THE LARVAL DEVELOPMENT OF PACIFIC *EUPHAUSIA GIBBOIDES* (EUPHAUSIACEA)

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ABSTRACT

The larval development of *Euphausia gibboides* is described and illustrated, including nauplius stages I and II, metanauplius stage, calyptopis stages I-III, and furcilia stages I-VI; dominant and variant forms, with respect to reduction in number of terminal telson spines, were found in furcilia IV-VI. Identification of developmental stages was substantiated by the study of a series of juveniles of *E. gibboides*, the largest of which had characters of both the furcilia phase and the adult. Larvae were studied in plankton samples from several areas within the range of the species in the Pacific Ocean; variation in size of calyptopes in different areas is described.

Euphausia gibboides Ortmann is a relatively large euphausiid of the temperate and tropical Pacific. It is closely related to *E. sanzoi* Torelli and *E. fallax* Hansen and with them forms a "*Euphausia gibboides* group" (Brinton 1962). In the North Pacific, *E. gibboides* is found in the transition zone between lat. 30° and 45°N and extending southward to about lat. 20°N in the east where it is considered a major species of the California Current system; in the South Pacific it occurs in the eastern equatorial zone. *Euphausia sanzoi* has been found in the Red Sea and western Indian Ocean, and *E. fallax* in the western tropical Pacific. The distributions of these species are discussed by Brinton (1962, 1967a, b, 1973), Brinton and Gopalakrishnan (1973), Roger (1967), and Mauchline and Fisher (1969). The distribution of the larvae of *E. gibboides* in the California Current is shown by Brinton (1967a, b, 1973).

Hansen (1911) divided the species of the genus *Euphausia* Dana into four groups with respect to armature of carapace and abdomen; of these, groups A and D were considered to be "well separated" but groups B and C "somewhat badly defined." Group C, the largest of the four, contains 12 of the 32 species now recognized in the genus: *E. mucronata*, *E. paragibba*, *E. pseudogibba*, *E. hemigibba*, *E. gibba*, *E. lamilligera*, *E. distinguenda*, *E. sibogae*, *E. gibboides*, *E. fallax*, *E. sanzoi*, and *E. vallentini* (*E. alvae* and *E. consuelae*, both considered difficult to evaluate are not included) (Boden et al. 1955). An early furcilia of *E. hemigibba* (Lebour 1949) and a late furcilia of *E. distinguenda* (Hansen 1912) have been identified, but a series of developmental stages has been described for only one of the group C species, *E. vallentini* (John 1936). In his investigation of the adults and larvae of the southern species of *Euphausia*, John has shown the affinity of *E. vallentini* and certain species of group B with which it may now be associated (Mauchline and Fisher 1969). Studies of the larvae of additional species should aid not only in identification of planktonic forms but also in definition of specific relationships within the genus.

The present paper provides descriptions of the developmental stages of *Euphausia gibboides*; it is part of a larger study whose purpose is to identify and describe larvae of the three species of the "*Euphausia gibboides* Group" and to compare the larval morphology of these closely related forms.

METHODS AND MATERIALS

Larvae of *E. gibboides* were obtained from preserved plankton samples in the Marine Invertebrate Collections of the Scripps Institution of Oceanography. They were sorted from net hauls, taken with the standard CalCOFI (California Cooperative Oceanic Fisheries Investigations) 1-m net (Ahlstrom 1954), which were known to contain larvae and juveniles of the species. The positions of these tows are given in Table 1; station data for the samples are given by Snyder

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Manuscript accepted March 1974.
FISHERY BULLETIN: VOL. 73, NO. 1, 1975.

TABLE 1.—The area, station number, and position of samples from which larvae of *E. gibboides* were obtained.

Area	Cruise	Station	Position (Lat., Long.)
North Pacific:			
Eastern	CalCOFI 6304	60.140	34°65.0'N, 129°19.5'W
	CalCOFI 6304	70.90	34°53.0'N, 125°13.0'W
	CalCOFI 6304	70.100	34°33.0'N, 125°13.0'W
	CalCOFI 6304	110.70	28°36.0'N, 118°18.0'W
	CalCOFI 6304	117.90	26°47.5'N, 118°50.0'W
	CalCOFI 6304	120.120	25°12.5'N, 120°22.5'W
	CalCOFI 6304	133.80	24°14.5'N, 116°17.5'W
	CalCOFI 6307	117.80	27°07.5'N, 118°06.0'W
Western	Transpac	56A + B	41°49.0'N, 166°38.6'E
	Transpac	76A	39°56.4'N, 143°38.5'E
Equatorial Pacific:			
Eastern	Shellback	187	1°39.5'N, 92°05.0'W
	Shellback	188	1°06.5'N, 93°14.5'W

and Fleminger (1965) and in University of California Data Reports (Scripps Institution of Oceanography 1964a, b).

The larvae were grouped by developmental phase, measured, and dissected for detailed study of appendages. The identification of eggs, nauplii, and metanauplius is based on their relative abundance in samples in which calyptopes and furcilia of *E. gibboides* were clearly the dominant euphausiid larvae. Identification of calyptopis and furcilia stages, based on morphology, distribution, and relative abundance with juveniles and adults of *E. gibboides*, was substantiated by the study of a series of juvenile forms the largest of which had characters of both the furcilia phase and the adult.

The identification of calyptopis I was confirmed by rearing after the manuscript had been accepted for publication. A gravid female of *E. gibboides*, caught in a mid-water trawl collection at lat. 27°35.5'N, long. 115°52.0'W, deposited her eggs soon after capture and larvae which hatched from the eggs were cultured through the first four developmental stages. I am indebted to Edward Brinton and Annie Townsend who undertook the rearing study of *E. gibboides* aboard RV *Alexander Agassiz* during Leg I of Scripps Institution of Oceanography Expedition Krill, May-June 1974.

Reviews of the literature dealing with the larval development of the Euphausiacea and discussions of their larval phases are given by Mauchline and Fisher (1969) and Gopalakrishnan (1973). The nomenclature used in the description of *E. gibboides* is modified from Sars (1885) as follows.

Nauplius phase (two stages): Body oval, unsegmented, without compound eyes; 3 pairs of limbs present, antennulae uniramous, antennae and mandibles biramous and natatory.

Metanauplius phase (one stage): Body unsegmented, with carapace; only 2 pairs of limbs present (antennulae and antennae); mandibles, maxillules, maxillae, and maxillipeds (first thoracic legs) present as bud-like prominences.

Calyptopis phase (three stages): Body divided into two principal sections; abdomen becomes segmented; thoracic segments develop but are much compressed; compound eyes imperfectly developed, immobile and covered by hood-like expansion of carapace; mandibles, maxillae, and maxillipeds distinct and functional; thoracic legs posterior to first leg and pleopods not present; uropods develop.

Furcilia phase (variable number of stages): Compound eyes more fully developed, mobile, and projecting beyond sides of carapace; antennae at first retaining original natatory structure, later transformed to adult form with scale and developing flagellum; legs and pleopods develop; method of locomotion thus changes as setose pleopods replace modified antennae for swimming; photophores develop; terminal telson spines become reduced in number, last furcilia stage with 1 terminal telson spine and 3 posterolateral spines.

Juvenile phase: Begins when telson has 2 posterolateral and 1 terminal telson spines, the adult number.

Individuals were straightened on a glass slide in a drop of preservative for measurement with an ocular micrometer. Measurements of developmental phases were as follows.

Egg: Diameter of capsule and width of perivitelline space measured only in specimens with undeveloped embryos.

Nauplius: Length between midpoints of anterior and posterior margins; width at widest point.

Metanauplius: Length between midpoints of anterior margin of rostral hood and posterior margin of abdomen; width of rostral hood at widest point; width of body at widest point posterior to rostral hood; measurements exclude spinose fringe on rostral hood and telson spines.

Calyptopis: Total length between midpoints of anterior margin of carapace and posterior margin of telson; carapace length from center of anterior margin to distal point on posterior margin excluding dorsal spine; carapace width at widest point on anterolateral margins; measurements exclude spinose fringe of carapace and telson spines.

Furcilia: Total length between midpoints of anterior margin of carapace and posterior margin of telson, the carapace measurement excludes spines until median spine appears and then is made from tip of spine, the telson measurement excludes spines until development of 1 terminal spine in last stage and then is taken from tip of spine; carapace length from posterior margin of orbit to distal point on posterior margin excluding spine in furcilia I; rostrum width at widest point proximal to eyestalks, excluding spines; eye height on cornea between upper and lower lobes measured in lateral view.

Juvenile: Total length as in last furcilia stage.

The range, mean ($\bar{x}$), and standard deviation (SD) of each measurement with number of specimens measured (n) is given in Tables 5-8.

Larvae were placed in glycerine for dissection. The description of setation and form of appendages is based on dissection of at least 10 specimens of each developmental stage. The common form of each appendage is figured; when the setation varies within a stage, the number of appendages with each setation observed is given in parentheses behind the number of setae. Only changes in setation or structure from the preceding stage are noted. Drawings were prepared with a Wild M-20 microscope[2] equipped with drawing attachment.

RESULTS

Developmental Stages

The following larval forms of *E. gibboides* were found: nauplius phase, stages I, II; metanauplius phase, one stage; calyptopis phase, stages I-III; furcilia phase, stages I-VI. There was no variation in the number of stages in nauplius, metanauplius, and calyptopis phases or in the first half of the furcilia phase in which stages are defined by the pattern of pleopod development. In the later furcilia stages, usually characterized by the sequential reduction in number of terminal telson spines, dominant and variant forms were found. The features used to differentiate furcilia in the initial sorting were: number and position of setose and non-setose pleopods, form of antenna, number of terminal telson spines, total length, and relative abundance. The furcilia identified are listed in Table 2.

When representatives of each stage were dissected and studied in more detail, two forms of the furcilia with 3 terminal telson spines were found; one was the dominant furcilia V and the other an advanced form which was comparable in size and development to the furcilia with 1 terminal telson spine. There also were two forms of furcilia with 2 terminal telson spines; the smallest was equivalent to furcilia V and the largest to furcilia VI. The relatively large furcilia with 2 and 3 telson spines considered to be variants of furcilia VI lacked the 2nd (middle) pair of posterolateral spines on the telson of the next instar developing beneath the cuticle and presumably would be classified as juvenile after the

TABLE 2.—The furcilia identified during initial survey.

Stage		Form of antenna	Pairs of pleopods		No. terminal telson spines
			Non-setose	Setose	
I		natatory	1	0	7
II		natatory	3	1	7
III		natatory	1	4	7
IV	dominant	natatory	0	5	5
	variant	natatory	0	5	7
	variant	natatory	0	5	6
	variant	natatory	0	5	4
V	dominant	juvenile	0	5	3
	variant	juvenile	0	5	5
	variant	juvenile	0	5	4
	variant	juvenile	0	5	2
VI		juvenile	0	5	1

TABLE 3.—Some of the characters used to group variant forms of furcilia stages IV-VI.

Character	Stage IV	Stage V	Stage VI
No. terminal telson spines: Dominant	5	3	1
Variant	7, 6, 4	5, 4, 2	3, 2
Antenna: Form	natatory	juvenile	juvenile
Right mandible: Dentate process near incisor teeth	+	+	–
Maxillule: Pseudexopod bud	–	–	+
Pleopod 5: Endopod setae	1	2	4

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

next molt. A few of the details which helped to clarify the relationship between furcilia with variant forms are noted in Table 3.

The total number of dominant and variant forms of furcilia IV-VI in samples examined and the percentage of each form within these stages is given in Table 4. The potential variation in reduction of the number of terminal telson spines was estimated by counting the number of spines developing on the telson of the next instar when possible. The range observed in each form is shown in Table 4.

John (1936) in describing larvae of species of *Euphausia* from the Southern Ocean noted that the "furcilia stages recognized by the number of terminal spines on the telson are not such natural groups as those recognized by the character and number of the pleopods"; this appears to be true as well for *E. gibboides*. As observed in other species (Mauchline and Fisher 1969), there is a general correlation between size of furcilia and the number of terminal telson spines (Tables 7, 8). As the larvae become larger, on the average, the number of spines usually decreases, and stages may be characterized by size, number of spines, and relative abundance. Furcilia identified by a wider range of developmental details, however, seem to be grouped more naturally.

Description of Stages

Nauplius I (Figure 1A)

Body egg-shaped, with 3 pairs of appendages. Antennule (Figure 6A) uniramous, unsegmented, with 1 seta and 2 small spines terminally, and 1 small subterminal spine.

Antenna (Figure 7A) biramous, unsegmented; exopod with 4 setae and tiny tooth distally; endopod with 2 setae and small spine terminally and 1 subterminal seta.

Mandible (Figure 7G) biramous, unsegmented; endopod and exopod each with 3 setae.

TABLE 4.—The number of dominant and variant forms of furcilia IV, V, and VI observed, the percentage of each form within stage, and the variation in number of terminal telson spines on developing telson of next instar among individuals of each form.

Stage	No. terminal telson spines	No. larvae	% of stage	No. terminal telson spines in next instar
IV dominant	5	242	88.6	5, 4, 3, or 2
variant	7	9	3.3	5
variant	6	17	6.2	5, 4, or 3
variant	4	5	1.8	3 or 2
V dominant	3	122	78.7	3 or 1
variant	5	11	7.1	3
variant	4	14	9.0	3, 2, or 1
variant	2	8	5.2	1
VI dominant	1	78	66.1	1
variant	3	21	17.8	1
variant	2	19	16.1	1

Nauplius II (Figure 1B)

Body longer, with 2 pairs posterior spines, outer pair very small.

Antennule (Figure 6B) with 2 setae and 1 spine terminally, and a small subterminal spine.

Antenna (Figure 7B) with 5 setae and sometimes a rudimentary 6th seta on exopod. Endopod with 3 setae and a small spine terminally, and 1 subterminal seta.

Mandible as in nauplius I.

Metanauplius (Figure 1C, D)

Carapace produced into wide rostral hood fringed with marginal spines; anterior margin with 3 or 4 relatively long pairs interspersed; posterolateral lobes curved ventrally around body; dorsal crest prominent, without spines. Abdomen short, posterior margin with median indentation and 5 pairs of spines; 3rd pair relatively long bearing setules, other pairs small and fused with telson, one or both of inner pair sometimes rudimentary. There are only 2 pairs of functional appendages.

Antennule (Figure 6C) with 2 setae, 1 aesthetasc (sensory seta), and 1 spine terminally and a small subterminal spine.

Antennal exopod and endopod (Figure 7C) articulated with basal segment which may show incipient segmentation. Exopod with 6 setae on 5 small distal segments; terminal segment, too small to be visible in figure, bears 2 setae. Endopod with 4 setae and 2 small spines distally and 1 subterminal seta on inner margin; rudiment of proximal 2nd marginal seta sometimes present.

Mandibles, maxillules, maxillae, and maxillipeds present as rudimentary buds.

Calyptopis I (Figure 2A-C)

Carapace with distinctive broad rostral hood fringed with small marginal spines; lateral

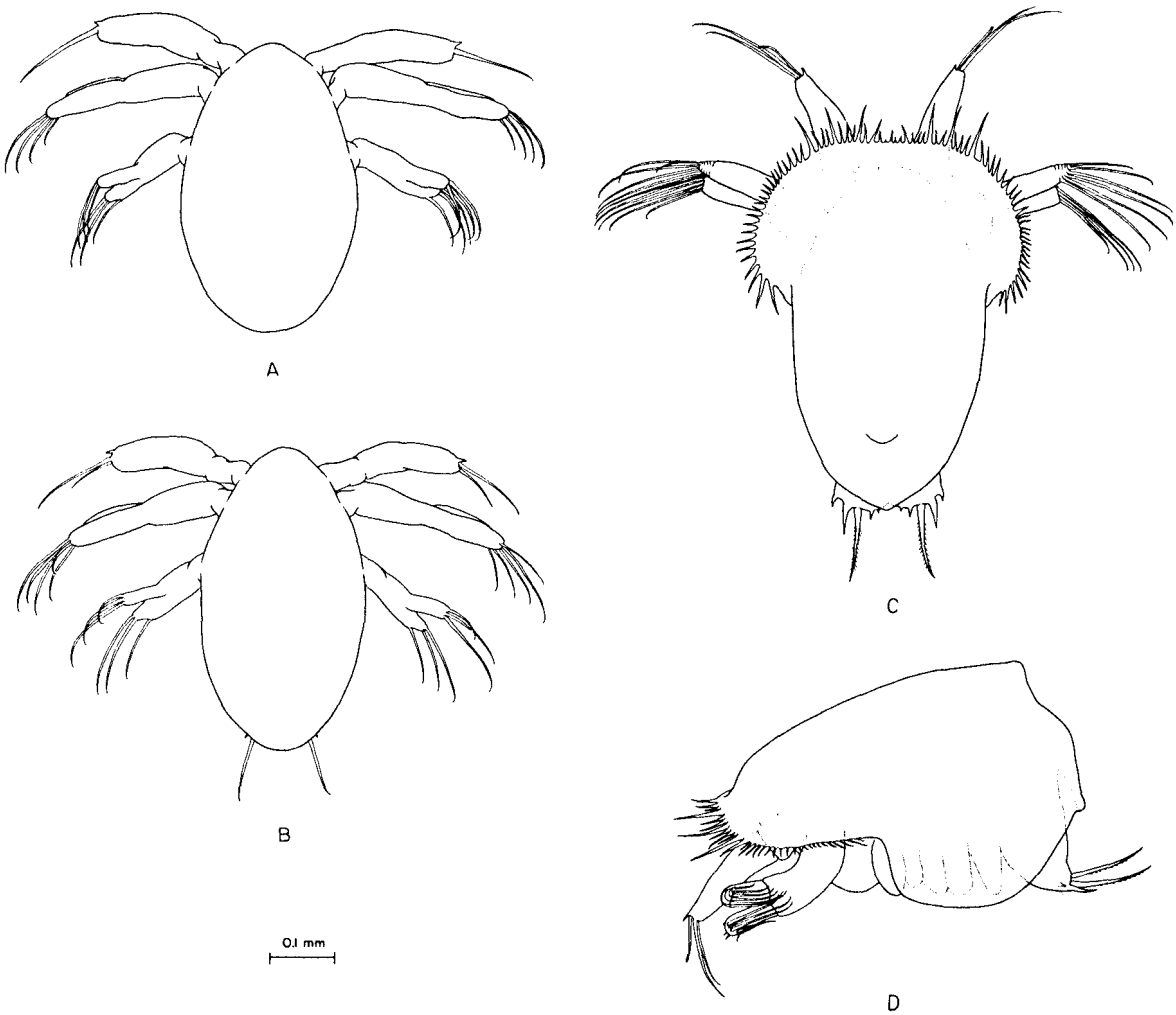

FIGURE 1.—Nauplius I: **A**, dorsal view. Nauplius II: **B**, dorsal view. Metanauplius: **C**, dorsal view; **D**, lateral view.

margins constricted behind eyes; posterior margin produced into strong dorsal spine; dorsal crest prominent. Compound eyes widen as they develop during stage, striated body of photophore visible. Thoracic segments may be visible; abdomen unsegmented.

Antennule (Figure 6D) 2-segmented, basal segment with 2 dorsal setae, 1 medial seta, and medial spine on distal margin; small terminal segment with 2 aesthetascs, 3 setae, 1 strong medial spine and tiny spine.

Antenna (Figure 7D) with 2-segmented protopod. Exopod with 7 setae on 5 distal segments; terminal segment with 3 setae, subterminal segments with 1 seta each. Endopod with 4 terminal setae and 2 setae on inner margin, the proximal marginal seta may be rudimentary; in addition to setules, distal marginal seta and 2 terminal setae bear small spinules and 3rd terminal seta armed with proximal row of comblike setules. This setation remains unchanged until furcilia V.

Mandibles (Figure 7H) asymmetrical; both with narrow plate near *pars molaris* and tuft of setae at base of plate; right mandible with dentate process near incisor teeth; when mandibles close dentate process bends inward toward mouth, the lower plates overlap. Conical anterolateral process and small prominent lateral knob present; lateral knob disappears in furcilia I, and anterolateral process decreases in size gradually up to late furcilia stages.

Maxillule (Figure 8A) with 6(1) or 7(20) setae

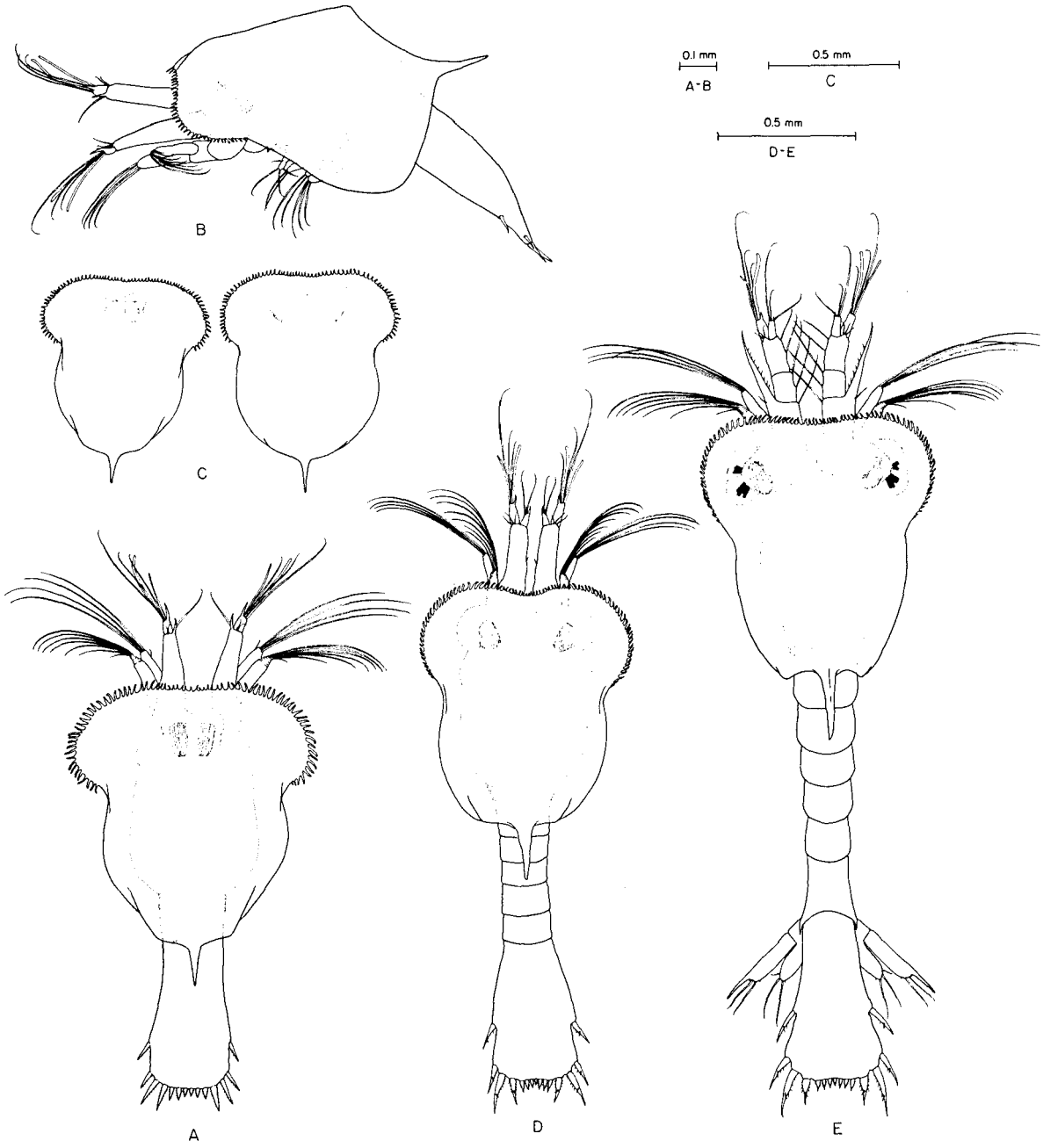

FIGURE 2.—Calyptopis I: **A**, dorsal view; **B**, lateral view; **C**, development of eyes within stage. Calyptopis II: **D**, dorsal view. Calyptopis III: **E**, dorsal view.

on coxal endite, 1 of 2 large setae distinctively armed distally with strong triangular spines rather than setules; basal endite with 3 spines armed with spinules. Endopod 2-segmented, terminal segment with 3 and proximal segment with 2 setae. Exopod a small lobe with 4 plumose setae. Setation of endopod does not change until furcilia V and that of exopod does not change throughout larval development.

Maxilla (Figure 8H) with 5 setose lobes on inner

margin (proximal 2 considered coxal and distal 3 basal although segmentation is unclear); setation of medial lobes 1-5 progressing distally is 8-4-4-4-3; 2 setae on lobe 1 and 1 seta on lobes 2-4 situated submarginally on posterior face. Endopod 1-segmented with 3 setae; exopod represented by 1 plumose seta on lateral margin. There is no change in setation in calyptopis phase.

Maxilliped (Figure 9A) usually with 5 setae on coxa, 4 marginal and 1 (sometimes absent) on posterior face, 4(3) or 5(17) setae were observed. Basis with 6 setae. Endopod 2-segmented; terminal segment with 4 and proximal segment with 3 setae; 1 distal seta on basis and 1 on proximal segment of endopod situated submarginally on posterior face; 1 marginal seta on basis and 1 on first segment of endopod relatively short and stout with tiny marginal spinules. Exopod with 4 terminal setae and 1 proximal seta near indistinct articulation with basis. Fine marginal hairs present as figured.

Telson with 1 pair of lateral spines, 3 pairs of posterolateral spines and 6 terminal spines, posterolateral spine 3 (inner) slightly longer than central posterolateral spine 2; terminal spines and posterolateral spine 3 armed with spinules on lateral margins, lateral spines and posterolateral spines 1 and 2 with spinules on inner margins only.

Calyptopis II (Figure 2D)

Broad rostral hood of carapace with more pronounced inward curve between eyes; dorsal crest less prominent. Abdomen with 5 segments.

Antennule (Figure 6E) biramous. Peduncle unsegmented but may be constricted with segmentation of calyptopis III visible beneath cuticle; distal margin with 3 dorsal setae and inner margin with 1 seta. Outer ramus with 2 aesthetascs, 1-3 setae and 2-4 spines terminally; inner ramus short, with 2 setae and 1-4 spines.

Maxillule (Figure 8B) with 6(3) or 7(15) setae on coxal endite; basal endite with 5 spines.

Maxilliped with 4(1) or 5(19) setae on coxa.

Telson, with addition of small median spine, armed with 7 terminal spines; posterolateral spine 2 now longest; lateral and posterolateral spines with relatively large dorsal spinule slightly more than halfway to tip.

Calyptopis III (Figure 2E)

Carapace with rudiment of small denticle on posterolateral margin present in furcilia I (Figure 4A). Abdomen with 6 segments; 6th segment, now separate from telson, with pair of biramous uropods.

Antennule (Figure 6F) with 3-segmented peduncle, basal segment produced distally into strong lateral spine extending to or slightly beyond tip of inner ramus, inner margin of spine setose. Peduncle segments 1-3 with 1-2-2 plumose setae on inner margins; segment 3 with dorsal lobe bearing 3 setae on distal margin; basal segment with 1 large lateral seta at base of spine. Inner flagellum about two-thirds length of outer flagellum and may have 3rd terminal seta; otherwise setation of rami unchanged.

Mandible armature (Figure 7I) unchanged.

Maxillule with 7 setae on coxal endite and 5 spines on basal endite; no variation observed.

Maxilla usually unchanged, with setation of 8-4-4-4-3 on lobes 1-5; lobe 3 varied with 3(1) or 4(20) setae and lobe 5 with 2(1) or 3(20) setae.

Maxilliped (Figure 9B) usually with 6 setae on coxa, 5(3) or 6(16) setae were observed.

Uropod (Figure 11Q) biramous; protopod with ventral spine above endopod; exopod with strong posterolateral spine, 2 small spines and 2 setae distally; endopod incompletely articulated with protopod, bearing 1 spine and 2 setae distally and 1 small subterminal dorsally projecting seta.

Telson armature unchanged.

Furcilia I (Figures 3A, 4A)

Eyes large, stalked and moveable, with 3-lobed appearance due to arrangement of ommatidia and concentrations of pigment as well as constrictions in cornea; lower lobe largest and most distinctly defined; convex middle lobe especially contributes to characteristic shape of eye. Carapace emarginate behind eyes; rostrum broad, blunt, fringed with small spines; posterior margin produced into dorsal spine; posterolateral margins with denticle; dorsal crest near midlength. First segment of abdomen with pair of non-setose pleopods; developing photophore between pleopods sometimes with faint pigment. Small anal spine present.

Antennule (Figure 6G) with lateral spine of peduncle segment 1 extending to distal margin

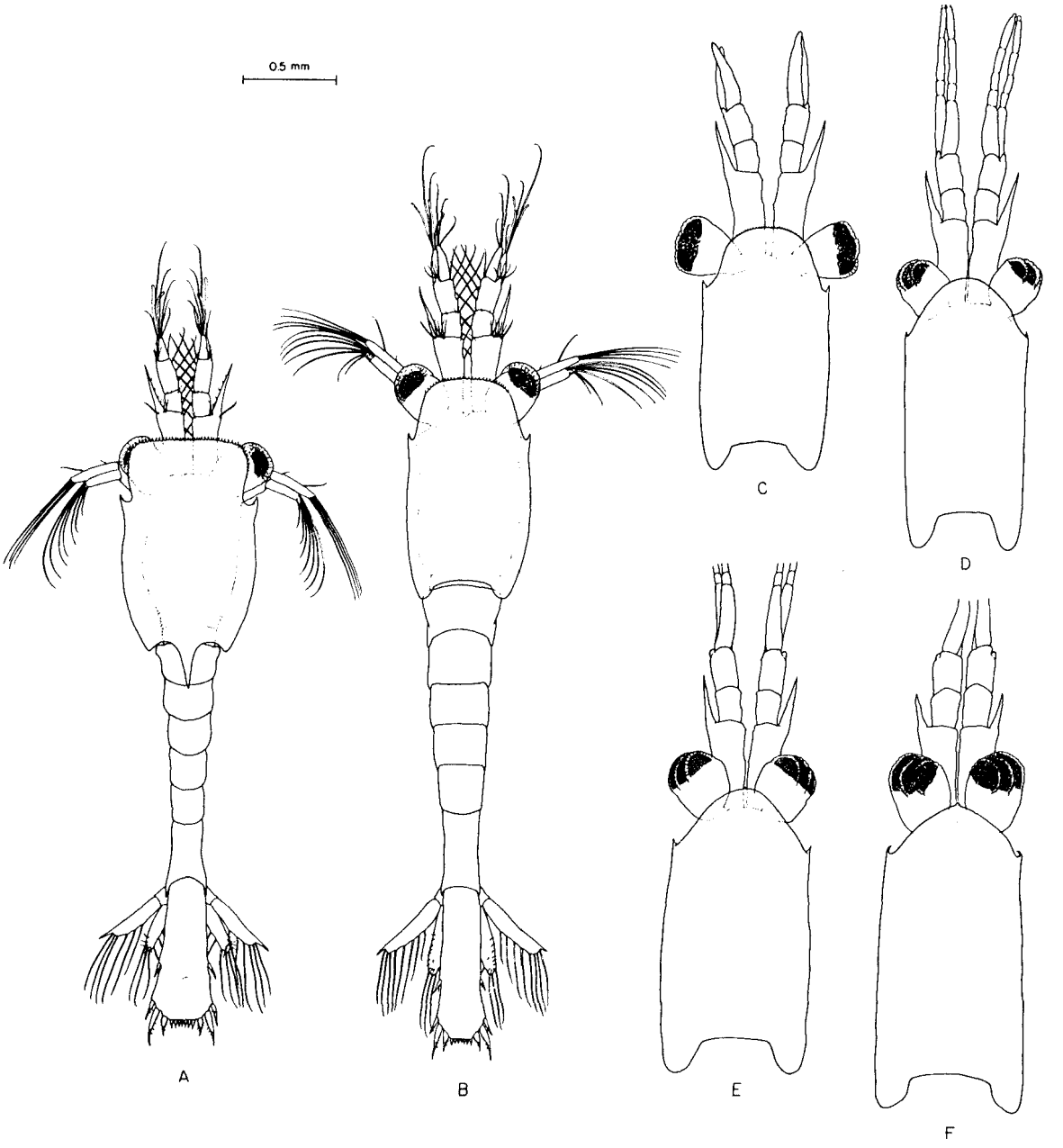

FIGURE 3.—Dorsal view: **A**, furcilia I; **B**, furcilia II; **C**, furcilia III; **D**, furcilia IV; **E**, furcilia V; **F**, furcilia VI.

of segment 3; spine with 5 pairs of setae spaced along inner margin and small setae between; peduncle segments 1 and 2 each with 2 plumose setae on inner margin and small dorsal setae; segment 3 with 3 setae on inner margin, a 4th slightly ventral seta on distal margin, and 4 setae on dorsal lobe. Flagella usually of equal length; outer ramus with 1 aesthetasc at about midlength of inner margin; terminal setation of flagella apparently unchanged but too frequently broken to determine. In subsequent furciliar stages numbers of setae on dorsal surface increase but

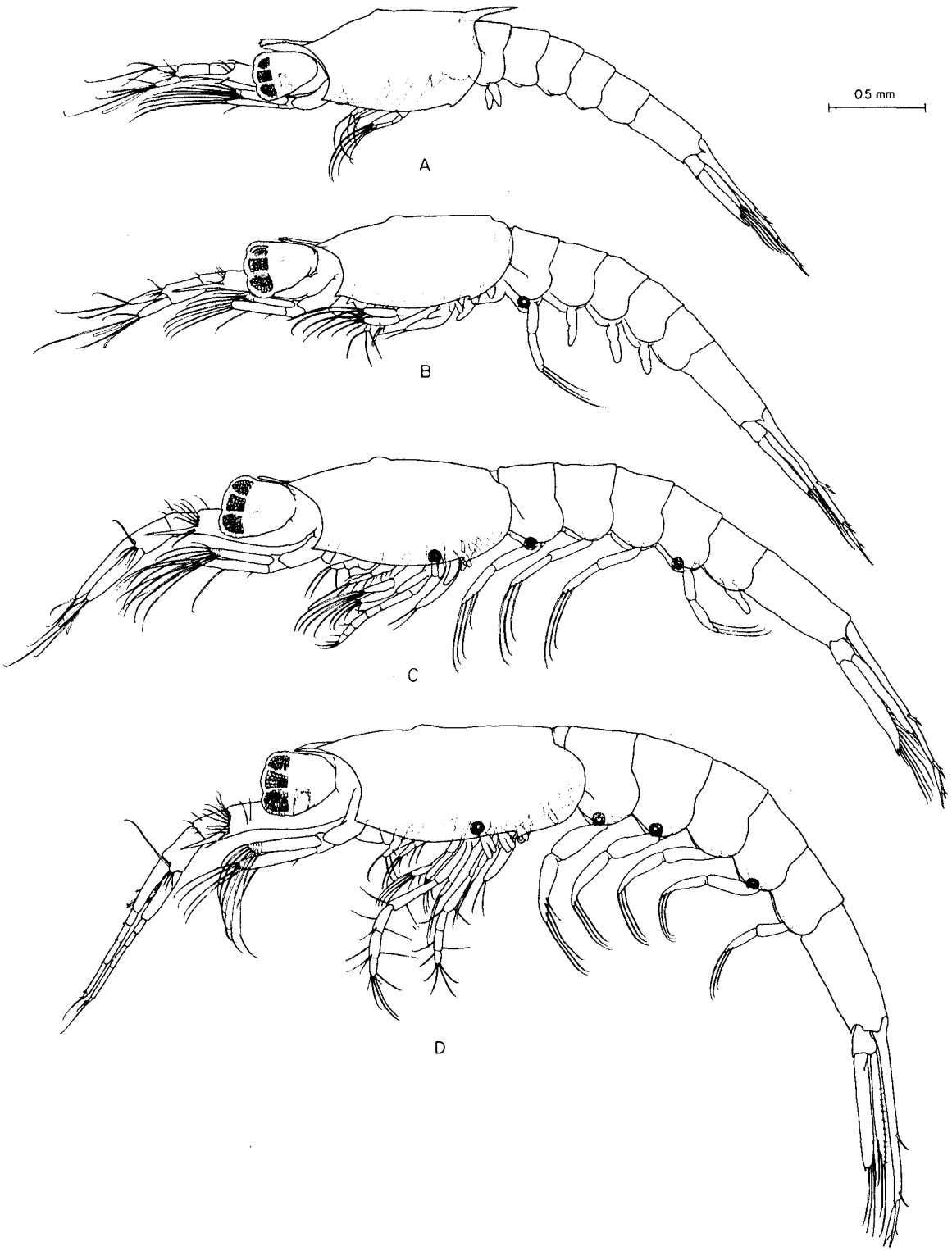

FIGURE 4.—Lateral view: **A**, furcilia I; **B**, furcilia II; **C**, furcilia III; **D**, furcilia IV.

number of plumose setae on medial margin remain the same; the lateral spine on segment 1 gradually decreases in length.

Maxillule with 6(2) or 7(20) setae on coxal endite; basal endite (Figure 8C) with 6(1) or 7(21) spines.

Maxilla (Figure 8I) usually with setation of 8-4-5-4-3 on inner lobes 1-5; lobe 3 now bears 5 setae; lobe 1 variable, with 7(1) or 8(20) setae.

Maxilliped with 5 setae on terminal segment of endopod (Figure 9C); coxa with 5(3) or 6(18) setae.

Leg 2 (Figure 10A) present, rudimentary; bud of leg 3 sometimes visible.

Pleopod (Figure 11L) non-setose and unsegmented, or with incipient segmentation and bud of endopod.

Uropod (Figure 11R) with 6 plumose setae on exopod; endopod articulated with protopod, bearing 6 marginal plumose setae and 3-5 small dorsal setae.

Telson (Figure 12A) with posterolateral spine 2 relatively longer.

Furcilia II (Figures 3B, 4B)

Rostrum of carapace a little narrower, with smaller marginal spines; posterior margin without dorsal spine; lobes of eye more defined (Figure 6K). Abdomen with 1 pair setose and 3 pairs non-setose pleopods on segments 1-4 respectively; photophore on segment 1 pigmented and functional, developing photophore on segment 4 sometimes with faint pigment.

Antennule (Figure 6H) with 5 setae on dorsal lobe of peduncle segment 3 one of which projects dorsally; this setation, with dorsally oriented seta becoming longer and stronger, is found in subsequent furcilia stages. Flagella now approximately as long as 3rd segment of peduncle.

Maxillule (Figure 8D) with 7(1) or 8(23) setae on coxal endite; basal endite with 7 marginal spines and often, in 16 of 24 appendages, with small seta on proximal margin.

Maxilla usually with setation of 8-4-5-5-3; lobe 3 variable with 5(23) or 6(1) setae and lobe 4 (Figure 8J) with 4(3) or 5(21) setae.

Maxilliped usually with 6 setae on terminal segment of endopod (Figure 9D), 5(3) or 6(21) setae were observed; coxa with 5(1) or 6(23) setae.

Leg 2 (Figure 10B) with endopod bearing 2 terminal setae and unsegmented or with 2 or 3 weakly defined segments; exopod rudimentary, without setae; gill bilobed; developing photophore on coxa sometimes with faint pigment. Leg 3 (Figure 10H) rudimentary, or with bud of exopod and gill. Bud of leg 4 may be present.

Setose pleopod 1 (Figure 11M) with 6 plumose setae on exopod, small endopod with single seta and median hook; non-setose pleopods 2-4 as in furcilia I.

Uropod (Figure 11S) with 8(21) or 9(1) setae on exopod, endopod with 7 marginal and 11 or 12 dorsal setae. This is the last stage in which numbers of setae can be counted; in preserved specimens the marginal setae are too frequently broken to attempt enumeration.

Telson (Figure 12B) narrower, posterolateral spine 3 wider basally.

Furcilia III (Figures 3C, 4C)

Carapace with rostrum narrowing, anterior marginal spines may be very small remnants. Abdomen with 4 pairs setose and 1 pair non-setose pleopods on segments 1-4 respectively; photophores on segments 1 and 4 pigmented and functional; developing photophore on segment 2 sometimes with faint pigment.

Antennular flagella (Figure 6I) almost twice as long as peduncle segment 3 and may be 2-segmented; outer flagellum with 2 aesthetascs on inner margin one of which bifurcates distally.

Mandible with anterolateral process about one-half as long as that figured for calyptopis III.

Maxillule with 8 setae on coxal endite; basal endite (Figure 8E) with 7(1), 8(4), or 9(17) spines on medial margin and 1 small seta on proximal margin.

Maxilla usually with setation of 8-4-6-5-3; lobe 3 (Figure 8K) now with 5(2) or 6(20) setae; lobe 5 variable with 2(1) or 3(20) setae.

Maxilliped with 5(3) or 6(16) setae on coxa and 6 on terminal segment of endopod.

Leg 2 (Figure 10C) with endopod 5-segmented, articulation with basis indistinct, setation variable, terminal segment with more than 2 setae; exopod with 0(7), 1(5), or 2(5) setae; gill bilobed; photophore pigmented and functional. Leg 3 (Figure 10I) with endopod unsegmented or with a few (less than 5) weakly defined segments, setation variable, distal segment usually with 2 terminal setae, 2(21) or 3(1) setae were observed; exopod rudimentary, without setae; gill bilobed.

Leg 4 (Figure 1ON) rudimentary, with bud of exopod and small bilobed or simple bud of gill; endopod usually without terminal setae, 0(22) or 1(2) seta were observed. Leg 5 present as bud. Leg 7 rudimentary with gill bud and developing photophore.

Setation of pleopods on abdominal segments 1-4 as follows: pleopod 1 (Figure 11N) — endopod 2, exopod 6(8), 7(11), or 8(1); pleopods 2-4 — endopod 1, exopod 6. Non-setose pleopod of segment 5 as in furcilia I. Endopod of pleopod 1 with *appendix interna*, a small medial lobe with tiny hooks.

Telson (Figure 12C) narrower; posterolateral spine 3 quite broad, inner margin smooth except for 1 or 2 tiny distal spinules near larger dorsal spinule. Five terminal spines of furcilia IV may often be seen beneath integument.

Furcilia IV (Figures 3D, 4D)

Rostrum of carapace usually with smooth margin, there may be tiny remnants of marginal spines but no median spine. Abdomen with 5 pairs of setose pleopods; photophores on segments 1, 2, and 4 pigmented and functional; developing photophore on segment 3 sometimes with faint pigment.

Antennular flagella (Figure 6J) with about 6 or 7 segments, segmentation usually indistinct; outer flagellum with 3 aesthetascs, 1 proximal to pair on medial margin, 1 aesthetasc no longer bifurcate.

Maxillule with 8(12) or 9(10) setae on coxal endite (Figure 8F); basal endite with 8(1) or 9(21) marginal spines and 1 seta on proximal margin.

Maxilla usually unchanged, with setation of 8-4-6-5-3; lobe 4 variable with 5(20) or 6(2) setae.

Maxilliped (Figure 9E) with 5(4) or 6(18) setae on coxa; basis with 6(9) or 7(10) setae. Endopod becoming 3-segmented as small terminal segment forms with setation of 3-2-4 for segments 1-3.

Leg 2 (Figure 10D) with endopod larger, more setose, and becoming geniculate with terminal 3 segments reflexed as in adult; exopod with 4(3) or 5(6) setae (seldom intact); gill bilobed. Leg 3 (Figure 10J) with endopod 5-segmented, sometimes slightly reflexed, articulation with basis indistinct, setation variable, terminal segment with more than 2 setae; exopod with 2(1), 3(1), or 4(12) setae; gill bilobed. Leg 4 (Figure 10O) endopod with few (less than 5) weakly delineated segments, terminal segment with 2 setae, other setation variable; exopod usually without setae, 1 of 15 appendages examined with 1 seta; gill bilobed. Leg 5 (Figure 11A) rudimentary with bud of exopod and bilobed or simple bud of gill. Bud of leg 6 present. Leg 7 (Figure 11I) with gill bilobed or with small bud of 3rd lobe, photophore may have pigment. Leg 8 (Figure 11F) represented by bilobed or trilobed gill.

Pleopod setation as follows: pleopod 1 (Figure 11O) — endopod 3(2) or 4(17), exopod 8; pleopod 2 — endopod 2, exopod 7(1) or 8(19); pleopod 3 — endopod 2, exopod 7(3) or 8(15); pleopod 4 — endopod 2, exopod 7(8) or 8(9); pleopod 5 — endopod 1, exopod 6.

Telson (Figure 12D) with 5 terminal spines, the 3 terminal spines of next instar often visible beneath cuticle.

VARIANT FORMS. — A small furcilia IV with 6 telson spines was less mature in that leg 4 had 1 terminal seta and exopods of pleopods 3 and 4 had only 6 setae. A furcilia IV with 4 telson spines showed bud of 3rd lobe of gill on leg 2.

Furcilia V (Figures 3E, 5A)

Rostrum usually with smooth margin, there may be a very small median spine. Photophores on abdominal segments 1-4 now pigmented.

Antennule with lateral spine of peduncle segment 1 extending to about midpoint of segment 3, none of the specimens available had flagella intact.

Antenna (Figure 7E) transformed, no longer natatory; basal segment with distolateral spine; endopod with 8 segments, 3 peduncular and 5 flagellar, division of terminal segment not always distinct; exopod (scale) with 13 or 14 plumose marginal setae.

Mandible (Figure 7J) with anterolateral process now considerably reduced in size.

Maxillule with 8(1) or 9(22) setae on coxal endite; basal endite with 9(21) or 10(2) marginal spines and 1(21) or 2(2) small setae on proximal margin. Endopod with segmentation weak or indistinct; in 6 of 21 appendages examined 1-segmented with 1 seta on lateral margin as figured for furcilia VI (Figure 8G).

Maxilla usually with setation of 8-4/5-6-6-3; lobe 2 (Figure 8L) variable with 4(15) or 5(9) setae and lobe 4 with 4(1), 5(4), or 6(19) setae.

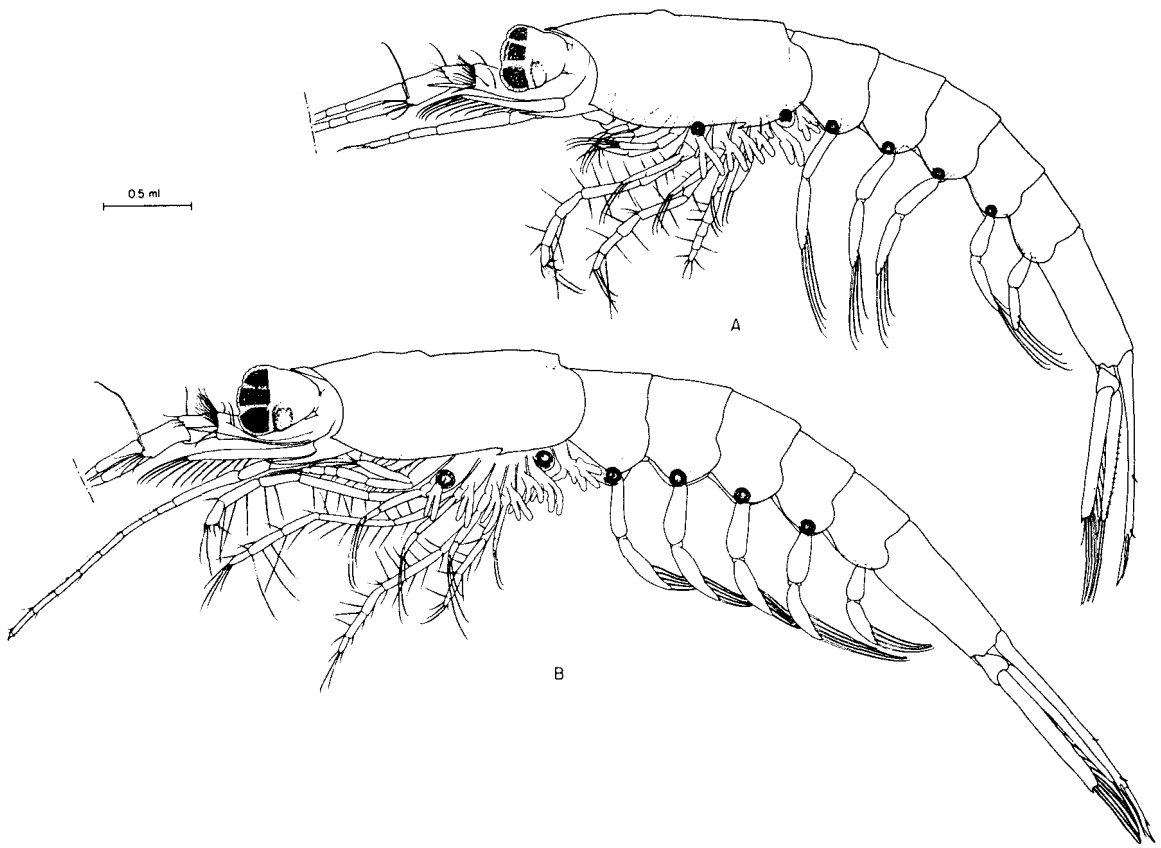

FIGURE 5.—Lateral view: A, furcilia V; B, furcilia VI.

Maxilliped (Figure 9F) with increasingly variable setation; coxa with 5(2), 6(12), 7(9), or 8(1) setae; basis with 6(2), 7(9), or 8(12) setae. Endopod lengthened, usually with 3 segments; 4 of 20 appendages examined with 4 or 5 segments indicated, distal segments weakly delineated; setations of 3-2-4, 3-1-1-4, and 3-2-0-1-4, progressing distally, were observed.

Leg 2 (Figure 10E) with dactyl of endopod becoming modified; exopod with 6 setae; gill usually with bud of 3rd lobe. Leg 3 (Figure 10K) with endopod reflexed, longer and more setose; exopod with 5(8) or 6(8) setae; gill with bud or sizeable rudiment of 3rd lobe. Leg 4 (Figure 10P) with endopod 5-segmented, articulation with basis never clear, setation variable, terminal segment with more than 2 setae; exopod with 4(16) or 5(1) setae; gill bilobed. Leg 5 (Figure 11B) with endopod unsegmented or weakly segmented with less than 5 segments, with 1(9) or 2(13) terminal setae and sometimes a few marginal setae; exopod with 0(22) or 1(1) seta; gill bilobed. Leg 6 (Figure 11D) rudimentary with gill bud, may be slightly bifid. Leg 7 (Figure 11J) with pigmented photophore; gill sometimes with bud of 3rd or 4th lobes. Leg 8 (Figure 11G) ramified, with varying numbers of lobes.

Setation of pleopods as follows: pleopod 1 — endopod 4, exopod 8(11), 9(5), or 10(2); pleopod 2 — endopod 4, exopod 8(7), 9(11), or 10(1); pleopod 3 — endopod 4, exopod 8(15) or 9(5); pleopod 4 — endopod 3(1) or 4(19), exopod 8; pleopod 5 — endopod 2, exopod 6(1), 7(17), or 8(5).

Telson (Figure 12E) narrow, with 3 terminal spines, 3rd pair of posterolateral spines lengthening relatively; single terminal spine of final furcilia may often be seen beneath cuticle.

VARIANT FORM. — A small furcilia V with 5 telson spines had antennal flagellum of about 5 segments, endopod of leg 5 without terminal setae, and endopod of pleopods 3-5 with 2, 2, and

1 setae respectively, one of the endopods of pleopod 5 had rudiment of 2nd seta.

Furcilia VI (Figures 3F, 5B)

Rostrum usually with small median spine.

Antennule with lateral spine of peduncle segment 1 about as long as segment 2; outer flagellum may have additional proximal aesthetasc; one apparently intact inner flagellum with 10 segments.

Antennal scale (Figure 7F) with approximately 15 or 16 setae; one intact flagellum with 3 peduncular and 11 flagellar segments.

Right mandible (Figure 7K) now without dentate process near incisor teeth; toothed plates relatively smaller; rudimentary palp may begin to increase in size.

Maxillule (Figure 8G) with 9(15) or 10(9) setae on coxal endite; basal endite with 9(4) or 10(20) marginal spines and 1(8) or 2(16) small setae on proximal margin. Endopod of 1 segment with 1 proximal lateral seta; terminal and medial setation unchanged. Coxa now with rudiment of pseudexopod.

Maxilla (Figure 8M) usually with setation of 8-6-6-6-3; lobe 2 variable with 4(2), 5(4), or 6(18) setae. Exopod represented by 1 (22) or 2(2) setae; endopod rounder.

Maxilliped (Figure 9G) modifying to adult form; coxa with 5-9 setae, long seta on posterior face no longer present; basis with 8(22) or 9(2) setae. Endopod of 5 segments with variable setation; articulation with basis not clear. Exopod still with 4 terminal setae.

Leg 2 (Figure 10F, G) with endopod more setose, dactyl with a few more "cleaning" comb setae; exopod with 6 setae; gill trilobed. Leg 3 (Figure 10L, M) with long terminal setae on dactyl of endopod; exopod with 6 setae; gill with bud of 3rd lobe or trilobed. Leg 4 (Figure 10Q) with endopod reflexed; exopod with 5(1) or 6(14) setae; gill with bud or larger rudiment of 3rd lobe. Leg 5 (Figure 11C) with endopod 5-segmented and setation variable, terminal segment with more than 2 setae; exopod with 1(2), 2(4), 3(2), or 4(10) setae; gill trilobed. Leg 6 (Figure 11E) with endopod unsegmented and nonsetose; exopod without setae; gill trilobed; exopod and gill may be rudimentary. Legs 7 (Figure 11K) and 8 (Figure 11H) with increasing number of gill lobes.

Pleopods with setation as follows: pleopod 1 (Figure 11P) — endopod 4(5), 5(10), or 6(7), exopod 9(7) or 10(12); pleopod 2 — endopod 4(14), 5(7), or 6(2), exopod 9(2), 10(13), or 11(3); pleopod 3 — endopod 4(17), 5(1), or 6(3), exopod 9(2), 10(13), or 11(1); pleopod 4 — endopod 4(21) or 6(2), exopod 9(10) or 10(7); pleopod 5 — endopod 3(1) or 4(20), exopod 8.

Telson (Figure 12F) quite slender with 1 terminal spine and 3 pairs posterolateral spines; posterolateral spine 2 was missing on one side in 5 of 12 larvae dissected. Developing telson of next instar is without spine 2 on either side.

VARIANT FORMS. — In furcilia VI with 2 and 3 telson spines, basis of maxilliped sometimes with 7 setae and exopod of leg 2 with 6, 7, or 8 setae. Once in furcilia with 3 telson spines, lobe 3 of maxilla with 7 setae and right mandible with tiny remnant of dentate process.

Measurements

The eggs assumed to be those of *E. gibboides* have a relatively wide perivitelline space. The measurements, in millimeters, of 100 eggs from one sample (6304-110.70) are: diameter of capsule, range = 0.61-0.75, $\bar{x}$ = 0.69, SD = 0.03; perivitelline space, range = 0.13-0.19, $\bar{x}$ = 0.16, SD = 0.01.

The measurements of developmental stages are given in Tables 5-8. The growth factor (mean length in stage divided by mean length in preceding stage) for dominant forms is as follows:

Stage	*Growth factor*	*Stage*	*Growth factor*
		Furcilia I	1.23
Nauplius II	1.04	Furcilia II	1.17
Metanauplius	1.08	Furcilia III	1.14
Calyptopis I	2.03	Furcilia IV	1.10
Calyptopis II	1.55	Furcilia V	1.10
Calyptopis III	1.39	Furcilia VI	1.12

There was variation in size of comparable developmental stages between the different areas from which samples were studied. The lengths of calyptopis stages are compared in Table 9. The larvae sampled in April 1963 (Cruise 6304) in the eastern North Pacific became larger, on the average, during the calyptopis phase in the

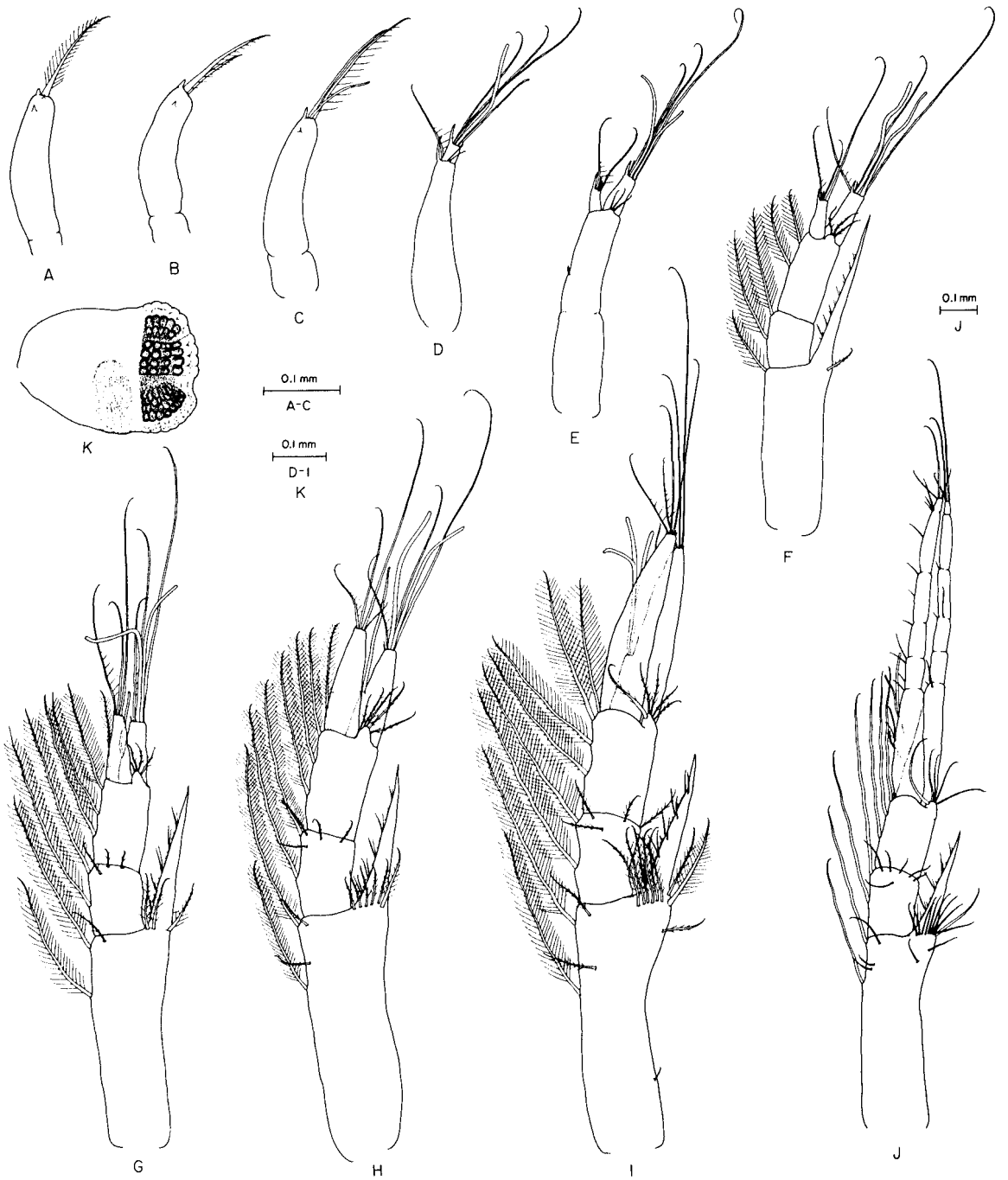

FIGURE 6.—Antennule: **A**, nauplius I; **B**, nauplius II; **C**, metanauplius; **D**, calyptopis I; **E**, calyptopis II; **F**, calyptopis III; **G**, furcilia I; **H**, furcilia II; **I**, furcilia III; **J**, furcilia IV. Eye: **K**, furcilia II.

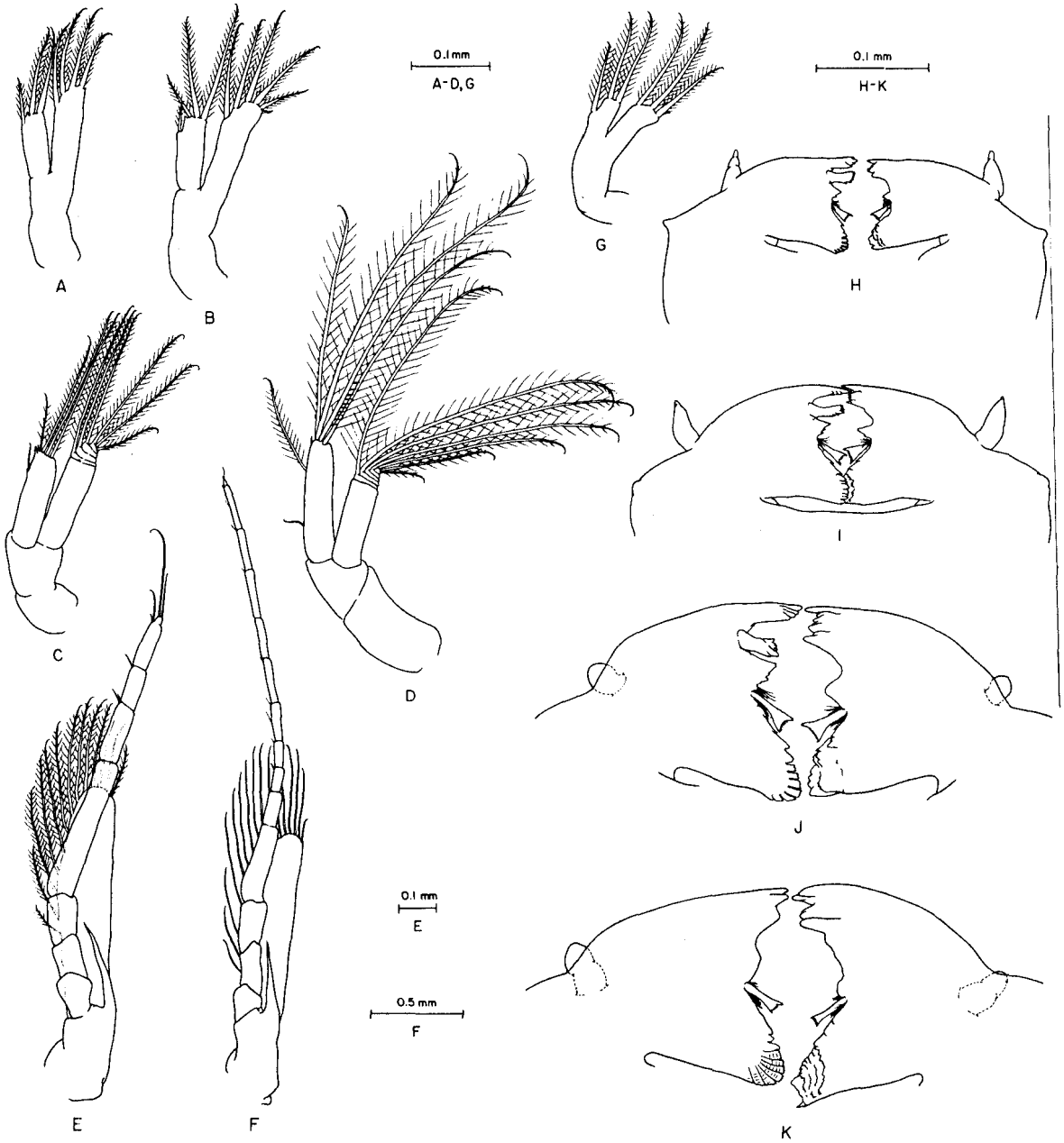

FIGURE 7.—Antenna: **A**, nauplius I; **B**, nauplius II; **C**, metanauplius; **D**, calyptopis I; **E**, furcilia V; **F**, furcilia VI. Mandibles: **G**, nauplius I; **H**, calyptopis I; **I**, calyptopis III; **J**, furcilia V; **K**, furcilia VI.

FIGURE 8.—Maxillule: **A**, calyptopis I; **B**, calyptopis II; **C**, furcilia I, basal endite; **D**, furcilia II; **E**, furcilia III, basal endite; **F**, furcilia IV, coxal endite; **G**, furcilia VI. Maxilla: **H**, calyptopis I; **I**, furcilia I; **J**, furcilia II, lobe 4; **K**, furcilia III, lobe 3; **L**, furcilia V, lobe 2; **M**, furcilia VI.

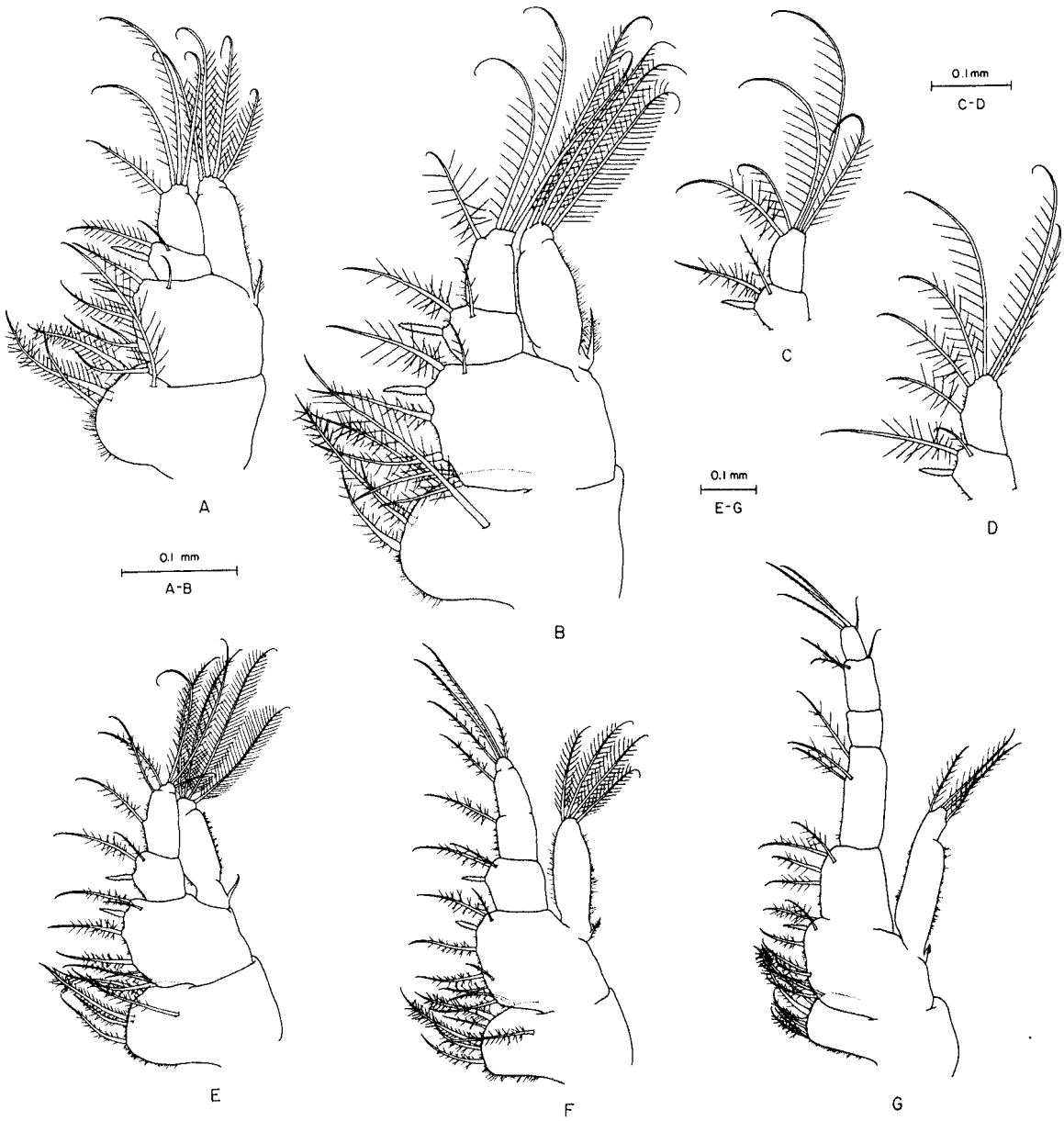

FIGURE 9.—Maxilliped (leg 1): **A**, calyptopis I; **B**, calyptopis III; **C**, furcilia I, endopod; **D**, furcilia II, endopod; **E**, furcilia IV; **F**, furcilia V; **G**, furcilia VI.

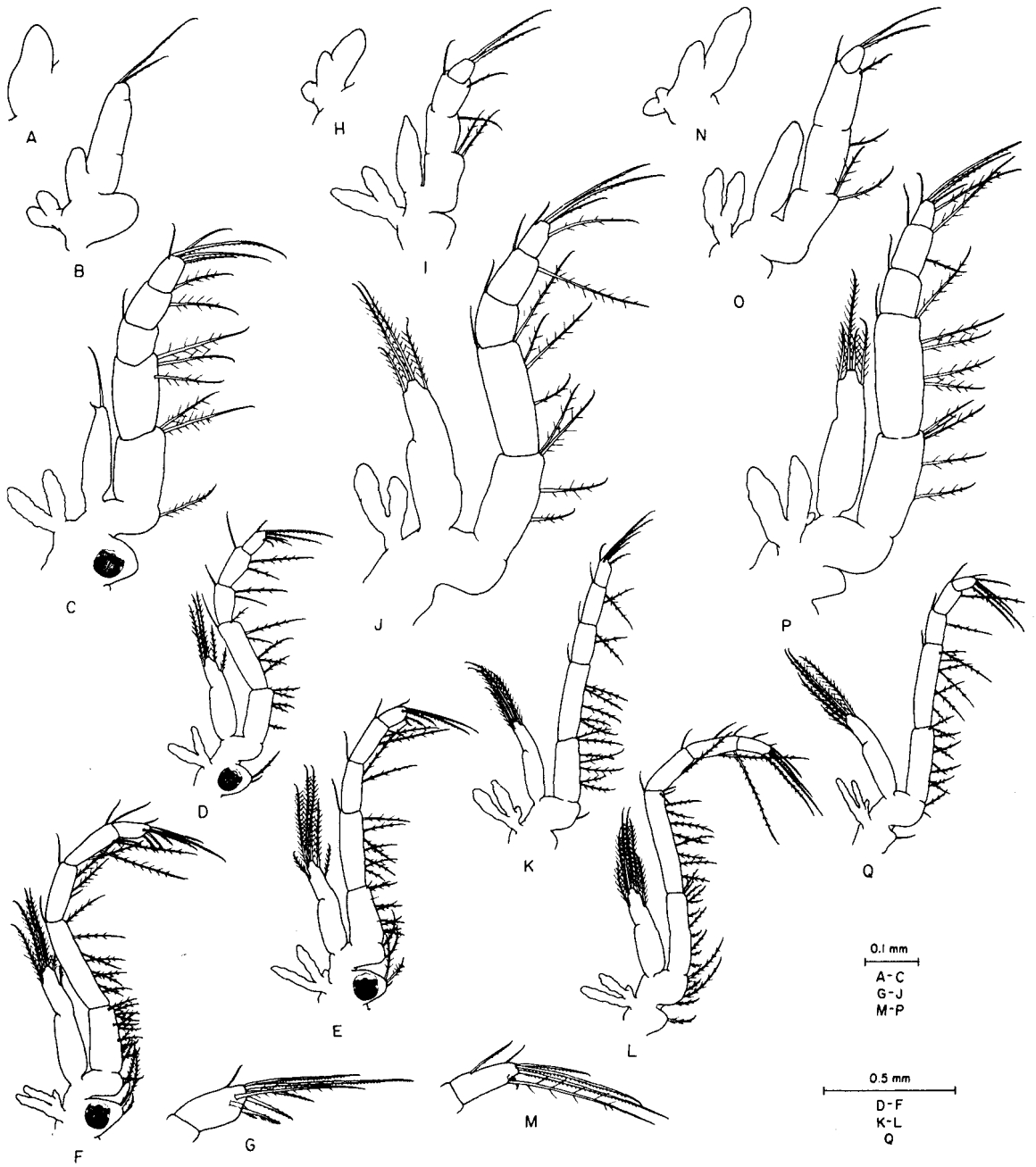

FIGURE 10.—Thoracic legs. Leg 2: **A**, furcilia I; **B**, furcilia II; **C**, furcilia III; **D**, furcilia IV; **E**, furcilia V; **F**, furcilia VI; **G**, dactyl, furcilia VI. Leg 3: **H**, furcilia II; **I**, furcilia III; **J**, furcilia IV; **K**, furcilia V; **L**, furcilia VI; **M**, dactyl, furcilia VI. Leg 4: **N**, furcilia III; **O**, furcilia IV; **P**, furcilia V; **Q**, furcilia VI.

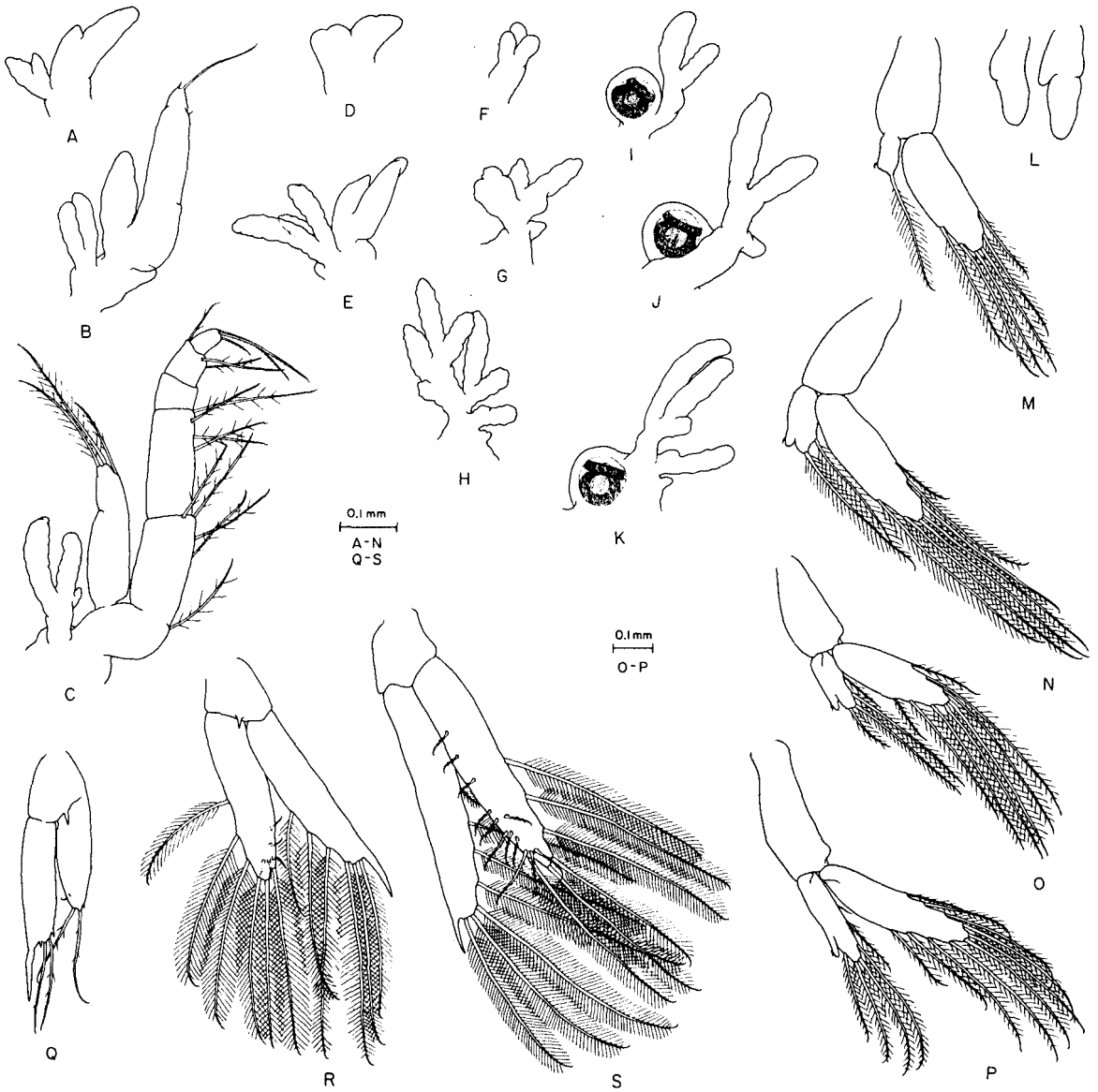

FIGURE 11.—Thoracic leg 5: **A**, furcilia IV; **B**, furcilia V; **C**, furcilia VI. Leg 6: **D**, furcilia V; **E**, furcilia VI. Leg 7: **I**, furcilia IV; **J**, furcilia V; **K**, furcilia VI. Leg 8: **F**, furcilia IV; **G**, furcilia V; **H**, furcilia VI. Pleopod 1: **L**, furcilia I; **M**, furcilia II; **N**, furcilia III; **O**, furcilia IV; **P**, furcilia VI. Uropods: **Q**, calyptopis III; **R**, furcilia I; **S**, furcilia II.

more northern areas. In the sample from August 1963 (6306-117.80), the sizes of developmental stages were similar to those found in the same general area in the spring. There is insufficient information at this time to consider the effects of environmental conditions on the rate of larval growth and development in *E. gibboides*, but similar variation has been observed in other species of euphausiids (Einarsson 1945; Mauchline 1965).

The range and mean of carapace width in calyptopis stages expressed as percent of carapace length is given in Table 10 as the proportional anterolateral expansion of carapace appears to be a useful character for identification of *E. gibboides*. Comparison by area shows

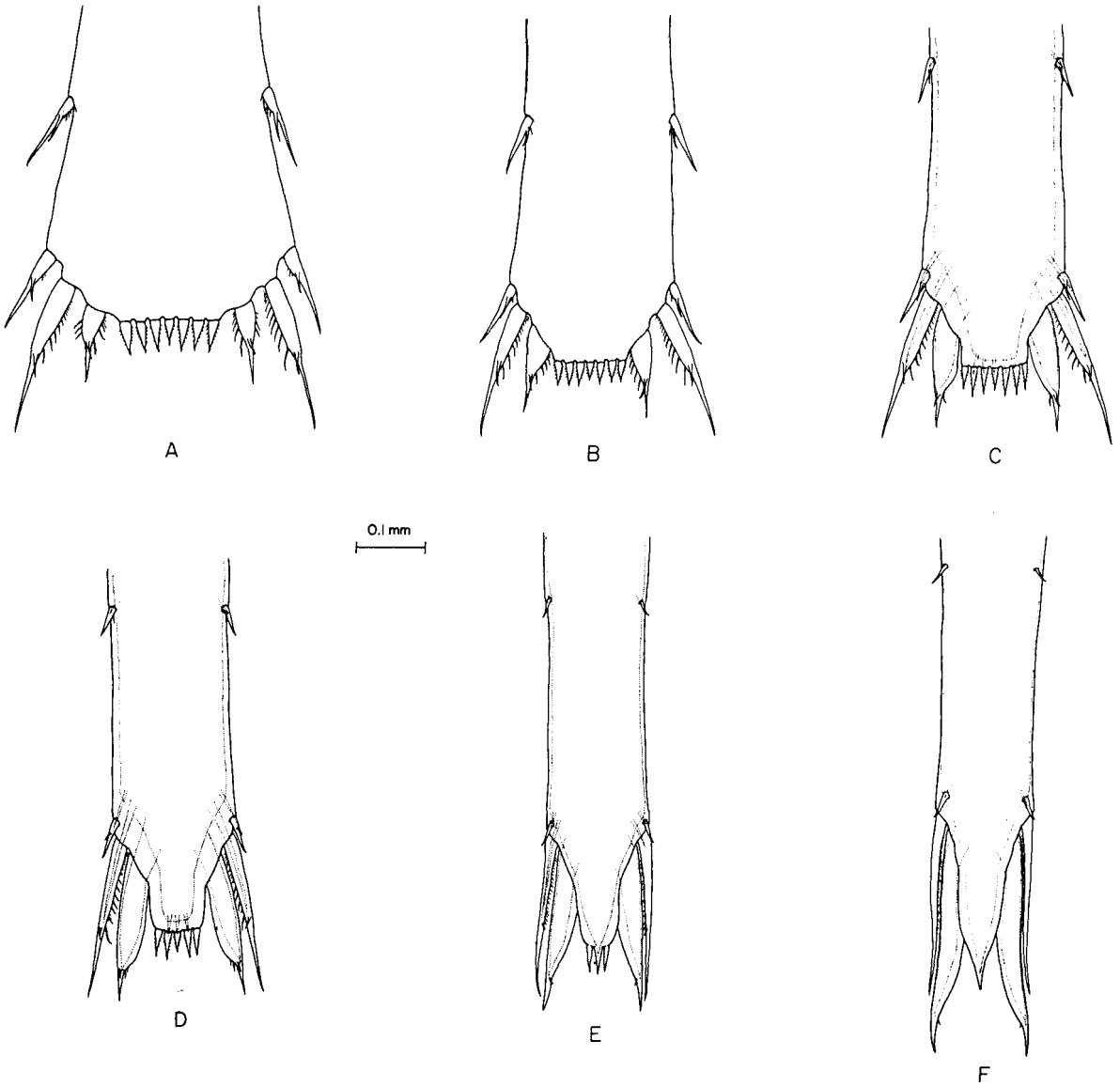

FIGURE 12.—Telson: A, furcilia I; B, furcilia II; C, furcilia III; D, furcilia IV; E, furcilia V; F, furcilia VI.

that the average ratio tends to increase in northern and western Pacific samples.

Juveniles

There was a good series of related juvenile euphausiids in the net haul from station 6304-117.90. Sixty-four were measured and examined in some detail. The smaller juveniles had the distinctive 3-lobed eye described for furcilia stages of *E. gibboides* while some of the larger individuals had the characteristic eye as well as a small dorsal spine on the posterior margin of the 3rd segment of the abdomen and a small dorsal lappet with triangular pointed tip on the margin of the 1st segment of the antennule. The abdominal spine and shape of rudimentary lappet together with the relatively large eye identify the juveniles as *E. gibboides* (Boden et al. 1955). The shape of the eye provides continuity with the

larvae described and confirms their identification.

The juveniles examined ranged from 5.3 to 8.2 mm in total length and a dorsal spine appeared on the 3rd segment of the abdomen at a length of 6.8 mm. A 3-lobed eye was found in a 7.2-mm individual. At 7.0 mm, the constriction between the upper and middle lobes of the eye may disappear; the lower large lobe remains well defined and, although the pigment still appears darker in the lateral position of the middle lobe, the eye becomes increasingly 2-lobed in appearance. The antennule may have a small lappet in 6.3-mm individuals, but the pointed triangular tip was not seen in animals less than 7.0 mm in length, and then it was not always directed outward as in the adult. The lobe and keel of the 2nd and 3rd antennular segments respectively were not developed. A rostral spine may be missing or very small in the early

TABLE 5.—Measurements of nauplius and metanauplius stages.

Stage	Total length (mm)	Width of body (mm)	Width of rostral hood (mm)
Nauplius I:			
Range	0.48-0.53	0.29-0.32	—
$\bar{x}$	0.51	0.30	
SD	0.02	0.01	
n	12	12	
Nauplius II:			
Range	0.51-0.56	0.28-0.32	—
$\bar{x}$	0.53	0.30	
SD	0.01	0.01	
n	12	12	
Metanauplius:			
Range	0.53-0.61	0.28-0.36	0.38-0.45
$\bar{x}$	0.57	0.32	0.42
SD	0.02	0.02	0.02
n	38	38	38

TABLE 6.—Measurements of calyptopis stages.

Stage	Total length (mm)	Carapace width (mm)	Carapace length (mm)
Calyptopis I:			
Range	1.09-1.27	0.59-0.71	0.69-0.79
$\bar{x}$	1.16	0.64	0.72
SD	0.03	0.03	0.02
n	124	124	124
Calyptopis II:			
Range	1.66-1.98	0.65-0.87	0.79-0.93
$\bar{x}$	1.80	0.76	0.86
SD	0.07	0.05	0.03
n	158	158	157
Calyptopis III:			
Range	2.34-2.71	0.75-0.99	0.89-1.09
$\bar{x}$	2.51	0.86	1.00
SD	0.09	0.06	0.05
n	149	149	148

TABLE 7.—Measurements of furcilia stages I-III.

Stage	Total length (mm)	Carapace length (mm)	Rostrum width (mm)	Eye height (mm)
Furcilia I:				
Range	2.85-3.37	0.75-0.85	0.51-0.65	0.24-0.28
$\bar{x}$	3.09	0.80	0.58	0.25
SD	0.10	0.02	0.03	0.01
n	123	104	107	109
Furcilia II:				
Range	3.19-3.94	0.79-0.97	—	0.26-0.32
$\bar{x}$	3.61	0.88		0.29
SD	0.14	0.04		0.01
n	104	98		103
Furcilia III:				
Range	3.80-4.57	0.91-1.09	—	0.30-0.34
$\bar{x}$	4.10	1.02		0.32
SD	0.13	0.04		0.01
n	143	82		83

TABLE 8.—Measurements of furcilia stages IV-VI.

Stage	Total length (mm)	Carapace length (mm)	Eye height (mm)
Furcilia IV:			
dominant — 5 ts (telson spines)			
Range	4.20-4.93	1.01-1.19	0.32-0.38
$\bar{x}$	4.53	1.10	0.34
SD	0.15	0.04	0.02
n	58	56	59
variant — 7 ts			
Range	4.34-4.85	1.05-1.17	0.32-0.36
$\bar{x}$	4.63	1.11	0.34
SD	0.16	0.05	0.01
n	7	5	7
variant — 6 ts			
Range	4.16-4.79	1.03-1.17	0.30-0.36
$\bar{x}$	4.47	1.08	0.34
SD	0.20	0.05	0.02
n	11	10	10
variant — 4 ts			
Range	4.36-4.61	1.07-1.15	0.34-0.36
$\bar{x}$	4.51	1.10	0.34
SD	0.12	0.03	0.01
n	5	4	5
Furcilia V:			
dominant — 3 ts			
Range	4.61-5.41	1.11-1.31	0.36-0.40
$\bar{x}$	4.98	1.20	0.37
SD	0.21	0.06	0.02
n	46	43	46
variant — 5 ts			
Range	4.57-5.25	1.09-1.27	0.36-0.40
$\bar{x}$	4.87	1.17	0.37
SD	0.24	0.05	0.01
n	10	9	9
variant — 4 ts			
Range	4.65-5.33	1.11-1.31	0.34-0.38
$\bar{x}$	4.96	1.19	0.37
SD	0.20	0.06	0.01
n	13	11	13
variant — 2 ts			
Range	5.01-5.29	1.17-1.29	0.36-0.40
$\bar{x}$	5.19	1.25	0.38
SD	0.09	0.04	0.02
n	7	6	8
Furcilia VI:			
dominant — 1 ts			
Range	5.13-5.90	1.17-1.45	0.38-0.44
$\bar{x}$	5.58	1.33	0.40
SD	0.21	0.06	0.02
n	36	35	35
variant — 3 ts			
Range	5.13-5.78	1.19-1.43	0.38-0.40
$\bar{x}$	5.40	1.28	0.40
SD	0.17	0.05	0.01
n	15	14	15
variant — 2 ts			
Range	5.17-5.78	1.23-1.41	0.38-0.42
$\bar{x}$	5.46	1.30	0.40
SD	0.21	0.05	0.01
n	11	10	7

TABLE 9.—Variation in total length of calyptopis stages between the different areas from which samples were studied.

Sample	Calyptopis I				Calyptopis II				Calyptopis III			
	Range	$\bar{x}$	SD	*n*	Range	$\bar{x}$	SD	*n*	Range	$\bar{x}$	SD	*n*
Equatorial Pacific:												
Eastern												
Shellback 187 + 188	1.11-1.17	1.14	0.02	9	1.70-1.94	1.82	0.07	13	2.36-2.63	2.49	0.07	21
North Pacific:												
Eastern												
6304-133.80	1.11-1.21	1.16	0.03	19	1.66-1.82	1.76	0.04	20	2.36-2.55	2.43	0.05	20
6304-120.120	1.09-1.19	1.15	0.02	20	1.66-1.80	1.72	0.04	20	2.34-2.50	2.40	0.05	9
6304-117.90	1.11-1.21	1.15	0.03	20	1.68-1.88	1.77	0.05	20	2.36-2.55	2.45	0.05	20
6304-110.70	1.09-1.19	1.16	0.03	20	1.72-1.86	1.80	0.04	20	2.34-2.67	2.51	0.09	20
6304-70.90 + 100	1.09-1.21	1.15	0.04	21	1.72-1.92	1.82	0.05	20	2.46-2.69	2.56	0.08	11
6304-60.140	1.13-1.27	1.19	0.04	11	1.82-1.98	1.88	0.05	19	2.55-2.71	2.62	0.05	15
6307-117.80	1.09-1.17	1.13	0.02	10	1.72-1.86	1.80	0.05	10	2.40-2.59	2.50	0.06	10
Western												
Transpac 56A + B	—	—	—	—	1.80-1.86	1.84	0.02	6	2.46-2.71	2.58	0.08	11
Transpac 76A	1.11-1.23	1.18	0.06	4	1.68-1.90	1.81	0.06	20	2.44-2.65	2.55	0.06	20

juveniles; it is well developed in larger individuals but never more than one-half the length of the eyestalk in specimens examined.

DISCUSSION

The larvae of many species of the genus *Euphausia* have not been studied but, although preliminary, it may be useful to note ways in which *E. gibboides* larvae differ from related identified forms. The described larvae of *Euphausia* which have features such as armature of carapace or telson similar to those of *E. gibboides* during some phase of development belong to the following species:

Group A *E. brevis* — (Gurney 1942)
E. krohnii — (Sars 1885; Lebour 1926; Frost 1934)
E. diomediae — (Ponomareva 1969)
E. eximia — (author unpubl.)
Group B *E. pacifica* — (Boden 1950; Banse and Komaki 1966[3]; author unpubl.)
Group D *E. longirostris* — (Tattersall 1924; John 1936)
E. spinifera — (Tattersall 1924; John 1936; Sheard 1953)
Euphausia sp. (Ruud 1932; Lebour 1949; Boden 1955)

A metanauplius with marginal fringe of spines on the rostral hood of the carapace is found in *E. brevis, E. krohnii, E. eximia, E. diomediae, E. pacifica,* and Ruud's *E.* sp. as well as in *E. gibboides*. The metanauplius figured by Ruud differs from the others, however, in that the

[3]Banse, K., and Y. Komaki. 1966. Studies of Euphausiidae (Crustacea) off the Washington and Oregon coasts. Annual Report to NSF (Natl. Sci. Found.), Grant No. GB-3360, 6 p. Unpubl.

TABLE 10.—Carapace width expressed as percent of carapace length in calyptopis stages of *E. gibboides* (the number measured is given in Table 9).

Sample	Calyptopis I		Calyptopis II		Calyptopis III	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
Equatorial Pacific:						
Eastern						
Shellback 187 + 188	86.1-91.4	89.3	85.7-92.9	90.1	83.7-91.8	87.7
North Pacific:						
Eastern						
6304-133.80	83.3-91.4	87.4	83.3-90.0	86.0	80.0-85.7	83.1
6304-120.120	83.3-91.2	87.1	82.1-90.0	85.5	80.4-88.6	83.5
6304-117.90	85.3-94.4	88.1	82.5-90.7	86.4	79.6-87.5	83.4
6304-110.70	82.8-91.4	86.8	82.9-90.5	86.5	80.0-87.8	83.8
6304-70.90 + 100	86.1-94.4	90.1	86.0-97.7	91.6	80.0-94.0	86.0
6304-60.140	86.5-91.9	90.1	88.9-95.3	91.0	86.8-92.4	88.8
6307-117.80	87.9-91.4	88.9	87.8-90.5	89.3	90.0-86.3	83.3
Western						
Transpac 56A + B	—	—	90.5-97.6	94.4	88.2-95.8	90.4
Transpac 76A	83.8-91.7	87.8	85.7-93.0	89.6	84.6-90.6	88.0

entire margin of carapace, not only the rostral hood, is spinose. *Euphausia brevis*, *E. krohnii*, and *E. eximia*, unlike *E. gibboides*, have two small dorsal spines on the carapace; *E. diomediae*, the only other species of Group A identified has instead a "sharp eminence" which, as figured (Ponomareva 1969, Figure 1c), is considerably higher and sharper than the dorsal prominence of *E. gibboides*. The metanauplius of *E. pacifica* has a dorsal crest more like that of *E. gibboides* but may prove, with further study, to be consistently smaller; 25 specimens measured from one location by the author ranged from 0.44 to 0.48 mm in total length with an average of 0.46 mm. A metanauplius with fringed rostral hood and two small dorsal spines is figured by Boden (1955) as one of the larval stages of *E. lucens*. It appears, however, that the larvae are those of another species of the genus (Bary 1956), and the form of the metanauplius suggests that it might belong to a species of Group A *Euphausia*.

Calyptopis stages with spinose anterior margin of carapace are found in all of the species listed above except *E. pacifica*. The calyptopes of Group A species may be easily distinguished from those of *E. gibboides* by relative width of carapace; they do not have the anterolateral expansion over the eyes. The carapace of the two species of Group D is wide but, unlike *E. gibboides*, with a very high peaked dorsal crest. Also, the entire margin of the carapace of *E. longirostris* is spinose, the first calyptopis is not described but presumably it does not differ from calyptopes II and III in this respect. The third calyptopis of Lebour's *E.* sp. (1949, Figure 4, 3-4) resembles *E. gibboides* in width of carapace, but the lateral margins of the carapace are spinose. The carapace of the calyptopis I described by Boden (1955, Figure 12) is expanded anterolaterally, but it appears to be proportionally longer than the carapace of *E. gibboides*. The relative lengths of the posterolateral spines of the telson also differ; the 3rd posterolateral spine is relatively short; as figured it is no longer than the terminal spines. The second and third calyptopes of this species have relatively narrow carapaces.

The most useful character for the identification of furcilia stages of *E. gibboides* is the relatively large 3-lobed eye; width of rostral plate and form of pleopods and telson may be helpful as well in differentiating furcilia with spinose anterior margin of carapace. Furcilia of *E. gibboides* may be separated from those of Group A *Euphausia* as follows:

Furcilia with 1 pair of non-setose pleopods — the rostral plate appears to be of greater width in *E. gibboides*;

Furcilia with both setose and non-setose pleopods — in Group A *Euphausia* there is usually only one form and it has 1 setose plus 4 non-setose pairs of pleopods on abdominal segments 1-5 respectively (Sheard (1953) reports numerous variants in the furciliar development of a species identified as *E. recurva*), *E. gibboides* has two forms, 1 setose plus 3 non-setose and 4 setose plus 1 non-setose pair of pleopods;

Furcilia with 5 pairs of setose pleopods — the inner margin of the 3rd (inner) posterolateral spine of the telson is smooth except for tiny distal spinules in larvae of *E. gibboides* and spinose in larvae of Group A.

A single character is sufficient to separate furcilia of *E. gibboides* from those of *E. longirostris* and *E. spinifera*; both Group D species have a dorsal spine on segment 3 of the abdomen beginning in furcilia I. The furcilia with 1 pair of non-setose pleopods figured as *E.* sp. by Lebour (1949, Figure 4, 5-6) differs from *E. gibboides* in relative length of posterolateral spines 2 and 3 of the telson; as drawn they are almost equal in length. The telson of the second furcilia which, like *E. gibboides*, has 1 setose and 3 non-setose pairs of pleopods is not figured, and details of the two forms are not described. The first furcilia figured by Boden (1955, Figure 15) also differs from *E. gibboides* in length of posterolateral spines of the telson; the 2nd pair are almost the same length as the 3rd pair and only a little longer than the 1st pair. The second furcilia of the species has 1 setose and 4 non-setose pairs of pleopods as found in species of Group A *Euphausia*.

ACKNOWLEDGMENTS

I am grateful to E. Brinton for encouragement and assistance as well as review of the manuscript. The work was supported by the Marine Life Research Program, the Scripps Institution of Oceanography's component of the California Cooperative Oceanic Fisheries Investigations, a project sponsored by the Marine

Research Committee of the State of California, and by the Oceanography Section, National Science Foundation, NSF Grant GA-31783.

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