THE NEMERTEAN PARASITES OF CRABS.

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IN 1844 Kölliker found a small species of nemertean among the egg masses carried about on the abdominal hairs of a "small crab" at Messina. This worm he named *Nemertes carcinophilos*[1] and gave a fairly good description of its anatomy ('45). Fifteen years later van Beneden found a similar species among the eggs of the green crab (*Carcinus mœnas*) on the coast of Belgium and, having overlooked Kölliker's descriptions, redescribed and figured it as *Polia involuta* ('61). The worms were said to be small, slender, yellowish or rosy in color, with two ocelli and a very short proboscis, armed with central stylet only. They lived in delicate mucous sheaths among the crab's ova, and often two individuals — a male and a female — lay side by side, or with their bodies somewhat folded, in the same tube. Van Beneden decided that the worm was not a true parasite, but rather that it merely occupied the egg masses of the crab as convenient places for building its tube and depositing its ova, as well as a place well protected and furnished with food. The females were 2–3 cm. in length, although the males measured scarcely 1 cm. Some of the younger individuals were only 2 mm. long. There are figures showing the form and color of the living worms, several of anatomical details, of the eggs in various stages of development, and of the early embryos before and after the molting of the larval skin. These figures are generally accurate, as is also the interesting account of the development. The large nerves passing forward from the dorsal ganglia are described as excretory canals opening on the lateral margins of the head, although the author states that they *seem* to be a continuation of the ganglia. The

[1] Spelled *cartinophilos*.

ciliated canals leading from the cerebral sense organs were in other species of nemerteans looked upon as excretory canals. The figures of the proboscis with its single central stylet and large glandular masses on each side are quite characteristic.

McIntosh ('73) gives a good description of the general anatomy of this species and an interesting account of its behavior in confinement, as well as the method of deposition of its ova. He also briefly describes the segmentation of the egg and gives several figures of the developing embryos. There is a good colored drawing of the living worm and figures illustrating the anatomy of the anterior portion of the body and of the proboscis, all of which are described in detail.

In 1874 Dieck ('74) found at Messina (where Kölliker's specimens of *N. carcinophilos* were obtained) a number of nemerteans among the egg masses of *Galathea strigosa*. But Dieck's description does not apply to any of the metanemerteans, and the species was named *Cephalothrix galatheæ*. The species agrees fully with Kölliker's *N. carcinophilos* in size, form, and color of body, in not having the head demarcated from body, in having two comma-shaped eyes in front of the ganglia, and in the absence of cerebral sense organs and cephalic furrows. In all these respects the description exactly corresponds with that of *N. carcinophilos*, but Dieck describes certain other anatomical peculiarities which separate the two forms widely, and certain others which have been found in no other nemertean. The proboscis is described as being without stylets, and the mouth is said to lie behind the brain. Dieck further describes remarkable appendages on the head which are believed to aid the worm in retaining its position on the crab. These "fingerförmige Greif oder Haftorgane . . . sind so contractil, dass sie nur bei starker Ausdehnung deutlich ins Auge fallen" ('74, p. 502); but he shows no indication of them in any of his figures. It seems possible that they may have been formed by a too severe pressure on the glass covering the worms, and thereby rupturing the integument. Dieck thinks he may have seen similar appendages on the posterior end of the single male which he found, but he could not be certain whether he saw them or not.

He also describes the ovarian pouches as opening ventrally, and states that their external openings are provided with contractile lids which serve to close the openings, except when the ova are being extruded. Both Dieck and van Beneden speak of the minute white specks seen on the bodies of the females with ripe ova, while Dieck's observations on the appearance of the egg strings, the eggs themselves and their early development, as well as the appearance and peculiarities of the embryos, answer equally well for Kölliker's species; and, finally, his statement that the worms, after having devoured the eggs of the crab, find their way to the gills, where they live as ectoparasites, is in perfect accord with the observations on *carcinophila* described below, although his interpretation of the life history of the worms seems to be in error.

While it would be unwarranted to say that Dieck's descriptions of the anatomy of his *Cephalothrix galatheæ* are incorrect in so far as they do not agree with the structures found in Kölliker's species, yet it would seem most remarkable if there were to be found in the same locality two species of nemerteans belonging to entirely different orders which agree so perfectly in color, size, external appearance; in possessing the same peculiarities in regard to the ocelli, structure of body walls, mucous glands, and other features; in having the same peculiar habits due to a parasitic life; in laying eggs which have the same appearance and mode of cleavage, and which in their development give rise to perfectly similar embryos. Likewise remarkable among the nemerteans, although it is known in a few forms, is Dieck's observation that while most of the eggs are laid before cleavage, yet fertilization and early cleavage sometimes take place within the body of the parent. McIntosh states that this is also true in *N. carcinophila*. It should be noted in this connection that Dieck found but a single male, which was 2 cm. in length, although the females were abundant and of much larger size, some of them being as much as 7 cm. in length. He considered it probable that the sperm from a single male entered the ovaries of all of the five or six females which might live on the same crab.

Whether the species described by Kölliker, van Beneden, and McIntosh will prove to be widely different, closely related, or identical with that studied by Dieck, future investigations must decide. Suffice it to add that Dieck was quite unacquainted with the descriptions of any of the other authors mentioned, and believed that he was describing a crab parasite for the first time. He shows by his descriptions that he knew very little of nemertean anatomy, and this fact might easily account for the strange anatomical peculiarities which he found the worms to possess. Careful comparison of his figures with those of van Beneden ('61) and McIntosh ('73) reveals such slight differences that we may well consider them as belonging to the same species; that they represent worms of different *orders* seems incredible.

Joubin ('93) has found Kölliker's species abundant on *Carcinus mœnas* at Roscoff, on the northern coast of France, and Giard ('88), on the coast bordering the Bay of Biscay, on the same species of crab. Giard (p. 496) found these worms on almost every crab examined which carried eggs, and has observed the same or a very similar species on *Xantho floridus*. This he calls *Polia xanthophila*, but gives no distinguishing peculiarities except that it is smaller in size.

On the *Challenger* Expedition Willemoes-Suhm ('74) found a small species of nemertean on the body of a species of crab (*Nautilograpsus minutus*) which lives on the gulf weed in the "Sargasso Sea," between Bermuda and the Azores. These little worms were only about 1–2 mm. long, but none of them were sexually mature. The suggestion was made that the nemertean inhabits the crab only when young, and that it lives freely on the gulf weed when mature. This form agrees with the other species of Carcinonemertes in possessing two large ocelli, although there is said to be a pair of accessory ocelli of extremely minute size near the proboscis. These are represented in the figure ('74). It is intimated also that the mouth lies behind the brain. The color of the worms was brownish. The stylet lies just back of the brain, and the proboscis is very short. The figure shows indications of two pouches of accessory stylets, although these are not mentioned in the

descriptions. Some of the worms are said to be found on various parts of the crab's body, being most abundant on the abdomen, but the gills are not mentioned. An account of this species is given also in the *Narrative of the Cruise of the Challenger*" (Vol. I, p. 169) and is reproduced in Hubrecht's report on the nemerteans ('87).

A further instance of a nemertean parasitic on Crustacea is mentioned by Quoy and Gaimard ('33), who describe from Amboina a small species, apparently belonging to the genus Tetrastemma, under the name of *Borlasia quadripunctata*. They state that although it usually lives in the sea, yet it is also found at times living in the barnacle (Anatifa).

So far as I know, the first observations of a nemertean parasite of the crab in this country are those by Prof. J. P. McMurrich, who writes me that he found the worms quite numerous among the egg masses attached to the abdominal hairs of a "lady crab" (*Platyonichus ocellatus*), July 6, 1889. These worms laid several strings of eggs in the manner characteristic of the species. The eggs developed normally, as described by van Beneden ('61), McIntosh ('73), and Dieck ('74).

I first found this nemertean on the gills of the lady crab at North Dennis, Mass., situated on Massachusetts Bay, Aug. 6, 1898, and have since found it abundantly in other regions south of Cape Cod.

The gills of a single crab often harbor as many as forty to sixty of these worms, which are of small size and sexually immature when found in this position, becoming full-grown and sexually mature only when living among the crab's ova. As found on the gills the worms vary in color from pale ocher to salmon, depending largely on the coloration of the intestinal canal. They are of all sizes up to about 15 mm. in length when extended and very slender — almost threadlike. The body is of about the same diameter throughout and is often folded once or twice on itself as it lies between the gill plates of the crab, imbedded in considerable mucus. The crab's gills are sometimes undoubtedly injured by the abundance of the worms, so that I am almost sure that the latter feed upon the blood in the gills. This was also Dieck's conclusion in regard to his

Cephalothrix galatheæ, where he believed that he found the crab's blood corpuscles within the intestinal canal of the worms.

In many of the crabs on which I found only a small number of the parasites no injury to the gills was apparent, the ability on the part of the crab to repair its injured tissues being sufficient to prevent the gills being destroyed. When the worms were abundant, however, some of the gill plates were blackened, torn, and degenerated.

A large number of lady crabs obtained from Woods Hole and Martha's Vineyard, Mass., in July and August, 1900, were examined, and the parasitic nemerteans found in the gills in about one-tenth of the number. When present on one side of the body they were almost always found on the other side also. I found them only on female crabs, and did not find them in the gills when the crabs were carrying eggs. The worms cling tenaciously to the gills when these are removed from the crab. A gill cut from a crab and placed in a dish of sea water is not deserted by its parasites for several days, — or not until it decomposes. When forcibly removed from the gills the worms live several weeks in sea water, crawling sluggishly about, and often collecting in masses with their bodies placed lengthwise or folded sharply so that the anterior portion of the body lies parallel and in contact with the posterior portion, exactly as when living in the gills. Masses of them often collect on the surface of the water where it comes in contact with the sides of the vessel.

They secrete a very sticky mucous covering and when touched with a needle or drawn into a pipette attach themselves to it with exasperating tenacity. After living several weeks without food the worms become much smaller than when first collected.

Several dozen spider crabs (*Libinia canaliculata*), some of which carried eggs, a number of blue crabs (*Callinectes hastatus*) with eggs, and many rock crabs (*Cancer amœnus*) and green crabs (*Carcinus mœnas*) without eggs were examined without finding any nemerteans. I quite expected to find them on the green crab because this is the same species as that on which they are so abundant in Europe. When a green crab is placed in a vessel containing the worms, these will crawl over the crab's

body, and a portion of them will be found among the gill plates after twelve to thirty-six hours, but many more remain clinging to the crab's legs. Their behavior to lady crabs, however, — males as well as females, — is quite different, and they quickly find their way to the gills. The few rock, spider, and blue crabs with which I experimented in this way did not prove attractive to the worms, although occasionally one of them would enter the gills. Far more of them remained attached to the basal joints of the legs for several days.

Sexually mature worms may be found early in July (and probably also in June) on the lady crabs carrying eggs. But the crabs with eggs are shy or else frequent deeper water, so that I did not find them nearly so abundant in the localities noted as were the males and smaller females without eggs.

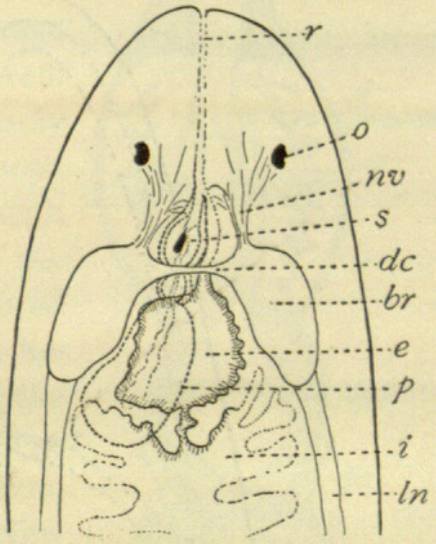

FIG. 1. — *Carcinonemertes epialti.* Anterior portion of body of living worm seen from dorsal surface. Slightly diagrammatic. *r*, rhynchodæum; *o*, ocellus; *nv*, nerve from dorsal ganglion supplying ocelli and other organs of head; *s*, central stylet; *br*, brain; *dc*, dorsal commissure of brain; *e*, œsophagus; *p*, posterior chamber of proboscis; *i*, intestine; *ln*, lateral nerve. × 80.

All my observations on the species seem to indicate that the worms spend their whole existence on the crab, for I have found them in nearly all stages of development from the egg to the sexually mature worm. I have not, however, followed their history during the winter months, but suspect that this time is occupied as a period of slower growth.

The worms apparently occupy nearly a year in attaining sexual maturity, and their life history is briefly as follows: Eggs laid in mucous tubes among the egg masses of the crab in June and July; cleavage regular and nearly equal, with the formation of free-swimming ciliated blastula which develops into a ciliated embryo provided with ventrally placed mouth, a pair of ocelli, and an anterior and a posterior flagellum, or tuft of much longer, consolidated cilia. The embryo leaves the egg membrane in this condition and usually remains in the mucous tube or among the egg masses of the host, but may swim freely

in the water. The larval integument with its cilia and flagella is apparently shed, as described by van Beneden ('61) and Dieck ('74). At this time the embryos assume the form of the adult and crawl about instead of swimming. The integument of the young worms now becomes covered with cilia, as in the adult. After remaining for a time among the egg masses of

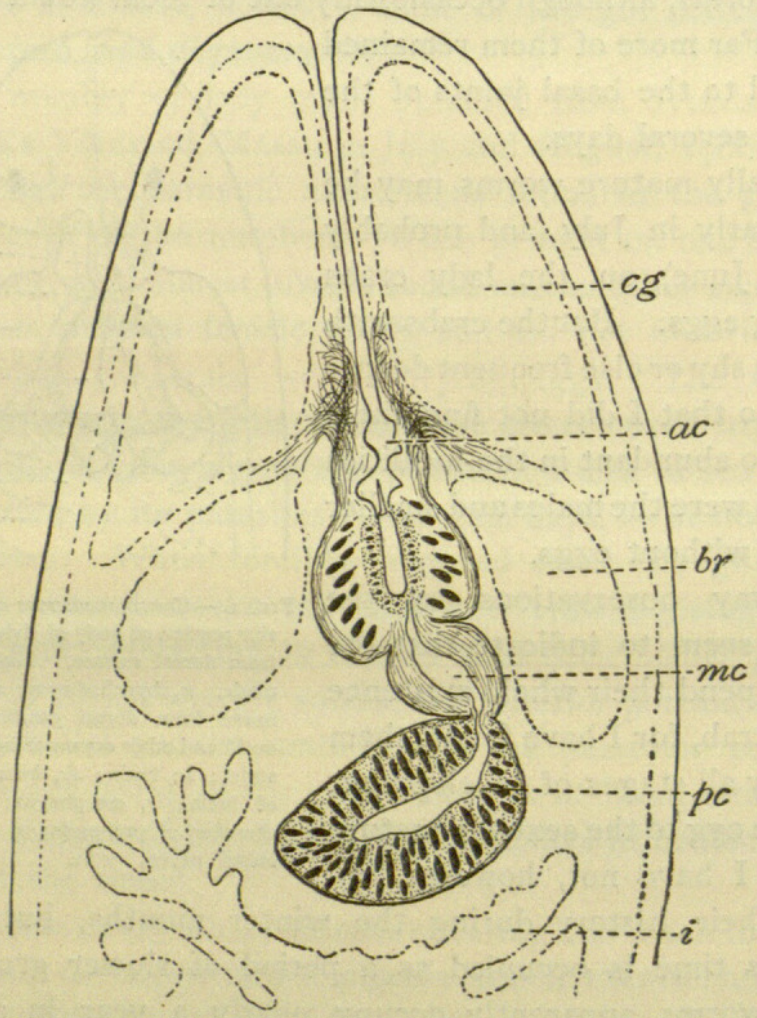

FIG. 2. — Horizontal section through anterior portion of body of *C. epialti*. Slightly diagrammatic, and the proboscis is represented a trifle too large. *cg*, outline of area occupied by cephalic gland; *ac*, *mc*, *pc*, anterior, middle, and posterior chambers of proboscis respectively; *br*, brain; *i*, intestine. × 150.

the host, or perhaps until her eggs have hatched, they wander about on her body, eventually reaching the gills. They are found in this position in July or August, and later, and here they probably remain until the crab produces another batch of eggs the following season. At this time they migrate again to the egg masses, where they become sexually mature. Those

embryos which swim away and which do not chance to find another suitable crab probably perish. The observations of the European writers mentioned above are mainly in accord with the account as here given.

The mature worms often become 25 mm. or more in length, are generally bright reddish orange in color, but some are reddish ocher and others brick red.

Their anatomical details agree closely with such descriptions of the European species as have been given, although these descriptions refer mainly to the external features. McIntosh's colored drawing (Pl. I, Fig. 5) of the worm, his figures of the anterior portion of the body and of the proboscis, as well as his detailed description of these parts, agree in most respects with the New England form, except that I find the posterior, glandular portion of the proboscis (Figs. 2–4, 6) much shorter than McIntosh represents. Yet it seems highly probable that such differences as appear to exist are largely accidental, and that the New England form is specifically identical with Kölliker's *Nemertes carcinophilos*. Joubin ('93) also gives a colored figure of the worm as it lies folded in its mucous sheath among the egg masses of the crab.

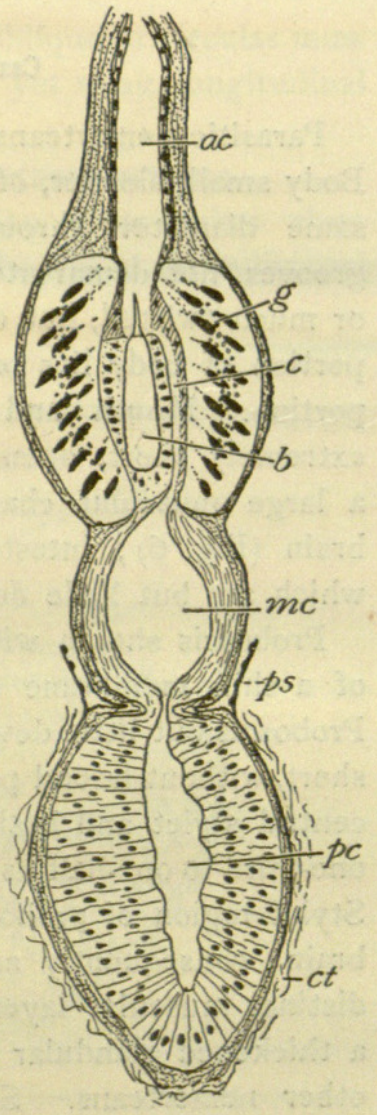

FIG. 3. — *Carcinonemertes epialti.* Optical section of proboscis removed from the worm. *ac*, *mc*, *pc*, anterior, posterior, and middle chambers respectively; *g*, gland cells; *c*, canal connecting anterior and middle chambers; *ps*, remnants of proboscis sheath attached to posterior chamber; *ct*, connective tissue in which posterior chamber is imbedded; *b*, basis of central stylet. × 300.

In internal organization the worms agree closely with a second species which I found abundantly on the gills of another species of crab (*Epialtus productus*) at Monterey, California, and which is described in detail below.

Both the Atlantic and the Pacific forms show such wide deviations from all other species of the genus Eunemertes, in

which Kölliker's form has been placed by Joubin, Bürger, and others, that the establishment of a new genus is imperative.

Carcinonemertes gen. nov.

Parasitic nemerteans living on various species of Crustacea. Body small, slender, often filiform, rounded, and of about the same diameter throughout; head without distinct lateral grooves, not demarcated from body. Body not usually coiled or much twisted, but often folded sharply so that the anterior portion of body lies parallel and in contact with the posterior portion. Mouth and proboscis open together; œsophagus extremely short, opening broadly into the intestine through a large muscular chamber situated immediately behind the brain (Fig. 6); intestine broad, with short lateral pouches which are but little developed in posterior portion of body.

Proboscis sheath without muscular walls, consisting merely of a thin membrane closely applied to the small proboscis. Proboscis but little developed, very small in size, and extremely short, without lateral pouches of reserve stylets, but armed with central stylet and basis only. Central stylet minute, usually one-third to one-half as long as basis, which is small and slender. Stylet region of proboscis can be withdrawn but little behind brain; consequently anterior chamber is very short, without distinct muscular layers, without distinct nerves, and without a thickened glandular epithelium such as occurs in almost all other nemerteans. Stylet apparatus imbedded in a strong muscular enlargement provided with numerous large glands (Figs. 2–4). Chamber immediately behind stylet, small but muscular, and with a lining of flattened epithelium, while the posterior proboscidial cavity is very short, often almost spherical, highly glandular, connected closely with the rudiments of the proboscis sheath and imbedded in the connective tissue which lies internal to the body musculature.

Cerebral sense organs probably wanting. Ocelli 2 (occasionally fragmented into 4).

Cephalic glands massively developed; a remarkable development of submuscular glands extends throughout the whole

length of the body, usually forming a distinct layer internal to the muscular walls of the body, and often thicker than all the other layers of the body wall combined.

Body musculature consists of a thin, oblique or circular muscular layer and a somewhat thicker, but yet weak, longitudinal layer internal to the former.

Brain and lateral nerves as in other metanemerteans.

Usually oviparous, though fertilization often takes place internally, and sometimes a portion of the ova of an individual

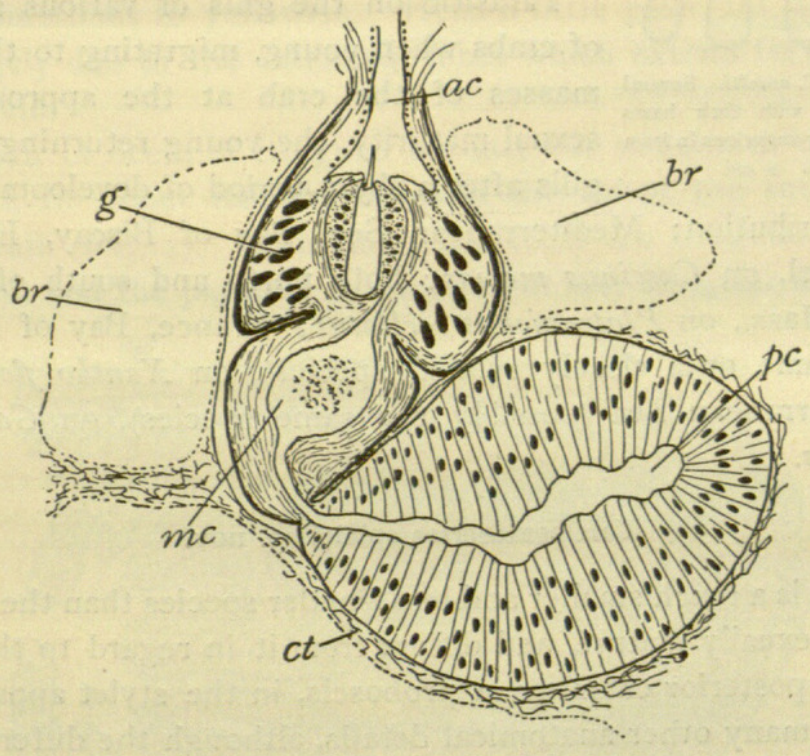

FIG. 4. — *Carcinonemertes epialti.* Horizontal section of proboscis in its natural position, showing the posterior chamber lying at right angles to the general axis of the proboscis. Reference letters as in Fig. 3. × 300.

may be retained in the body until the development of free-swimming embryos. Development without complicated metamorphosis, although the layer of ciliated cells originally covering the embryo is shed as development proceeds.

Carcinonemertes carcinophila (Kölliker).

Body slender, commonly 6–15 mm. long when found on gills, 20–70 mm. long when sexually mature; color yellowish orange,

pale reddish, rose pink (McIntosh), or bright brick red; posterior proboscis chamber very small, rounded; in ordinary states of contraction central stylet lies immediately behind brain. Basis of central stylet slender, about .025–.03 mm. in length by .006–.008 in average diameter. Central stylet about .008–.012 mm. long, or between one-third and one-half as long as basis. In general anatomical features the species closely resembles *C. epialti*, which is described in detail below.

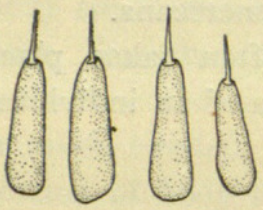

FIG. 5.—*C. epialti*. Several stylets, with their bases showing variations in form and size. × 400.

Parasitic on the gills of various species of crabs when young, migrating to the egg masses of the crab at the approach of sexual maturity, the young returning to the gills after a short period of development.

Distribution: Mediterranean Sea, Bay of Biscay, English Channel, on *Carcinus mœnas;* both north and south of Cape Cod, Mass., on *Platyonichus ocellatus;* France, Bay of Biscay (the same or a closely related species), on *Xantho floridus;* Mediterranean Sea (possibly the same species), on *Galathea strigosa.*

Carcinonemertes epialti sp. nov.

This is a much smaller and less slender species than the above when sexually mature, and differs from it in regard to the size of the posterior chamber of proboscis, in the stylet apparatus, and in many other anatomical details, although the differences, as will be described below, are not very considerable.

In general appearance, in color, arrangement of ocelli, œsophagus, intestine, and brain the two species are very similar. *C. epialti* also lives when sexually mature among the egg masses of a crab — in this case *Epialtus productus*, the common kelp crab of the California coast.

Upwards of one hundred of these little worms were found among the eggs of a single crab at Monterey, Cal., Sept. 3, 1901. In practically all, the sexual products were nearly mature, but no eggs were laid in confinement. The worms lived only a few days in a dish of sea water and appeared less hardy than the species on the Atlantic coast. I was unable to determine

whether the worms pass their early life on the gills of the crab, as does *C. carcinophila*, but suspect that this may be the case.

The species may be described in detail as follows: Body small, rounded, slender, of the same diameter throughout; sexually mature individuals about 4–6 mm. in length and less than half a millimeter in diameter; head not demarcated from body; lateral grooves and cerebral sense organs very inconspicuous or wanting.

Color, bright orange, sometimes inclining more to reddish and sometimes to yellowish. Head a little paler, for the color is largely due to the intestinal lobes which extend forward to the brain.

A pair of ocelli of irregular outline, but sometimes crescent shaped, lie about halfway between the tip of the snout and the brain (Fig. 1). Sometimes the ocelli are irregularly fragmented, and the pigment is arranged in four irregular masses.

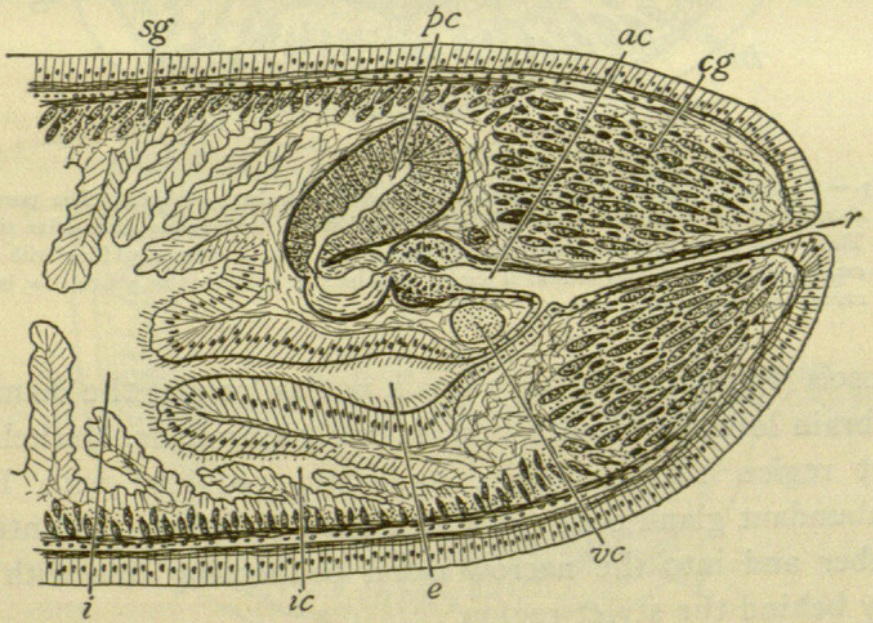

FIG. 6. — *C. epialti*. Oblique section through anterior portion of body. *r*, opening of rhynchodæum; *cg*, cephalic glands; *ac*, *pc*, anterior and posterior proboscis chambers; *sg*, submuscular glands; *vc*, ventral commissure of brain; *e*, œsophagus; *ic*, rudimentary intestinal cæcum; *i*, intestine. × 200.

Proboscis sheath greatly reduced, extending but little posteriorly to the brain, where it becomes united with the posterior chamber of the proboscis (Fig. 3). The sheath consists merely of few fibers of connective tissue supporting a very thin, flattened epithelium, and can be seen only in favorable preparations.

Proboscis very minute and short, extending scarcely more than its own diameter posteriorly to the brain (Figs. 1, 2, 6). Rhynchodæum (Fig. 6, *r*) slender; œsophagus separates from proboscis just in front of brain (Fig. 6). Anterior chamber of

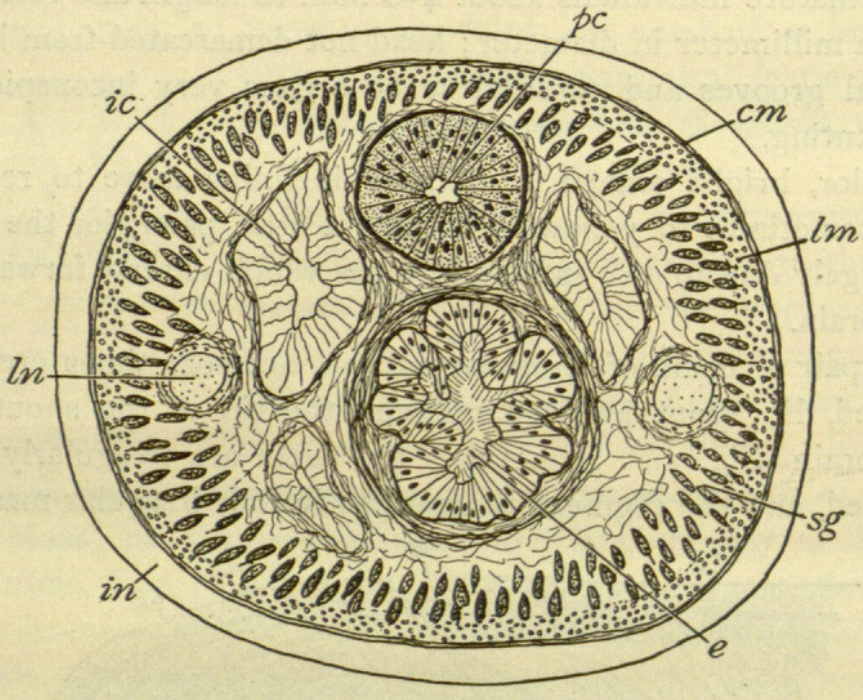

FIG. 7.—*C. epialti.* Transverse section of body immediately back of brain. The posterior chamber of the proboscis (*pc*) is firmly imbedded in the surrounding connective tissue. Three lobes of the very short intestinal cæcum (*ic*) are seen; *e*, œsophagus lined with cilia; *cm*, *lm*, circular and longitudinal layers of muscles; *sg*, submuscular glands; *ln*, lateral nerve; *in*, integument. × 200.

proboscis (Figs. 2, 3, *ac*) very small, not as long as the diameter of a brain lobe, lined with thin, scarcely glandular, epithelium. Stylet region swollen (Figs. 2–4) and provided with large and abundant gland cells (*g*) which open both into the anterior chamber and into the narrow canal connecting this with the cavity behind the stylet region.

Basis of central stylet slender, about three to five times as long as broad (Figs. 3–5), measuring about .027–.033 mm. in length and .005–.008 mm. in diameter. Basis slightly larger posteriorly than at attachment of stylet, often somewhat asymmetrical, as shown in Fig. 5. Stylet rather slender, a little less than half as long as basis, measuring .012–.015 mm. in length. Basis imbedded among the gland cells and surrounding muscles in a single layer of columnar cells with oval nuclei

(Figs. 3, 4) at right angles to its longitudinal diameter. There is no trace of accessory stylets.

The usual small, oval middle chamber lies directly behind the stylet region and connects with the anterior chamber by a canal (Figs. 3, 4) which passes close beside the basis of the central stylet and which, though narrow, is broader than in many other metanemerteans. The middle chamber, behind the stylet, is highly muscular, lined with flattened epithelium, and is often filled with fluid containing an abundance of granules resembling hardened secretions (Fig. 4). These, I think, originate in the posterior chamber as described below.

The proboscis now bends sharply on itself in ordinary states of contraction and ends in an oval chamber with small lumen and very massive glandular walls (Figs. 2–4, 6). The cells lining this chamber are highly columnar, irregularly arranged

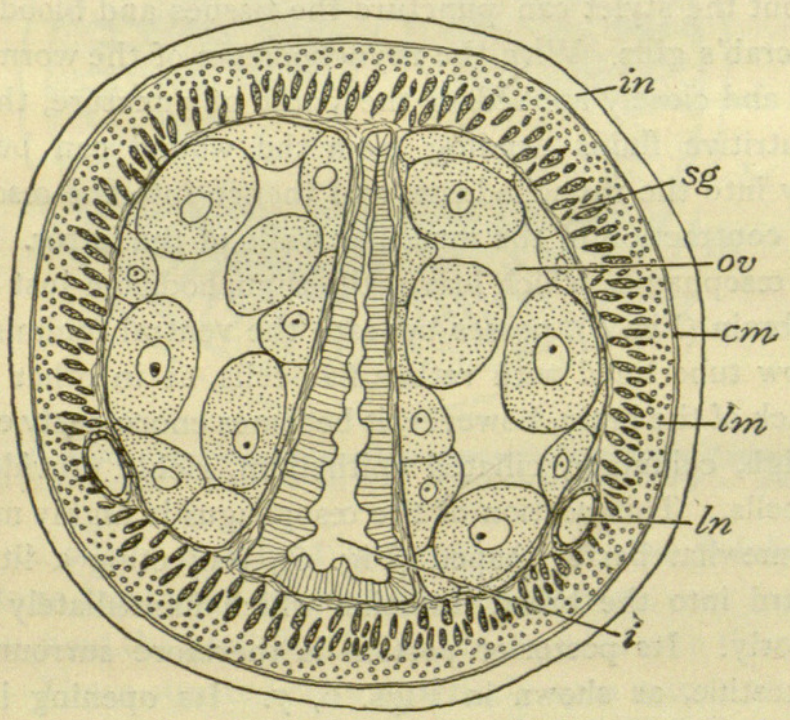

FIG. 8. — Transverse section of body of *C. epialti*, showing the thick layer of submuscular glands (*sg*) and the ovaries (*ov*) with large ova. The intestine (*i*) is reduced to a narrow canal. Other reference letters as in Fig. 7. × 200.

in several layers, and are thickly packed with secretions which have great affinity for ordinary stains. This posterior chamber is closely imbedded in the surrounding connective tissue (Figs. 4, 7), and this appears to be connected with the muscular

walls of the œsophagus. Its movements are doubtless to a great extent dependent on the contractions of the œsophagus, which, as described below, is converted into a sort of muscular pharynx.

The stylet can hardly be moved much beyond the external opening of the rhynchodæum, and from a study of its structure alone it is hard to conceive how it can be moved for even this short distance, imbedded as it is among the other tissues. By crushing and many kinds of stimuli I have seldom been able to cause the worms to move the stylet region to any extent either forward or backward. It nearly always remained in the vicinity of the brain, as shown in the figures. It is my opinion that the proboscis can be everted only far enough to bring the stylet a little beyond the opening of the rhynchodæum on the tip of the snout, as figured by van Beneden ('61), and that the œsophageal muscles aid in this movement. At the tip of the snout the stylet can puncture the tissues and blood vessels of the crab's gills. With the rhynchodæum of the worm widely opened and closely applied to the point of puncture, the blood and nutritive fluids exuding from the wound can be drawn directly into the rhynchodæum and thence into the œsophagus by the contraction of the muscular walls of the latter.

The œsophagus, which leaves the rhynchodæum just in front of the brain (Fig. 6), passes beneath the ventral commissure as a narrow tube lined with rather flat cells, as in other genera. Just back of the brain, however, it becomes enormously enlarged with high, columnar, ciliated epithelium, richly provided with gland cells. This portion of the œsophagus is highly muscular and somewhat barrel shaped (Fig. 6), projecting a little way backward into the broad intestine which immediately follows posteriorly. Its posterior portion is therefore surrounded by the intestine, as shown in Figs. 6, 7. Its opening into the intestine is wide and has thickened lips. The backward and forward motion of this barrel-shaped portion of the œsophagus in all probability aids in the eversion of the proboscis, as well as acts as a suction pump to draw in the nutritive fluids from the crab's gills.

The intestinal lobes surrounding the end of the œsophagus (Figs. 6, 7) indicate rudiments of the intestinal cæca found in

other genera. The intestinal canal is broad, with short lateral pouches which become very much reduced towards the posterior end of the body.

The nervous system shows few deviations from that in related genera. The brain is fairly well developed as shown in Fig. 1. From the dorsal lobes a pair of large nerves (Fig. 1, *nv*) pass anteriorly to the eyes and anterior portions of the head. These are easily seen in living worms. I found no indications of cerebral sense organs either when the specimens were stained

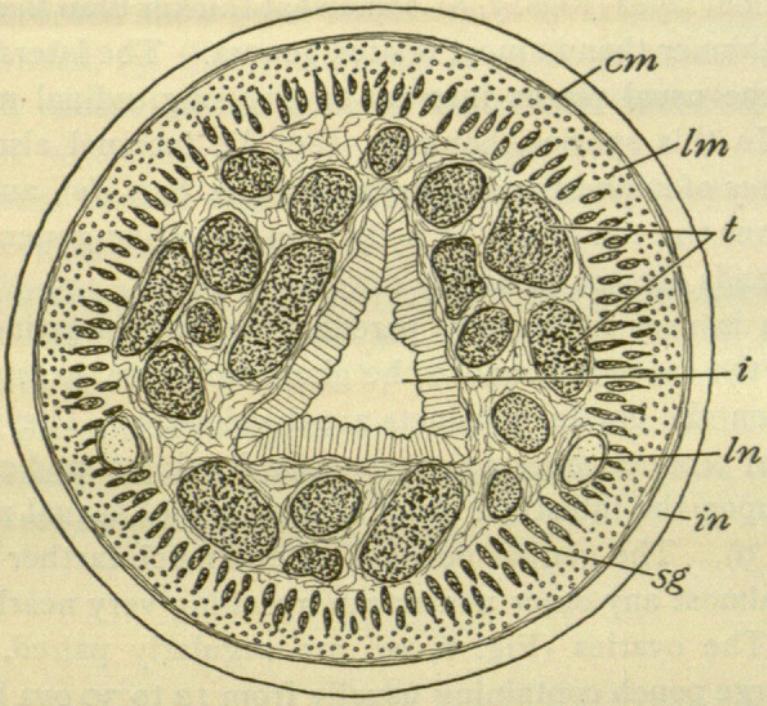

FIG. 9. — *C. epialti*. Transverse section of body showing the large number of spermaries (*t*) and their distribution throughout the body. Reference letters as in Fig. 7. × 200.

in toto or when examined in sections. I also failed in my attempts to locate the efferent nephridial ducts.

Throughout the head the tissues are crowded with the cephalic glands. Those situated more anteriorly open mainly on the tip of the snout (Fig. 6, *cg*), but farther back they open directly outwards on all sides of the body. Back of the brain they pass gradually into the submuscular glands which extend as a distinct layer throughout the length of the body. The glandular cells composing this layer open directly outward to the surface of the body (Figs. 6, 7, 8, *sg*) and are situated on the whole circumference of the body immediately internal to the

longitudinal muscular layer. The glandular layer is in most regions so massively developed that it exceeds in thickness all the other layers of the body wall combined. The secretions of these glands furnish the sticky mucus by means of which the worms cling so tenaciously to the crab or to other objects.

The outer epithelium is as in other genera, and is richly provided with glands.

The muscular layers of the body wall consist of a thin, external circular or oblique layer of muscles and an internal longitudinal layer (Figs. 7, 8), somewhat thicker than the former, but yet thinner than in most related genera. The lateral nerves occupy the usual places internal to the longitudinal muscular layer. In this species, however, they lie internal also to the thick layer of submuscular glands (Figs. 6, 8, 9, *ln*), and therefore nearer the center of the body than in other genera where these glands are not so highly developed.

There is very little body parenchyma, the intestine filling most of the space internal to the glandular layer, except at the time when the genital products are developing. The pouches of genital products become enormously developed and encroach greatly upon the intestinal canal at the time of sexual maturity (Figs. 8, 9). The genital pouches extend much farther forward than in almost any other nemertean, reaching very nearly to the brain. The ovaries (Fig. 8, *ov*) are regularly paired, with a single large pouch containing usually from 12 to 30 ova between each pair of intestinal lobes. The spermaries, on the other hand, are far more numerous, surrounding the intestinal canal on all sides. As many as fifteen or more separate spermaries (Fig. 9, *t*) are sometimes found in a single transverse section. As in most parasitic animals the abundance of sexual products is greatly in excess of that in related non-parasitic forms. This is also well illustrated in Bergendal's recent description ('00) of Gononemertes, a nemertean parasitic in the tunicate Phallusia. There is a resemblance also in other anatomical features, — in the excessive development of the cephalic glands, in the short posterior chamber of the proboscis, and in the slight development of the intestinal cæca. Of the two genera, Carcinonemertes appears to be far more degenerate than

Gononemertes, although it still retains ocelli and has a central stylet in the proboscis.

Summary. — The above observations seem to lead to the following general conclusions: (1) that the nemerteans inhabiting various species of crabs are distributed throughout the North Atlantic and into the Pacific Ocean, (2) that the New England form is identical with the long-known European species, (3) that several European forms thought to be widely different are either closely related or identical, (4) that *all* the species recorded show great similarity of structure, and may be closely related, (5) that the worms are true parasites and are not found except on the body of their host, spending practically their whole existence on the crab's body — in the gills when young, on the egg masses when mature, (6) that in different geographical regions the same species of worm may infest different species of crabs, (7) that the worms crawl about on the bodies of the crabs and are thus easily transferred from one host to another, (8) that by means of the free-swimming embryos the species may be distributed widely, although the young usually remain among the egg masses until they are past the free-swimming stage.

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