Station Neapel), in which he arrived at the same results; as his treatment of the question is very detailed and illustrated by several good and instructive figures, I can omit a special description and figures (drawn by me before 1893) in the present paper. But when he in a "Nachschrift" to his paper makes a curious attempt to secure for himself the priority of the discovery, I may only say that we quite independently had arrived at the same result, and that when I visited Naples in the latter half of April 1893 he had just received the number of "Zool. Anzeiger" containing the part in question of my preliminary paper, and he showed me his beautiful microscopical preparations, which were types for his then unpublished figures. — It may be mentioned here that Huxley in his "Anatomy of Invertebrate Animals", 1877, correctly spoke of two pairs of maxillæ in *Cyclops*.

It is interesting to see that Sars in his above-named work on the Calanoida figures the sympod of the mandible as three-jointed in most forms, but the small second joint is scarcely mentioned in his text. Furthermore he figures in some cases the sympod of the antenna as three-jointed (Pls. II, XXXV, XLVI, L, etc.), but says nothing in the text. He also figures the first short joint in the maxillipeds in several forms. He names erroneously the three pairs of mouth-limbs behind the mandibles maxillæ, anterior and posterior maxillipeds, following Kröyer, Claus, Grobben, Giesbrecht before 1893, and other authors.

Order Branchiura.

Krøyer, H.: Bidrag til Kundskab om Snyltekrebsene. Naturh. Tidsskrift, 3. Række, B. II. 1863.

Bouvier, E. L.: Les Crustacés parasites du genre Dolops Audouin. Bull. Société Philomathique de Paris. 8. Ser., Tome X. 1897—1898; 9. Ser. Tome I, 1898—1899.

Wilson, C. B.: North American parasitic Copepods of the family Argulidæ .... Proc. U. S. National Museum, Vol. XXV. 1902.

Thiele, Joh.: Beiträge zur Morphologie der Arguliden. Mittheil. Zoolog. Museum zu Berlin, Bd. II, Heft 4. 1904.

This very peculiar order of freely movable parasites comprises only four genera: *Argulus* O. F. Müll., *Dolops* Audouin, *Chonopeltis* Thiele, and *Dipteropeltis* Calman; the genera are valid, through rather allied to each other. All their appendages, excepting the four pairs of natatory thoracic legs, are very much altered, adopted for prehension or fastening as in numerous parasitic Copepods, and their structure, which on the whole is well known, does not show features bearing of the plan of the present paper.

Each thoracic leg consists of a sympod terminating in exopod and endopod, but the number of joints in the sympod is not easy to settle. Kröyer, who described 5 species of the family, says that the sympod of the natatory legs is three-jointed in *Argulus Funduli*, two-jointed in *A. Salminei*, but his figure of the animal from below exhibits three joints; in his *Gyropeltis longicauda* he mentions the sympod as three-jointed in the three anterior pairs of legs, while in fourth pair he could only observe "two distinct joints". — In 1893 I stated that the sympods are three-jointed. — Bouvier in his above-named fine paper writes (part I, p. 61): "Les pattes natatoires sont biramées et présentent trois articles basilaires qui ont été figurés par Kröyer, par Thorell et par Heller, aussi bien chez les Argules que chez les *Dolops* (1). Chez ces derniers, l'article basilaire est fréquemment subdivisé en plusieurs parties par des plissements annulaires." (In this quotation (1) points to a footnote, in which Bouvier refers to my paper from 1893.) — In his main paper on the Argulidæ (1902) Wilson counts only two joints in the sympod (p. 683). — And in 1904 Thiele writes (p. 7): "Ich muss hier noch einige Worte über die Beingliederung der Arguliden beifügen. Gewöhnlich werden die Basipoditen als dreigliedrig bezeichnet, indem der meist etwas faltige Anfangstheil als besonderes Glied angesehen wird. Mir scheint dazu kein genügender Grund vorzuliegen. Die weiche Haut lässt die Gliederung im ganzen wenig scharf hervortreten und die Muskulatur spricht durchaus nicht für die bezeichnete Auffassung, ich halte diesen Proximalteil nur für eine etwas ausgedehnte Gelenkverbindung zwischen dem zweigliedrigen Bein und dem Körper. Bei solcher Auffassung kann man die beiden Glieder denen von Copepoden, Leptostraken usw. homologisieren, die allgemein als Coxale und Basale bezeichnet werden. Die Borstenbesatz der Glieder in der Gattung *Dolops* spricht auch für meine Ansicht, der faltige Proximaltheil trägt niemals Borsten." Thiele's comparison with Copepoda and Leptostraca proves nothing in his favour, as three real joints are present in the sympods of these orders; as to setæ on the "Proximaltheil" in *Argulus* see below.

The real number of joints depends on the interpretation of the proximal part of the sympod. This part looks always at first sight generally as a short or moderately short joint well defined from the following long joint; that proximal part must be either a real joint or a protruding articulating membrane. The latter opinion is a priori improbable; the part in question is sometimes moderately long, and I cannot remember any parallel among Crustacea that the articulating membrane between the body and the leg protrudes as a free, nearly cylindrical joint. I examined the skin of a full-grown *Argulus foliaceus* cleaned in potash under the simple microscope with an enlargement of 100 times while manipulating it with two very fine knives, and then without pressure under the compound microscope. It was clearly seen that on the three anterior pairs of legs most of the posterior half of the surface of the supposed first joint, præcoxa, is well chitinized, and that this chitine, which is well marked off by articulating membrane from the next joint and from the body, even possesses some spinules as those found on a part of the long joint (fig. 7 a); the major portion of its anterior surface is less firmly chitinized or partly membranous. From these facts it can be concluded with certainty that the proximal part of the sympod is a real joint, consequently that the sympod is three-jointed in the three anterior pairs of legs; in the fourth pair the præcoxa can scarcely be pointed out.

A specimen of the gigantic *Argulus scutiformis* has been examined with a pocket-lens; the basal joint of the natatory legs seems to be divided by transverse membranous strips into two or partly into three subjoints, a structure which may be compared with the features found in the sympod of the antennæ in Conchostraca and Cladocera. Similar structure exists evidently in the genus *Dolops* as stated by Bouvier (see above). As pronounced by Wilson, the exopod of the natatory legs is unjointed, the endopod in third and fourth pair "jointed once near their centre", while the endopod of second pair (and of first pair in specimens seen by me) is unjointed.

Finally the "flagellum". Wilson writes (p. 685): "More than half the species (17 out of 26) have an appendage called a flagellum (*Geïsselanhang*) attached to the two anterior pairs of legs. This consists of a slender shaft attached to the distal end of the basipod, just above the base of the endopod. At first it is directed outward parallel to the endopod, but is bent abruptly upward and inward, so that it lies along the dorsal surface of the basipod." But Wilson's statement on the origin of the flagellum is erroneous. Bouvier says correctly on the exopod (in *Dolops*): "Ce dernier rappelle l'exopodite des *Limnadia* et des *Estheria*, en ce sens qu'il se prolonge vers la base de l'appendice sous la forme d'une lanière dorsale qu'on appelle *flagellum* (Fig. 10 I et II). Ce fouet n'est pas inséré sur le dernier article basilaire comme le dit Claus au sujet des Argules." In two species of *Argulus* I find the same origin of the "flagellum", which is only a branch from the exopod and not articulated to it; consequently I accept Bouvier's comparison of the structure of the exopod and its "flagellum" with that in *Estheria* (comp. my fig. 3 a on Pl. I).

SUB-CLASS CIRRIPEDIA

(Pl. II, figs. 8—10).

Darwin, C.: A Monograph of the Sub-Class Cirripedia. 2 vols. Ray Society, London. 1851—1854.

Gruvel, A.: Monographie des Cirrhipèdes ou Thécostracés. Paris. 1905.

On the following pages representatives of the first order, Cirripedia thoracica, are dealt with; the four other orders are either unknown to me or their adults have no legs or mouth-parts. When I began the investigation I did not expect any new result of some significance, but I became really surprised.

We begin with the six pairs of thoracic legs, the so-called cirri. Darwin writes in his splendid Monograph (II, p. 71): "Each cirrus consists of a pedicel, having a long basal and a short upper segment, supporting two multiarticulate rami"; consequently he found only two joints in the sympod of the legs. Gruvel says in his "Partie anatomique" of his work (p. 381): "Chaque cirrhe est formé (fig. 376) d'une partie basilaire courte, trapue (*basipodite*), généralement à deux ou trois articles portant les deux *rames*". His figure quoted shows only two joints in the sympod, and his statement shows that he did not pay any importance to the question; otherwise probably all authors agree that the sympod is two-jointed.

A good-sized and well preserved specimen of the common *Balanus porcatus* is an excellent object. The three anterior pairs of legs are moderately well, the three other pairs very well, chitinized which is of importance for obtaining absolute certainty as to the articulations and joints of the sympods; besides the sympods of the posterior pairs are much more slender than the others. I may recommend the following line of action. The major part of the long rami is removed by a pair of scissors.

Then the animal is taken between two fingers on the left hand, the three or four anterior legs on the right side are bent forwards and kept in position, and then the anterior and outer surface of the proximal part of fourth or fifth right leg is examined with a pocket-lens or, and still better, kept under the simple microscope. It will instantly be seen that the leg inspected has three very distinct joints in the sympod; the bottom between that leg and the preceding one is a membranous articulation; the first joint (*pc*) is well chitinized, moderately short and separated from the second long joint by a good articulation; third joint is rather short. All six pairs of legs have the sympod three-jointed; in the three, and especially in the two, anterior pairs the first joint is considerably longer and broader, the second joint shorter and broader than in the three, especially in the two, posterior pairs. — Furthermore the thorax was cut into two halves through the median plane, and the one half well cleaned in potash, so that particulars as to articulations and firm chitine could be investigated; fig. 8 a exhibits the sympod with the proximal part of its cirri of the penultimate right leg seen from in front. The piece marked *a* is the firmly chitinized lateral band of the segment bearing the leg. While both the anterior and the outer side of first joint of the legs are well chitinized, its posterior surface, which especially in the posterior pairs is considerably shorter than the anterior, is rather or partly very thin-skinned and either somewhat feebly or not marked off from similar thin skin on the posterior side of second joint; in the last pair the posterior side of first joint is even united with the body.

In a large and well chitinized specimen of *Conchoderma auritum* the sympods of the legs are, especially in the three posterior pairs, shorter and much broader than in *Balanus*. The first joint which especially in the anterior pairs is considerably shorter in proportion to second joint than in *Balanus*, is extremely well marked off on the anterior side and at the inner margin on first to fifth pair, but indistinct on sixth pair. The first leg has a "filamentary appendage", an epipod, on the outer side of second joint at its base; the following legs have on the outer side of second joint from its base to near the end a rather thin-skinned, protruding swelling, which proximally is rather broad, on second and third leg as broad as the outer surface of the joint, and tapers rowards the distal end; this swelling looks almost as a kind of rudimentary epipod. On the præcoxæ of the five anterior pairs the "filamentary appendages" mentioned by Darwin are very long, excellently developed, and may according to their origin be considered as præepipods; on second to fifth leg they are at their origin united with the base of the rudimentary epipods, though marked off from these by a transverse impression; in sixth leg the præepipod is wanting. — In *Lepas anatifera* first leg has an epipod and a præepipod.

I have examined the mouth-parts in *Lepas anatifera, Conchoderma auritum* and *Balanus porcatus;* the differences found are unimportant and most of them not noteworthy. With good reason Darwin writes (II, p. 81) that "the mouth, in the Cirripedia, does truly exhibit a compounded structure of a very peculiar nature". He mentions a labrum and enumerates three pairs of mouth-limbs, naming them mandibles (with palps), maxillæ and outer maxillæ, an interpretation generally adopted excepting partly by Gruvel. That his investigation is on the whole good and very detailed needs scarcely to be mentioned, but my examination of the "mandibles" and the "outer maxillæ" reveals such differences from corresponding limbs in all other Crustacea, and even in other classes of Arthropoda, that I can scarcely accept his nomenclature, though I must admit that my own interpretation is only a suggestion or hypothesis which cannot be proved with certainty. (Gruvel writes (p. 14—15): "La *bouche,* formée d'une pièce impaire antérieure (*labre*), avec deux palpes labiaux, pairs et symétriques; en arrière, une paire de *mandibules,* puis une paire de *machoires* et enfin une lèvre inférieure impaire, très réduite, avec deux palpes labiaux (2^e paire de mâchoires des auteurs), bien développés, pairs et symétriques"; I find, however, these views less acceptable than Darwin's.) The "mandibles" differ, as shall be shown later on, so strongly from the mandibles in other Arthropoda while agreeing much more with maxillulæ or maxillæ, that I may prefer to name them maxillulæ; consequently mandibles are absent. Darwin's first pair of maxillæ is rather simple in structure and may easily be considered as maxillæ. But the last pair, Darwin's second maxillæ, does not seem to be paired limbs. They are described as being completely fused, with a pair of "palps" on the end; each hairy, not articulated palp has in *Balanus* on the upper side at the base and at the outer margin a somewhat oblong, rounded, erect, spiniferous and hairy protuberance, which is wanting in *Lepas* and *Conchoderma.*

To begin with Darwin's "*outer maxillæ*", it is impossible to discover any vestige of a fusion in the median line of their proximal impaired part. A fusion in the median line of the major part of the maxillæ is besides unknown in all Crustacea excepting in some forms among the Lernæopodidæ; this statement is of course no absolute proof, but it makes the interpretation of the organ as a coalesced pair of limbs less probable. I am inclined to consider the organ as hypopharynx (paragnatha or lower lip); an examination of the part both from below and especially from above reveals strong agreement with the bifid or bilobed hypopharynx in several Copepoda, in Apodidæ and in most Malacostraca. Especially the investigation of a large *Conchoderma auritum* corroborates this interpretation; in that form the porrected hypopharyngeal lobes, the "palps", are laterally much compressed, the chitinisation before and at their base is easily studied, and it is seen that the lobes are not articulated at their base to the unpaired chitine. Only a single feature seems to make my interpretation somewhat doubtful, viz. the existence of the opening of the excretory organ "on the outer side of the maxillæ", but this fact does not seem sufficient for adhering to the common view set forth by Darwin.

The *maxillæ* Darw. (fig. 9 c) consist of two joints. The distal joint is large, strongly compressed, curved, with an oblique cutting edge. The free external part of first joint is extremely short, but its firm chitine is produced backwards into a very long and strong internal apodème. Judging from the structure it seems to be impossible to decide whether this pair of limbs ought to be considered maxillulæ or maxillæ; but if the mandibles auct. are homologous with maxillulæ in other Crustacea, his first maxillæ are homologous with second pair.

The "*mandibles*" show a complex structure. Seen from below (fig. 9 a) the "corpus mandibulæ" is most decidedly two-jointed; first joint (*e*) is a very firm plate, longer than broad, cut off transversely at both ends; its proximal end is excellently articulated to the lateral firm chitine (*d*) on the lower side of the head, while its distal end is well articulated to the firm chitine of second joint (*f*). This joint is very large, strongly compressed, nearly flat on the lower side; its distal part is curved inwards, much expanded and terminates in a very long cutting edge divided by some incisions into oblong, triangular processes. Fig. 9 a shows besides a somewhat narrow, rather thin-skinned part (*g*) along the outer margin of first joint and of the proximal part of second joint; this thinner skin has somewhat before its end a triangular firm transverse plate (*h*), the inner end of which, indicated on the figure by dotted lines, is narrow and articulated to the dorsal side of the strongly compressed firm chitine of second joint a little from its outer margin. This transverse plate and the rather thin-skinned very oblong external area belongs in reality to the vaulted upper part of the "mandible", being its lowest, incurved part.

The major proximal upper portion of the mandible is vaulted and broad. When the "mandible" with the adjacent parts of the dorsal surface of the head is seen from above (fig. 9 b) it is observed that its proximal portion between its base and the above-named transverse plate (*h*) is rather thin-skinned (grey on the figure) but, excepting at the base, only moderately marked off from the thicker part (*i*) of the front; the transverse plate on the lower side (*h* on fig. 9 a) continues on the outer surface and across a portion of its upper side (*h* on fig. 9 b) where it is badly marked off, but separated from the head itself by a feeble oblique suture (*k*). Beyond that transverse band the mandible is again rather thin-skinned, then suddenly much narrowed and in *Lepas* and *Conchoderma* produced as an oblong-triangular, free palp (*l*) which overlaps the antero-lateral part of the well chitinized clypeus (*m*); this clypeus is generally named labrum, but a real labrum does not exist. At its base the inner margin of the palp is strongly chitinized and coalesced with firm chitine to the lateral margin of clypeus. In Balanidæ the palp is generally somewhat or much longer and distally thickened.

Darwin writes (II, p. 79): "In the mandibles, the free upper part is separated, by a distinct articulation, from the square piece of thickened membrane (fig. 3, c 1) on which it is supported; and this latter is separated by a second articulation from a portion of thickened membrane (c 2), the basal edge of which forms the third and lowest articulation, separating the mouth from the body." And on p. 80: "Whether or no there really are two segments beneath the upper free portion of the mandibles, which have become laterally confluent with other parts, I must think that the square thickened piece of membrane (c 1) represents at least one segment." And he refers to Brullé's paper on the mouth-parts in Arthropoda (1844): "according to M. Brullé, there ought to be two basal segments (sous-maxillaire and maxillaire) bearing the proper mandible, and giving rise, on the outer side, to the palpus, — a structure which perfectly corresponds with my view of the mandibles and palpus in Cirripedes." Brullé's paper deals especially with Insects with biting mouth-parts; his interpretation of the mandibles, in which be will find the same parts as in the maxillæ, is most unfortunate and has only literary interest. If Darwin himself had studied the morphology of mandibles and maxillæ in such Arthropoda as Copepoda, Malacostraca and Orthoptera, he would never have written the lines quoted from his p. 80. It is just the compound structure of these mouth-parts in Cirripedia which makes his interpretation of them as mandibles questionable.

What Darwin names "the square thickened piece of membrane" — a somewhat unfortunate term — is according to his text and figures the piece mentioned by me as the basal joint of the "mandible". It is well developed both in Lepadidæ and Balanidæ, has according to Darwin two muscles and belongs unquestionably to the "mandible". But "corpus mandibulæ" in Crustacea and Insects is never divided into joints, putting aside the "lacinia mobilis" on the cutting edge in many forms. Only in the majority of Myriopoda the mandible is divided into joints or parts of secondary origin, and the structure in Cirripedia is extremely different from anything known in Myriopoda. The first joint of the mandible in Cirripedia is similar to the "cardo" in the maxillæ of many Insects, and even in outline similar to first joint of the maxillulæ in several Amphipoda. The chitinized part behind that "cardo" mentioned by Darwin as possibly belonging to the mandible is, as seen on my fig. 9 a, in reality the lateral skeleton of the head sending a chitinized band across the lower side of the head. The transverse plate (*h*) articulated near the outer margin of the chitine of second joint and going upwards along the outer side and then across a part of the dorsal side might be interpreted as the chitinized portion of a third joint, from which the "palp" originates.

Stages of Development. — Unfortunately our Museum does not possess specimens of the very large forms of *Nauplii* or of the corresponding *Cypris*-stages. The examination of middle-sized *Nauplius*-specimens gave no really certain result; the sympod of the antennæ and the mandibles contained two well developed joints, but whether rudiments of the third joint existed I could not decide. The investigation of the sympods of the legs in small *Cypris*-stages is extremely difficult, but in a specimen the last left leg shows (fig. 10 a), with certainty that its sympod (*sp*) consists of three joints, the third almost as long as the two proximal joints together which are nearly equal in length. The endopod consists of three joints, but the proximal articulation is rather feebly developed; the exopod (*ex*) is two-jointed. I suppose that the examination of a very large *Cypris*-stage well cleaned in potash will show that the sympods of all legs are three-jointed as in the adult Cirripedia thoracica.

SUB-CLASS OSTRACODA

(Pl. III, figs. 1—4; Pl. IV, figs. 1—5).

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Müller, G. W.: Die Ostracoden. Fauna und Flora des Golfes von Neapel, 21. Monogr. 1894.

Skogsberg, T.: Studies on marine Ostracods. Part I. Zoolog. Bidrag från Uppsala. Suppl.-Bd. I. 1920.

Sars, G. O.: An Account of the Crustacea of Norway. Vol. IX, Parts I—IV. 1922—1923.

Sars divided the Ostracoda into four groups or orders, viz. Myodocopa (comprising several families), Cladocopa (only a single family, Polycopidæ, with two genera), Podocopa (comprising five families), and Platycopa (the single genus *Cytherella*). I accept this classification, though in important characters the Halocypridæ differ much from the other members of the Myodocopa, viz. Cypridinidæ, Asteropidæ, etc., and might be established as a fifth order. I have examined species of all four orders and of most of their families, viz. *Conchoecia, Cypridina, Gigantocypris, Philomedes, Rutiderma, Sarsiella, Asterope,* — all belonging to the Myodocopa — *Polycope, Macrocypris, Cypris, Cythere* (sens. lat.), and *Cytherella*.

The appendages in the animals of this sub-class exhibit a few analogies to features found in the Copepoda and somewhat more to peculiarities within two orders of the Branchiopoda, but taken as a whole they differ strongly from those in the other sub-classes. The number of appendages varies from five to seven pairs (antennulæ included) and is consequently lower than in Branchiopoda or Copepoda. In this enumeration the unjointed, brush-like lateral appendages found in the males of several forms are not included, as it seems uncertain whether that pair can be considered homologous with a pair of real legs; the seven pairs of branchial lamellæ in *Asterope* are scarcely rudiments of undeveloped legs.

Antennulæ. — They are always simple without accessory flagellum; the number of the joints scarcely exceeds eight, but it is generally somewhat, or sometimes much, lower.

Antennæ. — In all Myodocopa (as *Conchoecia, Cypridina, Asterope*) the antennæ are always described as consisting of an extremely large, much compressed, oblong or subcircular and very deep, unjointed sympod terminating in a rather long and robust exopod divided into several joints equipped with extremely long natatory setæ; a much smaller or even rudimentary endopod is inserted at the lower margin on the inner side of the big joint before its end. But a closer examination of the sympod shows, that its structure is much more complex. In *Asterope sp.* (from off St. Croix, West Indies) the big joint is inserted not directly on the head but by its proximal end on a rather long and less deep stalk (Pl. III, fig. 3 a); the wall of this stalk is nearly membranous, but has on the outer side a longitudinal narrow rib of firm chitine (*r*) articulated by its two ends respectively to the skeleton of the head and to the chitine of the big joint; this stalk with its longitudinal firm rib is evidently the first joint of the sympod. In the Cypridinidæ and Halocypridæ etc. the stalk is also found but less easy to make out, as it is shorter and goes not from the proximal end but from the inner side of the big joint to the head.

Furthermore the distal part of the same big joint exhibits a structure which induces one to conclude that a third joint is united with it. The structure is most complicated in *Cypridina* and *Gigantocypris*. On the outer side (Pl. IV, fig. 1 a) the most distal part is occupied by a subcircular membranous area (*a*) surrounded proximally, above and partly in front by a thickened band (*r*) in the chitinized wall. The front end is curved as a firm hook which fits into an excavation of the most proximal part of the exopod (*ex*), and the end itself of the exopod is even curved forward as a hook. Through the membranous area is seen a strong internal tendon terminating in a large disk to which an enormous muscle to the exopod is fixed, as the tendon (*t*) goes to the exopod a little beyond its curved end. Towards the lower margin of the membranous area is seen a strongly chitinized, rather narrow strip (*h*) proximally articulated to the hard chitine surrounding the membrane, and distally to the exopod somewhat beyond its base; the last-named articulation is very close, while the junction between the curved base of the exopod and the curved end of the big joint is rather loose. On the lower margin of the big joint somewhat before the exopod is seen the short and very thick basal joint of the three-jointed endopod (*en*). On the inner side of the big joint (fig. 1 b) a much smaller membranous area (*a*), limited above by the thickened margin of the wall, occupies the lower half of the surface; this area is traversed by a chitinized strip (*e*) running obliquely from the base of the endopod upwards and forwards to the firm chitine a little behind the base of the exopod, and this strip is movably articulated at both ends; besides the lower margin itself has a firm strip (*f*) from the exopod to near the endopod; finally one sees a more proximal vertical rib (*g*) which towards the endopod is strongly expanded, much thinner and badly limited. Other minor particulars are seen on the two figures. I think that the structure with movable chitinous strips must be considered as remnants of the third joint of the sympod, and the features found in *Philomedes* (see later on) highly corroborates that interpretation. — In *Asterope* the structure is a little less complicated. On the inner side (Pl. III, fig. 3 b) the oblique strip (*e*) and the strip of the lower margin (*f*) are well developed, and the vertical proximal rib (*g*) better marked off, while on the outer side (fig. 3 a) the large membranous area shows only a strong strip at the lower margin.

In *Philomedes* the structure towards the base of exopod and endopod is less complex than in *Cypridina*, but very instructive. The proximal end of the exopod and the apex of the big joint are both curved as hooks in opposite directions as in *Cypridina*, but the union between them is very loose and it is easily seen that it is no real articulation. The outer side has the large, subcircular membranous area, but the longitudinal firm strip is wanting. On the inner side (Pl. III, fig. 4 a) the membranous area is longer than in *Cypridina*, as in that genus limited above by a firm ridge, but proximally the area (*a*) is also distinctly marked off by a thinner and narrow ridge. The thick basal joint of the two-jointed endopod (*en*) is near the lower margin most distinctly attached to the external side of a plate (*l*) which runs forwards along the lower margin, tapers forwards forming a strip, the distal much incurved end of which is firmly articulated to a strong, curved process of the exopod. From the oblique proximal end of that plate a very oblong-triangular rib (*g*) runs upwards across the membranous area and is articulated to its limiting upper ridge. In *Philomedes* it is especially evident that the endopod is firmly inserted on a plate which is the expansion of the lower rib articulated to the exopod, and at its base to the vertical movable rib, while the terminal union between the exopod and the big second joint is loose; consequently the two movable, chitinized ribs and the surrounding membrane are certainly the third joint of the sympod.

In *Conchoecia* the structure is more simple. On the inner side of the second big, oblong joint (Pl. III, figs. 2 a and 2 b) is found a very oblong membranous area (*a*) from the exopod (*ex*) to the large, plate-shaped first joint of the two-jointed endopod (*en*), while the margin has the chitinized strip (*l*) distally articulated to the exopod and proximally to the outer side of the endopod. It seems that this strip, the remnant of the third joint of the sympod, is the essential more firm attachment of the endopod, and the movement of the exopod is transferred to the endopod, as I have been able to discern during manipulation under the simple microscope.

Turning now to the order Cladocopa we find that the antennæ differ only in points of secondary importance from those in the

Myodocopa. First joint (Pl. III, figs. 1 a and 1 b) is rather large, scarcely as long as thick, with some irregular thickenings in its membranous walls. Second joint is very large, compressed and rather oblong, with both rami inserted close together on its very oblique end. Seen obliquely from above and from the inner side (fig. 1 a) no distal membranous area is visible; the endopod is more than half as long as the exopod, three-jointed, and both rami possess very long and strong natatory setæ omitted in the figure. Seen obliquely from below and from the outer side the distal part of second joint has a large membranous area (*a*) with a longitudinal strip (*f*) of firm chitine, but other minute particulars have not been investigated.

In the order Podocopa the antennæ differ much from those in the two previous orders. G. W. Müller says that the sympod (his "Stamm") is unjointed, the endopod at most four-jointed, while the exopod, which is placed outside at the end of first joint, is only a small setiferous plate or a single seta. Sars says on the Cypridæ: "Posterior antennæ originating by a short and somewhat imperfectly defined root-joint followed by a much larger joint, which constitutes the main part of the basal portion [the sympod], the latter provided at the end outside with a small scale-like appendage [the exopod] carrying a slender anteriorly curved seta accompanied by one or two very small bristles; terminal part [the endopod] abruptly curved downwards and composed of 3 or 4 somewhat unequal joints . . . ." Thus Sars counts two joints in the sympod, but its structure is more complex.

The sympod, which must be studied in specimens cleaned in caustic potash, consists of three joints. Fig. 3 a on Pl. IV represents the left antenna of *Macrocypris minna* from the outer side. The third joint (*3*) which is rather long and geniculate upwards, thus quite opposite the direction found between the two corresponding joints in the order Platycopa (see later on), has the minute, squamiform exopod (*ex*) at the upper end. Second joint (*2*) is much shorter than the third and especially its upper margin is very short; its wall shows strongly chitinized ridges both at the distal and at the proximal end, and a thickened ring on the outer side. First joint (*1*) which is well developed on the outer side and below and is longer than second, has a distinctly thinner wall, which on the outer side has a strong longitudinal ridge (*r*) articulated to the proximal transverse ridge of second joint and at its proximal end confluent with a very slender ridge on the basal margin of the joint. This first joint is attached with its inner side and above to the head of the animal; it can on the whole be compared with first joint in the antennæ of the sub-order Asellota among Isopoda. The endopod is strong, rather long, four-jointed. — In *Cythere* sp. the sympod itself shows a rather similar structure.

In the order Platycopa the antennæ differ strongly from those in the three other orders. In *Cytherella* (Pl. IV, fig. 5 a) the sympod consists of a large proximal joint and a much shorter distal joint, which is bent downwards, as the articulation between the two joints is very geniculate. The proximal joint is certainly homologous with the big second joint in *Asterope* and other Myodocopa, and I am not sure that a short first joint does not exist, but my material is at present very scanty and the investigation very difficult. It is well known that both rami are terminal, well developed, robust, with many strong setæ; the endopod is three-jointed and longer than the two-jointed exopod.

Mandibles. — Authors agree that this pair of appendages consists of the mandible itself and a well developed palp with two to four joints, furthermore that the first joint of the palp is rather long and strong, most frequently with an always unjointed exopod, which is from rather small to minute, seldom wanting. Consequently the sympod should always consist of two joints — but in several Myodocopa three joints can be pointed out.

The best starting point is the Halocypridæ, especially forms of the genus *Conchoecia*. In this genus the masticatory process of the mandible is somewhat short and seen from behind (Pl. III, fig. 2 c) partly overlapped by a flattened masticatory expansion of the proximal inner part of the long joint of the palp; fig. 2 d, which represents the distal part of the mandible and the proximal part of its palp seen from in front, shows consequently how the masticatory process of the mandible covers partly that of the palp. The articulating membrane between mandible and palp is, as shown by the figures, rather broad on both sides, but on the posterior side (fig. 2 c) near the outer margin it contains an oblong, triangular piece of hard chitine articulated to mandible and palp. This piece (*c*) represents the second joint, the coxa, of the sympod and is homologous with the first small joint of the mandibular palp in *Calanus* and many other Copepoda. The piece, which has been overlooked by all Carcinologists, is very conspicuous in a mandible well cleaned in potash, but scarcely discoverable without such preparation. The exopod is small and placed on the upper margin towards its end of the third joint, the basis (*b*). The endopod (*en*) is three-jointed.

In the other families of the Myodocopa we find a somewhat different structure. Fig. 1 c on Pl. IV represents left mandible of *Cypridina norvegica* from behind; it is seen that the corpus mandibulæ, præcoxa, has on the outer side a long and very strong ridge (*r*) which is produced forwards as a process articulated to the long joint, the basis (*b*), of the palp. In the posterior articulating membrane I found besides a minute oblong piece of chitine between mandible and palp, thus a tiny remnant of the coxal joint. On the anterior side (fig. 1 d) the articulating membrane between præcoxa and basis is very large and is traversed by a somewhat long, oblique rib (*c*) of firm chitine articulated to both joints mentioned; this rib is a more considerable remnant of firm chitine of the second joint of the sympod. The masticatory process of the mandible is a recurved, rather thin-skinned and hairy lobe. The oblong, rather small exopod (*ex*) is inserted on the upper end of the very long basis; the endopod is three-jointed, simple. — The structure in *Gigantocypris* is nearly as in *Cypridina*.

In *Philomedes* and *Rutiderma* the chitinous rib representing the coxa on the anterior side is present; in *Sarsiella* this rib seems to be fused with the mandible. In these types the masticatory process is either small, firmly chitinized and terminating in a tooth or in two teeth, or it has nearly disappeared. In *Asterope* the membrane on the anterior side between mandible and "palp" is exceedingly large, but the rib seems to have disappeared; the masticatory process is moderately broad at the base, but tapers instantly and very strongly, being produced as a very long, very slender, much curved and quite recurved process with some low saw-teeth along the convex margin.

The mandibular palp in the genus *Rutiderma* (Pl. IV, fig. 2 a) must be mentioned. The distal joint of the sympod is rather long; the exopod (*ex*) is rudimentary. The three-jointed endopod is very transformed, and is a gigantic chela; its hand is formed by the two proximal joints which are extremely inflated but well marked off from each other by a somewhat sinuate band of a little thinner chitine; the end of second joint is produced into a long, moderately slender, but very strong and somewhat curved process which is the immovable finger of the chela; the terminal third joint (*t*) is rather small with a few setæ and on the end fused with an enormous claw (a transformed terminal spine, *s*) which is a little longer than the immovable finger, distally much curved, and together with the third joint constitutes the movable finger. It may be added that the upper margin of this finger is sharp and very finely serrate (the serration was too fine to be rendered in fig. 2 a). In a cleaned specimen one sees in the interior of the distal part of the hand a very oblong and much curved chitinized piece (*t*), which is fixed to third joint and in reality is a kind of tendon serving for the attachment of the enormous musculus adductor. — It may be pointed out that in no other genus among the Crustacea the mandibular palp is transformed into a chela, but nearly the same structure is found in Scorpions and Pseudoscorpions among the Arachnida.

In *Polycope* (the order Cladocopa) the sympod of the mandible is only two-jointed (Pl. III, fig. 1 c); the second joint, which distally is expanded much inwards and has an unjointed exopod of moderate size near the end, shows on the outer margin a little from the base a rudimentary emargination which perhaps is a remnant of the articulation; the endopod is two-jointed. — *Macromysis*, which may serve as the type for the order Podocopa, differs from *Polycope* in having the endopod three-jointed (Pl. IV, fig. 3 b, *en*) and the exopod (*ex*) placed on the proximal half of the outer margin of the somewhat robust second joint of the sympod. This exopod which is turned outwards and much backwards, is larger than in the Myodocopa and equipped with several strong, plumose setæ; it is probably a vibrating organ. It may be added that in different genera of Podocopa the size of the exopod and the number of its setæ show much variation. — In *Cytherella* the palp is rather long but only two-jointed (see Sars op. cit. Pl. XIX), as the proximal joint of the endopod seems to be coalesced with the distal joint of the sympod, and the very long joint formed in this way is equipped with a close row of extremely long and thin setæ placed a little from the inner margin and turned inwards; the exopod is rather short with several pubescent setæ.

As shown above, many pelagic Copepoda have a three-jointed sympod in the mandible, and its second joint is rather small and very short, but f. inst. in *Cyclopina* this small joint has completely disappeared, certainly being fused with the following one. In Ostracoda the structure is parallel, and the steps are: Halocypridæ — Cypridinidæ — Cladocopa — Podocopa.

Remarks on the post-mandibular Appendages. — Before describing the four pairs of post-mandibular limbs in Ostracoda some words may be said on their homologies with appendages in higher Copepoda and Malacostraca. The first pair is generally considered to be the maxillulæ, and though I cannot point out any special feature in their structure corroborating this view, I think it to be correct. On the next pair (the fifth pair of appendages) Dr. Calman writes in his handbook (p. 62): "The completely pediform character of this appendage in many Ostracoda suggests a doubt as to the homology with the maxilla of other Crustacea. This doubt is further strengthened by Müller's statement that the limb appears to belong to the thoracic rather than to the cephalic division of the body. More important still is the fact that in the course of development a pause in the successive appearance of the limbs occurs before this limb is added to the series. On these grounds there seems to be considerable probability in Müller's view that the maxilla has been entirely lost in the Ostracoda and that the appendage which occupies its place is to be regarded as homologous with the first thoracic appendage of other Crustacea". This view is also accepted by me; it may be pointed out for comparison that in the Cladocera the maxillæ are only present as a distinct rudiment in the embryo, but disappear completely in the adults. Consequently the three posterior pairs of appendages typically present in the Ostracoda must be interpreted as thoracic legs, but the first pair among them I will name maxillipeds for comparison with the corresponding pair in most orders of Crustacea.

Maxillulæ. — The order Cladocopa presents an excellent starting point. In *Polycope* the sympod consists of three extremely distinct and well developed joints (Pl. III, fig. 1 e). First joint (*1*) which is about twice as long as the second (authors have generally drawn it somewhat or much too short by overlooking its proximal portion), has distally near the inner margin on the anterior side a somewhat small, a little oblong, triangular lobe (l^1) well marked off and equipped with a number of setæ, while at the outer distal angle a rounded protuberance is found which I cannot interpret with certainty, but it looks nearly as a quite small præepipod. Second joint (*2*) has on the inner margin two small protuberances, rudimentary lobes, equipped with some setæ. Third joint (*3*) is long, with a small setiferous protuberance or rudimentary lobe on the inner margin before the middle; somewhat less than the proximal half of the joint is even slightly broader than second joint, being somewhat expanded outwards, and the expanded part is even produced obliquely backwards and outwards as a kind of protuberance containing muscles. On the distal end of the expansion the very oblong, rather long, moderately robust, unjointed exopod (*ex*) is articulated, while the third joint itself is suddenly much narrowed at that insertion, so that more than the distal half of the joint is only moderately robust; it terminates in the short, two-jointed endopod (*en*). It may be remarked that Sars and G. W. Müller draw an articulation across the third joint from the base of the exopod, but this articulation does not exist, which also agrees with the musculature; consequently the endopod is not three-jointed, and the exopod is not inserted on the end of third joint of the sympod, but before its middle on the outer side.

In all other Ostracoda the maxillulæ look very different from those in Cladocopa, and they have no exopod. It may be practical to begin with the Halocypridæ. The maxillula in

Conchoecia (Pl. III, figs. 2 e and 2 f) is rather easy to study, especially in a cleaned specimen. The firm chitine of first joint, præcoxa (*1*), is long and narrow, and from its distal half projects forwards and inwards a very long, moderately broad but beyond the middle narrowed plate which is the lobe (l^1) from first joint, and at the end it is armed with spiniform setæ. The second joint, coxa (*2*), is shorter than the first and produced forwards and inwards into a long and rather broad plate, the lobe (l^2), distally armed with spines and setæ. The apparent third joint, when seen obliquely from behind and from the outer side, is an oblong, large plate, the outer margin of which is rather incurved somewhat from the base, while the short proximal part of the inner margin, is produced as a rounded and rather low protuberance. In Sars' drawing this proximal part of the long joint is marked off as a separate joint; though I could not discover a vestige of this articulation in the firm chitine, a correct idea underlies nevertheless Sars' figure, as in the Cypridæ the corresponding part is distinctly marked off as a joint, and the outline in *Conchoecia* indicates also that the proximal part with the convex inner and outer margin of the apparently third joint in reality is a joint fused with the next longer fourth joint. Furthermore that rather short third joint has on its anterior side a rather small, somewhat oblong lobe (fig. 2 f, l^3) terminating in a long and very strong seta. The result is that we must consider the third joint, which is imperfectly marked off, as the third joint of the sympod, in this genus fused with the first oblong joint of the endopod; consequently we have a three-jointed sympod, each of its joints with a lobe, and the lobe from second joint more than twice as broad as the proximal lobe; exopod and epipod are wanting. The endopod consists of two joints; the first is broad, rather long and curved inwards, while the second which is much shorter and terminates in some curved spines, is directed not only inwards but even somewhat backwards.

The maxillula in *Cypridina* (Pl. IV, fig. 1 e) looks very different from that in *Conchoecia*, but at a closer study the differences, though considerable, are yet somewhat smaller than judged from the first impression. Its structure must be studied not only in its natural state but especially when cleaned in potash, and seen from behind. The firm chitine of first joint (*1*) is rather long, with almost the proximal half quite slender, and it is expanded forwards, oblong triangular and to the distal anterior angle of this expansion is articulated the lobe (l^1) which looks as a long, firmly chitinized rib directed forwards and inwards and terminating in a small transverse piece with several nearly spiniform, pubescent setæ. Second joint (*2*) has its firm chitine divided into parts separated by a thinner and partly thin area; the joint has two lobes (l^2). Along the end of first joint the proximal portion of its firm chitine is attached; it is produced much forwards and to its narrow end a rather long rib is articulated, and this rib which is the firm element of the proximal lobe of second joint, has on its thicker end some strong setæ. More than the distal half of second joint has a subquadrangular area which is somewhat or considerably thin-skinned and at the end connected with the proximal inner margin of third joint (*3*), but anteriorly we find a firmly chitinized, very oblong and rather narrow, somewhat curved piece (*r*) going from the middle of third joint inwards and forwards to the place where the proximal lobe of the joint begins, and here the transverse piece bears the second lobe which is similar to the preceding one. That the two slender lobes described belong to the same joint, the second, is seen by comparison with the maxillula of the Cypridæ (see later on); in *Polycope* the second joint has, as already stated, two rudimentary, setiferous protuberances representing the lobes. On the anterior side of second joint at its distal posterior end originates a very thick plumose seta (*ep*) which I think is a rudiment of the epipod well developed in the Cypridæ. Third joint (*3*) which is directed forwards, is nearly vertical on second joint which projects mainly outwards; its chitine is very firm and very oblong, but from its distal inner part a narrow strip of firm chitine projects forwards and mainly inwards, and to the distal margin of this strip the very long and rather narrow lobe of the joint is attached; this lobe (l^3) runs along the inner margin of the next joint and has a few long, plumose setæ. The three joints described with their four lobes constitute the sympod. The endopod (*en*) has two joints; the first is broad, very long and strongly chitinized; the second is broad and quite short; exopod wanting.

The maxillulæ in *Gigantocypris* are completely as in *Cypridina*; those in *Philomedes*, *Rutiderma* and *Sarsiella* differ only in features of minor importance, as the relative length of joints and lobes. The maxillulæ in *Asterope* are very different (Pl. III, fig. 3 c) but the chitinization is weak and lobes so rudimentary that it may be impossible to interpret all points with real certainty before forms intermediate between *Cypridina* and *Asterope* have been discovered — if they exist. I have examined a perhaps undescribed species taken near St. Croix, West Indies. Fig. 3 c shows that the maxillula has a rather broad and moderately low protuberance on the inner side near the base; this protuberance has the margin feebly trilobate and a couple of small knots on the anterior side. I consider this protuberance and the corresponding broad part of the limb as produced by the fusion of the two proximal joints; that part of the limb is marked off from a kind of "palp" by a transverse line and bears distally on the outer margin an oblong-triangular, naked plate which projects forwards and certainly is the epipod (*ep*). The "palp" is very long, very curved and has two joints well marked off from each other; the proximal joint is long and its outer margin is incurved beyond the middle as if it consists of two joints, consequently as in *Conchoecia* the third and the fourth; the third joint will then be the terminal one of the sympod, while the fourth is the proximal one of the two-jointed endopod; the terminal joint of the limb is rather long and slender with a very long and robust seta on the end. Parallel with the whole inner margin excepting that of the last joint the maxillula is equipped with a very close row of extremely long setæ inserted on the posterior surface; it may be added that proximally these setæ originate at the base of the protuberance and are therefore here more remote from the margin. As the figure exhibits the anterior side of the maxillula, the real insertion of all these curious setæ is invisible.

In the rich order Podocopa the maxillulæ are rather uniform, differing mainly only in points of minor importance as length and size of the lobes and the epipods. The maxillula in *Macrocypris* (Pl. IV, fig. 3 c) is an excellent type for the order. The maxillula — when the epipod is not taken into account — looks almost as the maxilla in some Insect, showing a "cardo", an oblong, very robust "stipes", three lobes and a three-jointed "palp". In a cleaned maxillula the first joint (*1*) shows a proximal transverse piece of rather firm chitine with its distal end articulated to second joint; from the middle of that piece a very long, moderately chitinized plate runs forward to the base of the well chitinized, long and slender lobe (l^1). Second joint is, seen from behind, a large and very oblong piece (*2*) which runs forwards and is gradually broader towards the lobes; the wall is moderately chitinized with a few thinner or thicker portions or stripes, and near the middle on the outer half of its posterior side a large, very oblong and distally broader, lamellar epipod (*ep*) is attached; this epipod, which evidently is a vibrating organ, is directed outwards and backwards, has numerous long and strong setæ on the distal and especially on the inner margin, and in this genus on the proximal end three long setæ directed forwards. It may be emphasized that this epipod is well developed in all genera of the rich order Podocopa. The second joint terminates in two long and slender lobes (l^2) not marked off at their base. On the outer distal angle of second joint the long and slender three-jointed "palp" is inserted; its proximal joint which is short, is the third joint (*3*) of the sympod, but the lobe found in *Cypridina* is wanting; consequently the endopod has two joints as in Cladocopa and Myodocopa; the first joint is long, the other short.

In *Cytherella* (the order Platycopa) the maxillulæ are most characteristic (Pl. IV, figs. 5 b and 5 c). The two proximal joints are short, broad and cannot be separated with certainty excepting at the outer margin, as this margin of each joint is convex (fig. 5 c); their wall is not firmly chitinized, but they possess on the inner margin three oblong, rather small, setiferous lobes, the proximal lobe (l^1) belonging to first joint (*1*), the two others (l^2) to second joint (*2*). On the posterior side near the outer margin of second joint an extremely large, subovate plate with strong and very long plumose setæ on the anterior, the outer and the posterior margin is attached, and this plate (*ep*) which is turned backwards and inwards, is in fig. 5 b even turned with the outer setose margin inwards, and the proximal part of the sympod was maltreated in the leg figured, while fig. 5 c, representing the parts from in front and from the outer side, exhibits the two proximal joints and the most basal portion of the plate, in their natural position; the plate is homologous with the large epipod in the Podocopa. The distal portion of the maxillula is a rather long and broad three-jointed "palp"; its proximal joint is about as long as the two distal joints together, has a deep incision on the inner side and may be interpreted as the third joint (*3*) of the sympod; consequently the endopod (*en*) is two-jointed as in the three other orders. The posterior side of first and second joint of the "palp" is equipped rather far from the inner margin with a close row of very long setæ directed inwards; as fig. 5 b shows the appendage mainly from in front the proximal part of these setæ is hidden.

Let us briefly recapitulate. The maxillulæ consist typically in all Ostracoda of a three-jointed sympod and a two-jointed endopod; an exopod exists only in Cladocopa (*Polycope*); an epipod is well developed as a vibrating organ in Podocopa and Platycopa, wanting in Cladocopa and Halocypridæ, while a remnant as a strong seta is present in many Cypridinidæ and developed as a somewhat small, naked plate in *Asterope*. First joint of the sympod has always an inner lobe (it is indistinct in the anomalous maxillula of *Asterope*). Second joint has either a single broad and long lobe (in Halocypridæ) or two lobes; these are rudimentary in Cladocopa, somewhat small in Platycopa, long and well developed in most Cypridinidæ with allied forms and in all Podocopa. Third joint has a lobe in Halocypridæ and in most of the other Myodocopa, a rudiment in Cladocopa, while in Podocopa the joint is simple without any lobe, and in *Cytherella* (Platycopa) it is incised on the inner side, so that we have two very low and broad lobes.

Maxillipeds. — A high and peculiar development is found in *Cypridina* (Pl. IV, fig. 1 f) and *Gigantocypris*. The first joint (*1*) is lamellar, extremely long, distally broad, and with its inner margin to somewhat from the end attached to the side of the animal. Its entire free outer margin bears a moderately high vibratory plate (*pe*) equipped along its whole margin with a very large number of strong, long and pubescent setæ; this plate is the præepipod (comp. many Cladocera). At the distal free part of the inner margin of the joint one sees two small, transverse pieces (l^1) of strong chitine, each with some setæ and thus representing a rudimentary lobe. Second joint (*2*) is very broad and rather short; its interior part is cleft into two lobes (l^2) with several setæ; the figure exhibits also how the skeleton produced into the anterior free lobe is marked off by thinner chitine. Third joint (*3*) is shorter and much less broad than the second; it has two setiferous lobes, the distal one small. These three joints constitute the sympod; on the end of third joint a small, two-jointed endopod (*en*) is inserted, and on its outer margin an unjointed, slender exopod (*ex*) as long as the endopod. (It may be added that the structure described is not very easy to make out, but the maxilliped of *Gigantocypris* is so large that a cleaned specimen can be manipulated under the simple microscope so that the articulations and the constituting elements can be traced with less difficulty than in *Cypridina,* though *C. norvegica* shows exactly the same details). — In allied genera, f. inst. *Philomedes,* the maxillipeds show proportionately minor differences from those in *Cypridina,* but in *Asterope* the part beyond the distal end of the præepipod is much reduced so that lobes and exopod have disappeared (see Sars op. cit. Pl. X).

The maxillipeds in *Polycope* (Pl. III, fig. 1 f) are on the whole related to those in *Cypridina,* though the differences are very pronounced. First joint is broad and very long (*1*), attached not by its side but by the base to the body and has distally on the inner side a low but broad and hairy protuberance; the præepipod (*pe*) which occupies the outer side excepting a short distal part, is lower and considerably smaller than in *Cypridina.* At first sight the sympod seems to be two-jointed, with the somewhat broad exopod (*ex*) inserted on the distal and very tapering part of second joint, but for various reasons, as the position of a couple of setæ and the insertion of the exopod, I suppose that the tapering part of second joint is in reality the third joint, though a transverse articulation between them could not be discerned with certainty. The endopod (*en*) consists of a single, very slender joint. — In *Cytherella* the maxilliped of the female (see Sars op. cit. Pl. XIX) is allied to that in *Polycope*; the first joint is similar in both genera, but in *Cytherella* we find only a very oblong, distally rounded second joint without endopod or exopod; the maxilliped in the male is unknown to me, and I am quite unable to interpret most of the fine figure drawn by Sars (Pl. XIX).

In the Halocypridæ we find maxillipeds of a different type. When omitting the vibratory plate, the maxilliped in *Conchoecia* (Pl. III, fig. 2 g) looks almost as a large and robust mandible with a slender, three-jointed "palp". The first joint, præcoxa (*pc*), which is inserted by the proximal part of its inner side, is distally produced inwards as a broad and somewhat short, flattened lobe, which even is somewhat excavated on its inner side and has a number of strong setæ on its inner margin. The proximal two-fifths of the joint has somewhat from the outer margin a moderately low vibratory plate, the præepipod (*pe*) with the free margin feebly trilobed and equipped with a number of radiating, strong and long, pubescent setæ. The "palp" is inserted on the outer margin where first joint begins to be produced inwards as a lobe; it consists of three joints, the terminal one short and the two others rather long, but the first considerably thicker than the second. (In a very large species of *Conchoecia* I found in a cleaned specimen the first joint of the "palp" moderately distinctly divided into two joints somewhat before the distal end.) (G. W. Müller's description in 1912, p. 53, of the maxilliped is wrong.) In comparing the maxilliped of *Conchoecia* with that in *Cypridina* and with the mandibles in the majority of Ostracods my interpretation is that the big proximal joint is the præcoxa with a præepipod; that the proximal joint of the "palp" is the third joint of the sympod, while its second joint has disappeared or is fused with the third as in the mandibular "palp" of most Ostracoda; the two distal joints of the "palp" are the endopod, and the exopod is wanting.

The maxilliped of *Cypris pubera* (Pl. IV, fig. 4 a) differs only from that of *Conchoecia* in secondary points, viz. that the masticatory process from first joint is very much longer, the "palp" only two-jointed, and the præepipod (*pe*) more narrow, without lobes and placed just behind the "palp". — The maxilliped of *Macrocypris minna* (Pl. IV, fig. 3 d) differs from that of *Cypris* in having the masticatory process much shorter and very slender, while the præepipod is wanting and the "palp" four-jointed. This maxilliped, which therefore consists of five joints (as in *Halocypris* I suppose that the sympod consists of the two proximal joints), constitutes a transition to the Cytheridæ, in which this appendage is shaped as a five-jointed leg without masticatory process on the long first joint, while the præepipod is small or wanting.

First Legs. — In *Conchoecia* (Halocypridæ) this leg (Pl. III, fig. 2 h) agrees with the maxilliped in possessing a feebly trilobed, well developed præepipod (*pe*) on first joint, but it differs in being shaped as a leg, as the first joint is of moderate length and breadth and without any masticatory process, while the second joint is attached to its end; the leg has five joints, and I suppose that as in the maxilliped the two proximal joints belong to the sympod. — In all Podocopa (Cypridæ, Cytheridæ) this leg is in the main as in *Conchoecia*, but without præepipod; this leg of *Macrocypris minna* (Pl. IV, fig. 3 e) is a good type. — In *Polycope* first leg is wanting. — In *Cytherella* the leg is a rudimentary lappet in the female; in the male it is well developed as a prehensile organ, but I am not able to propose any probable interpretation of the figure given by Sars (op. cit. Pl. XIX) of this curious organ. — In the Cypridinidæ the leg is shaped as a mouth-part (Pl. IV, fig. 1 g), being lamellar with four or three more or less developed lobes on the antero-interior margin, while the terminal joint is a large sub-triangular plate turned outwards. I do not venture any morphological interpretation of the lobes and joints in *Cypridina*, but may refer to my drawing quoted. — In *Asterope* the entire appendage is even only an oblique subtriangular plate without articulations or lobes (see Sars op. cit. Pl. X).

Second Legs. — In Podocopa this leg is similar to the first pair excepting in minor particulars of slight interest. — In *Cytherella* and *Polycope* it is wanting. — In Halocypridæ it is minute, nearly rudimentary, and consists of one or two simple joints (Pl. III, fig. 2 i) terminating in two setæ, one of which is exceedingly long. — In the Cypridinidæ sens. lat. it is developed in a quite anomalous way, being extremely long, vermiform and divided into innumerable joints; besides its distal portion is equipped with setæ and peculiar spines (see Sars op. cit. Pls. II and VI).

Summary on the Appendages. — A number of more important points in the structure of the appendages in this sub-class may be summed up here. In mandibles and the post-mandibular appendages the number of joints in sympod and endopod together never exceeds six (excepting in the anomalous multi-articulated second leg in Cypridinidæ sens. lat.), but this number seems also to be the typical one, though in numerous cases it is somewhat reduced. Thus we have here the same number as typical as has been pointed out above to exist in the post-maxillary appendages of all Branchiopoda.

The sympod consists of three distinct joints in the antennæ of all families excepting the Cytherellidæ; in the mandibles of Halocypridæ and several Cypridinidæ; in the maxillulæ of Cladocopa and also, though less obvious, in all other Ostracoda; finally in the maxillipeds of *Cypridina* and allied genera. As to the interpretation of the elements of the sympod the reader is referred to the treatment of each pair.

A vibratory or respiratory organ is frequently found in appendages excepting in the antennæ and second legs. On the mandible the exopod is certainly such an organ in the order

Podocopa. On the maxillulæ the epipod is highly developed as such an organ in Podocopa and Platycopa. On the maxillipeds it is neither exopod or epipod, but a præepipod, which constitutes a vibrating or respiratory organ; it is highly developed in Cypridinidæ, Cladocopa and Platycopa, well developed in Halocypridæ and more or less in many Podocopa, while it is absent in other forms of this order. Only the Halocypridæ possess a vibrating præepipod on first legs.

Finally it may be mentioned here that in the interesting genus *Asterope* the maxillulæ have along nearly their whole length an extremely close row of exceedingly long setæ originating rather near the inner margin and directed inwards, and that in the Cytherellidæ not only the major part of the maxillula but also most of the long mandibular "palp" have rather similar rows of setæ directed inwards. These peculiarities are interesting analogies to features found in many Cladocera, especially in the tribe *C. ctenopoda*.

On the Literature. — The two works most important for our knowledge of the appendages in Ostracoda are those by G. W. Müller in 1894 and G. O. Sars in 1922—1923; their titles are given above on p. 56. Especially Sars' work has been quoted or referred to several times on the preceding pages. But the results of my investigation differ as to very numerous points so much from the views or interpretations of Claus, G. W. Müller, G. O. Sars and other authors that a special discussion or criticism of their opinions is deemed superfluous. The differences are partly due to my study of appendages not only in their natural state but also cleaned in caustic potash. However, the two works mentioned together with the Monograph of northern Ostracoda by Brady and Norman (1889 and 1896) have been most useful as a survey of the extreme variation in the shape of the appendages; especially Sars' work with its excellent and very numerous figures is most instructive.

SUB-CLASS TRILOBITA

Jaekel, O.: Ueber die Organisation der Trilobiten. Zeitschr. der Deutschen geolog. Gesellschaft, 53 Bd. 1. Heft. 1901.

Raymond, P. E.: The Appendages, Anatomy, and Relationships of Trilobites. Memoirs Connect. Acad. f. Arts and Science. Vol. VII. 1920.

Walcott, C. D.: Cambrian Geology and Palæontology. IV. No. 7. Notes on Structure of *Neolenus*. Smithson. Miscell. Collect. Vol. LXVII, No. 7. 1921.

As our Mineralogical Museum possesses next to nothing of Trilobita with appendages, this chapter must be founded exclusively on the literature. I cannot see any valid reason why Trilobita should not be considered as true Crustacea, and I follow some earlier authors in regarding them as a sub-class as f. inst. Branchiopoda or Cirripedia.

The literature on the legs is essentially American, but the German Professor Otto Jaekel has published the above-named paper which is very interesting, and as to the proximal part of the thoracic legs it differs profoundly from the works of Beecher, Raymond and Walcott. Jaekel examined the sympods of several of the more anterior pairs of thoracic legs of a specimen of *Ptychoparia striata* Emmr. from Middle Cambrian in Bohemia. He came to the result that the sympod consists of three joints, the first subquadratic without any gnathobase, the second much shorter than the first; from the end of third joint originates a many-jointed, setiferous exopod and a six-jointed endopod; as to an epipod he has no observation. On his photographs the sympods of the legs differ exceedingly from those of all American authors, and it seems to me very interesting that he describes them as consisting of three joints, though according to his text he certainly did not know that several years before I had stated that three joints in the sympod is the primary number in the appendages of Crustacea. (It may be mentioned that Beecher (in 1902) critisized Jaekel's view and attempted to give a very different explanation of the facts described.) As to the number of joints in the endopod Jaekel agrees with Raymond and Walcott, and we arrive at the result, that according to his statement the walking leg consists of nine joints, the same number as found be me in two genera of Leptostraca described later on, and with some modification of the præcoxa also in types of two other orders of Malacostraca. I think to draw attention to other points in Jaekel's paper in the future second part of this work.

Then the American authors. Raymond says (p. 126): "In all Trilobites the endopodite consists of six segments, and the coxopodite of a single segment the inner end of which is prolonged as an endobase"; and some lines before: "Since the exopodite articulates with the basipodite as well as with the coxopodite." Walcott (op. cit. p. 421 and fig. 21 A) writes on the thoracic limbs in *Neolenus*: "The broad, flat arm of the exopodite is represented as attached to the limb at the proximal end of the basipodite, and both join the distal end of the coxopodite . . ." In Crustacea the exopod originates always from a single joint (only in the so-called third maxillipeds of *Eupagurus* and other Paguridea I have found the exopod articulated to the basis and besides by a special protuberance attached to the coxa, a structure to be considered as a secondary development — see later on in the chapter on Decapoda). I think that the exopod was never in any Trilobite articulated to two joints, as expressly stated by Raymond and more vaguely by Walcott, though according to his diagrammatic figure both endopod and exopod seem to be articulated to the end of the coxopodite, while the lower proximal side of the exopod touches the upper side of the endopod. In order to make clear the difficulty in such a topic I may refer readers to G. O. Sars: Account Crust. Norw. Vol. III, Cumacea; in a large number of his drawings, even in many of the analytical figures of thoracic legs, it is impossible to see whether the exopod originates from the first quite short joint, the coxa, or from the proximal end of the long second joint, basis, or from both joints, and in several of the figures it seems to be attached to first joint. In fact the exopod in the Cumacea is always inserted very near the base of second joint, and Sars' figures convey an excellent idea of the general impression made by the legs on the investigator. But when the real structure of these parts in the legs of Cumacea is so difficult to perceive, that a special study of the movable insertion is needed, it may be a very difficult thing for a student of Trilobites to decide whether the exopodite originates from the "coxopodite" or from the "basipodite".

According to Walcott and Raymond the thoracic leg has seven joints. The six distal joints, the endopod, agree with Jaekel's diagrammatic figures excepting in the fact, that according to these the first joint of the endopod has no connection with the exopod. But the "coxopodite" as described and figured by the Americans is a very curious thing. It is from moderately long to very elongated, and its major proximal portion is a spiniferous process, the "endobasis", projecting freely inwards and somewhat backwards below the ventral surface of the animal. Raymond says (p. 126) "that the limb is articulated with the dorsal skeleton in a manner which is very peculiar for a Crustacean." According to his figure the "coxopodite" is attached on its upper side far from its inner, free end and somewhat or a little from its outer end to an "appendifer", a process originating from the dorsal skeleton and going down through the body to the "coxopodite" (see his fig. 19 in the text). It is certainly "very peculiar", and I think it to be impossible. Walcott (p. 384) discards the term "appendifer", says that there is not one but two processes from the dorsal skeleton, and thinks these to be points of attachment for muscles, and one among them "a strong base for the muscles connecting the coxopodite of the ventral limb to the dorsal test". I am apt to suppose that points of interest as to the coxopodite are still undiscovered; I cannot understand various questions which present themselves. Walcott also described an epipodite originating from the coxopodite a little from its distal end.

According to the American authors the antennulæ of Trilobites are well developed, simple, multiarticulate. Behind the antennulæ four pairs of appendages have been found in several genera; all pairs are biramous and in the main built as the thoracic limbs, but the free process of each coxopodite is more or less altered in shape, as in order to serve "as mouth-parts (gnathites)". These four pairs may represent antennæ (in Nauplii the proximal joints of the antennæ function as mouth-parts), mandibles, maxillulæ, and maxillæ.

Raymond disproves with good criticism (p. 117—118) Lankester's reasons for referring the Trilobites to the Arachnida instead of the Crustacea. But two objections raised by Dr. W. T. Calman (Geolog. Magaz. Decade VI, Vol. VI, No. 662, 1919) against the reference of the Trilobites to the Crustacea may be mentioned. Calman says that an important point is the total absence of a carapace in Trilobites; "only in Anostracous Branchiopoda, in some Syncarida (*Bathynella*) and possibly in the Copepoda, is the shellfold entirely absent, and it is a reasonable conclusion that it must have been present in the ancestral stock of the Crustacea. No Trilobite shows any trace of such a fold". The other point is that in Trilobites the eyes are sessile. "Sessile eyes are indeed common enough among recent Crustacea, but there are good reasons for thinking that the condition is in all cases a secondary specialization, and that the eyes were primitively pedunculate and movable." To this statement on

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the eyes I may answer that it seems to me highly probable that the paired eyes in the ancestors began to develop as single sensory spots at the front end of the head, and not on the end of a pair of stalks. Raymond says also (p. 151): "The simplest Trilobites are nearly or quite blind." And as to the other point, the carapace, I cannot see any reason why it "must have been present in the ancestral stock of Crustacea". It may be possible that my faculty as to speculation on structure in unknown ancestors is feebly developed and that consequently my opinion on such matters is valueless. But I may point out that though the relatively small difference between the different pairs of mouth-parts, and between mouth-parts and the thoracic legs seems to be a primitive feature, the structure of the legs with their seven fine joints (if not nine) in the stem, their very developed exopods and epipods indicate a high degree of development, in some respects higher than in Leptostraca — consequently the animals possessing such legs must have had a very long series of ancestors. And can the Trilobites not be a lateral branch which died out, thus a branch from the unknown stem, unknown ancestors, from which both two other exstinct sub-classes of Crustacea (see below) and recent Crustacea originated? There may also be other possibilities.

Finally another point. From the Cambrian period especially Walcott described not only a good number of genera of Trilobita but besides several other very curious animals with biramous appendages. Raymond arranges them in three sub-classes, viz. Trilobita, Haplopoda and Xenopoda. The Haplopoda he divides into two orders with four genera, one among them being the Trilobite-like *Marrella* Walc. which has the antennæ long, simple, multiarticulate and similar to the antennulæ; Xenopoda comprises four genera. Most of these forms are imperfectly known, but they differ widely from each other. When Crustacea have been so richly developed in so old strata as the Cambrian period — and most among the non-Trilobites have been discovered by Walcott even in a quite small portion of Middle Cambrian in British Columbia — it seems to me to be nearly hopeless to speak of ancestors of Crustacea and their structure. Our knowledge as to the Cambrian fauna is evidently still in its infancy, and when we in a remote future know ten, or better a hundred, times more of the forms of such very old Crustacea and their structure, it may perhaps be possible to solve partly some of the riddles on ancestors. From the history of our knowledge of the structure of the Arthropoda during the last hundred years, and partly from my personal experience, I am tolerably acquainted with the difficulty to study the morphology of the skeleton even in good material preserved in spirit, the difficulty as to the counting of segments and joints and to discover leading features. Taking such facts into consideration, one may better understand the enormous difficulties connected with the study of Cambrian fossils, generally poorly preserved, flattened or crushed, and frequently hitherto very rare.

SUB-CLASS MALACOSTRACA

This extremely rich sub-class is divided by Calman (1904 and 1909) into two series, viz. Leptostraca (comprising only the order Nebaliacea) and the Eumalacostraca, comprising four divisions: Syncarida (the order Anaspidacea), Peracarida (comprising five orders: Mysidacea, Cumacea, Tanaidacea, Isopoda, and Amphipoda), Eucarida (the two orders Euphausiacea and Decapoda), finally Hoplocarida (the order Stomatopoda). On the following pages the appendages in Leptostraca, in each of the four divisions of Eumalacostraca and in the orders of Peracarida and Eucarida shall be treated separately. After this preparation a concluding chapter follows, in which it is attempted to write more general comparative statements on the appendages in the whole sub-class. But before the whole task some notes on a small number of morphological papers may be given.

Milne-Edwards, H.: Observations sur le squelette tégumentaire des Crustacés Décapodes et sur la morphologie de ces animaux. Ann. Sci. Natur. Zool. 3[e] Ser. T. XVI. 1851. In this highly remarkable paper the renowned author builds the foundations for the general morphology of the appendages in the order Decapoda, and thereby indirectly to some degree in other orders. He gives names to the constituting elements of the appendages, including each of the seven joints found in thoracic legs. He does not separate the sympod (Huxley's protopodite) from the endopod, but as to second and third maxillipeds he considers the appendage as consisting of an endognath with an exognath from the second and an epignath from the first joint; at the walking legs he uses the names exopodite and epipodite, but has forgotten — as pointed out by Boas — the name endopodite.

Boas, J, E. V.: Studien über die Verwandtschaftsbeziehungen der Malakostraken. Morphol. Jahrb. Bd. VIII, 1883. One part of this rather important paper, viz., the author's opinions on the orders of Malacostraca, their boundaries, their affinities to each other, and their phylogeny is outside the scope of the present treatise, but his investigations on the morphology of the appendages are of interest. He refers *Nebalia* to the Phyllopoda, but makes it a starting point for his considerations. He speaks of eight pairs of thoracic limbs, naming them "cormopoda", as he includes the maxillipeds; from a general morphological standpoint this view is correct, but I do not apply it, as the maxillipeds (only first pair when more than one pair is present) in most orders differ so much from the following pairs that they must be dealt with separately, and as they in Tanaidacea, Isopoda, Amphipoda, Insects, etc. are attached to the head, forming a lower lip. Boas says that these eight pairs consist of a seven-jointed endopod, an epipod from the outer side of the first, and an exopod from second joint. Putting aside cases of reduction in number by fusion of joints in the endopod he evidently takes it for granted that f. inst. the fifth joint in a leg of *Penæus* is homologous with fifth joint in *Mysis* or *Asellus* — an opinion which can not be maintained. He saw that the "Hauptbiegungsstelle", the "knee", in the thoracic legs is situated between the fourth and the fifth joint in Euphausiacea and Decapoda, but between fifth and sixth joint in Mysidacea, Isopoda, etc.; this very important difference was not understood, as the author did not suspect its origins, which would have shown him that f. inst. fifth joint in the legs of Decapoda is not homologous with fifth joint in *Mysis* or *Asellus*, and that the primitive number of joints in the thoracic legs is not seven. — The abdominal appendages he finds to consist of endopod and exopod, the endopod of a two-jointed peduncle and an unjointed or many-jointed terminal part; proceeding from this view he was able to point out a frequently overlooked quite short proximal joint in the peduncle, but his starting point made it impossible for him to discover that the peduncle consists in some forms of three joints.

While Boas' statement on "corpus mandibulæ" as first joint (not formed by fusion of joints) of an appendage is correct, his interpretation of the antennæ in Mysidacea, Isopoda and Gammaridea is less fortunate. His erroneous starting point, that the exopod, the squama, shall proceed from second joint proved to be fatal; he found that in *Mysis*, *Janira*, etc. the squama projects from third joint, and then he concludes that the first joint must be a part of the head produced and marked off as a joint; his interpretation of the structure in Gammaridea is tainted in a similar way. He made real progress in the investigation of the sympod of the antennæ in the orders mentioned; but his theory that the exopod shall proceed from second joint hindered a correct interpretation, though just the existence of three distinct joints in *Janira*, *Mysis*, etc. ought to have shown him that his theory was wrong. — But the worst part of his paper is his treatment of the maxillulæ and maxillæ in the whole sub-class. He started as usual from the theory on the origin of the exopod from second joint, and he did not investigate the more firmly chitinized elements in these two pairs of mouth-parts, though the study of these parts and of the whole structure would have shown that in most orders three joints in the sympod can be pointed out with absolute certainty. He gives a large number of outlines of maxillulæ and maxillæ in representatives for the orders of the sub-class, and they are consequently nearly all wrong and valueless from a morphological standpoint.

It is deemed appropriate to write this somewhat detailed criticism of the morphological investigations and views published by Boas. His treatise is the first attempt in the literature to give a comprehensive study of the morphology of the appendages in the orders of Malacostraca; it is carried out with great consistency, it has produced real progress as to several particulars, and it has greatly influenced many later Zoologists; f. inst. Giesbrecht's treatment of the appendages of Malacostraca in Lang's Handbuch (1913) is in the main only a kind of reproduction of the same views. The numerous shortcomings in his treatise originate partly from his theory on the exopod from second joint — thus only two joints in the sympod — in all appendages excepting antennulæ (and eye-stalks), and partly from superficial investigation; besides his dealing with earlier authors is not unfrequently somewhat unfair and written in a way as if he himself was nearly faultless.

Hansen, H, J.: Krebsdyr, in Dijmphna-Togtets zoologisk-botaniske Udbytte. 1887 (p. 185—286 and p. 508—511). In this paper the writer began the revolt against Boas' treatment of the mouth-parts in Malacostraca. In the "résumé" I wrote (p. 509) a long passage quoted on p. 9—10 in the present treatise. I studied the mouth-parts, especially maxillulæ and maxillæ, in representatives for the orders Isopoda, Amphipoda, Cumacea and Mysidacea. The results are that in these orders the maxillulæ possess a lacinia from first and one from third joint, while second joint has no lobe; the maxillæ have a lobe from second and none from the first joint, but as to the distal portion of the appendage in Isopoda, Cumacea and Mysidacea I made the error to describe and figure two joints each with its lobe, while in reality it is only the third joint which is bipartite (in 1890, in the paper on Cirolanidæ, I corrected that error); the representation of the maxilla in Amphipoda is correct. Furthermore I showed that the exopod of the maxilla in Mysidæ and Cumacea is attached to the outer margin of third joint. It was also pointed out that the maxillula in *Euphausia* has lobes from first and third joint as in the above-named orders, and besides that in the adults the plate named exopod by Boas and exognath by G. O. Sars is in reality a large expansion of the lobe from first joint, while the real exopod exists in larval stages of *Euphausia* and then disappears. Excepting the point mentioned on the third joint of the maxillæ in the three orders, these old results (illustrated by a number of figures) are the same as those given in the present treatise; they differ consequently widely from those set forth by other authors.

Hansen, H. J.: Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen und Insecten. Zoolog. Anzeiger Bd. XVI, 1893. This preliminary paper is mentioned in the Preface, and besides a passage is reprinted on p. 10, but a resumé of its contents as to the Malacostraca may be omitted here. Yet two points may be noted. I committed an error in considering the real claw in several orders as a joint; it is, as pointed out especially by Racovitza (1923), only a terminal spine. All the other statements on the structure of the appendages are maintained in the present treatise, in which the order Anaspidacea, unknown to me in 1893, is added, and besides a number of new facts discovered since that year are given.

It may be inserted here that in some papers published by me between 1893 and 1924 morphological descriptions with figures of mouth-parts, etc., in animals of several orders are given, especially in Crust. Malac. I (1908) and III (1916) of "The Danish Ingolf-Expedition", in "The Schizopoda of the Siboga Expedition" (1910) and in the book (Fasc. LXIV) on the Monaco-Sergestides (1922).

In some few preliminary notes, especially in "Comptes Rendus" from 10. July 1905 and 26. May 1919, *H. Coutière* has published several statements on the comparative morphology of the appendages in various Malacostraca. I can not accept all his statements, f. inst. I can not now count the claw, his "stylocerite", as representing a joint, and I can not admit that the third joint, basis, in the maxilla of *Gennadas* and other low forms of Decapoda (or their larvæ) consists of two joints, "probasis" and "metabasis", but I consider it very meritorious that in *Gennadas* and in Caridea he points out a "segment pré-ischial", which he proposes to name "pré- ou amphischiopodite"; later on in the present treatise it is pointed out that this joint, which I name *præischium*, can be pointed out in the thoracic legs of numerous Decapoda and that this name ought to be applied to a well developed joint in Peracarida and *Anaspides*.

Papers published by Claus, Thiele, Borradaile, etc., and dealing — among other topics — with the morphology of appendages in Malacostraca are mentioned in the "Introduction" (p. 14—17). A remarkable paper "Notes sur les Isopodes" by *E. G. Racovitza* (1923) is mentioned later on at the order Isopoda, but as some of his pages (p. 93—96) take a wide outlook a few remarks may be made. The author writes: "Pour établir l'homologie des articles des péreiopodes chez les Crustacés, il faut d'abord déterminer leur basis et les comparer ensuite en les alignant sur cet article." His first requirement, to determine their basis (the place of insertion of the exopod, when it exists) is correct, but as to his second demand it may be remarked, that as a præischium is more or less distinct in the legs of many Decapoda and very developed in *Anaspides*, we have consequently both in these orders and in Isopoda, Mysidacea, etc., three joints between basis and the "knee", and the place of the "knee" proves itself to be of the highest importance for determining the homologies of the joints in the distal half of the endopod, or sometimes in the entire endopod. But Racovitza does not state anything on the præischium, and the primitive number of joints in the endopod of Malacostraca is six, not five as counted by him (p. 95). On the primitive number of joints in the exopod I have not the slightest idea; when Racovitza writes "deux rames [endopod and exopod] à cinq articles", I cannot see anything on which this statement as to the exopod may be founded, but perhaps it is a misscript.

Series Leptostraca.

Order Nebaliacea.

(Pl. IV, fig. 6; Pl. V. figs. 1—2.)

Sars, G. O.: Report on the Phyllocarida. Rep. Voy. "Challenger", Zool. Vol. XIX. 1887.

Claus, C.: Ueber den Organismus der Nebaliiden und die systematische Stellung der Leptostraken. Arb. zool. Inst. Wien. Bd. VIII. 1888.

Sars, G. O.: Fauna Norvegiæ. Vol. I. Phyllocarida and Phyllopoda. 1896.

Thiele, J.: Die Leptostraken. Wiss. Ergebn. der deutschen Tiefsee-Expedition "Valdivia" Bd. VIII. 1904.

Hansen, H. J.: The Order Nebaliacea. The Danish Ingolf-Expedition. Vol. III. 6. Crustacea Malacostraca. IV. 1920.

The four first-named papers, which are comparatively large, are the main sources to our knowledge of not only the genera and species, but of the whole external and internal structure of this highly interesting order. The present paper shows that I cannot accept several of the statements on the appendages made in these works. The description given here is partly reprint, with several alterations and especially additions, of my above-named "Ingolf"-paper, and the analytical figures of *Nebalia bipes* are copies from that treatise. *Thiele's* paper: Betrachtungen über die Phylogenie der Crustaceenbeine (1905) which has been mentioned in the Introduction (p. 14), may also be taken into account. The author lays stress on the musculature, especially on the absence of special muscles to the præcoxa of the thoracic legs, and therefore he somewhat imprudently denies the existence of the præcoxa. To this the following answer may be given. The musculature in legs may sometimes be of importance for the study of existence or homology of joints, but the disappearance of musculature to a joint cannot as a rule be used in morphological interpretation, because muscles are not found when the next joint shall not be moved (comp. the absence of a muscle in carpus of legs in *Siriella* and several other genera of Mysidæ); by fusion of two joints in an appendage the movement between them ceases, and when a joint is much reduced, f. inst. its more firmly chitinized part proportionately small, muscles to its movement are sometimes wanting. From detailed study of the musculature in the head of various families of Diptera (Nat. Tidsskr. 3. Række, B. XIV.

1884) I have learnt that a moderately well developed morphological element is in one family completely without musculature (f. inst. the unjointed maxillary palp in Bombyliidæ and Asilidæ), while in another family is has an active, not only a passive function, is consequently larger and equipped with a muscle (in the Tabanidæ the first joint of the two-jointed palp has a muscle from one wall to another) and in all three families there is no muscle in the head or from the stipes maxillaris to the first joint of the palp. The chitinized tubes or plates of an appendage are the most important elements in morphological investigation, the musculature is secondary, but in some cases its existence or nature is most useful for solving a morphological question. Thiele's examination of the musculature in the thoracic legs of *Paranebalia* is, for the rest, of slight value, as he overlooked no less than four small muscles of real value for the counting of the joints of the endopod.

The order Nebaliacea comprises four valid genera. The following treatment is based essentially on *Nebalia bipes* and *Paranebalia longipes*. Of the genus *Nebaliella* I have only seen a single young specimen, while of the very large but much reduced and feebly chitinized *Nebaliopsis typica* I have inspected some specimens, but not made any dissection. As *Nebaliella* exhibits two primitive features in the antennæ, Thiele's representation (1904) and an observation of my own are referred to at the description of these appendages.

A segment bearing the movable eye-stalks is not marked off.

The *antennulæ* (Pl. V, fig. 1 a) are described by Sars and Thiele as having the peduncle four-jointed, with a plate-shaped upper ramus projecting from the end of fourth joint. This is correct, but what they name first joint consists of two different parts. The large proximal part of this so-called joint is a protruding portion of the head (*h*); it is on the outer side marked off from the skeleton behind it by a fine, curved line, which neither in *Nebalia* nor in *Paranebalia* shows the slightest degree of movability, when one attempts to move it by two minute knives; furthermore the portion protruding on the right side is united on the lower surface with the left portion without any median suture, and the whole lower wall is undivided and well chitinized. At the distal end of this solid part is seen a narrow transverse band (1), which is firmly chitinized and very movable, in reality the first joint of the antennula. The three following well developed joints of the peduncle and the upper ramus (*u*) are seen on the figure and need scarcely any special description.

The *antennæ* (Pl. V, fig. 1 a) are described by authors as having the peduncle three-jointed in *Nebalia* and *Paranebalia*, four-jointed in the two other genera; it has been seen by Sars and Thiele that third joint consists in *Nebalia* of two joints completely fused, while these joints are well separated in *Nebaliopsis* and *Nebaliella*. It is now generally admitted that the Nebaliacea are on the whole more related to the Mysidacea than to any other order. Furthermore it is known that the antennal peduncle in Mysidacea and Isopoda Asellota consists of the sympod itself and the three proximal joints of the endopod; these three last-named joints are in Mysidacea and Asellota quite different from the distal multiarticulate and somewhat cirrus-like part of the endopod, and the first of these three joints is short; finally it is proved later on that the sympod in Mysidæ, Asellota, etc., consists of three joints, and thus we have in all six joints in the antennal peduncles of these groups. And we find the same joints and a similar structure in Nebaliacea. What authors considered to be first joint in *Nebalia* consists of two well separated joints (fig. 1 a), the first (*1*) being well chitinized on the outer side and separated from the second (*2*) by a narrow membrane. Near the end of third joint (*3*) is on the outer side at the lower angle in *Nebalia* an insignificant low elevation, but in *Nebaliella antarctica* is found, as figured by Thiele (1904), an oblong protuberance, which in the young specimen in our Museum is well marked off, and certainly is the reduced squama or exopod; in some Asellota the squama is also quite small and of similar shape. At the end of third joint the fourth (*4*) is represented in *Nebalia* by a transverse, movable, well chitinized plate; in Mysidæ and Asellota this fourth joint is short as stated above, and f. inst. in *Gammarus* it is present but even scarcely as developed as in *Nebalia*. As already said, fifth and sixth joint are fused in *Nebalia* (fig. 1 a, *5—6*) and *Paranebalia*, well separated in *Nebaliopsis* and *Nebaliella*.

The *mandibles*, well figured by Sars (1896, op. cit. Tab. II, fig. 10) show nothing of special interest. The distal part of the præcoxa or corpus mandibulæ is turned inwards and split into a short, triangular incisive part and a long molar process. The palp is three-jointed, and the interpretation of its joints is given later on in the chapter on the Syncarida by comparison with the mandibular palp in *Anaspides*, *Paranaspides* and *Calanus*.

The *maxillulæ* (Pl. IV, fig. 6 a) are rather easy to investigate. Each consists of a proximal broad part, the sympod, and an extremely long "palp", the endopod. The sympod — seen from behind — consists of three joints; first joint, præcoxa (*1*) has a rather long lobe (l^1), the firmly chitinized part of which has a distal, ovate, partly free plate with setæ on the inner margin, while its proximal part is rather long, narrow, articulated to the joint itself near its base, and with a geniculate articulation somewhat from its origin. Second joint (*2*) has no lobe, and its firm chitine is a narrow strip at the outer margin. Third joint, basis (*3*), is a broad and large plate, with the very broad lobe (l^3) not marked off from the joint and equipped with setæ near the inner margin. The proximal part of the endopod (*en*) is at least three-jointed, moderately long and somewhat robust, while the distal part is slender, extremely long, and seems to be divided into a few joints impossible to count with certainty. Fig. 6 a shows in greyish tint the membranous part of the maxillula. Exopod and epipod wanting.

The *maxillæ* (Pl. V) consist in *Nebalia* (fig. 1 b) and *Paranebalia* (fig. 2 a) of a sympod with an unjointed, slender exopod (*ex*) and a two-jointed endopod. The sympod is most easy to understand in *Paranebalia*, where it consists of three moderately distinct joints; first joint, præcoxa (*1*), is rather large without any lobe; second joint, coxa (*2*), which is short and thin-skinned at the outer margin and at least on the outer half marked off from first joint by a somewhat oblique line, has two lobes well separated from each other, in reality a lobe cleft to the bottom; third joint, basis (*3*) has proximally on the inner side a long, narrow lobe (l^3), while distally it is a little produced inwards and forwards into a rounded protuberance with three gigantic setæ. In *Nebalia* (fig. 1 b) the præcoxa is united with the coxa, as their is no distinct line between them.

The *maxillipeds* and the seven pairs of *thoracic legs* are similar in all features worth mention. Especially their proximal portion is very compressed, nearly lamellar. *Paranebalia* (figs. 2 b and 2 c) affords an excellent starting point. A leg consists of a three-jointed sympod (*sp*), a six-jointed long and rather slender endopod, a long and slender unjointed exopod (*ex*) and a somewhat small, oblong epipod (*ep*). The præcoxa (*pc*) is very short, but at the outer margin quite distinctly marked off from the body and from the coxa. This joint (*c*) is a rather large subquadratic plate containing several muscles; its inner margin is a little convex feebly indicating a lobe, and a little from its distal end a distinct, somewhat oblique linear incision runs from the margin, so that we have a division of the feeble lobe; the epipod (*ep*) is attached near the distal outer angle of the joint. The basis (*b*) is rather well marked off from the coxa, and the articulation between basis and endopod is indicated by a fine transverse line running from the outer margin and more or less inwards. But here we find the most interesting feature that a minute muscle (m^1) runs longitudinally near the inner margin, and comparing this muscle with four corresponding muscles (m^2—m^5) in the endopod it is evident that the first-named muscle runs from towards the end of bases to slightly beyond the here invisible limit between sympod and endopod. The long endopod, which tapers gradually to the end, is divided into six distinct joint, the articulations are very oblique, and the four proximal articulations are near the inner margin crossed by the above-named four small muscles. These five pairs of muscles near the inner margin are found in every one of the eight pairs of appendages. There is no muscle from fifth to sixth joint, but a very long and thin muscle runs near the outer margin of the endopod from near the base of its second joint to beyond the base of fifth joint. For comparison with the joints in the endopod of other Malacostraca the six joints in *Paranebalia* may be named præischium, ischium, merus, carpus, propodus and dactylus. It may also be mentioned here that we have the same six joints in the endopod of Trilobites.

The legs in *Nebalia* (fig. 1 c) are considerably shorter and broader than in *Paranebalia;* the epipod is an enormous oblong plate (*ep*) and the exopod a large oblong plate (*ex*). When one removes the carapace on the one side of a well-sized *N. bipes* and then discards or cuts off the epipods, the præcoxæ in the row of thus denuded legs are easily seen with a good pocket-lens as transverse plates well marked off from body and from coxæ, and by touching these præcoxæ with a minute knife they are observed to be better chitinized than the narrow articulations. The sympod in *Nebalia* is nearly as in *Paranebalia*, with an incision into the lobe of the coxa, but the five longitudinal muscles near the inner margin of the leg are all wanting. The articulations in the endopod are transverse, but while those separating the three or four distal joints are generally very distinct across the endopod, the proximal articulations, including that between sympod and endopod, are generally only visible near the inner margin. As in *Paranebalia* the endopod has six joints.

In *Nebaliopsis* the legs are very reduced with at most a single articulation in the endopod, but the præcoxa is rather large and distinctly marked off on the outer and on the posterior side. In *Nebaliella*, according to Thiele, the epipod is wanting and the endopod very distinctly articulated.

The *natatory abdominal legs*, four pairs, are strong and have, according to authors, a two-jointed sympod. But on the exoskeleton of a *Nebalia* cleaned in caustic potash (Pl. IV, fig. 6 b) it is not difficult to see that between the tergite (*t*) and the long distal joint (*3*) of the sympod small chitinized plates are found, and these are very naturally interpreted as belonging to two joints (*1* and *2*); the lettering on the figure may be sufficient for the understanding. This structure is similar to that found in *Cirolana, Æga, Arcturus,* mentioned below. Both rami are strong; the exopod unjointed; the endopod consists of a quite short basal joint with an oblong lobe, *"appendix interna"* or retinaculum, articulated to its inner side, while the distal joint is very long. — The two posterior pairs of legs placed on fifth and sixth abdominal segments are much reduced, uniramous; first pair is two-jointed, second pair unjointed. — The abdominal appendages in the other genera do not show differences of greater morphological interest from those in *Nebalia*. The *furcal rami* are long, strong, unjointed; they are noted here for comparison with the rami in larval stages of Mysidacea.

The morphology of the appendages in Leptostraca given here differs in many particulars from those published by Boas

Claus, Sars, Thiele, Borradaile, etc., but as a detailed criticism of the descriptions and opinions of these authors would require some pages, the remarks in my text above may be sufficient.

Division Syncarida.

Order Anaspidacea.

(Pl. V, fig. 3.)

Calman, W. T.: On the genus Anaspides and its Affinities with certain fossil Crustacea. Trans. Roy. Soc. Edinburgh, Vol. XXXVIII. 1896.

Sayce, O. A.: On Koonunga cursor, a remarkable new type of malacostracous Crustaceans. Trans. Linn. Soc. London, Zool. 2. Ser. Vol. XI. 1908.

Smith, Geoffrey: On the Anaspidacea, living and fossil. Quart. Journ. Microsc. Science. Vol. 53. 1909.

Calman, W. T.: Notes on the Morphology of Bathynella and some Allied Crustacea. Quart. Journ. Micr. Science. Vol. 62. 1917.

In the last-named paper Calman gives the classification of this curious order. He divides it into five families, two of which founded exclusively on extinct forms. The three other families comprise in all four genera, each with a single species, and all living. The family Anaspididæ has two genera, *Anaspides* and *Paranaspides*. I have dissected *Anaspides* and looked on immature specimens of *Paranaspides*, but the two other living forms of the order, viz. *Koonunga cursor* and *Bathynella natans*, I never saw. The external morphology of the four living genera is on the whole well known; on the following pages some points are added to our knowledge of *Anaspides*. It may be emphasized here that the structure of the maxillipeds and the thoracic legs is of the highest importance for comparison with those in Peracarida and Eucarida, and the same is the case with the mandibular palp in *Paranaspides*. — The following description is based almost exclusively on *Anaspides*, with several statements taken from the literature as to the three other types, while the extinct forms are omitted.

The *paired eyes* in *Anaspides* have the stalk distinctly two-jointed and fixed to a common transverse piece, a kind of ocular segment, which is well marked off above by a deep transverse suture or articulation, and this segment seems to be a little movable. Just below it is found a large, protruding, semi-globular, black *unpaired eye*, which seems to have been overlooked by the authors. — The eyes are sessile in *Koonunga* and wanting in *Bathynella*.

The *antennulæ* have a three-jointed peduncle and two well developed rami.

The *antennæ* in *Bathynella* have a three-jointed sympod with all the joints well developed, an oblong unjointed exopod and a five-jointed endopod; judging from the shape the three proximal joints in this endopod may, as in Mysidæ, be interpreted as the distal joints of the peduncle. In *Koonunga* the exopod is wanting and the sympod described as two-jointed. In *Anaspides* the sympod is described as two-jointed, but on the so-called first joint which is not strongly chitinized, I find on an antenna cleaned in potash (fig. 3 a) a transverse strip of still thinner chitine a little before the middle, thus indicating a division. The exopod is the plate-shaped squama; the endopod possesses only two joints referable to the peduncle, and a multiarticulate flagellum.

The *mandibles*. — In *Anaspides* (fig. 3 b) — according to Smith also in *Paranaspides* — corpus mandibulæ has a well developed incisive part with saw-teeth, a short and rather thick molar protuberance, and between both a kind of a rather well-sized, oblong, very oblique and only moderately chitinized lobe (*l*) with a considerable number of thin, elegant marginal spines; this lobe deviates considerably from the structure in the orders of the Peracarida and especially from that in Eucarida. The mandibular palp is in *Anaspides* simple and three-jointed as typically in all orders and genera of Malacostraca possessing a palp, but G. Smith found a most interesting feature in *Paranaspides*. He says (op. cit. p. 506): "In old specimens it appears to be distinctly four-jointed, and the basal joint carries a very definite, little, external branch tipped with two setæ. In young specimens the extra joint, i. e. between segment two and three, may be absent, and the external branch is not so conspicuous. The external branch occupies the position of an exopodite, and if the mandibular palp in this form is really biramous it would be unparalleled in Crustacea except among the Copepoda and Ostracoda." I cannot see the slightest reason for supposing that the palp is not "really biramous", though Smith adds: "Considering, however, that *Paranaspides* is otherwise a rather specialised form, and that the character in question is best marked in old specimens, it seems doubtful if we are really dealing with a primitive characteristic". I may remark that as far as I know, there is also something in the doctrine of evolution which with good reason is named atavism.

The structure described in *Paranaspides* makes it possible to determine the morphological value of the three joints in the mandibular palp of Malacostraca. In *Calanus* and many other Copepoda the mandible consists (see above) of a three-jointed sympod and two rami; the præcoxa is the mandible itself, the coxa is quite short, and basis is large; in *Cyclopina* (and many other Copepoda) the coxa has disappeared, being fused with the basis, but both rami remain. We find that the mandible in *Paranaspides* exhibits quite the same parts as that in *Cyclopina*, viz. præcoxa, basis and the two rami while coxa has disappeared; besides Smith's figure on p. 506 shows that basis is much thicker than the joints in the endopod. The result is that the proximal joint of the three-jointed palp in *Anaspides* and other Malacostraca is the third joint, basis, of the sympod, while the two distal joints are the endopod.

The *maxillulæ* (fig. 3 c) in *Anaspides* are as to structure intermediate between those in the Euphausiacea and the lower Decapoda, but different from the Peracarida. While in Euphausiacea the two proximal joints, præcoxa and coxa, are separate, they are completely fused in Decapoda; in *Anaspides* the second joint (*2*) is feebly marked off from the first (*1*) by a strip of somewhat thinner chitine. As in not specially reduced types of all orders of Malacostraca the præcoxa has a long lobe (l^1) with the distal margin setiferous; this lobe has on the posterior side of the maxillula an external moderately high and very broad expansion (*ps*) which is also found in *Penæus*, *Stenopus*, *Galathea*, etc., and is extremely developed in the majority of Euphausiacea. Calman in 1896, but not in 1909, and Sayce names the expansion the exopodite respectively in *Anaspides* and *Koonunga*; the same interpretation of the same plate in Decapoda and Euphausiacea has been given by Boas, Claus (1885) and Sars, while Giesbrecht in 1913 named it epipod. The interpretations are wrong; the plate-shaped expansion originating from the lobe issuing from the præcoxa, has nothing to do with exopod or epipod, and already in 1912 I named it *pseudexopod*. Second joint has as usual in Malacostraca no lobe; the lobe from third joint is normal and as usual not marked off from the joint itself; the endopod (*en*) consists of a minute joint, the palp.

The *maxillæ* (fig. 3 d) have been insufficiently studied and incorrectly interpreted in *Anaspides*, *Paranaspides* and *Koonunga* by the principal authors on the Syncarida. The maxilla is somewhat similar to that in *Glyptonotus* (Pl. VII, fig. 3 b) and consists of three joints, all belonging to the sympod. First joint (*1*), præcoxa, which is very oblong and moderately small, is transverse and as in all Malacostraca without any lobe. The coxa (*2*) is large, distally widened and produced into a very large, free lobe (l^2) which is deeply bifid. The third joint (*3*) lies along the outer side of the second and has a long, narrow, firmly chitinized piece constituting much of the outer margin of the appendage; at the distal end the joint is suddenly expanded inwards as an extremely broad lobe (l^3) which is divided into two secondary lobes by a rather deep cleft; the outer one of these secondary lobes is generally described as the "palp", but it is far from well marked off at the base, and even if it had been so, it could not be interpreted as a separate joint, as the comparison with *Glyptonotus* and especially *Mysis* (Pl. VI, fig. 1 b) will show plainly. G. Smith's figures of the maxillæ in *Anaspides* and *Paranaspides* are very poor and erroneous. Endopod and exopod are wanting.

The *maxillipeds* and the *thoracic legs* in *Anaspides*, *Paranaspides* and *Koonunga* have been well examined by the above-named principal authors. But for comparison with other Malacostraca it is necessary to deal with their structure in this paper; some particulars are to be specially emphasized, and I can add one important feature. The following description is based exclusively on *Anaspides*.

It may instantly be stated that for two reasons to be given below the præcoxa of eight pairs of limbs is not fused with the coxa. Beginning with the coxa the maxilliped (fig. 3 e) consists of eight very distinct joints and terminates in a well developed claw. The coxa (*c*) is broad and moderately long, with two freely projecting, oblong, setiferous lobes (figs. 3 f and 3 g, *l*) articulated at the inner margin, and two very oblong, plate-shaped epipods (*ep*) on the outer side; on a coxa cleaned in potash most of its posterior side is well chitinized (fig. 3 f) without any vestige of a fusion of two joints, and its anterior side (fig. 3 g) is rather firmly chitinized excepting anteriorly towards the inner side. Basis (*b*) is short, transverse, and its firm chitine does not reach the inner margin neither on the posterior nor on the anterior side; on the distal outer angle it has an unjointed, slender, thin-skinned exopod somewhat similar to the distal one of the epipods. The endopod consists of six joints: præischium (*pi*), ischium (*i*), merus (*m*), carpus (*cp*), propodus (*pp*), and dactylus (*d*); the knee is between merus and carpus.

The thoracic legs have in the male no lobe from the coxa, but according to G. Smith fourth, fifth and sixth pairs have in the female a "small setose lobe" on the inner surface. In the anterior pairs (fig. 3 h) basis is nearly as in the maxillipeds, but in the posterior pairs, seventh pair excluded, it is gradually more narrow and more closely united with the præischium; in sixth pair (fig. 3 i) basis is scarcely half as broad as præischium and marked off from it only by a sub-longitudinal suture. Furthermore the præischium, which is long in the maxilliped (fig. 3 e), is gradually shorter from before backwards in the legs, so that in sixth leg (fig. 3 i) it is conspicuously shorter than ischium (*i*), and owing to its union with basis it seems at first sight to be the second, exopod-bearing joint of the leg. In the five anterior pairs of legs the exopod is built about as in Mysidacea, long, many-jointed, etc.; in sixth leg the exopod is in the main similar to that of the maxillipeds, though somewhat broader. Each leg of these six pairs has two plate-shaped, oval epipods. In the seventh pair of legs both epipod and exopod are wanting (fig. 3 l), and basis is fused completely with præischium, so that the leg exhibits only seven free joints, with the knee between the fourth and the fifth.

The question then arises: has the præcoxa disappeared completely in or at the thoracic legs? When the side of a well preserved specimen is inspected, it is observed that the lower part of each tergite (fig. 3 k, *t*) above the origin of the five anterior pair of legs is marked of by a longitudinal impression, and on a skin cleaned in potash it is easily seen that this impression is thin-skinned as the membrane of an articulation; the area below the impression is divided into a small anterior and a rather large posterior portion, and the skin of the latter somewhat rounded portion is distinctly thicker than that of the longitudinal impression, and along the articulating membrane at the coxa that chitine is thickened as a narrow, brown strip. Above the sixth leg this structure is less distinct, as the chitinized area is much smaller. Above seventh leg the structure is more aberrant (fig. 3 l), developed almost as an oblong joint (*pc*). I think that the part marked off above each of the thoracic legs is the præcoxa (*pc*) united with the body, quite as the coxa itself is in numerous Isopoda a feeble movable or immovable epimeron, distinctly or indistinctly or not at all marked off from the body. (The structure in *Mysis* and in *Thysanopoda* described later on corroborates strongly my interpretation in *Anaspides*).

At the maxillipeds in *Anaspides* the question on præcoxa is more difficult. Their segment is fused with the head which is divided by the transverse mandibular groove; the portion of the head behind this groove bears maxillulæ, maxillæ and maxillipeds, and it has on each side a horizontal groove, much deeper behind than in front. It seems to me not improbable that the part *below* this groove has something to do with a præcoxa of the maxilliped, but it can not be proved; if this interpretation might be adopted the præcoxa is expanded forwards as a plate above both maxilliped, maxilla and maxillula, and the two last-named mouth-parts have their own præcoxa well developed and turned inwards below the head to its median skeleton. This interpretation is only set forth as a suggestion. — On the structure of maxillipeds and thoracic legs in *Paranaspides, Koonunga* and *Bathynella* the reader is referred to G. Smith, Sayce, and Calman.

As to the pleopoda and uropoda in *Anaspides* the reader is referred to Calman (1896). The rami do not exhibit any morphological feature of special importance; I have been unable to point out chitinized parts of more than two joints in the sympod of the anterior pleopods, but the quality of the ventral chitine is not well fit for such study.

The structure of the maxillipeds and thoracic legs is of the highest importance in presenting starting-points for the understanding of the corresponding appendages in Peracarida and Eucarida. G. Smith (p. 525—526) has suggested something in that direction, but as he evidently had not studied the legs in Mysidæ and in a number of genera of shrimps his proposals as to the places of fusion of joints in Peracarida and Eucarida are not correct. All the other appendages in Syncarida — excepting the mandibular palp in *Paranaspides* — present no feature useful as starting point for interpretation of the constituting elements of the appendages in other Eumalacostraca.

Division Peracarida.

As already stated, this division comprises five orders: Mysidacea, Cumacea, Tanaidacea, Isopoda, and Amphipoda. As an introduction to the treatment of each order some features in the appendages may be mentioned, thus in the main a kind of abbreviated resumé of results proved on the following pages.

It is a well known fact that the distal part of corpus mandibulæ has typically between the incisive and the molar part a lacinia mobilis and a row of setæ. — In many representatives of three of the orders the sympod of the antenna is three-jointed, a number which therefore is considered typical. — In the maxillulæ second joint is distinct and generally, but not always, movable against the first; the last-named joint has most frequently a distinct or well developed lobe; third joint is always produced into a lobe. — In the maxillæ the exopod, when existing, is distinctly attached to third joint.

The maxillipeds differ considerably or very much in general aspect from the thoracic legs, but in all these eight pairs of appendages three joints, viz. præischium, ischium and merus, are typically found between the frequently exopod-bearing basis and the knee; besides it shall be shown that in some forms of three of the orders it is possible to point out with certainty the præcoxa either in the maxillipeds or in most thoracic legs. A still more important fact may be mentioned here, viz. that according to all morphological investigators the legs in these orders have only two joints (the distal one most frequently with a terminal claw) beyond the knee, but I am now able to show that in the sub-order Mysida about half of the genera has in second to seventh pair of legs three real joints beyond the knee, thus the same number as in Syncarida and Eucarida, and the proof is essentially based on the musculature. These three joints beyond the knee are of course carpus, propodus and dactylus, and the consequence of this structure in many Mysidæ is that we must conclude that in the other Mysidacea and in the four other orders of Peracarida the carpus is fused with the propodus, an interpretation strenghtened by the typical length of carpus, propodus and dactylus in Syncarida and the Mysidæ in question as compared with that of carpo-propodus and dactylus in the other Mysidacea and the four other orders, and even with the relative length of carpus, propodus and dactylus in the legs of numerous Decapoda. — It may be added that in all orders of this division the females carry their eggs and young in a marsupium consisting of lamellæ issuing from the coxæ of at least two pairs and at most all seven pairs of thoracic legs; these lamellæ may perhaps be of epipodial nature.

As to the abdominal appendages it is most frequently possible to point out two joints, viz. basis and a quite short coxa in their sympod, but in several cases and especially in the uropoda of Amphipoda the coxa has vanished. It shall be shown later on that in representatives of some families of Isopoda all three joints are present in at least the anterior pairs of pleopoda. Excepting this point the abdominal appendages are nearly omitted on the following pages, as their morphology as far as it concerns the theme of the present treatise is on the whole well known.

Order **Mysidacea.**

(Pl. V, fig. 4; Pl. VI, figs. 1—8.)

Sars, G. O.: Carcinologiske Bidrag til Norges Fauna. I. Monographi over de ved Norges Kyster forekommende Mysider. 1—3. Hefte. 1870—1879.

— Report on the Schizopoda. Rep. Voy. "Challenger". Zool. Vol. XIII. 1885.

Hansen, H. J.: The Schizopoda of the Siboga Expedition. Siboga-Expeditie, XXXVII, 1910.

The two works of Sars contain together descriptions of most of the more important types of the order, and the high number of generally excellent figures on the numerous plates convey a fair idea on the appendages in the different genera. The "Siboga" work is referred to because it contains my classification of the sub-order Mysida used in the present paper. In earlier papers (1887 and 1908) I have figured maxillulæ and maxillæ of some types.

The order is correctly divided by Boas (1883) into two sub-orders: Lophogastrida and Mysida. The main difference between them is that in the Lophogastrida we find highly developed branchiæ at the base of the legs, while branchiæ are entirely wanting in Mysida. Especially in the structure of the thoracic legs a large part of the Mysida shows decidedly more primitive features than the Lophogastrida; the existence of ramified branchiæ is certainly a secondary feature; the fusion of joints in the antennal sympod of *Gnathophausia*, the shape of the maxillæ in Lophogastrida, the high number of marsupial plates in Lophogastrida, in the family Petalophthalmidæ and in the sub-family Boreomysinæ can scarcely be considered primitive features.

In *Mysis* is found between the insertions of the extremely movable eye-stalks a transverse, very movable piece well chitinized above, thus a kind of an ocular segment. The lower side shows a moderately large antennular segment about as long as broad, but scarcely movable; the dorsal part of this segment is a small triangle in front of the ocular segment. In *Boreomysis nobilis* a somewhat similar structure is observed. In *Gnathophausia* we find above a well chitinized pentagonal piece, posteriorly raised as a transverse immovable keel, and to the ends of this keel the jointed eye-stalks are articulated. Consequently we have in this genus no separate ocular segment, but the whole pentagonal piece is movable, and behind it is seen above a very developed articulating membrane. Whether this rather interesting difference between *Mysidæ* and *Gnathophausia* is found in all main genera of the two sub-orders has not been investigated.

The *antennulæ* have the peduncle three-jointed, and both rami well developed.

The *antennæ* have the exopod shaped as a plate. In *Mysis* the sympod is distinctly three-jointed (Pl. V, fig. 4 a), with thin membrane between the more firmly chitinized plates. In *Gnathophausia* the number of joints may be said to be the same, but the first joint is feebly chitinized, and the two other joints are immovably fused, with a conspicuous transverse impression but without any articulation or suture between them in the rather firm chitine. The peduncle of the antennæ in this order is six-jointed, as the three proximal joints of the endopod are quite different from the somewhat cirrus-like flagellum, and the first joint in this endopod is short.

The *maxillulæ* (Pl. VI, figs. 1 a, 7 a, and 8 a) have always a well developed lobe (l^1) from first joint, and of course one from third joint; the second joint (*2*) is well marked off. In *Gnathophausia* (fig. 7 a) a well developed, two-jointed palp is inserted near the base of third joint and directed backwards; it is wanting in all other genera of the order. In *Mysis* (fig. 1 a) the first joint (*1*) has a somewhat short but very broad and thin-skinned pseudexopod (*ps*) developed from the lobe (l^1) and turned outwards, covering a part of the maxillula on its posterior side; the margin of the pseudexopod is fringed with minute hairs. This pseudexopod seems to be found in the whole large family Mysidæ, but is almost or quite wanting in the sub-order Lophogastrida; the family Petalophthalmidæ has not been investigated.

The *maxillæ* are as to general shape most normal in the Mysidæ. In *Mysis* (Pl. VI. fig. 1 b) the first joint (*1*) is a transverse triangular plate vertical on second joint (*2*) which is somewhat oblong and anteriorly produced into a very long lobe (l^2) sharply marked off at the base, directed forwards and inwards, distally much expanded and besides by the curvatures of its terminal very long margin feebly incised and with its most distal part produced as a quadrangular lobe. The firm chitine of third joint (*3*) consists of a long, narrow and distally broader piece projecting from the end of second joint and separated from the lobe of this joint by an oblong-triangular area of thinner chitine; the lobe of third joint (l^3) is rather large, well chitinized, articulated to the distal inner angle of the joint, divided to somewhat from its base into two secondary, setiferous lobes. The endopod consists of two well developed joints, the palp. The exopod (*ex*) is a setiferous plate, the base of which occupies the whole outer margin of third joint. — In the Lophogastrida the maxilla consists of the same elements. In *Gnathophausia* (fig. 7 b) it differs somewhat from that of *Mysis*, especially in the shape of third joint which at least by one author has been erroneously interpreted as the first joint of a three-jointed palp; in *Eucopia* (Sars, 1885), *Lophogaster* and *Paralophogaster* (Hansen, 1910) the shape of the maxilla is more anomalous and its elements more difficult to make out.

The *maxillipeds* and *thoracic legs* are generally described as seven-jointed and the last joint terminating in a claw; furthermore the exopod is well developed, many-jointed in all eight pairs excepting on the maxillipeds in Lophogastrida, as in this sub-order it is wanting in *Gnathophausia*, somewhat small and unjointed in the other genera; it may be added that the exopod is wanting on the last pair of legs in *Ceratolepis*. The maxillipeds differ considerably from the intermediate legs, and the first pair of legs, the so-called gnathopods, differ somewhat or considerably from the following pairs which generally are rather uniform. It is well known that in all forms the maxillipeds have a large, oblong, plate-shaped epipod; an epipod is wanting in all thoracic legs in the sub-order Mysidæ; on the Lophogastrida see later on.

When comparing the legs in most Mysidacea with those in *Anaspides* two difficulties are instantly observed, viz. the fate of the præcoxa, and, according to the literature, the existence of only two real joints beyond the knee in Mysidacea but three in *Anaspides*. For the solution of these questions the Mysidæ are the best starting-point. In this family one finds always in second to seventh pair of legs three, four, five or more joints beyond the knee, and authors agree that this number is due to the subsividion of a single joint. But this interpretation is partly or completely erroneous in many Mysidæ, and the study of the musculature reveals interesting facts.

In most species of *Siriella*, f. inst. in *S. Clausi* (and at least in the elongated second pair of legs in *Hemisiriella*) we have in reality the same three joints: carpus, propodus and dactylus beyond the knee as in *Anaspides;* in both forms carpus is much shorter than propodus and much longer than dactylus (Pl. VI, figs. 2 a and 2 b). In *Siriella* the carpus (*cp*) contains no musculature, while in the propodus (*pp*) *musc. flexor dactyli* (fig. 2 b, *m*) is highly developed and fills towards its base at least most of or even the whole lumen of the joint; a *musc. extensor dactyli* seems to be wanting. In *S. Thompsoni* the articulation between carpus and propodus is difficult to discern, but the musculature is as in *S. Clausi.* — In the sub-family Boreomysinæ, f. inst. in *Boreomysis nobilis* (fig. 3 a) the carpus (*cp*) is nearly as long as, and thicker than, propodus (*pp*), from which it is separated by an oblique articulation, and it contains no muscle; propodus is divided by a transverse articulation, and *musc. flexor dactyli*, which fills up nearly the lumen of the proximal subjoint just to its base, is continued but tapers in the distal subjoint, and its tendon is long. — In most genera of the tribe Erythropini of the large sub-family Mysinæ, f. inst. in *Amblyops abbreviata* (fig. 4 a), the carpus is marked off by an extremely oblique articulation from the two-jointed propodus which contains *musc. flexor.* — In the other tribes of the Mysinæ, viz. Leptomysini, Mysini and Heteromysini, the structure is very different; carpus seems to be fused with propodus, and the joint carpo-propodus is divided by two, three or several vertical articulations into subjoints (figs. 5 a and 1 c), *musc. flexor* begins at or rather near the base of the joint, is well developed and f. inst. in *Mysis flexuosa* the tendon is as long as the muscle itself. In *Heteromysis* the strongly thickened second leg has the carpo-propodus undivided. — In the sub-family Gastrosaccinæ a strong difference exists between the legs in two of the most representative genera, *Anchialus* and *Gastrosaccus.* In *Anchialus* second legs differ from the following pair and show sexual differences; in third leg (fig. 6 a) carpus (*cp*) is separated from the two-jointed propodus by a feebly oblique articulation, and a thin muscle with its long tendon runs through the whole propodus (*pp*) to the minute dactylus. In *Gastrosaccus spinifer* carpo-propodus is divided by vertical articulations into several sub-joints, all subsimilar and not containing any muscle.

The description with figures given here of types of second or third to seventh pair of thoracic legs in the family Mysidæ may be sufficient for our purpose. According to my opinion it is proved that the carpus exists as a separate joint in the two sub-families Siriellinæ and Boreomysinæ, in certain Gastro-saccinæ and in one of the four tribes of the Mysinæ, while in the three other tribes of the Mysinæ and in certain Gastro-saccinæ a carpus can not be pointed out, but we have a carpo-propodus divided into subjoints. In first pair of legs and in the maxillipeds carpus and propodus are completely fused without vestige of any division. The same is the case as to maxillipeds and all legs in the family Petalophthalmidæ and in the sub-order Lophogastrida.

Then the question on the præcoxa in maxillipeds and thoracic legs in the Mysidæ. When the carapace is removed on one side of a good-sized and well chitinized *Mysis* the coxa is seen to be well marked off above and below (Pl. V, fig. 4 b, *c*) as a plate which is less than half or one-third as long as broad. Above each coxa of all seven pairs of legs, but not above the maxilliped, is found a subquadrangular plate about as long as broad (*pc*) and rather well marked off above from the tergite (*t*) of the segment; these plates are separated from each other by deep vertical impressions, and besides the distal end of each plate, excepting the first, protrudes freely below the ventral side of the body. (On fig. 4 b the ventral side of the body is to the left, and especially the præcoxæ of third and fourth leg are seen to protrude considerably). There can be no doubt that these plates are the outer surface of a joint, a præcoxa, developed to some degree as the "epimera" in many Isopoda, and homologous with the structure found in *Anaspides*. The absence of the plate above the maxillipeds may possibly be compared with the structure in the Isopoda, where the præcoxa has disappeared in most forms but is present as a small plate in some types (see later on). The interpretation of the plates as the outer wall of præcoxæ is corroborated by the structure in Lophogastrida.

As type for this sub-order the common and rather large *Gnathophausia zoëa* is taken; a specimen not shrunk or too hardened in spirit, consequently with the joints movable, ought to be chosen. The last pair of legs is most easy to study and most convincing. The coxa, which is somewhat short, is well chitinized on the outer side, in front and behind, and very movable. Above it is seen a really movable præcoxa, the outer wall of which is a rather large plate considerably broader than long and articulated to the tergite; this præcoxa has also an anterior and a posterior wall, but scarcely any inner wall, and is thus developed as a somewhat movable epimeron. A small, oblong, ramified branchia originates on the antero-lateral margin of the præcoxa just above the articulation between this joint and the coxa; this branchia may be considered a kind of præepipod. Above the coxæ of first to sixth pairs of legs we find the insertions of four branchiæ very different in size and direction; from the structure of seventh leg we may safely conclude that these branchiæ originate from the præcoxa (are of præepipodial nature), though this joint is scarcely marked off above from the tergite and is more feebly chitinized than on seventh leg. First to sixth legs have on the outer side of the coxa a subcylindrical immovable process, which Sars considers as a rudimentary epipod bearing some setæ on its end; on the coxa of seventh leg the process is wanting, but the setæ remain. — In *Eucopia* the structure of the basal elements of the thoracic legs seems in the main to be similar to that in *Gnathophausia*; the rudimentary epipods are wanting.

As to the pleopods in Mysidacea the quality of the chitinous skeleton seems to make it nearly impossible to point out with certainty more than two joints, coxa and basis, in their sympods.

Finally an interesting fact. In Mysidacea the penultimate stage of the young in the marsupium possesses a pair of well developed, moderately long furcal rami equipped with marginal setæ; fig. 4 c on Pl. V exhibits the end of abdomen with the rami of that stage of *Mysis flexuosa*. In the following stage the young has acquired the final structure with telson and uropods, and the rami are wanting. These rami have already been seen and figured — but not interpreted — by E. van Beneden in 1869; they are found even in the first larval stage.

Order Cumacea.

(Pl. VI, fig. 9).

As to the appendages in animals of this order I can add almost nothing to the good and well known works published by G. O. Sars, W. T. Calman and C. Zimmer; the best general information is found in Calman's hand-book. Only a few points may be mentioned here.

The *maxillula* (fig. 9 a) is in the main rather similar to that in Mysidacea; the second joint (*2*) is marked off, and in most forms we find a retroverted palp from third joint. — The *maxilla* (fig. 9 b) differs from that in *Mysis* mainly in having no "palp", thus containing only the three joints, the sympod; the major part of the deeply bifid lobe of third joint lies in many forms wholly on the posterior side of the distal part of the extremely long lobe from second joint; the exopod is shaped nearly as in *Mysis* but lower and without marginal setæ; in some forms (*Campylaspis*) the maxillæ are strongly reduced (see Sars, 1900).

In the *thoracic legs* we find at most seven joints in the stem, viz. coxa, basis, præischium, ischium, merus, beyond the knee carpo-propodus and dactylus, but in first pair (the so-called second maxillipeds) and in the last pair this number is sometimes reduced. It seems to be impossible to find any vestige of a division of carpo-propodus into its two constituting elements, and in the rather large *Diastylis Rathkei*, in which the legs have the full number of joints, it was impossible to point out any vestige of a suture marking off an epimeron, a præcoxa. In the *maxillipeds* only at most two joints are found between the basis and the knee and it is perhaps præischium which has disappeared; in *Campylaspis* the whole endopod has only two joints, and the terminal one is rudimentary.

Order Tanaidacea.

(Pl. VI, fig. 10; Pl. VII, fig. 1).

Sars, G. O.: Middelhavets Saxisopoder (Isopoda chelifera). Archiv for Mathem. og Naturvidenskab, B. XI, 1886.

— An Account of the Crustacea of Norway, Vol. II. Isopoda. 1896—1899.

The reference to these two papers may be sufficient. The order consists of two families, Apseudidæ and Tanaidæ; the first-named family shows all the appendages more developed and specialized than in the Tanaidæ. As type for the following description *Apseudes spinosus* is taken.

In the *antennulæ* the peduncle is apparently four-jointed, but from comparison with the structure in *Apseudes talpa* we may infer that the fourth joint originates from a partial or — in several species — complete fusion of the first joint of both rami. — In the *antennæ* it is impossible to find even a vestige of more than two joints in the sympod, but the three following joints of the endopod belong evidently to the peduncle, and the proximal joint is quite short in comparison with the following joints. The exopod is rather well developed.

The *mandibles* have the lacinia mobilis (fig. 10 a and 10 b, *l*) more developed than probably in any other family of the Peracarida; the setæ near the laciniæ are peculiar and the thin skin at their base is uncommonly long. — Fig. 10 c exhibits the hypopharynx, the "paragnatha"; it is observed that at each antero-lateral angle is articulated an oblong plate, and therefore one might be tempted to guess that hypopharynx is a pair of appendages united in the middle. This erroneous interpretation is more natural than that set forth by Claus (1885) who thinks that the paragnatha belong to the maxillulæ as their lower lobe. A cautious dissection of the mouth-parts or any other type of Malacostraca shows with absolute certainty that the paragnatha have nothing to do with maxillulæ, but are a produced, free and laterally expanded part of the skeleton of the head behind the mandibles.

The *maxillulæ* (fig. 10 d) in the main as in *Gnathophausia*, with long lobes from præcoxa and from basis; the endopod is a retroverted two-jointed palp. — The *maxillæ* (Pl. VII, fig. 1 a) are related to those in *Mysis*, and differ mainly in the following three particulars: the second joint is not marked off from its very lobe; the endopod (palp) and the exopod are wanting.

As to the *maxillipeds* I may refer to Sars' figures; the præcoxa has disappeared; the short coxa has an enormous epipod serving respiratory purpose; basis is large and anteriorly produced into a lobe; the endopod has only four joints, and it is probably præischium which has disappeared, but whether it is fused with basis or with ischium or is reduced to invisibility cannot be made out. — It is a well-known fact that first thoracic segment is fused with the head and laterally covered by a small carapace.

First leg has a minute coxa which generally has not been observed, but in a female with the marsupial plates half developed I found such a plate originating from the extremely short joint; basis has a quite short, three-jointed exopod near its origin. The endopod consists of only four joints as the præischium has disappeared; Boas (1883) draws this joint (Taf. XXI, fig. 18, *3*) as coalesced with though very feebly marked off from the next, ischium, but neither in *A. spinosus* or in some other forms of the family I found the slightest vestige of any such suture, and consequently an interpretation is as uncertain as at the maxillipeds. Beyond the knee we have only two joints, the carpo-propodus constituting the hand with the immovable finger of the chela, while the movable finger is the dactylus terminating in a spine.

Second to seventh pairs of thoracic legs have in the endopod the usual three joints between basis and the knee, beyond the knee carpo-propodus and dactylus, with terminal spine. Second leg (fig, 10 e) has a small exopod (*ex*), while coxa is thick, produced forwards in a spiniform process, and movable. The coxa of third and especially of fourth leg is much smaller; on fifth to seventh leg coxa is again thicker and has an outer somewhat flattened surface, so that these movable coxæ have some similarity with epimera. While these facts are well known, *a most interesting and hitherto unnoticed fact* shall be pointed out. When examining the skin of a specimen cleaned in potash with an enlargement of 100 or 140 times, it is seen that the præcoxa is marked off above each of these six pairs of legs, and more distinct above second to fifth leg than at sixth and seventh leg. The præcoxa (figs. 10 e and 10 f, *pc*) is marked off from the tergite by a more or less pronounced longitudinal impression, in which one sees a very thin, sharp line which is lighter than the surrounding chitine when seen with transmitted light. In a considerably smaller species of the same family from Singapore, in which the skeleton is less firmly chitinized than in *A. spinosus*, I found even this suture movable when the præcoxa was touched with the end of a tiny knife. — Epipods are wanting in all thoracic legs, and the five posterior pairs have no exopod. —

In the pleopoda it was impossible to point out any præcoxa, but the two other joints of the sympod and both rami are well developed.

It is well known that the family Tanaidæ is sharply separated from the Apseudidæ by a good number of characters, and that nearly all these may be considered as reductions. Among these characters some of the more interesting may be enumerated. Antennulæ uniramous; antennæ without exopod. Maxillulæ without any distinct inner lobe. Maxillæ extremely reduced. Maxillipeds with at least the coxæ, generally also the bases coalesced in the middle line as in Amphipoda. Thoracic legs without exopods; præcoxa not distinguishable.

Order Isopoda.

(Pl. VII. figs. 2—9).

Sars, G. O.: An Account of the Crustacea of Norway. Vol. II. Isopoda. 1896—1899.

Hansen, H. J.: The Order Isopoda. The Danish Ingolf-Expedition. Vol. III. 5. Crustacea Malacostraca. III. 1916.

Racovitza, E. G.: Notes sur les Isopodes. Arch. Zool. Expér. et Génér. T. 61. 1923.

Calman divides this very rich order into six sub-orders, to which in 1916 I added a seventh, the Gnathiidea, and this high number shows sufficiently that the animals belonging to the Isopoda are extremely varied in structure. Among the big literature only the above-named three works and papers shall be briefly mentioned. Sars' book contains on 86 plates a rich representation of animals and their appendages in six of the seven sub-orders and of the majority of the families. In the "Ingolf" book (with its 16 large plates) are references to literature as to the morphology of appendages in various forms, together with additional observations on antennæ, maxillipeds and pleopods in some types. On the following pages I can add only little to our knowledge, but I put together main points on the morphology, because f. inst. descriptions with figures of the structure of maxillulæ, maxillæ and maxillipeds scattered in various papers of mine between 1886 and 1916 need a review for comparison with other orders. — Racovitza's paper and a few of its most important points are mentioned above (p. 89). It may be added here that the joint in the legs of Isopoda I name præischium he names ischium, consequently his nomenclature as to the following joints, dactylus excepted, differs from that used and proved by me. The author proves that the claw in the legs of Isopoda is not a joint but a terminal big spine; besides his paper which is somewhat speculative or discursive, contains statements on the "epimera" and especially on the keels of the joints and the lines of setæ or spines, but these and other topics are outside the scope of the present paper.

It may be stated that it is only my intention on the following few pages to mention main points in the structure of the appendages and especially in their less modified forms. Such particulars as the reductions of the mouth-parts in Epicaridea, their strong modifications in Anthuridæ and Gnathiidea, the fusion in the median line of pleopods of first pair or besides or exclusively of second pair in Asellota, and many other secondary modifications in various types are as a rule omitted; they may be found in Calman's hand-book, and some among them in the "Ingolf" work. They are omitted because they are only secondary adaptations, reductions or fusions.

The *antennulæ* "are never biramous except in *Bathynomus* where a minute vestige of the inner flagellum is present, and in the cryptoniscan larvæ of some Epicaridea" (Calman).

The *antennæ* have three movable joints in the sympod of the Asellota (fig. 4 a), in *Bathynomus giganteus* and in some large species of *Cirolana* (Hansen, 1903), in *Conilera* (Hansen, 1905), in two subterranean genera of Cirolaninæ (Racovitza, 1912), and in *Ligia* (Hansen, 1916) (fig. 5 a). The third joint has a distinct and most frequently movable squama (*ex*) in the large majority of Asellota and in *Ligia*. In the other types of Isopoda the præcoxa has vanished. In Asellota (fig. 4 a) and in many other Isopoda the three proximal joints of the endopod are developed as belonging to the peduncle.

The *maxillulæ* (figs. 2 a and 3 a) consist only of the sympod, as endopod (palp) and exopod are wanting. In the majority of forms they consist of three joints, the second (*2*) small and as usual without lobe, while præcoxa has a slender, and basis a more robust lobe, both long. In parasitic forms the maxillulæ are considerably or much reduced or lost.

The *maxillæ* (figs. 2 b and 3 b) are somewhat similar to those in *Anaspides* and consist only of a three-jointed sympod without any trace of endopod (palp) or exopod. The two figures quoted represent types rather different in aspect and good representatives for the order. The præcoxa (*1*) is well developed and without lobe. The coxa (*2*) is produced into a very long lobe without terminal incision; the basis (*3*) runs as a strong and narrow chitinous piece along the outer margin of the coxa from somewhat from its base; its lobe is cleft to near its base into two secondary lobes which in *Munnopsurus* (fig. 2 b) are extremely long, and of very moderate length in *Glyptonotus*. The two drawings exhibit the more firmly chitinized pieces making out together this third joint. — The reductions of the maxillæ in several types may be looked for in the literature quoted.

The *maxillipeds* (fig. 2 c and 3 c) are interesting. In most genera they consist of the sympod, præischium, ischium, merus, and beyond the knee carpo-propodus and dactylus. The sympod consists in most forms of a shorter coxa (*c*) and a large basis (*b*) produced into a porrected lobe which is sometimes marked off by an articulation and generally equipped with one or several coupling-hooks near the inner margin. But in some forms of the Asellota a præcoxa (*pc*) is very distinct; in *Munnopsurus* (fig. 2 c), in *Janira pulchra* ("Ingolf" Pl. I, fig. 4 a) and in a probably undescribed species of *Stenethrium* from the Virgin Islands (fig. 7 a) the præcoxa is a transverse, rather short joint well marked off both from coxa and from the sternite (*st*); in *Munna acanthifera* (fig. 6 a) it is a subtriangular, somewhat rounded piece occupying an incision into the proximal middle part of the coxa. (In vain I have looked for a præcoxa in *Iæra marina, Haploniscus bicuspis, Pleurogonium spinosissimum, Ilyarachna hirticeps, Eurycope inermis* and *Munnopsis typica*, but I suppose it may be possible to find it in several forms not investigated by me, as f. inst. in large species of *Ianira* and *Storthyngura*.) Besides I have discovered the præcoxa in *Glyptonotus sibiricus*; in this animal (fig. 3 c) it is a transverse, firm plate well separated from the coxa by a strip of quite thin chitine, but it lies close to the sternite and is marked off from it by an impression and a suture. That the piece found in the four very different forms of Asellota and in *Glyptonotus* is the real præcoxa seems to me to be quite certain.

The maxillipeds have no exopod but always a plate-shaped epipod, the proximal part of which is not uncommonly, f. inst. in the *Stenethrium* mentioned (fig. 7 a), in *Munna acanthifera* (fig. 6 a) and in *Glyptonotus* (fig. 3 c) marked off by a transverse suture from the distal major part. As to the interesting, large, or in many forms enormous plate-shaped expansions in ovigerous females of the epipod, the coxa and frequently of the outer side of the basis in Idotheidæ, Arcturidæ, several Sphæromidæ and especially in Cymothoidæ (sens. lat.) and Bopyridæ the reader is referred to Hansen (1900, 1905 and 1916), and as to the Bopyridæ to Bonnier (1900).

On the seven pairs of *thoracic legs* I cannot add anything to our knowledge, and Calman gives a good resumé in his handbook. But some main points may be stated for comparison with other Peracarida and with *Anaspides*. It is impossible to point out a præcoxa in any family. Coxa of first leg is completely fused with the side of its segment, but f. inst. in the large *Munnopsurus giganteus* (sub-order Asellota) the coxa is marked off in front, posteriorly and on the outer side by an impression but no suture; only in *Plakarthrium* (fam. Sphæromidæ) the joint is a movable lateral plate as the coxæ of the other legs. The coxa in the six other pairs of legs in Asellota is a movable joint, in the other sub-orders it is developed as a coxal plate which may be somewhat movable or immovable, separated by a suture or even in most Oniscoidea not at all marked off from the body. Præischium, ischium and merus are generally well developed; beyond the knee carpo-propodus (without any trace of division) and dactylus, the latter most frequently terminating in a spine, the claw. Epipods and exopods always wanting.

The pleopoda consist generally of sympod, exopod and endopod, all flattened as plates. In 1902 E. L. Bouvier showed that the sympod of the pleopods in the gigantic *Bathynomus* (sub-fam. Cirolaninæ) consists of three joints; in 1912 Racovitza mentioned and figured the same number of joints in first pair of pleopods in *Sphæromides* (sub-fam. Cirolaninæ); in 1916 I described the same three joints in the first pleopod of *Cirolana borealis*, *Æga arctica* and *Arcturus Baffini*. My drawings in the "Ingolf" work of this appendage in *Æga* and *Arcturus* are reproduced in the present treatise as fig. 8 a and fig. 9 a on Pl. VII. On the first-named form I wrote (p. 163): "The third joint (*3*) of the sympod is firmly chitinized, while first and second joints are thin-skinned with chitinous plates as remnants of the joints. Second joint shows a long transverse plate (*2 o*) reaching the outer margin and divided into two pieces, and a small plate (*2 i*) at the inner margin. First joint has a somewhat large transverse plate (*1 o*) reaching the sternite, while at its inner angle a very firm subquadrangular plate (*1 i*) is seen, which is deeply cleft in the median line and, according to my opinion, consists of the inner part of first joint of both pleopods of first pair, and these two parts are fused at the base. As the pleopods of same pair are moved simultaneously, this fusion of their inner basal part must give strength and uniformity to their movement." And on *Arcturus Baffini* I said (p. 185): ". . . the first pair of pleopods have, seen from in front . . . . three joints in the sympod. First joint, *præcoxa* (*1*) is a strongly bent plate of considerable size touching the sternite and the triangular plate representing second joint (*2*), but it does not touch the proximal margin of third joint, while the plate representing second joint is articulated to the third firmly chitinized joint (*3*) and does not reach the sternite. The intervals between the firm parts are membranous."

The animals mentioned are large, a fact which rendered it possible to examine the elements in the sympod with certainty, while in smaller forms it will generally be difficult or impossible to point out the elements of præcoxa and coxa, if both joints are really present as chitinized pieces. But it is highly probably that in large forms of different families it may be possible to make out the three primary joints in one pair or in some pairs of the pleopods. — In the uropods it is probably always impossible to discern more than a single joint, basis, in the sympod. (Calman gives in 1909 — op. cit. p. 204—207 — a much more detailed account of pleopoda and uropoda in the Isopoda).

Order Amphipoda.

(Pl. VII, figs. 10—13).

As to this order I can add nothing to the knowledge of the morphology of the appendages except the antennæ, and refer readers to Dr. Calman's book, where not only a resumé of the morphology is found, but also the classification and a list of the principal papers are given. It may, however, be useful to mention a number of selected points.

The *antennæ* "when fully developed have a peduncle of five segments and a more or less elongated flagellum. A scale or exopodite is never developed" (Calman, op. cit. p. 228). Boas was of the opinion that as the tubercle or process bearing the aperture of the antennal gland is found on second joint, this must in reality be first joint, and the part considered as the first must be a protuberance from the head marked off as a joint, furthermore that the joint beyond that with the aperture for the gland must originate from a complete fusion of two joints. Calman discards with good reason the first-named point, but accepts the second, because he thinks that the "five segments of the peduncle must be derived from the six-segmented condition by coalescence of two segments .... probably the third and fourth". But it is unnescessary to suppose such coalescence, because f. inst. in a good-sized *Gammarus Locusta* (figs. 10 a and 10 b) it is not difficult — especially in an antenna cleaned in potash — to find a remnant of the fourth joint as a transverse chitinized piece (fig. 10 b, *4*) in the broad articulating membrane on the lower side of the antenna at the end of third joint. In the six-jointed peduncle in Mysidæ and Asellota the fourth joint is always short or very short as compared with the fifth or the sixth. In *Stegocephalus inflatus* the same fourth joint is well chitinized and surrounded by narrow membrane; it can certainly be found in several and probably in many genera of Gammaridea. — Among Caprellidea and Hyperiidea various and sometimes very strong reductions are found in the antennal peduncles.

In the *maxillulæ* the three joints of the sympod are well developed; the second is triangular and as usual without lobe. First joint has in most Gammaridea a lobe from first joint; in *Gammarus* (fig. 10 c) the distal part of this lobe (l^1) is rather broad and united with the plate of its joint by a curved chitinous band; in *Anonyx nugax* (fig. 11 a) the distal part of the lobe is oblong and rather small; in Caprellidea and in many Hyperiidea, f. inst. *Euthemisto* (fig. 12 a), this lobe is at least rudimentary and generally wanting. The third joint together with its lobe, which is not marked off by any transverse suture, is always a large, oblong and firmly chitinized piece. At the beginning of the lobe is inserted the "palp", in reality the endopod (fig. 10 c, *en*) which is directed forwards, two-jointed with the first joint short, the second long in most *Gammaridea;* this palp is quite rudimentary in *Talitrus* and *Orchestia* (see Sars' Account) and at least in many Hyperiidea consisting of a single well developed joint, f. inst. in *Euthemisto* (fig. 12 a).

The *maxillæ* are always rather small and consist of a three-jointed sympod (fig. 10 d), with a distally undivided lobe from second joint (*2*), while third joint is produced into a somewhat similar lobe without trace of any terminal incision. Exopod and endopod wanting.

In the *maxillipeds* a præcoxa could not be detected. Both coxæ (*c*) are completely fused in the median line (figs. 10 e and 13 a); the same is partially or completely the case with the bases (*b*) and each of these is always produced into a porrected lobe (*l*), but in Hyperiidea, f. inst. *Vibilia,* these lobes are also fused to the end (fig. 13 a). In Hyperiidea, *Platycyamus* and adults of some species of *Cyamus* the remainder of the maxillipeds is on each side a single, generally oblong joint (fig. 13 a); in most Gammaridea, in Ingolfiellidea, in the young of *Cyamus* and also in adults of certain species of the Cyamidæ the "palp" consists of five joints corresponding to the joints in the thoracic legs, but the præischium is in Gammaridea produced into a lobe (fig. 10 e); in *Talitrus* and *Orchestia* the palp is, according to Sars, only four-jointed.

The *thoracic legs* agree with those of the Isopoda in most of the morphological features mentioned at this order. A præcoxa is never found; the coxa is generally free, movable and frequently expanded as a plate; beyond the knee only carpopropodus and dactylus with claw are found. The branchiæ attached to the coxæ of two to six pairs of legs may be interpreted as a kind of epipods. In the Cyamidæ the number of joints in the legs is reduced by fusions. — Pleopods and uropods may be omitted here as well known (see Calman, p. 232—233).

Division Eucarida.

This division comprises the small and somewhat uniform order Euphausiacea and the very rich and extremely varied order: the Decapoda. The Euphausiacea are generally considered to present more primitive features than even the lowest Decapoda; as to the structure of maxillulæ and maxillæ, the similarity between the maxillipeds and the intermediate thoracic legs, the absence of arthrobranchiæ and pleurobranchiæ, etc., this order is certainly more primitive than the Decapoda, but in a large number of the macrurous Decapoda we find a most important feature of primitive nature in the thoracic legs, viz. a very distinct though generally not movable præischium, which is completely lost, i. e. fused with ischium, in the Euphausiacea.

In order to avoid unnecessary repetitions some structural features common to both orders (or at least to Euphausiacea and macrurous Decapoda) may be pointed out here. The *eyestalks* are at least two-jointed and sometimes three-jointed. The *antennulæ* have a three-jointed peduncle and generally two rami. The *antennæ* have only two joints in the sympod; it is impossible to discover any chitinized piece which can be interpreted as the præcoxa; the exopod is present as a squama in lower Decapoda and Euphausiacea, wanting in higher Decapoda.

The *mandibles*, at least in post-larval stages, without rudiment of lacinia mobilis. — The *maxillulæ* frequently with a more or less developed pseudexopod (erroneously considered as exopod by most authors). The stem of the *thoracic legs* consists according to the literature typically of the following seven joints: coxa, basis (with or without exopod), ischium, merus, and beyond the knee carpus, propodus and dactylus; a præischium can, however, be pointed out in many lower Decapoda, and the præcoxa is easily observed in very large specimens of Euphausiacea.

Order **Euphausiacea.**

(Pl. VII, figs. 14—15; Pl. VIII, figs. 1—3).

The following three papers may be enumerated, because they contain descriptions with figures of morphological significance of appendages in adult specimens and in larval stages.

Sars, G. O.: Report on the Schizopoda. Rep. Voy. "Challenger", Zool. Vol. XIII. 1885.

Hansen, H. J.: The Schizopoda of the Siboga Expedition. Siboga-Expeditie. XXXVII. 1910.

— The Schizopoda (from the "Albatross" Expedition 1904—1905). Memoirs Mus. Compar. Zool. Vol. XXXV, No. 4. 1912.

In the *maxillulæ* (Pl. VII, fig. 14 a; Pl. VIII, figs. 1 a and 1 b) the sympod consists of three joints well marked off from each other; as f. inst. in Mysidacea or Isopoda, first joint (*1*) has a well developed articulated lobe (l^1), while second joint (*2*) has no lobe, and third joint (*3*) is produced into a large lobe not marked off. In most genera, as *Bentheuphausia* (fig. 14 a), *Thysanopoda*, *Meganyctiphanes* (figs. 1 a and 1 b), *Euphausia*, *Thysanoëssa*, the lobe from first joint has on the posterior side of the maxillula a large to extremely large plate, the pseudexopod (*ps*), directed outwards and somewhat forwards and reaching somewhat to very much beyond the outer margin of third joint. Fig. 1 a exhibits a maxillula with a somewhat large pseudexopod, and fig. 1 b the same appendage with the pseudexopod removed in order to show the joints otherwise mainly overlapped by it. In *Nematobrachion* and *Nematoscelis* the pseudexopod is moderately small or almost rudimentary, and in *Stylocheiron* it has nearly or quite vanished (The "Albatross" Report quoted contains figures of the maxillulæ in many forms). In *Bentheuphausia* (Pl. VII, fig. 14 a) the endopod is a two-jointed palp (*en*), but in the other genera it has only a single joint in the adult (Pl. VIII, fig. 1 a); an exopod is always wanting in the adults.

It may be convenient to say here a little on the maxillulæ in the larval stages; the topic has been elucidated by Sars (op. cit. Pl. XXX), but he interpreted the pseudexopod as exopod. Fig. 3 a exhibits the maxillula of a younger larva belonging in all probability to *Thysanoëssa inermis;* it is seen that its endopod (*en*) is two-jointed and that it possesses a small exopod (*ex*) but no pseudexopod. As there is no difference of any importance between the development as to the maxillulæ in *Thysanoëssa* and *Euphausia,* fig. 2 a, which is taken from an older larva of *Euphausia* (of the *E. Krohnii*-group), may represent the following stage; it is seen that the endopod (*en*) is only one-jointed, that the exopod is still present but is overlapped by the pseudexopod (*ps*) which has not yet arrived at full size; at least in the adults the exopod is wanting.

The *maxillæ* are completely plate-shaped and consist of a three-jointed sympod, a quite short and very broad exopod (*ex*) along the outer margin of third joint, and an endopod (*en*) which in *Bentheuphausia* (Pl. VII, fig. 14 b) has three joints — the first long and broad — but in all other genera only a single joint (Pl. VIII, fig. 1 c). Præcoxa (*1*) is oblique; the coxa (*2*) is transverse, very narrow at the outer margin of the maxilla and widened much inwards as a large lobe, which in some genera has a rather short incision on the inner side. The basis (*3*) is a large plate, as its lobe is not marked off; in *Bentheuphausia* (fig. 14 b) this lobe is deeply divided by a long incision, while in the major part of the genera this incision is moderately (fig. 1 c) or very short, and in *Stylocheiron* and most species of *Nematoscelis* wholly absent.

The *maxillipeds* are similar to the *thoracic legs;* each leg consists according to the literature typically of seven joints, viz. coxa with an epipod, basis with a well developed exopod, ischium, merus, and beyond the knee carpus, propodus and dactylus. I have not been able to discover any trace of a præischium; it is probably as in numerous Decapoda completely fused with ischium. The epipod is developed as a ramified branchia except in the maxilliped (*ep* on fig. 15 a) .In some genera either first or second pair of legs is elongated and modified as a raptorial organ. Only in *Bentheuphausia* all legs are fully developed; in the other genera either the last pair (*Thysanopoda, Meganyctiphanes*) or the two posterior pairs have lost their endopod, while the branchia is always present, and the exopod most frequently preserved, but in some genera the endopod of sixth, or even of fifth and fourth pair has the number of joints reduced.

But the most interesting and hitherto overlooked feature is *the existence of the præcoxa.* It is easily detected in very large forms as specimens of *Thysanopoda egregia.* When the carapace is lifted a little and some or most of the gills discarded by the aid of a minute knife and a pocket-lens, we see the coxa (Pl. VII, fig. 15 a, *c*) well marked off above by an articulation and that the legs continue most distinctly above these articulations, being separated from each other; besides we see above each of the limbs, the maxillipeds included, a plate (*pc*) which is shorter than broad, rather well chitinized and marked off both above and posteriorly by a narrow articulation or movable suture, while the tergite (*t*) above it is firm. This plate is the outer wall of the *distinctly protruding præcoxa*, and when it is touched lightly with the knife, we see it be moved a little against the tergite. — In *Meganyctiphanes norvegica* a rather similar structure is found, but in this and especially in numerous other somewhat small species the chitinization is generally less firm and consequently less easy to investigate.

In the *pleopoda* the coxa is easily seen, but whether a præcoxa exists may be difficult to decide.

Order Decapoda.

(Pl. VIII, figs. 4—10).

The great majority of forms belonging to this extremely large and very varied order may be said to be rather large to very large Arthropoda. During more than a hundred years numerous authors have described and figured appendages in representatives for genera and families, but in the paper from 1851 mentioned above *H. Milne-Edwards* laid the foundation for the comparative morphology of the appendages. Since that year the literature has increased enormously. Among the papers dealing with or touching the morphology of the appendages some few may be named here, thus *J. E. V. Boas:* Studier over Decapodernes Slægtskabsforhold, in Kgl. Danske Vid. Selsk. Skr. 6. Række, naturv. og math. Afd. I, 2. 1880, and his paper on the Malacostraca (1883) mentioned above on p. 84; furthermore the big work of *C. Spence Bate:* Report on the Crustacea Macrura, in Rep. Voy. "Challenger" Zool. Vol. XXIV. 1888. An important contribution is the paper published by C. Claus and mentioned on p. 14; small papers by Coutière and Borradaile are mentioned respectively on p. 88 and p. 15. Calman gives a good resumé of the structure of the external skeleton and the appendages in his hand-book, and since that year extremely little of more general importance has been added to our knowledge. At two occasions, viz. in the "Ingolf" paper dealing with the Decapoda (1908) and in the work on the Monaco-Sergestides (1922), I have dealt with the maxillulæ and maxillæ in two types, and the results are incorporated in the following text.

In many forms, f. inst. in the Paguridæ, a movable *ocular segment* is well developed.

As stated above, the *antennæ* have typically two joints in the sympod, but in many higher forms the first of these is fused with the head. I think that the first joint is homologous with the second in Mysidæ, Gammaridea, etc., as in these types the antennal gland has its aperture in second joint, while in Decapoda the opening is typically found in first joint. From these facts I am apt to conclude that the representative in Decapoda for the first joint, the præcoxa, in Mysidæ has been suppressed in one way or another, either by not being chitinized and consequently indistinguishable in the articulating membrane, or being fused with the head. In one form among the Caridea I saw a structure which might indicate a rudiment of that joint, but I did not undertake a special inquiry as to this topic in a number of genera, and the question cannot be solved without sacrificing many specimens.

The *maxillulæ* differ both in larval stages and in adult animals from those in all other Malacostraca excepting Stomatopoda in the fact that the two lobes on the inner side project from first and second joint, while in the preceding orders from first and third joint. The explanation is that second joint, coxa, present in the other orders is in Decapoda so completely fused with the first that not even any suture or line between them can be observed. The most primitive form of the maxillula is found in the *Acanthosoma*-stages of *Sergestes*. Fig. 5 a exhibits a maxillula of *S. arcticus*; it shows that the lobe issuing from first joint (*1*) has its firm chitine on the lower (posterior) side divided into two pieces, the proximal one narrow and rather short, while the other piece (l^1) is several times longer, with the distal half rather broad and the inner margin setiferous. The following joint and its large lobe are together a large, undivided plate, with a small, unjointed exopod (*ex*) on its outer margin and more distally the three-jointed endopod (*en*). — In the Zoëa-stage of the large crab *Chionoecetes Opilio* (from Greenland) the maxillula differs only in points of secondary nature from that in the *Sergestes*-Acanthosoma: the endopod is only two-jointed with first joint short, the other rather long, and instead of the exopod only a single robust and very plumose seta.

The maxillula of the adult *Nephropsis atlantica* is shown in fig. 4 a. The endopod (*en*) is long, slender, two-jointed; the exopod is wanting; the second joint with its lobe is a single plate; the lobe from first joint consists as in the larva described of a narrow and somewhat short proximal piece (*m*), while the distal piece is a large, broad and very long plate (l^1). But this distal piece exhibits the interesting feature that its most proximal part is expanded outwards (*ps*) as a thin plate overlapping — when seen from behind — the proximal portion of second joint. This exterior expansion is rudimentary in some types of Decapoda, but much more developed in many types than in *Nephropsis*, and especially in *Gebia, Porcellana, Galathea, Munida, Dromia* it is a rather large plate. It is the same plate which is found in the majority of Euphausiacea and described above as the pseudexopod. Boas (1880) in his outlines (on Tab. III) of the maxillulæ in thirty genera of Decapoda shows it in a number of forms, but interprets it erroneously as exopod, because he in reality did not examine its origin, and the error has, as far as I know, not been corrected by later authors except Calman (1909).

The *maxillæ* are frequently less easy to investigate. A really primitive state is found in the Acanthosoma of *Sergestes*. Fig. 5 b shows that in this form the maxilla consists of a three-jointed sympod, an unjointed, plate-shaped exopod (*ex*) from third joint, and a five-jointed endopod (*en*), which is shaped as a leg, and its distal joint may perhaps, judging from its shape and setæ near the end, even have been formed by the fusion of a proximal rather long and a terminal quite short joint. First joint of the sympod (*1*) is long and as usual in all Malacostraca without lobe; second joint (*2*) is quite short but produced inwards into a long lobe (l^2) which at its base is marked off by a suture from the joint itself, while its distal part is somewhat bifid. Third joint (*3*) is moderately long and produced into a lobe (l^3) which has its distal part bifid, and the incision is on the lower surface elongated as a somewhat feeble suture outwards and a little backwards to the end of second joint in *S. arcticus*, but in *S. corniculum* (Hansen, 1922, Pl. VIII, fig. 3 d) this suture is only half as long. In the *Mastigopus*-stages and in the adults of *Sergestes* the firm chitine on the posterior surface of the sympod is so much fused that the limits between its constituting elements have partly disappeared; the endopod is unjointed, and the exopod is the well-known large, oblong vibrating plate.

Fig. 6 a exhibits left maxilla of the Zoëa of *Chionoecetes Opilio*. First joint (*1*) is well developed; second joint (*2*) is a small triangle with its very long and at the end deeply incised lobe issuing from the narrow inner end of the triangle; third joint with its lobe is a long, undivided plate incised on the terminal margin. The endopod (*en*) is an oblong, unjointed palp; the exopod the very large plate attached to third joint and shaped mainly as in adults. — In looking over maxillæ in adult Decapoda I found the maxilla of *Nephropsis atlantica* (fig. 4 b) to be a rather good object, because its second and third joints can be ascertained with certainty. First joint (*1*) is a well chitinized piece sharply separated from second joint (*2*) which is represented by a transverse, curved and narrow plate, to the inner end of which the very long and distally deeply bifid lobe (l^2) is attached. Third joint consists of two essentially transverse, curved and narrow pieces (*3*) forming a sharp angle with each other, and to the inner piece the base of the very long and distally deeply bifid lobe (l^3) is attached, while the remainder of the lower surface of third joint is membranous skin. Yet it may be said that what looks as the proximal portion of an undivided lobe from third joint is the inner portion of the joint itself, because the endopod (*en*), shaped as a two-jointed, slender palp, is attached to its outer margin by a long articulation. By preparation it can be seen with certainty that the very large exopod, which has the usual shape, is connected only with chitinized elements of third joint, and has no connection with second joint.

The three following pairs of appendages are generally named maxillipeds. Third and especially second pair shows more or less strong modifications of walking legs with fusions of joints, exopods and frequently epipods; first pair is intermediate between maxillæ and second maxillipeds in several points, and exhibits proximally masticatory expansions on the inner side. I can add next to nothing to our knowledge of these three pairs of appendages and may refer readers to the figures given by Boas (1880) and many other authors, especially Bate, Bouvier and Stebbing; besides to Calman's book. Only a single new point in the structure of third maxillipeds in types of lower Decapoda is treated later on together with their thoracic legs.

The five posterior pairs of thoracic appendages, generally called peræopods, are typically ambulatory legs, and according to all authors composed of seven joints: coxa, basis, ischium, merus, carpus, propodus, and dactylus. It is well known that in most forms at least the first pair, in many forms two or sometimes three pairs, and in a few forms four or even all five pairs terminate in a chela, in which the propodus constitutes the hand and the movable finger is the dactylus. The knee is found between merus and carpus, consequently we have as in *Anaspides* and in some Mysidæ (and the Euphausiacea) the full number of joints, viz. three, beyond the knee; fig. 4 c, exhibiting second peræopod of *Nephropsis atlantica*, agrees with this description and may serve as illustration or type for such a leg — excepting that it possesses a part marked *pi* which shall be mentioned later on. The result is that according to the literature the peræopods have only four joints before the knee, while in most thoracic legs of *Anaspides, Mysis, Apseudes* six joints can be pointed out, and five among them are generally very conspicuous. It may be added here that in many Penæidæ and Caridea the second joint bears an exopod; in all Decapoda excepting Penæidea, Caridea, Stenopidea, Eryonidea (and partly Nephropsidea) basis is immovably coalesced with the following joint, though frequently marked off from it by an impression. The four joints before the knee accepted by authors are: coxa, basis, ischium, merus, consequently præcoxa and præischium should be completely wanting. Both these elements shall be treated separately; it may be said here that Coutière in a preliminary note (1919) points out the existence of a præischium in some forms.

Already in 1893 I put forward the theory that the first joint in the typically three-jointed sympod has not vanished in the thoracic appendages in Decapoda but constitutes a larger or smaller part of the thoracic pleuræ. I compared it with the well known fact, that in Idotheidæ the coxa does not disappear, but constitutes a portion of the lateral parts of thorax; I could have added that while the coxa in *Glyptonotus* is well marked off above as a large triangular plate by a slightly movable articulation from the six posterior thoracic segments, we find neither articulation nor suture in our common forms of Oniscidæ, in which not only the præcoxa seen in *Apseudes*, but also the coxa is so completely fused with the thoracic segments that every vestige of a limit has disappeared. To the theory on the pleuræ I added in 1893 (op. cit. paragraph 24): "Diese Auffassung scheint erklären zu können, dass man bei den Decapoden Kiemen findet, sowohl auf den Pleuræ, auf der Gelenkhaut zwischen Pleuræ und dem Beine, wie auf dem Coxopodit, indem der mit Kiemen versehene Theil der Pleuræ als ursprünglich dem Beine angehörig aufzufassen ist, so dass man nur Kiemen von seinem Gliedern erhält. Vergleiche hiermit die wahrscheinlich im Dienste der Respiration stehende Platte auf der Aussenseite von eben diesem ersten Gliede bei *Branchipus* und *Cladocera*."

But in 1893 I had overlooked interesting statements made by Claus in 1885 (op. cit.) and pointing in the same direction. Calman writes on the Decapoda in 1909 (p. 275—276)[1]: "The typical number of branchiæ which may be present on each side of a somite is four, arranged as follows: One is attached to the lateral wall of the somite dorsal to the articulation of the appendage (*pleurobranchia*), two to the articular membrane between the coxopodite of the appendage and the body-wall (*arthrobranchiæ*), and one, representing a differentiation of part of the epipodite, is inserted on the coxopodite itself (*podobranchia*). Four series of gills corresponding to these can be traced in a more or less incomplete form throughout the whole series of the Decapods. They are, however, not invariably distinguished from each other by the position of attachment in the manner just described. In particular, the distinction between arthrobranchiæ and pleurobranchiæ is often very difficult to draw in practice, and there are some cases where an arthrobranchia in one species is plainly homologous with a pleurobranchia in

[1]) In the long quotation from Calman references to his text-figures are omitted.

another. Claus has shown that in the development of *Penæus* three bud-like outgrowths appear on the proximal part of most of the thoracic limbs. The distal one gives rise to the epipodite with its podobranchia and the two others are the arthrobranchiæ. As development proceeds an apparent change in the position of these last is brought about by coalescence of the proximal part of the appendage with the body, so that the branchiæ no longer appear as outgrowths of the limb but spring from that part of the body-wall which afterwards forms the articular membrane of the joint. The pleurobranchia appears a little later than the other two, but its place of origin is very close to if not actually on the basal part of the limb itself. Williamson has observed a similar transference of the gills from the limb to the body-wall in the development of *Crangon* (Caridea), and Bouvier in *Uroptychus* (Galatheidea). Claus concludes from these observations that not only the podobranchiæ but also the arthro- and pleurobranchiæ are originally appendages of the limb. The absorption of the proximal part of the limb into the body-wall is of importance in view of Hansen's recognition of a præ-coxal element in the appendages of various Crustacea."

This long quotation from Dr. Calman is very illuminating and may give rise to some reflections. If the lower part of the præcoxa is thin-skinned it looks as an articulating membrane, and this membrane is frequently, f. inst. in *Nephrops* and *Eupagurus*, very or extremely broad, far broader than necessary for the movement of the coxa, and for this reason one may suppose that its upper portion is the thin-skinned lower part of the præcoxa; this supposition may explain why an arthrobranchia in one species is a pleurobranchia in another. In my opinion both arthrobranchiæ and pleurobranchiæ belong to the præcoxa absorbed in the body-wall; a comparison with the legs and their præepipods in Branchiopoda Anostraca suggests the same interpretation of arthrobranchiæ and pleurobranchiæ.

On earlier pages I point out that in *Mysis, Thysanopoda* and *Apseudes* the præcoxa is dorsally well marked off by a longitudinal articulation or suture from the tergite in at least six pairs of legs, but judging from the inspection of a few forms of Decapoda I think that in this order the upper limit of the præcoxæ may at least as a rule be impossible to point out. The only way to arrive at definite results as to that limit seems to be the investigation of a good number of large types among Penæidea, Caridea, Nephropsidea and Paguridea together with a fine material of their older larvæ.

According to all authors except Coutière the peræopods of the Decapoda have only two joints, ischium and merus, between basis and the knee, while three joints — according to my new interpretation præischium, ischium, and merus — are found well developed in Mysidacea and other Peracarida. In 1893 I suggested that the place of the knee is firm in the Eumalacostraca, consequently that ischium and merus combined in Decapoda must in one way or another be homologous with the three joints in Peracarida (and *Anaspides*). This idea of mine was not adopted by subsequent authors who follow the old mode of counting five joints in the endopod in all Eumalacostraca, the result of which is that in the Eucarida the carpus is beyond the knee, and in Peracarida before the knee; the structure in *Anaspides* with six joints in the endopod, three before, and three beyond the knee, did not agree with that counting. Today, however, I am able to prove the correctness of my old idea by pointing out the existence of the præischium in several families and in a large number of genera among macrurous Decapoda; this præischium is in the genera in question more or less conspicuously marked off by an oblique transverse impression or a suture and at least in one generic type even movable in two pairs of peræopods. The question on the præischium is so important for the comparative morphology of the thoracic legs in the Malacostraca that it ought to be dealt with in some detail.

The highest or, one may say, the most primitive stage I have found in forms of the rich genus *Alpheus*. The common species *A. ruber* (from the Mediterranean) is taken as type. In the strong third and fourth peræopods we find (Pl. VIII, fig. 7 a) the limit between the short præischium (*pi*) and the rather long ischium (*i*) strongly developed on the lower (posterior) side of the leg by an oblique, extremely conspicuous, much impressed furrow, on the lower margin by a small incision and on the upper (anterior) side by a conspicuous impression. Such a leg was taken off, put in glycerine with water during 24 hours in the hollowing of a thick object-glass so that the water could evaporate, then taken out and its surface rinsed in water; in the leg prepared in this way in order to lie dry for hours without being exsiccated and thereby making it easy to draw fig. 7 a correctly, I was surprised by seeing that the præischium is even very distinctly movable against the ischium and the skin in the oblique impression flexible on both sides, while the chitine of both præischium itself and ischium is hard; consequently it seems to me impossible to deny that here we have the præischium homologous with the same joint in Mysidæ — where the joint is also quite short (Pl. VI, fig. 2 a) — and in the other orders of Peracarida. — In the feeble second peræopod the limit between præischium and ischium is well developed on the lower side; in fifth peræopod the limit is only vestigial; in first peræopod a strong impression is found on the lower surface, while upwards on the side it is scarcely discernible; in third maxilliped no vestige. — In the large *Alpheus avarus* (from the Nicobar Islands) the legs are on the whole as in *A. ruber*, but the limit in question is in first peræopod very conspicuously marked off both below, on the sides and above.

Before dealing with other Caridea we turn to the Penæidea. In the genus *Penæus* (as *P. caramote* and *P. brasiliensis*) all peræopods have a movable articulation between basis (fig. 8 a, *b*) and the next joint. This joint is generally described as ischium, but on the lower margin and on the lower third to nearly half of the outer (posterior) surface is seen at a rather short distance from its proximal end a distinct very oblique suture indicating that the joint consists of præischium (*pi*) and ischium (*i*) immovably coalesced but yet partly marked off from each other by the suture. As to third maxilliped all authors agree that basis (with its exopod) is fused with the following joint, but at a closer examination the structure shows itself to be more complex. In such a maxilliped cleaned in caustic potash (fig. 8 b) a distinct transverse suture is seen with transmitted light as a lighter line slightly beyond the insertion of the exopod on the upper half of the outer (posterior) side of the leg; furthermore one observes somewhat more distant on the lower fourth of the outer side downwards to the lower margin a similar very sharp, light, oblique line; this line can also be seen without cleaning. The first-named light line indicates the limit between basis and præischium, the distal line between the last-named joint and ischium.

In *Sicyonia sculpta* the peræopods are rather similar to those in *Penæus*, but the suture between præischium and ischium goes longer upwards on the outer side (fig. 9 a), while near the lower margin it is more pronounced, and the lower short margin of præischium (*pi*) has a feeble but distinct curvature of its own. Third maxilliped essentially as in *Penæus*. — In *Aristeus Edwardsianus* the peræopods are essentially as in *Peneus caramote*, but the impression on the lower half of the outer (posterior) side is much deeper and towards the lower margin even whitish, indicating thinner skin, while præischium protrudes considerably as a rounded protuberance on the lower margin. Third maxilliped as in *Penæus*. — The legs in *Hymenopenæus robustus* and *Solenocera Agassizii* subsimilar; in both intermediate between *Penæus* and *Aristeus*.

In the big tribe Caridea we find great differences as to præischium; yet it may be stated that in third maxillipeds the limit between it and ischium has nearly always vanished completely. In a number of types that joint is not at all marked off from ischium on any of the peræopods; such complete fusion is observed in *Pasiphaë* (*P. multidentata*), *Hymenodora* (*H. glacialis*), *Caridina* (*C. Desmarestii*), *Atya* (*A. occidentalis*), *Acanthephyra* (*A. multispina*), and *Notostomus* (*N. atlanticus*). — In *Lysmata seticauda* præischium is quite feebly marked off from ischium, or the limit is scarcely discernible; in *Rhyncho-cinetes typus* a rather feeble vestige of a limit between the joints is seen on the lower surface of all five pairs of legs. — In *Pandalus Montagui* præischium is in second peræopod marked off by a distinct impression on the almost sharp lower margin and on the lower half of the outer (posterior) side; in third leg it is distinctly marked off below, but scarcely on the outer side, in fourth and fifth legs its distal limit has nearly, and in first leg completely, disappeared. — In *Nematocarcinus exilis* præischium is marked off on all peræopods at least on the major part of their outer side by a distinct impression, which in first pair is very developed and, as far as I could see, is even a little movable articulation. — In *Anchistia antennata* præischium is distinctly marked off in all peræopods and most conspicuously on the posterior pairs.

In *Spirontocaris groenlandica* we find in the three posterior pairs of legs præischium marked off discernibly, though frequently feebly, below and on the outer side; in the slender second peræopod it is limited by a well developed oblique impression, while in the robust first leg the impression is rather curved. In third maxilliped a feeble vestige below is scarcely discernible. — In *Nika edulis* præischium is marked off in all five pairs of legs below and on the outer side by a rather distinct impression, which in the two anterior pairs is nearly transverse and not sharp, but sharp and very oblique in the three other pairs.

Sclerocrangon boreas is interesting. In third peræopod the præischium is well limited below, on the outer side and on the lower half of the inner side by an impression which may be a little lighter than the joints and looks almost as a feeble articulation, but this seems yet to be immovable. In the still more slender second leg a vestige of similar kind can be discerned with some difficulty. In fourth and fifth peræopods the impression is shallow and partly indistinct. In "Crustacea I" (1885) in The Norwegian North-Atlantic Expedition G. O. Sars gives (Pl. II) numerous figures of an animal he names *Sclerocrangon salebrosus* Owen (it is in reality a separate species, *S. ferox* Sars), and it is interesting to see that on his drawings of second, third and fourth legs he has five joints before the knee, as he really figures the præischium as a separate, short, triangular joint, but while in this way he gets eight joints in each of these legs, he mentions only seven joints in the text, omitting the præischium.

Among the tribe Stenopidea I have only examined *Stenopus hispidus*. In first and second peræopods præischium protrudes considerably on the lower margin of the leg as a rounded protuberance well marked off from ischium by an impression, besides it is marked off both on the outer (posterior) side and above by a very fine curved line, and if the investigator by some pression on the distal end of the long ischium attempts to turn the leg forward, it is seen that the limit between præischium and ischium may act as a very feebly developed articulation. In the thick third leg præischium is sharply marked off below and on the inner (anterior) side by a very conspicuous impression, while on the outer side I have found — perhaps casually — the impression much more pronounced in one leg than in the other. In fourth and fifth legs præischium is marked off only below by a rather short, transverse and not sharp impression. On third maxillipeds nothing.

Of the tribe Eryonidea only *Pentacheles phosphorus* has been inspected; præischium is completely fused with ischium, not marked off. — Of the tribe Galatheidea *Galathea intermedia* and *Munida tenuimana* were inspected, with similar negative result. — Of the tribe Thalassinidea a large exotic *Callianassa* sp. and *Gebia stellata* were inspected; no vestige of the præischium was found.

In the tribe Scyllaridea positive results are obtained. In *Palinurus argus* (a small specimen) basis, præischium and ischium are fused in all peræopods, but basis is marked off from præischium below and on both sides by a sharp darker line, and the last-named joint is distally marked off below and on the posterior side by a quite similar line, which has disappeared on the anterior surface. — In *Scyllarus arctus* the features are not very different. In the three anterior legs on the whole rather distinct impressions mark off basis from præischium, and the latter from ischium below and on the anterior side, while on the posterior (lower) side the impression is short. On fourth and fifth leg especially the distal one of these impressions is scarcely or not at all traceable.

Among the tribe Nephropsidea representatives for the following eight genera have been examined: *Nephrops, Nephropsis, Enoplometopus, Homarus, Paranephrops, Astacus, Cambarus, Astacoides.* In all these types præischium is marked off from ischium by a distinct or an extremely conspicuous oblique impression (fig. 4 d) both below and on one or on both sides or on the lower half of both sides, but generally not above, in the four posterior pairs of legs, while on the robust first pair the impression is much less developed, frequently only visible below or besides as a line on one of the sides. F. inst. in *Nephropsis atlantica* (fig. 4 d) and *Homarus vulgaris* the impressions in question are strong on the four posterior pairs, but there is no movement between præischium and ischium.

Among the tribe Paguridea representatives for seven genera have been inspected: *Eupagurus, Clibanarius, Coenobita, Lithodes, Paralomis, Lithodina,* and *Cryptolithodes.* All gave positive results, but a more special account of some of the types is needed. *Eupagurus Bernhardus* is interesting. In second and third peræopod basis, præischium and ischium are all fused in a single piece (fig. 10 a), but on the posterior (outer) side and below præischium (*pi*) is well marked off from the nearly still shorter basis (*b*) by a rather narrow and somewhat to very dark line slightly impressed across the whole height, and at the lower margin the impression is more pronounced so that the margin itself of both basis and præischium is each a little convex; præischium is separated from ischium by a somewhat similar dark line very conspicuous below but occupying only the lower two-thirds or three-fourths of the outer surface. On the anterior (inner) side of these legs the proximal line is dark, but instead of a line between præischium and ischium a much broader and very distinct impression or rather excavation is seen which is not dark. In first leg both lines reach the dorsal margin on the posterior side. In fourth leg the line between basis and præischium is very distinct, but the limit between præischium and ischium is wanting; in fifth leg both lines have vanished. In third maxilliped basis is well marked off from the next joint by an impressed furrow, but no limit between præischium and ischium is visible. But in this appendage we find the curious structure that the exopod is articulated not only to basis but is also attached to coxa, to each of these joints respectively by a chitinized piece and protuberance from its first short joint; these parts are directed respectively inwards to basis and mainly backwards to coxa. The attachment to the coxa must be interpreted as a secondary development; in order to study this remarkable feature the maxilliped ought to be examined from all sides. I have found the same feature developed with variations of particulars in other Paguridea, as *Coenobita* and *Lithodes*. (It may be noted that in a quite recent paper, "Die verwandtschaftliche Stellung der Gattung *Lithodes* (Kgl. D. Vid. Selsk. Biol. Meddel. IV, 4, 1924). Boas gives (p. 10) four figures of third maxilliped in three genera of Paguridea, and on these figures the curious position of the base of the exopod is rather well seen, but neither in this paper nor in his large treatise from 1880 the author has any remark on that particular in the text.) I have not observed that anomalous insertion of the exopod in any appendage in any other family or genus of the class Crustacea, but may yet add that I have not inspected the insertion of the exopod in representatives for the families of Brachyura or of the tribe Hippidea, etc.

In *Clibanarius vittatus* basis, præischium, and ischium of the legs nearly as in *Eupagurus*. — In *Coenobita rugosa* second and third legs are essentially as in *Eupagurus;* in first leg only a single line is found which is narrow and dark, but curiously enough this line seems to be the distal one, while the proximal line is represented by an excavation of the same light colour as the surroundings. On fourth leg we find only a single line, sharp, dark, well developed, which seems to be that between basis and præischium, while the distal line is lost. On fifth leg no lines. — In *Paralomis spectabilis* all five pairs of legs have the same appearance: a very conspicuous, sharp, rather dark line is developed below and on both sides; it is the limit between basis and præischium, while the last-named joint is only marked off from ischium by a rather feeble transverse line across the lower surface. — In *Lithodes Maja* all legs have the limit between basis and præischium rather well marked off, while that between the last-named joint and ischium is rather feeble and imperfect. — In *Lithodina verrucosa* all five pairs are uniform in structure, which is somewhat similar to that found in second and third legs of *Eupagurus*. — Finally *Cryptolithodes ritchensis:* in all legs basis, præischium and ischium are excellently marked off from each other on the lower surface and upwards on the posterior side by conspicuous and probably less chitinized lines; on the anterior side these lines are, at least partly, vanished.

As to the abdominal appendages, pleopods and uropods, the reader is referred to Calman's book. In vain I have looked in a few forms for a præcoxal joint; the quality of the skeleton makes frequently the interpretation of elements very difficult and uncertain.

Division Hoplocarida.

Order Stomatopoda.

(Pl. VIII, figs. 11—12).

Giesbrecht, W.: Stomatopoden. I. Fauna und Flora des Golfes von Neapel. 33. Monogr. 1910.

This rather small order comprises only a single family, but according to the general and well founded opinion it occupies an isolated position among Eumalacostraca. As even the smallest species is more than an inch in length, a number of species three to five inches (several forms even very much longer), and not a few species are common, I expected to find only little in the structure of any of the appendages (maxillæ excepted) not elucidated either by earlier authors or at least by Dr. Giesbrecht in his large book. But I found not only that Giesbrecht's descriptions, figures and interpretations as to the morphology of the appendages contain next to nothing of more general interest not already pronounced by earlier authors, but besides that some interesting structural features have been generally overlooked (Giesbrecht's extremely detailed representation of the skeleton of *Squilla mantis* published eight years after the author's death in Mitth. Zool. Station Neapel, 22. Bd., 1921, agrees as to counting and interpretations of the joints in the appendages with those in his above-named volume, and is therefore not taken into account in the following treatment). The reader is referred to Calman's good summary of our earlier knowledge in his hand-book as to the points not mentioned here later on.

The *antennæ* have the sympod two-jointed as in Eucarida; in vain I attempted to find any rudiment of a præcoxal joint. — The *mandibles* also agree with Eucarida in having no vestige of a "lacinia mobilis". — The *maxillulæ* (fig. 11 a) agree with those in the Decapoda — and differ consequently from all other Malacostraca — in the fact that second joint has disappeared, being fused with the first joint. The lobe (l^1) from first joint has, as generally among Decapoda, its firm chitine on the lower surface divided into two pieces, the proximal one narrow and rather short, while the other is several times longer and distally much expanded; the following joint and its lobe is a single long and rather narrow piece terminating in a thick spine; a one-jointed small endopod is generally present; exopod and pseudexopod wanting.

The *maxillæ* (fig. 11 b) differ much in general aspect from these appendages in other Crustacea, but at a closer investigation they agree with those in many Malacostraca as to the most important facts. Calman writes (l. c. p. 322): "They appear to consist of four segments of which first and second are indistinctly separated". Boas (1880) and Giesbrecht (1910) counts the same number, but Boas correctly points out a small somewhat protruding piece on the outer margin as a rudimentary exopod, a fact not remarked by the two other authors. Borradaile (1917) counts six joints in *Lysiosquilla*; he recognizes the first joint, but his third and fourth joints are in reality only a single joint with its lobe divided into two parts or secondary lobes, as is the case in Isopoda, in Mysidacea, etc. — An examination of the hard pieces in the maxilla, especially on its lower surface, and comparison of these elements with those in other Malacostraca gives the result that it possesses five joints. Under the simple microscope it is easily seen that the proximal inner lobe (fig. 1 b, l^2) which touches or even slightly overlaps the inner margin of the first joint, præcoxa (*1*), of the maxilla, is in reality not at all connected with it, and by the aid of two minute knives or needles the lobe can be pushed a little away from the inner margin of first joint, as shown on fig. 11 b. The firm chitine of this joint is on the lower surface a very oblong longitudinal plate at the inner margin, while the remainder of the surface is thin-skinned. Second joint (*2*) contains below two oblong plates, while more than half of its surface is thin-skinned, and its subtriangular, rather large and well chitinized, simple lobe (l^2) projects inwards and especially backwards. Third joint (*3*) shows a transverse, much curved, firm plate from the outer margin across the appendage, and towards the interior side the plate is much expanded, constituting the proximal part of the lobe (l^3) of the joint, while more than the distal half of this lobe is a still larger plate, longer than broad, sharply and movably separated from the proximal part of the lobe. At the outer distal angle of this joint is seen a small, subtriangular, a little protruding plate, the exopod (*ex*). The two distal joints, the endopod, look rather curious; each is well chitinized with a longitudinal and narrow membranous strip nearer to the outer than to the inner margin of both joints; perhaps this structure may be interpreted thus that the outer part of the firm chitine is the real joint, while the inner part is a kind of lobe, and the shape of the distal half of the terminal joint corroborates this interpretation.

The five following pairs of appendages are generally mentioned as maxillipeds; I name the first pair *maxillipeds*, the others are *first to fourth pair of thoracic legs*. But before dealing with these interesting appendages the *three posterior pairs of thoracic legs* may be mentioned. Their structure is well known; they consist of a sympod with three well developed joints, a two-jointed endopod and a two-jointed exopod. First joint, præcoxa, of the sympod is short, well chitinized with the articulations at both ends very movable. In the interpretation of the rami of these legs Giesbrecht commits a curious error in naming the exopod in the adults (and in the littoral larval stages) the endopod, and vice versa, though the exopods on the four anterior pairs of legs in a larval stage shows the same structure as the exopod of the walkings legs in the important fact that it consists of a short proximal and a long distal joint, while the endopod has a long proximal and a much shorter distal joint.

Calman writes (op. cit. p. 322): "The first five pairs of *thoracic appendages* are similar in structure and commonly called maxillipeds, though, as they possess no endites or other adaptations for mastication, the name is hardly appropriate. Each consists of only six segments (there is no evidence to show these are related to the seven segments commonly recognized in other Malacostraca) and terminates in a prehensile "hand" or sub-chela; there are no exopodites, but epipodites (fig. 190, A, *ep*) are present on all five pairs in the form of discoid membranous plates or vesicles attached to the basal segment by a narrow neck". Giesbrecht (1910) counts also only six joints in each of these appendages. But it shall now be shown that each leg of the four anterior thoracic pairs consists not of six, but with absolute certainty of at least seven joints, and in my opinion chitine of a separate eighth joint is very distinct, finally that the so-called epipod or branchia is a præepipod; the single pair I name maxillipeds shall later on be compared with the legs. I entertain not the slightest doubt that the joints in the four pairs of legs are homologous with the joints in other Malacostraca, and especially they may be compared with the legs in *Anaspides* or *Thysanopoda*. The direction and strong movability of the articulation between the major part of the leg and the antepenultimate joint shows that the three distal joints are carpus, propopus and dactylus (fig. 11 c), but the major proximal part of each leg is somewhat more difficult.

The investigation of this proximal part may be undertaken on adult and well-sized specimens of *Squilla mantis* and *Lysiosquilla maculata*, but the specimens must not have been too much hardened in strong spirit so that their legs are too stiff, as all their articulations must be easily movable. It is instantly seen that the branchia of fourth leg originates from rather thin skin considerably above the proximal end of the joint generally considered as the first. In the three anterior pairs of legs the branchia (fig. 11 c, *pe*) is attached at the distal margin of a short or — in *Lysiosquilla* — moderately short, well chitinized piece (*pc*) articulated to the tergite of the respective segment of the body and having its distal end connected with the following joint (*c*) by a movable articulation; this piece, præcoxa, is easily seen without preparation on the outer side and posteriorly on first to third leg, especially in *Lysiosquilla*, and by moving the very thick next joint, the coxa, in different directions, it is observed that the branchia does not follow the movements of the coxa but those of the præcoxa, and the outlines of the firm chitine of the præcoxa and of the articulating membrane can be ascertained by pricking cautiously with the end of a minute knife. As already said, the præepipod originates in fourth leg considerably above the base of coxa on rather thin chitine; in this leg the præcoxa is therefore indistinct, being represented in the big *Lysiosquilla* by a feebly thickened external and moderately small area in the very large membranous area above and behind the coxa.

The four pairs of legs show still an other and hitherto overlooked interesting feature. In examining the articulation between coxa and the apparently following long joint one sees on the inner side of the leg an oblong, firmly chitinized, movable piece (*b*) connecting the coxa with the firm chitine of next joint; this very obvious piece I interpret as the rudimentary third joint of the sympod: basis. Still we have two well developed, even long joints between basis and carpus (*cp*); the first of these may be named ischium, as præischium has completely disappeared quite as in Euphausiacea, many Caridea and higher Decapoda, being fused with ischium; the other joint is merus (*m*). — But it may be added that the development at least apparently presents a difficulty for interpreting the firm piece in the articulation at the distal end of coxa as the basis. Fig. 12 a exhibits first to third leg of the larval stage named the third by Giesbrecht of a *Lysiosquilla* (from the Bay of Bengal). It is seen that the sympod is three-jointed with præcoxa short, protruding, but scarcely marked off from the body, while a two-jointed exopod (*ex*) originates on the side at the end of third joint (*b*). By a later moulding the exopod is lost, and if my interpretation in the adult is correct, basis which is well developed in the legs figured, must be strongly reduced, while the first larval joint in the endopod shall be divided into two joints. The difficulty lies in supposing a strong reduction of basis in a later stage of development, but neither Giesbrecht's detailed investigation of the gradual development of the thoracic legs in *Lysiosquilla occulta* nor the material seen by me can decide anything with certainty. Another possibility is that basis in the larval stage gives rises to both the rudimentary basis and the ischium in the older stages. The fact that speaks strongly for the interpretation of the chitinized piece in the articulation mentioned of the adult as basis is that I do not know any single instance among Arthropoda in which such a firm piece is found in an articulation of a leg without being decidedly a reduced joint.

Finally the single pair of maxillipeds. They look essentially as second to fourth leg, but they are less robust, basis could not be discovered in the articulation beyond coxa, and præcoxa is coalesced with coxa so that the præepipod looks as being an epipod. — In the three pairs of walking legs the endopod is only two-jointed; when compared with the corresponding legs in other Malacostraca the first joint seems to be formed by the fusion of the three joints before the knee, while the second joint answer to the joints beyond the knee. — In the abdominal appendages præcoxa has disappeared, and I have not even been able to discover a remnant of second joint of the sympod with any certainty, while third joint is large.

Summary on the Sub-Class Malacostraca.

Antennæ. — They consist typically of a three-jointed sympod and two rami, endopod and exopod. The sympod has three distinct joints in *Nebalia,* among the Syncarida at least in *Bathynella* and less distinctly in *Anaspides*, in Mysidæ, in many Isopoda and in Gammaridea, while in Tanaidacea, Eucarida, Hoplocarida, many Isopoda, etc. only two joints are found, as the first joint, præcoxa, has disappeared, probably fused with the head. The endopod consists generally of three proximal specially developed joints and a multiarticulated flagellum; the proximal three joints — of which the first is short, rudimentary or sometimes wanting — constitute together with the sympod the antennal peduncle. The exopod is always unjointed; it is lamellar or plate-shaped in some Syncarida, in Apseudidæ, Mysidacea, Euphausiacea, Hoplocarida, and many Decapoda; in many Isopoda it is shaped as a kind of process articulated to basis, in Leptostraca it is a small protuberance; in many types the exopod is wanting, as in *Koonunga,* in Tanaidæ, numerous Isopoda, all Amphipoda, and in crabs.

Mandibles. — These appendages consist typically of the very large præcoxal joint which is the mandible itself, and the "palp". The distal part of the mandible varies exceedingly in shape and structure, and has in several orders a process cut off by a secondary articulation and a row of setæ behind the incisive part of the inner margin. The palp is wanting in many types; when present and well developed it consists always of three simple joints except in *Paranaspides.* In this genus old specimens have — according to G. Smith — the palp biramous, as an unjointed small exopod is found on its first joint. A comparison with the Calanoida gives the result that the joint bearing the exopod is the basis, while the coxal joint found in *Calanus,* etc., has disappeared as in *Cyclopina* and an immense number of other Copepoda; in *Paranaspides* the endopod is three-jointed in old, but only two-jointed in young specimens. From this structure we may conclude with certainty that the three-jointed palp existing in the majority of Malacostraca must be interpreted in this way that its two distal joints belong to the endopod, while the proximal joint is the basis, or rather basis fused with coxa, of the sympod.

Maxillulæ. — The sympod consists of the three joints except in Decapoda and Stomatopoda. The præcoxa has generally a well developed lobe, the firm chitine of which is proximally slender and articulated to the joint itself; this lobe is wanting in Hyperiidea and some other Amphipoda, in Tanaidæ and some few Isopoda. In many types belonging to several orders and especially in most Euphausiacea this lobe is expanded feebly or considerably or extremely outwards as a plate overlapping below a part or much of the sympod; this plate is named pseudexopod. The coxal joint is generally small, has never any lobe, and is in Decapoda and Stomatopoda completely fused with first joint. Third joint, basis, is produced into a lobe never marked off from its joint. The endopod is long with several joints in *Nebalia*; in *Gnathophausia*, Tanaidacea and Cumacea it is a rather long palp with one or frequently two joints and directed backwards; in Amphipoda it is directed forwards, most frequently well developed, two-jointed in most Gammaridea, one-jointed in Hyperids, and sometimes rudimentary (*Orchestia*). In Euphausiacea it is two-jointed in *Bentheuphausia*, one-jointed in the other genera; in Decapoda it is rarely three- or four-jointed (*Penæus*), generally two- or one-jointed; it is one-jointed and small in Anaspidacea and Stomatopoda, wanting in Mysidacea except Gnathophausia, and in all Isopoda. The exopod is wanting in adults of all orders; it is found as a single joint in certain larval stages of Euphausiacea and lower Decapoda (as in the Acanthosoma-stages of *Sergestes*).

Maxillæ. — The sympod is typically and most frequently very distinctly three-jointed. Præcoxa has never any lobe, while second joint, coxa, always is produced into a considerable or long lobe, which distally is rather frequently incised or bifid or even cleft (*Nebalia, Anaspides*, many Euphausiacea and Decapoda). Third joint is produced into a lobe which in most types is rather deeply incised or even deeply cleft into two secondary and parallel lobes; in Amphipoda the lobe has no vestige of any incision. — The longitudinal incision or division of the lobe of third joint has originated a good deal of misinterpretation by various authors (in 1887 also by myself), as they thought that each of the two parallel secondary lobes originated from its own joint in the stem of the appendage. — The endopod is completely wanting in Amphipoda, Isopoda, Cumacea, Tanaidacea, Syncarida, while in the other orders it is generally present, most frequently one- or two-jointed, three-jointed in *Bentheuphausia* and even five-jointed in the Acanthosoma of *Sergestes*. The exopod is wanting in Syncarida, Tanaidacea, Isopoda and Amphipoda, feebly developed in Stomatopoda, Cumacea and Euphausiacea, well developed in Mysidacea and *Nebalia,* extremely developed as a vibrating plate in the Decapoda. The exopod, when present, is always unjointed, and of course attached to the outer margin of the basis. An epipod is always wanting.

Maxillipeds and thoracic Legs. — These eight pairs of appendages belong originally to thorax. The are similar in structure in Leptostraca, while in the othei orders the fiist pair, the real maxillipeds, differ somewhat or considerably or very much from the following pairs, the legs. In Decapoda authors generally speak of three pairs of maxillipeds, in Stomatopoda even of five pairs. — The sympod consists typically of three joints. Præcoxa is a distinct joint in all eight pairs in Leptostraca and in second to eighth pair in Stomatopoda, while in the last-named order præcoxa is fused with coxa in the real maxillipeds, and feebly chitinized in the fourth pair of legs. In Leptostraca a præepipod is wanting, but it is developed as a stalked branchial plate in the five anterior pairs of appendages in Stomatopoda. In *Anaspides,* in large forms of Mysidæ and in Euphausiacea the præcoxa is seen as a separate plate articulated to the tergite of its segment above maxillipeds and legs in Euphausiacea, but only above the legs in *Anaspides* and Mysidæ, as in these types the præcoxa could not be made out with any certainty above the maxillipeds. In *Gnathophausia* præcoxa of the last pair of legs has not only an outer but also an anterior and a posterior chitinized wall, is consequently developed as a short, protruding joint marked off above. In the sub-order Lophogastrida the branchiæ, judging especially from the last pair of legs in *Gnathophausia,* are modified præepipods, while an appendix of this kind is wanting in the sub-order Mysida, as in Syncarida and Euphausiacea. Furthermore the præcoxa is marked off by a fine, sharp suture on the six posterior thoracic segments in

Apseudes, while it is wanting in Tanaidæ, in Cumacea, Amphipoda and Isopoda, except as a separate firm plate in the maxillipeds of some Isopoda. In the Decapoda præcoxa is without doubt the branchiferous part of the thoracic pleuræ, but their limits from the skeleton belonging to the trunk has at least not yet been indicated and may probably be impossible to point out with certainty in at least the large majority of genera.

The coxa is most frequently free and well developed. In *Nebalia* each coxa of maxillipeds and thoracic legs has an epipod, in *Anaspides* two epipods excepting in the last leg; in Stomatopoda epipods are wanting. In Mysidacea, Cumacea, Tanaidacea and Isopoda the epipod is found on the maxillipeds, and in the three first-named orders it is even very or extremely large and specially developed in the service of respiration, while in these orders epipods are wanting on all thoracic legs excepting in a certain sense in *Gnathophausia* — but the marsupial plates in the females of these orders and of Amphipoda may perhaps be considered of epipodial nature. In Amphipoda external epipods are wanting, but the vesicular or lamellar or — rarely — ramified branchiæ originating from the inner surface of the coxæ in at least two and most frequently in some or several pairs of the legs may be considered as a special development of epipods. In many Isopoda the coxæ of the six posterior pairs of legs are developed as "epimera" on the sides of the segments, frequently marked off from these by a slightly movable articulation or a suture and in several forms completely fused with the segments; in all Isopoda except *Plakarthrium* the coxa of first leg is coalesced with its segment but may yet possess a marsupial lamella. In the order Euphausiacea the coxa of the maxilliped has a simple epipod, while in the legs this epipod is a highly ramified branchia. In Decapoda an epipod partly or wholly or not modified as a branchia (podobranchia) is frequently present (as to the "setobranchia" found in many macrurous forms I refer to Calman op. cit. p. 277). In Anaspidacea all coxæ except the last pair have two epipods. The maxillipeds in Tanaidæ and Amphipoda have their coxæ fused with each other in the median line.

The third joint of the sympod, basis, is a free joint in the legs of most forms, viz. in all Peracarida, in Euphausiacea and in the five posterior pairs, the real legs, in the majority of macrurous Decapoda. In several macrurous types and in Paguridea it is coalesced with the first joint of the endopod but yet marked off in most or all legs by a line; in higher Decapoda the fusion is complete. In Stomatopoda basis is well developed in the three pairs of walking legs, rudimentary but movable in the four anterior pairs. In *Anaspides* basis is moderately developed in first leg, but backwards in the other pairs of legs it is gradually more narrow, more closely united with the next joint, in sixth leg only marked off from it by a suture, in last leg united with it. — As to the maxillipeds in all orders and the appendages named second and third maxillipeds in Decapoda (and partly in Cumacea) the variation is too rich to be mentioned in this somewhat short summary.

In maxillipeds and all thoracic legs the exopod is wanting in Amphipoda, Isopoda and Tanaidæ; in Apseudidæ, Cumacea, Stomatopoda and most Decapoda it exists in some and is wanting in other pairs. In *Nebalia*, Mysidacea, Euphausiacea and several genera of lower Decapoda the exopod is generally found in maxillipeds and all legs — only in very rare cases it is wanting either on maxilliped or on the last leg. — The endopod which together with the sympod constitutes the stem of the legs, is much more interesting.

In *Nebalia*, *Paranebalia* and *Anaspides* the endopod has six joints, which in the last-named genus are all well developed with the essential vertical flexion, the knee, between third and fourth joint. In Peracarida the three joints before the knee:

præischium, ischium and merus, are generally free and well developed; in Eucarida and Stomatopoda præischium is typically coalesced with ischium, frequently without vestige of any suture between them, but in the four or five posterior pairs of legs in numerous types among macrurous Decapoda and Paguridea præischium is more or less distinctly marked off from ischium by an impression or a suture, in rare cases even by a feebly movable articulation. In Eucarida the three joints beyond the knee: carpus, propodus and dactylus, are typically all free and well developed; in Stomatopoda the same is the case as to the five anterior pairs of appendages, while they are fused in the three posterior pairs. In Peracarida the same three joints are reduced to two in most forms by the complete fusion of carpus with propodus, but in many genera of the family Mysidæ the carpus is preserved as a separate joint in the six posterior pairs of legs.

Finally the abdominal legs. In *Nebalia* the four anterior pairs have three joints in the sympod, and both rami, while the two posterior pairs are very reduced. The six pairs in Eumalacostraca consist typically of sympod, endopod and exopod; the rami differ frequently extremely in shape and sometimes one among them is wanting. In the sympod of the anterior legs in some Isopoda the three typical joints can be pointed out, but in the great majority of Eumalacostraca third joint, basis, is highly developed, the coxal joint short or very short and partly somewhat feebly developed, while the præcoxa seems to have disappeared or is at least not discernible from the ventral skeleton of abdomen. And even the coxal joint disappears completely, f. inst. in the three posterior pairs of appendages in Amphipoda, and in the uropods of at least most genera in the other orders.

Explanation of the Plates.

Plate I.

Fig. 1. *Lepidurus productus* Bosc. Female.

Fig. 1 a. Hypopharynx and maxillulæ, from below; × 9. — *h.* hypopharynx; *m.* muscle to the mandible; m^1. maxillula, and *1.* its first joint; *o.* oesophagus.

— 1 b. Left maxillula, from behind; × 8. — *1.* first joint; *2.* second joint.

— 1 c. Left maxilla, from behind; × 8. — *d.* duct from the maxillary gland.

— 1 d. Fifth left thoracic leg, from behind; × 5. — *1*—*6.* the six joints in the stem; l^1—l^5. lobes from the five proximal joints; *ep.* epipod; *ex.* exopod; *s.* sternal piece, on which the leg is articulated.

— 1 e. Fifth left leg, from in front; × 5. — Epipod and exopod only partly drawn, but each showing the strip of firmer chitine. Lettering as in fig. 1 d.

— 1 f. First left thoracic leg, from behind; × 5. — Lettering as in fig. 1 d.

— 1 g. Left maxilliped, from behind; × 5. — Lettering as in fig. 1 e.

— 1 h. Tenth left leg, from behind; × 5. — The exopod, *ex.*, which constitutes the cover of the egg-box, is turned backwards; *ep.* rudimentary epipod.

— 1 i. Tenth left leg, from in front; × 5. — *4.* and *5.* firmer chitinized plates of fourth and fifth joint; *6.* sixth joint.

Fig. 2. *Chirocephalus Grubei* Dyb.

Fig. 2 a. Fifth left leg, from behind; × 15. — *en.* endopod; *ep.* epipod; *ex.* exopod; l^1. lobe of first joint; *pe.* præepipod; *6.* sixth joint of the stem.

Fig. 3. *Estheria dahalacensis* Rüpp.

Fig. 3 a. Fifth left leg, from behind; the exopod, *ex*, cut off and removed to the right but connected with the stem by dotted lines; × $^{25}/_{2}$. — *sp*. sympod with its three lobes, the first marked l^1; *t*. tactile process on the lobe from fifth joint; *6*. sixth joint.

Fig. 4. *Limnetis brachyura* O. F. Müll.

Fig. 4 a. Fifth left leg, from behind; × 18. — Lettering as in fig. 3 a.

Fig. 5. *Polyphemus pediculus* De Geer.

Fig. 5 a. First thoracic limb, or maxilliped; × 54. — The sympod is feebly three-jointed; the endopod, *en.*, distinctly three-jointed; exopod, *ex.*, unjointed.

Fig. 6. *Daphnia magna* Straus.

Fig. 6 a. First right thoracic appendage (maxilliped), from in front; × 33. — *en*. endopod; *ep*. epipod; *sp*. sympod. (The plumosity on the setæ omitted.)

Plate II.

Fig. 1. *Sida crystallina* O. F. Müll.

Fig. 1 a. First right thoracic limb (maxilliped), from in front; × 44. — *en*. endopod; *ep*. epipod; *ex*. exopod; *pe*. præ-epipod; *sp*. sympod; l^1. lobe from first joint of the sympod.

Fig. 2. *Daphnia magna* Straus (Continued).

Fig. 2 a. Second right thoracic appendage, from in front; × 33. — *en*. endopod; *ep*. epipod; *ex*. exopod, *3*. third joint of the sympod; l^3. its lobe. (The plumosity on the setæ omitted.)

Fig. 2 b. Third right thoracic appendage, from in front; × 33. — *pe.* præepipod; *sp.* sympod; the other letters as in fig. 2 a. (Plumosity on the setæ omitted.)

Fig. 3. *Calanus finmarchicus* Gunnerus.

Fig. 3 a. Frontal filaments; × 33.

— 3 b. Left antenna, from behind; × 35. — *1.* first joint; *3.* third joint; *en.* endopod. (Of most setæ only the basal part is drawn.)

— 3 c. Left mandible, from behind; × 35. — *c.* coxa; *b.* basis; *en.* endopod. (Of most setæ only the basal part is drawn.)

Fig. 4. *Calanella hyalina* Claus.

Fig. 4 a. Left maxillula, from behind; × 61. — *pc.* first joint, præcoxa; *pe.* præepipod; l^2. lobe from second joint; *en.* endopod; *ex.* exopod. (Of many setæ only the proximal part is drawn.)

Fig. 5 a. *Megacalanus princeps* Wolf.

Fig. 5 a. Left maxilla, from behind; × 33. — *pc.* first joint, præcoxa; *c.* second joint, coxa; l^2. deeply bifid lobe from second joint; *b.* third joint, basis; l^3. deeply bifid lobe from third joint; *ex.* rudimentary exopod with a robust, plumose seta. (Of nearly all setæ, which are very long, only the proximal part is drawn.)

— 5 b. Left maxilliped, from behind; × 18. — *pc.* first joint, præcoxa; *b.* third joint, basis. (Distal portion of most setæ omitted.)

— 5 c. Second pair of natatory legs, from in front; × $^{25}/_{2}$. — *pc.* first joint, præcoxa; *pl.* plate connecting second joint, coxa (*c*), of the same pair of legs; *b.* basis.

Fig. 6. *Setella* sp.

Fig. 6 a. Antenna; × 127. — *1.* first joint.

Fig. 7. *Argulus foliaceus* Lin.

Fig. 7 a. Second left natatory leg, from behind; × 18. — *ex.* exopod; *fl.* "flagellum".

Fig. 8. *Balanus porcatus* da Costa.

Fig. 8 a. Fifth leg, from in front; × 9. — *a.* the firmly chitinized lateral band of the segment bearing the leg; *pc.* præcoxa, first joint of the sympod; *c.* coxa. (Major part of the cirri omitted.)

Fig. 9. *Lepas anatifera* Lin.

Fig. 9 a. First left mouth-limb (mandible, Darw.), from below; × 11. — *d.* lateral and ventral skeleton of the head; *e.* first joint of "mandible"; *f.* second joint; *g.* thin-skinned part; *h.* firm transverse plate.

— 9 b. First left mouth-limb (mandible, Darw.), from above (from in front); × 11. — *d.* skeleton of the head; *f.* second joint; *g.* thin-skinned part; *h.* transverse plate; *i.* more firmly chitinized part; *k.* suture between the last-named part and the transverse plate; *l.* palp; *m.* clypeus.

— 9 c. Second left mouth-limb (maxilla, Darw.), from below; × 11.

Fig. 10. *Cypris-stage* (of *Balanus* sp.).

Fig. 10 a. Last thoracic leg and abdomen (*a*) of a Cypris-stage, from the left side; × 134. — *ex.* exopod; *sp.* sympod.

Plate III.

Fig. 1. *Polycope* (?)*orbicularis* G. O. Sars (Female).

Fig. 1 a. Right antenna, obliquely from the inner side and from above; × 143. — *1.* first joint; *2.* second joint of the sympod; *en.* endopod; *ex.* exopod. (The natatory setæ on the rami omitted.)

Fig. 1 b. Left antenna, obliquely from below and from the outer side; × 143. — *1.* first joint; *2.* second joint; *a.* membranous area; *f.* firmly chitinized strip. (Most of the rami omitted.)

— 1 c. Left mandible, from behind; × 168. — *2.* the probable second joint of the sympod only marked off from the third joint, *3.*, by an emargination on the outer margin; *ex.* exopod.

— 1 d. Distal part of the endopod of the mandibular palp, from behind; × 400. — *m.* muscle, visible with transmitted light, to the terminal joint. (Major part of the setæ omitted.)

— 1 e. Right maxillula, from in front; × 168. — *1*—*3.* the the three joints in the sympod; l^1. lobe on first joint; *ex.* exopod.

— 1 f. Left maxilliped, from behind; × 168. — *1.* first joint; *2.* second joint; *en.* endopod; *ex.* exopod; *pe.* præepipod.

Fig. 2. *Conchoecia elegans* G. O. Sars (Female).

Fig. 2 a. Left antenna, from the inner side; × 30. — *2.* second joint of the sympod; *i.* insertion of the first, thin-skinned joint. (Major portion of the setæ on the rami omitted.)

— 2 b. A part of the organ shown in fig. 2 a; × 57. — *2. second* joint of the sympod; *en.* endopod; *ex.* exopod; *a.* membranous area; *f.* firmly chitinized strip, a remnant of third joint of the sympod.

— 2 c. Left mandible, cleaned in caustic potash, from behind; × 45. — *pc.* præcoxa; *c.* coxa; *b.* basis; *en.* endopod; *ex.* exopod.

Fig. 2 d. Distal part of first joint, *1.*, and proximal part of third joint, *3.*, of the mandible shown in fig. 2 c; from in front; × 61.

— 2 e. Left maxillula, cleaned in potash, from behind; × 115. — *1.* first joint; *l*[1]. its lobe; *2.* second joint; *l*[2]. its lobe; *3.* third joint, marked off from the two-jointed endopod, *en.*, by a strong external emargination.

— 2 f. "Palp" of left maxillula from in front; × 115. — *3.* third joint of sympod; *l*[3]. lobe of third joint; *en.* endopod (its setæ omitted.)

— 2 g. Left maxilliped, from the inner side; × 64. — *pc.* præcoxa; *pe. præepipod.*

— 2 h. Left first leg, from the inner side; × 52. — *pe.* præepipod.

— 2 i. Second leg; × 80.

Fig. 3. *Asterope* sp.
(from Buck Isl. at St. Croix, West Indies).

Fig. 3 a. Left antenna, from the outer side; × 60. — *1.* first joint of the sympod, thin-skinned with a firm longitudinal rib, *r*; *s.* skeleton of the head. (Setæ on the rami omitted.)

— 3 b. Distal part of sympod with endopod, *en.*, and proximal part of exopod, *ex.*, of right antenna, from the inner side; × 122. — *a.* membranous area; *e.* strip of firm chitine from the firm margin of second joint downwards to the longitudinal ventral strip, *f.*, between endopod and exopod; *g.* vertical firm strip.

— 3 c. Right maxillula, from in front; × 118. — 1 + *2.* first and second joint completely fused; *ep.* epipod.

Fig. 4. *Philomedes globosus* Lilljeborg (Female).

Fig. 4 a. Distal part of sympod with endopod, *en.*, and proximal part of exopod, *ex.*, of right antenna, from the inner side; × 40. — *a.* membranous area; *f.* and *g.* firmly chitinized strips, remnants of third joint of the sympod.

Plate IV.

Fig. 1. *Cypridina norvegica* G. O. Sars (Female).

Fig. 1 a. Distal part of sympod with endopod, *en.*, and proximal part of exopod, *ex.*, of left antenna, from the outer side; × 41. — *a.* membranous area; *h.* firm chitinous strip; *r.* thickened marginal band of the chitinized lateral wall; *t.* tendon of the musculus adductor of the exopod seen through the membrane.

— 1 b. Distal part of sympod with endopod, *en.*, and proximal part of exopod, *ex.*, of right antenna, from the inner side; × 41. — *a.* membranous area; *e.*, *f.*, and *g.* firmly chitinized strips.

— 1 c. Left mandible, from behind; × 37. — *pc.* præcoxa; *r.* longitudinal firmly chitinized rib; *b.* basis; *en.* endopod; *ex.* exopod.

— 1 d. Proximal part of the appendage shown in fig. 1 c, from in front; × 37. — *pc.* præcoxa; *c.* coxa; *b.* basis.

— 1 e. Left maxillula, cleaned in potash, from behind; × 54. — *1.* first joint; l^1. its lobe; *2.* second joint; l^2. the two lobes from second joint; *r.* chitinous rib belonging to second joint; *3.* third joint; l^3. its lobe; *en.* endopod (two-jointed); *ep.* rudiment of epipod.

— 1 f. Left maxilliped, from behind; × 37. — *ex.* exopod; *pe.* præepipod; the other lettering as in fig. 1 e. (Only the proximal part of the marginal setæ on the præepipod is drawn.)

— 1 g. Left first leg, from behind; × 37.

Fig. 2. *Rutiderma* sp. (from Gulf of Siam).

Fig. 2 a. Left mandible, from the outer side; × 131. — *ex.*

rudimentary exopod; *f.* third joint of endopod, base of the movable finger of the chela, with a gigantic terminal spine, *s.*; *t.* tendon of its musculus adductor seen through the skin.

Fig. 3. *Macrocypris minna* Baird.

Fig. 3 a. Left antenna, from the outer side; × 41. — *1.* first joint, with its firm longitudinal rib, *r.*; *2.* second joint; *3.* third joint; *en.* endopod, four-jointed; *ex.* rudimentary exopod.

— 3 b. Left mandible, from behind; × 50. — Lettering as in fig. 1 c.

— 3 c. Left maxillula, cleaned in potash, from behind; × 168. — Lettering as in fig. 1 e. (Only the proximal part drawn of most of the long setæ on the epipod.)

— 3 d. Left maxilliped, from behind; × 50.

— 3 e. Left second leg, from the outer side; × 32.

Fig. 4. *Cypris pubera* O. F. Müll.

Fig. 4 a. Left maxilliped, from behind; × 50. — *pc.* præcoxa; *pe.* præepipod.

Fig. 5. *Cytherella abyssorum* G. O. Sars (Female).

Fig. 5 a. Left antenna, from the outer side; × 81.

— 5 b. Right maxillula, from in front and obliquely from the inner side; × 100. — *ep.* epipod, turned inwards and its base covered by the most proximal and damaged part of the appendage; l^1. lobe from first joint; l^2. bifid lobe from second joint; *3.* third joint; *en.* endopod. (Only the basal portion of the setæ on the epipod is drawn.)

— 5 c. Proximal part of right maxillula, obliquely from in front and from the outer side; × 120. — *1.* first joint.

The other lettering as in fig. 5 b. (Of the epipod only its basal part with the proximal portion of the marginal setæ is drawn.)

Fig. 6. *Nebalia bipes* O. Fabr.

Fig. 6 a. Left maxillula, from behind; the distal part of the very long endopod, *en.*, omitted; × 23. — *1.* first joint; l^1. its lobe; *2.* second joint; *3.* third joint; l^3. its lobe.

— 6 b. Proximal part of left third abdominal leg, from the outer side; × 11. — *t.* tergite of the segment; *1.* and *2.* chitinized plates of first and second joints in the leg; *3.* proximal part of third joint of the sympod.

Plate V.

Fig. 1. *Nebalia bipes* O. Fabr. (Continued).

Fig. 1 a. Front end of the head with the right eye, antennula and antenna of a female, from the right side; × 13. — *h.* parts of the head; *u.* upper ramus of antennula. The ciphers at antennula and antenna indicate the number of the joints.

— 1 b. Left maxilla, from behind; × 23. — *1.* first joint; *2.* second joint; l^2. its lobe; *3.* third joint; l^3. its lobe; *ex.* exopod.

— 1 c. Left third thoracic leg, from behind; × 17. — *pc.* præcoxa; *c.* coxa; *b.* basis; *ep.* epipod; *ex.* exopod. (Major portion of the setæ on the terminal joint and on the inner margin of the two preceding joints omitted.)

Fig. 2. *Paranebalia longipes* Will.-Suhm.

Fig. 2 a. Left maxilla, from behind; × 51. — Lettering as in fig. 1 b.

Fig. 2 b. First thoracic leg, from behind; × 34. — *pc.* præcoxa; *c.* coxa; *b.* basis; *sp.* sympod; *ep.* epipod; *ex.* exopod.

— 2 c. Distal end of sympod with the entire endopod and the proximal part of the exopod of the leg shown in fig. 2 b, from behind; × 57. — m^1. muscle from sympod to endopod; m^2.—m^5. muscles crossing the following articulations and seen through the skin. (Setæ on the interior margin omitted.)

Fig. 3. *Anaspides Tasmaniæ* Thomson.

Fig. 3 a. Proximal part of left antenna, from above and from the outer side; × 9. — *1—3.* joints of the sympod. (Setæ omitted.)

— 3 b. Terminal part of left mandible, from below; × 20. — *l.* lobe.

— 3 c. Left maxillula, from below; × 14. — *1.* first joint; l^1. its lobe; *2.* second joint; *en.* endopod; *ps.* pseudexopod.

— 3 d. Left maxilla, from below; × 14. — Lettering as in fig. 1 b.

— 3 e. Left maxilliped, from behind; × vix 9. — *c.* coxa; *b.* basis; *pi.* præischium; *i.* ischium; *m.* merus; *cp.* carpus; *pp.* propodus; *d.* dactylus; *ep.* epipods; *ex.* exopod.

— 3 f. Proximal parts of the maxilliped shown in fig. 3 e, from behind; × 13. — *c.* coxa; *l.* its lobes; *pi.* præischium. (Most of epipods and exopod omitted.)

— 3 g. Same parts of shown in fig. 3 f, from in front; × 13. — *b.* basis; *ep.* epipods; *ex.* exopod; *l.* the two lobes from coxa (setæ on the anterior lobe omitted.)

— 3 h. Proximal parts of left second leg, from behind; × 14. — *s.* piece of sternal plate; the other lettering as in fig. 3 e.

Fig. 3 i. Proximal parts of left sixth leg, from behind; × 14. — Lettering as in fig. 3 e.

— 3 k. Proximal part of right seventh leg, from the outer side; × 9. — *pc.* præcoxa; *c.* coxa; *b.* + *pi.* basis plus præischium completely fused.

— 3 l. Lower part of right lateral surface of thorax with the proximal parts of third and fourth leg, from the outer side; × 9. — *t.* thoracic tergite; *pc.* præcoxa; the other lettering as in fig. 3 e.

Fig. 4. *Mysis flexuosa* O. F. Müller.

Fig. 4 a. Proximal part of right antenna, from below; × 11. — *1.* first joint of the sympod; *2.* second joint; *3.* third joint; *ex.* exopod.

— 4 b. Lower part of left lateral surface of thorax with the proximal parts of first to fourth leg; × 10. — *t.* thoracic tergites; *pc.* præcoxa; *c.* coxa; *b.* basis, *ex.* exopod; *m.* merus.

— 4 c. End of abdomen of a larva in the penultimate stage found in the marsupium, showing the furcal rami which are lost in the next stage; × 74.

Plate VI.

Fig. 1. *Mysis flexuosa* O. F. Müll. (Continued).

Fig. 1 a. Left maxillula, from below; × 28. — *1.* first joint; l^1. its lobe; *2.* second joint; *3.* third joint; *ps.* pseudexopod.

— 1 b. Left maxilla, from behind; ×28. — *1.* first joint; *2.* second joint; l^2. its lobe; *3.* third joint; l^3. its deeply bifid lobe; *en.* endopod; *ex.* exopod.

— 1 c. Part beyond the knee of left second thoracic leg, from behind and showing the muscle; × 23.

Fig. 2. *Siriella Clausi* G. O. Sars.

Fig. 2 a. Left second thoracic leg, from behind; × 21. — *c.* coxa; *b.* basis; *pi.* præischium; *i.* ischium; *m.* merus; *cp.* carpus; *pp.* propodus; *d.* dactylus.

— 2 b. Distal part of the endopod of the leg shown in fig. 2 a, from behind; × 47. — *cp.* carpus; *pp.* propodus; *d.* dactylus; *cl.* claw; *m.* musculus adductor to dactylus.

Fig. 3. *Boreomysis nobilis* G. O. Sars.

Fig. 3 a. Distal part of left leg of an intermediate pair, from behind; × 10. — *cp.* carpus; *pp.* the two-jointed propodus.

Fig. 4. *Amblyops abbreviata* G. O. Sars.

Fig. 4 a. Distal part of left leg of an intermediate pair, from behind; × 30. *cp.* carpus.

Fig. 5. *Mysidopsis didelphys* Norman.

Fig. 5 a. Part beyond the knee of an intermediate leg, from behind; × 30.

Fig. 6. *Anchialus typicus* Kröyer.

Fig. 6 a. Distal part of left third leg, from behind; × 108. — Lettering as in fig. 2 b.

Fig. 7. *Gnathophausia zoëa* Will.-Suhm.

Fig. 7 a. Left maxillula, from behind; × vix 8. — *2.* second joint; *en.* endopod.

— 7 b. Left maxilla, from behind; × vix 8. — Lettering as in fig. 1 b. (On the exopod the distal half of most marginal setæ omitted.)

Fig. 8. *Lophogaster typicus* M. Sars.

Fig. 8 a. Left maxillula, from behind; × 28.

Fig. 9. *Diastylis Rathkei* Kröyer.

Fig. 9 a. Left maxillula, from behind; × 31. — Lettering as in fig. 1 a.

— 9 b. Left maxilla, from behind; × 40. — Lettering as in fig. 1 b.

Fig. 10. *Apseudes spinosus* M. Sars (Subadult Female).

Fig. 10 a. Distal part of left mandible, from below; × 60. — *l.* lacinia mobilis; *m.* membrane.

— 10 b. Distal part of right mandible, from behind; × 60.

— 10 c. Hypopharynx (paragnatha, Claus), from in front; × 26.

— 10 d. Left maxillula, from below; × 37. — *2.* second joint; *en.* endopod.

— 10 e. Left second thoracic leg, from the outer side and from above; × 10. — *pc.* præcoxa; *c.* coxa; *l.* half-developed marsupial lamella; *b.* basis; *ex.* exopod; *pi.* præischium; *i.* ischium; *m.* merus; *cp.* + *pp.* carpus and propodus fused; *d.* dactylus.

— 10 f. Left fourth thoracic leg, essentially from above; × 10. — Lettering as in fig. 10 e.

Plate VII.

Fig. 1. *Apseudes spinosus* M. Sars (Continued).

Fig. 1 a. Left maxilla, from below; × 37. — *1.* first joint; *2.* second joint; l^2. its lobe; *3.* third joint; l^3. its bipartite lobe; *st.* part of sternum.

Fig. 2. *Munnopsurus giganteus* G. O. Sars.

Fig. 2 a. Left maxillula, from below; × 9. — *1.* first joint; l^1. its lobe; *2.* second joint; *3.* third joint.

— 2 b. Left maxilla, from below; × 9. — Lettering as in fig. 1 a.

— 2 c. Left maxilliped, from below; × 6. — *st.* sternum of the segment; *pc.* præcoxa; *c.* coxa; *b.* basis; l^3. lobe from third joint; *ep.* epipod.

Fig. 3. *Glyptonotus sibiricus* Birula.

Fig. 3 a. Left maxillula, from below; × $^{14}/_{3}$. — Lettering as in fig. 2 a.

— 3 b. Left maxilla, from below; × $^{28}/_{3}$. — Lettering as in fig. 2 b.

— 3 c. Left maxilliped, from below; × $^{14}/_{3}$. — Lettering as in fig. 2 c. (The appendage is removed a little forwards and obliquely outward from the sternum in order to show the excavated articulation.)

Fig. 4. *Janira maculosa* Leach (Female).

Fig. 4 a. Left antenna, from below; × 11. — *4.* fourth joint of the peduncle; *ex.* exopod, squama. (Most of the flagellum omitted).

Fig. 5. *Ligia oceanica* Lin.

Fig. 5 a. Peduncle of left antenna, from above and a little from the outer side; scarcely × 3. — *1.* first joint; *3.* third joint; *ex.* exopod.

Fig. 6. *Munna acanthifera* H. J. H.

Fig. 6 a. Proximal half of left maxilliped, from below; × 52. — Lettering as in fig. 2 c.

Fig. 7. *Stenethrium* sp. (from near St. Jan, Virgin Isl.).

Fig. 7 a. Proximal part of left maxilliped, from below; × 39. — Lettering as in fig. 2 c.

Fig. 8. *Æga arctica* Lütken.

Fig. 8 a. Proximal half of first left pleopod, from in front;

$\times\ ^9/_2$. — *st.* sternite; *1 i.* plate of first joint, præcoxa, formed by the fusion in the median line of two chitinized pieces belonging to both left and right pleopod; *1 o.* major chitinized plate of first joint; *2 i.* small chitinized inner plate of second joint; *2 o.* large more outer transverse plate of second joint; *3.* third well chitinized joint; *en.* endopod; *ex.* exopod.

Fig. 9. *Arcturus Baffini* Sabine.

Fig. 9 a. Sympod with the proximal parts of the rami of first right pleopod of a female, from in front; $\times\ ^{15}/_2$. — *1—3.* the three joints in the sympod.

Fig. 10. *Gammarus Locusta* Linn.

Fig. 10 a. Peduncle and base of flagellum of left antenna, from the outer side; $\times\ ^{11}/_2$. — *1.* first joint; *2.* second joint; *4.* fourth rudimentary joint; *6.* sixth joint.

— 10 b. Proximal part of the same antenna; $\times$ 11. — Lettering as in fig. 10 a.

— 10 c. Left maxillula, from below; $\times\ ^{33}/_2$. — *en.* endopod; the other lettering as in fig. 2 a.

— 10 d. Left maxilla, from below; $\times\ ^{33}/_2$. — *2.* second joint, produced into a lobe; *3.* third joint.

— 10 e. Maxillipeds, from below; $\times$ 10. — *c.* coxa; *b.* basis, produced into a lobe, *l.*; *pi.* præischium, produced into a lobe; *i.* ischium; *m.* merus. (On the left side of the figure only the two proximal joints are rendered. Setæ omitted).

Fig. 11. *Anonyx nugax* Phipps.

Fig. 11 a. Left maxillula, from below; $\times\ ^{17}/_2$.

Fig. 12. *Euthemisto Libellula* Mandt.

Fig. 12 a. Left maxillula, from below; × 13. — Lettering as in fig. 2 a.

Fig. 13. *Vibilia Jangerardi* Lucas.

Fig. 13 a. Maxillipeds, from below; × 31. — *c.* coxa; *b.* basis; *l.* lobe from basis.

Fig. 14. *Bentheuphausia amblyops* G. O. Sars.

Fig. 14 a. Left maxillula, from below; × 21. — *1.* first joint; l^1. its lobe; *ps.* pseudexopod, overlapping a portion of first joint, the whole second joint, *2.*, much of third joint, *3.*, and most of the endopod, *en.*

— 14 b. Left maxilla, from below; × 16. — *1.* first joint; *2.* second joint, very short, with a large lobe; *3.* third joint with its bifid lobe; *ex.* exopod.

Fig. 15. *Thysanopoda egregia* H. J. H.

Fig. 15 a. Lower anterior part of the left lateral surface of the thorax with the proximal parts of the maxilliped and the two following legs, from the left side; × $^{13}/_{3}$. — *t.* thoracic tergite; *pc.* præcoxa; *c.* coxa; *b.* basis; *ep.* epipod (of the epipod of first leg its branchial part omitted); *ex.* exopod.

Plate VIII.

Fig. 1. *Meganyctiphanes norvegica* M. Sars.

Fig. 1 a. Left maxillula, from below; × 17. — *1.* first joint; l^1. its lobe; *2.* second joint, almost overlapped by the pseudexopod, *ps.*; *3.* third joint partly overlapped by the same plate; *en.* endopod.

— 1 b. The maxillula shown in fig. 1 a, but the pseudexopod is omitted in order to exhibit the joints. — *3.* third joint.

Fig. 1 c. Left maxilla, from below; $\times$ 17. — *1.* first joint; *2.* second joint; l^2. its lobe; *3.* third joint; *en.* endopod; *ex.* exopod.

Fig. 2. *Euphausia* sp. (Young stage).

Fig. 2 a. Left maxillula, from below; $\times$ 66. — The pseudexopod, *ps.*, which is still rather small, overlaps the exopod, *ex.*, not yet lost; *en.* endopod.

Fig. 3. *Thysanoëssa* (probably *T. inermis* Kr. in a *Calyptopis* stage).

Fig. 3 a. Left maxillula, from below; $\times$ 66. — Lettering as in fig. 1 a, but the exopod, *ex.*, is present, and the pseudexopod not yet developed.

Fig. 4. *Nephropsis atlantica* Norman.

Fig. 4 a. Left maxillula, from below; $\times$ 7. — *1.* first joint; l^1. its lobe; *m.* chitinized piece between lobe and joint; *ps.* pseudexopod, very small; *3.* third joint; *en.* endopod.

— 4 b. Left maxilla, from below; $\times$ $^{13}/_2$. — l^3. lobe from third joint; the other lettering as in fig. 1 c.

— 4 c. Left second walking leg, from behind; $\times$ $^7/_3$. — *c.* coxa; *b.* basis; *pi.* præischium; *i.* ischium; *m.* merus; *cp.* carpus; *pp.* propodus; *d.* dactylus.

— 4 d. Proximal part of the leg shown in fig. 4 c; $\times$ 4. — Lettering as in fig. 4 c.

Fig. 5. *Sergestes arcticus* Kr. (*Acanthosoma* stage).

Fig. 5 a. Left maxillula, from below; $\times$ 54. — Lettering as in fig. 3 a.

— 5 b. Left maxilla, from below; $\times$ 54. — Lettering as in fig. 4 b.

Fig. 6. *Chionoecetes Opilio* O. Fabr. (*Zoëa* stage).

Fig. 6 a. Left maxilla, from below; × 36. — Lettering as in fig. 1 c. (Only the base indicated of most marginal setæ on the exopod.)

Fig. 7. *Alpheus ruber* H. Milne-Edwards.

Fig. 7 a. Proximal joints of left third walking leg, from behind; × 4. — Lettering as in fig. 4 c.

Fig. 8. *Penæus caramote* Risso and *P. brasiliensis* Latr.

Fig. 8 a. Proximal joints of left fourth walking leg of *P. caramote*, from behind; × 3. — *ex.* exopod; the other lettering as in fig. 4 c.

— 8 b. Proximal joints of left third maxilliped of *P. brasiliensis*, from behind; × $^{13}/_{3}$. — Lettering as in figs. 4 c and 8 a.

Fig. 9. *Sicyonia sculpta* H. M.-Edw.

Fig. 9 a. Proximal half of left fourth walking leg, from behind; × $^{13}/_{3}$. — Lettering as in fig. 4 c.

Fig. 10. *Eupagurus Bernhardus* Lin.

Fig. 10 a. Proximal joints of left second walking leg, from behind; × $^{7}/_{3}$. — Lettering as in fig. 4 c.

Fig. 11. *Squilla nepa* Latr. and *S. mantis* Lin.

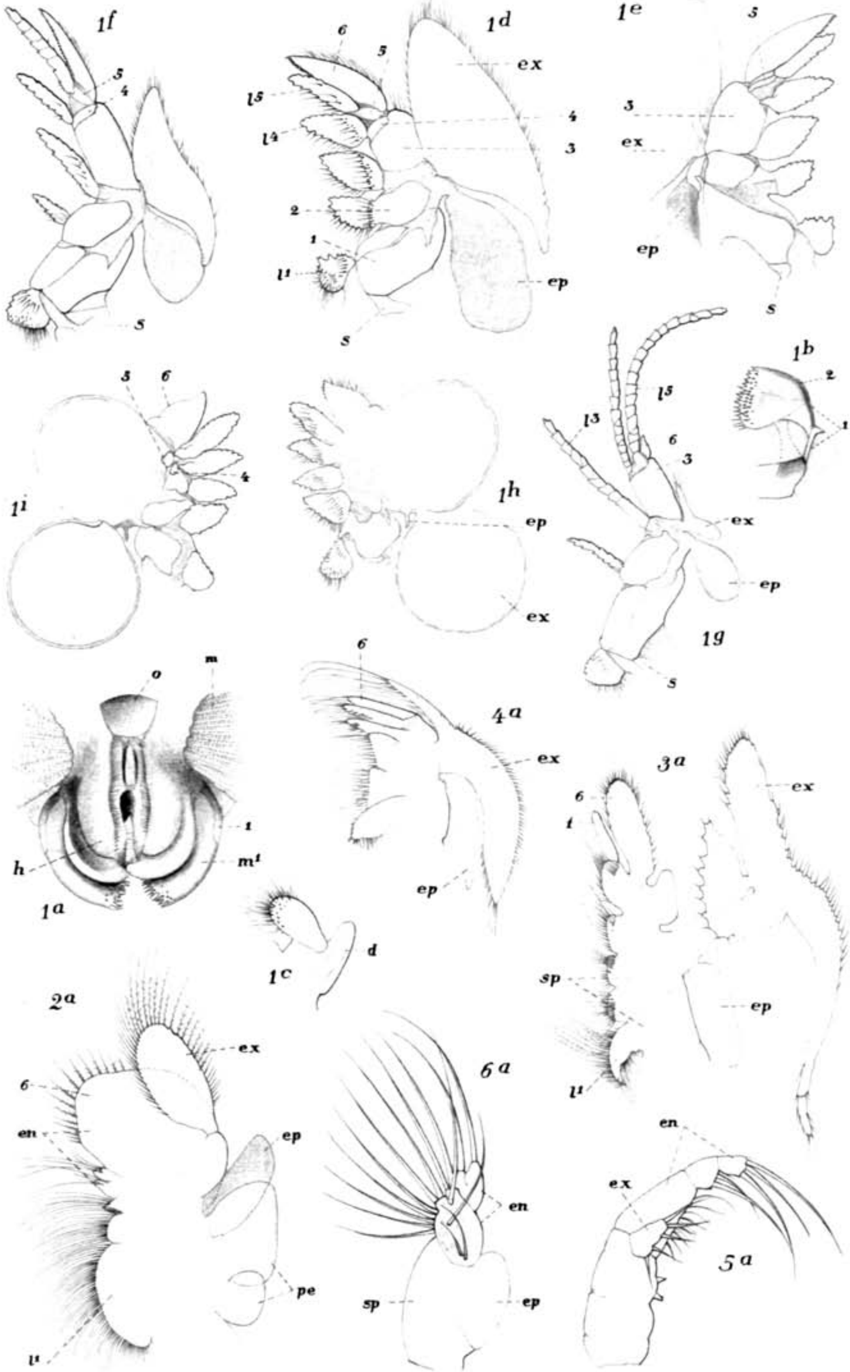
Fig. 11 a. Left maxillula of *S. nepa*, from behind; × 4. — l^1. lobe from first joint.

— 11 b. Left maxilla of *S. nepa*, from behind; × 4. — Lettering as in figs. 4 b and 1 c.

— 11 c. Left second thoracic leg of *S. mantis*, from the outer side; × 2. — *pc.* præcoxa; *pe.* præepipod; the other lettering as in fig. 4 c.

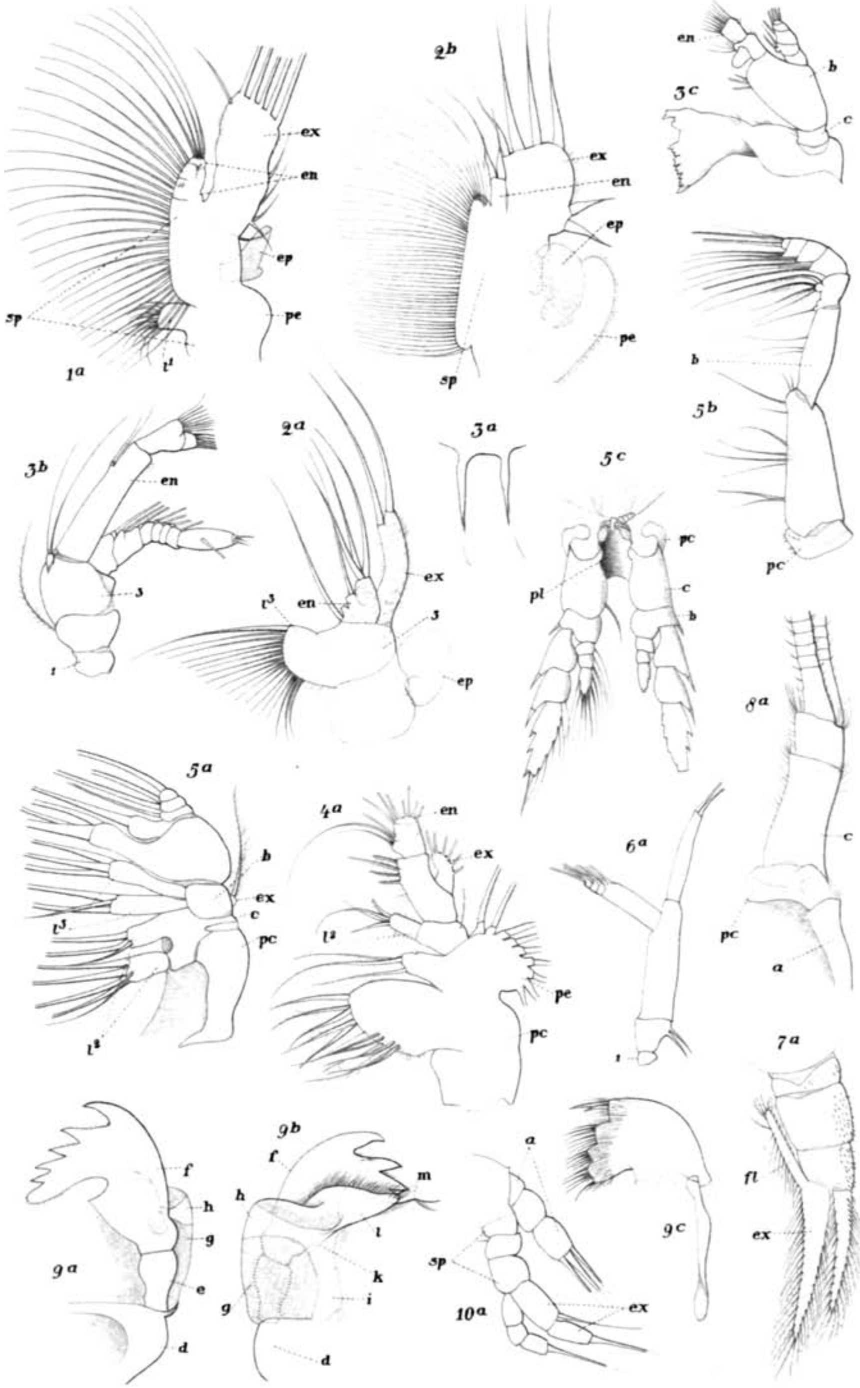
Fig. 12. *Lysiosquilla* sp. (Larva from the Bay of Bengal).

Fig. 12 a. The three anterior left legs, from the outer side; × 24. — *pc.* præcoxa; *c.* coxa; *b.* basis; *ex.* exopod. (Setæ on third leg and plumosity on the figured setæ omitted).



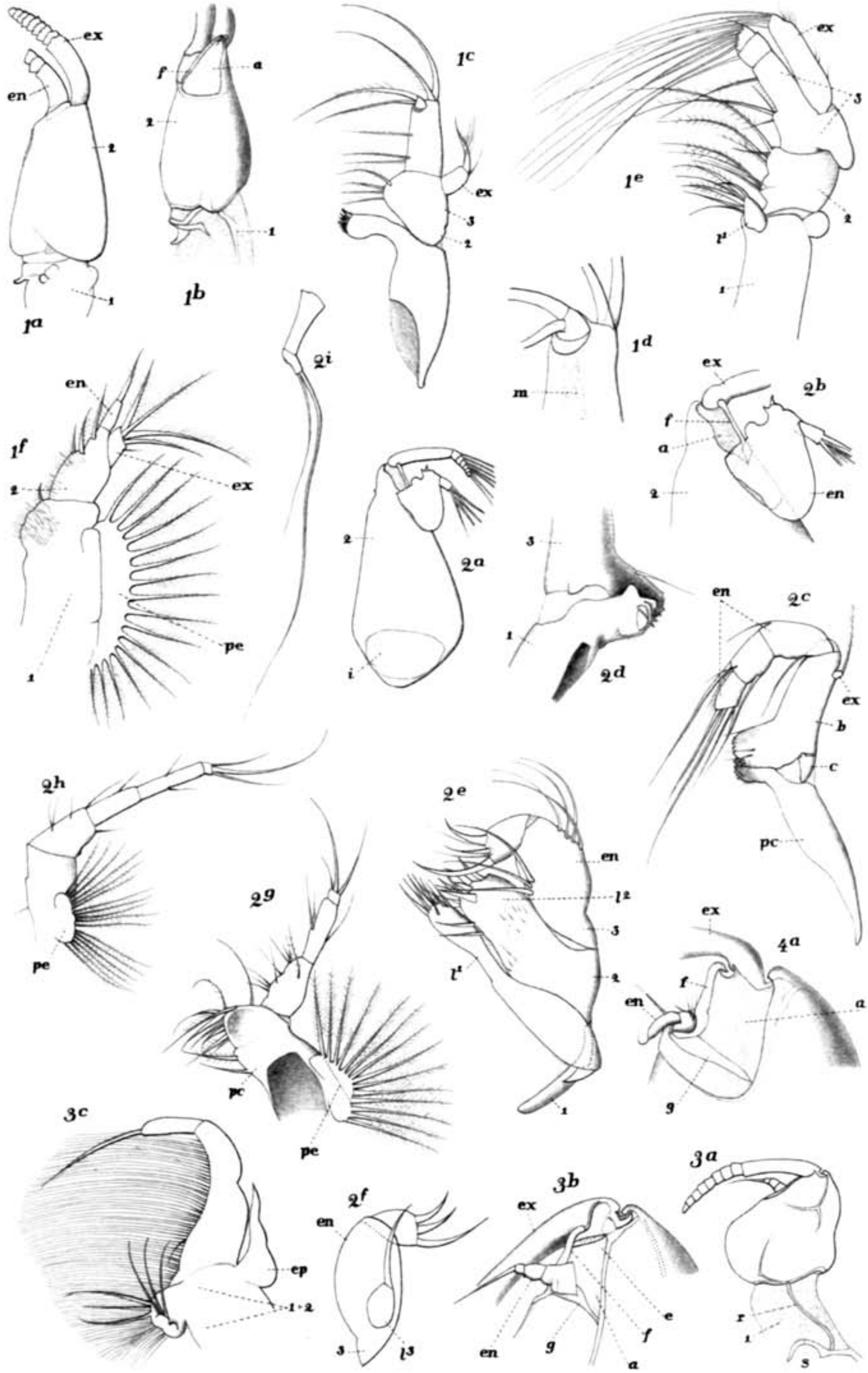
1. *Lepidurus.* 2. *Chirocephalus.* 3. *Leptestheria.* 4. *Limnetis.*
5. *Polyphemus.* 6. *Daphnia.*

H. J. Hansen del. J. Britze sc.



1. Sida. 2. Daphnia. 3. Calanus. 4. Calanella. 5. Megacalanus.
6. Setella. 7. Argulus. 8. Balanus. 9. Lepas. 10. Cypris-stage.

H. J. Hansen del. J. Britze sc.



1. Polycope. 2. Conchoecia. 3. Asterope. 4. Philomedes.

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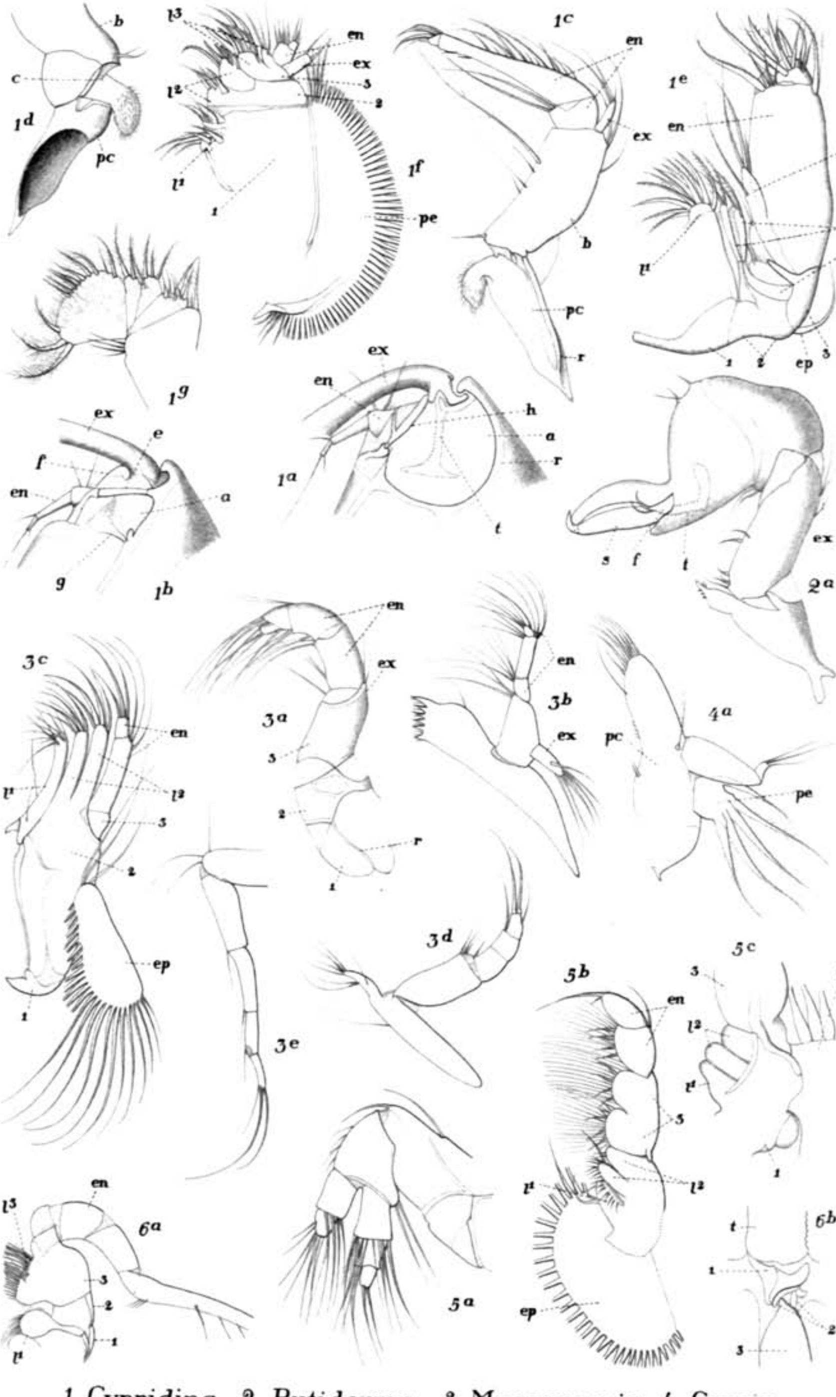
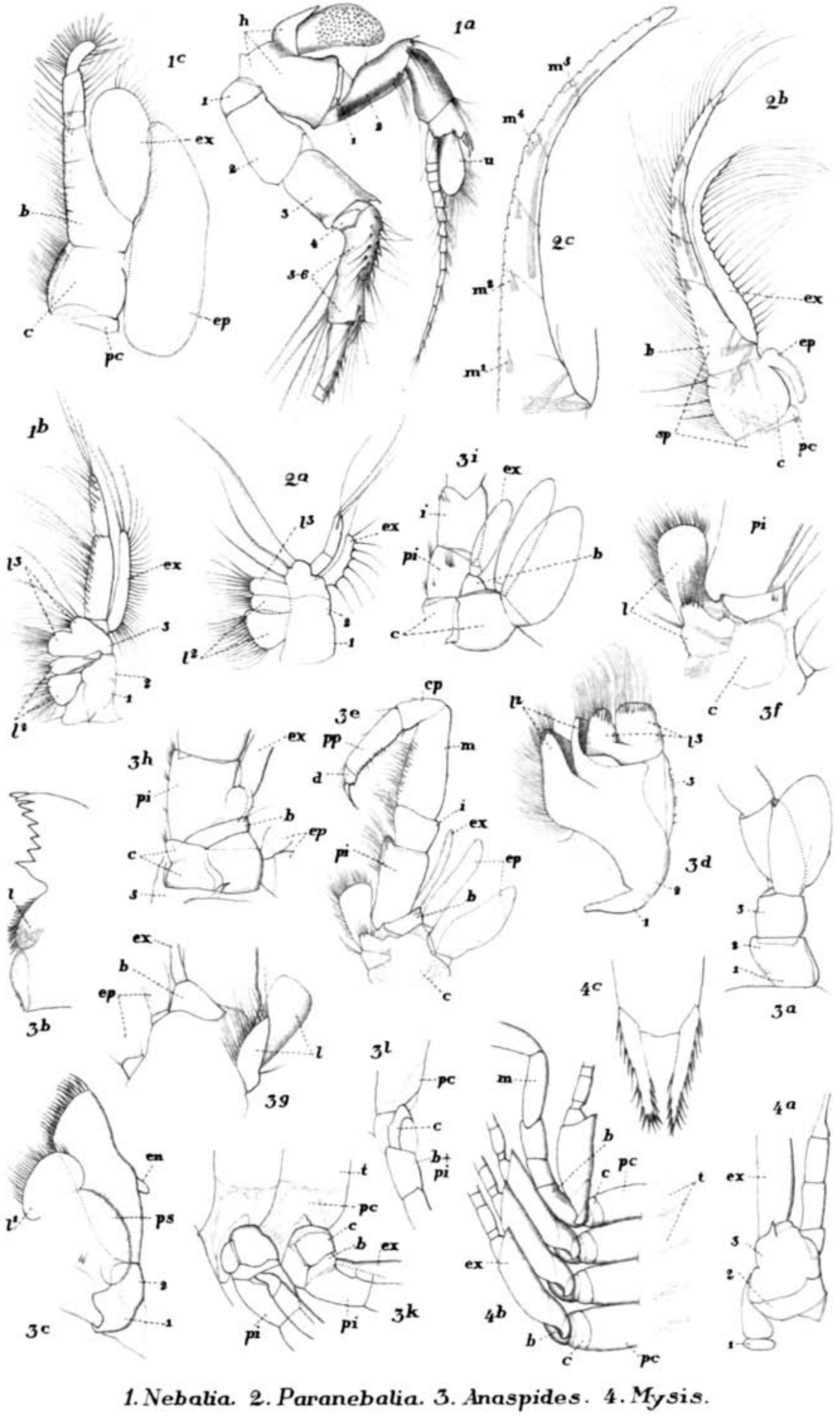


1. *Cypridina.* 2. *Rutiderma.* 3. *Macrocypris.* 4. *Cypris.*
5. *Cytherella.* 6. *Nebalia.*

H. J. Hansen del. J. Britze sc.



1. Nebalia. 2. Paranebalia. 3. Anaspides. 4. Mysis.

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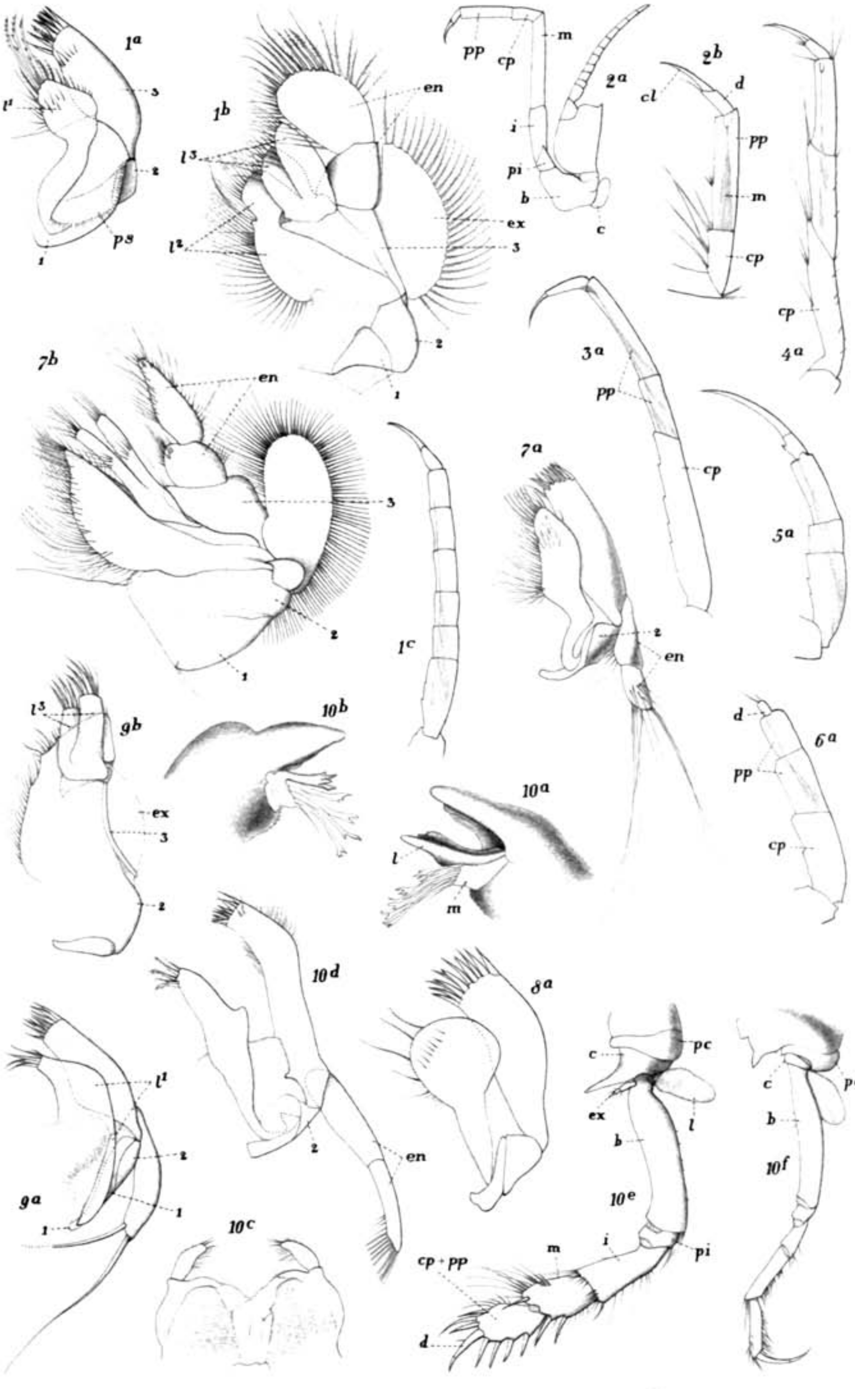

1. Mysis. 2. Siriella. 3. Boreomysis. 4. Amblyops. 5. Mysidopsis. 6. Anchialus. 7. Gnathophausia. 8. Lophogaster. 9. Diastylis. 10. Apseudes.

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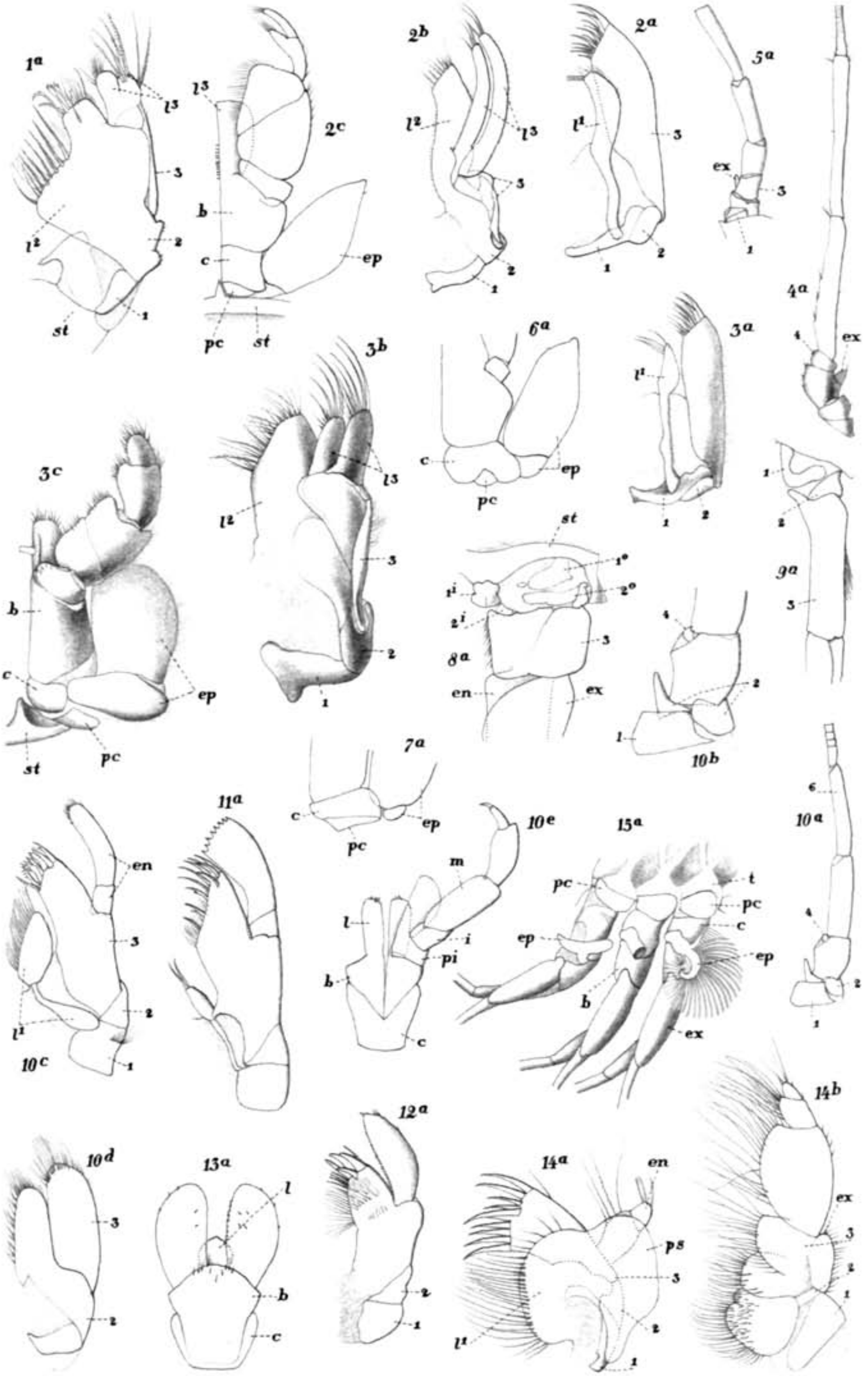

1. Apseudes. 2. Munnopsurus. 3. Glyptonotus. 4. Janira. 5. Ligia. 6. Munna. 7. Stenethrium. 8. Æga. 9. Arcturus. 10. Gammarus. 11. Anonyx. 12. Euthemisto. 13. Vibilia. 14. Bentheuphausia. 15. Thysanopoda.

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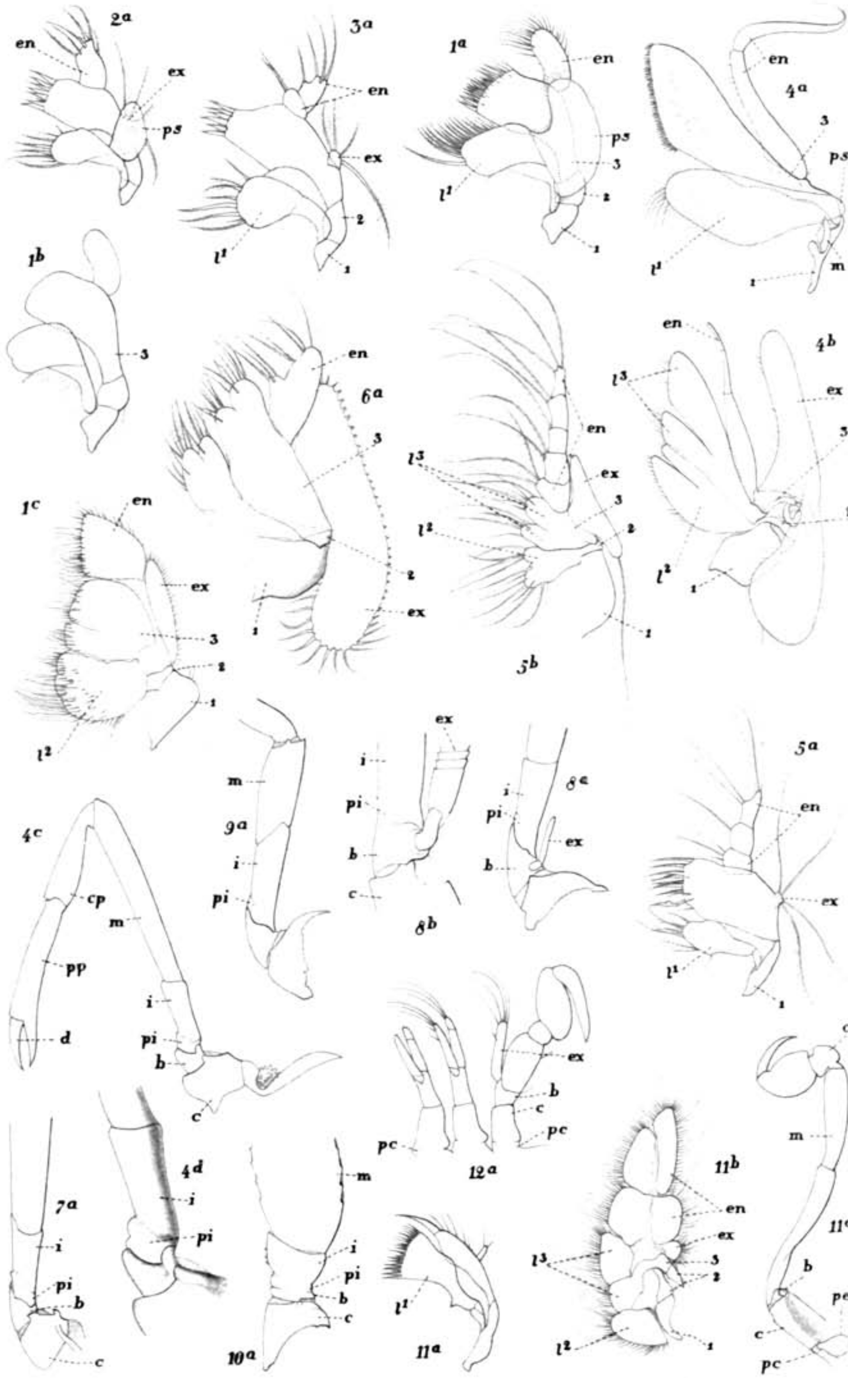

1. Meganyctiphanes. 2. Euphausia. 3. Thysanoessa. 4. Nephropsis.
5. Sergestes. 6. Chionoecetes. 7. Alpheus. 8. Penæus. 9. Sicyonia.
10. Eupagurus. 11. Squilla. 12. Lysiosquilla.

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