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---

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1909.

No. I.

---

REPORT ON LARVAL AND LATER STAGES OF  
CERTAIN DECAPOD CRUSTACEA

(WITH 5 PLATES).

BY

H. C. WILLIAMSON, M.A., D.Sc., F.R.S.E.

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*"Fisheries, Scotland, Sci. Invest., 1909, I. (Dec. 1910).*



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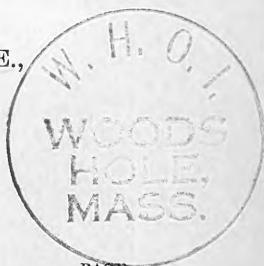
# FISHERY BOARD FOR SCOTLAND.

REPORT ON THE LARVAL AND LATER STAGES OF *PORTUNUS HOLSATUS*, Fabr.; *PORTUNUS PUBER*, L.; *PORTUNUS DEPURATOR*, Leach; *HYAS ARENEUS* (L.); *EUPAGURUS BERNHARDUS*, L.; *GALATHEA DISPERSA*, Spence Bate; *CRANGON TRISPINOSUS* (Hailstone); *CANCER PAGURUS*, L.

BY

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MARINE LABORATORY, ABERDEEN.

(Plates I.-V.)



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The following pages contain observations made on Plankton Zoëæ which have been obtained from the Moray Firth and Aberdeen Bay.

While dealing chiefly with the structure of these forms, I purpose to devote some attention to the colours of these larvæ.

While only slight structural differences can sometimes be made out between Zoëæ, the pigmentation affords an important aid to specific identification. The Zoëæ are usually well supplied with pigment, and, when alive, may in some cases be separated into species by the naked eye. The pigmentation is specific, and remains constant through all the Zoëa and Megalops stages.

The colouration does vary considerably, but not, so far as I have noticed, sufficiently to confuse the identity of the form, when attention is also paid to the main structural features.

It is therefore easy to select from a tow-net collection the Zoëæ of one species, even although they are in different stages. It is thus possible to connect two Zoëa stages which are structurally different. The later Zoëa stages of *Portunus* have long spinous processes projecting from the hind lateral border of three of the abdominal segments. These are not present in the earliest Zoëa stage.

The material upon which this research is founded was obtained almost wholly from the plankton. The Zoëæ were brought to the Laboratory, and, after being separated into different stages, were kept alive in order that their moults might serve to connect the stages.

*Portunus.*

The three species which are here dealt with, viz., *holsatus*, *puber*, and *depurator*, have Zoëæ which exhibit many points of resemblance. The carapace has four spines, viz., a rostral, dorsal, and two lateral. The dorsal and rostral spines are plain, without serrations, and the dorsal is markedly curved.

Cano\* was of the opinion that there were three Zoëa stages and two Megalops stages in this genus. I am of the opinion that there may be five Zoëa stages, but only one Megalops stage. Cano's three Zoëa stages correspond to my I., IV., and V. stages. He pointed out that the spinous prolongations of the hind border of the third, fourth, and fifth abdominal segments are absent in the I. Zoëa, but appear in his second Zoëa stage.

*Portunus holsatus*, Fabr.*Colour of Larvæ.*

The larvæ of this form hatched on July 19, 1900. They were in the protozoëa stage (fig. 7). The pigmentation of the protozoëa was of service in enabling me to recognise among the Plankton Zoëa stages belonging to this species. The colours present are yellow and black. There are two black stellate corpuscles on the side of the carapace near the position of the base of the lateral spine. A small bright yellow spot is situated dorsal to the eye. The black retinal portion of the eye is surrounded by a deep yellow network, from which a delicate yellow tracery extends over part of the anterior surface of the eye. None of the protozoëæ lived to cast into the I. Zoëa. For the Zoëa and Megalops stages I therefore made use of plankton material.

The Zoëæ, which were obtained by the *Garland* in the Moray Firth, were of a general dark colouration. A large quantity of brown pigment was present in the cephalothorax. The cephalothoracic mass is also dorso-laterally slightly greenish-coloured. To the naked eye this region was by reflected light almost black, when the dark brown pigment was dense. The eyes are blue, and they are covered with luminous yellow. A bluish-yellow luminous spot is situated medially just behind the eyes. On the under surface of the abdomen, and especially at each point, there was a large quantity of brown pigment. Yellow pigment accompanies the brown in certain parts.

In a IV. Zoëa the joints of the maxillipedes were touched off with pink. The dorsal spine had some amber pigment about the middle of its length. A V.-stage Zoëa showed three bronze-blue luminous areas round the base of the dorsal spine. One was situated in front, and one on either side. On the side of the carapace there was a large yellow area. The eyes were very blue.

*Megalops.*

Specimens of the Megalops stage were obtained on 23rd June. They are dark, with blue eyes. They show on the dorsum of the cephalothorax two luminous lemon-yellow spots in the middle line. The larger, which is posterior to the less, may be resolved into two spots (fig. 3). The stomachial region is pigmented a dark brown, and brown patches are present on the lateral regions of the abdominal segments and on the lateral region of the carapace.

\*Cano: "Sviluppo dei Portunidi. Morfologia dei Portunidi e Corystoidei." *Memoria di Matematica e di fisica della Società Italiana delle Scienze (detta dei XL.)*. Serie 3a, T. VIII.

*First Young Stage.*

The crab which resulted from the moulting of the *Megalops* is shown in fig. 13. The cephalic region is of a beautiful blue colour; the pigment consists there of minute yellow spots. Over the hepatic and cardiac regions these little yellow spots are present, but fewer in number. The digestive track is coloured dark brown.

*Colours after Preservation.*

The bright colours vanish with preservation. A certain amount of pigmentation persists, however. Some larvæ which had been preserved in formaline solution for ten years were examined. The protozoëa shows brown eyes, and pigment of that colour internally dorsal to the maxillipedes. Brown pigment is also present in the abdominal segments, a prominent amount being visible in the last segment.

Zoëæ which, when alive, had blue eyes, green and brown pigment, with luminous yellow on the outside of the eye, were, after preservation, coloured as follows:—The retinal region of the eye was a brown ball. Brown pigment was present on the anterior side of the eye-stalk, on the base of the antennules, in the mouth region, and along the ventral surface of the abdomen. Similar pigment was present in the dorsal surface of the last abdominal segment; there (at the anus) the ventral pigment extends to the dorsum. In the other segments the pigment is slight on the dorsum.

The pigmentation of the preserved *Megalops* is similar to that of the Zoëa, viz., brown. It is present in the body, eyes, and the abdomen. In one specimen the brown pigment was almost entirely gone. This *Megalops* had evidently been dead some time before being preserved. A crab of the first young stage exhibited dark brown pigment in the eyes and a lighter brown or amber colouration in the central portion of the cephalothorax. The latter pigment is seen both from the dorsal and ventral sides. A little brown colour was observed in the abdomen about the middle of its length.

*Structure of Larvæ.**Protozoëa.*

The protozoëa is the I. Zoëa confined in a delicate sac which is prolonged into plumose digitate processes at the anterior and posterior extremities. The covering shows no segmentation into cephalothorax and abdomen. The I. Zoëa issues from the protozoëa not as the result of a regular moult, but through the rupture of this skin.

Faxon,\* in several instances, observed some of the terminal digitate processes invaginated just as were the spines of the I. Zoëa. He considered that all these processes were invaginated while the larva is in the egg. "The cuticle is not conformable to the underlying Zoëa integument, as it has neither dorsal nor frontal spines, and the antennæ and tail are very different." This author found that the protozoëa of *Carcinus maenas* remained unchanged in confinement for 24 hours. Meanwhile, it increased to such a degree that the delicate investing membrane was no longer ample enough for the enclosed Zoëa, and the first exuviation took place. The cuticle of the abdomen was cast off in one piece, and the telson was used for removing the remainder of the covering. The cuticle was ruptured over the dorsum of the cephalothorax by the dorsal spine erecting itself.

\* Faxon: "On Some Points in the Structure of the Embryonic Zoëa." *Bull. Mus. Comp. Zool., Harvard, Cambridge, Mass., Vol. VI., No. 10, 1880.* 2 plates.

While the protozoëa may persist for some time after hatching, it seems to be usually a very short stage. In the case of *Gelasimus pugnax*, according to Faxon, the escape from the egg and the first moult appear to take place simultaneously.

Cano\* says with reference to the Oxyrhynchi—"With the breaking of the shell of the egg the larva evaginates all its spines, and the larval cuticle, reduced to fragments, remains adherent for some time, but it is got rid of with the first movements of larval life."

The size of the protozoëa of *holsatus* was as follows:—The cephalothorax portion measured in length  $\cdot 35$ – $\cdot 5$  mm., and in dorso-ventral extent  $\cdot 3$  mm. The abdominal portion, which was curved, measured, excluding the plumose appendages, approximately  $\cdot 55$ – $\cdot 6$  mm. in length.

### I. Zoëa, figs. 25, 85; Abdomen, figs. 15, 18.

SIZE.—Distance in a straight line from the tip of the rostral to the tip of the dorsal spine,  $1\cdot 25$ – $1\cdot 35$  mm.; dorsal spine measured from the hind surface of the carapace, close to the base of the spine, across the arc to the tip,  $\cdot 5$  mm.; rostral spine measured from the anterior border of the eye to the tip,  $\cdot 3$  mm.; length of lateral spine,  $\cdot 12$  mm.; abdomen and telson,  $\cdot 92$  mm.

There is no very convenient method of measuring a Zoëa, but the distance between the tips of the rostral and dorsal spines is a useful standard.

I was unable to make out any hairs on the dorsal spine or on the free hind edge of the carapace. A hair is present on the carapace on each side of the base of the dorsal spine. In one Zoëa two other small hairs were made out close to the preceding.

The small lobe of the edge of the carapace, named the branchiostegal tooth (*brst.*), is present (fig. 25).

The exopodites of the first and second maxillipedes had each four plumose setæ. The buds of the pereopods and third maxillipede are present, but usually visible only after dissection. The abdomen has no long processes on its segments (fig. 15). Segments 2, 3, 4, and 5 show toothed hind borders. A pair of large studs are present on the second segment, and a pair of very small studs are found on the third segment.

The pleopods are not visible. A pair of short hairs was found on the dorsum of all the abdominal segments except the first.

The telson (fig. 18) is a typical structure.

### II. Zoëa.

This stage is wanting.

### III. Zoëa, fig. 12; Abdomen, figs. 10 and 20.

SIZE.—Distance in a straight line between the tips of the rostral and dorsal spines,  $2\cdot 6$  mm.; length of the rostral spine beyond the eye,  $\cdot 85$  mm.; length of carapace,  $\cdot 8$  mm.; length of abdomen, including telson, about  $1\cdot 6$  mm.

This stage differs from the I. Zoëa in the structure of the abdomen (fig. 10). The hind edges of the third, fourth, and fifth segments are produced into spines. That of the fifth segment is not yet very large. The studs are present on both the second and third segments, and a suggestion of a stud was made out on the fourth segment also. The developing pleopods are now visible (*pl.*, figs. 10 and 20.) The sixth abdominal

\* Cano: "Sviluppo e Morfologia degli Oxyrhynchi." *Mittheil. Zool. Stat. Neape* 10 Bd., 1891–1893, p. 27. 2 plates.



segment is now separated from the telson. The anus is partly attached to the telson (fig. 20). The latter resembles the condition in I. Zoëa, but differs in having a small hair on either side of the contained angle of the fork. Each prong has three teeth on its external edge.

The exopodites of the first and second maxillipedes had each eight setæ.

The tip of the rostral spine was in one specimen well curved downwards. Three pairs of little hairs were observed on the dorsal spine. Some hairs were present on the free hind edge of the carapace. One was much larger than the rest.

A III. Zoëa moulted into a IV. Zoëa.

IV. Zoëa, fig. 21; Abdomen, fig. 19; Telson, fig. 23.

SIZE.—Distance between the tips of the rostral and dorsal spines, 2.9, 3.2 mm.; length of rostral spine beyond the eye, .95–1.1 mm.

The abdomen shows a farther development of the spinous prolongations (fig. 19); they are now prominent, resembling in some degree similar processes in the Zoëa of *Hyas*. The stud was not now visible on the third segment. A short hair was found in this stage on the dorsum of the first segment. The pleopods now project as conical processes.

The telson (fig. 23) has an additional pair of hairs at its contained angle.

The exopodites of the first and second maxillipedes had each ten setæ.

The antenna now consists of three branches. The jointed branch with its terminal spine is considerably shorter than the serrated branch.

Five or six little hairs were made out on the dorsal spine. The hairs were present also on the edge of the carapace.

A IV. Zoëa moulted into a V. Zoëa.

V. Zoëa, fig. 14; Abdomen, fig. 16; Telson, fig. 22; Antenna, fig. 22A.

SIZE.—Distance between the tips of the rostral and dorsal spines, 3.9–4.4 mm.; length of rostral spine beyond the eye, 1.1–1.4 mm.; length of dorsal spine, from posterior edge of carapace, 1.75 mm.; distance from the eye to the hind margin of the carapace, 1.6 mm.

There is a close resemblance to the last stage. The pereopods and pleopods are now large, and the Zoëa is much larger than stage IV. The exopodites of the first and second maxillipedes have each twelve setæ.

The antennule has a large number of filaments, at least eleven. This appendage has a small round branch. The third branch of the antenna has increased in length. It was not so long as the serrated branch, but very nearly equalled the jointed branch, including its spine. The latter is much shorter than the serrated branch. Without its terminal spine the jointed branch is less than half the length of the serrated branch.

Four little hairs were found on the dorsal spine. The hind free edge of the carapace has a fringe of long fine hairs.

The abdomen is shown in side view in fig. 16. A pair of short hairs was present on the dorsum of each of the first five segments.

The telson (fig. 22) resembles that appendage in the previous stage. The uropods are, however, larger.

V. Zoëa cast into Megalops.

The Zoëa stages are characterised in each species by the progressive development of the pereopods and pleopods which became functional for the first time in the Megalops. But in this species there is a secondary Zoëa character developed. The spinous processes from certain of the abdominal segments are required for some function in the III.–V. Zoëæ, but are not needed in I. Zoëa.

In *Carcinus maenas* the hind border of the third, fourth, and fifth abdominal segments is extended posteriorly into a triangular expansion,

but it does not form a long spine as in *holsatus* and *puber*. These prolongations of the abdominal segments probably function in connection with the ecdysis of the cephalic and thoracic appendages, in which process the abdomen and telson play an important part. The last Zoëa (IV.) of *Carcinus* is much smaller than the last Zoëa of *P. holsatus* and *puber*, and very long processes from the segments may not be required.

*Megalops*, figs. 3, 24, 27, 28.

This stage has a short rostral spine, but no dorsal spine. It has a prominently long narrow abdomen. There is a large hook on the ischiopodite of the chela, and the coxopodite joint of the second, third, and fourth pereopods has a large tooth-like process (*cox.*, figs. 28 and 24). The tooth on the fourth pereopod is turned slightly backward. The hooks differ slightly in appearance when seen from different directions.

In preserved specimens of *Megalops* the rostrum is often bent downwards. The long spinous processes of the abdominal segments are absent. This stage varies in size. A *Megalops* just cast from a V. Zoëa was smaller than one which had been in this stage for some time.

The *Megalops* casts into the first Young Stage. The *Megalops* of this species is large. It is much larger than the same stage of *Hyas areneus*. The I. Zoëa of *holsatus* is smaller than the I. Zoëa of *areneus*, and it has a longer Zoëa period, but it reaches the megalops condition in a larger form than the latter.

*First Young Stage*, figs. 13, 26.

The crab which appeared as the result of the moult of a *Megalops* is shown in fig. 13. The broad frontal region is divided into three rounded portions, all of which have a minutely crenate margin. The middle portion projects a little. The antero-lateral denticulations of the carapace are five in number. Two of these are smaller than the three others. The posterior edge of each tooth is minutely serrated. The serration nearest the apex of the tooth is generally the largest. A few little hairs are visible on the carapace, but no needle-point cilia such as are present in the first young stage of *Carcinus menas*\* were made out. There is no hook on the ischiopodite of the chela. The surface of the chela is much serrated along ridges (fig. 26). On the side of the chela there is a translucent ridge shown shaded in the figure. The abdomen is now tucked in under the thorax; the pleopods, still large, are without the plumose setæ.

*Second Young Stage*.

A crab of the first young stage had partly cast and died. The second young stage did not appear to differ materially from the first young stage.

PORTUNUS PUBER.

Two berried female crabs were obtained in the Bay of Nigg in July. The eggs hatched on August 13, 1900. The larvæ were obtained in the first Zoëa stage.

I. Zoëa, figs. 4 and 49.

COLOURATION.—The eyes appear blue to the naked eye, and so does the luminous area at the base of the dorsal spine. Magnified, the eyes appear covered with luminous greenish-yellow pigment. In the dead larva the eyes are reddish.

\* "On the Larval and Early Young Stages and Rate of Growth of *Carcinus menas*." 21st Annual Report Fishery Board for Scotland, Pt. III., for 1902-1903.

On the first third of the dorsal spine there is a luminous yellow spot; the last third of this spine is deeply tinted with red. The lateral spine also is red, and red pigment is to be seen on the lateral region of the carapace in front of the lateral spine. There is a bright yellow spot and a large amount of black pigment in the mouth region.

Bright luminous yellow spots are present on the lateral region of each abdominal segment. When the abdomen is seen in front view the yellow spots form a luminous line mid-ventrally. The later larvæ got in the plankton show a beautiful red colouration, and exhibit this line very characteristically.

#### *Later Zoëa (Plankton).*

This Zoëa was comparatively large. It had a large quantity of red pigment. The rostral spine had a slight pink colouration. On the proximal half of the dorsal spine there were two small patches of yellow. The bases of the antennæ and the region of the labrum were a deep red. Two widely-ramifying red corpuscles were prominent on the side of the carapace, one in the inferior hind lateral region, the other at the base of the lateral spine. The latter pigment-mass was accompanied by a black corpuscle. The lateral spine was coloured yellow at its base, red in its distal half. At the base of the dorsal spine there was a large quantity of diffuse yellow. One or two minute yellow luminous spots were seen anterior to the dorsal spine and one or two laterally. Red pigment was visible on the ventral aspect of the retina, black or bluish-black above.

On the abdominal joints there was yellow pigment accompanied by black and red. The two latter colours were little in quantity, and were situated on the joints. The yellow, which was concentrated at the joints, ramified over the sides of the segments. At the anus there was a large quantity of deep red pigment. The prongs of the telson were red in colour. The first portion of the intestine was red.

The general colouration seen by reflected light resembled the stain of an aqueous solution of eosin. When the Zoëa was resting on its rostral and dorsal spines—in other words, upside down—the luminous yellow spots on the mid-ventral region of the abdomen showed as a bright line to the naked eye. When the Zoëa is preparing to cast, the red colour seems to lose a certain amount of its brightness.

#### *Colours of Preserved Larvæ.*

Some of the I. Zoëa of *puber*, hatched in the Laboratory, were preserved in formaline. Ten years later they presented the following appearance:—The retinal portion of the eye was amber-brown. The pigment along the abdomen, specially noticeable in the anal region, was a dark-brown, nearly black. In the other segments there was a strip of pigment along the ventral edge, and some on the sides in the anterior half of the abdomen. The bases of the maxillipedes were pigmented dark brown. Some brown pigment was seen about the mouth appendages.

#### ZOËA STAGES.

With the exception of the first Zoëa, all the stages of Zoëa and Megalops were obtained from the plankton. The specimens belonging to this species were easily recognised by the pigmentation.

*I. Zoëa*, fig. 4; Abdomen, fig. 45; Telson, fig. 47;  
Carapace, fig. 49.

This Zoëa resembles much the I. Zoëa of *Portunus holsatus* in general structure.

No hairs were made out on the dorsal spine nor on the hind edge of the carapace. A hair is present on the carapace on either side of the base of the dorsal spine. The lateral spine is slender, straight and longish (fig. 49). The "branchiostegal tooth" was present (*brst.*, fig. 4).

The antenna consists of two branches; the longer is serrated, the short branch bears two hairs (fig. 82). In some later Zoëæ the difference in size between the two branches was not so marked as in this stage. The serrated branch remains the longer.

The abdomen is seen in fig. 45. The edges of the third, fourth, and fifth segments are serrated. The end of the gut was everted in a number of the Zoëæ as here shown. The studs are present on the second and third segments.

The telson (fig. 47) closely resembles that of *holsatus*. The serrated spines end in fine bare needle-like tips. The rest of the spine is elaborately serrated. Sometimes it appears as if the relative lengths of these serrated spines might be of some diagnostic value. But where two spines appear to be of different lengths it may happen that they are not lying in the same plane. In a moulted skin of this stage the middle spine of each lot of three was longer than the spine on either side of it. The drawing of the telson of this stage (fig. 47) does not, however, show this.

A plankton I. Zoëa cast into a II. Zoëa.

#### II. Zoëa, fig. 36; Abdomen, figs. 35, 37; Telson, fig. 33.

Three little hairs were visible on the dorsal spine, but none were made out on the free edge of the carapace. The exopodites of the first and second maxillipedes had each six setæ. The cast from which it came had four setæ on the exopodites.

The toothed edges of the second, third, fourth, and fifth abdominal segments are prominent. The little stud was not made out on the third segment, nor could I see it in the cast skins of two specimens of I. Zoëa.

In fig. 35 the abdomen is shown obliquely; the ventral integument of the second segment is reflected.

The telson is shown in fig. 33. It is twisted a little. There are only two teeth present on the prong of the telson, that is one less than was shown in the moulted skin (I. Zoëa) from which this specimen came. The middle long spine on each side of the fork is evidently a little longer than the two others.

#### III. Zoëa, fig. 43; Abdomen, fig. 32; Telson, fig. 42.

The first and second maxillipedes have eight setæ on the exopodites. The antenna has now three branches. The developing third maxillipede and the pereopods are easily seen in this stage. There are three hairs at least on the free edge of the carapace.

The prolongations of the sides of the abdominal segments are now prominently spinous (fig. 32).

The telson had two new serrated hairs; they are very small and situated in the fork (fig. 42). The middle long spine on each side was longer than the spines on either side of it.

A III. Zoëa cast into a IV. Zoëa.

#### IV. Zoëa, fig. 46; Abdomen, fig. 30; Telson, fig. 48.

Three little hairs were present on the dorsal spine. Four hairs were seen on the edge of the carapace.

The new branch of the antenna is about as long as the smaller of the two original branches. The jointed branch without its terminal spine is longer than the new branch; with its terminal spine it is a little shorter than the serrated branch.

The exopodites of the first and second maxillipedes had ten setæ.

The pleopods were prominent (fig. 30). The drawing of the abdomen was made from a III. Zoëa which had cast off the integument of the abdomen, but not that of the thorax. The newly-exposed abdomen appeared normal, but the telson had not yet swollen out.

The telson of this stage (fig. 48) shows an additional pair of hairs in the fork. The two which appeared in III. Zoëa have increased in length.

A IV. Zoëa cast into a V. Zoëa (fig. 34a).

V. Zoëa, fig. 34a; Abdomen, fig. 40; Telson, fig. 38; Antenna, fig. 34.

The first maxillipede had eleven setæ on the exopodite of both sides. The second maxillipede had twelve setæ on one side and eleven on the other. In the case of the twelve setæ, two were situated a little way along the exopodite, separated from the rest of the setæ by an interval. On the other side, one of the eleven setæ was separated from the rest by an interval.

This stage, except in being bigger, generally resembles the last. The pereopods are now almost full-sized.

The new branch of the antenna is as long as, or greater than, the original serrated branch (fig. 34). The jointed branch with its spine is nearly as long as the serrated branch; without its terminal spine it is two-thirds the length of the serrated branch.

Five hairs were observed on one side of the dorsal edge of the dorsal spine, and four hairs on the other. I did not make out the hair on the carapace at the base of the dorsal spine. Eight sparsely plumose setæ were noticed on the free edge of the carapace.

The abdomen (fig. 40) resembles the last stage, except that the pleopods and uropods are much larger.

The telson (fig. 38) closely resembles that of the last stage. Some of the spines in the specimen drawn had been broken off.

The new hairs that appear in the fork of the telson in the III. and IV. Zoëa, and which continue in the V. Zoëa, are, it may be inferred, correlated to new conditions in the cephalic appendages, which require extra armature in the telson for its work in effecting the ecdysis.

A V. Zoëa cast into a Megalops.

#### *Megalops*, figs. 11, 17.

This stage has a comparatively long rostral spine and a stout dorsal spine. All the appendages are functional, the pleopods being plumose. The spines are absent from the abdominal segments. The antenna has four (or five) terminal stiff cilia. There are comparatively few hairs on the dorsal surface; they are generally small.

The first, second, third, and fourth pereopods bear large hooks (fig. 17). That of the chela is on the ischiopodite; in the other three the hook is on the coxopodite joint. The fifth pereopod is without a hook; the dactyl of this pereopod has the three long curved spines characteristic of the genus *Portunus*.

Fig. 17 was drawn from the cast integument of a *Megalops*.

A *Megalops* cast into a first young stage.

#### *First Young Stage*, fig. 29.

The margin of the rostrum is serrated.

There are three principal lateral denticulations to the carapace, the outer angle of the orbit being regarded as one of the series. Two smaller teeth occupy positions between the principal teeth. In the adult the five denticulations are equal in size.

The hooks which were present in the Megalops on the coxopodites of the second, third, and fourth pereopods and on the ischiopodite of the chela are absent. There is a big angle tooth on the carpopodite of the chela (fig. 29).

There appear to be minute needle-point cilia on the carapace, but this was not satisfactorily determined.

In the cast integument (Megalops) from which came the first young stage I was unable to make out the presence of a dorsal spine. The region from which it rises was crumpled. The long rostral spine was present.

The abdomen of the first young stage is closely applied to the thorax; the pleopods are still large, but are without setæ.

#### PORTUNUS DEPURATOR.

The I. Zoëæ of this species have been kindly supplied to me by Mr. H. T. Waddington, Bournemouth.

The eggs hatched under observation. "Five days after the crab had got rid of its eggs it extruded a new batch. These proceeded to develop regularly."

I. Zoëa, figs. 31, 84; Abdomen, figs. 41, 44; Telson, fig. 39.

After being preserved in formaline this Zoëa resembled much the preserved Zoëæ of *holsatus* and *puber* in pigmentation. In structure also this Zoëa is very similar to those of *holsatus* and *puber*.

The lateral spines of the carapace are long and slender.

No hairs were made out on the free edge of the carapace. The "branchiostegal tooth" is present.

The abdomen is shown in side view in fig. 41. The studs are present on the second and third segments. The lateral hind edge of the second, third, fourth, and fifth segments is slightly serrated. The ventral tooth (*sp.*) is evidently the principal one. The serrations may be detected in front view, fig. 44. A pair of hairs is present on the posterior dorsal edge of the second, third, fourth, and fifth segments.

On the telson (fig. 39) the teeth on the outside of the prong are prominent. The proximal tooth is very large. The middle tooth is markedly curved, and ends in a fine apex.

I have not had the opportunity of examining any later stages of this species.

#### *Comparison between the Zoëæ of Portunus holsatus, puber, and depurator.*

I. ZOËA.—The Zoëæ of *holsatus* and *puber* which have been preserved in formaline show a very different naked-eye appearance. The body of *puber* is white, or nearly colourless, with the brown eyes prominent. The larvæ of *holsatus* show a good deal of dark brown pigment in the body and eyes.

The lateral spines of the carapace seem to be longer in *holsatus* and *depurator* than in the *puber*. In the abdomen, *puber* (fig. 45) shows the most prominently serrated edges to the second, third, fourth, and fifth segments: *cp. holsatus*, fig. 15; *depurator*, fig. 41. Little difference is made out in the telson, except that in *depurator* (fig. 39) the proximal tooth in the prong is very large, being much larger than the two other teeth. In *holsatus* (fig. 18) the proximal tooth is the largest, but it is a smaller tooth than that of *depurator*. In *puber* (fig. 47) the proximal tooth was not larger than the distal.

III. ZOËA.—The main difference noticed between the Zoëæ of *holsatus* and *puber* was in the telson. The prong of the telson of *holsatus* (fig. 20) had three teeth on its external edge, while that of *puber* (fig. 42) had two. The telson of *puber* appears to be rather broader than that of *holsatus*. The long spines of the telson are in *holsatus* practically equal; in *puber* the middle one of each set of three is the largest.

Differences may be observed in the rostral spine in respect to its length, straightness, and curvature. But these are difficult to found upon, as the position in which the Zoëa lies, or slight damage, may alter the appearance of the part. It is probable, however, that some distinguishing characters might be made out from the large spines.

The difference between the antennæ of the two species, which is of value in the IV. and V. stages, was not sufficiently marked to be of much value.

IV. ZOËA.—The telson furnished distinguishing characters between the species. As in the preceding stage, the prong in *holsatus* had three teeth, and in *puber* two teeth. The telson of *puber* is of a broader build than that of *holsatus*. The spines in the angle of fork differ in the two species. In *holsatus* (fig. 23) they remain very small, whereas in *puber* one pair is much larger than the other, having more of the character of a spine (fig. 48). The relative length of the long spines was as in the preceding stage.

Differences are to be seen also in the antenna. The serrated branch of this appendage, when compared with the jointed branch, is much longer in *holsatus* than in *puber*.

V. ZOËA.—In the telson the same differences hold as in IV. Zoëa. The telson of *puber* (fig. 38) did not, however, appear broader than that of *holsatus* (fig. 22).

The new developing branch of the antenna was in *holsatus* much shorter than the serrated branch; in *puber* it was as long as, or longer than, that branch (fig. 34). In *holsatus* the jointed branch without its terminal spine was about half the length of the serrated branch, while in *puber* it was two-thirds the size of that branch.

MEGALOPS.—The differences between the Megalopa of *holsatus* (fig. 3) and *puber* (fig. 11) are well marked. *Puber* has a longer rostrum, and it has a dorsal spine. There is no dorsal spine in *holsatus*. The long teeth on the coxopodites of the second, third, and fourth pereopods had a more hook-like appearance in *puber* than in *holsatus*, where they are practically straight. As Cano pointed out, the Megalops of *Carcinus* may be distinguished from that of *Portunus*, or *Lupa*, by the shape of the dactyl of the fifth pereopod. In *holsatus* (fig. 3) and *puber* (fig. 17) this joint ends in a very short blunt claw, whereas in *Carcinus* the claw is long and tapering. There are other characters by which these Megalopa can be separated. In *Carcinus* the coxopodites of the second, third, and fourth pereopods have no long teeth. The Megalops of *Carcinus* is much smaller than that stage in the two *Portuni* here dealt with.

FIRST YOUNG STAGE.—*Holsatus* (fig. 13) has a very short rostrum; *puber* (fig. 29) has a prominent triangular rostrum. The carapace of *puber* is broader and bigger all over. Differences are also to be made out in the character of the antero-lateral denticulations.

#### CARCINUS MËNAS.

The last Zoëa (IV.) is shown in fig. 9. The pigmentation is characteristic.

#### HYAS ARENEUS.

The berried females of this species have at several times been kept alive at the Laboratory in order that the Zoëæ might be obtained. Those that

were captured in May in the crab creels at the Bay of Nigg bore eggs which had been lately extruded. The mass of eggs was of a bright orange colour; it is hidden by the abdomen.

Some crabs which were captured in June 1909 survived till the following spring. They had by then lost most of their eggs, and although some eggs hatched, the larvæ were not secured.

I have therefore been indebted to Mr. Waddington for specimens of the I. Zoëa stage. Mr. Waddington had had a berried crab in confinement for three months when it died on January 1st. "The eggs were removed, and two months later successfully hatched."

Megalopa which have been ascribed to this form were obtained by the Garland in May 1900. The eggs, therefore, hatch comparatively early in the year.

I. Zoëa, fig. 73; Abdomen, fig. 77; Telson, fig. 70; Cephalic Region, fig. 75.

In general structure the Zoëa of this species recalls that of the Zoëa of *Portunus*, in that it has a rostral, dorsal, and two lateral spines on the carapace (fig. 78). It is, however, larger than the I. Zoëa of the three species of *Portunus* dealt with here. It is at once distinguished from *Portunus* in all its stages by the fact that the rostral and dorsal spines are serrated. These spines are, moreover, practically straight. The "branchiostegal tooth" is present.

The third, fourth, and fifth abdominal segments (fig. 77) have long spines projecting from their hind borders.

The serrated branch of the antenna reaches to about the tip of the rostral spine; in the specimen drawn it projected a little beyond that point. The serrations on the rostral spine increase in size from the base towards the tip. The teeth on the dorsal spine are much smaller than those on the rostral spine. The exopodites of the maxillipedes had four setæ. The hind free border of the carapace bore three hairs, two of which at least were plumose.

Studs are present on the second and third segments of the abdomen. A pair of hairs was found on the dorsum of the first to fifth segments.

The narrow telson (fig. 70) is noteworthy. The prongs are minutely serrated.

#### *Colours of Preserved I. Zoëa.*

The retinal region of the eye is a dark brown, almost black in some specimens. In the thorax there is behind the eye some deep amber pigment. On the abdomen the pigment is a pale brown with red spots. To the naked eye the Zoëa has an amber colouration, generally all over, certainly in the thorax, and often in the abdomen also.

#### *Later Stages of Zoëa.*

The later stages were procured by means of the tow-net. The various Zoëæ and the Megalops which were obtained in the plankton were readily recognised as belonging to one species by their characteristic pigmentation (fig. 1). This species is, I consider, *Hyas areneus*. The plankton Zoëæ agree closely in structure with the Zoëæ of that form.

#### *Colours of Plankton Zoëæ when Alive. (Fig. 1.)*

The chief colour in the thorax was chocolate. Some had dark brown in the cephalic region. A luminous band, gold or silver in appearance, was present across the dorsum just behind the eyes. Posterior to that there



was a mass of dark brown tissue. The eyes were of a bright silver on the outer surface. Red pigment was located deep in the eye. A dark brown tracing is present on the side of the carapace and extending down the abdomen. In an early stage the red pigment was not nearly so prominent, and below the dorsal spine there was a large mass of yellow pigment.

Generally there is an extensive chocolate-coloured area round the stomach. It may be very dark, almost black. In one larva, however, the chocolate colouration was absent. The Zoëa otherwise resembled the others, and was very lively.

A number of specimens became whitish in appearance. All the chocolate-coloured pigment in the cephalothorax disappeared. It was succeeded by a whitish tinge. This may have indicated a preparation for casting. Some of those, however, which were moulting had the chocolate-coloured area.

When about to cast the sides of the carapace spread out laterally; this gives a greater size to the larva. The Zoëa first withdraws the abdomen. The pereopods come out as soon as the carapace is raised. The carapace is pushed over the head, the eyes and the appendages being the last to be shed. In some the abdomen appears to be last, but only rarely, if at all, in normal circumstances. Some Zoëæ which had commenced moulting had not finished the operation a day later.

#### *Plankton Zoëæ.*

The youngest Zoëa was that shown in fig. 71. I regard it as a II. Zoëa. It has four setæ on the exopodites of the first and second maxillipedes.

The abdomen consists of five segments and the telson. The pleopods are represented by conical swellings on the lower surface of the abdomen. The little stud is present on the third segment.

The telson (fig. 80) is narrow, resembling generally the telson of the I. Zoëa. There are three teeth on each prong—two, a large and a small tooth, on the outer edge, and a large tooth on the dorsal surface. The prongs are minutely serrated. The middle spine on each side of the fork was larger than the spines flanking it.

This stage cast into III. Zoëa.

#### *III. Zoëa. Fig. 1.*

The exopodite of the maxillipede had 6 plumose setæ; but instances of 4 and 8 were observed.

This form has long branched pleopods (fig. 1B). The abdomen consists of six segments and the telson. The telson retains the narrow form of the I. Zoëa, but it has an extra little hair on the inside of the fork. Sometimes one, sometimes the other, tooth on the outside of the prong appears the bigger.

III. Zoëa cast into the Megalops.

The Zoëa period therefore appears to consist of three stages.

#### *Megalops. Fig 2.*

This stage resembles in pigmentation the Zoëa. The red colour in the drawing is not quite the right shade. The pereopods are red in parts. The abdomen also has red pigment, although none had apparently been present in the specimen drawn. The eyes show a white exterior, but some purple pigment is present within.

The Megalops has a tridentate frontal region. A smooth dorsal spine rises from the hind half of the carapace. Just behind the eyes there is a pair of lateral hooks, and between them in the middle dorsal line there is a median ridge, seen in side view in *mr.*, fig. 83.

The coxopodites of the second, third, and fourth pereopods have large teeth (*t.*, fig. 74). A large tooth is also present on the ischiopodite of the second pereopod. The armature of the legs is not shown: it consists of hairs and short toothed spines. The abdomen is narrow, and is furnished with five pairs of plumose swimmerets.

The Megalops when it swims tucks its pereopods over the carapace, and swims forward. It also walks. A number of Megalopa had cast on 14th June into the first young stage. More ecdyses were found than there were of first young stage crabs. The remains of some of the latter were found more or less eaten, probably by Megalopa.

*First Young Stage.* Figs. 76, 72.

The first young stage is a little crab having some points of resemblance to an adult Hyas. The rostrum is forked. The abdomen is applied to the thorax; the pleopods are still large, but unprovided with setæ. The carapace is adorned with hooked hairs similar to those on the adult. The hairs have been omitted from the right hand branch of the rostrum in figs. 76 and 72.

There is an elaborate toothed process of the carapace at the posterior corner of the orbit.

The crab is of a sandy colour. Large stellate black pigment corpuscles are present just behind the rostrum. One is situated about the middle of the carapace. The crab picks off and eats the debris (fine sand and diatoms) which becomes attached to its carapace and limbs. One was observed to eat a copepod.

This stage does not swim.

The plankton Zoëæ and Megalopa all belonged to one species. I have regarded that species as being *Hyas areneus*, but that diagnosis is open to question.

*Parasite of Hyas areneus.*

The adult Hyas, captured in the Bay of Nigg and in other localities, were often infected by very long nematodes (fig. 79, *n.* and *n*<sup>1</sup>). The nematode is coiled round and between the organs. There are usually two worms present, one situated on each side. They are seen as soon as the carapace is removed.

A crab died in the Laboratory on August 3, and at the same time two long nematodes were found to have issued from it. The worms, which wriggled about in the water, were white, except for the translucent extremities. When the Hyas was opened the organs, liver, and ovary appeared to be quite healthy. Next day a quantity of white spawn had been deposited on the bottom. One worm was partly emptied of spawn. At one part its skin was translucent and shrivelled; at another part the white ova, instead of forming a continuous streak, were in pieces. The eggs examined on August 4 measured 0.5 mm. in diameter. The egg (figs. 68 and 68*a*) has two investments. On the outside there was a layer of protoplasm which was in some ova extended into little radiating processes. The following day they showed the condition seen in fig. 69. Some of the spawn still lay on the bottom on August 6. No development seems to have taken place.

*Eupagurus bernhardus*, L.

The eggs were found to have hatched on June 15.

The first Zoëa stage (fig. 6) shows a large silvery-luminous yellow corpuscle in the dorsum of the cephalothorax. The red ochre pigment is

deep, the yellow is superficial. A red corpuscle was present on each side of the mouth region.

Thompson\* describes the first Zoëæ of *Eupagurus longicarpus* and *Eupagurus annulipes*:—"The transparent body is pigmented with contractile scarlet and yellow chromatophores; the eyes are black with yellow pigment diffused over them. The livers contain strongly refractive yellow globules."

Sars† describes and figures the Zoëæ of *bernhardus*, but the pigment is not shown.

#### *Galathea dispersa.*

The protozoëa of this species is shown in fig. 8. Date, June 4.

#### *Crangon trispinosus* (Hailstone).

The eggs of this form hatched on August 18. The I. Zoëa (fig. 5) resembles much the I. Zoëa of *Crangon vulgaris*. The dorsal spine is absent from the hind border of the third abdominal segment, and the fifth segment is not provided with lateral teeth on its posterior border.

The colouration is more intense than in *Crangon vulgaris*. Yellow pigment is present on the eye, maxillipedes, side of the thorax, and along the side of the abdomen. At places on the sides it is concentrated into luminous spots. Purple-pink pigment is located ventral to the eyes, laterally and ventrally in the cephalothorax, and over the lower surface of the abdomen. Medially in the cephalothorax there is situated both dorsally and ventrally a large quantity of purple pigment. The antennules are deeply coloured with yellow and purple.

Gurney,‡ who described and figured the first and last Zoëa of this species, gives the following account of the colouration:—"The body is light greenish-yellow in colour, with a conspicuous branching chromatophore placed dorsally in the middle of the thorax."

#### *Cancer pagurus*, L.

When the eggs are ready to hatch both protozoëa and I. Zoëæ may be obtained at once by washing the ova. It is evident from this fact that the normal procedure is for the larva to get rid of the protozoëan cuticle at once on becoming free from the egg.

#### Protozoëa. Fig. 51.

One specimen measured 1.3 mm. in length. The antennæ, antennules (fig. 57), and telson (fig. 62) are furnished with plumose appendages. The lateral spines were almost full-sized, but the rostral spine, *r*, was only represented by its point which projected from the cushion-like anterior extremity of the larva (figs. 51 and 57). The dorsal spine is still invaginated. The second maxillipede (fig. 61) is without projecting spines and setæ. The limb is covered with a delicate cuticle.

\* Millet T. Thompson: "The Metamorphosis of the Hermit Crab." *Proceedings of the Boston Society of Natural History*, Vol. 31, No. 4. Boston, 1903, pp. 147-209, pl. 4-10.

† G. O. Sars: "Bidrag til Kundskaben om Decapodernes Forvandlinger" II. *Lithodes Eupagurus, Spiropagurus Galathodes, Galathea, Munida, Porcellana, Nephrops.* *Archiv for Mathematik og Naturvidenskab*, 13 B. 1890, p. 133, 7 plates.

‡ Gurney: "Metamorphoses of the Decapod Crustaceans," *Ægeon (Crangon) fasciatus*, Risso, and *Ægeon (Crangon) trispinosus* (Hailstone). *Proc. Zool. Socy., Lond.*, 1903. Vol. ii., p. 24, 2 plates.

The pigmentation of this stage is similar to that of the I. Zoëa. A description of this stage has been given by Pearson.\*

### I. Zoëa.

PIGMENTATION.—A yellow corpuscle is present on the hind dorso-lateral and the hind lateral regions of the cephalothorax and on the posterior lateral region of the second to fifth abdominal segment and telson. Each yellow patch is accompanied by green, red (purple), and black pigments. The dorsal and rostral spines and fork of the telson are coloured red. The colours are shown in a sketch of this stage, published in an earlier communication.† In this drawing short, very delicate hair-like filaments are shown attached all over the integument. These do not belong to the larva; they are of secondary appearance, and may be of fungoid origin. They are not present in the newly hatched Zoëa, *i.e.*, within 24 hours of hatching.

To the naked eye the larva has a whitish appearance.

The I. Zoëæ are brightly phosphorescent.

Zoëæ which have been preserved in formaline are whitish or colourless to the naked eye. The eyes are reddish-brown. Those which have been preserved in alcohol have black (very dark brown) eyes.

### Structure of I. Zoëa.

This Zoëa has a dorsal, a rostral, and two lateral spines on the carapace. The lateral spines are long (fig. 63a). The rostral spine is long and straight and slightly bent upwards. In some Zoëæ the dorsal and rostral spines are a little bent at the point, but this may be due to handling. No hairs were made out on the hind free edge of the carapace. A small hair is, however, present on the carapace on each side of the base of the dorsal spine. A slight "branchiostegal tooth" is present. This Zoëa has been described by several authors, and lately by Pearson, but, so far as I am aware, detailed drawings of the appendages have not been published.

The various appendages are shown in Plate IV. They conform closely to such a type as *Carcinus maenas*. This is well seen in respect to the mandible and first and second maxillæ and two maxillipedes. The antenna (fig. 66), however, is noticeable on account of the difference in size between its two branches. The serrated branch is very much longer than the jointed branch.

The labrum (*lr.*, fig. 59) is covered with small teeth.

In dissecting off the appendages the second maxilla usually tends to remain attached to the first maxillipede. The first maxilla may go either with the mandible or the second maxilla. The lower lip is attached to the sternum. The mouth marks the separation between the cephalon and the thorax.

The stalked eyes are shown in fig. 64. The torn edge, *t.*, indicates where the carapace was attached.

Two views are given of the mandible. In fig. 52 it is seen from below, and in fig. 52a from outside. The plate (*pl.*) when seen from the side resembles a tooth. A portion of the mandible is shown in fig. 50; *d.* indicates the dorsal edge.

The buds of the pereopods (*p.*) are contained in a sac covered by a thin skin (fig. 54). The pit is shown in ventral view in fig. 56. All the buds were not visible; *ant.* indicates the anterior edge. The skin covering the pit may be a portion of the protozœan cuticle which had remained attached.

\* "Memoir on *Cancer pagurus*." No. 16 Report for 1907 of the Lancashire Sea-Fisheries Laboratory and the Sea-Fish Hatchery at Piel. Liverpool, 1908.

† Williamson: "Contributions to the Life-history of the Edible Crab (*Cancer pagurus*)." 18th Ann. Report of the Fishery Board for Scotland, Pt. III., p. 76.

The first abdominal segment forms the posterior side of the pit in which the pereopods lie.

The hind lateral border of the second to fifth segments of the abdomen is serrated (fig. 65). It is not always possible to make out exactly the same serration on both sides of the segment. I made out no pleopods. On the dorsum of each of the abdominal segments except the first, there is a pair of little plumose hairs. A pair of studs is present on the second segment, but none was made out on the third.

The telson differs from that appendage in *Carcinus* and the *Brachyura* dealt with in this paper in having only two external teeth on each prong (fig. 63).

Several attempts were made to rear the Zoëæ, but without success.

Zoëæ which had been kept for four or five days were covered with the fine hair-like filaments referred to above.

## LETTERS USED.

<i>A.</i> —antenna.	<i>m. r.</i> —median ridge.
<i>a.</i> —antennule.	<i>1 mp.</i> —first maxillipede.
<i>ab.</i> —abdomen.	<i>2 mp.</i> —second "
<i>an.</i> —anus.	<i>n, n'.</i> —nematodes.
<i>ant.</i> —anterior.	<i>oc.</i> —eye.
<i>brst.</i> —branchiostegal tooth.	<i>ov.</i> —ovary.
<i>cæ.</i> —cæcum of gut.	<i>p.</i> —pereipod.
<i>cox.</i> —coxopodite.	<i>pl.</i> —pleopod.
<i>d.</i> —dorsal.	<i>post.</i> —posterior.
<i>ep.</i> —epipodite.	<i>pr.</i> —process.
<i>g.</i> —gut.	<i>r.</i> —rostrum.
<i>I.</i> —First Young stage.	<i>sp.</i> —spine.
<i>I. V.</i> —First to Fifth Zoëa stages.	<i>T.</i> —telson.
<i>l.</i> —liver.	<i>t.</i> —tooth.
<i>la.</i> —lateral.	<i>Th.</i> —Thorax.
<i>M.</i> —Megalops.	<i>ur.</i> —uropod. •
<i>mn.</i> —mandible.	

## DESCRIPTION OF PLATES.

## PLATE I.

- FIG. 1. *Hyas areneus*, Last Zoëa III.; fig. 1A, do., nat. size; fig. 1B, do., pleopod.  
 " 2. " " Megalops.  
 " 3. *Portunus holsatus*, Megalops; fig. 3A, do., nat. size; fig. 3B, do., fifth pereipod, propodite and dactylopodite.  
 " 4. *Portunus puber*, I. Zoëa; fig. 4A, do., nat. size.  
 " 5. *Crangon trispinosus*, I. Zoëa.  
 " 6. *Eupagurus bernhardus*, I. Zoëa.  
 " 7. *Portunus holsatus*, Protozoëa.  
 " 8. *Galathea dispersa*, " "  
 " 9. *Carcinus maenas*, IV. Zoëa.

## PLATE II.

- FIG. 10. *Portunus holsatus*, III. Zoëa; abdomen.  
 " 11. " " *puber*, Megalops; fig. 11A, do., nat. size.  
 " 12. " " *holsatus*, III. Zoëa; fig. 12A, do., " "  
 " 13. " " First Young Stage; fig. 13A, do., nat. size.  
 " 14. " " V. Zoëa; fig. 14A, do., nat. size.  
 " 15. " " I. " abdomen.  
 " 16. " " V. " "  
 " 17. " " *puber*, Megalops, pereipods, ventral view; drawn from the cast integument of a Megalops.  
 " 18. *Portunus holsatus*, I. Zoëa, abdomen, ventral view.  
 " 19. " " IV. Zoëa, " oblique view.  
 " 20. " " III. " " ventral view.  
 " 21. " " IV. " fig. 21A, do., nat. size.  
 " 22. " " V. " Telson.  
 " 22A. " " V. " Antenna. (Drawn from a cast integument.)  
 " 23. " " IV. " "  
 " 24. " " Megalops, coxopodite of third pereipod.  
 " 25. " " I. Zoëa; fig. 25A, do., nat. size.  
 " 26. " " First Young Stage, chela.  
 " 27. " " Megalops, chela; drawn from the cast integument of a Megalops.  
 " 28. *Portunus holsatus*, Megalops, bases of pereipods; drawn from the cast integument of a Megalops.

## PLATE III.

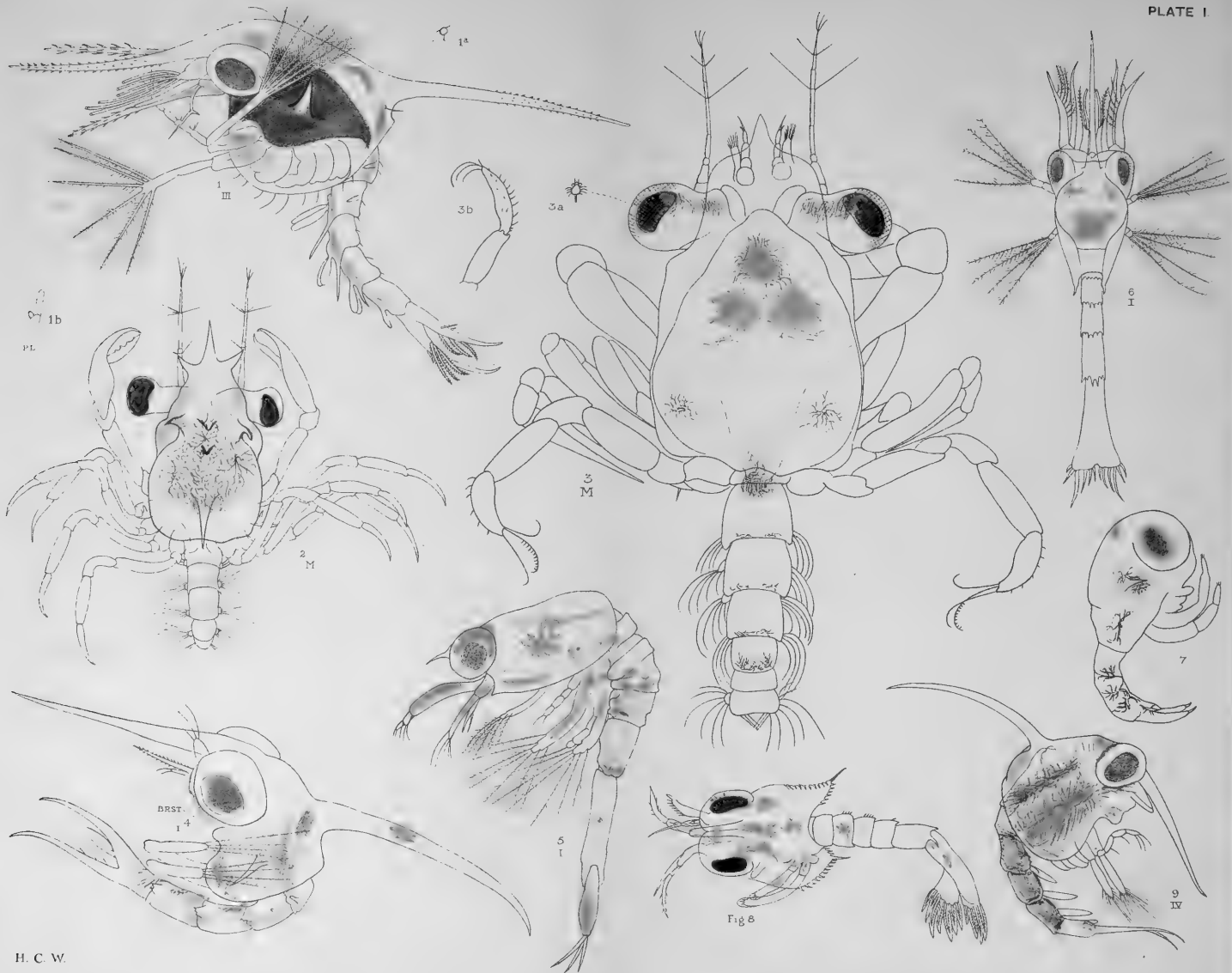
- FIG. 29. *Portunus puber*, First Young Stage.  
 30. " " IV. Zoëa, abdomen.  
 31. " " *depurator*, I. Zoëa, fig. 31A, do., nat. size.  
 32. " " *puber*, III. Zoëa, abdomen.  
 33. " " II. " Telson.  
 34. " " V. " antenna.  
 34A. " " V. " nat. size.  
 35. " " II. Zoëa, abdomen.  
 36. " " II. " "  
 37. " " II. " abdomen.  
 38. " " V. Telson; certain of the long spines are damaged.  
 39. " " *depurator*, I. Zoëa, Telson.  
 40. " " *puber*, V. Zoëa, abdomen.  
 41. " " *depurator*, I. Zoëa; abdomen twisted slightly.  
 42. " " *puber*, III. Zoëa, Telson.  
 43. " " III. " fig. 43A, do., nat. size.  
 44. " " *depurator*, I. Zoëa, abdomen, third and fourth segments seen in ventral view.  
 45. *Portunus puber*, I. Zoëa, abdomen; a portion of the hind gut is everted.  
 46. " " IV. Zoëa; fig. 46A, do., nat. size.  
 47. " " I. Zoëa, Telson.  
 48. " " IV. " "  
 49. " " I. Zoëa, carapace seen from above.

## PLATE IV.

- FIG. 50. *Cancer pagurus*, I. Zoëa, mandible, inner lobe.  
 51. " " Protozoëa.  
 52. " " I. Zoëa, mandible seen from below; fig. 52A, do., mandible seen from outside.  
 54. *Cancer pagurus*, I. Zoëa, view of buds of pereopods, maxillipedes, and first and second segments of abdomen.  
 55. *Cancer pagurus*, I. Zoëa, first and second maxillipedes.  
 56. " " " ventral view of sac in which the pereopods lie.  
 57. " " Protozoëa, cephalic region seen from below.  
 58. " " I. Zoëa, antennule.  
 59. " " " cephalic region seen from below.  
 60. " " " second maxilla.  
 61. " " Protozoëa, second maxillipede.  
 62. " " " Telson; the appendages have been slightly damaged.  
 63. *Cancer pagurus*, I. Zoëa, Telson; fig. 63A, do., carapace showing lateral spines.  
 64. *Cancer pagurus*, I. Zoëa, eye stalks, seen from above; carapace removed.  
 65. " " " abdomen.  
 66. " " " antenna.  
 67. " " " first maxilla.

## PLATE V.

- FIG. 68. 68A. Eggs of Nematode parasite of adult *Hyas areneus*.  
 69. Eggs as above (fig. 68), a day later.  
 70. *Hyas areneus*, I. Zoëa, Telson.  
 71. " " II. " "  
 72. " " First Young Stage; cephalic region, dorsal view.  
 73. " " I. Zoëa; fig. 73A, do., nat. size.  
 74. " " Megalops, coxopodite, etc., joints of the pereopods, showing the teeth (*t*).  
 75. *Hyas areneus*, I. Zoëa, cephalic region seen from above.  
 76. " " First Young Stage.  
 77. " " I. Zoëa, abdomen.  
 78. " " " carapace to show lateral spines.  
 79. " " adult, carapace removed to show the parasitic nematodes, *n*, *n'*; *l*, liver; *ov.*, ovary.  
 80. *Hyas areneus*, II. Zoëa, Telson.  
 81. " " I. " antenna.  
 82. *Portunus puber*, I. Zoëa, antennule and antenna.  
 83. *Hyas areneus*, Megalops, side view of dorsum of carapace.  
 84. *Portunus depurator*, I. Zoëa, carapace to show lateral spines.  
 85. " " *holsatus*, " " " " " " " " " "

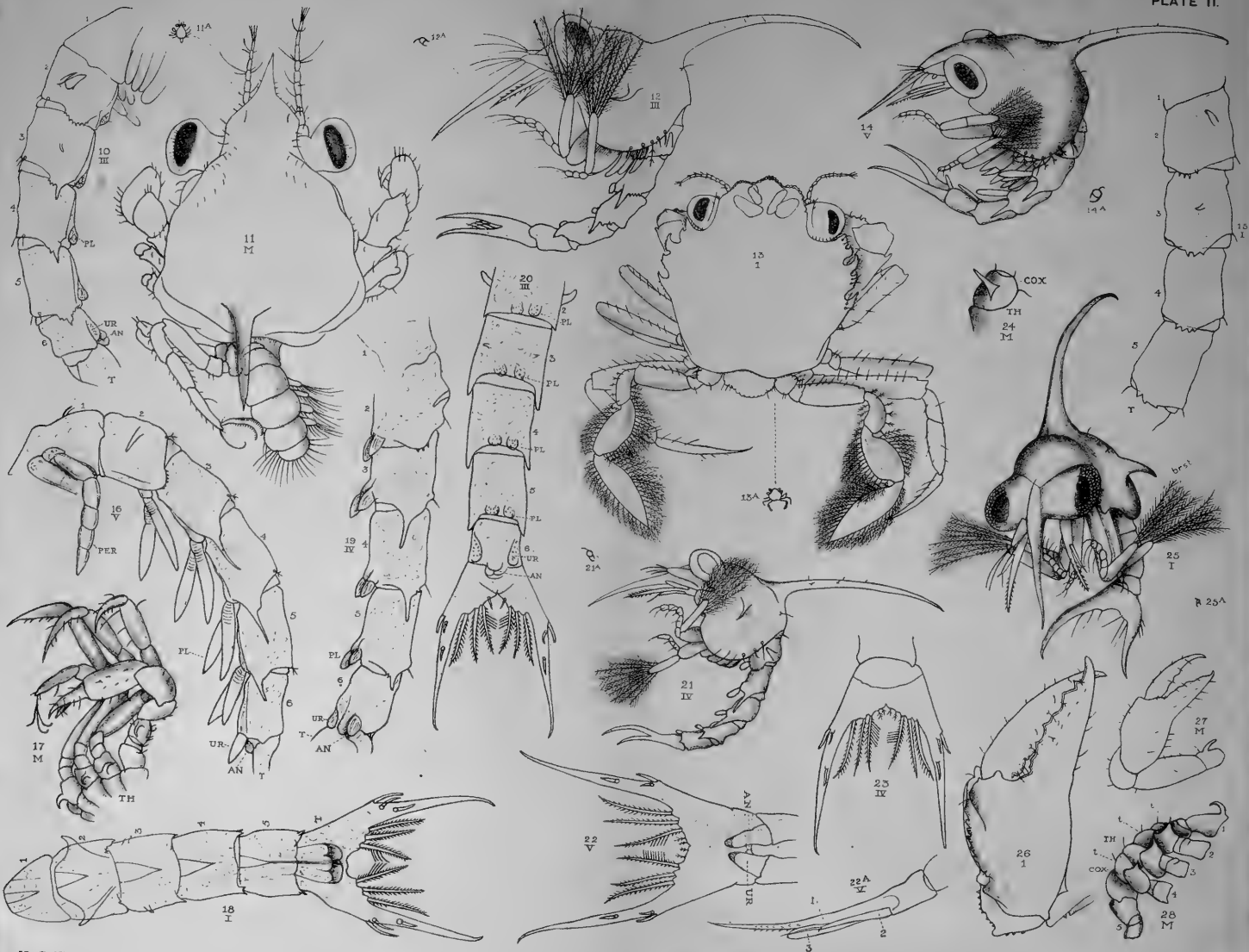


H. C. W.

Larvæ of *Portunus*, *Hyas*, *Eupagurus*, *Galathea*, *Carcinus*.



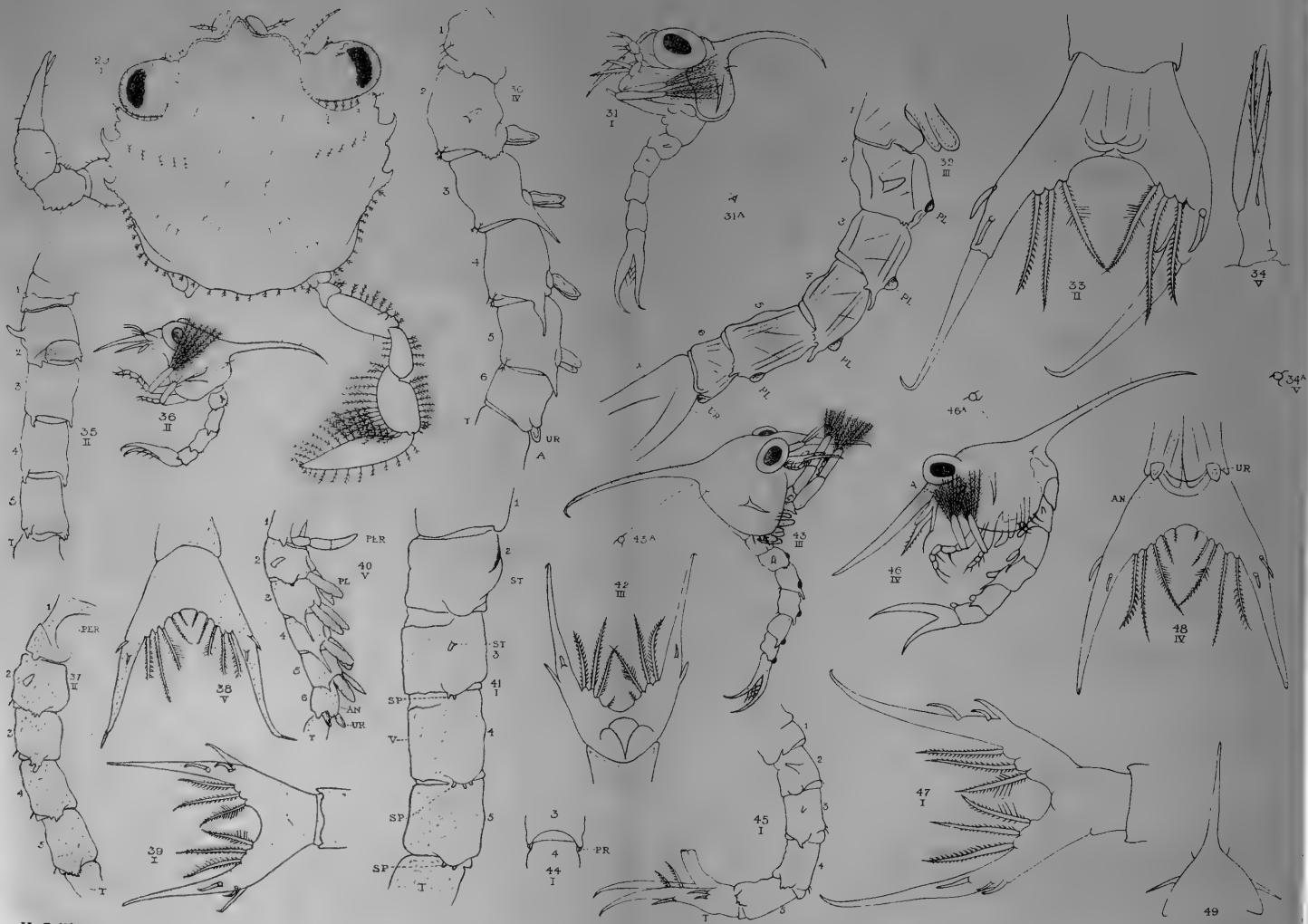




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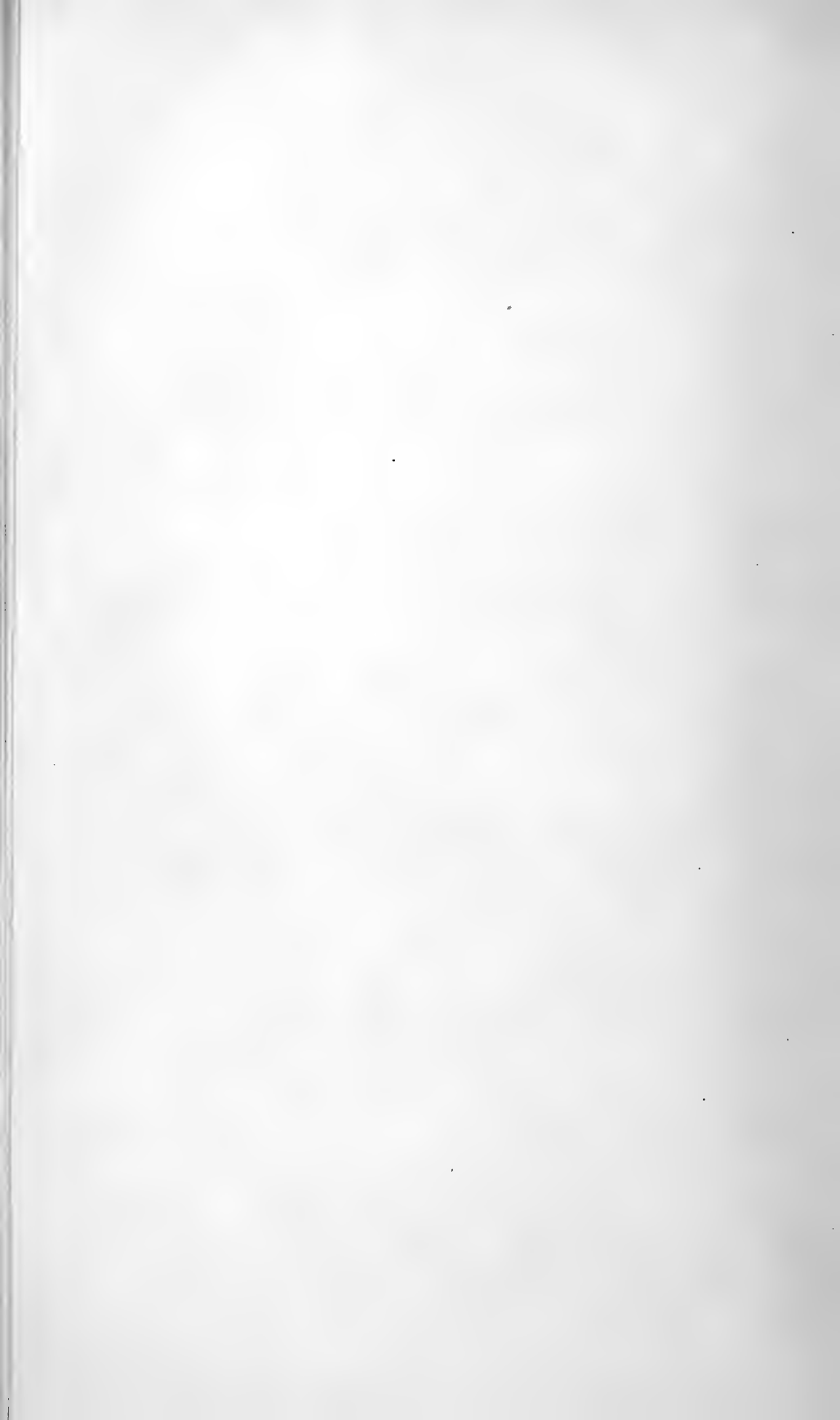
Figs. 11, 17. *Portunus puber*; cetera *Portunus holsatus*.

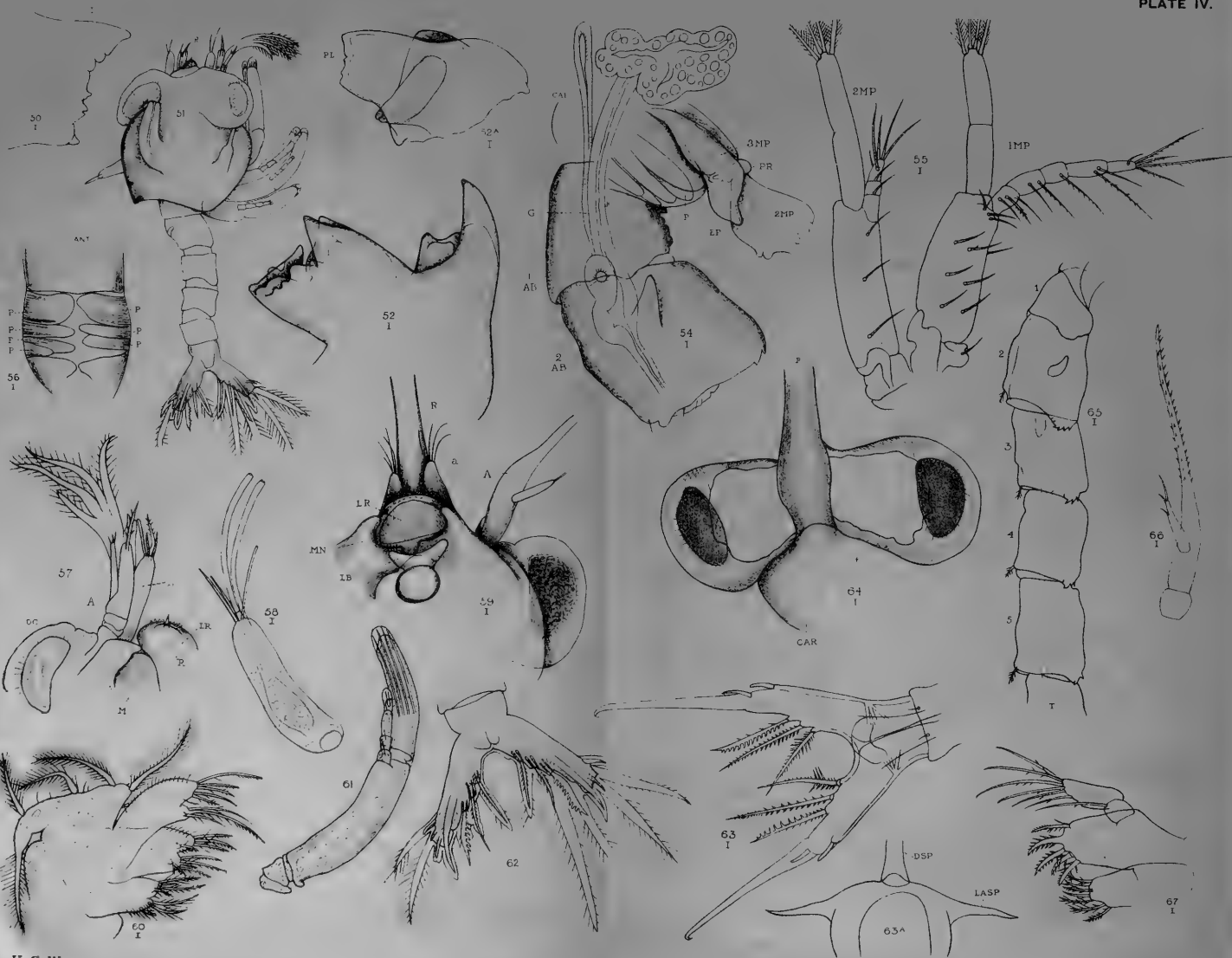




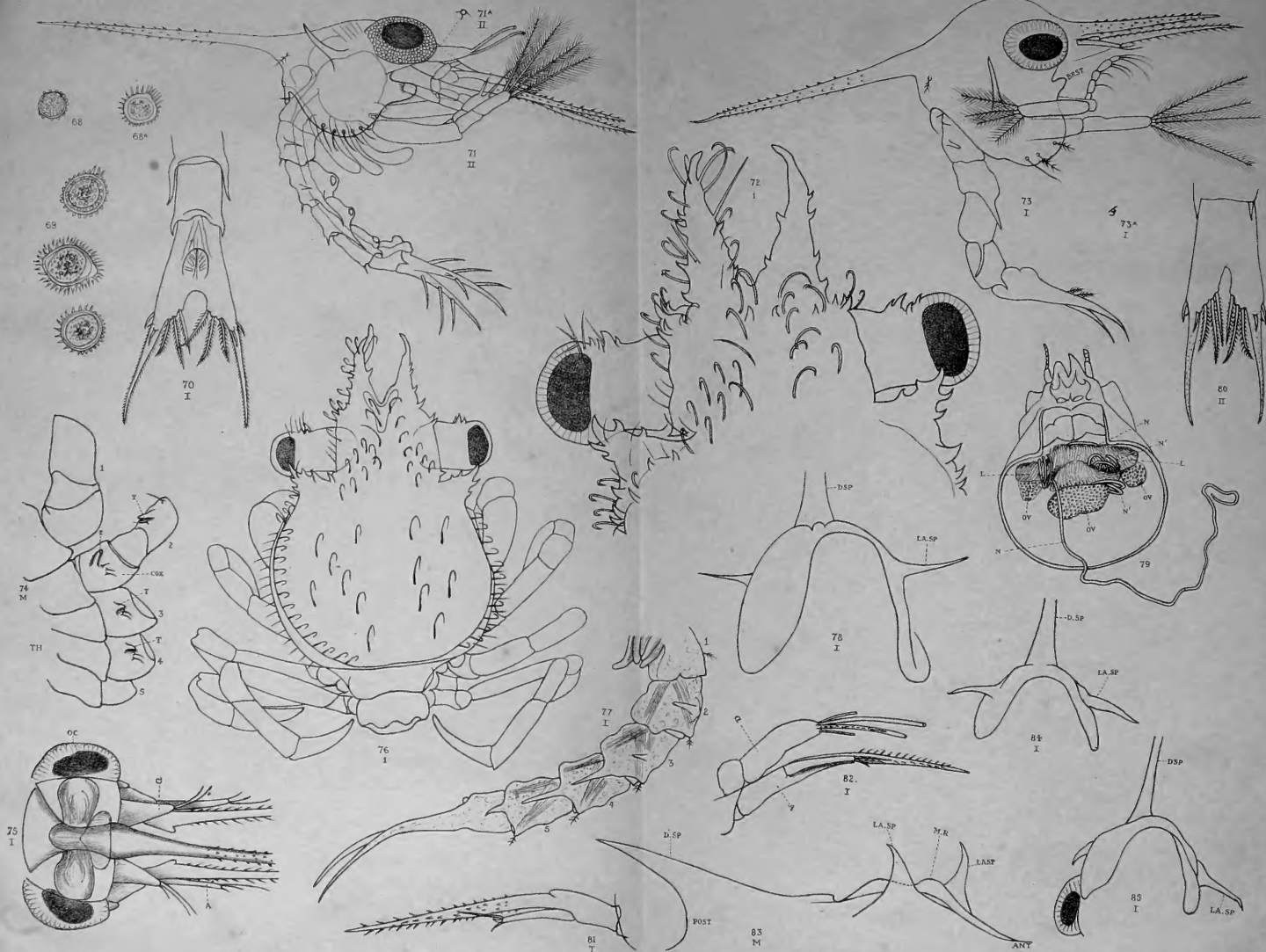
H. C. W.

Figs. 31, 39, 41, 44. *Portunus depurator*; *caetera Portunus puber*.









H. C. W.

Figs. 68, 69, Eggs of Nematode; Fig. 82, *Portunus puber*; Fig. 84, *Portunus depurator*;

Fig. 85, *Portunus holsatus*; caetera, *Hyas arenicus*.





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