DEVELOPMENT OF THE PELAGIC OSTRACOD, *EUCONCHOECIA ELONGATA* MÜLLER

by

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A general zooplankton survey conducted from October 1971 to July 1972 revealed that Euconchoecia elongata Müller was one of the predominant species occurring in Apra Harbor, Guam.

Continuous breeding was apparent for this species throughout the study period and larval liberation took place nocturnally. Mean sex ratio for the species was 1:4 (male to female). One-third of the mature females were found to be gravid. Embryonic development occurred inside the brood chamber of the female. Individual larvae of E. elongata hatched asychronously in the same brood chamber which differs from other crustaceans, such as cladocerans.

A new classification of larval and juvenile stages of E. elongata is proposed. This classification is based on each molt, on growth of the shells, and on the addition of claws to the furca. There are seven developmental stages: metanauplius, first through fifth ostracodite, and adult.

ACKNOWLEDGMENTS

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INTRODUCTION

The purpose of this paper is to describe morphological development of the pelagic ostracod _Euconchoecia elongata_ Müller (Ostracoda: Myodocopa) based on field samples taken from Apra Harbor, Guam, and from laboratory observations. This work was conducted from October 1971 to July 1972.

Although the life histories of several benthic ostracods have been investigated (Theisen, 1967; Hulings, 1969), those of pelagic species are relatively unknown. A description of the juvenile development of one deep-water species (Angel, 1970) and the identification of juvenile stages of several other pelagic ostracods have been made (Poulsen, 1962, 1965, 1969; Deevey, 1968a).

Females of _E. elongata_ were first illustrated and described from the Indian Ocean (Müller, 1906a). Poulsen (1969), studying the Dana and Galathea collections, found six female _E. elongata_ from the Malayan Archipelago. Both male and female specimens of this species have been reported from the waters of the Taiwan Strait (Tseng, 1969).

METHODS AND MATERIALS

A. Field

Two types of Norpac Standard Nets were used throughout the field study. One was a 45 cm closing net and the other a 50 cm nonclosing net. Both were 180 cm in length with an outside mesh of XX13, aperture 0.094 mm and an inside mesh of GG54, aperture 0.330 mm. Each was equipped with a flow meter.. Vertical samples were made at a speed of approximately 0.5 to 1.0 m/sec. The hauls were initiated near the bottom at each sampling station in Apra Harbor (Fig. 1). All samples were preserved in 5 percent formalin and returned to the laboratory for analysis.

All field samples were taken from the R/V "Tanguisson". Monthly samples were made near the end of each month.

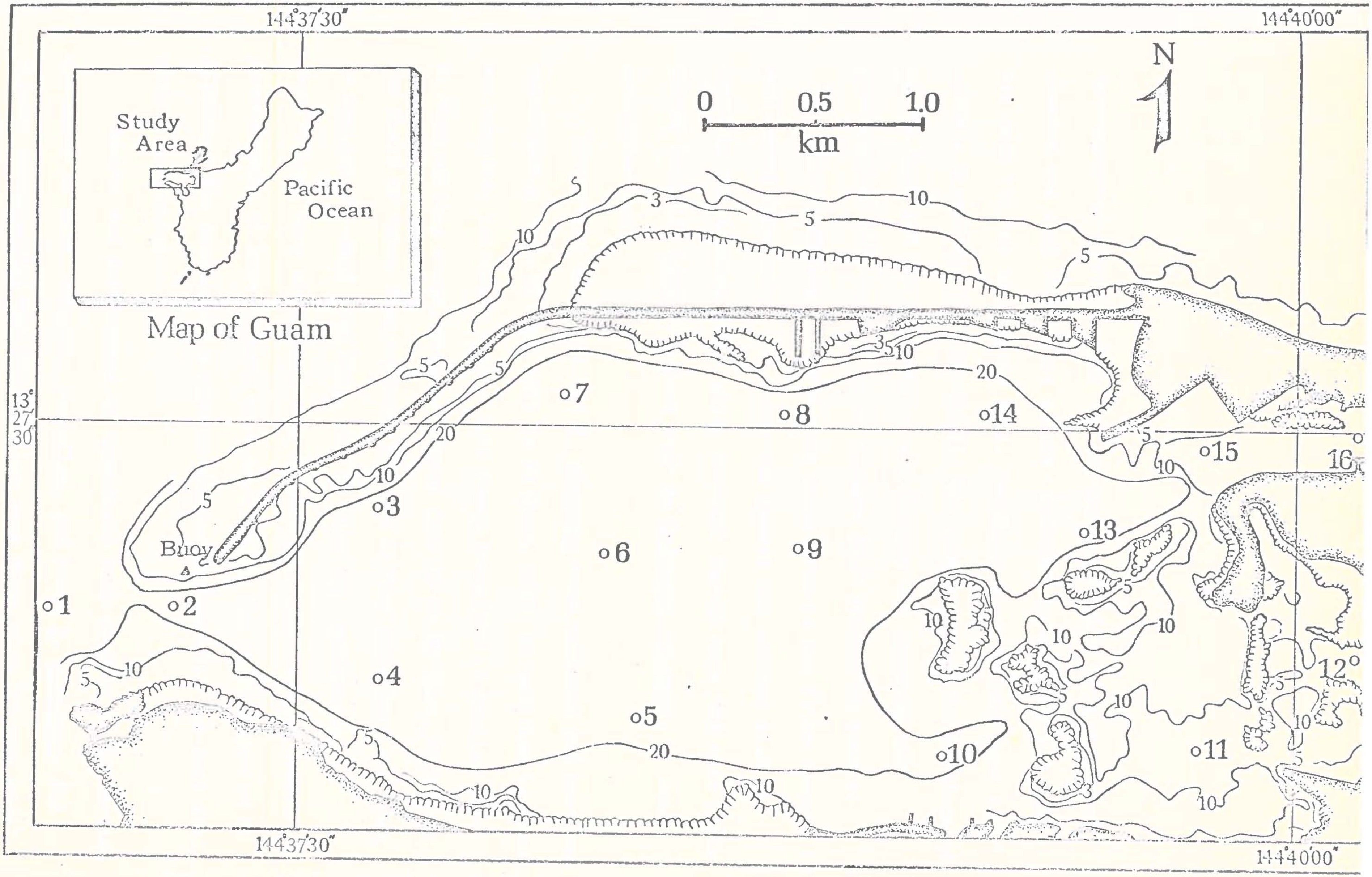
Sea water from Apra Harbor was transported to the laboratory each day and used in the culture studies for growth and development.

B. Laboratory

Individual specimens of E. *elongata* in each sample were sorted, sexed, measured, counted, and recorded. Length and height of the left shells were measured using the techniques of Poulsen (1962, 1965, 1969) and Kornicker (1958, 1964a, 1964b). In addition, the number of eggs within the brood chamber was counted.

Live specimens of E. *elongata* were also caught and transferred to laboratory. Several mature females were selected for embryonic

Fig. 1. Map of Apra Harbor showing sample localities and general harbor morphometry (in meters).



144°37'30"
144°40'00"
N
0
0.5
1.0
km
Study Area
Pacific Ocean
Map of Guam
13° 27' 30"
Buoy
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2
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4
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11
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16

developmental studied. Eggs and embryos were taken from the brood chamber and kept on culture slides. Filtered Apra Harbor sea water was used for the developing eggs. Continual observations were made under a microscope (ca. X40-X100). The time sequence for development of the eggs and for hatching of the embryos was recorded and photographed with the aid of an Olympus PM-7 microscope camera.

After hatching, embryos were transfered to two liter beakers of unfiltered Apra Harbor sea water for growth and culture studies. Water in the beakers was lightly aerated. Larvae were fed dead brine shrimp nauplii, large copepods such as Undinula vulgaris, or dead euconchoecians.

Twenty-six newly hatched E. elongata were cultured and observed continuously from 30 May, 1972 to 14 June, 1972. In addition to these, ten samples, totalling forty-eight young juveniles of similar size to each molting stage, were collected from 15 to 30 June, 1972 from the field or taken from cultures hatched in the laboratory and used to replace the dead ones (Fig. 2). In this way, continuous observations were made until they reached the adult stage. Growth measurements of live animals were made during the culture period by pipetting the animals to a culture slide and measuring the left shell with a micrometer.

Growth and development of appendages were studies by dissecting specimens of eggs, embryos, juveniles, and young E. elongata. All figures accompanying the descriptions were drawn with Unitron Model

A Camera Lucida drawing apparatus.

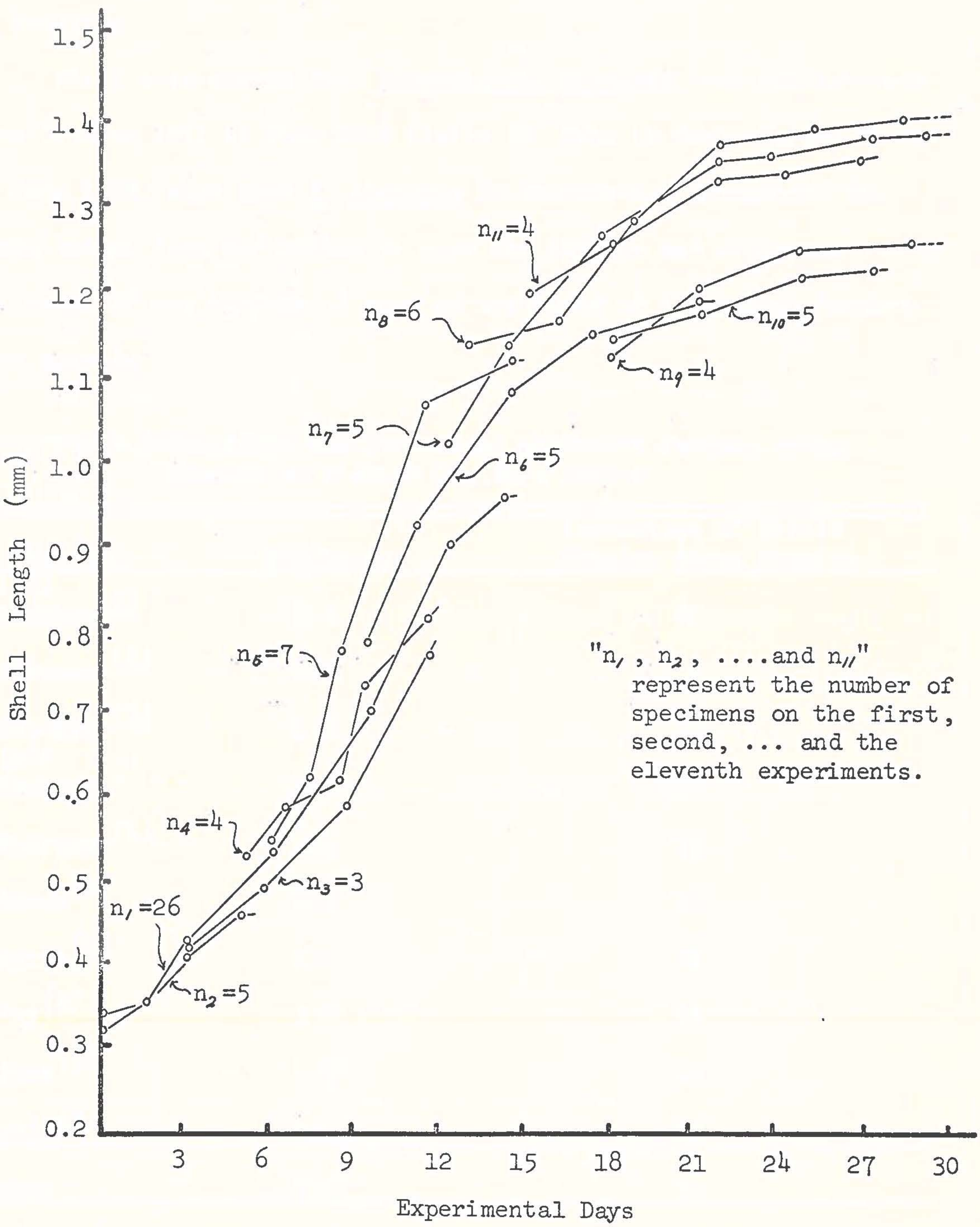


Fig. 2. Repeat culture experimental data for checking the molt animals during 30-day culture period.

DEVELOPMENT

A. Breeding

Field data showed that *Euconchoecia elongata* bred continuously from October 1971 to July 1972 (Table I). Data in Table I, for March to July 1972, show that *E. elongata* is distributed throughout the water column from the bottom to near the surface and occurs in a mean sex ratio of one to four. A mean of one-third of the mature females were gravid.

Table I-Sex Ratio and Percentage of Gravid Females Among Females at Station 14, Apra Harbor

Month	Sex Ratio	Percentage of Gravid Females Among Females
1971 October(1)	1:3	60
November(1)	1:8	6
December(1)	1:2	50
1972 January(1)	1:1	100
February(1)	1:1	33
March(2)	1:4	35
April(2)	1:4	39
May(2)	1:4	34
June(2)	1:4	40
July(2)	1:3	33
Mean	1:4	34

(1). 50 cm diameter Norpac Net, sampling from 10 m to surface.
(2). 45 cm diameter closing Norpac Net, sampling from 30 m to surface.

Larvae (metanauplii) of Euconchoecia elongata are released, after hatching inside the brood chamber. Hatching was observed during the night and the early morning but not during daytime (Table II). This was true for field samples and laboratory observations. Metanauplii of the species were found from the surface to about 30 m during the day and the night at Apra Harbor.

Examination of five of the daily samples taken from Station 14 on 4-8 April, 1972, showed 942 females carrying embryos in the 30 m-to-surface sample. Data from these samples (Table III) suggest that some E. elongata mature and carry embryos after attaining a shell length of 1.00 mm. The data also show that most of females around 1.35 mm to 1.45 mm in length may carry zero to ten embryos in the brood chambers. Table III also shows that young mature stages of the E. elongata female start from 1.00 mm to 1.25 mm in shell length and fully mature stages, from 1.30 mm to 1.55 mm. The largest specimen examined was 1.60 mm in length but should be considered rare. Copulation of this animal was not observed in both field and laboratory observations.

Table II-Number of Young <u>Euconchoecia</u> <u>elongata</u> Hatched in a Twenty-Four-Hour Observation Period of in a Culture Beaker

Hour	30.5.72 12-16	17	18	19	20	21	22	23	24	31.5.72 01	02	03	04	05	06	07-11	Total (1)
No. of Juveniles Hatched		1			2	1	1	4	7	3	1	5			1		26

(1). Total eggs and embryos in five females were 39, among them 26 hatched, and the other 13 did not hatch.

Table III-Left Shell Length (mm) of Females and Number of Embryos in the Female brood chambers from the Five Samples (0-30 m) of Station 14 at Apra Harbor on 4-8 April, 1972.

No. Embryos / Shell Length (mm)	(0)	1	2	3	4	5	6	7	8	9	10	Sum
1.00	(268)	1	1	1								3
1.05	(231)		1									1
1.10	(202)		1	1								2
1.15	(175)	1	1	2	1	2	1					8
1.20	(152)	2	1	4		2		1				19
1.25	(131)	1		13	3	2	1	4	2			26
1.30	(90)	3	8	9	5		2	20	10			57
1.35	(105)	10	32	39	20	15	13	65	44			238
1.40	(93)	26	19	50		35	53	47	22	3		255
1.45	(57)	17	12	25	24	25	29	38	24	5		199
1.50	(28)	1	2	6	16	13	23	19	4	4	1	89
1.55	(38)	8	4	8	10	3	5	5			2	45
Sum	(1570)	78	82	158	79	97	127	199	106	13	3	942

(0) means without embryos in the female brood chamber.

B. Embryonic Development

Embryonic development takes place inside the brood chamber. Individual larvae hatch asychronously and are released from the brood chamber into the water, a pattern which is quite different from other crustaceans. As the female _E. elongata_ matures (ca. 1.00mm in length) several ova are usually found in the ovary. Ten such ova can be seen in the ovary shown in Fig. 3. The diameter of developing ova is around 0.02-0.10mm, and the color is yellow-gold. After the ova reach 0.10-0.12 mm in diameter, the color changes to dark yellow, and the ova are released from the genital opening into the anterodorsal part of the brood chamber as mature eggs which begin cell division. Each mature female of _E. elongata_ carries one to ten embryos of different developmental stages in the brood chamber at the posterior portion of the shell (Fig. 3). The diameter of the developing embryo is 0.17-0.20 mm. The color of the embryo changes from dark yellow to dark green or gray. Embryonic development from cleavage to hatching (Figs. 4a-c and 5a-b) takes 15-19 hours.

The nauplius stage occurs inside the egg membrane. The rostrum, second antenna, and furca (with two pairs of claws) can be seen inside the egg membrane. After hatching, the metanauplius grows slightly more elongate than the nauplius stage. The early metanauplius is oval-elongate (Figs. 5c and 6a-b). The second antennae move slightly, and the larva swims slowly. One hour later, the larva grows more elongate and swims rapidly with fully extended and fast-moving second antennae and furcal lamellae (Fig. 6c). Females released all metanauplius within two to four nights in two liter beakers in filtered sea water.

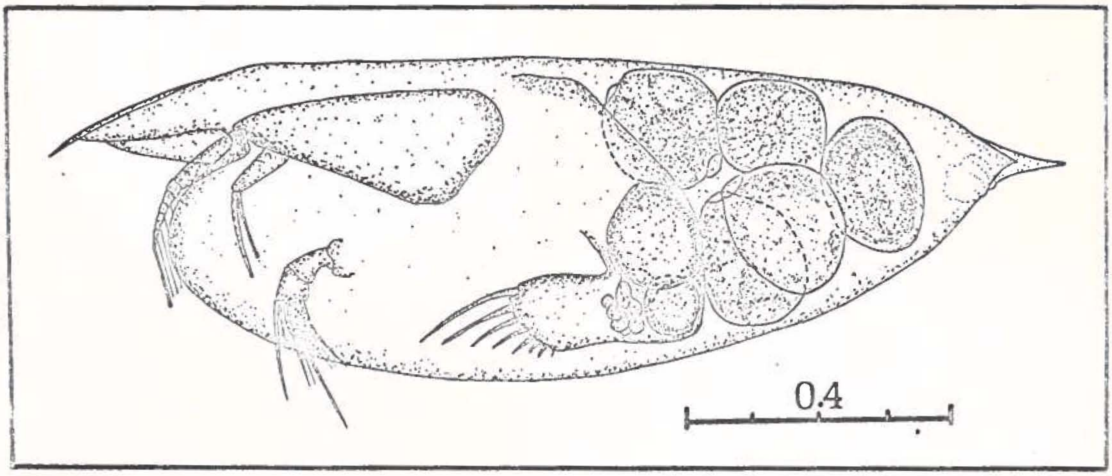


Fig. 3. Five embryos in brood chamber and ten large and small ova in ovary of a 1.35 mm Euconchoecia elongata Müller female. Scale in mm.

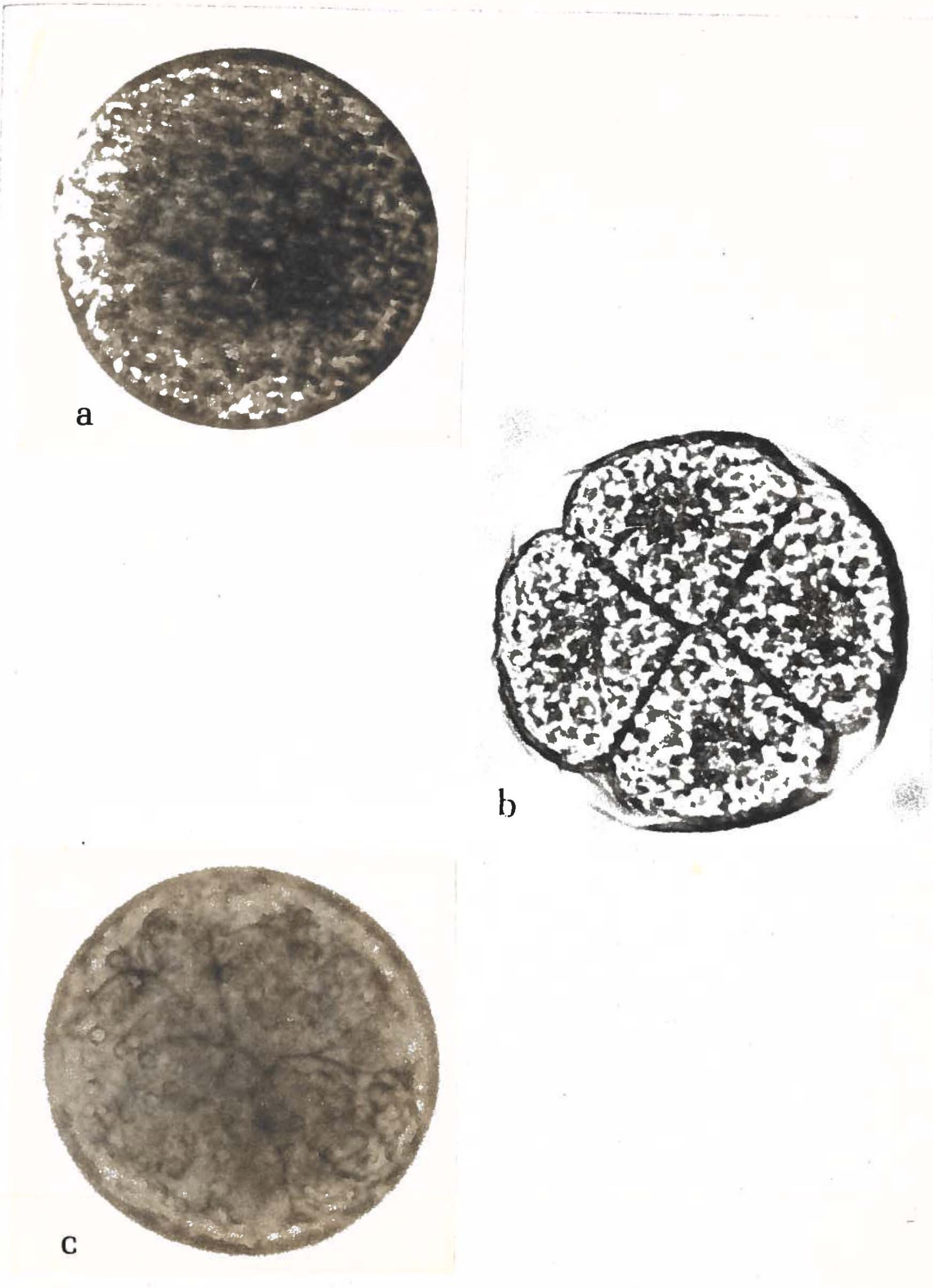


Fig. 4. Egg and embryo of Euconchoecia elongata Müller. a, mature egg; b, four-cell stage; c, gastrula.

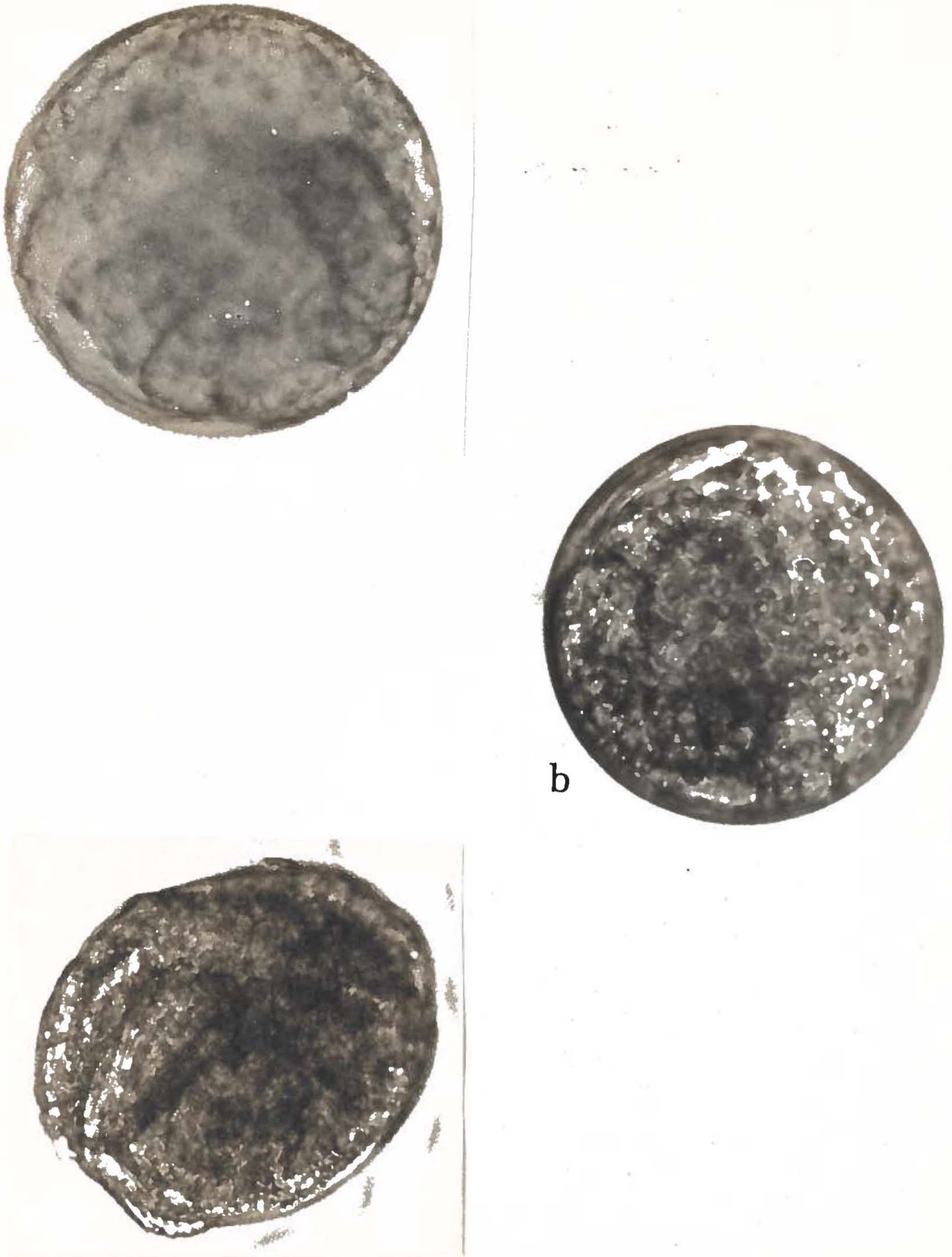


Fig. 5. Embryos and early hatched larva of <u>Euconchoecia</u> <u>elongata</u> Müller. a and b, naupii inside the egg membrane; c, early hatched larva-metanauplius.

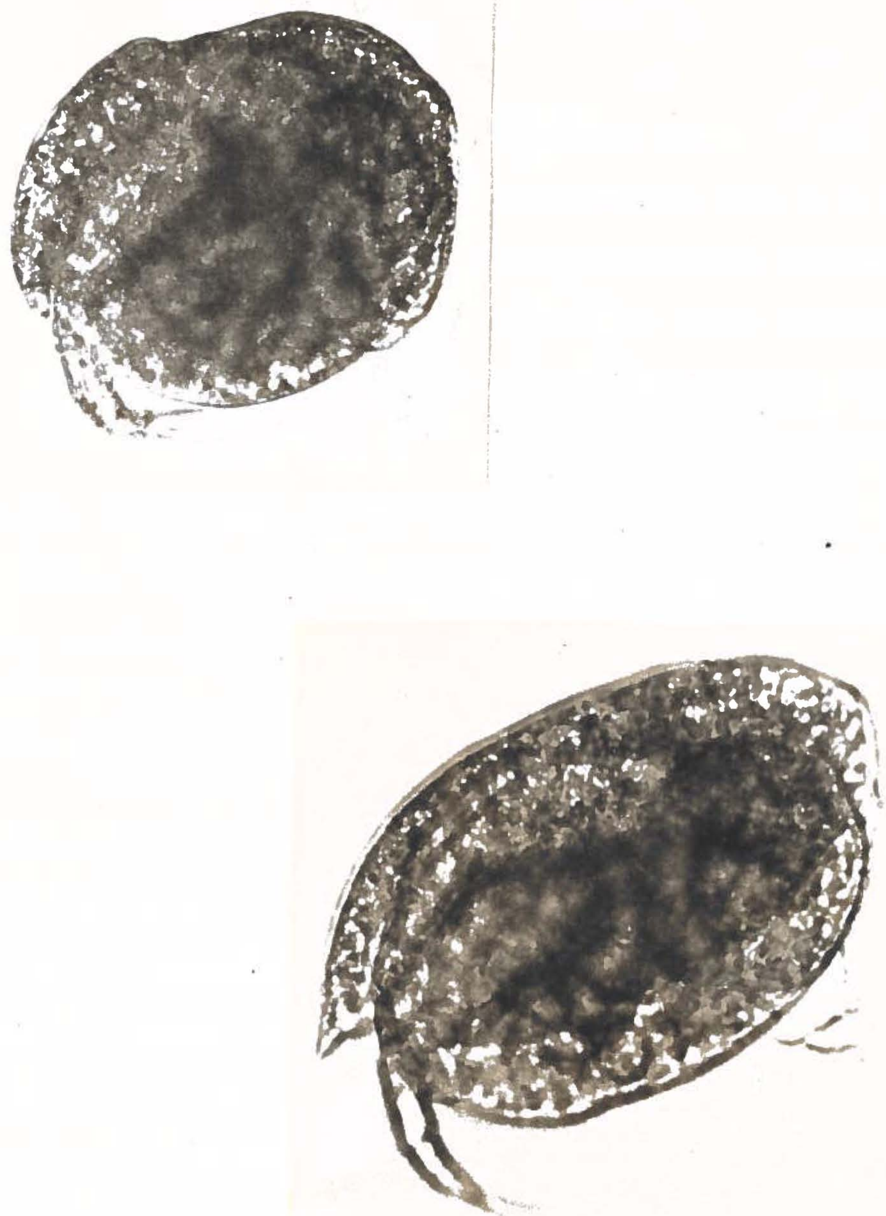


Fig. 6. Larval stage of Euconchoecia elongata Müller. a and b, early metanauplius stage; c, later metanauplius stage.

C. Juvenile to Adult Development

1. Shell

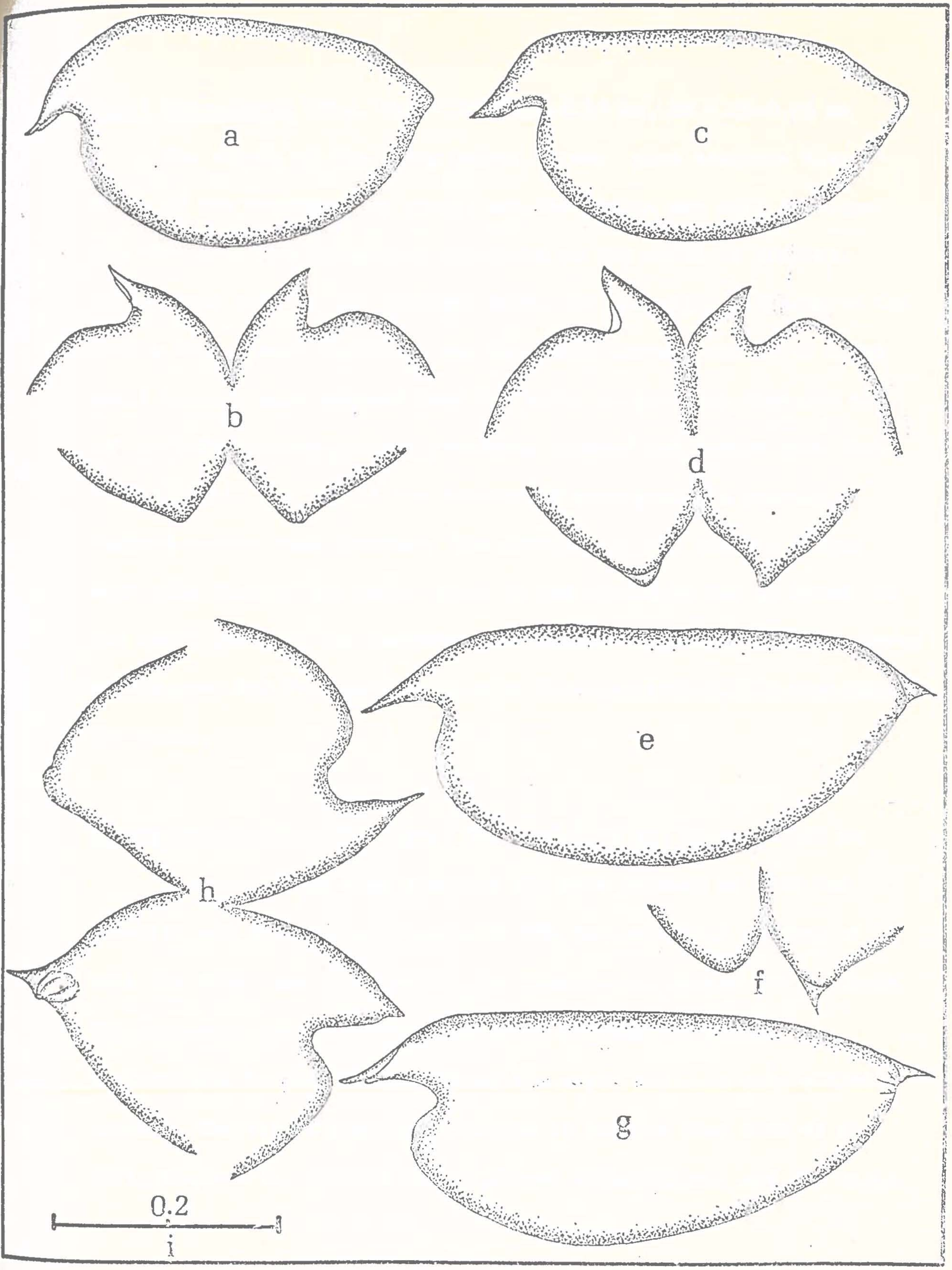
The bivalved shells (valves) of successive juvenile stages of a growing Euconchoecia elongata commonly differ not only in size but also in proportion. There are seven juvenile stages-(a) metanauplius, (b) first ostracodite, (c) second ostracodite (d) third ostracodite, (e) fourth ostracodite, (f) fifth ostracodite. The seventh stage is the young adult stage. The method of classification of stages is based on each molt, length of the shells, and the addition of claws to the furca. The major developmental characteristics of the shells are as follow:

Metanauplius (Figs. 5c, 6a-c, and 7a-b) LSL(1) 0.30-0.35 mm, BH(2) 0.20-0.22 mm.

As soon as each larva hatches, the shell length and height are slightly larger than the diameter of the embryo and within 5-6 hours the shell of the metanauplius is about 0.35 mm with a body height of 0.22 mm. All shells were gray-white, semi-transparent, and coated with an adhesive, mucus-like substance. The symmetrical glands of both right and left shells are seen clearly. The dorsoposterior corners are round or semi-round. The tips of both right and left rostra are pointed and deflected inferiorly downward. The shells are not well developed in this stage. The right and left shells are almost equal in length. Sex can not be determined.

(1). Left shell length (LSL) in mm.
(2). Body height (BH) in mm of left shell.

Fig. 7. <u>Euconchoecia</u> <u>elongata</u> Müller, juvenile development. a and b, shell of metanauplius; c and d, shell of early first ostracodite; e and f, shell of later first ostracodite; g and h, shell of second ostracodite; b, d, f and h, open shells from outside views. All scales in mm


a
c
b
d
e
h
f
g
0.2
i

First Ostracodite (Fig. 7c-f) LSL 0.36-0.45 mm, BH 0.22-0.23 mm

The shells of the young animal become more elongate than those of the metanauplius stage, and the shells are well developed and distinct. The mucus-like substance on the shell is limited, being found only on the smallest ones. The symmetrical glands of the shells become more distinct, and the posterodorsal corner of right shell becomes more pointed than the left. At the same time the tip of the left rostrum gradually becomes pointed and longer than that of the right. The tip of the rostrum of each shell is pointed forward rather than downward. The features of the animals become more like that of the adult. Some of the specimens can be sexed, if the small penis of the immature male can be seen under the high power microscope, but for the most part it is very difficult to distinguish the sexes.

Second Ostracodite (Fig. 7g-h) LSL 0.46-0.55 mm, BH 0.22-0.25 mm

The shells are more elongate and more pointed at both the anterior and the posterior ends. At the posterodorsal corners of both the right and left shells, the symmetrical glands are distinct. The posterior point of the right shell is long and pointed horizontally backward, but that of the right shell is only slightly pointed. The tip of the right rostrum is shorter than that of the left. The two shells have very distinct orientations, and the right shell is a little bit longer than the left shell.

Third Ostracodite (Fig. 8a-b) LSL 0.56-0.70 mm, 0.23-0.27 mm

The shells continue to elongate. In the posterodorsal corner the symmetrical gland opening of each shell becomes clear. The posterior point of the left shell also becomes more elongate than that for the second ostracodite. As soon as the animal is about 0.70 mm, the margins from the mid-anterior through anteroventral, mid-ventral, posteroventral to mid-posterior margins turn from gray-white in color to light violet (or bluish blue-red).

Fourth Ostracodite (Fig. 8c-d) LSL 0.71-0.85 mm, BH 0.24-0.30 mm

The shells continue to elongate, and become more pointed at both the anterior and posterior ends. The symmetrical gland opening of each shell becomes more distinct than before. The shell margin is medium violet in color. The male shell is slightly higher than the female shell.

Fifth Ostracodite (Fig. 8e-f) LSL 0.86-0.95 mm, BH 0.25-0.36 mm

Shells of this stage continue to elongate. Sculpturing begins to appear in the ventral regions, and the ventral margins of the shell become medium violet in color. Males and females can be distinguished by the length-height ratio of the shell (Table IV).

Young Adult (Fig. 9f-h) LSL 0.96-1.20 mm, BH 0.27-0.40 mm

Shells of this stage are fully developed, and the ratio of

Fig. 8. <u>Euconchoecia</u> <u>elongata</u> Müller, juvenile development. a and b, shell of third ostracodite; c and d, shell of fourth ostracodites; e and f, shell of fifth ostracodite; a, c and e, lateral views of left shells with bottom left i scale; b, d and f, outside views of shells. Scales g for b and f, h for d. All scales in mm.


a
b
0.3
g
h 0.1
d
e
c
f
0.1
i

length-height can be used as the index of identification of sex. Male shell height is 36-46 percent of shell length, and female, less than 36 percent. The color of the margins of the shell are still medium violet, but the ventral tip margins of rostrum and the posterodorsal corner points of both sides of the shells have turned into a light pink color. From this stage eggs can be found in the ovary, and females begin to carry embryos in the brood chamber.

Adult (Fig. 9a-e) LSL 1.20-1.58 mm, BH 0.40-0.48 mm

Male (Fig. 9c): The shell is about 1.20-1.25 mm in length and 0.42-0.48 mm in height. The height of the shell is about 36 percent that of the length. The rostrum is elongated and sharply pointed. The left rostrum is much longer than the right and more narrow. The posterior dorsal angles are strongly pointed, with one spine on each side, the right one much longer than the left. The greatest depth of the shell is just anterior to the middle of the length, and the depth gradually decreases toward the posterodorsal corners. Both the right and left symmetrical glands are located just below the posterodorsal corners.

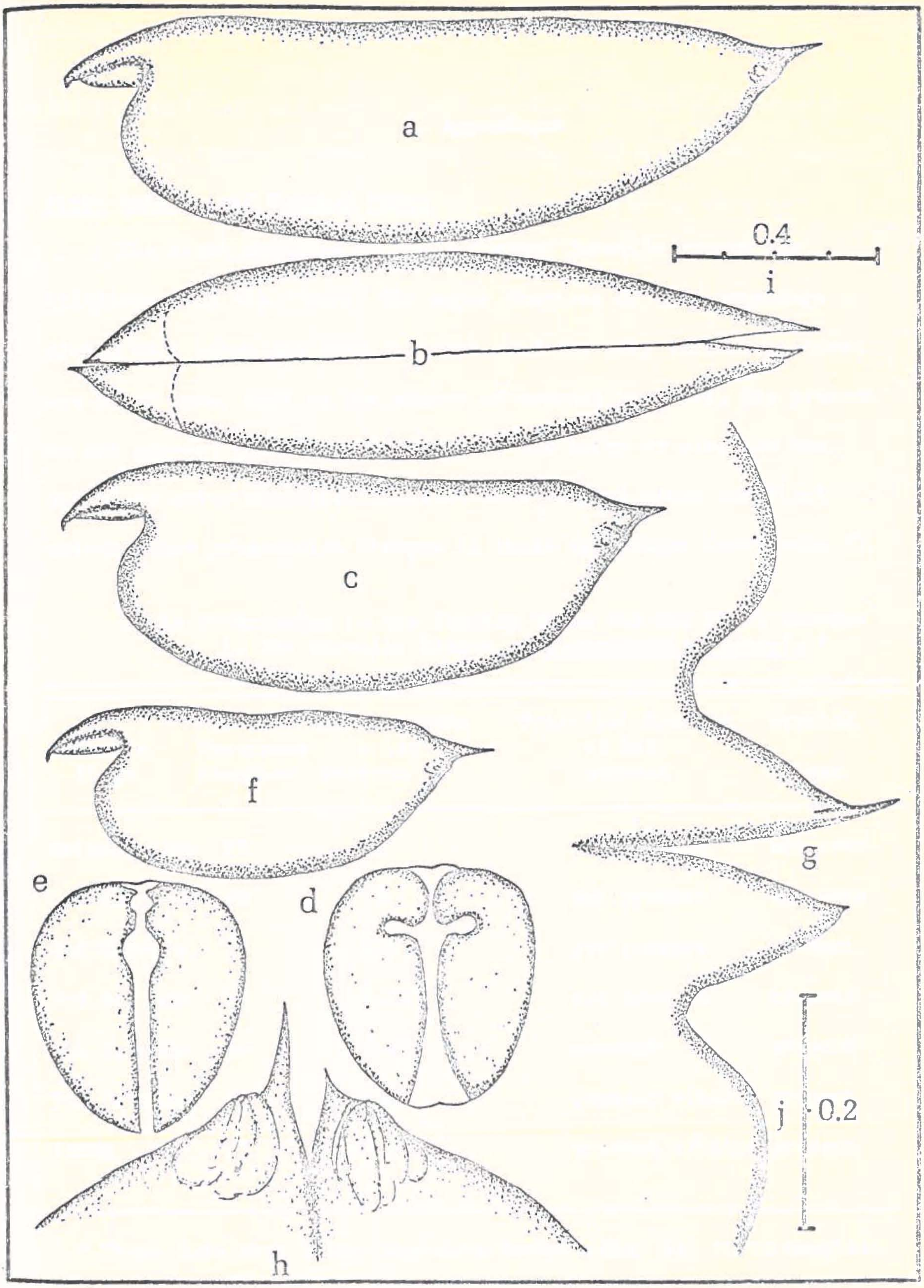
Female (Fig. 9a-b, d-e): The shell is about 1.58 mm in length and 0.41 mm in height. The height of the shell is about 26-36 percent that of the length. The shell is longer and more slender than that of the male shell and usually contains one to ten eggs. The rostrum is similar to that of the male, slim, elongate, and sharply pointed. The left rostrum is longer than the right. The posterodorsal corners are also strongly pointed, the right one being longer than the left. The greatest depth of the shell valves is at mid-length, and this depth decreases toward the posterodorsal corner. The opening of the symmetrical gland is located below the posterodorsal corner spine, as in the male. Data for shell length-height of both male and female are shown in Table VI.

Table VI-Relationship of Shell Length and Height (Expressed as Percentage) of Male and Female E. elongata*

Stage	Height (mm) / Length (mm)	0.25 – 0.29	0.30 – 0.34	0.35 – 0.39	0.40 – 0.44	0.45 – 0.49	Total No. of Specimens Examined
5th	0.86-0.90	7	3(1)	(2)			
Ostra.	0.91-0.95	6	3(1)	(3)			19(7)
	0.96-1.00	2	1	(1)			
	1.01-1.05	4	3				
Young	1.06-1.10	3	4	(3)			
Adult	1.11-1.15			(1)	(2)		
	1.16-1.20	2	2	(1)	(6)		21(14)
	1.21-1.25	1	2	(1)	(4)	(4)	
	1.26-1.30		3	3			
	1.31-1.35		2	2			
Adult	1.36-1.40		1	1	5	1	
	1.41-1.45			3	1	1	
	1.46-1.50				2	3	
	1.51-1.55			1	2	3	37(9)
Sum		25	24(2)	10(12)	10(12)	8(4)	77(30)

* Number of males in parenthesis, and females in nonparenthesis.

Fig. 9. _Euconchoecia_ _elongata_ Müller, young and adult. a, b, d and e, shells of female for lateral, dorsal, frontal and rear views; c, shell of adult male; f, g and h, young male for lateral, outside anterial and posterial views. Scale i for a-f. Scale j for g and h. All scales in mm.


a
0.4
i
b
c
f
g
e
d
h
j
0.2

2. Appendages

First Antenna and Frontal Organ

The first antennae of the different juvenile stages are illustrated in Fig. 10c-j. The major features of this appendage within each stage are very constant, and the only variations noted are minor ones, such as the number of sensory bristles, the present or not present principal bristle, and the hairs or setae on the dorsal or outer principal bristle. Both frontal organ and first antenna show progressive changes in these appendages (see Table V).

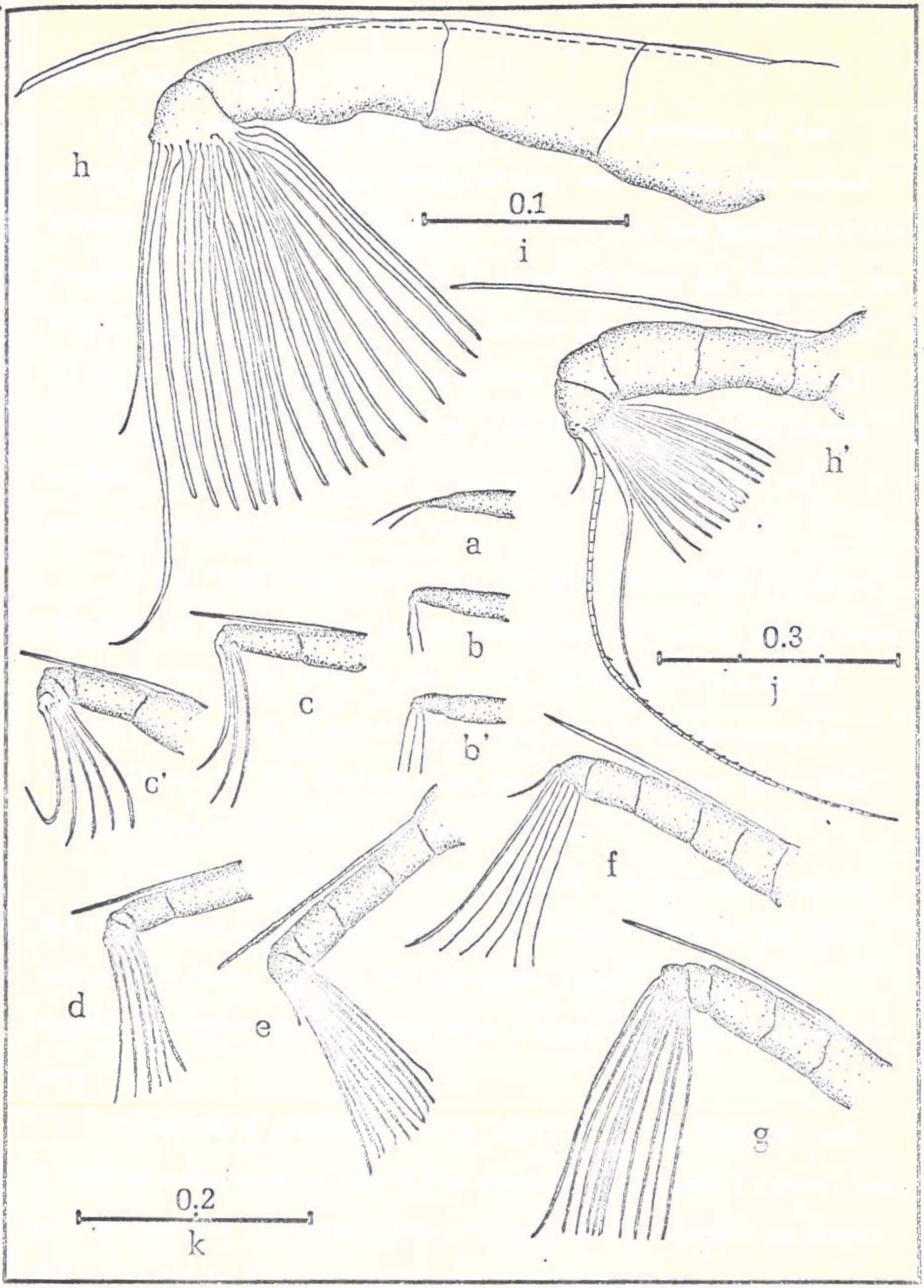
Table V-Variation in the Frontal Organ and the First Antenna in the Juvenile Stages of *Euconchoecia elongata* *

Juvenile Stage	No. of Specimens Examined	No. Filaments in 1st Antenna	Principal Bristle of 1st Antenna	Frontal Organ
Metanauplius	25	2	not present	not seen
1st Ostraco.	20	3	not present	not seen
2nd Ostraco.	27	3-5	not present	present
3rd Ostraco.	18	6-12	not present	present
4th Ostraco.	20	13-18	present	present
5th Ostraco.	26	19-22	present w/hairs	present
Young	35	20-25	present w/hairs	present

* These data were taken from Apra Harbor (Sta. 14) field samples.

The frontal organs of both male and female (Fig. 10a-b) are slim, undifferentiated, and reach beyond the tip of first antenna as in *E. aculeata* (Müller, 1906a; Deevey, 1968a). The male first antenna (Fig. 10b) has 26 sensory filaments. There are 28-30 sensory filaments on the ventral terminal segment of the female first antenna (Fig. 10a).

Fig. 10. <u>Euconchoecia</u> <u>elongata</u> Müller, frontal organs and first antennae. a, metanauplius; b and b', early and later first ostracodite; c and c', early and later second ostracodite; d, e, and f, third, fourth and fifth ostracodites; g, the young; h and h', adult female and male. Scales i for h, j for h', k for a-g. All scales in mm.


h
0.1
i
h'
a
b
0.3
j
c
b'
c'
f
d
e
g
0.2
k

Second Antenna

In the metanauplius stage (Fig. 11a), the protopod of the second antenna is distinct, large, strong, and movable. The second antenna is attached to the sides of the head near the junction of the forehead and mandible, from which it curves forward and downward. The exopod is long and bears 4-6 long natatory setae on the distal two-thirds of its medial margin. The endopod is shorter and monomorphic. The endopod is about one-tenth the size of the scale of the second antennal scale at this stage. It carries one terminal seta and another very small subterminal seta.

In the first ostracodite (Fig. 11b-c), the protopod is larger than that in the metanauplius. The exopod on its ventral margin bears seven long natatory setae on the distal two-thirds of its medial margin. The endopod is relatively longer than in the metanauplius stage. It carries one long seta and one short seta, each being more distinct than those of the metanauplius stage.

In the second ostracodite (Fig. 11d-e), the protopod, exopod, and the endopod grow larger. The shapes resemble those of the first ostracodite stage. In this and subsequent juvenile stages, the endopod is either naked or armed with a single nonplumose terminal seta.

In the third ostracodite (Fig. 11f), there are 8 joints and 7 long natatory setae on the distal portion of the last 7 joints. The endopod consists of two distinct joints; both are elongate in shape. The first joint is approximately two times longer than the second joint. In addition to the two natatory setae at the end of the second joint, there is a small and slender, short seta on the distal dorsal corner of the first joint.

In the fourth ostracodite (Fig. 11h), the exopod carries 8 joints and 8 long and 1 short natatory setae on the distal 7 joints. The endopod is definitely two-jointed and the longest terminal seta is as long as the seta of the 8th joint of the exopod of the male and slightly shorter than that in the female.

In the fifth ostracodite (Fig. 11g), the exopod has 9 joints with 9 long and 1 short natatory setae on the distal portion of the last 8 joints. The endopod is longer than the length of the exopod of the young male. Small distinct clasping organs are formed in the male.

In the young adult stage (Fig. 11i), the protopod, exopod, and endopod become larger and more distinct. The male can be distinguished from the female by the distinct clasping organs on the endopod of the second antenna.

In the adult male, the inner terminal filament is very long. The endopodites of the right and left second antennae have clasping organs (Fig. 12a-c). In the female, the endopodite is small and without a clasping organ (Fig. 12d-f).

Fig. 11. Euconchoecia elongata Müller, second antennae. a, metanauplius; b and b', early and later first ostracodite; c and c', early and later second ostracodite; d, e and f, third, fourth and fifth ostracodites g, the young. All scales in mm.

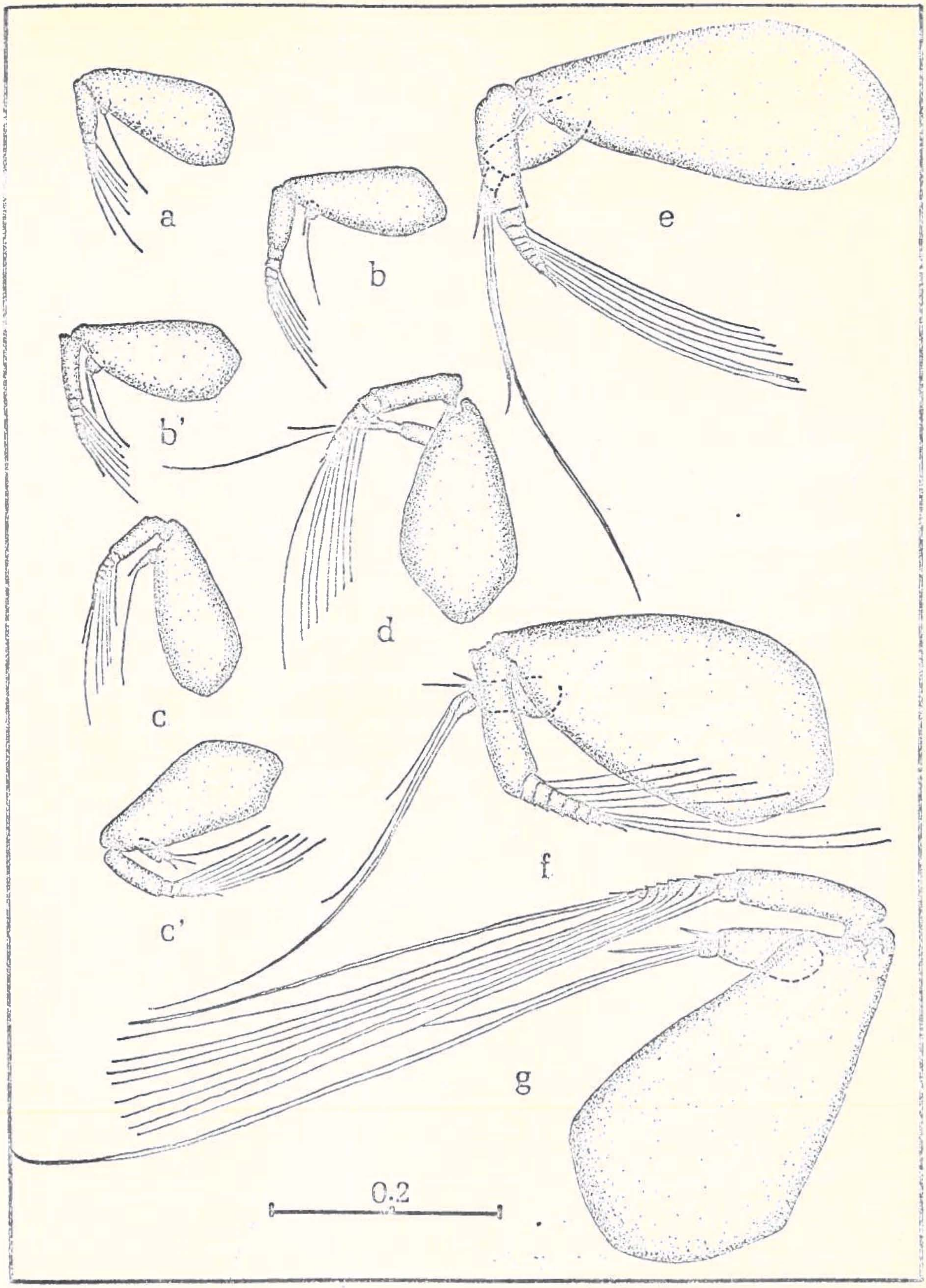
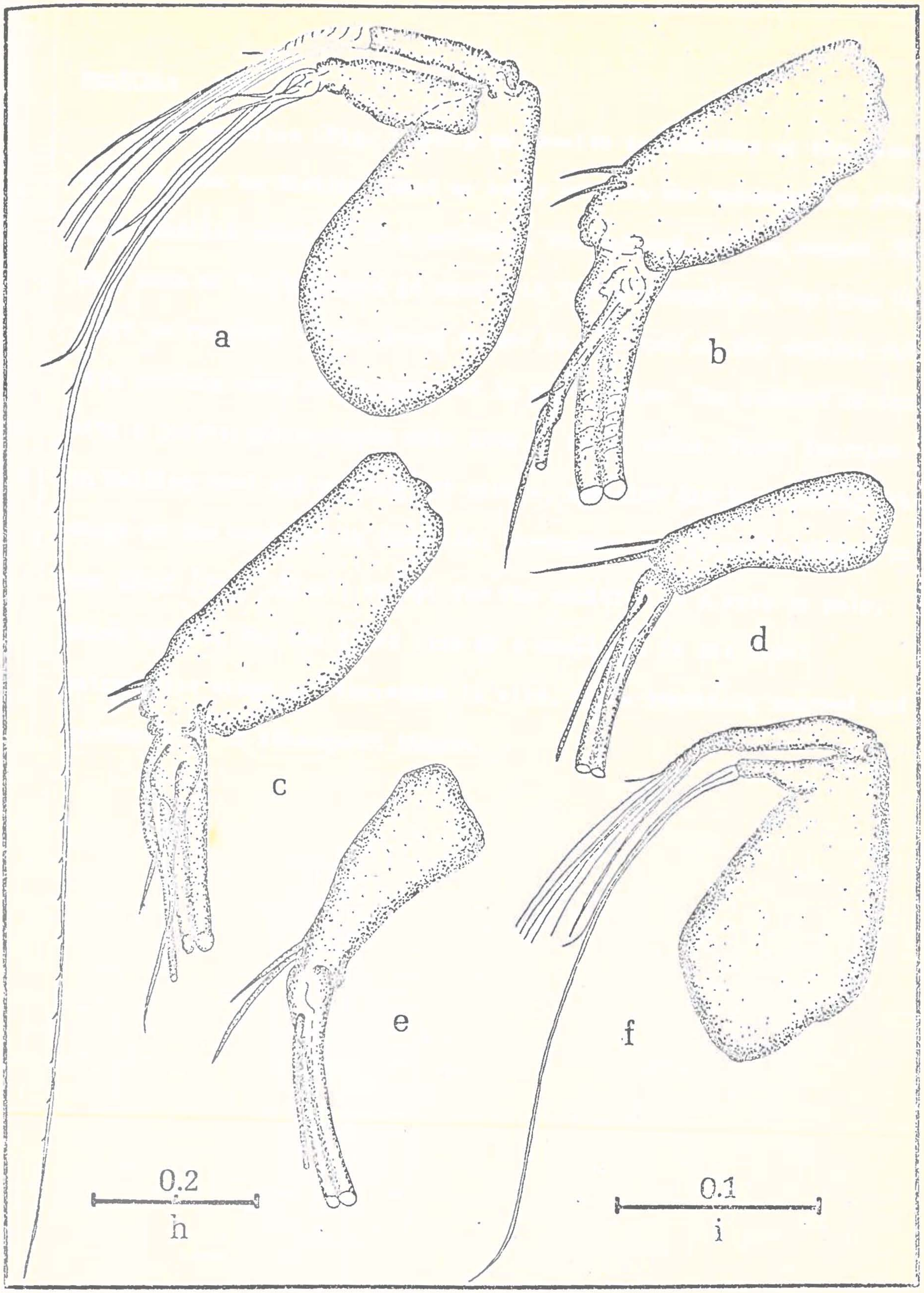

a
b
e
b'
d
c
f
c'
g
0.2

Fig. 12. *Euconchoecia elongata* Müller, second antennae. a, male adult; b and c, endopodites of adult male; d and e, endopodites of adult female; f, adult female. Scales h for a and g, i for b-e. All scales in mm.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0.1
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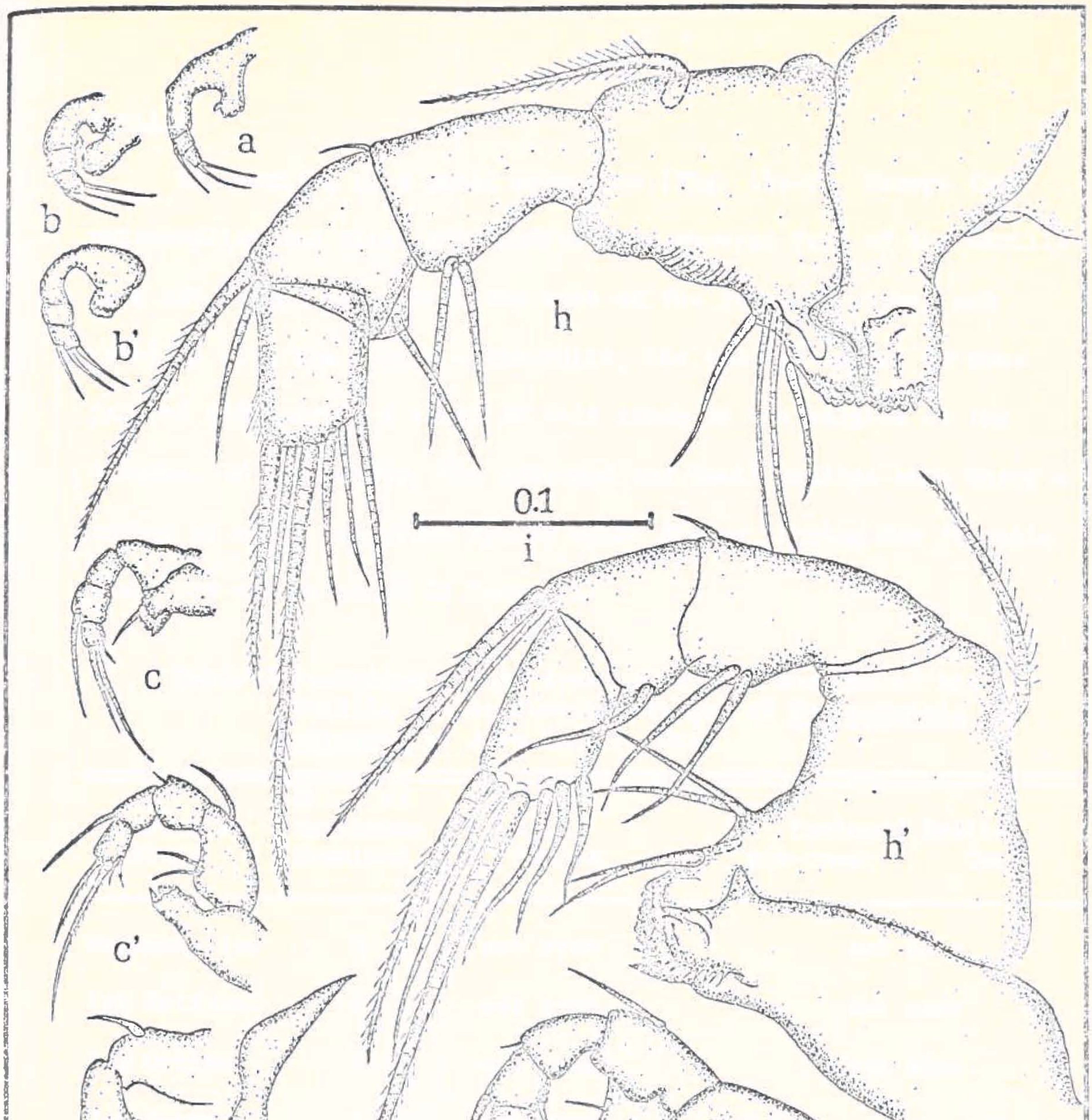
Mandible

The mandible (Fig. 13a-i), as massive a structure as the second antenna, can be distinguished as early as from the metanauplius stage. Each mandible consists of a protopod, and endopod, and an exopod. The long coxa of the protopod is smooth in the metanauplius, but from the first ostracodite to the young stages is equipped at the ventral end with cutting teeth which are used in mastication. The endopod is large with 3 joints and equipped with long or short setae. These function in holding food and cutting off pieces, and also aid in swimming. The shape of the mandible is identical throughout the juvenile stages to the adult (Fig. 13j-k), except for the addition of a seta or palp, which appears for the first time as a small bud in the first ostracodite stage and increases in size, while remaining unarmed and unsegmented, in subsequent stages.

Fig. 13. Euconchoecia elongata Müller, mandibles. a, metanauplius; b and b', early and later first ostracodites; c and c', early and later second ostracodites; d, e and f, third, fourth and fifth ostracodites; g, the young; h and h', adult female and male. All scales in mm.


a
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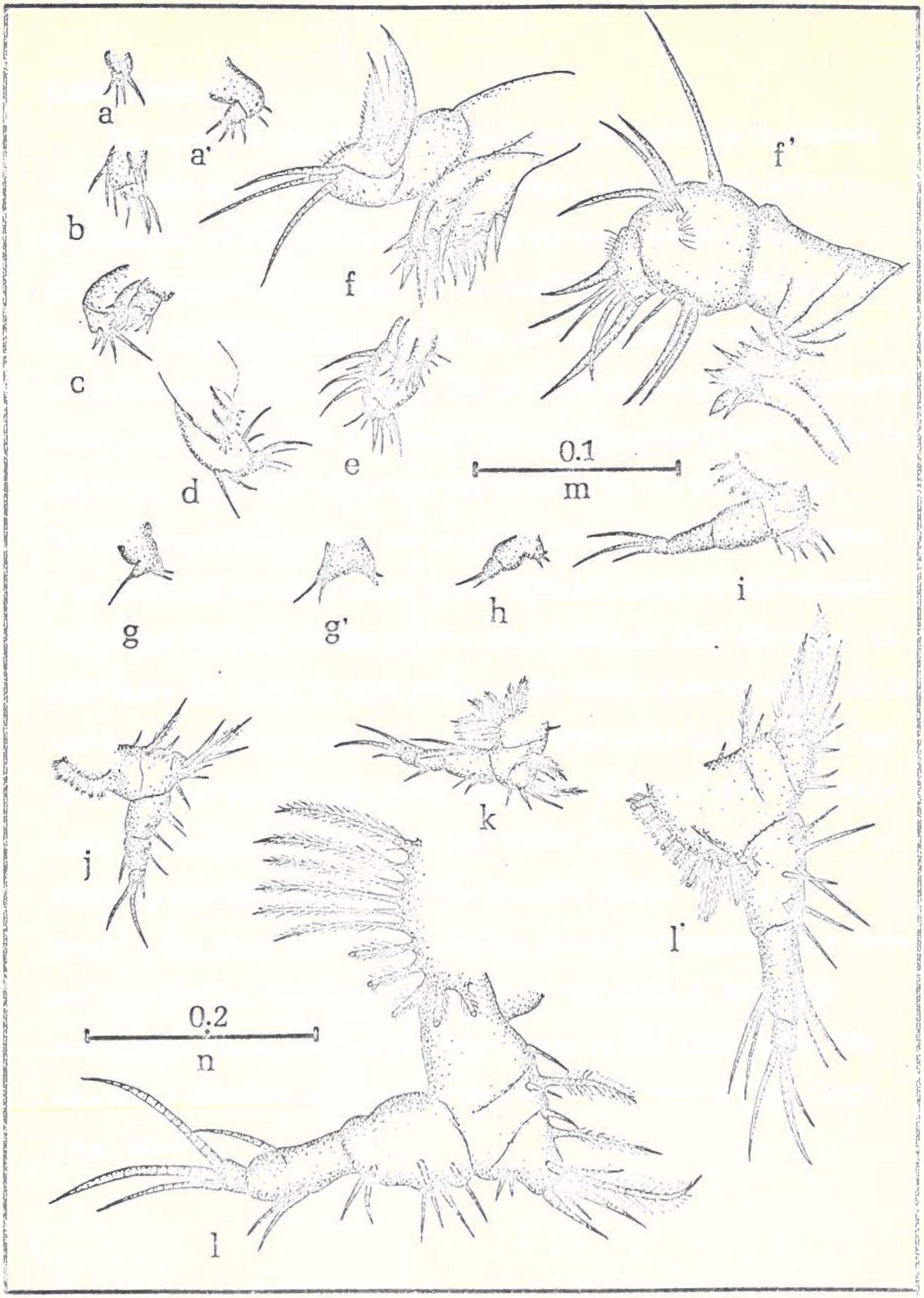
Maxilla

The maxilla is a small structure (Fig. 14a-f). Except for metanauplius and first ostracodite, the general form of the maxilla does not change throughout the rest of the juvenile stages and starting with the second ostracodite, the endopod is one or two-jointed and carries a total of 4-15 setae on the margins or the terminal of the joints. The protopod and basal endites each carry a number of setae and stout spines which change during the juvenile phase, as can be noted in Table VI.

Table VI-Variation in the Armature of the Endites of the Maxilla in the Juvenile Stages of *Euconchoecia elongata* at Apra Harbor, Guam

Juvenile Stage	No. of Specimens Examined	Basal Endite	Protopod Endites pre-coxa	Protopod Endites Coxa
Metanauplius	4	not seen	not seen	
1st Ostraco.	4	not seen	not seen	
2nd Ostraco.	4	not seen	not seen	
3rd Ostraco.	3	not seen	0-2	1-4
4th Ostraco.	4	not seen	2-4	3-5
5th Ostraco.	5	1	3-5	5-6
Young	3	1	4-6	4-8
Adult	3	1	5-8	6-10

Fig. 14. Euconchoecia elongata Müller, maxillae and first thoracic leg. a and a', early and later second ostracodites; b, c and d, third, fourth and fifth ostracodites; e, the young; f and f', adults of male and female. The first thoracic leg: g and g', early and later second ostracodites; h, i and j, third, fourth and fifth ostracodites; k, the young; l and l', adults of male and female. Scale m for f, f', l, l'; n for a-e, g-k. All scales in mm.


a
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b
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d
e
f
f'
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m
g
g'
h
i
j
k
l'
0.2
n
l

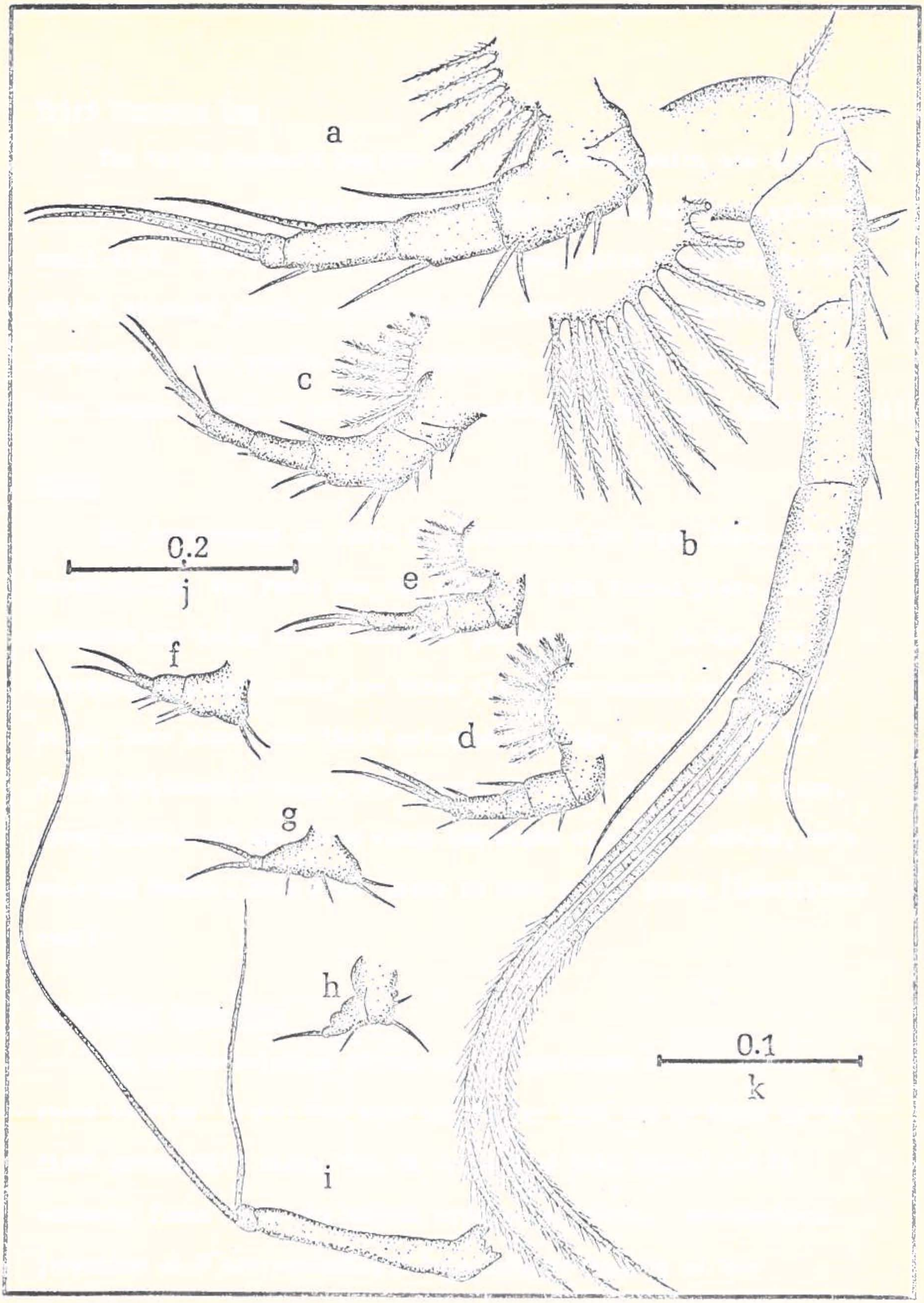
First Thoracic Leg

The course of development of the first thoracic leg throughout the juvenile stages is illustrated in Figs. 14g-l. No variation in the armature of the appendage is noted in the first and second juvenile stages. The armature of the exopod shows some variation in the later juvenile stages, having one or two natatory setae in the early second ostracodite stage, two to three in the third ostracodite stage, three to four in the fourth ostracodite stage, four to five in the fifth ostracodite stage and six to eight in the young stage. In the second ostracodite, the medial margin of the endopod carries a total of two to three setae in the distinct group at the terminal end of the endopod. In the later stages, there is some variation, in that there are three to four setae in the third, four to six setae in the fourth, five to seven setae in the fifth ostracodite stages, and seven to nine setae in the young stage. The protopod with two joints bears a single seta medially in the fourth ostracodite stage; two or three are present in the later two juvenile stages. No epipod is found in the first four stages. In the fourth ostracodite stage there are four to five feathered setae; six to ten setae in the fifth ostracodite stage; and ten to twelve setae in the young stage. The male first thoracic leg is slightly larger than that of the female (Fig. 14l-l').

Second Thoracic Leg

The course of development of the second throacic leg through the juvenile stages is shown in Figs. 15a-h. As with the first throacic leg, no variation in the armature of the second thoracic leg is noted in either the metanauplius or the first ostracodite stages. The armature of the exopod with four joints shows some variations in the later juvenile stages. The number of natatory setae on the exopod varies; the second ostracodite has two to five; the third ostracodite, four to eight; the fourth ostracodite, five to nine; the fifth ostracodite, eight to ten; and the young setae, nine to thirteen. The protopod is large in size and carries one to two setae, starting with the fourth ostracodite stage. No endopod is ever present. The epipod carries five to nine feathered setae in the fourth ostracodite stage, nine to thirteen in the fifth, and fourteen to seventeen in the young stage. The male second thoracic leg is much longer than that of the female (Figs. 15a-b). The terminate of the male second thoracic leg has three long feathered setae (Fig. 15b).

Fig. 15. Euconchoecia elongata Müller, second and third thoracic legs. Second thoracic leg: a and b, adults female and male; c, the young; d, e and f, fifth, fourth and third ostracodites; g and h, later and early second ostracodites; i, the third thoracic leg of male or female. Scale j for c-h, k for a-b and i. All scales in mm.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k

Third Thoracic Leg

The third thoracic leg has two small joints which are difficult to find in the early five juvenile stages because of their extremely small size. The terminal end of the second joint bears two to three apical natatory setae, one of which is very long, extending to the posterior dorsal margin of the carapace. The second is only half that length. There is no sexual dimorphism of this appendage(Fig. 15i).

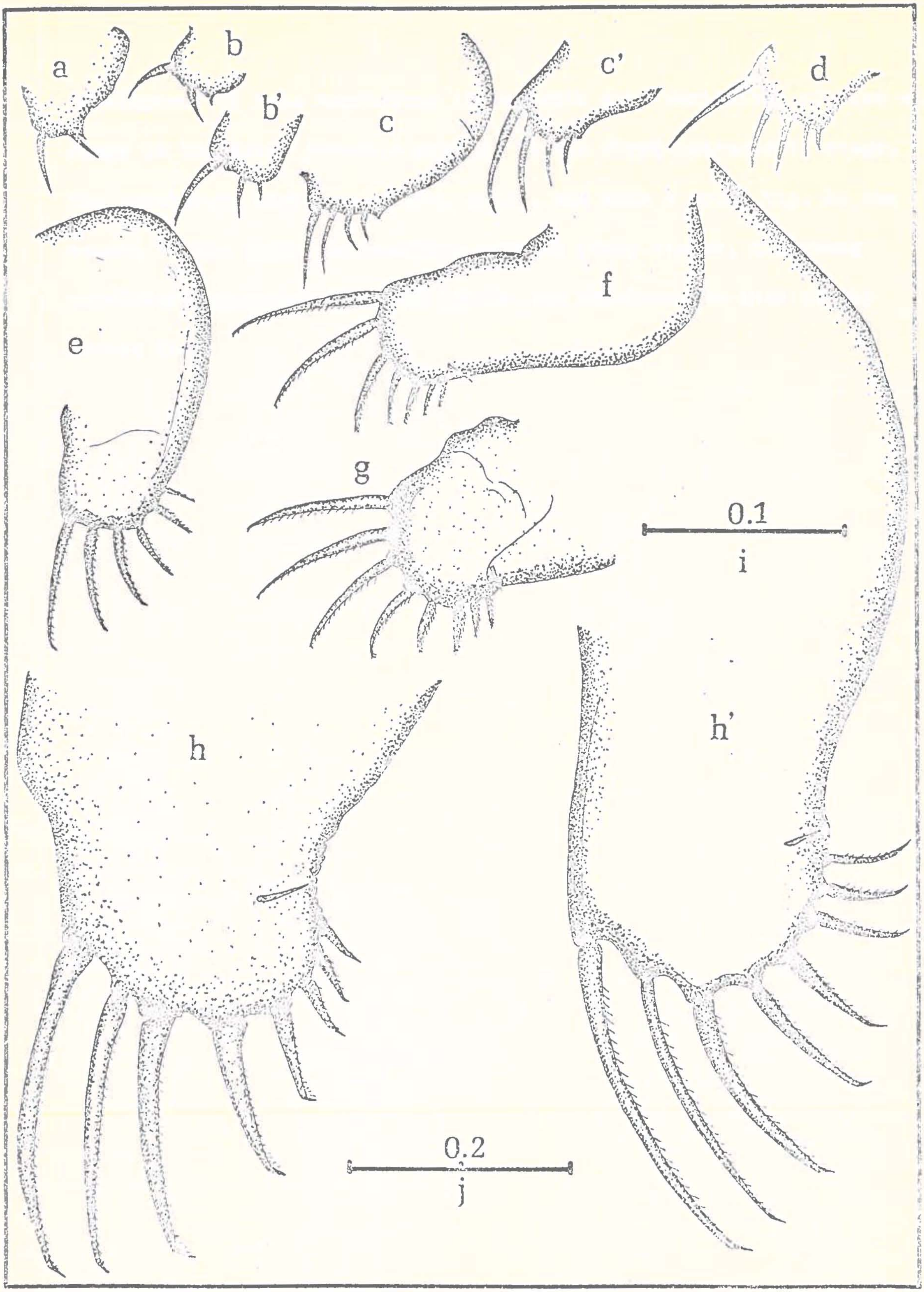
Furca

The development of furca is illustrated in Figs. 16a-h. In the metanauplius, the furca has two claws on each furcal plate, the anterior one being longer than the posterior one. In the first ostracodite stage, there are three claws; the second ostracodite stage, four claws; the third ostracodite stage, five claws; the fourth ostracodite stage, six claws; the fifth ostracodite stage, seven claws; and the young stage has eight claws. The adults, both male and female, have eight claws on each furcal plate (lamelliform rami).

Copulatory Apparatus

The differentiation of the male, copulatory apparatus, is shown in Figs. 17a-h. The male copulatory limb can be found at the first ostracodite stage, but it is rare at this stage, and is commonly found after the fourth ostracodite stage. Intermediate juveniles show correspondingly intermediate degrees of the

Fig. 16. <u>Euconchoecia</u> <u>elongata</u> Müller, furca. a, metanauplius; b and b', early and later first ostracodites; c and c', early and later second ostracodites; d, e and f, third, fourth and fifth ostracodites; g, the young; h and h', the adults female and male. Scale i for h and h', j for a-g. All scales in mm.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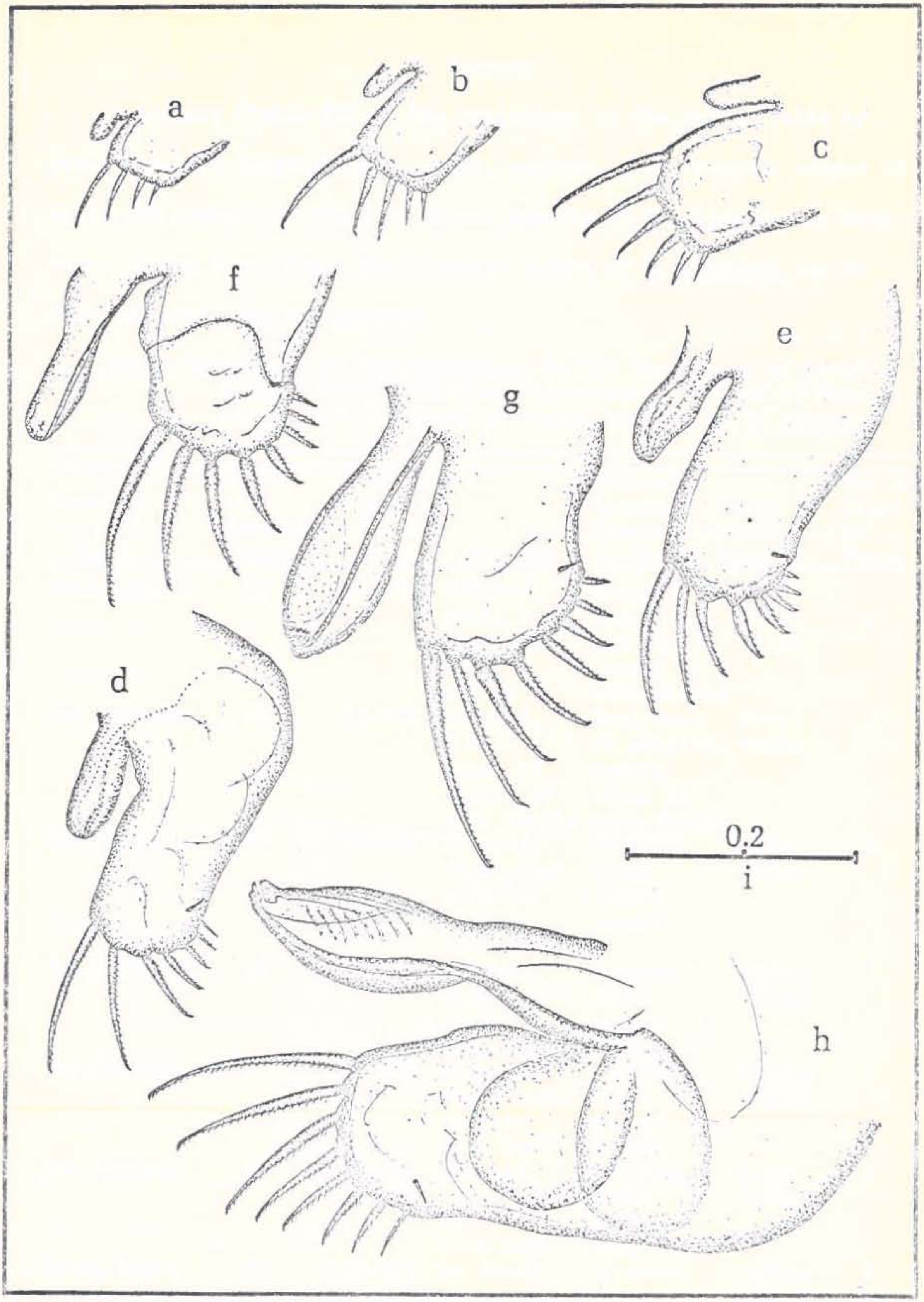
development of male copulatory limbs, with some variations of size and shape in the later juvenile stages. In the first ostracodite stage, the copulatory limb is short, small, and with a round tip. In the second to the fifth ostracodites and the young stages, the young copulatory apparatus grows in length and thickness to that of the mature form.

Fig. 17. Euconchoecia elongata Müller, the size and shape of young copulatory limbs at different juvenile stages, young and adult. a, b, c and d, second, third, fourth and fifth ostracodites; e and f, the young; g and h, adults. All scales in mm.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3. Summary

A summary (Table VII) of the variations in the ratio (ratio by percentage) of length-height, color, rostrum, posterodorsal corner of shell and numbers of claws in furcal lamella of E. elongata has been made. Using these data, the juvenile stages of E. elongata can be distinguished from one another.

Table VII-Summary of the Variations in the Percentage of Length-Height, Color, Rostrum, Posterodorsal Corner of Shells, and Numbers of Claws in Furcal Lamella of E. elongata

Juvenile Stage	Number of Specimens Examined	Percentage* of Length-Height	Rostrum	Posterodorsal Corners of Shells	Color of Shell Margins	No. of Claws in Furca
Metanauplius	25	63-80%	Pointed, equal in length of both shells	Round or semiround, and equal length in both shells	Gray-white	2
1st Ostraco.	20	51-61%	Pointed, & near equal in length of both shells	Semiround or pointed, nearly equal in both shells	Gray-white	3
2nd Ostraco.	27	45-48%	Pointed, right rost. slightly shorter than left	Pointed, right corner longer	Gray-white	4
3rd Ostraco.	18	34-41%	Pointed, right rost. shorter than left	Pointed, right corner longer	Light-violet	5
4th Ostraco.	20	32-36%	Pointed, right rost. shorter than left	Pointed, right corner longer	Medium violet	6
5th Ostraco.	26	♂ 38-42% ♀ 32-34%	Pointed, right rost. shorter than left	Pointed, right corner longer	Light violet	7
Young Adult	35	♂ 40-45% ♀ 33-36%	As Above	As Above	Medium pink	8

* Ratio of length to height expressed as percentage.

DISCUSSION AND CONCULUSION

A general zooplankton survey conducted from October 1971 to July 1972 revealed that Euconchoecia elongata Müller was one of the dominant species occurring in Apra Harbor, Guam.

The present investigation proposes a new method to identify the early and young stages of pelagic ostracods. The life history of E. elongata includes a metanauplius larval stage, five ostracodite juvenile stages, and a young adult stage after which the animal shows adult structures. This life history is different from that of copepods, which includes six nauplius and six copepodite stages after the animal hatches from the egg. The method of classification of stages is based on molt, length of the shells, and on the addition of claws to the furca. The nauplius stage of E. elongata occurs inside the egg membrane, before the animal hatches to the metanauplius. The nauplius has well-developed second antenna and furca. After the animal hatches from the membrane, it becomes elongata and carries three pairs of appendages--first and second antenna and mandible. After the molting of the metanauplius, the animal become more elongate, and other appendages are gradually formed.

The furcal development of E. elongata is very important. The molting process of the E. elongata juvenile begins with the splitting of the inner lamella of furca from the outside along the front edge, and after each molt a new claw is added to the lamella of the furca. The metanauplius has two pairs of claws, the first ostracodite, three pairs, and so forth through the fifth ostracodite which was seven pairs. The young and the adult have eight pairs of claws. An interpretation of the above results permits easy identification of the developmental stages of juvenile E. elongata. These results also agree with the results given by Angel (1970) who studied the juvenile development of Bathyconchoecia subrufa. He found that the caudal furca of B. subrufa showed the same progressive increase of one pair of claws for each molt, but he found only four pairs of claws present at the second ostracodite stage, and eight at the young and the adult stages. McKenzie (1969) said that the furca itself, as in all crustacean groups, is a very conservative character and is used in identification. For this reason, Rome (1969) studied the furca and furcal attachment in a large number of genera and species of benthic ostracods. He tried to use furca as a major taxonomic character. The furca has been commonly used by many workers for identification of ostracods (Müller, 1890, 1894, 1906a, 1906b, 1908, 1912, 1927; Poulsen, 1962, 1965, 1969; Deevey, 1968a, 1968b).

The morphological analysis of other appendages and the changes of shell length and shell height can also be of value for species identification, as well as for juvenile, young, and adult stage determination.

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