The Zoeal Stages and Glaucothoe of the Tropical Eastern Pacific Hermit Crab *Trizopagurus magnificus* (Bouvier, 1898) (Decapoda; Diogenidae), Reared in the Laboratory[1]

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ABSTRACT: Larvae were reared under various temperature conditions. Those maintained at 15°C were unable to moult to the second instar although some individuals lived as long as 35 days after hatching. At 20°C some individuals were able to reach fifth instar, but glaucothoes were obtained only at 25°C, 33–52 days after hatching. Effects of starvation and temperature on larval survival are discussed. The number of zoeal stages in the development of this species is variable, as it is in other diogenids which have been studied in the laboratory, glaucothoes of this species being obtained after four or five zoeal instars. Descriptions and illustrations of the zoeal stages and the glaucothoe are presented. No other larvae of this genus have been described and intra-generic comparisons of larval morphology were not possible, but a comparison was made of the zoeal and glaucothoe stages of this species with those of others in the family.

THE EASTERN PACIFIC contains a relatively rich hermit crab fauna but one which is still rather poorly known systematically. In spite of the great number of species which occur even in shallow waters from Alaska to the Equator, very little is known concerning the life histories or larval development of eastern Pacific hermit crabs. One of the first successful attempts to rear anomuran larvae in the laboratory was made by Hart (1937), who described larval stages of two species of *Pagurus* and one of *Paguristes* and of the mud shrimp *Upogebia*, all from British Columbian waters. Coffin (1960) studied another species of *Pagurus*. No papers describing development of any tropical eastern Pacific hermit crab have been published.

The genus *Trizopagurus* occurs in tropical seas around the world with the exception of the Caribbean (Forest, 1952). In the eastern Pacific, the genus is represented by *T. magnificus*, a not uncommon hermit crab of moderate size,

black with orange spots and orange antennae and antennules. The species was first described by Bouvier (1898) as *Clibanarius magnificus*, and was redescribed and illustrated by Boone (1932) as *Clibanarius chetyrkini*. Forest (1952) recognized it as belonging to his newly established genus. The species is distributed from the Gulf of California southward at least as far as La Plata Island, Ecuador, and occurs also in the Galapagos Islands, but nothing is known of its ecology. The limited data available from various systematic papers which have dealt with *T. magnificus* and the data accompanying specimens in various collections are sufficient to indicate that this species seems to prefer rocky areas, from the intertidal zone down to a few tens of meters. The female from which the larvae were obtained for the present study was collected in an area where the substrates consisted of rocky patches surrounded by mud. Species collected with *Trizopagurus* in this locality included *Dardanus sinistripes* Stimpson and *Clibanarius panamensis* Stimpson, both typical of inshore waters along the major part of the range of *T. magnificus*. *C. panamensis* is most often found in brackish water and muddy areas, often close to mangrove shores. Also collected with adults of *T. magnificus* were a species of *Isocheles,* about which virtually

nothing is known, and a specimen of an un-described species of *Clibanarius*.

In recent years there has been an increasing amount of effort to study the larvae of the several families of hermit crabs especially to obtain ontogenetic information useful in clas-sification and phylogeny of the group. No lar-vae of the seven currently recognized species of *Trizopagurus* have been studied previously. The purpose of the present work is to provide de-scriptions of the zoeae and glaucothoe of this tropical eastern Pacific hermit crab based on laboratory reared specimens, and to make avail-able the limited ecological data obtained inci-dental to the rearing experiments.

METHODS

Several females were collected in January 1964 by F. M. Bayer and R. Chesher at sev-eral intertidal localities near Venado Island in the Bay of Panama off the Canal Zone. One female *Trizopagurus magnificus* retained her eggs during passage back to Miami and yielded larvae during 16–18 January 1964. The tem-perature of the running sea water in which the female was kept was less than 20°C for one week prior to hatching and was 18°C during the hatching period. More than 800 larvae were obtained from this hatching and were placed in plastic compartmented trays as de-scribed in previous papers (Provenzano, 1962*a*; Provenzano and Rice, 1964), 1–10 larvae per compartment. Trays to which no food was added were placed in four experimental tem-peratures (10°, 15°, 20°, and 25°C) to de-termine survival time of starved larvae. Addi-tional trays, to which *Artemia* nauplii were added as food for the zoeae, were placed at the same temperatures. The three lower tempera-tures were maintained by thermostatically con-trolled refrigerators with fans to circulate air within the cabinets so that temperatures during the experimental periods did not vary more than ±0.1°C. For the highest temperature an air-conditioning unit in the culture room kept air temperature at 25°C ± 1.5°C.

Two lots of filtered sea water were used dur-ing the experiments, 32.6 parts per thousand from 16 January–3 February and 35.7 parts per thousand from 3 February to termination of the experiments.

Specimens and exuvia were preserved in al-cohol or formalin. Specimens were cleared in 3–5% KOH and whole specimens and exuvia were dissected after staining with Mallory's acid fuchsin red, lignin pink, or chlorozol black, and were mounted. Study sketches were made with a Bausch & Lomb microprojector, and details were checked under higher magni-fication using a Tasco compound microscope. Final drawings were made with the aid of a Wild binocular M-5 dissecting scope equipped with a camera lucida.

The term stage is used herein in the sense of instar or intermoult.

All scales in the illustrations represent 0.5 mm. Carapace length of zoeae was measured from the tip of the rostrum to the most pos-terior lateral margin of the carapace, not to the dorsal posterior margin. Total length was measured from tip of rostrum to the median posterior margin of the telson exclusive of tel-son spines. Because of the flexible nature of the abdomen, the total length is less reliable a measure than the carapace length, which is based on a rigid structure. In the glaucothoes, shield length was measured from the tip of the rostrum to the cardiac suture. Carapace length was taken from the tip of the rostrum to the dorsal posterior transverse margin, and total length was measured from the tip of the ros-trum to the posterior margin of the telson exclusive of setae.

The female from which the larvae were

hatched has been deposited in the U. S. National Museum (Catalog No. 113559).

EXPERIMENTAL RESULTS

Effect of Starvation at Various Temperatures

In order to determine the maximum survival time for unfed animals, several trays of larvae without food were placed in each experimental temperature. At 25°, 20°, and 15°C, 7–8 days were required for 50% mortality of the 54 starved larvae in each temperature, but at 10°C only 3 days were required for 50% mortality of 36 larvae. At 25°C, total mortality of the starved group required 10–12 days; at 20°C, 9–11 days; at 15°C, 8–10 days; and at 10°C all larvae were dead by the sixth day after hatching.

Survival at Various Temperatures of Larvae Fed with Artemia

At 10°C, 36 larvae were placed two per compartment. They began dying on the third day and by the seventh day all were dead. At 15°C, 145 larvae were placed one, two, or five per compartment. None moulted to stage II. By 21 days after hatching, approximately one-half had died, but a few survived as long as 35 days, then died in stage I.

At 20°C, 329 larvae were placed in trays, one, two, four, or more per compartment. Most moulted to stage II within 13–18 days after hatching, but a few lived to stage III. None became glaucothoe, but three specimens lived to stage V and died at approximately 85 days after hatching.

At 25°C, 305 larvae were placed in trays, one, two, or four per compartment. Nearly all survived the first moult, which took place 7–8 days after hatching. Glaucothoes were obtained at this temperature in as few as 33 and as many as 52 days after hatching. Only 18 glaucothoes were obtained. One specimen spent 23 days as a glaucothoe, then died in the moult to first crab stage, 56 days after hatching.

CAUSES OF MORTALITY

At 10°C the mortality of fed animals paralleled quite closely that for starved animals, indicating either that, despite presence of food,

the animals were unable to feed or that the temperature alone was sufficiently low to kill the animals directly. Even at the higher temperatures starved larvae did not swim during the last few days. Hence we may suppose that in nature larvae unable to feed within the first few days after hatching seldom survive as long as they did in these experiments, but nothing is known of the capacity of larvae to resume feeding and normal growth after varying periods of starvation. The shorter survival time at lower temperatures indicates that, at least at temperatures below 25°C, the exhaustion of yolk reserves was not the factor causing death among starved larvae, but that temperature had a direct negative effect on survival.

Because of the large number of larvae hatched and the limited time available to tend to them, some were placed together in compartments. It is unlikely that crowding was a primary cause of mortality since each compartment contained 40–60 ml of water and, in a few compartments in which as many as 10 larvae were together, survival was better than in many others with fewer animals. There was no apparent negative effect of crowding on survival.

It is obvious that the temperatures used were mostly below the satisfactory range for this species. At 10°C the larvae could not swim and died very quickly even though they had been gradually reduced to that temperature from the hatching temperature of only about 18°C. At 15°C the larvae were below the temperature at which normal development must take place, since none of them were able to moult. The fact that some lived as long as 35 days indicates that a few must have been able to feed at least occasionally even at that temperature, for starved larvae at 15°C were all dead by the tenth day after hatching. Even at 20°C larvae were apparently under very marginal conditions, since only three out of 329 lived to stage V.

At 25°C, although the percentage of survival to metamorphosis was low (18 glaucothoes were obtained from 305 original larvae), and although none of the glaucothoes actually survived to crab stage, the temperature was probably satisfactory, if still less than optimal. Contributing to the high mortality under laboratory conditions at 20° and 25°C

was an infection by a filamentous fungus-like organism which has occasionally struck experiments in the laboratory but which has not been identified. It is unfortunate that higher experimental temperatures were not available at the time. The 7–8 days required to reach the first moult at 25°C is approximately the same amount of time as is required by some other tropical species of hermit crabs in the laboratory, but is longer than for others. This period would almost certainly be shortened by several days at still higher temperatures.

DESCRIPTION OF THE LARVAL STAGES

There may be four or five zoeal instars in the development of *T. magnificus* prior to the glaucothoe stage.

General Features of the Zoeal Stages

The rostrum is long, exceeding the cephalic appendages, rather broad and deep, with the tip slightly curved ventrad. Each of the anterioventral corners bears a small blunt spine projecting anteriolaterally. The carapace bears no large spines posteriolaterally on the margins, but has numerous spinules which give the carapace a roughened appearance. These spinules extend onto the more posterior portions of the body as well, being especially noticeable on the dorsal surface of the abdominal somites and on the telson. As development proceeds, the spinules become relatively smaller until they are hardly noticeable in the last zoeal stage (Figs. 1 and 2). The telson is much broader than long in the first stage and in subsequent stages becomes progressively more elongate (Fig. 7).

The appendages are generally symmetrical throughout larval development, with occasional differences of one or two setae between one side and the other, but a notable exception is the pair of mandibles which are quite asymmetrical throughout the zoeal stages. Because zoeal mandibles have seldom been described or illustrated in detail, the functional and possible systematic significance of mandible armature is not well understood. Therefore both mandibles of each stage of this species have been illustrated from two aspects.

The zoeal stages have a yellow-orange overall color. Some of the parts of the exoskeleton,

notably the tip of the rostrum and the ends of the antennules, are yellowish but not from chromatophores. The carapace has a very diffuse yellow-orange color, also apparently not due to chromatophores. There are orange-red chromatophores laterally under the anterior half of the carapace, and others deep in the body at the bases of the maxillipeds, and there is a very large orange chromatophore on each side of the fifth abdominal somite near the base of the lateral spines. There are two pairs of similar large orange chromatophores anteriorly on the telson. Red chromatophores are found at the base of the antennae, on the labrum, and perhaps on the bases of the mandibles. A pair of red ones occurs on the first abdominal somite.

First Zoea

CARAPACE LENGTH: 1.4–1.6 mm
TOTAL LENGTH: 2.7–2.9 mm (3 specimens)

The first larval instar, as is typical of hermit crab larvae generally, has the eyes fused to the carapace. The sixth abdominal somite is fused to the telson, which bears the normal complement of 7 + 7 marginal telson processes, the outermost of which is a heavy spine, the second a delicate hair, while the others are articulated plumose setae.

The appendages of the first zoea (refer to figures) differ in no important respect from those of other species of hermit crabs at that stage (except that the well formed anteriolateral spine on the antennal scale is not always present in other diogenid hermit larvae and the medio-proximal corner of the basipodite of the first maxilliped has only setae, not a hooked process as in some other species of Diogenidae).

Second Zoea

CARAPACE LENGTH: 1.8–1.9 mm
TOTAL LENGTH: 3.5–3.8 mm (4 specimens)

The second larval instar differs from the first in many respects. The eyes are now free of the carapace and are stalked. The telson, while still fused to the sixth abdominal somite, has added a median pair of telson processes. All of the appendages have changed as shown in the figures.

The antennule has added some terminal aesthetascs, for a normal total of 6 or 7 terminal
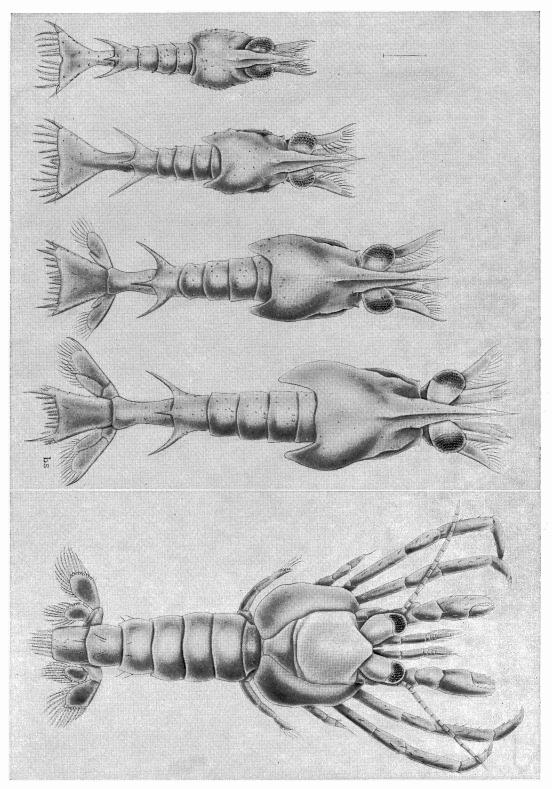
FIG. 1. *Trizopagurus magnificus*. Dorsal views of the four zoeal stages and the glaucothoe.
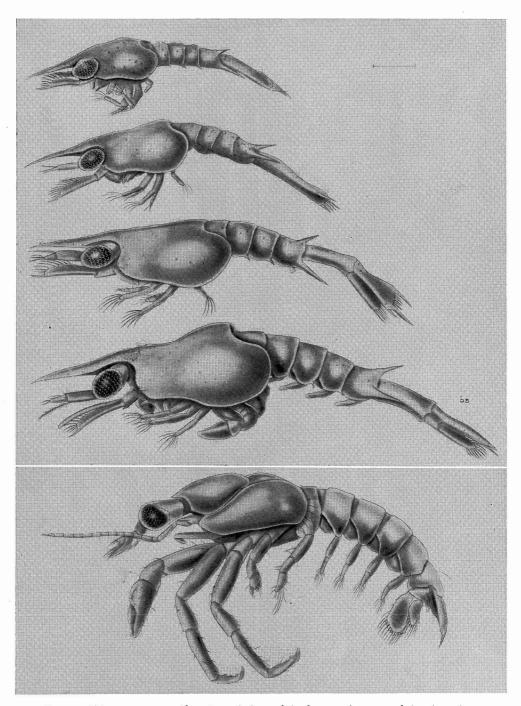
FIG. 2. *Trizopagurus magnificus*. Lateral views of the four zoeal stages and the glaucothoe.
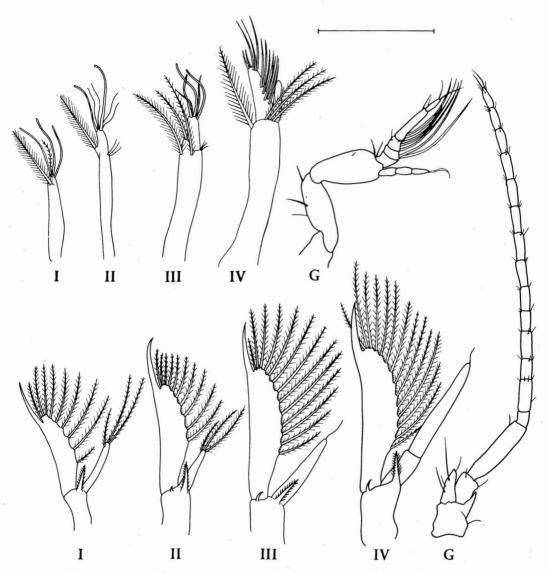
FIG. 3. *Trizopagurus magnificus*. *Top*, the antennule of zoeae I–IV and glaucothoe; *bottom*, the antenna of zoeae I–IV and glaucothoe.

processes and 3 subterminal setae at approximately the location of the future articulation of the rami.

The antenna has changed little, adding only a seta on the scale and a small tooth at the base of the scale.

The mandibles are not changed significantly.

The maxillule now has 4 strong teeth on the distal endite instead of 2. There may be a very short seta on the proximal segment

of the endopodite, but usually it is not discernible.

The maxilla has added 1 or 2 setae to the scaphognathite and 1 or 2 setae to some of the basal and coxal endites.

The first maxilliped has added 2 natatory setae to the exopodite. The endopodite has lost the row of extremely fine setules on the lateral margins of the segments and has added to the three most proximal segments a single
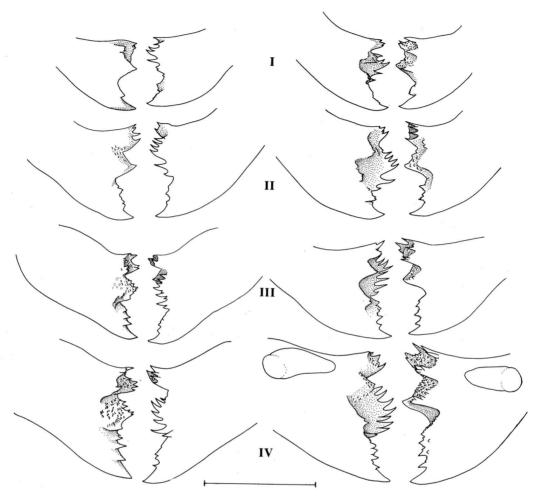
FIG. 4. *Trizopagurus magnificus*. The paired mandibles of zoeae I–IV. *Left column*, posterior surface; *right column*, anterior surface.

long plumose seta at the distal lateral margin. The appendage is otherwise basically unchanged.

The second maxilliped, like the first, has lost the fine row of setules on the endopodite, replacing them with long plumose setae on the two middle segments, and the exopodite has added 2 natatory setae.

The third maxilliped, a mere bud in the first stage but now functional, consists of a basipodite bearing an exopodite with 5 or 6 natatory setae. On the basipodite a lobe which will be the endopodite originates proximally and may bear a terminal seta.

Third Zoea

CARAPACE LENGTH: 2.15–2.40 mm (8 specimens)

TOTAL LENGTH: 4.25–4.55 mm (5 specimens)

The most obvious gross change is that the telson is now articulated with the sixth abdominal somite, and a pair of uropods has appeared. The posterior telson margin bears $8 + 1 + 8$ telson processes, the median process being articulated and of the same type as the adjacent ones. However, the fourth process from each side is much enlarged, nonplumose, and is fused to the telson. There is

now a pair of fine plumose setae submarginally on the dorsal surface of the telson. The uropods consist of unarmed and nonarticulated endo-uropodites and setose exo-uropodites, each of which bears 8–10 marginal setae and 2 sub-marginal ones ventrally. There is a small ventral spine on the posterior margin of the sixth abdominal somite.

The antennule consists of a long peduncle with an articulated segment terminally which will be the dorsal flagellum. Proximal to the articulation there are 2 long plumose setae in place of 1 in the previous stages and 3–5 short simple setae. Usually there is evident a simple lobe which will become the ventral flagellum and which bears a plumose seta.

The antenna has 11–13 plumose setae on the scale and the endopodite (which has elongated considerably) has lost its 2 long and 1 short plumose setae and replaced them with a single terminal process which appears to be a single flexible seta.

The mandibles have added teeth.

The maxillule has 7 or 8 setae on the proxi-mal endite and now the tiny seta occasionally present on the proximal segment of the endo-podite in earlier stages is missing.

The maxilla bears 9–11 plumose setae on the scaphognathite, the endopodite carries a total of 6 or 7 setae. The basal endites each carry 4 or 5 setae. The distal coxal endite may have 3–5, the proximal coxal endite usually has 8 or 9 setae.

The first maxilliped is basically unchanged but a third seta has been added to the medial margin of the proximal segment of the endo-podite.

The second maxilliped is essentially un-changed.

The third maxilliped is little changed except for a slightly greater development of the endo-podal lobe. The terminal seta of this lobe is sometimes missing.

Fourth Zoea

There is considerable variation in setation and relative degree of development of appen-dages in the fourth zoeal instar. Some individ-
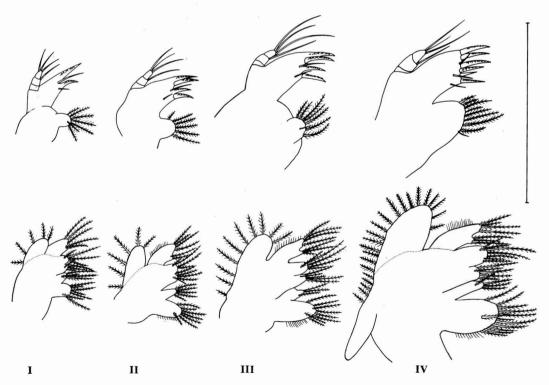

I   II   III   IV

FIG. 5. *Trizopagurus magnificus*. *Top,* the maxillule of zoeae I–IV; *bottom,* the maxilla of zoeae I–IV.
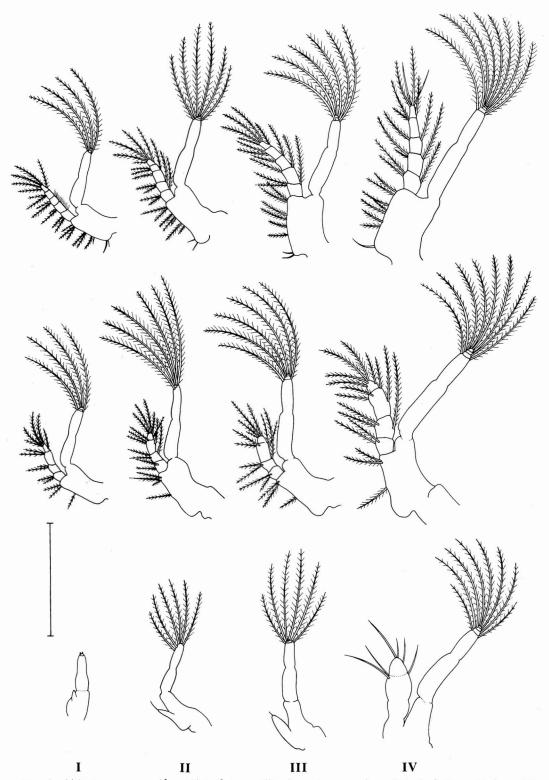
FIG. 6. *Trizopagurus magnificus. Top,* first maxilliped; *center,* second maxilliped; *bottom,* third maxilliped; of *(left to right)* zoeae I–IV.

uals, better developed than some of their siblings, were able to moult directly to the glaucothoe stage following this zoeal instar, but others, less developed, moulted into a fifth zoeal instar before the glaucothoe. In all fourth stages, however, the uropods are articulated with the sixth abdominal somite via a protopodite. Each exo-uropod now has a large fused spine at the posteriolateral margin and in addition may have 11–13 plumose setae marginally with 1–4 submarginally on the ventral surface. The endo-uropodites usually carry 5–7 marginal plumose setae and may have 1–3 submarginal setae ventrally. The telson itself is basically
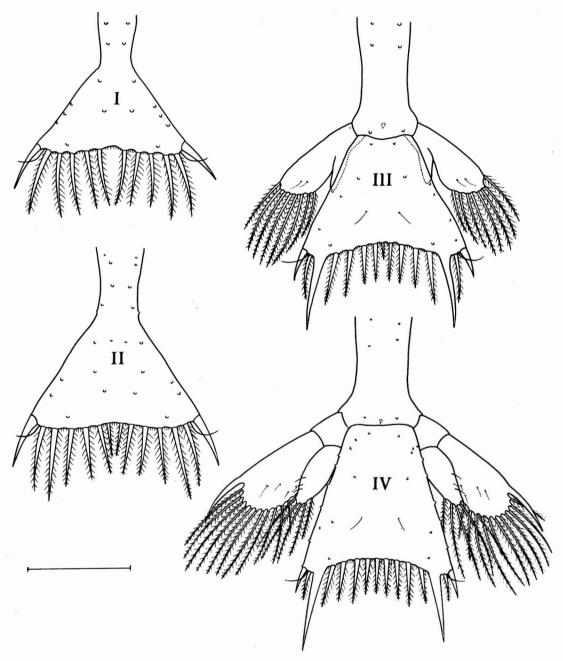

FIG. 7. *Trizopagurus magnificus*. Details of the telson of the zoeal stages.

unchanged from the previous stage except that it is more elongate and now may have either 1 or 2 pairs of submarginal setae. The medial telson process may be replaced by a pair of articulated processes. In series where the fourth zoeal instar was followed by another zoeal stage, the appendages were less well developed and the resulting fifth stage zoea did not differ significantly from the advanced fourth stage here described. The following remarks are based on specimens which moulted directly to glaucothoe from this stage.

Terminal Zoea

CARAPACE LENGTH: 2.4–2.9 mm (9 specimens)

TOTAL LENGTH: 5.5–6.2 mm (8 specimens)

The antennule shows subterminal groups of aesthetascs on the dorsal flagellum, and the lobe which will become the ventral flagellum is well marked and may have a terminal seta. There are 3 or 4 large plumose setae proximal to the distal articulation of the peduncle.

The antennal scale may have 13–15 plumose setae on the medial margin. The endopodite may now reach as far as the base of the terminal spine of the scale, is still terminated with a single process, but consists of at least 2 or 3 segments with one or more distinct articulations.

The mandibles are still more complex and show buds of the palps.

The maxillule has added 2 strong teeth on the basal endite, and usually 1 or 2 setae on the coxal endite.

A naked proximal lobe is present on the scaphognathite of the maxilla and as many as 22 plumose setae may be on the margin of the scaphognathite. The proximal lobe of the coxal endite of the maxilla has also increased in setation.

The first maxilliped usually carries 7, sometimes 6 or 8, natatory setae on the exopodite. The proximal medial corner of the basipodite may be rather prominently produced, with the usual pair of setae often reduced to a single seta.

The second maxilliped may have 7 or 8 natatory setae on the exopodite but is otherwise unchanged.

The third maxilliped has 7 or 8 (rarely 6)

natatory setae on the exopodite. The endopodite is very well developed, segmented, and bears a total of 1–5 setae on the terminal segments.

The pereiopods are well developed buds. The pleopods are represented by unarmed buds on abdominal somites 2–5.

Glaucothoe

SHIELD LENGTH: 0.9 mm (3 specimens)

CARAPACE LENGTH: 1.3–1.4 mm (2 specimens)

TOTAL LENGTH: 3.8–4.0 mm (3 specimens)

The post-zoeal stage in hermit crabs, as in all reptant decapods, is radically changed from the last zoeal stage: the long rostrum has disappeared, the carapace of the glaucothoe being almost the form of the juvenile, the pereiopods are free and functional, the pleopods are setose, the telson and all the cephalothoracic appendages have undergone radical change. The illustrations show how the gross external morphology of the glaucothoe of *T. magnificus* differs from the zoeal stages which preceded it.

As in all other described glaucothoes of the family Diogenidae, except that of *Diogenes pugilator*, there are no ocular scales at the bases of the eyestalks. In three specimens checked, the setation of the pleopods varied from 8–10 per pleopod, with no consistency in pairs or by somite. Other morphological features of particular significance are shown in the illustrations and will be discussed below.

The abdomen of the glaucothoe bears a few prominent chromatophores. In lateral view there is one red chromatophore anterior to the pleopods of the fourth abdominal somite. On the fifth abdominal somite there are two lateral and three ventral red chromatophores. Each of the protopods of the uropods, attached to the sixth abdominal somite, bears one red chromatophore. In dorsal view the fifth abdominal somite shows a pair of chromatophores on the anterior border and a pair on the posterior dorsal margin. The telson bears a pair dorsally and two pairs ventrally. Other chromatophores may be present, but only those mentioned above were noted in a brief examination of a living specimen. Diffuse orange color was seen under the eyestalks and in the region of the mouth, but the precise location of the origin of the pigment was not determined.
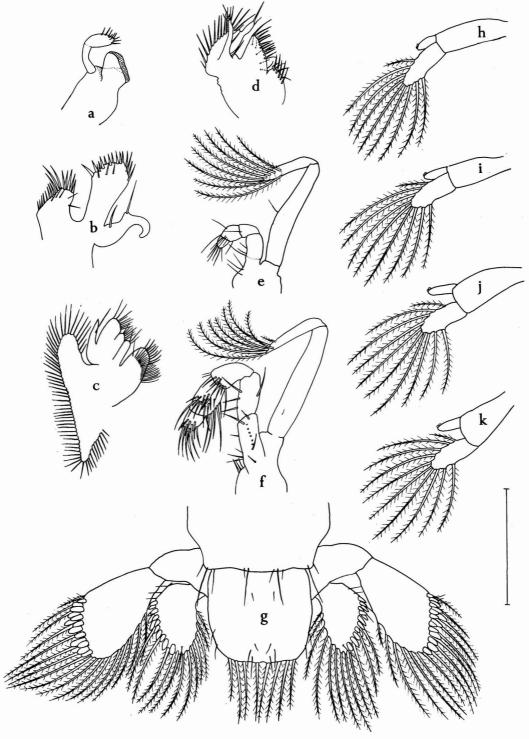
FIG. 8. *Trizopagurus magnificus*. Appendages of the glaucothoe. *a*, Mandible; *b*, maxillule; *c*, maxilla; *d*, first maxilliped; *e*, second maxilliped; *f*, third maxilliped; *h–k*, pleopods of abdominal somites 2–5; *g*, the tail fan. The posterior spine on the protopodite does not show in this view of the uropods.
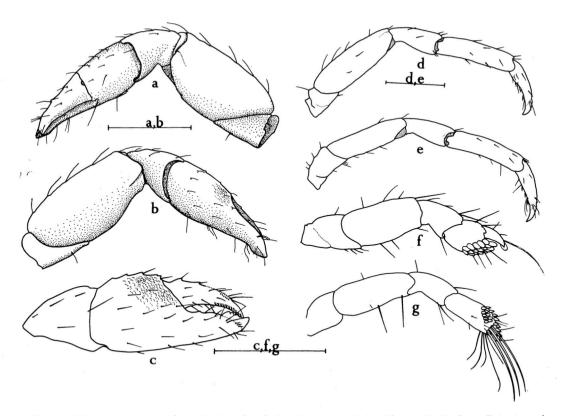
FIG. 9. *Trizopagurus magnificus*. Pereiopods of the glaucothoe, right side. *a*, Cheliped, medial view; *b*, same, lateral view; *c*, same, dorsal view, slightly enlarged; *d*, second pereiopod; *e*, third pereiopod; *f*, fourth pereiopod; *g*, fifth pereiopod.

DISCUSSION

Variability in the number of larval instars in anomuran development is now established as a widely occurring phenomenon. Species of Coenobitidae (Provenzano, 1962*a*), Diogenidae (Provenzano, 1962*b* and unpublished data), Galatheidae (Boyd and Johnson, 1963) and Hippidae (Rees, 1959) have been shown to have a variable number of instars in larval development of single species. Nor is this flexibility in development restricted to the anomurans. Caridean shrimps (Provenzano and Dobkin, 1962; Broad, 1957), scyllaridean lobsters (Robertson and Provenzano, unpublished), some brachyurans (Costlow, 1965; Yang and Provenzano, unpublished data), and at least one dromiid crab (Rice and Provenzano, 1966) have shown this pattern when reared in the laboratory. This phenomenon apparently results from the independence of the moulting

and growth processes and probably is of positive adaptive significance.

Although apparently there is not the uniformity in general appearance among larvae of the family Paguridae, as was thought only a few years ago, all described larvae of that family differ in certain features from larvae of the Coenobitidae and Diogenidae. The pagurid larvae which approximate most closely the diogenid larvae are those of the genu *Parapagurus*, some of which have been described by Dechancé (1964). The larvae of one species (Dechancé's sp. 1, which may be *P. pilosimanus* Smith), like those of *Trizopagurus magnificus*, have minute denticulations over at least parts of the body surface.

The only diogenid larvae which have been described as having any sculpturing on the cuticle are those of *Dardanus* as reported by Dechancé (1962), in which the cuticle was reported to have extremely small overlapping

scales with minute spinules. Larvae of a West Indian species, *D. venosus* (H. Milne-Edwards), have scutellations only on the rostrum in advanced stages and these scales are seen only with great difficulty, even under high magnification (Provenzano, unpublished data), but in that species there are minute tubercles distributed over the carapace and abdomen. These tubercles, much resembling those of *Trizopagurus* larvae, are more readily apparent in the early stages and, as development progresses, they become less apparent, as in *T. magnificus*. With this exception, *T. magnificus* is the only diogenid thus far known in which the larvae are so obviously ornamented that at least in the early stages the sculpturing is sufficiently obvious that it aids in identification. Perhaps this sculpturing will prove to be a generic character, but otherwise it is not possible yet to designate any single feature of these larvae of *T. magnificus* as being generically distinctive.

Since this is the first species in the genus *Trizopagurus* for which the larvae have been studied, it is not possible to compare these presently described stages with congeneric larvae from other parts of the world nor to point out which features may be reliable as specific *versus* generic characters. Moreover, since *T. magnificus* is the first species of Diogenidae of the tropical eastern Pacific for which a description of the larval stages is now available, it is not possible to offer a list of characters by which larvae of this species can be separated with certainty from other diogenid larvae with which they might occur in plankton.

The enlargement and fusion to telson of the fourth telson process in the third and fourth zoeal stages of *T. magnificus* is found in the two species of *Calcinus* which have been studied, in *Dardanus arrosor,* and in the land hermit crab *Coenobita clypeatus*. None of the three species of *Paguristes* so far studied show any change in this process in their zoeal stages, but since there are at least 25 species of *Paguristes* in the West Indian faunal region alone, and probably well over a hundred world-wide, this character may show some variation. In *Clibanarius* and *Diogenes* there is fusion of this process, but instead of enlargement there is reduction, even approaching apparent absence.

Some characters, such as the spine of the antennal scale, may vary in size within a particular genus (see Dechancé, 1962: Fig. 3), and hence may be of little value as an indicator of genus but may be reliable as a specific character. The mediodorsal spine of the fifth abdominal somite in *Trizopagurus* is not known to occur in larvae of *Clibanarius* or *Dardanus,* but may be characteristic of *Coenobita* and of *Calcinus, Diogenes,* and at least some species of *Paguristes,* while the posteriolateral spines on that somite usually are found in these latter genera and in *Dardanus* as well.

In combination, the characters which distinguish the larvae of *T. magnificus* from all other described diogenid larvae are: the peculiar surface sculpturing, the trio of large spines on the fifth abdominal somite (shared with several genera, but not with *Dardanus* or *Clibanarius*), and the absence of the posteriolateral carapace spines which apparently characterize *Calcinus*.

In addition to *Coenobita, Calcinus, Clibanarius,* and *Dardanus,* for which larvae have been described from other faunal regions, there are within the range of *T. magnificus* other related genera (*Cancellus, Aniculus, Allodardanus, Isocheles,* and *Petrochirus*) for which no larvae have been described from any part of the world.

The glaucothoe of *T. magnificus* is typical of the family Diogenidae in general features. As opposed to glaucothoes of the Paguridae, those of the Diogenidae (and of the Coenobitidae) are generally symmetrical (the aberrant genus *Diogenes* is an exception), the chelae being of subequal size, and the tail fan especially being similar in both sides. The uropods in Diogenidae and Coenobitidae have well developed, functional endopodites, whereas in Paguridae the endopodites are very much reduced.

This glaucothoe differs in many respects from those known from other faunal regions and it is reasonable to expect that these features will be of value in separating planktonic *T. magnificus* glaucothoes from those of other hermit crabs in the eastern Pacific when the latter have been studied.

With respect to described glaucothoes of non-pagurid hermit crabs, that of *T. magnificus*

differs notably from that of the West Indian *Coenobita clypeatus* in having a well developed exopodite on the third maxilliped and in not having an extremely long terminal seta on the antennal flagellum (both the reduced exopodite and the long terminal seta probably are generic or familial characters of the land hermit crabs (Provenzano, 1962*a*). The glaucothoe of *T. magnificus* differs from those of the Pacific *Dardanus scutellatus* and the West Indian *D. insignis* and *D. venosus* (Provenzano, 1963*a*, 1963*b*) in size (all of which are much larger), in eye shape (in *Dardanus* the cornea is wider than the eyestalk, not narrower), in not having their peculiar armature of the ambulatory dactyls, in having a shorter telson, and in having a reflexed palp on the endopodite of the maxillule, which those species lack. The glaucothoe attributed to the West Indian *Petrochirus diogenes* (Provenzano, 1963*b*) was erroneously identified (Provenzano, in preparation), but the true glaucothoe of *Petrochirus* (a genus represented in the eastern Pacific by *P. californiensis*) probably differs from that of *Trizopagurus* in those same features as does *Dardanus*.

The glaucothoe of *Clibanarius erythropus* from the Mediterranean (Dechancé, 1958) differs from that of *T. magnificus* in being smaller, in having a suboval telson, in lacking a prominent spine on the protopodite of the uropod, in having a smaller number of segments on the antennal flagellum, and in details of setation. The four species of *Paguristes* for which glaucothoes have been described, *P. turgidus* Stimpson, from the northeastern Pacific (Hart, 1937); *P. oculatus* (Fabricius), from the Mediterranean (Issel, 1910 and Pike and Williamson, 1960); *P. abbreviatus* Dechancé, from the western Indo-Pacific (Dechancé, 1963); *P. sericeus* A. Milne-Edwards, in the West Indies (Rice and Provenzano, 1965), all differ from that of *T. magnificus* in having longer dactyls on the second and third pereiopods, in armature of the chelipeds, in having a very small number of segments in the antennal flagellum (8 segments or less), and in having only 2 segments in the ventral ramus of the antennule. Glaucothoes of *Calcinus*—specifically, *C. ornatus* (Roux), in the Mediterranean (Pike and Williamson, 1960); and *C. tibicen*

(Herbst), in the West Indies (Provenzano, 1962*b*)—apparently bear closest resemblance to that of *T. magnificus*, but when the eastern Pacific glaucothoes of *Calcinus* have been studied, probably there will be size differences and details, such as armature of the protopodite of the uropod, by which these forms may be distinguished.

An apparently unique feature of the glaucothoe of *T. magnificus* is the patch of granulations on each chela.

The only other diogenid genera occurring in the range of *T. magnificus,* and for which no glaucothoes have been described from other regions, are *Allodardanus* (*A. bredini* Haig and Provenzano, 1965), *Isocheles* (several species), *Aniculus* (*A. elegans* Stimpson) and *Cancellus* (*C. tanneri* Faxon). In *Allodardanus* and *Isocheles* the dactyls of the second and third pereiopods are rather long, and it is likely, though not certain, that the glaucothoe will show the same condition. Both *Aniculus elegans* and *Cancellus tanneri* have very short dactyls, but neither species has a reflexed palp on the endopodite of the maxillule, and so their glaucothoes should be distinguishable from that of *Trizopagurus*.

Particularly important characters for the future discrimination of diogenid glaucothoes should be the overall body size, the shape and armature of the telson, the armature of the protopodite of the uropods, the shape of the eyes, the relative lengths of the dactyls and propodi of pereiopods two and three and the armature of these dactyls, the length of the setae on the antenna relative to lengths of antennal segments, presence or absence of a reflexed palp on the endopodite of the maxillule, and the armature of the chelipeds.

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