LAND CRUSTACEANS.

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I. Introduction.

In the economy of a coral island no group of animals is of greater importance, from the biological point of view, than the land Crustaceans. Their numbers, their ubiquity, their activity combine to give them a prominence, which is all the more marked from the absence of so many of the other land animals of continental areas. They are the chief scavengers of the island, play a great part in the destruction or disintegration of fruits, and probably aid in the distribution of seeds. The work done by them in burrowing along the sandy lagoon shore has a possible importance not hitherto noticed[1]. And it is likely that their omnivorous appetite renders them enemies of many animals, which cannot be specified in the present state of our knowledge: indeed it is highly improbable that the foregoing paragraph exhausts the list of instances in which their behaviour is a factor of importance in the economy of the island[2]. No study of a coral island, in fact, would be complete without an account of this constituent of its fauna.

For five weeks, in the months of June and July, 1899, I was with Mr Stanley Gardiner in the Atoll of Minikoi. During this time I gave considerable attention to the structure and habits of the land crustaceans of the island. My observations form the bulk of the present paper, but there is included a report on the forms collected by the expedition in the Maldives. In treating of Minikoi I shall begin with a short enumeration of the various species to be found there, and the situations in which they respectively live, and then pass on to some remarks on the structure and habits of the land hermit-crabs (*Coenobita*), and the habits of the true crabs of the genus *Ocypode*. The report on the Maldive collection ends the article.

In the section dealing with the genus *Coenobita* I have thought well to enter into some detail, and this for two reasons. First, that the peculiar habits of these animals give them an interest of their own, and thus lend an importance to the investigation of their anatomy, and secondly that, in spite of several excellent descriptions of separate systems of organs to be found in the series of elegant and accurate works on the comparative anatomy of the Decapods which we owe to various French observers, there is still need of an account of the organization of a hermit-crab. In that *Coenobita* presents the Pagurine type in its most highly developed form (at least as regards many of the organs), it is the most suitable genus for this purpose. In that it contains land animals only, and is not found in Europe or temperate North America, it is less so. I have endeavoured to overcome this difficulty by indicating, in the course of the article, those points in which, to my knowledge, *Coenobita* differs from the hermit-crabs of the sea (Paguridae). My dissections have been made on fresh and spirit specimens of the Minikoi species[3] only, and principally on *C. clypeatus* and *C. perlatus*, but, in the few cases where other information has been available, it has been used to check the dissections. Except in a few instances, the musculature has not been dealt with, and histological details have been entirely avoided.

The introduction to this paper would not be complete without an acknowledgment of the generosity of the Drapers' Company of London and of the Managers of the Balfour

[1] See below, p. 95.

[2] See *e.g.* Alcock, *Sci. Mem. Med. Off. Ind.*, XII, p. 59 (1901).

[3] See below, p. 68.

Memorial Fund, by which I was enabled to visit Ceylon and join Mr Stanley Gardiner's expedition, and to undertake, among other pieces of work, that which is here set forth. My best thanks are also due to Mr Stanley Gardiner for much kind advice and assistance, and to Mr Edwin Wilson for the care which he has bestowed upon the illustrations.

II. The Land Crustaceans of Minikoi.

1. General.

The dozen crustacean species living on land in the Island of Minikoi more than make up in number and activity for their comparative poverty in kinds. They are certainly the most conspicuous, as they are probably the most numerous, animals in the island. The Crabs are represented by six species only. Living in burrows, close along the high-water mark of the sandy shore of the lagoon, the sage-green and yellow coloured *Ocypode ceratophthalma* (Pallas) is very numerous. Inland, the place of this species is taken by the brownish *Ocypode cordimana* Desm., whose underground galleries are plentiful in the sandy soil, especially along paths and open spaces. Two species of *Geograpsus*—*G. grayi* (H. M.-Edw.) and *G. crinipes* (Dana)—are common, the former more so than the latter, which seems to like damp spots by the side of pools and tanks of fresh water for which *G. grayi* shows no great preference. These active and conspicuous species, though they are rather hard to distinguish as spirit specimens, are perfectly distinct in life, their colour alone serving to separate them, were there no other differences. *G. grayi* gives the impression of being black and white (in point of fact the back is purple and the legs and underside yellowish), while *G. crinipes* is of a bright orange colour[1].

Another small Grapsid belongs to Kingsley's subgenus *Orthograpsus*[2], which is included by Alcock[3] in the genus *Geograpsus*, Stimps. Unfortunately, a part of the Minikoi collection was damaged on the way home, and there are left of this crab only two badly mangled specimens. So far as can be seen from these, it is near to, but not the same as, Dana's *Grapsus longitarsis*[4]. The points in which the two forms differ are as follows (fig. 12):—1. In the Minikoi specimens the teeth on the underside of the outer end of the meropodites of the walking legs are low and blunt, and much less marked than in Dana's figure. 2. The same is the case with the tooth at the end of the upper edge of this joint. 3. The hairy line along the dactylopodites of the walking legs is wanting. 4. The tooth at the outer angle of the orbit is shorter than in *G. longitarsis*. It shields only about a fourth of the cornea, instead of more than a half, as in Dana's figure. The colour of the crab when alive is a dull brownish-green, and is not much altered by preservation in spirit. The length is about half an inch.

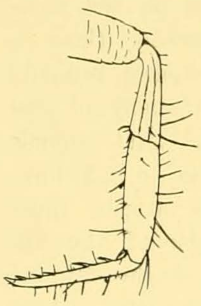


Fig. 12. Second walking leg of right side of *Geograpsus longitarsis*, var. *minikoiensis*.

In the absence of better material, I am unwilling to give any opinion as to the specific distinctness of this little crab. In the list below[5], it will appear as a variety (*minikoiensis*) of Dana's species.

The last of the crabs, the little *Metasesarma rousseauxi* H. M.-Edw., is

[1] For a careful discussion of the differences between these species, see De Man, *Zool. Jahrb. Syst.* IX. pp. 80 ff. (1895).

[2] Kingsley, *P. Acad. Philad.* 1880, pp. 180, 194 (1880).

[3] Alcock, *Journ. As. Soc. Bengal*, LXIX. ii. 3, p. 394 (1900).

[4] For references to literature see below, p. 68.

[5] p. 67.

found in various situations, generally taking advantage of the shelter of some object. It often hides under timber, where, as Dr Alcock remarks[1], its greenish mottled coloration is protective. De Man records[2] some examples of this species from a stream in Flores, but it is certainly not restricted to the water, nor even to particularly damp spots. With the exception of *Geograpsus longitarsis*, all the above crabs are included by Major Alcock among the Indian Fauna[3].

The land hermit-crabs (genus *Coenobita*) are no less numerous than the true crabs on Minikoi. Three species are found—*C. perlatus* H. M.-Edw., *C. rugosus* H. M.-Edw. and *C. clypeatus* Latr. Of these the first two show a preference for the neighbourhood of salt water, while the third is chiefly to be found in the jungle. I shall return, later on, to the subject of the genus *Coenobita*.

Three species of Isopod make up the tale of Minikoi land Crustaceans to twelve. Two woodlice, belonging respectively to the genera *Cubaris* and *Philoscia*, are found, as might be expected, in rotten timber and loose earth, while a *Ligia* (*L. exotica* Roux) lives in certain localities along the lagoon shore, and is chiefly conspicuous in running about on boats drawn up on the beach.

The following is a complete systematic list of the land Crustacea of Minikoi:—

DECAPODA, BRACHYURA, CATOMETOPA.

Family **Ocypodidae**. Genus *Ocypode*, Fabr., 1798[4].

1. *Ocypode ceratophthalma* (Pallas), 1772.
   Cancer ceratophthalmus, Pallas, Spicilegia Zool. IX. p. 83, pl. V. figs. 7, 8 (1772).
   Ocypoda ceratophthalma, Ortmann, Zool. Jahrb. Syst. X. p. 365 (1897) [synonyms]; Alcock, Journ. As. Soc. Bengal LXIX. ii. 3, p. 345 (1900).

2. *Ocypode cordimana* Desm., 1825.
   Ocypoda cordimana, Desmarest, Consid. gen. Crust. p. 121 (1825); Ortmann, Zool. Jahrb. Syst. X. p. 362 (1897) [synonyms]; Alcock, Journ. As. Soc. Bengal LXIX. ii. 3, p. 349 (1900).

Family **Grapsidae**. Genus *Geograpsus*, Stimps., 1858.

3. *Geograpsus grayi* (H. M.-Edw.), 1853.
   Grapsus grayi, H. Milne-Edwards, Ann. Sci. Nat. Zool. (3) XX. p. 170 (1853).
   Geograpsus grayi, Alcock, Journ. As. Soc. Bengal LXIX. ii. 3, p. 395 (1900) [synonyms].

4. *Geograpsus crinipes* (Dana), 1851.
   Grapsus crinipes, Dana, Proc. Ac. Philad. 1851, p. 101.
   Geograpsus crinipes, Alcock, Journ. As. Soc. Bengal LXIX. ii. 3, p. 396 [synonyms].

[1] Alcock, *op. cit.*, p. 428.
[2] De Man, Max Weber's "Reise O. I." II. p. 350 (1892).
[3] Alcock, *op. cit.*, *passim.*
[4] Ortmann [*Zool. Jahrb. Syst.* X. p. 359 (1897)] states that Fabricius spelt this name *Ocypoda*. In the copies of the *Ent. Syst. Suppl.* in the Cambridge University and Zoological Society's libraries the spelling is *Ocypode*.

5. *Geograpsus longitarsis* (Dana), 1851, var. *minikoiensis* n. (fig. 12).
Grapsus longitarsis, Dana, Proc. Ac. Philad. 1851, p. 249; U.S. Expl. Expd. Crust. I. p. 339, pl. XXI. fig. 4 (1852).
Orthograpsus longitarsis, Kingsley, Proc. Ac. Philad. 1880, p. 195.

Genus *Metasesarma*, H. M.-Edw., 1853.

6. *Metasesarma rousseauxi* H. M.-Edw., 1853.
Metasesarma rousseauxi, H. Milne-Edwards, Ann. Sci. Nat., Zool. (3) XX. p. 188 (1853); De Man, Zool. Jahrb. IX. Syst. p. 138 (1895); Alcock, Journ. As. Soc. Bengal, LXIX. ii. 3, p. 427 (1900).

ANOMALA, PAGURINEA.

Family **Coenobitidae.** Genus *Coenobita*, Latr., 1826.

7. *Coenobita perlatus* H. M.-Edw., 1837.
Cenobita perlata, H. Milne-Edwards, Hist. Nat. Crust. II. p. 242 (1837); Id. Atlas to Crust. Cuvier's R. An. pl. XLIV. fig. 1.
Cenobita perlatus, Ortmann, Zool. Jahrb. Syst. VI. p. 319 (1892) [synonyms].

8. *Coenobita rugosus* H. M.-Edw., 1837.
Cenobita rugosa, H. Milne-Edwards, Hist. Nat. Crust. II. p. 241 (1837).
Coenbita rugosus, Ortmann, Zool. Jahrb. Syst. VI. p. 317, pl. XII. fig. 22 (1892) [synonyms].

9. *Coenobita clypeatus* Latr., 1826. (Fig. 13.)
Coenobita clypeata, Latreille, Fam. Nat. R. An. p. 277 (1826).
Coenobita clypeatus, Ortmann, Zool. Jahrb. Syst. VI. p. 315, pl. XII. fig. 20 (1892) [synonyms].

ISOPODA, ONISCOIDEA.

Family **Armadillidiidae.** Genus *Cubaris*, Brandt, 1833.

10. *Cubaris murinus* Brandt, 1833.
Cubaris murinus, Brandt, Consp. Onisc., Bull. Soc. Nat. Mosc. VI. p. 190 (1833).
Armadillo murinus, Budde-Lund, Crust. Isop. Terrestr. p. 27. Hauniae, 1885 [synonyms].

Genus *Philoscia*, Latr., 1803.

11. *Philoscia*, sp.
Near *P. gracilis* Budde-Lund, 1879, but cannot be more accurately determined, as the single specimen now available for examination is in a somewhat damaged condition, and has lost both uropods.

Family **Ligiidae.** Genus *Ligia*, Fabr., 1798.

12. *Ligia exotica* Roux, 1828.
Ligia exotica, Roux, Crust. Médit. 3, pl. XIII. fig. 3 (1828); Budde-Lund, Crust. Isop. Terrestr. p. 266. Hauniae, 1885 [synonyms].

2. Some points in the structure and habits of the land hermit-crabs (*Coenobita*).

i. **External features.**

The genus *Coenobita* contains those hermit-crabs which have left the sea and taken to a life on land, but have not, like *Birgus*, lost the habit of shielding the abdomen with a shell, or some such covering. In their outer, as in their inner organisation, the members of the genus closely resemble the hermit-crabs of the sea, and even present many

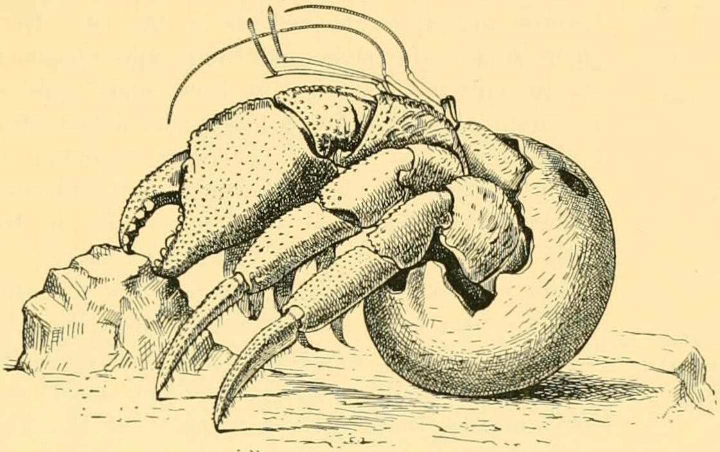


Fig. 13. *Coenobita clypeatus* using a broken coconut as shell.

characteristic features of Pagurine[1] structure in a more highly developed form than any other branch of the group. The most striking of these features are, of course, those connected with the habit of sheltering within the empty shell of a gastropod mollusk, and it is perhaps worth while recapitulating them, even at the risk of ploughing the sands of well-known fact.

Physiologically, then, the body may be divided into three regions as regards its outward aspect: (1) a *fore-part* carrying the complex of organs—sensory structures, legs and jaws—by which the animal enters into relation with the outer world, and containing internally the central nervous system and stomach, both intimately connected with the external organs just mentioned, and the excretory organs. This part of the body can be completely extruded from the shell, while the animal still retains a firm hold on the latter. (2) A *mid-part*, which, when the fore-part is thrust out, fills the mouth of the shell, and is provided with limbs, which help in retaining a grasp of it. This region carries the main respiratory apparatus—delicate organs which need a certain amount of protection and yet should be in free communication with the surrounding medium—and the heart. (3) A *hind-part*—the abdomen—which contains the bulky liver and the generative organs, and carries on its appendages the eggs, which thus obtain the shelter provided by the shell. This division of the body, which is at all times completely protected by the shell, is also provided with an apparatus by means of which, in normal circumstances, the latter is retained. This apparatus consists of an anchor, formed by the sixth abdominal segment and its appendages (fig. 18), and a broad band of muscle—the cable of the anchor—along the ventral side of the abdomen, serving roughly the same purpose as the columella muscle of the original maker of the shell.

[1] In the present article, the term "Pagurine" will be used to include the most typical members of the Pagurinea—the Paguridae and the Coenobitidae. The word "Pagurid" will be applied to the former of the two families alone.

The *fore-part of the cephalothorax* is strongly compressed, having a narrow, vaulted roof and flat vertical sides. Its compression extends also to the antennae and the first three pairs of legs, enabling the whole complex, including the limbs, to be withdrawn into shelter when necessary. The absence of the rostrum is, no doubt, an adaptation to the same end. The cuticle over the whole of these exposed structures is strongly calcified.

The *eyestalks* are narrow and elongated and directed straight forwards above the antennules; the eyes themselves are small. Some rather abnormal features appear in the *antennules* (fig. 14). By the lengthening of their joints, the stalks of these appendages far outreach those of the antennae, bearing at their ends each a long and a short flagellum, the whole being able to be folded up lengthwise and concealed under the body. The long flagellum, which is the more dorsal of the two, is compressed and club-shaped, with a blunt, rounded end. Its lower edge is covered, in the distal two-thirds, with a close fur of short "olfactory" hairs[1]. The short flagellum tapers at the end, and bears on the penultimate joint a long bristle, which looks as if it were adapted for cleaning the olfactory hairs of the long flagellum. The opening of the otocyst is small, but situated in its usual position on the dorsal side of the basal joint of this limb. The antennules of the Pagurids (fig. 14), on the other hand, are relatively short, and bear each two short flagella, like those of the crabs. The dorsal (outer) flagellum tapers to a point and bears below a fringe of olfactory hairs much longer than those of *Coenobita*. These peculiarities of *Coenobita* are perhaps in connection with the habit of exercising the sense of smell in the search for food[2], and that in a different medium from the one in which the Paguridae live, while at the same time it is necessary that the organs be able to be withdrawn into a small space.

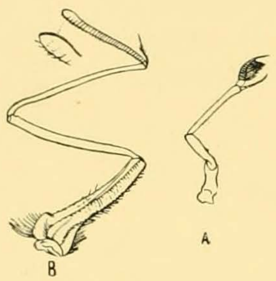


FIG. 14. Left Antennules. A. *Eupagurus bernhardus*; B. *Coenobita clypeatus*.

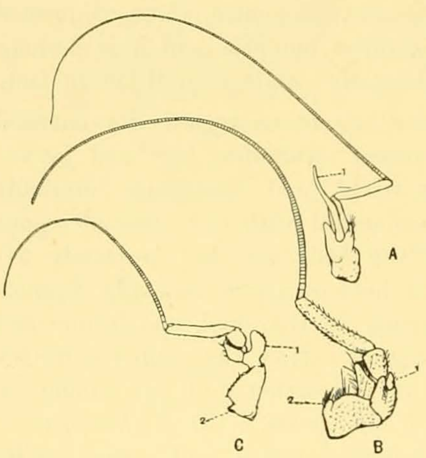


FIG. 15. Left Antennae. A. *Eupagurus bernhardus*; B. *Coenobita clypeatus*; C. *Coenobita perlatus*. 1. Antennal scale. 2. Tubercle with opening of green gland (not seen in A).

The scale of the *antenna* (fig. 15), which in the Pagurids is well developed and moveable, is, in *Coenobita*, reduced in size and, except in one instance[3], fused with the second joint of the flattened stalk of the limb. The flagellum ends bluntly instead of tapering to a point like those of most marine Decapods—a feature, which must probably be attributed to the same cause, which has shortened the sensory hairs of the antennule. The *mouth-limbs* (fig. 16) present no remarkable features. They are all stout and show a tendency to develope tufts and fringes of strong, close set, hairs. The powerful cutting edge of the mandible is not toothed, and the lash of the exopodite of the first maxilliped is wanting.

[1] The statement of Ortmann [Bronn's *Thierreich*, v. 2, p. 1146] that these appendages "langen Sinneshaare entbehren" is thus somewhat misleading, though strictly true. The shortness of the hairs, which would be apt to become matted in the absence of a supporting medium such as water, is no doubt an adaptation to terrestrial life.

[2] See below, p. 92.

[3] *C. clypeatus*, Latr.

The *legs* (figs. 13 and 17) of the first pair are unequal, though both are chelate. The larger, left chela, used for seizing and holding the food and as a weapon of offence and defence, serves, when the animal is withdrawn into the shell, as a very perfect lid or operculum, for which purpose its stout, rounded shape is clearly adapted. It may also (*C. rugosus* A, fig. 17) bear a stridulating organ in the form of a series of parallel ridges on its outer surface. The smaller chela is used for tearing the food and conveying the fragments to the mouth. The second and third pairs of legs are adapted for walking.

The *hinder part of the thorax*, forming the middle of the three regions alluded to above, may be said to begin at the level of the transverse portion of the cervical groove and to include the two hinder pairs of legs. It is distinguished from the preceding region by

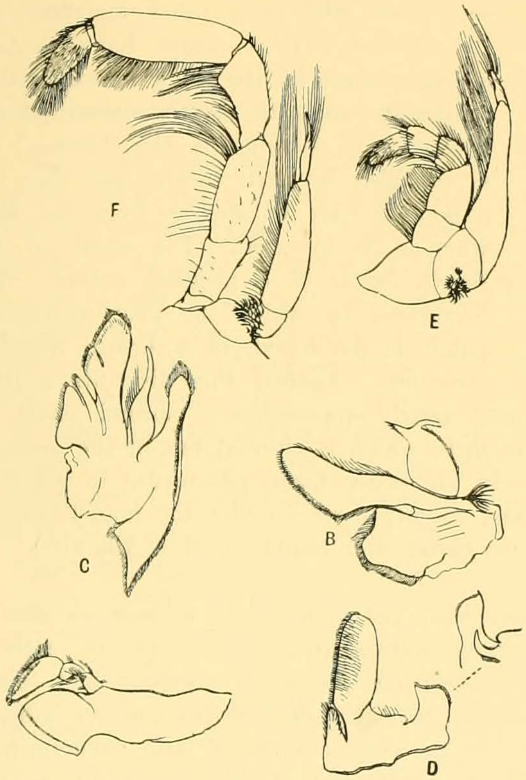


Fig. 16. Mouth-limbs of the left side of *Coenobita clypeatus* from behind. A. Mandible; B. 1st maxilla; C. 2nd maxilla; D. 1st maxilliped; E. 2nd maxilliped; F. 3rd maxilliped. A small portion of the anterior side of D is attached to show the endopodite.

In *Pagurus* the maxillipeds bear on their exopodites long, slender, curved lashes, fringed with fine hairs and much resembling those of many crabs. The absence of these structures in *Coenobita* is perhaps due to the loss of their functions in the absence of water. The little backward hook on the first maxilla is wanting in *Pagurus*.

being rather depressed than compressed and by less strong calcification of its integument. The branchiostegites, which anteriorly share in the general compression and calcification of the body, are here soft and tend to be depressed. But the legs of the fourth pair are carried pressed up against the sides of the body in such a way that the soft branchiostegites are indented by them and only project dorsally and posteriorly where they overhang the limbs in question. Behind, the branchiostegites gape widely from the body, and leave an opening, through which the legs of the fifth pair can be thrust into the gill chamber.

The *fourth and fifth legs* (B—E, fig. 17) of each side are markedly smaller than the preceding ones. Each of them is chelate after its own fashion, and each bears a part in the work of holding the animal into its shell. This is accomplished by means of a definite patch on the propodite of the limb, which is covered with a fine sculpture in the form of rounded scales, overlapping one another so as to produce a surface capable of friction. In cases, which often occur, when the animal, either from its size, or from the lack of suitable gastropod shells, is forced to content itself with some other receptacle for its abdomen[1], these limbs have to take a larger share of the work in which they ordinarily assist the sixth abdominal appendages, of keeping on the "house." It is probably by their means also that the animal is able to emerge from the shell when it is inverted. The chela of the *fourth leg* is of a peculiar nature. The propodite, on which the above-mentioned patch is developed, is a broad, discoidal structure. Against this disk fits a little sickle-shaped dactyle. In *Pagurus* the limb more nearly approaches a normal chela, in *Eupagurus* it is sub-chelate. The *fifth leg* has a chela which is clumsy, but of the ordinary shape, with two approximately equal fingers. As in the other forms (Anomala) in which it is a gill-cleaning organ, it is covered with hairs and usually carried under the branchiostegite during life, though upon occasion it can be used to assist in retaining hold of the shell.

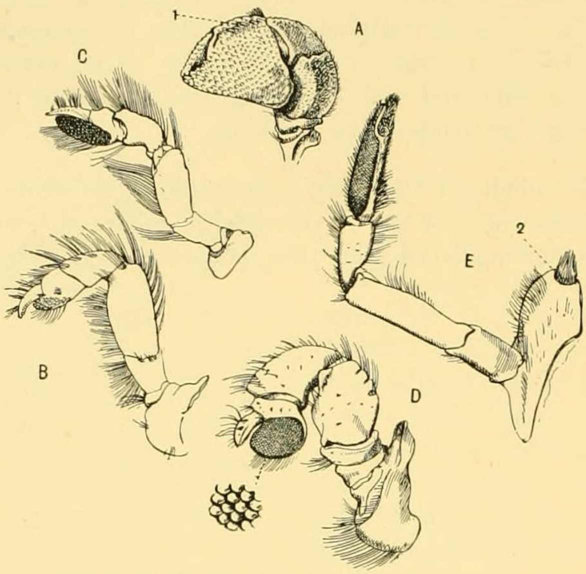


FIG. 17. Legs of hermit-crabs from left side. A. 1st leg (cheliped), *Coenobita rugosus*; B. 4th leg, *Eupagurus bernhardus*; C. 4th leg, *Pagurus deformis*; D. 4th leg, *Coenobita clypeatus*; E. 5th leg, *Coenobita clypeatus*. 1. Stridulating organ. 2. Male generative opening.

The *abdomen* is connected by a narrow waist with the thorax. It is covered with a soft, flexible skin, save for a narrow transverse ridge representing the tergite of each of the first five abdominal segments, and broader plates on the sixth segment and telson. The whole is spirally twisted to the right, to fit in with the dextral twist of an ordinary gastropod shell. In correspondence with this twist, the appendages are also asymmetrical. In the male they are absent from the first five segments[2], but in the female the second, third and fourth are provided, on the left side with long, biramous limbs, covered with hairs and used in the breeding season for carrying the eggs. The sixth pair of abdominal limbs (fig. 18) are present in both sexes, but that of the right side is larger than that of the left. The exopodite is sickle-shaped and longer than the endopodite; both are provided, on the outer surface, with friction organs like those of the last two thoracic legs, and the function of the whole limb is obviously to anchor the animal into its shell.

[1] *e.g.* the shell of the fruit of *Calophyllum* or of the coconut. See p. 92.

[2] *C. clypeatus* has short, uniramous limbs on the left side in the 2nd, 3rd and 4th abdominal segments of the male.

The family Coenobitidae, containing besides *Coenobita* the Robber-Crab *Birgus*, differs from the Pagurids, or hermit-crabs of the sea[1], in the following external features:—1. The

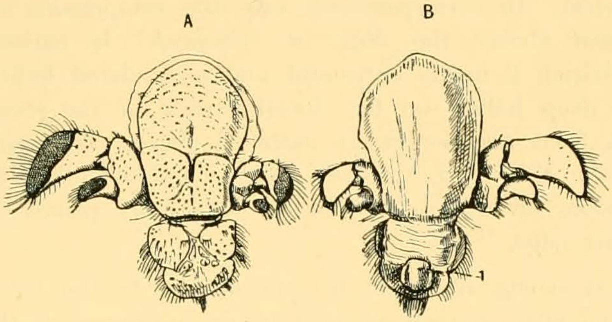


FIG. 18. Last two abdominal segments of *Coenobita clypeatus*. A. Dorsal view; B. Ventral view. 1. Valve guarding the anus.

structure of the antennules (*see above*). 2. The structure of the antennae (*see above*). 3. The greater compression of the fore-part of the body. 4. The habitat—on land.

The genus *Coenobita* differs from *Birgus* in the form of the abdomen, which in *Birgus* is short, untwisted, provided with broad terga, and not carried in a shell. The points in which the outward features of *Coenobita* vary from species to species are small and unimportant. The most interesting is perhaps that which separates *C. clypeatus* Latr. from the rest of the genus. In this species the vestige of the antennal scale is still loosely articulated with the stalk. In all the others it is fused. *C. diogenes* (Catesby) is distinguished by its cylindrical eyestalks from the other species, in which these structures are always compressed. Of the remaining four forms, *C. rugosus* H. M.-Edw. and *C. perlatus* H. M.-Edw. are distinguished from *C. compressus* Guérin and *C. spinosus* H. M.-Edw. by the elongation of the basal joint of the fifth leg of the male into a genital process, and by the presence of stridulating ridges on the outside of the hand (propodite). The small grey or purple *C. rugosus* is very variable (Bouvier[2] enumerates several varieties), but may be easily distinguished from the larger, scarlet, *C. perlatus* by the greater development in the latter of the genital process. *C. compressus* is recognisable by its small size, grey, or purple colour and less hairy integument from *C. spinosus*, which is larger, of a brown colour, and considerably hairy in parts. The last revision—and the one adopted in this paper—is to be found in Ortmann's well-known work on the Decapods of the Strassburg Museum[3]. It differs in several points from that of Bouvier[4], but has the merits of simplicity and clearness, and has satisfactorily accounted, so far, for every one out of the many specimens that have passed through my hands.

The distribution of the genus would appear, from the data in Ortmann's paper and others since published, to be as follows:—*C. diogenes* is found in the West Indian region alone, and is the only representative of the genus there. The other species are all restricted to the Indo-Pacific area, but are there of almost universal distribution, *C. rugosus* being perhaps the most widespread.

[1] See footnote to p. 69 above.

[2] Bouvier, *Bull. Soc. Philem.*, Paris, (8), II. p. 143 (1890).

[3] Ortmann, *Zool. Jahrb. Syst.*, VI. p. 315 (1892).

[4] Bouvier, *loc. cit.*

ii. **The Alimentary Canal.**

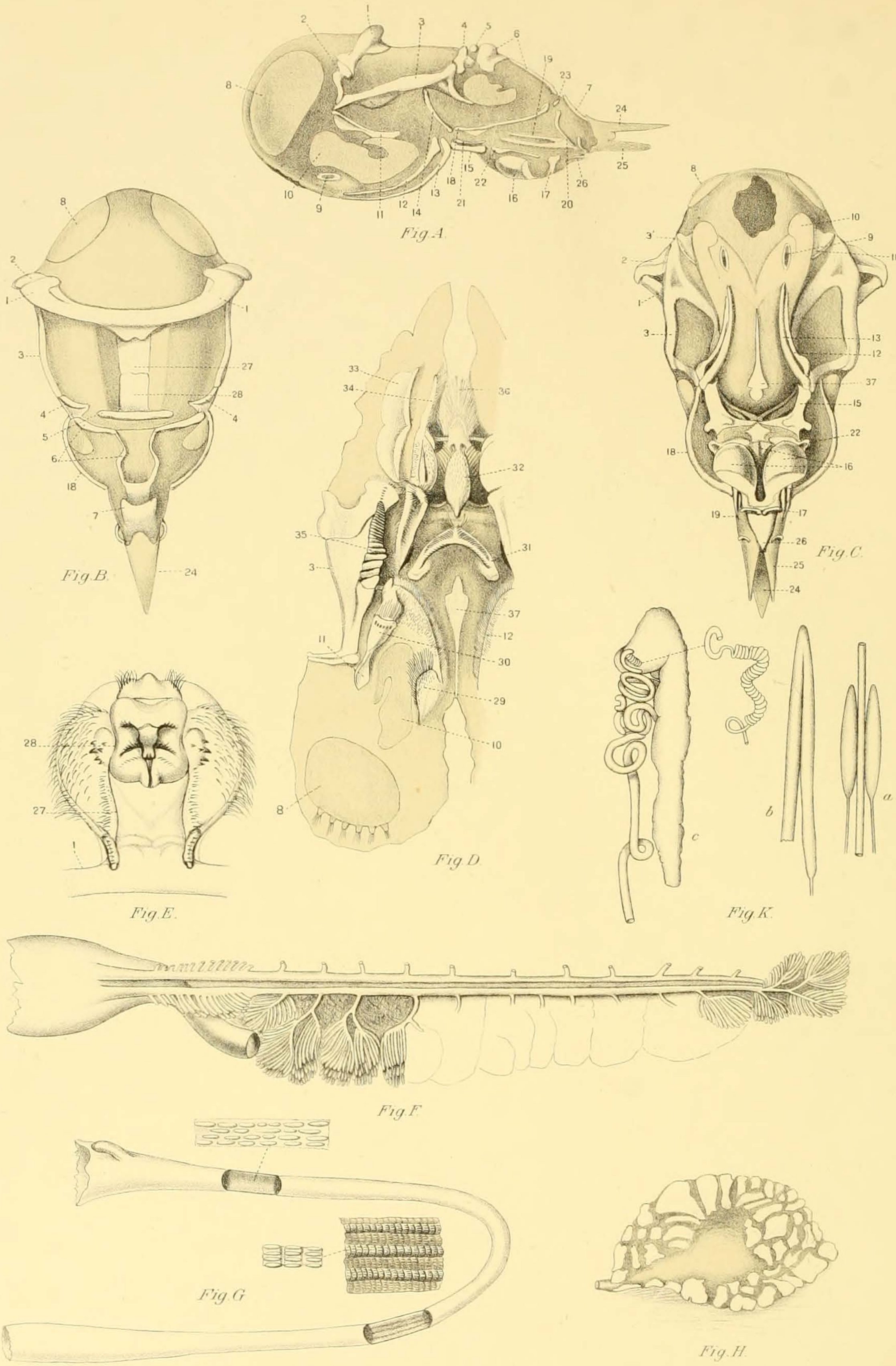
A. The Fore-gut[1]. (Pl. III. figs. A—E). The short, wide *oesophagus* presents no feature of special interest. In correspondence with the compression of the fore-part of the cephalothorax mentioned above[2], the *Maw* or "*Stomach*" is narrow and elongated. The hinder or "pyloric" division is nearly horizontal, and is sundered from the anterior "cardiac" portion by the usual deep hollow on the dorsal surface of the stomach. The *cardiac sac* is narrow, rounded in front and somewhat flattened above. The walls of its thin fore-part show on each side the thickened "cardiac disk" found in other Pagurinea (8, Pl. III.). Internally, this disk bears seven or eight tufts of long hairs, placed on pointed prominences arranged along its lower edge.

The *gastric mill* is strong, no doubt in connection with the nature of the food, which is chiefly vegetable, and often consists of such tough substances as the fruits of the screw-pine (*Pandanus*). In the *mesocardiac ossicle* (1, Pl. III.), the most prominent part is a strong band across the roof of the cardiac division of the stomach, bent in the form of a bow, and lying with the hollowed side forward; its ends are broadened. In front of this is a thinner portion, which merges gradually into the thin wall of the fore-part of the stomach. Behind the ossicle the roof of the stomach falls away into the hollow between the two divisions. The rounded hinder edge of the bow projects somewhat over this gap, and overhangs a wide, triangular process from its own underside, which forms part of the hind wall of the cardiac portion—the anterior wall of the hollow. The apex of this triangular plate, by which it joins the fore end of the urocardiac ossicle, is not pointed, but ends in two rounded lobes, of a bright white colour and strongly calcified. The *pterocardiac ossicles* (2, Pl. III.) are triangular or rather three-lobed structures in the side wall of the cardiac division, at the outer ends of the bow of the mesocardiac. One lobe is directed outwards, one inwards, and one downwards. Between the outward and the inward lobes lies that edge of the ossicle which articulates with the broadened outer end of the mesocardiac bow. The *zygocardiac ossicles* (3, Pl. III.[3]) also lie in the side walls of the stomach, but behind the mesocardiac. Each is a roughly diamond-shaped plate of large size, placed so that its longer diagonal runs fore and aft. There are thus an anterior and a hinder angle. The latter is directed somewhat downwards, so that, of the two edges of the diamond which are uppermost, the hinder slopes downwards, while the more anterior is almost horizontal. This latter edge is much thickened and curled inwards, towards the cavity of the stomach. The other edges are also thickened, though not to the same extent. The *lateral tooth* (35, Pl. III.), borne internally by the zygocardiac ossicle of each side, is strong, and bears a series of transverse ridges which grow smaller from before backwards. The first three or four of these are much larger than the hinder ones, and are set farther apart.

[1] In writing the following account of the fore-gut and its armature in *Coenobita*, I have been much helped by Mocquard's work on these organs of the Decapoda [*Ann. Sci. Nat.* (6) *Zool.* xvi. i. (1883)], and especially by the numerous allusions to this genus scattered through his section on the Pagurinea. Though he figures no *Coenobita*, Mocquard had dissected three species—*C. compressus*, *C. spinosus*, and a third whose name he did not know. The present account is based on the information given by Mocquard and on dissections of the three Minikoi species. Thus the total material available has reference to at least five out of the six species of the genus.

[2] p. 70.

[3] This ossicle is so placed that it overhangs and presents one face downwards and an edge (the horizontal one) outwards. Its shape is therefore not properly seen in a full side view and cannot be made out in fig. A, Pl. III. but may be seen in the ventral view (fig. C).



Figs. A-E, E.W. del.

E. Wilson, Cambridge.

Borradaile - Coenobita.

The *exopyloric ossicles* (4, Pl. III.), which lie in the roof of the pyloric division of the stomach to the outside, and rather in front, of the medium pyloric ossicle, bearing to this latter much the same relation that the pterocardiacs bear to the mesocardiac, are stout, broad, and roughly diamond-shaped. One diagonal runs transversely and the other fore and aft. The hinder angle is rounded. The whole ossicle has a saddle-like double curvature, and its outer surface is roughened. The *pyloric ossicle* (6, Pl. III.) consists of two parts—an anterior expansion, and a hindward median process from this. The anterior expansion lies with its long axis across the stomach. Its outer ends are thickened, and so shaped as to embrace the ends of the prepyloric ossicle. These thickenings each send backward a very narrow strip to border the hindward process of the ossicle. The whole middle region of the ossicle, between the thickenings, is thin, and of a membranous, or, in the hinder part, cartilaginous consistency.

The *urocardiac ossicle* (27, Pl. III.) is an oblong, semi-transparent plate, of simple form, lying in the anterior wall of the dorsal hollow of the stomach, with its long axis fore and aft. Its anterior end abuts on the mesocardiac ossicle, from which, however, it is

EXPLANATION OF PLATE III.

Reference Numbers.

1. Mesocardiac ossicle
2. Pterocardiac ,,
3. Zygocardiac ,, horizontal (upper) edge
3'. Zygocardiac ,, anterior angle
4. Exopyloric ,,
5. Prepyloric ,,
6. Pyloric ,,
7. Uropyloric ,,
8. Cardiac disk ,,
9. Opening of invagination to bear postoesophageal brush
10. Cardiac side plate
11. Prepectinate ossicle
12. Pennate ,,
13. Inferolateral cardiac ossicle
14. Subdentary ossicle
15. Auricular ,,
16. Ampullar ,,
17. Posterior subampullar ossicle
18. Anterior pleuropyloric ,,
19. Middle pleuropyloric ossicle
20. Posterior ,, ,,
21. Anterior subampullar ,,
22. Middle ,, ,,
23. Posterior mesopyloric ,,
24. Dorsal terminal valve
25. Lateral ,, ,,
26. Ventral ,, ,,
27. Urocardiac ossicle
28. Median tooth
29. Postoesophageal brush
30. Comb
31. Median inferior tooth
32. Interampullary process
33. Upper pyloric side-valve
34. Lower ,, ,,
35. Lateral tooth
36. Interampullary valve (overlying ventral terminal valve)

Fig. A. Stomach of *Coenobita perlatus* from the left side.

Fig. B. Ditto, from above.

Fig. C. Ditto, from below.

Fig. D. Ditto, with roof of cardiac portion removed and the pyloric portion opened along the middle of the roof, the side walls being reflected.

Fig. E. Median tooth of same from within.

Fig. F. Liver of *Coenobita clypeatus*, ventral view.

Fig. G. Mid- and hind-gut of same species; portions opened to show texture of lining.

Fig. H. Green gland of same species from above.

Fig. K. Generative glands; *a*, ovaries of *Coenobita clypeatus*; *b*, ovaries of *C. perlatus*; *c*, testis of *C. clypeatus*. Anterior end towards bottom of plate in each case.

sharply marked off. The *median tooth* (28, Pl. III.), is large and well-developed. It is an oblong plate, somewhat shorter than the urocardiac ossicle, at the hinder end of which it is placed, and with concave sides. The inner surface bears a median longitudinal and four or five pairs of lateral transverse ridges, of which the two hindermost are the stoutest. The details vary considerably in different species[1]. The *prepyloric ossicle* (5, Pl. III.) is a T-shaped structure, placed vertically in the front wall of the pyloric division of the stomach, *i.e.* in that wall which faces the hollow between the two divisions. The stem of the T has concave sides and broadens considerably, where it joins the cross-piece. The latter is slightly concave on its anterior side.

The ossicles described in the foregoing paragraphs constitute the gastric mill, and, with the muscles which move them, are the apparatus by which the food is triturated. To complete the account of the skeleton of the stomach it is now necessary to mention certain less important pieces, by which the organ maintains its shape, and which support internally the various tufts and fringes of hairs with which it is provided. We may consider these in four groups:—

(1) Those of the cardiac region, all of which lie in the ventral, or ventro-lateral wall. They comprise the cardiac disks (described above), the post-oesophageal brushes, the cardiac side-plates, the prepectinate ossicles, the combs, subdentary, pennate and inferolateral cardiac ossicles, and the cardiopyloric valve.

(2) Those on the ventral wall of the pyloric region; comprising the auricular, anteroinferior pyloric, preampullar, and posterior subampullar ossicles.

(3) Those at the sides of the pyloric region; comprising the anterior, middle, and posterior pleuropyloric and anterior and middle subampullar ossicles.

(4) Those in the dorsal wall of the pyloric region; comprising the mesopyloric and uropyloric ossicles.

Group 1. *Postoesophageal brushes* (29, Pl. III.). A patch of hairs on each side of the stomach, situate on a lobe formed by invagination of the wall on the ventral side, a little behind the oesophagus. The outer opening of the invagination is surrounded by a calcified ring.

Cardiac side-plates (10, Pl. III.). Large thickenings of the ventrolateral wall behind the oesophagus. They are covered internally with tufts of hairs, especially long towards the hinder end.

Prepectinate ossicles (11, Pl. III.). Elongated plates in the side wall of the stomach, above the cardiac side-plates. The fore end of each is thin and expanded and the upper edge thickened along its whole length, but especially at the hinder end.

Combs (30, Pl. III.). An invagination of the wall of the stomach at the hind end of the prepectinate ossicle of each side, producing internally a cushion on which are a number of short, stout spines.

Pectinate and post-pectinate ossicles are wanting.

Subdentary ossicles (14, Pl. III.). A slender bar running backward and downward on each side from the zygocardiac ossicle to the fore end of the anterior subampullary ossicle, with which and not with the inferolateral cardiac ossicle, it articulates.

Pennate and inferolateral cardiac ossicles (12 and 13, Pl. III.). Two slender bars running parallel with one another along the line of junction of the ventral and lateral walls of the stomach, which line is defined by their presence. At their hinder ends they curve upwards, in corre-

[1] See Mocquard, *op. cit.*, p. 131.

spondence with the diminishing height of the cardiac division. Each of them grows gradually broader from before backwards, and is expanded at its posterior end. The ventral surface of the stomach, between the two inferolateral cardiac ossicles, is thickened on each side into a plate of cartilaginous consistency. In the middle line these two plates are sundered by a strip of thin chitin, in which lies a median ossicle having the shape of a dagger, placed lengthwise with the blade forwards. The pennate ossicle, which is the more dorsal of the two, bears internally a fringe of long hairs.

Cardiopyloric valve (31, Pl. III.). This has the form peculiar to the Pagurinea and Galatheinea; that is to say, it bears a V-shaped elevation composed of close-set lamellae not unlike the ridges of a file. The lamellae are flexible and the point of the V is backwards. The whole structure is known as the "median inferior tooth."

Lateral cardiopyloric ossicles are wanting.

Group 2. *Auricular ossicles* (15, Pl. III.). A pair of stout troughs, running backwards and inwards from the hinder ends of the inferolateral cardiac ossicles, on the ventral side of the stomach. The hollow of the trough is towards the inside of the stomach, and the hind end of each is expanded and less stout than its fore-part. There are no auricles.

Anteroinferior pyloric ossicles. A semi-transparent, four sided, median plate with a triangular projection from the middle of its fore edge. Behind it, and separated from it by the inner ends of the preampullar ossicles, are two small, semi-transparent, triangular plates, one on each side of the middle line.

Preampullar ossicles. Semi-transparent, transverse plates, just in front of the ampullae on the floor of the pyloric division.

Posterior subampullar ossicles (17, Pl. III.). Stout transverse bars, one on each side just behind the ampullae. Their inner ends are expanded and meet, but do not fuse.

Group 3. *Anterior pleuropyloric ossicles* (18, Pl. III.). Each of these starts at its hinder end by a roughly triangular expansion, with the apex directed downward and forward. From this apex proceeds a stout ridge on the side wall of the stomach, which, running forward, ends by articulating with the ventral end of the subdentary. The lower side of the ridge bears a triangular expansion. In the space between this ossicle and the pyloric, the wall of the stomach is thickened to form a cartilaginous plate.

Middle pleuropyloric ossicles (19, Pl. III.). A slender horizontal rod, behind and below the preceding ossicle on each side.

Posterior pleuropyloric ossicles (20, Pl. III.). A short, curved bar, with the convexity forwards, behind the middle pleuropyloric of each side.

Anterior subampullar ossicles (21, Pl. III.). An elongated calcified strip, hollowed on the outer surface, lying above the auricular ossicle of each side.

Middle subampullar ossicles (22, Pl. III.). Thickenings of irregular form, bearing to the ampullae the same relation that the anterior subampullars do to the auricular ossicles.

Group 4. *Uropyloric ossicle* (7, Pl. III.). A broad median plate in the pyloric roof, with the anterior edge very concave, and the anterior angles produced and strongly calcified.

Mesopyloric ossicles. The anterior pair are wanting; the hinder ones (23, Pl. III.) are present as a small oval plate on each side, in front of the uropyloric and outside its produced fore angles.

Internally the pyloric division presents the usual filtering apparatus of valves and fringes without any remarkable features. Of the *terminal valves* the dorsal and lateral are much elongated and pointed.

It will perhaps be of interest here to indicate the bearing of the gastric armature just described on the systematic position of the genus[1]. The following characters belong especially to the fore-gut of the Pagurinea:—(i) The long, narrow shape of the stomach. (ii) The slight inclination of the pyloric region. (iii) The form of the mesocardiac ossicle. (iv) The longitudinal direction of the dorsal edge of the zygocardiac ossicle. (v) The elongation of the cardiac side plates. (vi) The almost horizontal direction of the pennate and inferolateral cardiac ossicles.

Within the Pagurinea, the following characters separate the Coenobitidae[2] from the Paguridae: (i) The lower edge of the cardiac disk has its hairs arranged in tufts on pointed projections of the body of the disk. (ii) The lateral tooth has no notch on its lower edge. (iii) The median tooth carries transverse ridges. (iv) The exopyloric ossicles have a strong saddle-shaped curvature. (v) The pyloric ossicle is expanded and strengthened at its anterior angles.

The differences which separate *Coenobita* from *Birgus* are small, but the following may be mentioned:—(i) The anterior tubercle of the lateral tooth is wanting in *Coenobita*. (ii) The hinder edge of the mesocardiac ossicle is rather more convex than in *Birgus*. (iii) The anterior edge of the cross-piece of the prepyloric ossicle is more concave. (iv) The calcified ring round the opening of the invagination on which the post-oesophageal brush is borne, articulates, in *Birgus*, with an elongated triangular strip in front of the pennate ossicle. (v) In *Birgus*, the cardiac disk and the arrangement of hairs on its lower edge are more developed than in *Coenobita*, and form the "suboesophageal valves" of Mocquard[3].

The *gastric musculature* shows no important difference from that of the Pagurids as figured and described by Mocquard. The strong gastric mill is provided with a correspondingly powerful set of muscles to work it. The *anterior gastric muscles* are a pair of stout strands inserted on the mesocardiac ossicle and diverging slightly as they run forward thence to their origin from the under side of a low, rounded, transverse ridge of the carapace, situated above the bases of the antennae and eye-stalks. This ridge is the "procephalic apophysis." The posterior gastric muscle of each side is divided into two bundles—an inner one, inserted on the thickened plate at the outer end of the pyloric ossicle, and an outer one, somewhat broader than the inner, inserted on the exopyloric ossicle. The origin of the inner bundle is partly from the anterior side of a thin, flat, triangular apophysis, which projects inwards and somewhat forwards from the cervical groove a short distance from the middle line, and partly from the carapace in front of this apophysis[4]. The outer bundle arises in front, and a little to the outside, of the other. The *cardiopyloric* or *superior cardiac muscles* consist on each side of three bands running backwards from the hind edge of the mesocardiac to be attached to the exopyloric ossicle. Of these three,

[1] For the facts on which the following paragraph is based I am indebted to Mocquard (*op. cit.*).

[2] The family Coenobitidae includes the genera *Coenobita* and *Birgus*.

[3] *Ann. Sci. Nat.*, (6), XIII. 3 (1883).

[4] Such an apophysis seems, from Mocquard's remarks on the gastric musculature of *Pagurus*, to be wanting in that genus. It is however present in *Eupagurus bernhardus*, where it is directed *forwards*.

that which is outermost at its origin from the mesocardiac ossicle passes under the middle one and is attached posteriorly between this latter and the inner band[1].

The cardiac disks are provided, as in the other Pagurinea, with *dilator muscles*, running forward to the cephalic wall. Mocquard[2], discussing the working of the gastric musculature of the Decapoda, concludes that the function of the dilators of the stomach[3] is, by enlarging its cavity, to draw into it fluids, carrying with them the solid particles of the food. On the relaxation of the dilators, the constrictors[4] of the stomach will drive out the liquid, while the solid matters will be caught on the filter provided by the hairs on the cardiac disks or elsewhere near the opening of the oesophagus. This theory is very plausible, but there are considerable difficulties in the way of its acceptance in the case of the genus *Coenobita* at least. For the great majority of the food is by these creatures eaten absolutely dry, with only such juices as it naturally contains. If, for instance, an individual be watched in the act of consuming one of its most common articles of food —the fruit of the *Pandanus*—it will be seen to hold the food firmly with the great chela, while the smaller one is employed in stripping off the fibres of the fruit and placing them between the maxillipeds of the third pair, which open to receive them, and then pass them on towards the mouth. They are not immediately rejected, and presumably are sent into the stomach after having undergone a first crushing by the mandibles. In any case the powerful gastric teeth argue a mastication of some part of the food there. Now the *Pandanus*-fibres, and indeed the majority of the food of all sorts, cannot be supposed to contain enough moisture to convey the solid part to the stomach, however much it may be broken up by the mandibles. And the fact that the stomach, when opened, contains but little fluid, precludes the suggestion that its watery contents, passing backward and forward, continually perform the same function of carrying solid food from the mouth to the stomach.

These considerations appear to conclusively negative Mocquard's theory of swallowing in the Decapods. For, although the same difficulty does not exist in marine forms, the similarity of the mechanism in the two cases makes it difficult to suppose that a different method is adopted in each. The subject is at all events worthy of further investigation. It may prove to be the case that the more liquid part of the food is swallowed in the way described by Mocquard (and suggested before him by Parker[5]) while the more solid portion is either rejected or swallowed by some other mechanism, as, for instance, by the constrictors of the oesophagus.

B. The Mid-gut[6]. (Pl. III. figs. F, G.) As in other Decapods, the stomach of *Coeno-*

[1] The mode of action of the gastric mill of Decapoda is discussed in Mocquard's paper and in Huxley's "Invertebrates." Briefly put, it is as follows:—The contraction of the anterior and posterior gastric muscles has the result of bringing the three teeth (median and lateral) together. On their relaxation the ossicles return to their normal position by the elasticity of the stomach-walls, and also partly by the action of the cardiopyloric muscles.

[2] Mocquard, *Ann. Sci. Nat.*, (7), XIII. 3, p. 3 and XVI. 1, p. 255.

[3] Of course the above-mentioned dilators attached to the cephalic disks, though they are the chief, are not the only ones. Setting aside the dilators of the oesophagus and those of the pyloric division, the following, attached on the cardiac half of the stomach, are described by Mocquard; the antero-superior (on the cephalic disk), the anteroinferior, the anterior and the posterior lateral.

[4] Of these there is one on each side—a band of fibres inserted on the cardiac wall at the front end of the side-plate, and running downwards and a little forwards to the oesophagus.

[5] T. J. Parker, *Journ. Anat. Phys.* XI. p. 59 (1876).

[6] Bouvier, in a short article " Sur la Respiration et quelques dispositions organiques des Paguriens terrestres du Genre Cénobite " [*Bull. Soc. Philomath.*, Paris, (8) II. p. 194 (1839)], remarks briefly on this and other internal organs of *Coenobita*. His observations were made on *C. diogenes*, and it is interesting to find that, so far as they go, they support mine, which relate to the Indo-Pacific species.

bita is followed by the *mid-gut* or *mesenteron*—a short, soft-walled tube, which grows gradually narrower from before backwards in consequence of the difference in width between the pyloric division of the stomach and the hind-gut. Through the roof of the mid-gut there opens on each side a short, curved coecum of simple form with its blind end directed forwards. Through the floor open the two bile ducts.

The Liver (Pl. III. fig. F). The same compression of the thorax, which has affected the shape of the stomach, has brought about the displacement of the liver of the hermit-crabs backwards into the abdomen. Starting from the underside of the mid-gut, one close on each side of the middle line, the bile ducts may be traced backwards below the hind-gut, gradually diminishing in calibre all the way. On its outer side each duct bears, at almost regular intervals, about a dozen stout tubes or primary ductules, the first of which enters nearly at the level of the last thoracic leg. Each of these ductules curves upwards and inwards over the hind-gut, diminishing in diameter by giving off secondary ductules along its outer side. These in turn give off ductules of a third order, and the latter bear the terminal tubules of the system arranged in tufts. Each tuft opens by a short tube (ductule of the fourth order) on the outer side of the tertiary ductule. The terminal tubules are long and usually cylindrical, though some of them show bead-like swellings at intervals. The whole of the tubules borne on a secondary ductule form, in the natural position of the organs, a well-marked secondary lobule, and all the secondary lobules of a primary ductule form a primary lobule. These lobules, though they are placed at fairly regular intervals along the bile-duct, and roughly correspond on the two sides of the body, are not segmentally arranged in the abdomen. Moreover, owing partly to the fact that the primary ductules run, not straight upwards round the hind-gut, but also somewhat backwards, the lobules come to overlap one another on the dorsal side of the gut, and their arrangement appears at first less regular than it really is. Besides those arranged on the above system, each bile-duct bears, on its anterior portion, a certain number of tubules directly sessile upon it. These gradually diminish in size from behind forwards, till a short stretch of the bile-duct, just behind the opening, is left quite free from them. Hindwards the bile-duct begins by the junction of two primary ductules.

We may speak of the whole of the lobules of each side as forming a right and a left liver respectively. The left liver, then, is somewhat smaller than the right, though the difference is not very marked. At the hind end of the abdomen the left liver passes dorsal to the right. The whole of the structures just described are bound together by strands of connective tissue carrying blood vessels. This circumstance, combined with the soft, easily-breakable texture of the liver, makes that organ rather difficult to unravel.

C. The Hind-gut. (Pl. III. fig. G.) Behind the mid-gut, and stretching from it to the anal opening in a direct course, runs the chitin-lined hind-gut. Its width is even for the first three-fourths or so of its length and then it increases gradually to a greater diameter. There are no rectal coeca.

Outwardly, the surface of the hind-gut is smooth, but within it is thrown into ridges. These ridges, which are twelve in number, are most marked at the hind end, grow gradually lower forwards, and finally fade away in the middle of the first abdominal segment, some distance from the end of the mid-gut. They are not all of equal size, being alternately large and small, or rather high and low, for there is not much difference in breadth. Each bears a series of small transverse ridges, and each of these is again made up of a row of four or five minute oval beads set with their long axes lengthways in the intestine, that is transversely to the ridge which each row of them composes. The whole of these structures are, of course, covered with a delicate chitinous pellicle. In the anterior region of the hind-gut, where the ridges are wanting, the inner surface is covered with similar small beads, less regular in shape, set in longitudinal rows. The transition from the mid- to the hind-gut is hardly visible outwardly in fresh specimens, but in a gut which has been for a few hours in spirit it is very easy to see, owing to the difference in calibre brought about by the shrinkage of the mid-gut. Internally, the beaded appearance of the hind-gut makes the distinction a sharp one. In the natural position of the organs in the body a great part of the hind-gut is hidden by the overlapping lobules of the liver, but more or less of the hinder part usually comes into sight amongst the lobules.

The *anus* (fig. 18) is situated on the under side of the telson. It is guarded by a strong valve in the form of an oval calcified convex plate (1, fig. 18), attached to the soft ventral wall of the telson in front of the anus, and projecting back under it. If this plate be parted from the body of the telson, the anus is seen as a longitudinal slit at the bottom of the hollow between it and the telson. Between these two structures, then, there is a sort of cloaca, into which the anus opens. The aperture of the cloaca is surrounded by a thick growth of hairs. The result of this arrangement is that the opening for the discharge of faeces is directed, not ventralwards, in which case it would be liable to be pressed against the columella of the shell and thus obstructed, but backwards, and is further protected from pressure by the stout plate beneath it. Possibly the object of the hairs round the opening is to prevent the entrance of faecal matter as the animal shifts in its shell, though it is remarkable that the shells of these voracious creatures contain quite a small quantity of dung. In the Galatheinea and Brachyura, groups whose members carry the abdomen pressed more or less strongly against the underside of the thorax, the same arrangement is found in a less complete form, the anus being usually prominent and directed more or less backwards.

(iii) **The vascular system** (fig. 19).

The rather large, muscular *heart* (19, fig. 19) lies, as usual in the thorax, close under the dorsal carapace behind the cervical groove, surrounded by the thin-walled pericardial sinus, in which it is suspended by the three pairs of fibrous *alae cordis*, and with which it communicates by the usual three pairs of ostia. In shape it appears roughly four-sided from above, the anterior end being drawn out into a low prominence from which arise the three anterior arteries. The hind end has also a low, rounded, median bulge. At about a third of its length from the hind end there is on each side a notch. The dorsal surface is slightly convex; the sides slope inwards to the ventral surface, which is flat, and is raised, at the hind end, into a round, median lobe, from which the sternal and abdominal arteries arise.

Arteries. Seven vessels are given off from the heart. At the front end there arises a group of three—a median *ophthalmic* and two lateral *antennaries.* A short distance behind these the paired *hepatics* are given off from the ventral surface of the heart; and at the hind end the ventral lobe bears two median arteries, a more anterior, ventrally directed *sternal,* and a more posterior, terminal *abdominal.*

The *ophthalmic artery* (1, fig. 19) runs straight forward over the roof of the stomach without giving off any branches, and finally divides into two vessels which diverge forwards at an acute angle, to supply the eyes. There is no swelling, or median prolongation beyond the bifurcation. The *antennary arteries* (2, fig. 19) run forwards and outwards from their origin on each side of the ophthalmic artery. On the inner side each gives rise to

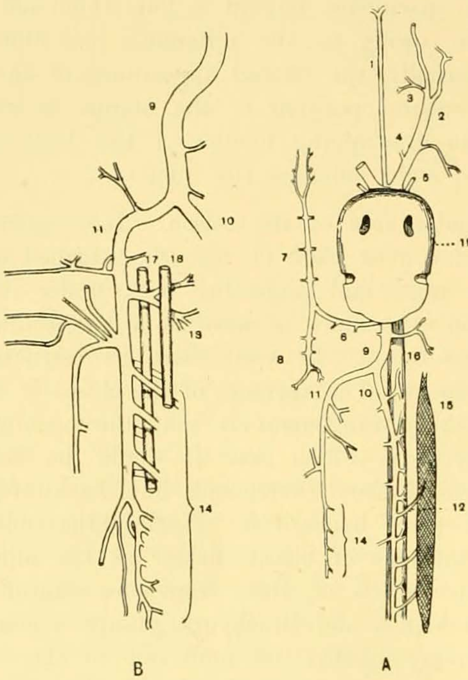


FIG. 19. Arterial system of *Coenobita clypeatus*. A. Arteries of female from above; B. Left or lower branch of abdominal artery of male (enlarged). 1. Ophthalmic. 2. Antennary. 3. Anterior gastric. 4. Posterior gastric. 5. Hepatic. 6. Sternal. 7. Ventral thoracic. 8. Ventral abdominal. 9. Dorsal abdominal. 10. Right branch of abdominal. 11. Left branch of abdominal. 12. Ovarian. 13. Spermatic. 14. Branches to liver. 15. Ovary. 16. Hind-gut. 17. Right bile duct. 18. Left bile duct. 19. Heart (represented too large).

an anterior and a posterior gastric artery, which supply the musculature of the stomach. At about the level of the anterior gastric artery there is given off on the outer side a stout branch, which runs downwards and forwards to the green gland. At a short distance in front of the posterior gastric artery a less important outer branch arises, to be distributed to the muscles of the adjoining part of the thorax. In front of the stomach the diminished artery is continued forwards to supply the antennae. Besides the above, there are other smaller and more variable branches.

The hepatic arteries (5, fig. 19). The position of the liver in the abdomen deprives these arteries of the function which gained them their name in other Decapods. It is perhaps best, however, to retain it, rather than add to an already overladen terminology. The hepatic arteries, then, in *Coenobita* do not supply the liver, but run downwards and forwards from the heart to supply the sides of the stomach. *The sternal artery* (6, fig. 19) on leaving the heart runs directly downwards, passes on one side or other of the intestine, and ends by going through the oval hole in the thoracic ganglion and dividing immediately underneath the latter into two branches, one of which passes directly forwards in the middle line and is known as the ventral thoracic artery, while the other runs directly backwards. This latter is the homologue of the ventral abdominal artery of other Decapoda. It has here very little right to the name, but to avoid confusion, and also because it does actually send two small branches into the abdomen, may be allowed to retain it. The sternal artery, in its vertical course, that is before its bifurcation, gives off two or three small branches backwards towards the abdomen. The *ventral thoracic artery* (7, fig. 19) gives off branches right and left to the third, second and first pairs of legs and then bifurcates into two trunks, one for each side, which supply the mouth-limbs and send a branch to the green gland of each side. The *ventral abdominal artery* (8, fig. 19), in its course through the hinder part of the thorax gives off vessels to the last two legs and then, on arriving at the base of the abdomen, divides into two small branches, which ramify among the abdominal organs. In the possession of these two little vessels, and in the greater regularity of the arrangement of vessels to the limbs, the sternal arterial system of *Coenobita* differs from that of *Eupagurus* described by Bouvier[1].

The *abdominal artery* (9, fig. 19). For a short distance this great vessel runs a straight course backwards, giving off a few small twigs to the muscles of the hinder part of the thorax. But a little behind the junction of thorax and abdomen it divides into two branches. Of these one, the smaller (10, fig. 19), passes on in the middle line above the hind-gut, lessening as it goes by giving off small vessels to the gut and ovary. The larger of the two, however, turns downwards and then backwards again, and continues its course below the liver and above the broad band of muscle which represents, in the Pagurinea, the abdominal muscular system of other Decapods[2]. As it goes, this vessel gives off branches upwards to the liver and testis and downwards to the muscles. In particular one large branch, given off not long after it resumes the backward direction, supplies much of the muscle-band and even sends a branch forward into the thorax. Further back still, the main vessel divides into two. One division passes into the muscles, the other runs on dorsal to the muscle-band, continuing to supply it and the liver. The sub-muscular division reappears at the hind end of the abdomen and curves forward, breaking up and anastomosing with the other vessels of the liver.

Venous system. The arteries, after dividing into finer and finer branches, end by discharging their blood into the great venous sinuses in which all the organs of the body are bathed. The arrangement of these in *Coenobita* seems to be much the same as in other Decapods. In connection with the respiratory organs, however, certain peculiarities must be noticed. Roughly speaking, the blood from a sternal sinus passes to the gills and so to the pericardium, that from a gastric sinus to the branchiostegite and so to the pericardium, and that from an abdominal sinus to a plexus under the skin of the abdomen and thence by two veins on each side to the pericardium. Some further particulars will be found in the next section.

iv. **Respiratory Organs**. Respiration takes place in three distinct regions of the body of a *Coenobita*: (1) in the gills, (2) in the lining of the branchiostegite, (3) in the abdominal skin. It must, of course, be borne in mind that in this case the surrounding medium is not water, as with the great majority of Decapods, but air.

The gills are of the type known as "phyllobranch"; that is to say they consist of an axis bearing on each side a series of thin-walled plates through which the blood flows

[1] Bouvier, "Récherches anatomiques sur le Système Artériel des Crustacés Decapodes." *Ann. Sci. Nat.* (7), v. p. 197 (1891).

[2] See above, p. 69.

freely. The axis is attached at one point to the side of the thorax, and there the blood enters it. The lamellae diminish in size towards each end of the axis, whereby the whole gill becomes spindle-shaped. The gill-formula is as follows[1]:—

	Podobranch	Anterior arthrobranch	Posterior arthrobranch	Pleurobranch	Total
1st maxilliped ...	0	0	0	0	0
2nd „ ...	0	0	0	0	0
3rd „ ...	0	rud.	rud.	0	2 rud.
1st leg...............	0	rud.	rud.	0	2 rud.
2nd „	0	1	1	1	3
3rd „	0	1	1	1	3
4th „	0	1	1	1	3
5th „	0	0	0	1	1
Totals...	0	3+2 rud.	3+2 rud.	4	10+4 rud.

The arrangements for the supply of blood to the gills consist, as usual, of afferent branchial vessels, arising from the sternal sinus, and of efferent vessels leading to the pericardial sinus and so to the heart.

The lining of the branchiostegite is a thin, smooth membrane. There is no spongy tissue such as is found in *Ocypode* or vascular tufts as in *Birgus*. According to Bouvier[2], blood enters the branchiostegite from the large sinus which encloses the stomach, and leaves by the great vein, which may easily be found at the hinder edge of the organ. This starts in front as a small vessel and runs backward round the lower edge of the branchiostegite, enlarging as it goes. Finally it curves inwards with the hinder edge of the branchiostegite and, when this rejoins the body, passes on to the pericardium. I did not find it possible by injecting this vessel to irrigate any definite plexus in the branchiostegite. The coloured fluid passes with great readiness into the space between the strong outer and the delicate inner wall of the organ, but it is here contained in a loose and irregular system of lacunae, or rather in a single cavity divided by strands of tissue.

The gill chamber. Provision for moistening the gills. The third leg in its normal position, pressed up against the soft branchiostegite, indents the latter in such a way as to limit the branchial chamber to a comparatively small region in the hinder and upper parts of the thorax. This chamber is widely open behind, so that the gills can generally be partly seen without lifting the branchiostegite. The animal seems to be able to increase this opening at will, but over the greater part of their surface the branchiostegite lies fairly close above the gills. There is thus no attempt at the formation of anything like a lung. The free edge of the branchiostegite is incurved, and the trough thus formed is lined with hairs and usually very moist. Another hairy surface, possibly of importance in the retention of water, is to be found on the wall of the thorax above the gills, between them and the origin of the branchiostegite.

[1] The gill-formula of *Pagurus* is the same as that of *Coenobita* save that the gills on the third maxilliped and first leg are better developed. *Eupagurus* differs in having only one pleurobranch—that on the fourth leg.

[2] Bouvier, *C. Rend.* cx. pp. 1211 ff. (1890). My observations, which confirm those of Bouvier, were made when I was in ignorance of his researches on the blood supply of the branchiostegite.

The source of the moisture is a problem of some obscurity. It is of the very rarest occurrence for a *Coenobita* to be found in the water except at the breeding period[1]. Ortmann states quite distinctly that, out of many hundreds, he has never seen one in the water. Nor have I myself succeeded any better in this respect. That they do visit the sea, however, I am convinced by two facts. First, that Mr Stanley Gardiner had the good fortune to find a specimen of *C. perlatus* in the water a few feet from the lagoon beach in Minikoi. It is true that this was a female, but there were no eggs or young, nor any traces of them, on her abdominal limbs. Secondly, that the body of a freshly caught specimen is always moist, and in a great many cases (certainly the majority of *C. perlatus* and *C. rugosus*) the shell actually contains a small quantity of salt water[2].

Another possible method of moistening the gills must not be overlooked. In some experiments to test the effect of drying the gill chamber it soon became evident that this was an impossibility. By the careful use of cotton-wool and blotting-paper, a great part of the moisture could be removed, but absolutely dry it was quite impossible to make the chamber. After a time the limpid salt water became replaced by a more sticky fluid, which frothed with the violent efforts of the scaphognathite. Of course it is possible that this was blood, flowing from wounds in the delicate cuticle lining the chamber, made during the process of drying. But I was unable to detect any such wounds, and the same thing happened in each of several experiments. Another explanation of the phenomenon is that the fluid was provided by exudation through the lining of the chamber. No doubt in this case the exudation was abnormal in quantity and quality. But it served to indicate a possible method of keeping the gills moist. In support of this is the fact that specimens made approximately dry[3] with cotton-wool and then placed in a dry wooden box, lived, and remained in good health for weeks. No doubt, if the suggested process of exudation takes place, the different species of the genus are dependent on it to different extents. One would expect, for instance, that it would play a greater part in species such as *C. spinosus*, which often live at some distance from the sea, than in *C. rugosus*, which is generally to be found close to sea-water.

The movements of the scaphognathite. On raising the forepart of the branchiostegite of a *Coenobita* the plate on the second maxilla, to the movements of which the respiratory current in water-living Decapods is due, will nearly always either be found to be in motion or shortly begin to move. When the animal is placed in water, either fresh or salt, it is easy to show, by means of a little carmine or other coloured fluid, that the ordinary current is produced here also. It enters at the hind end of the branchial chamber and between the last two legs, passes over the gills and through the narrow passage which leads downwards and forwards from the upper part of the gill-chamber proper, and finally issues under the antenna. I have not been able to observe a reversal of the current, such as that described by Bohn[4] in many Decapods. The meaning of the movement of the scaphognathite when the animal is on land is not clear. It is possible that its object is, by acting as a fan, to create a draught of air through the gill chamber. In considering this view, however, we are met by the difficulty that there are often long pauses in the movements, and that removal of the scaphognathite has no perceptible effect on the animal.

[1] See below, p. 91.

[2] See below, p. 91.

[3] If the drying process be continued too long, it is apt to kill the animal.

[4] Bohn, *C. Rend.* cxxxv. p. 539.

It may be that the stimulus of lifting the branchiostegite is sufficient to set the appendage in motion, but in this case one would expect the movements either to cease directly or to continue as long as the branchiostegite is raised. This is not what happens, the movements being sometimes steady and sometimes fitful and irregular. A third explanation, and the one which at present seems the most probable, is that we have here an instance of a vestigial habit, retained after it has ceased to be of use to the animal. Lastly, if it could be shown that both sexes are in the habit of going into the water at frequent intervals, yet another solution of the question could be offered. For in that case it would be possible to suppose that the motion of the scaphognathite was retained on account of its being indispensable to the animal under water and at the same time, for some physiological reason, not susceptible to inhibition for long periods and thus perforce continued on land. But this view would require assumptions, which there is no justification for making.

Abdominal respiration. At the time of my sojourn in the Island of Minikoi, I was unaware of Bouvier's[1] researches on this point. My own observations were much less complete than his, but I can confirm his statements with regard to the various channels carrying blood back from the abdominal walls to the pericardium, at least as regards the dorsal pair, the ventral I failed to observe. While he paid considerable attention to the anatomical side of the question, Bouvier does not appear to have made any experiments to test his theories. It is interesting to observe that if the gills of both sides be cut off, leaving small stumps to avoid loss of blood (it would be better to ligature the gills in a future experiment), the animal is still capable of living. Indeed one, on which I performed this experiment, lived several days, and finally escaped from the vessel it was confined in. Taken in conjunction with the fact that the action of the scaphognathite may be suspended without harm to the animal, this fact seems to indicate that abdominal respiration is of considerable importance in *Coenobita*. It is further interesting to note that the soft skin of the abdomen is always damp. Possibly the object of the hairs and fleshy processes on the ventral surface of the abdomen is as much to retain water as to play any part in respiration by movement, as Bouvier suggests. It would certainly appear, from the elaborate precautions taken in various groups of land Decapoda to ensure the presence of moisture on the breathing organs, as though respiration were, in them at least, impossible except through a moist surface.

v. **Kidneys (green glands)** (Pl. III. fig. H).

The kidney of *Coenobita* is a large oval cushion, of a pale greenish colour in the living animal, placed in the head on each side of, and rather behind, the brain, and behind the base of the antennae. The surface of the cushion is not even, but raised into a number of irregular rounded lobes, except in the middle of the upper side, where a space is left smooth, and forms a depression amongst the lobes. The hilum of the gland is in front and on the outside. I am quite unable to distinguish, by injection or otherwise, any vesicle such as is found in nearly all other Decapods and is especially well developed in the Pagurids. The only other instances in which this does not occur are quoted by Marchal

[1] Bouvier, *Bull. Soc. Philomath.*, Paris (8), II. p. 194 (1890). Briefly put the apparatus consists of a tegumentary plexus, fed from the abdominal sinus and communicating with the pericardium on each side by two veins—a long dorsal and a short ventral one. The two veins of each side join before entering the pericardium.

in his work[1] on these organs in the Decapoda. They are afforded by the genera *Porcellana* and *Axius*. A short duct leads from the gland to the opening at the base of the antenna.

vi. **The Nervous System** (fig. 20).

As might be expected, this shows a great general resemblance to that of the Pagurids[2] the chief difference being in the greater concentration of the thoracic ganglia. The *brain* (1, fig. 20) is large, transversely elongated, and swollen at the sides. It gives off nerves to

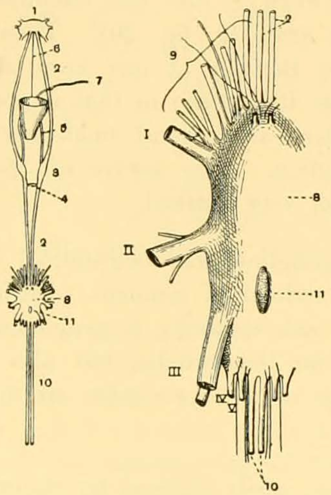


FIG. 20. Central nervous system of *Coenobita clypeatus* from above with abdominal chain removed. To the right an enlarged view of the thoracic ganglion is shewn. 1. Brain. 2. Circumoesophageal commissures. 3. Oesophageal ganglia. 4. Transverse commissure. 5. Oesophageal nerves. 6. Cerebral branch to the visceral nerve. 7. Visceral nerve. 8. Thoracic ganglion. 9. Nerves to the mouth-parts. 10. Longitudinal commissures. 11. Perforation for sternal artery. I—V. Nerves to the legs.

the eyes and antennae. The *circumoesophageal commissures* (2, fig. 20) are very long. For the first part of their course they diverge and again converge in such a manner as to enclose a long oval area, in the middle of which the oesophagus lies. At the hinder end of the oval area a delicate transverse commissure (4, fig. 20) delimits it sharply. Behind this point the circumoesophageal commissures converge much more gradually towards the thoracic ganglion presently to be mentioned, finally running almost parallel for some distance. Just in front of the transverse commissure there is a gentle swelling on each of the longitudinal ones. These are the oesophageal ganglia (3, fig. 20) from which arise the two rather large oesophageal nerves (5, fig. 20). These are joined by a fine nerve (6, fig. 20) which runs backward in the median line from the brain—the three anastomosing in front of the oesophagus. From their point of junction the median visceral nerve (7, fig. 20) runs upwards over the anterior wall of the stomach, to which organ it is distributed as in other Decapods.

The *thoracic ganglion* (8, fig, 20). In the Paguridae the thoracic ganglia are, with the first abdominal, fused into an elongate mass in which, however, certain of the constituents can still be made out, owing to the presence of constrictions in the mass and of perforations to admit the passage of certain small arteries (besides the sternal artery). *Coenobita* shows an advance on this in that the whole of the ganglia are fused into one oval body, through

[1] Marchal, "Récherches...sur l'appareil excréteur des Crustacés Décapodes." *Arch. Zool. Exper.* (2), x. p. 57 (1892). See this work for the excretory organs of the Paguridae (not Coenobitidae), *Porcellana*, and *Axius*.

[2] See Bouvier, *Ann. Sci. Nat.* (7), VII. p. 87 (1839).

which there is but one perforation—that for the sternal artery (11, fig. 20). On each side of the ganglion arise, at wide intervals, three stout nerves for the first three legs. In front and behind, the longitudinal commissures join it as two more slender strands, one close on each side of the middle line but quite distinct. Behind the nerve for the third leg of each side, between it and the longitudinal commissures, the small nerves for the fourth and fifth legs arise. In this region there are also several very fine, thread-like nerves arising from the dorsal surface of the ganglion and running backwards.

In front of the nerve for the first leg, between it and the circumoesophageal commissures, half-a-dozen nerves for the mouth parts arise (9, fig. 20). These come off, not as in the thoracic ganglion of *Pagurus* figured by Bouvier, at one level, along the edge of the ganglion, but at different points scattered over its surface in that region. Two, in fact, arise quite on the dorsal surface. Here again there are several small nerve-threads intermingled with the stouter nerves leaving the ganglion. The nerves of the two sides are not absolutely symmetrical but the asymmetry is not very marked.

The *abdominal chain*. Leaving the thoracic ganglion the longitudinal commissures run backwards as far as the beginning of the sixth abdominal segment. During the whole of their course they remain distinct save where, in each segment, a ganglionic swelling binds them together. Nerves are given off, not only from the ganglia, but also from the intermediate portions of the commissures. The nerves of the two sides are not strictly symmetrical.

The brain and circumoesophageal commissures are easily exposed by removing the stomach from above, when they are found lying respectively against the anterior and ventral body-wall. The hinder part of the circumoesophageal commissures, with the thoracic ganglion and the nerves leaving it, is protected by a stout endosternal skeleton of the macrurous type, joined by the usual rib-like bars with the endopleurae and epimera, which form the rest of the internal skeleton. The abdominal chain lies along the ventral side of the abdomen under the muscle-band.

vii. **The generative organs** (Pl. III. fig. K, *a*—*c*).

A. *The male organs.* The *testes* lie imbedded in the dorsal part of the liver and more or less completely hidden by the lobes of that organ. They are not symmetrical, the right being placed farther back than the left. It is also rather the larger of the two. Each consists of a much coiled, sacculated tube compacted into a firm, elongate mass, enlarged at the hind end. From this enlarged part arises the *vas deferens,* a somewhat complicated structure, divided into three regions—(1) the conducting tube, (2) the spiral, (3) the glandular tube. The *conducting tube* is a short, irregularly twisted duct arising from the inner, ventral aspect of the testis at its hinder end. In calibre it is smaller than the glandular tube, but rather larger than the spiral. This latter is a fine, semi-transparent pipe arranged in one close coil of about thirty turns. The glandular tube is stout, of an opaque white colour, and thrown into many irregular loops. It runs forward along the inner side of the testis, becoming less convoluted as it goes, traverses the anterior part of the abdomen, and finally passes almost insensibly into the *ductus ejaculatorius*—a simple, uncoiled tube, slightly wider than the vas deferens.

Comparing these structures with the same parts in *Paguristes* and *Eupagurus*[1], the following points appear. The testis is more compact in *Coenobita* than in either of the Pagurid genera. In shape it represents, with its hinder swelling, a more definite form of the type foreshadowed by *Eupagurus*, which is, in this respect, intermediate between *Paguristes* and the land genus. On the other hand, in having one spiral section (instead of two, sundered by a straight tube), as also in the small calibre of this region, *Coenobita* approaches *Paguristes* rather than *Eupagurus*. But in the shortness of the very narrow tube which comes immediately before the spiral, that is which separates the spiral and the conducting tube proper, it again resembles *Eupagurus*. The *male opening* is in the usual position on the coxopodite of the fifth leg of each side. The portion of the joint which bears the opening is always more or less prominent and, in some cases (*C. rugosus*, *C. perlatus*) is, on the right side of the body, prolonged into a penis-like process. In *C. perlatus*, however, in which this feature is very marked, bringing about a complete dissimilarity between the openings of the two sides, there is no sign of degeneration in the left testis, and its duct may contain sperm. The first abdominal segment being, in both sexes, unprovided with appendages, there is here no copulatory organ of the type common in other Decapods.

B. *The female organs.* The *ovaries* are a pair of simple cylindrical structures lying in the abdomen one on each side of the median line close above the hind-gut along the middle portion of its course. In *C. clypeatus* the ovaries are separate. In *C. rugosus* and *C. perlatus* they join for a short distance at their hind ends[2]. The *oviduct* is a simple tube, arising from the anterior end of the ovary and running straight forwards to its small round opening on the ventral face of the coxopodite of the third leg.

C. *The relative numbers of the sexes* seem fairly equal, a collection taken at haphazard giving sometimes a small preponderance of one, sometimes of the other.

viii. **Reproduction**. Whether *Coenobita* have a definite breeding season or not, and, if so, when it occurs are questions that still remain to be settled. Certainly, females with eggs may be taken throughout the summer in Ceylon[3]. The copulation is another point deserving further investigation. Very little is known on this subject as regards most Decapods. *Paguristes* is said to insert a penial process into the vulva of the female[4], and possibly the same use is made of the "penis" of *C. perlatus*. That of *C. rugosus* is too broad for insertion, but is no doubt of use in placing the sperm in some required position. At the same time the reproductive organs of the left side of the body show every sign of being functional in these, as in the other species of the genus, and the problem is thus complicated by the probability that their sperm is deposited in a different way from that of the right side of the body.

The eggs are carried in large masses attached to the long hairs on the well-developed limbs on the right side of the second, third and fourth abdominal segments of the female. They are arranged irregularly along the hairs[5] and fixed, as in other Decapods, by an

[1] Grobben, "Beit. Kennt. Männ. Geschlechtsorg. Dekapoden," *Arb. Zool. Inst. Wien*, I. 2 (1878).

[2] In *Pagurus* they are said to remain separate.

[3] Mr Stanley Gardiner suggests to me that the south-west monsoon is the main breeding season in the Maldives. He was in these islands during the north-east monsoon, and found great difficulty in finding females with eggs at that season. The same is the case in Ceylon.

[4] Ortmann, Bronn's *Thierreich*, v. 2, p. 1075.

[5] In *Birgus* they are in clumps at intervals along the hair. Borradaile, Willey's "Zool. Results," Pt. v. p. 585 (1900), "On the Young of the Robber Crab."

outer shell, prolonged into a stalk which adheres to the hair. The ripe egg is ellipsoidal, and measures, when preserved in spirit, 7·5 mm. by 7 mm. in *C. perlatus*, and in *C. rugosus* rather less. It is thus a little smaller than that of *Birgus*[1]. In two species at least (*C. rugosus* and *C. perlatus*) the young are hatched as zoaea larvae[2] of a type much resembling those of other Pagurinea[3] and washed off into the sea. They are not swept out in the respiratory current in the manner described by Bate[4] for *Eupagurus* nor is it necessary for the female to issue from her shell, though she may do so if kept under water too long in a state of captivity. It is possible, though perhaps not very likely, that the habits of some of the other species, especially those which live at greater distances from the water, may have led to their young being hatched in a later stage[5], as is said to be the case with some land crabs[6]. A zoaea which seemed identical with that of *C. rugosus* was taken at night with the tow-net in the lagoon at Minikoi.

The embryonic skin, which encloses the Decapod zoaea before hatching, and is retained for a varying period in different forms, is here lost very shortly after leaving the egg. It is of simple form and much resembles that found by Sars in other Pagurine zoaeas, though I have not been able to discover any feathering on the processes of the glove-like structure which encloses the telson and its spines. The larva (fig. 21) is rather smaller than that of *Birgus*[7] (the length is, in *C. perlatus*, 3 mm. and in *C. rugosus* 2·5 mm., as against 3·5 mm. in *Birgus*), which it otherwise very closely resembles in all but a few points of detail. The *carapace* has a curved, pointed rostrum of moderate length. The hinder edge is hollowed, and at each side a rounded side-lobe replaces the spine usually found here. The *abdomen* consists of five segments and an end part, which shows indications of its coming division to form the sixth segment and telson[8]. The *telson* (*a*, fig. 21) has the usual fan shape with a rather deep median notch. On each side of the notch are five bristles, increasing in length from the first to the fourth, which is longer than the fifth. These bristles are feathered. The outer angle is provided with a stout tooth. None of the other abdominal segments are armed, save the fifth, which has a single strong spine on each side at the hind end. There are eight pairs of limbs, including a rudimentary pair of third maxillipeds. These limbs are almost exactly like those of the first zoaea stage of *Birgus*[9], except for the mandible (*b*, fig. 21), which has

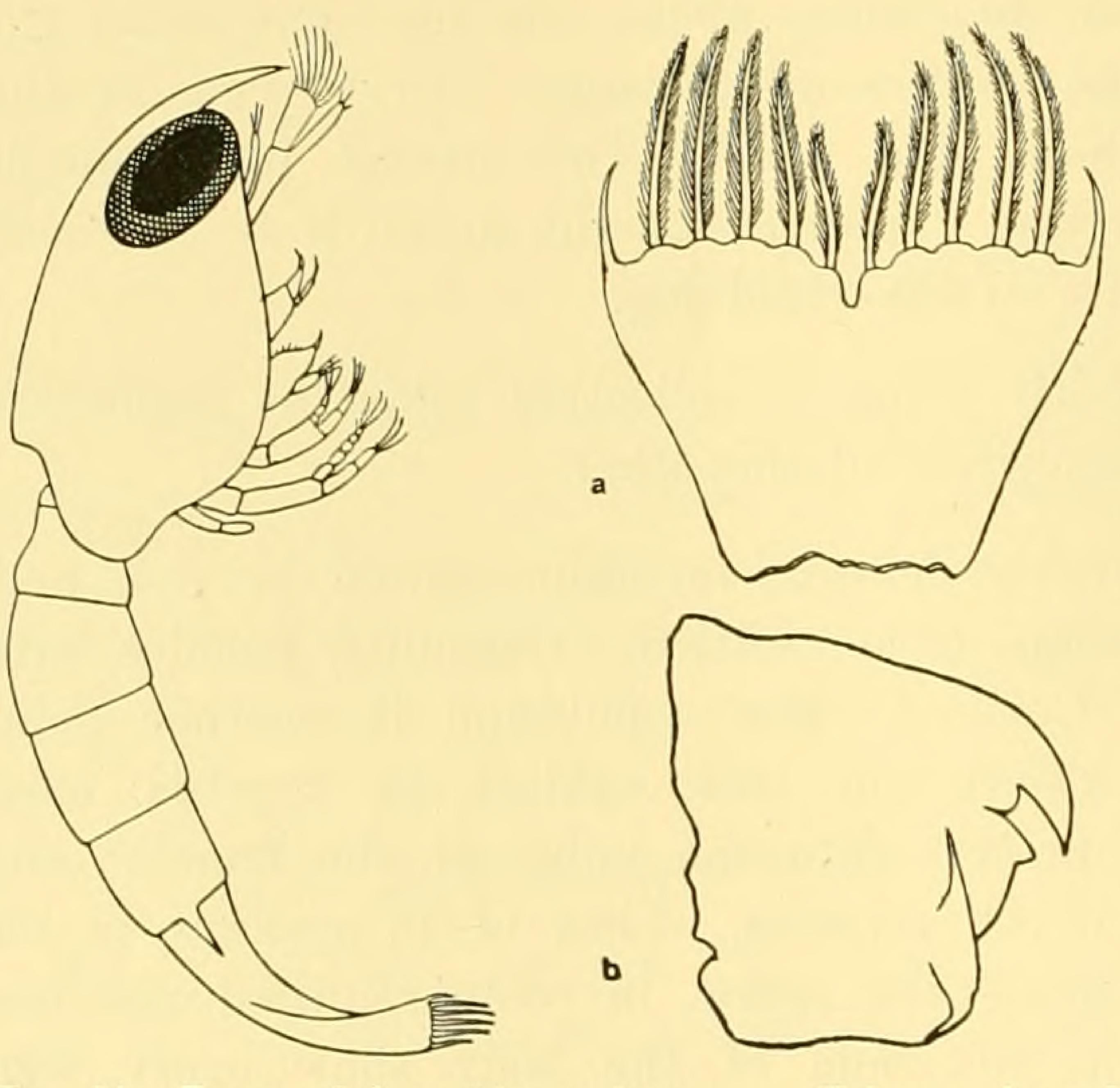


Fig. 21. Zoaea of *Coenobita perlatus*. *a*. Telson enlarged. *b*. Mandible enlarged.

[1] Borradaile, *loc. cit.*

[2] Borradaile, *P. Z. S.*, 1899, p. 937.

[3] G. O. Sars, *Arch. Math. og Naturvid.*, XIII. p. 133 (1839).

[4] Bate, quoted by Stebbing "Crustacea," p. 164, London, 1893.

[5] *C. clypeatus* a few mm. long are found in the jungle in Minikoi in sea shells. For *C. diogenes*, see below, p. 91.

[6] *Gecarcinus* sp. Westwood, *Phil. Trans.*, 1835.

[7] Borradaile, Willey's "Zool. Results," *loc. cit.*

[8] These indications are not altogether wanting in *Birgus*, so far as can be seen in the ill-preserved material from the Pacific at my disposal.

[9] For figures of these see Borradaile, Willey's "Zool. Results," *loc. cit.*

the same main features but is simplified by the absence of its numerous small denticulations. The first antennae are simple, unjointed structures with a few hairs at the free end. The second antennae have a large scale with a tooth at the outer angle and feathered bristles along the inner edge. The endopodite is unjointed. The first maxilla has a jointed palp, two stout feathered spines, and a broad gnathobase. The second maxilla is not much removed from the adult form. The first two maxillipeds are the swimming organs and have long, jointed endopodites and exopodites, bearing hairs.

In every respect the larva has a typical Pagurine organization, but resembles *Birgus* more nearly than the Pagurids. It differs from *Birgus* in: (1) its smaller size; (2) the arrangement of the bristles of the telson, which in *Birgus* are of nearly equal length; (3) the greater length and slenderness of the side spines of the fifth abdominal segment; (4) the greater simplicity of the mandible.

ix. **Notes on the habits**[1].

A circumstance which makes the habits of *Coenobita* somewhat more easy of investigation than those of other hermit-crabs, is that almost the whole of their life is spent on land. It has already been remarked[2] that the animals are rarely to be found in the water, but we must at the same time admit that this question is far from being disposed of. Their organization seems well adapted for a stay under water, and they may be proved experimentally, as we shall see, to have the power of living for some time in that medium, though it eventually proves fatal to them.

According to Hughes[3] *C. diogenes* is "often found cleaving to rocks in the sea" and "sometimes it is caught upon the rocks at a considerable distance from land." Again, in Minikoi, the shells of many examples of *C. rugosus* and *C. perlatus* contained considerable quantities of salt-water, and that in both sexes and irrespective of the carrying of eggs by the females. On the other hand Catesby[4] does not "remember to have seen any of them (*C. diogenes*) go into the sea," Ortmann[5] states that, out of hundreds of examples observed by him in East Africa, not one was found in the water, and, with a single exception[6], the same was the case in Minikoi. Moreover, in the case of species found at a considerable distance from the sea[7], frequent visits to salt water are out of the question. *C. rugosus, C. perlatus* and, according to statements[8], *C. diogenes* undoubtedly go down to the sea, when their young are hatching for the purpose of washing them off. Should they be proved to frequent the water at other times, it will be interesting to discover whether this be in connection with their breathing arrangements[9], or merely for some such purpose as obtaining a favourite food or escaping an enemy, and further whether it take place by night or by day[10].

With regard to the food of *Coenobita*, there is not much that can profitably be said. Their staple is, in Minikoi at least, the fruit of the *Pandanus*, but they are like many

[1] Broderip [*Zool. Journ.*, IV. p. 205] and Ortmann [Bronn's *Thierreich*, v. 2, *passim*] quote passages from various authors on the subject of the habits of *Coenobita*.

[2] See above, p. 85.

[3] Hughes, *Nat. Hist. Barbadoes*, p. 265.

[4] Catesby, *Nat. Hist. Carolinas*, II. p. 33.

[5] Ortmann, Bronn's *Thierreich*, v. 2, p. 1183.

[6] See above, p. 85.

[7] Such as *C. spinosus*, see Borradaile, *P. Z. S.*, 1898, p. 459.

[8] Quoted by Broderip [*Zool. Journ.*, IV. p. 205] from the old "Encyclopédie" [Paris, 1751].

[9] In order to moisten their gills etc. See above, p. 85.

[10] For some remarks on the same problem with regard to *Birgus*, see Borradaile "Willey's Zool. Results," v. p. 585.

other Decapods in being practically omnivorous[1]—belonging, in fact, to the class of scavengers. They pick up various dead sea-animals along the beach, and get other refuse elsewhere. On occasion, even cannibalism is not beyond them, when one of their number is wounded or killed. They are able to find their food in the dark, and there can be little doubt that this is due to a sense of smell, by which, rather than by sight, they are most likely guided in their search. Substances with a strong odour such as roasted coconut or the fruit of the *Pandanus* (which has a distinct and characteristic smell) are particularly attractive to them. It is interesting to watch the way in which a *Coenobita* will pause in its walk, unfold its long antennules[2] (see p. 70) and seem to explore the air with them, waving their flagella gently to and fro over its head. The same limbs are advanced and held over the food during feeding. They find the fruit of the *Pandanus* on the ground, but will also climb the bushes to reach it. On one occasion an individual was found in a *Hernandea peltata* about twenty feet from the ground, but its object in going there is hard to surmise. The curved end-joints of the legs can clasp tightly quite small twigs, and the sharp claws with which they are provided are, no doubt, of use in climbing. The food is often dragged for some distance, and in the case of fruits this is, no doubt, a method of distributing the seeds, which should be taken account of in considering the extension of vegetation over the land surface of a coral island.

In the matter of habitations, the choice is as varied as in that of food. Every available kind of land or sea gastropod shell is used, provided that it be of the right size and not so encumbered with spines as to be awkward in use. Weight seems to be of little account, the heavy *Turbo*-shells being especial favourites with *C. clypeatus*, although only comparatively small individuals can use them. One small specimen of *C. rugosus* in Ceylon was carrying the empty tube of a Serpulid worm. *C. spinosus* is known to use the nutshell of *Calophyllum inophyllum*[3], and *C. clypeatus*, when it has grown too large for gastropod shells, takes the half of a coconut[4]. A case even occurred in which a broken glass tube was made use of[5].

Ortmann[6] has pointed out the existence in *C. rugosus* (traces of the same structure are found in most *C. perlatus*) of an apparatus, which he regarded as adapted for producing a sound. This consists of a row of small ridges on the outside of the great (left) chela and a longitudinal ridge on the underside of the second walking leg of the same side. It is interesting to know that a number of these creatures shut up in a large tin

[1] Ortmann [Bronn's *Thierreich*, I. 2, p. 1234] seems to be of the opinion that *Coenobita* is purely vegetarian in its feeding, and quotes Dahl and Streets in support. But Catesby [*Nat. Hist. Carolinas*, II. p. 33] long ago observed that *C. diogenes* will occasionally take animal food.

[2] These appendages are, of course, those in which a sense resembling that of smell has been found to be located in other crustaceans. Lack of time unfortunately prevented me from making any experiments on this point, which I am sure would repay investigation in *Coenobita*.

[3] Borradaile, *P. Z. S.*, 1898, p. 459. Gastropod shells are probably scarce where this is done.

[4] In such cases as this, the means by which the creature retains its house are of interest. The abdomen is doubled forwards under the thorax, so as to present the roughened surfaces on the 6th abdominal limbs to the inside of the shell, and at the same time the 4th and 5th thoracic limbs make use of the similar patches on their propodites. Even so the hold on the shell is but a feeble one (see p. 72).

[5] A similar case is mentioned by Brock [quoted by Ortmann, Bronn's *Thierreich*, v. 2, p. 1216]. The interest of this observation lies in its bearing on the question of the means by which the animal recognises an object as being suitable for its "house." In this case it seems far more likely that the sense of touch was employed than that of sight. On the other hand, an individual removed from its shell, will make for another shell placed at some distance in a manner which seems to indicate that this is seen.

[6] Ortmann, Bronn's *Thierreich*, v. 2, p. 1249. Hilgendorf is said to have first called attention to the existence of this arrangement.

box, gave out continually a low, chirping sound, though it was not possible to discover how they did this[1]. The object of the sound is not clear, and theories on this subject must wait till the question of the hearing of the creatures is decided. They certainly often seem to be affected by sounds, but whether this may not be due to other vibrations started at the same time in the earth and surrounding objects is still doubtful to me, my information on the point being limited to desultory observations made at Minikoi before I was obliged to leave the island.

While they are not strictly nocturnal animals, the land hermit-crabs are certainly more active by night than by day. They seem to avoid the heat of the sun by preference, and to shelter, during the middle of the day, in nooks and crannies. Their habit of crowding together in any place, where food is to be found, makes them seem gregarious—which, in a strict sense of the word they probably are not. At the same time they may sometimes be found collected in considerable numbers for no apparent cause.

They are not given to fighting to the same extent as the hermit-crabs of the sea. When molested they withdraw quickly into their shells, closing the opening with the big left chela, which is specially adapted for this purpose. In this condition a *Coenobita* in a strong shell, such as that of *Turbo argyrostomus* must be an exceedingly tough nut for most animals to crack, and can also fall from a considerable height without injury. If they are unable to withdraw into their shells they will sometimes endeavour to defend themselves with the same powerful limb that is used to close the shell, but it often requires a considerable amount of teasing to induce them to do this. The grip of the great chela is exceedingly strong and will easily snap a twig which the animal has been made to seize.

If an individual be placed on its back, that is with the mouth of the shell uppermost, it will thrust out its body till the shell overbalances and the animal is able to recover the normal position. In moving, they crawl obliquely forward and to the left. From the accounts of eye-witnesses[2], it would seem that *C. diogenes* is considerably swifter than the Indo-Pacific species.

A series of experiments carried out with the object of investigating the vitality of the animals in fresh and salt water led to the following conclusions:—

(i) Continuous submersion under water is always fatal after a more or less prolonged period. (ii) There is great individual variation in the length of this period, but the sexes do not differ greatly[3]. (iii) The creatures are very sensitive to the effects of overcrowding. (iv) Tinned vessels are more injurious than enamelled ones. (v) There is a difference between the powers of resistance to fresh and salt water in favour of the latter, but the difference is not so great as might have been expected. The greatest length of life in salt water reached by any individual during the experiments was 6 days, but this was exceptional. In fresh water 24 hours was not exceeded. (vi) Of the three species, *C. perlatus* showed the greatest vitality in water and *C. clypeatus* the least, but the number of individuals of the latter experimented with was small. (vii) Before death the animal generally, but not invariably, comes out of

[1] Broderip [*Zool. Journ.*, IV. p. 205] quoting from the old "Encyclopédie" (Paris, 1751) states that *C. diogenes* makes a small sound when it is seized.

[2] Soane, *Nat. Hist. Jamaica*, II. p. 272; Catesby, *Nat. Hist. Carolinas*, II. p. 33.

[3] Females with eggs do not differ from others in this respect, and the hatching larvae died almost as soon in salt as in fresh water. Had it been possible to rig up a "dipper," no doubt some of these might have been reared.

its shell. (viii) An individual, seemingly dead, may often be revived by being placed in the air, just as a marine crab, dying from exposure to the air, will come to life in water[1].

Some 200 specimens, mostly of the species *C. rugosus* and *C. perlatus*, were experimented with. The fresh water used was rain gathered in a "galvanised" iron tank. Owing to the limited number of vessels available and lack of time, the experiments were not as complete as they should have been. Still, they may perhaps serve to induce some more fortunately situated observer to carry on the enquiry. To obtain good results, each individual should be placed by itself in a vessel with a considerable quantity of water, which should be frequently changed. It would be interesting to try and induce the animals to feed under water. The few attempts, which I made at this, were unsuccessful. That death is not due to starvation is, however, certain from a consideration of the fact that they will live for weeks without food, if not placed under water.

3. Some notes on the land crabs of the genus *Ocypode*.

i. *Ocypode ceratophthalma* (Pallas).

This species lives in burrows in the sandy strand of the lagoon. Large warrens of these burrows extend along the shore just below extreme high-water mark. They are thus covered and destroyed at high tide, but during many hours are completely exposed. The mouth of the burrow is not always situated so as to be covered by an average tide, but the lower part always falls in at high water, owing to the loosening of the sand. The crab, which awaits this event at the bottom of its hole, is thus buried for some hours. When the tide falls it works its way out and repairs its burrow, and until the water returns may be seen moving about the shore near the opening[2], and running with extraordinary swiftness when threatened with capture. Under these circumstances the first impulse of the animal is to make for its hole, but, if cut off from this, it will seek safety in the water. The crabs double readily, and a favourite device with them is to remain still till the pursuer approaches and then suddenly dart off. These manœuvres are carried out on the tips of their slender legs and with the eyestalks raised so as to survey as wide a field as possible, and give the impression that the animals possess intelligence of a high order. When finally seized, they make vigorous efforts to defend themselves with their chelae.

As might be supposed from their burrows being submerged at high tide, and from their readiness to take refuge in the sea, the crabs are able to endure immersion in salt water for a number of hours, though they are eventually killed by it. Fresh water, on the other hand, is rapidly fatal, two hours being the longest period that any of them survived an experiment.

The burrows are inhabited each by a single crab, and Major Alcock[3] has shown that the stridulating apparatus, possessed by this species in common with most others of the

[1] In this connection it is interesting to note that the heart of the common hermit-crab [*Eupagurus bernhardus* (Linn.)] and the shore crab [*Carcinides moenas* (Penn.)] may often be found to be beating some time after every outward sign of life is lost from exposure to the air. Even when it has stopped, it may sometimes be induced by mechanical stimulation to give a few beats.

[2] In the hottest part of the day, when the sun shines full upon the beach, they are less active than at other times.

[3] Alcock, *Ann. Mag. N. H.* (6), x. (1892). For *O. ceratophthalma* see Anderson, *Journ. As. Soc. Bengal*, LV. (1894).

genus, is used, in *O. macrocera* at least, to warn out intruders. They differ somewhat in construction with the age of the inhabitant. The full-grown crab, of the sage-green and yellow coloration, makes a hole two or three feet deep with a spiral inclination of about one and a half turns either to the right or to the left indifferently. The burrow grows smaller from above downwards and, in the largest examples, has at the top a sort of vaulted chamber excavated in the sloping beach and leading downwards on one side into the spiral. In this chamber the crab may sometimes be seen sitting. The younger individuals, of a paler, whitish tint and with undeveloped horns on the eyestalks[1], make tubular holes at right angles to the surface of the sand and usually curving to one side or the other at the bottom—the beginning, perhaps, of the spiral of older individuals. There is often a small second opening to these burrows, which thus become roughly U-shaped. When an attempt is made to dig out the crab, it escapes by the smaller opening if one be present. If not, it makes a bolt to get out past the intruder. The larger individuals usually prefer to retire to the bottom of the hole and fight it out.

In digging its burrow, the crab brings up armfuls of sand between the chelae and the body, and throws it away at some little distance from the opening, thus making a low mound, and of course burying any object that may have been there. This process being repeated twice a day by a large number of crabs, a very considerable amount of sand is thus turned over[2], and the burrowing of these creatures must tend in the long run to the same end as that of earthworms—namely to the gradual sinking of any object originally lying on the surface to the level of the bottom of the burrows. That this really happens is shown by the fact that, in digging through the sand, one comes across objects that must have originally lain on the surface, and are now sunk to varying depths. This is the case not only with coral stones but with leaves, sticks, etc., often fresh and of recent burying at a considerable depth. In this connection it must, of course, be borne in mind that the food of the crabs consists largely of leaves and seaweed, which they are in the habit of carrying with them into their burrows[3]. They do not, however, do this with sticks, and a large mass of mammalian dung, found intact at a depth of about a foot in the sand, points to the same conclusion as the sticks. The larger holes reach a layer of coral pebbles interspersed in places with twigs, but in one locality Mr Stanley Gardiner found a mass of decaying vegetable matter containing earthworms. This probably consisted largely of material carried by the crabs to the bottom of their burrows for food.

It is possible that, in addition to their vegetable food, these crabs may be in the habit of catching and eating sandhoppers in the same way as *C. arenaria* (Catesby)[4]. I have not been able to see them do this, but some small individuals, shut up in a bottle with some sandhoppers and a little sand, caused the Amphipods to disappear in the course

[1] These horns, from which the species takes its name, are, of course, well known to be of very variable length in the adult.

[2] I am indebted to Mr Stanley Gardiner for the following figures, which he very kindly obtained for me after my leaving the Island. "Observations in 14 places between Lighthouse and west end of island. Lagoon shore. In areas of 5 sq. yds., greatest number 28 holes; least 2; average 14—15; sand thrown out twice in 25 hrs. Weight of sand from 12 large holes 19 lbs. 3 ozs.; average weight 9—10 ozs. Positions selected quite at random, at too great a distance to allow me to see whether they contained any holes or not."

[3] One or two leaves or pieces of seaweed may often be found in the burrows, but I have never come across anything like a lining of these materials. The destruction of the burrows by the tide would probably prevent this.

[4] S. I. Smith, cited by Stebbing, "Crustacea," p. 86, London, 1893.

of a few hours. The Ocypodes appear to find their food by sight, rather than by smell like *Coenobita*.

ii. *Ocypode cordimana*, Desm.

While it is alive, this crab is easily distinguished from *O. ceratophthalma* by its darker and more brownish colour, but when preserved in spirit it takes on much the same dull greyish-green hue as the other species. The two are, however, always quite easily separated by the absence, from *O. cordimana*, of the stridulating apparatus found in *O. ceratophthalma* as in all the rest of the genus. Their habits are also considerably different. Unlike the strand-haunting *ceratophthalma*, *cordimana* lives inland, digging its burrows in the light sandy soil along the paths and open spaces of the island. Instead of being directed downwards, these burrows usually take the form of more or less horizontal galleries with two, or sometimes three, openings. I have not found leaves, seaweed or food of any sort in those that I have opened, but they run among the roots of the vegetation and these may perhaps serve for food.

Two points of interest are raised by the facts just mentioned. In the first place it is worth remarking that the darker colour of *O. cordimana* harmonises better with that of its earthy environment than would the sandy hues of *O. ceratophthalma*. In the second, the existence of a species whose burrows are situated on land, well above the tide-mark, invalidates the conclusions, as to the raising of the land in Diego Garcia, drawn by Bourne[1] from the presence of Ocypod-holes in certain situations there. The form of these holes would have to be carefully investigated before any such conclusions could be drawn from them.

III. A list of land and fresh water Crustaceans collected in the Maldive Islands.

I am indebted to Mr Stanley Gardiner for the notes incorporated in the following list.

BRACHYURA, CATOMETOPA.

Family **Ocypodidae**. Genus *Ocypode*, Fabr., 1798.

1. *Ocypode ceratophthalma* (Pallas), 1772.

For references, see above, p. 67.

Generally distributed throughout the group.

2. *Ocypode cordimana* Desm., 1825.

For references see above, p. 67.

All the larger islands of the group except in Suvadiva and Addu atolls.

Genus *Uca*, Leach, 1815.

3. *Uca annulipes* (H. M.-Edw.), 1837.

Gelasimus annulipes, H. M.-Edwards. Crust. II. p. 55, pl. XVIII. figs. 10—13 (1837); Alcock, As. Soc. Bengal LXIX. ii. 3, p. 353 (1900) [references].

Uca annulipes, Ortmann, Zool. Jahrb. Syst. X. p. 355 (1897).

Mangrove Swamp, Furnardu, Miladumadulu atoll.

[1] Bourne, *P. R. S.*, vol. 43, p. 445 (1888).

Family **Grapsidae**. Genus *Geograpsus*, Stimps., 1858.

4. *Geograpsus grayi* (H. M.-Edw.), 1853.

For references see above, p. 67.
In every inhabited island of the group.

Genus *Metasesarma*, H. M.-Edw., 1853.

5. *Metasesarma rousseauxi* H. M.-Edw., 1853.

For references see above, p. 68.
General distribution throughout the group in damp land, especially at dry edges of mangrove swamps. Not found in Addu atoll.

Family **Geocarcinidae**. Genus *Cardiosoma*, Latr., 1825.

6. *Cardiosoma carnifex* (Hbst) 1794.

Cancer carnifex, Herbst, "Krabben" II. v. p. 263, Pl. XLI. figs. 1, 2 (1794).
Cardiosoma carnifex, Alcock, As. Soc. Bengal, LXIX. ii. 3, p. 445 (1900) [references].

Of general distribution throughout the northern atolls. Especially common in Miladumadulu and Mahlos. Generally makes its burrows under coconut trees at the edges of *kuli* or swamps, the openings being often covered at high tide. Not found in Addu atoll.

ANOMALA, PAGURINEA.

Family **Coenobitidae**. Genus *Coenobita*, Latr., 1826.

The distribution of this genus in the Maldives is somewhat peculiar. In nearly every island one species at least is found, but it is rare to find three. Two are frequently met with in the same island, and *C. rugosus* is the most common. In Goidu all four are met with, and Hulule, Male, has *perlatus, rugosus* aud *clypeatus*.

7. *Coenobita perlatus* H. M.-Edw., 1837.

For references see above, p. 68.
Of general distribution throughout the group.

8. *Coenobita rugosus* H. M.-Edw., 1837.

For references see above, p. 68.
Of general distribution throughout the group.

9. *Coenobita compressus*. Guérin, 1830.

Coenobita compressa Guérin, Voy. "Coquille," II. 2, p. 29 (1830).
Coenobita compressus, Ortmann, Zool. Jahrb. Syst. VI. p. 318 (1892) [references].
Goidu, and probably elsewhere.

10. *Coenobita clypeatus* Latr., 1826.

For references see above, p. 68.
Of general distribution throughout the group.

CARIDEA.

Family **Palaemonidae**. Genus *Leander*, Desm.

11. *Leander debilis* (Dana), 1852.

Palaeman debilis, Dana, U.S. Expl. Expd., Crust. I. p. 585, Pl. XXXVIII. figs. 6, 7 (1852).
Leander debilis, Ortmann, Zool. Jahrb. V. Syst. p. 515 (1890) in part.

Ortmann (*loc. cit.*) included under this species, as varieties, several other Leanders described by various authors. Among these was *L. longicarpus*, Stimps, 1860, which has since been identified by de Man and Coutière with *L. concinnus* Dana, 1852. The present collection contains examples of a form allied both to *L. debilis* and to *L. concinnus*, though more closely to the former than to the latter. In fact the points of difference between the preserved specimens would certainly be sufficiently small to justify their inclusion in a single species were it not that they exhibit considerable differences in colour and habitat. For notes on these I am indebted to Mr Gardiner.

The present species has 6—9 teeth on the underside of the rostrum and 4—6 above, and the carpopodite of the second leg just reaches the end of the antennal scale. Its size is rather greater than that of *L. gardineri.* When alive it is colourless, but has eggs of a brilliant dark green.

The only locality in which it was found in the Maldives was a kuli surrounded by a mangrove swamp in Landu, Miladumadulu atoll. It was here few in numbers and solitary in its habits.

12. *Leander gardineri*, n. sp.

Under the rostrum of this species are 4—6 teeth, and above it 5—6. The second leg of full grown individuals is longer than in *L. debilis* and its carpopodite exceeds the antennal scale. The size is less than that of *L. debilis*, the largest specimen being 33 mm. in length. The third flagellum of the antennule resembles that of *L. debilis*, and not *L. concinnus*, in being free for less than half its length. The colour is intermediate between straw and brown, the eggs being of a darker shade of the same; the branchiostegites a silvery-white.

This prawn was found in enormous numbers at the edges of a large fresh-water kuli in Ekasdu, Miladumadulu atoll. Both it and the former species are thus of interest in that, contrary to the usual habits of the genus, they live in fresh water. The allied *L. concinnus* lives indifferently in fresh, brackish or salt water.

ISOPODA, ONISCOIDEA.

Family **Ligiidae**. Genus *Ligia*, Fabr., 1798.

13. *Ligia exotica* Roux, 1828.

Ligia exotica, Roux, Crust. Médit. III. Pl. XIII. fig. 3 (1828).

Fairly common throughout the group on boats, ships, wharves, etc. At Mahugudu, Miladumadulu atoll, extremely common all round the shores of the island on the rocks. The specimens from the latter locality are somewhat smaller than those from other places in the group or than those met with in Ceylon or Minikoi, and their colour is different, consisting of a white ground covered with microscopic dark spots, giving a greyish appearance unlike the uniform dark green of typical specimens. Possibly this is due to a state of contraction of the chromatophores at the time of capture. It may be, however, that we have here a local variety of the species.

Family **Oniscidae**. Genus *Porcellio,* Latr., 1802.

14. *Porcellio maldivensis,* n. sp. (fig. 22).

Definition:—A *Porcellio* with the body oblong-oval, rather more than twice as long as broad, not very convex, covered with large granules; lateral lobes of front moderate, rounded, anterior border of the same not much produced in the middle; hinder edge of first free thoracic segment curved forwards at the sides, that of the second less so, that of the third transverse; on the fourth a backward trend appears and grows increasingly strong till the seventh is reached; hinder angles of first three segments rounded, of fourth rectangular, of fifth to seventh acute; antennae rather more than half the length of the body, the two joints of the flagella equal; epimera of third, fourth and fifth abdominal segments of moderate size, very acute; somewhat adpressed; anal ring long, narrow, very acute, projecting well beyond the epimera of the fifth abdominal segment.

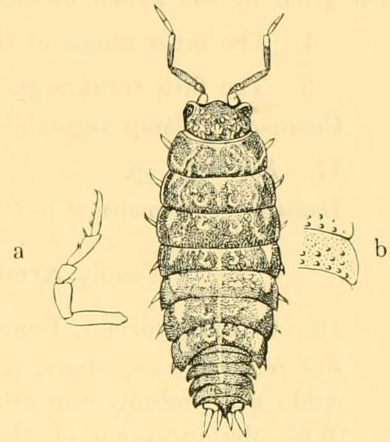


FIG. 22. *Porcellio maldivensis* (×8). *a.* Leg enlarged. *b.* Portion of segment enlarged to show sculpture.

Colour in spirit: brown mottled with yellowish; legs yellowish.

Length of longest specimen 6 mm.

This species seems somewhat transitional to *Metoponorthus.*

Mafaro, Miladumadulu atoll, under damp leaves.

Genus *Alloniscus,* Dana, 1854.

15. *Alloniscus maldivensis,* n. sp. (fig. 23).

Diagnosis:—An *Alloniscus* with the body oval and convex; the antennae not quite half the length of the body, the first two joints of the flagellum subequal, the third somewhat longer; the hinder margin of the first trunk segment curved forwards, those of the second and third transverse, that of the fourth slightly recurved at the sides, that of the fifth more strongly so, those of the sixth and seventh bent backwards sharply at an obtuse angle; the epimera of the third, fourth and fifth abdominal segments moderately large, acute and subequal; the end segment nearly twice as broad as long, triangular, acute, its sides slightly concave.

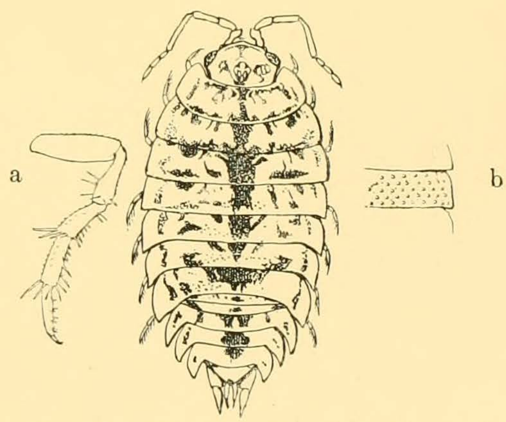


FIG. 23. *Alloniscus maldivensis* (×6). *a.* Leg enlarged. *b.* Portion of segment enlarged to show sculpture.

Colour in spirit: yellow marbled with black. Legs yellow with a few black spots.

Length of longest specimen: 3·5 mm.

Hedufuri, Mahlos atoll, under stones at edge of well.

Genus *Philoscia*, Latr. 1803.

16. ? *Philoscia gracilis*, Budde-Lund, 1879, var.

The collection contains specimens of a *Philoscia* taken in several different localities, but unfortunately all more or less damaged. They are at all events allied to *P. gracilis* (Budde-Lund Prosp. 2, 1879, and Isop. Terrest, p. 220, 1885), but differ from the description given by the author of that species in the following points:

1. The inner ramus of the uropod, though well-developed, is shorter than the outer.
2. The fifth trunk segment is no darker in colour than the rest.

Common in damp vegetable matter throughout the group, from Mahlos to Addu atoll.

17. *Philoscia*, sp.

Damaged specimens of a *Philoscia* from Hedufuri, Mahlos atoll.

Family **Armadillidiidae**. Genus *Cubaris*, Brandt, 1833.

18. *Cubaris murinus*, Brandt, 1833.

For references see above, p. 68.

Addu and probably also other atolls.

With the exception of the new species, all the above crustaceans are Indo-Pacific in distribution. The only feature of interest in this respect exhibited by the collection is the absence from Addu of several species found in the more northern atolls.