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DEVELOPMENT OF *THYSANOPODA EGREGIA* (EUPHAUSIACEA) FURCILIAE AND EARLY JUVENILE

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ABSTRACT

Nine furcilia and the early juvenile phase of the deep-sea euphausiid *Thysanopoda egregia* Hansen, 1905 are described and illustrated for the first time. This identification of the bathypelagic species is made on the basis of the very large, well-developed and dark-brown eyes, short sixth pleomere, large body size relative to stage of development, ripple-like sculpturing of the posterior and lateral parts of the carapace, and the number of terminal telson spines in the first five stages, F1-F5. The ripple marks on the carapace are a particularly distinctive characteristic of *T. egregia*. Because of the rarity of the nauplius, metanauplius, and calyptopis phases for this species and the unknown identification of the other three deep-living species of *Thysanopoda*, we are not yet able to positively identify these phases with confidence and that information is not presented here. A distribution map of records of furciliae of *T. egregia* from our samples and published sources corresponds with the previously described distribution of the adults, showing a cosmopolitan distribution in waters mainly equator-ward of the subpolar ocean provinces.

KEY WORDS: biogeography, deep sea, euphausiids, larval development

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INTRODUCTION

The order Euphausiacea contains 86 species living in all basins of the world ocean, from the surface to just above the bottom (Brinton, 1962, 1987; Brinton et al., 2000). Euphausiids play a major role in the food chain, often being the primary food source for whales, fish, squids, birds, and larger zooplankton. Most species live in either the epipelagic or mesopelagic zones while only five species are known to live in the bathypelagic or abyssal zones. The four bathypelagic species are *Bentheuphausia amblyops* Sars, 1885, *Thysanopoda egregia* Hansen, 1905, *T. cornuta* Illig, 1905 and *T. spinicaudata* Brinton, 1953; the one known abyssal species is *T. minyops* Brinton, 1987. These species are characterized as "giants" of euphausiids because their adult sizes are between 51 mm and $\geqslant$150 mm (Brinton, 1987).

Species of euphausiids freely spawn their eggs or brood their eggs; species of *Thysanopoda* freely spawn their eggs (Brinton et al., 2000). The developmental pathway is egg, nauplius, metanauplius, calyptopis, furcilia, juvenile, and adult phases. The larval development of most epipelagic euphausiid species is reasonably well known; less is known about the mesopelagic species and very little is known about the bathypelagic and abyssal species. Early developmental forms of *B. amblyops*, the only species in the genus, are presented in Brinton et al. (2000).

Of the fourteen known species of *Thysanopoda*, ten species have some of the larval stages described (Mauchline and Fisher, 1969; Brinton et al., 2000). Brinton (1987) summarized what was known to date about the adults of the four species of bathypelagic/abyssal *Thysanopoda* and inferred the depth-ranges of their life phases. Brinton proposed that both *T. cornuta* and *T. egregia* have six furcilia and two cyrtopia (which would now be termed late furcilia) stages. To date the larval development of neither of the bathypelagic species of *Thysanopoda* has been fully described. Brinton et al. (2000) summarized the known forms of *T. cornuta* and *T. egregia*. No information has been published on the developmental phases of the other two giant *Thysanopoda*: *T. minyops*, and *T. spinicaudata.*

Because the adults of these animals live below 1000 m, a scarcity of material has made studies of development and specific identification of bathypelagic species difficult. The purpose of this paper is to describe the nine furcilia stages and early juvenile phase of *Thysanopoda egregia*. We are confident of our identifications because furcilia F1-F9 illustrated here possess the unique character of ripple-like sculpturing on the posterior and lateral parts of the carapace. In addition, furcilia F1-F5 have eight terminal telson spines and three pairs of postero-lateral spines on the telson; F7-F9 show a precocious trait in reduction of the three pairs postero-lateral spines to two pairs before reaching the juvenile phase.

MATERIAL AND METHODS

The Pelagic Invertebrates Collection (PIC), Scripps Institution of Oceanography/UCSD archives more than 130 000 whole zooplankton samples taken from all ocean basins, with depths ranging from the surface to greater than 4000 meters. The specimens of *Thysanopoda* considered bathypelagic were

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sorted if encountered when analyzing samples from more than 259 cruises, including the CalCOFI (California Cooperative Oceanic Fisheries Investigations) portion of the collection. All specimens were preserved in 1.8% buffered formaldehyde. Samples from several types of nets, including a bongo, 1 m MOCNESS, and mid-water trawls were sorted. Only a small percentage of the tows were from discrete depths, hence exact depth provenance is usually unknown.

Only about two hundred furcilia of *T. egregia* were identified from these samples. Often the specimens sorted were damaged in some way and only 106 specimens were considered to be in sufficiently good condition to be assigned unambiguously to a furcilia stage. Einarsson (1945) defined early furciliae by the number and state of the pleopods, with pleopods first appearing as non-setose rudiments becoming setose after the next molt. The intermediate and late furcilia stages are defined by reduction in terminal telson spines, once five setose pleopods are attained. We follow Einarsson (1945) in assigning the nine furcilia stages we recognize of *T. egregia*.

Total length (TL, tip of rostrum to end of telson) was measured for each specimen using a Wild M5 dissecting microscope equipped with an ocular micrometer. The number of pleopods and pleopod state (non-setose [′] or setose [″]), the number and pattern of terminal telson spines and state of antenna 2 (natatory, transitional or juvenile) were recorded [Table 1; see Knight (1980) for terminology].

RESULTS

Furcilia Stages of *Thysanopoda egregia*

The spiniform dorso-lateral processes on the sixth pleomere, and the eyes, are features of all of the furcilia of *T. egregia*. The eyes of the larvae are very large, well developed, and dark brown in color.

Furcilia 1 (F1).—(Figs. 1A, 2A; Table 1)

Carapace: Our six specimens have damaged carapaces and there is little evidence of ripple marks. Four of the six specimens appear to be in the process of molting.

First antenna: The flagella are slightly shorter than the third segment of the antenna. They are unsegmented, have terminal setae, and the inner flagellum is slightly longer than the outer ramus. The basal segment is armed with a baso-lateral tooth that reaches about to the mid-point of the third segment. The distal, dorsal surface of the first segment is flattened and possesses a few fine setae.

Table 1. *Thysanopoda egregia* furcilia stages and early juvenile phase. *N* indicates the number of specimens measured. [1]′ = pair non-setose, ″ = pair setose pleopods. [2]t = terminal, pl = posterolateral spines. [3]Terminal telson spine length asymmetry: Single number (e.g., 8) indicates all spines of similar length. Three numbers (e.g., 3 + 1S + 4) indicate numbers of left, medial, and right telson spines, respectively, that cluster in groups of similar lengths. L indicates medial spine(s) longer than surrounding spines; S indicates medial spine(s) shorter than surrounding spines. [4]Antenna 2 = Nat (Natatory); Trans (Transitional); Juv (Juvenile). *Indicates the telson spine variant illustrated in Fig. 2. **The dactylus of the second leg bears, for the first time, a series of strong, flattened, hook-like setae.

Phase	Stage	Pleopods (number and setation[1])	Telson spines[2]	Terminal telson spine asymmetry[3]	Antenna 2[4]	Total length (Min-Max, mm)	Mean length (mm)	*N*
Furcilia	F1	3′	7t + 3pl	1 + 3S + 3	Nat	4.90-5.49	4.89	5
	F1		8t + 3pl	3 + 1S + 4				
	F1*			3 + 2S + 3				
	F2	3″	8t + 3pl	8	Nat	4.57-5.56	5.02	40
	F2			2 + 2S + 4				
	F2*			3 + 2S + 3				
	F2			4 + 1S + 3				
	F3*	3″ 1′	8t + 3pl	8	Nat	4.90-6.23	5.45	22
	F3			3 + 1S + 4				
	F3			3 + 2S + 3				
	F3			3 + 1L + 1S + 3				
	F3			4 + 1L + 3				
	F4	4″ 1′	8t + 3pl	2 + 2S + 1L + 3	Nat	5.00-6.64	6.26	16
	F4			3 + 1L + 4				
	F4			3 + 1S + 1L + 3				
	F4			4 + 1S + 3				
	F4*			4 + 1L + 3				
	F5	5″	8t + 3pl	3 + 1L + 1S + 3	Nat	6.23-8.30	7.55	6
	F5			3 + 1L + 4				
	F5*			4 + 1L + 3				
	F6	5″	7t + 3pl	4 + 3	Trans	7.14-9.13	8.41	9
	F6*			3 + 1L + 3				
	F7*	5″	7t + 2pl	3 + 1L + 3	Juv	9.85-10.35	10.13	3
	F8*	5″	7t + 2pl	3 + 1L + 3	Juv	11.19-11.36	11.31	4
	**F9*	5″	6t + 2pl	3 + 1L + 2	Juv	–	13.00	1
Juvenile	J*	5″	1t + 1pl	1	Juv	13.36-15.70	14.70	4

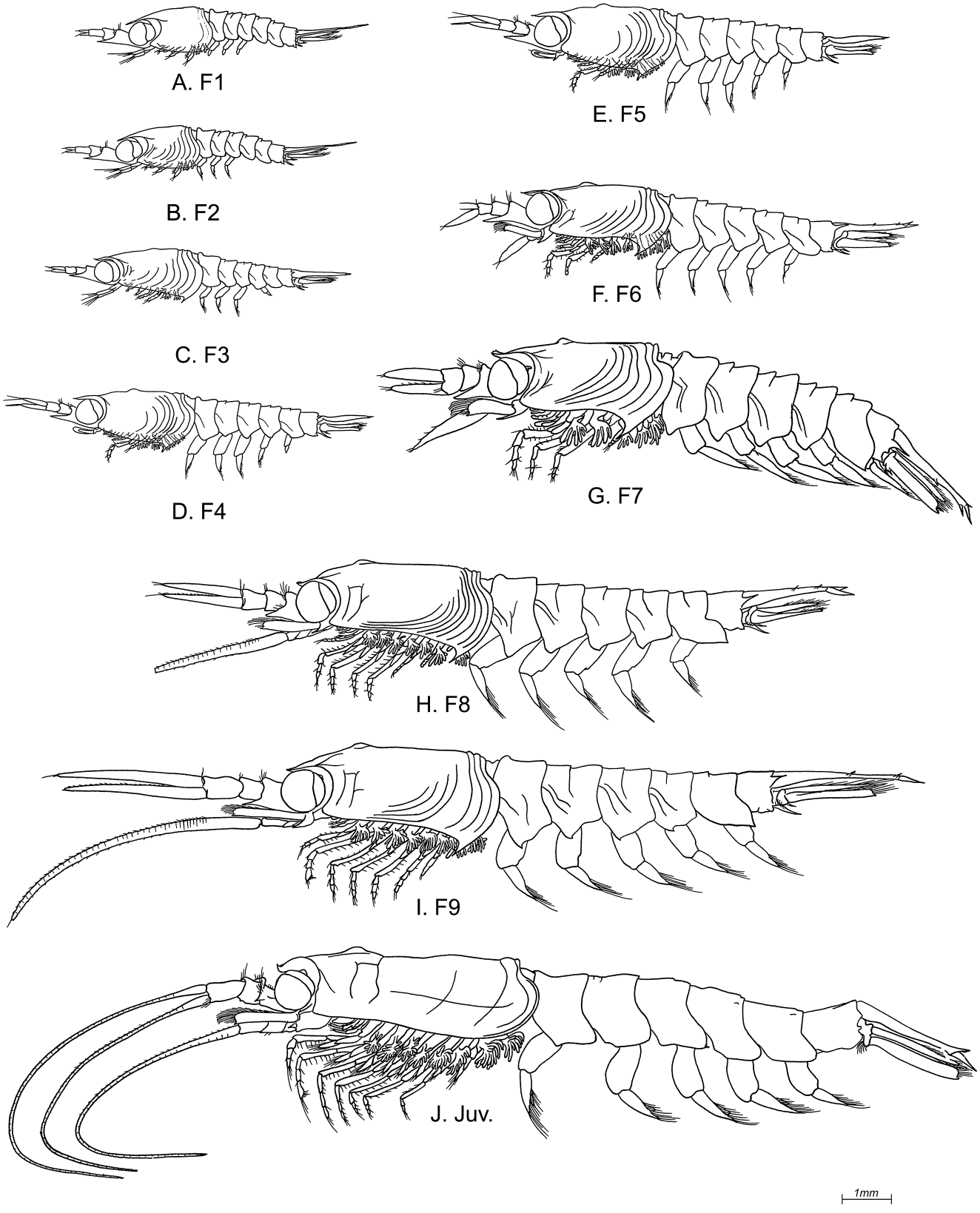

Fig. 1. Lateral view of *Thysanopoda egregia*. A-I, furcilia F1-F9; J, juvenile (Juv). Scale bar (1 mm) applies to all stages.

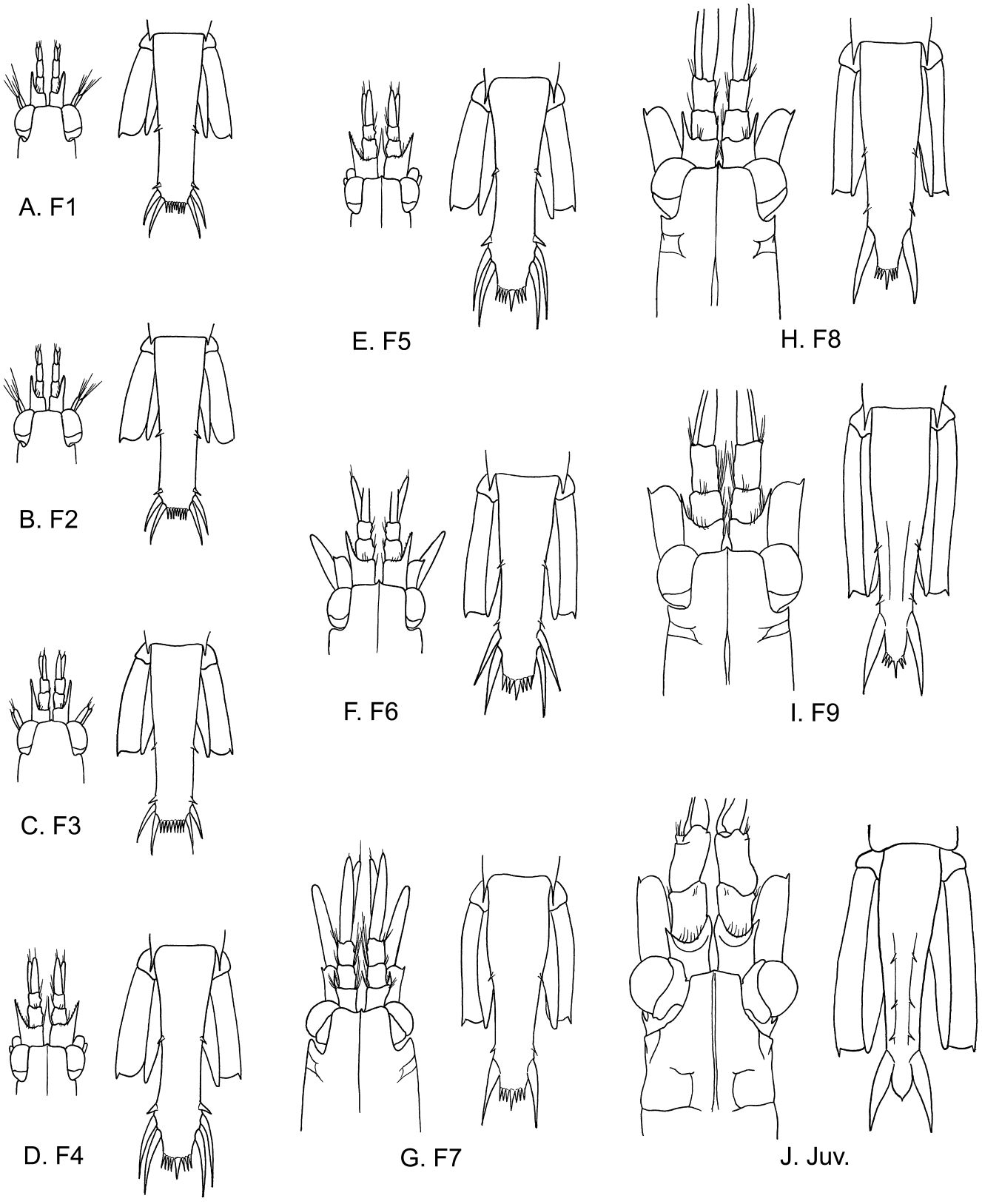

Fig. 2. Dorsal view of *Thysanopoda egregia*. A-I, furcilia F1-F9; J, juvenile (Juv).

Second antenna: The antennae are natatory, and reach to the anterior limit of the eyes. The endopod bears long setae, and is slightly shorter than the exopod, which also bears setae.

Pleopods: (3′) The first three pairs of pleopods are present, nearly equal in length and without setae.

Thoracic legs: The first thoracic leg (maxilliped) has one partially segmented distal segment.

Telson, Uropods: Three of the six specimens have eight terminal telson spines; the medial spine(s) is (are) very small and can only be seen clearly under higher magnification. The terminal telson spine length is variable and asymmetrical (Table 1). The other three specimens are pre-molt and seven terminal telson spines can be seen on the external exoskeleton but eight terminal telson spines can be seen beneath it. The terminal spines are flanked by three pairs of postero-lateral spines, the two more distal pairs are long. The basal segments of the uropods each bear ventrally an acute caudally directed tooth.

Pleon: The dorsal plates of the pleomeres are finely sculptured. The second through the fifth segments are barely cleft dorsally.

Furcilia 2 (F2).—(Figs. 1B, 2B; Table 1)

Carapace: The carapace is ovate and of simple structure. The rostral plate is very slightly cuspate medially on its anterior margin. A small lateral denticle is present. No carination is yet evident on the roof of the carapace. The "ripple" ridges, conspicuous features of this series of larvae, are present on the lateral and posterior parts of the carapace.

First antenna: The flagella are shorter than the third segment of the antenna. They are unsegmented, have terminal setae, and the inner flagellum is slightly longer than the outer ramus. The basal segment is armed with a baso-lateral tooth, which reaches about to the mid-point of the third segment. The distal, dorsal surface of the first segment is flattened and possesses a few fine setae.

Second antenna: The antennae are natatory, and reach to the anterior limit of the eyes. The endopod, bearing six long setae, is slightly shorter than the exopod that bears four setae.

Thoracic legs: The first thoracic leg (maxilliped) has one partially segmented distal member; the endopod of the second leg has two such segmental indentations. The third leg is present as an undifferentiated "sausage-shaped" protuberance, which reaches to the carapace margin, and possesses a rudiment of an exopod. A rudimentary leaf-like gill is present on the second leg; gills of the third and fourth legs are simple with 3-5 lobes.

Pleopods (3″ setose): The first three pairs of pleopods are present. All are setose and well developed.

Pleon: The dorsal plates of the pleomeres are finely sculptured. The second through the fifth segments are partially cleft dorsally so as to subdivide those segments. This probably increases the flexibility of an otherwise rather ponderous pleon.

Telson, Uropods: Eight terminal telson spines are present; the terminal telson spine length is variable and usually asymmetrical (Table 1). The terminal spines are flanked by three pairs of postero-lateral spines, the two more distal pairs being long. The endopods and exopods of the uropods are of equal length, and extend about two-thirds of the length of the telson. The sixth pleomere bears a pair of short dorsal spines at the point reached by the uropods. The basal segments of the uropods each bear ventrally an acute caudally directed tooth, which flank the spiniform pre-anal spine.

Furcilia 3 (F3).—(Figs. 1C and 2C; Table 1)

Carapace. The dorsal keel is perceptible as a slight, very local, mid-dorsal rise in the carapace. The lateral denticle and the ripple marks are better developed than in the previous stages. These may be traced through the developmental series, and are seen to be precursors of a specific lateral groove complex which, together with the form of the rostral spine, is diagnostic of *T. egregia* furcilia.

First antenna: The flagella are equal in length to the third peduncular segment.

Second antenna: The rami are undifferentiated, setose, and natatory.

Thoracic legs: The first two legs are segmented. The sausage-shaped rudiment of the 4th leg is present.

Pleopods (3″ + 1′): A fourth, poorly developed, non-setose pleopod is present.

Telson and Uropods: Eight terminal spines; the terminal telson spine length is variable and usually asymmetrical (Table 1). The postero-lateral spines and uropods are as in the preceding stage.

Furcilia 4 (F4).—(Figs. 1D and 2D; Table 1)

Carapace: The dorsal keel is perceptible as a slight, very local, mid-dorsal rise in the carapace. The lateral denticle and the ripple marks are as in the previous stages.

First antenna: The flagella are longer than the third peduncular segment.

Second antenna: The endopod is heavier and longer than the exopod and reaches the anterior limit of the eye. The rami are setose.

Thoracic legs: Legs 1-3 present.

Pleopods (4″1′): Four setose pleopods and a fifth, poorly-developed, and non-setose pleopod are present.

Telson and Uropods: The terminal telson spine length is variable and asymmetrical (Table 1). Eight terminal telson spines are present, but the medial one is longer and three pairs of postero-lateral spines are present. The endopods and exopods of the uropods extend about three-fifths of the length of the telson.

Furcilia 5 (F5).—(Figs. 1E and 2E; Table 1)

Carapace: An acute, forward-directed rostral spine is present. A low keel extends caudally from the spine to the low, mid-dorsal carina.

First antenna: The flagella are nearly as long as the sum of the lengths of the second and third segments. The lateral spine from the first segment reaches to two-thirds the length of the third segment. The first peduncular segment is now slightly elevated and rounded on its distal upper margin.

Second antenna: The endopod is heavier and longer than the exopod and reaches beyond the anterior limit of the eye. The rami are setose.

Thoracic legs: Five thoracic legs are discerned, the fourth and the fifth being very rudimentary. The gills of the second through fifth legs are well developed. Those of the sixth through eighth legs are simple.

Pleopods (5″): All of the swimming legs are present and setose. The fourth and the fifth pleopods are, however, somewhat smaller than the first three.

Telson and Uropods: The terminal telson spine length is variable and asymmetrical (Table 1). Eight terminal telson spines are present, but the medial one is longer. The endopods and the slightly longer exopods of the uropods extend about three-fifths of the length of the telson.

Furcilia 6 (F6).—(Fig. 1F and 2F; Table 1)

Carapace: The rostral spine is better defined than in the earlier stages, and the dorsal keel is now anterior to the midpoint of the carapace.

First antenna: The setose, unsegmented flagella are equal in length to the combined length of the two distal peduncular segments. The lateral spine from the first segment reaches nearly to the end of the third segment.

Second antenna: The scale, or exopod, is flattened, setose, and well developed. It bears a spine at its distal-lateral angle. The antennae are still not completely segmented (transitional) and are more bulbose than the flagella. Their basal segments bear lateral spines that are directed antero-laterally along the scale.

Thoracic legs: The rudiment of the sixth thoracic endopod is present. The fifth leg is very short but bears terminal setae. All seven of the gills are well differentiated.

Pleopods: All of the swimming legs are present and setose.

Telson and Uropods: The terminal telson spine length is variable and asymmetrical (Table 1). Seven terminal telson spines, the most median of which is elongate, are present and three pairs of postero-lateral spines. The uropods extend about three-fourths of the length of the telson.

Furcilia 7 (F7).—(Figs. 1G and 2G; Table 1)

Carapace: The mid-dorsal keel is again more anteriorly displaced and now lies about two-fifths of the length of the carapace back of the rostrum. The lateral denticles are very large and strong.

First antenna: The flagella are equal in length to the three proximal segments. The outer flagellum is finely setose along its length. The rudiment of the dorsal lappet of the first segment is present as a setose elevation.

Second antenna: The scale reaches to the end of the second segment of the first antenna. The antennae are more elongate than before, reaching nearly to the end of the flagella, and are setose along their distal inner margins.

Thoracic legs: The exopod of the partially segmented sixth leg is half the length of the endopod. The latter ramus is as long as the gill of the fifth leg. The seventh leg is half the length of the sixth, is undifferentiated, and has a nub of an exopod.

Pleopods (5″): The pleopods are of nearly equal size.

Telson and Uropods: Seven terminal telson spines, the most median of which is elongate, are present and now with two pairs of postero-lateral spines. The uropods, with endopods slightly longer than exopods, reach about four-fifths of the length of the telson.

Furcilia 8 (F8).—(Figs. 1H and 2H; Table 1)

Carapace: The keeled anterior one third of the carapace slopes downward from the dorsal keel and terminates in an acute forward-directed spine. The antero-lateral sub-vertical grooves are well developed. The lateral denticle is smaller in relation to the size of the carapace than in earlier stages.

First antenna: The length of the flagella is very slightly increased, but these appendages are more slender than before. The lateral tooth from the first segment reaches to the end of the second segment.

Second antenna: The antennae are flattened, elongate, segmented, finely setose along their length and much longer than the previous stage.

Thoracic legs: The sixth thoracic leg is as long as the first leg, but is little more than half as long as the second through fifth legs, which are well developed. The seventh leg is not completely segmented, and the endopod of the eighth leg is present as a sausage-shaped rudiment.

Pleopods (5″): The pleopods are of equal development.

Telson and Uropods: The terminal telson spines are as in the preceding stage. The postero-lateral pair of spines is even heavier than before, and is better articulated.

Furcilia 9 (F9).—(Figs. 1I and 2I; Table 1)

Carapace: The anteriorly-directed rostral spine extends beyond the antero-lateral margin of the rostral plate. The dorsal keel is prominent, while the ripple-marks are less well defined than in preceding stages. The lateral denticle is still conspicuous.

First antenna: The flagella are longer than the combined length of their peducular segments. The third segment is half again as long as the second segment. The first segment is quite heavily setose in the region of the developing lappet. The lateral spine of that segment now bears no setae on its inner margin, and is reduced in size.

Second antenna: The scale extends beyond the second segment of the first antenna. The flagella, still incompletely segmented, remain rather heavy and swollen in appearance. Their length is now greater than that of the carapace.

Thoracic legs: The dactylus of the second leg bears, for the first time, a series of strong, flattened, hook-like setae. These setae are to be found on the second dactylus of all adult thysanopods. Banner (1950) aptly described them as "scythe-spines." The sixth and seventh legs are incompletely developed, while the eighth exopod is still very rudimentary.

Telson and Uropods: Asymmetry is evidenced in the distribution of terminal telson spines. Three and two spines, respectively, are to be found on each side of the strong median spine. The rami of the uropods are of equal length.

Early Juvenile Phase

Juvenile (J).—(Figs. 1J and 2J; Table 1)

Carapace: The carapace retains feeble vestiges of the larval ripple mark, but the rostral spine is now directed upward. The specimen has attained the essential appearance of the adult *T. egregia*.

Thoracic legs: All of the thoracic appendages are well developed, except the eighth endopod, which does not develop in this genus.

Remarks.—Illig (1930) describes a specimen of 14.5 mm that possesses all of the typical larval characters, while Hansen (1912) had a specimen of nearly the same length that possessed many of the features of our post-larval individual. The specimen at hand has a single terminal telson spine and

three pairs of lateral spines on the dorsal side of telson. The uropods reach to the base of the strong postero-lateral telson spines. Certain features that persisted throughout the larval history are no longer present. The lateral carapace denticles are lost. The heavy denticles that are lateral to the first antennal segments are very reduced, as are the spiniform processes on the dorso-lateral margins of the sixth pleomere and those on the ventral side of the basal uropod segments. The dorsal clefts of the second through fifth pleomeres are not present. Three small carinae (keels) are present on each of the fourth and fifth pleomeres; the cervical groove is well developed, and the flagella and antennae are slender and segmented.

The shape of the eyes and of the rostral plate and the presence of grooves and vestigial ripples on the carapace make it possible to relate this specimen with confidence to the preceding series.

DISCUSSION

Furciliae of *Thysanopoda egregia*

The larval development of the giant euphausiids, *T. cornuta* and *T. egregia*, has been a subject of speculation among students of these Crustacea. A scarcity of material has made studies of development and specific identification of individuals difficult. The larvae of *T. egregia* are similar to the larvae of *T. cornuta*. However, *T. cornuta* furciliae are characterized by the development of the pleopods as $4'$, $4'' + 1'$, $5''$ (Einarsson, 1945, where $'$ indicates non-setose and $''$ indicates setose pleopods), which differs from our specimens of *T. egregia*. Mostly furcilia stages (rather than nauplii, metanauplii, or calyptopis phases) have been reported in the literature as belonging to this group of giant euphausiids. They have been identified on the basis of their short sixth pleomere and their large size relative to their stage of development. Tattersall (1939) summarized most of the early records, and tentatively assigned the specimens to a "Species A" and a "Species B." The present material provides evidence that "Species A" is *T. egregia*.

Banner's (1950) specimens from the Gulf of Alaska are somewhat enigmatic due to their limited description. They probably both belong to *T. egregia*. Converging rostral margins and a long rostral spine were not noted. Banner remarked that the eyes of the smaller specimen were laterally compressed as is consistent with larvae of *T. egregia*, as compared with *T. cornuta* larvae. No ripple markings, however, were mentioned as carapace features on either the 10 mm or the 15 mm specimen.

The present material provided a sequence of furcilia stages of *T. egregia*. It is the general practice (Lebour, 1926; Macdonald, 1927; John, 1936; Fraser, 1936; Einarsson, 1945; and Boden, 1951) to regard certain stages of euphausiid development, those that are of greatest abundance in the plankton throughout the breeding season, as "dominant stages." Developmental stages are commonly distinguished by the degree of pleopod development, whether or not the antennal endopod is segmented, and by the number of terminal spines on the telson.

The larval and post-larval stages described here may be of unequal importance in the development of *T. egregia*. It seems probable, however, that under the condition of a comparatively uniform physico-chemical environment, such as is believed to prevail in deep oceanic water, development may proceed in a constant manner, relative to the development of forms living in the surface layers. Indeed, the present material shows that the length-measurement, Table 1 and Fig. 3, of a larva of *T. egregia* is a good measure of its stage of development. Specimens of the same length, captured many miles and seasons apart, are found to have attained the same developmental status.

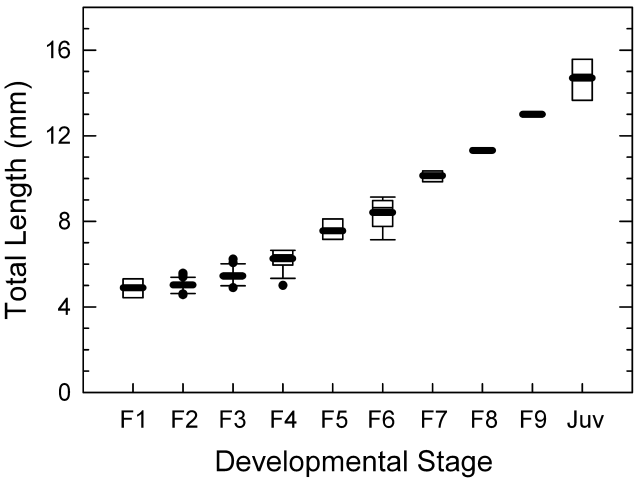

Fig. 3. Total length as a function of developmental stage (Furcilia 1 through Juvenile) of *Thysanopoda egregia*. (Heavy horizontal lines = mean; box boundary percentiles: lower = 25th, middle = 50th, upper = 75th; whiskers = 10th, 90th; dots = outliers.) Sample sizes ranged from 1 to 40 specimens per stage.

Thysanopoda egregia Distinctive Characters

Our specimens show two distinctive characters that were first reported by Illig (1930): (1) The "ripple" ridges, conspicuous features present on the lateral and posterior parts of the carapace on F1-F9. (2) Furcilia 1-Furcilia 5 possesses eight terminal telson spines and 3 pairs of postero-lateral spines on the telson. Illig (1930) illustrated a 14.5 mm specimen with ripple ridges and a 6 mm specimen with 8 terminal spines plus 3 pairs of postero-lateral spines.

In nearly all of our specimens, the terminal telson spine length is variable and asymmetrical. The environment in which these animals live, or the fact that many specimens were either about to molt or newly molted, might contribute to this variability. We note that two F4's from the same plankton sample had different terminal telson spine asymmetry.

As reported by Einarsson (1945) for *T. acutifrons* Holt and Tattersall, 1905, *T. egregia*'s precocious reduction in postero-lateral spines (from 3 pairs to 2 pairs) in furcilia 7 is different than other euphauiid species and thus far only these two species have been reported to have this trait. The three other bathypelagic and the abyssal species of *Thysanopoda* may yet prove to have this trait as well.

Depth Range

Thysanopoda egregia furciliae have been caught from depths of 70-2000 m (Brinton, 1962). In Table 3 Brinton (1962) lists a series of developmental stages, including six furcilia and two cyrtopia stages. From the present study, our shallowest

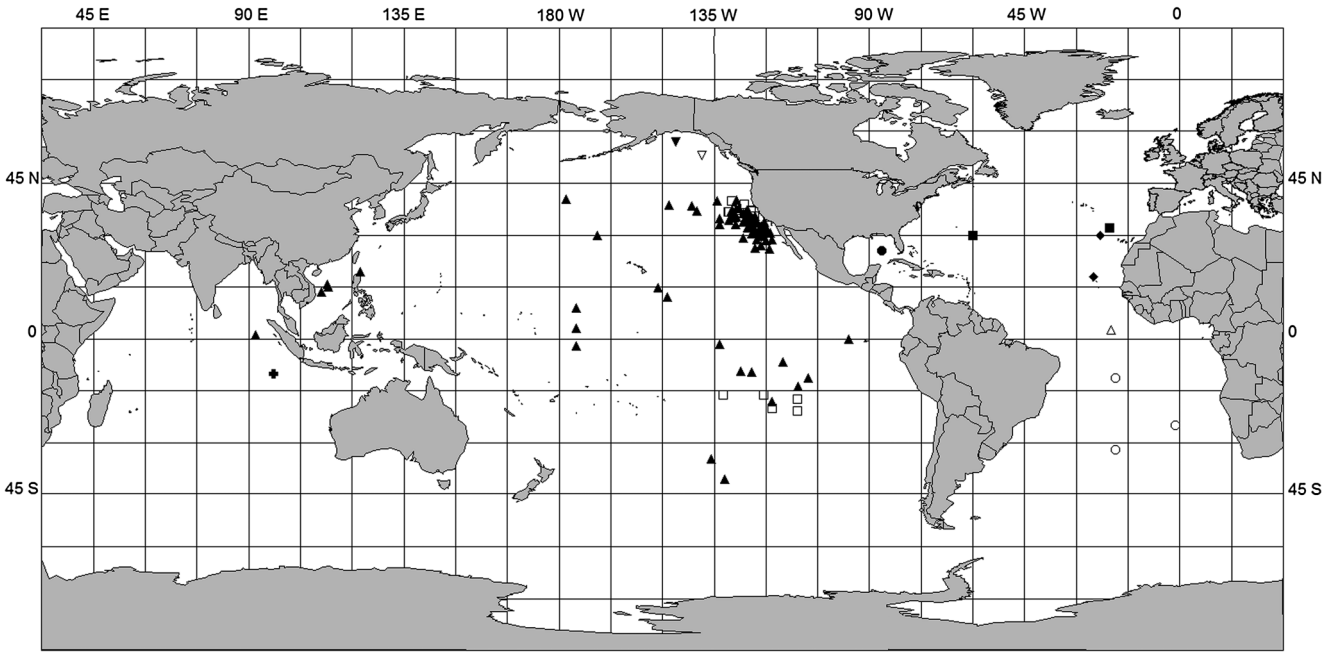

Fig. 4. Geographical distribution of *Thysanopoda egregia* furciliae (F1-F9) and juvenile. ▲ = present study, ◆ = James (1987), △ = Weigmann-Haass (1986), ■ = James (1983), □ = Youngbluth (1973), ● = James (1970), ▼ = Banner (1950), ✚ = Illig (1930), ○ = Zimmer (1914), ▽ = Hansen (1915).

discrete sample was from a cruise off southern California, ZB2 (74-50 m), containing an F3. Our deepest discrete sample was from the South Pacific, Aries I (600-200 m), containing an F1.

Brinton's (1987) description of *Thysanopoda minyops* and the three other giant *Thysanopoda* compared all four species in relationship to habitat. His Fig. 12 inferred depth ranges of life history stages of these deep-living euphausiids.

The biomass of euphausiids in the deeper zone of the northwestern Pacific has been discussed by Vinogradov (1968), who estimated that euphausiid biomass is about ten percent of the total biomass at a depth of about 3000 meters. The only euphausiids known to inhabit this zone are *Bentheuphausia amblyops* and four species of *Thysanopoda*. The adults of the four *Thysanopoda* are large and long-lived. They are carnivorous and are considered to play a significant role in this environment (Nemoto, 1977).

Geographical Distribution

Thysanopoda egregia adults are known from 40°N to 53°S in the Pacific, from 3°S to 45°S in the Indian Ocean, and, in the Atlantic, from the Gulf of Mexico and west of North Africa (Brinton et al., 2000). Many of our specimens of furciliae and early juvenile of *T. egregia* are from the California Current between 26°N and 40°N (Fig. 4), with specimens most common between 35.3-38.0°N. However, the overall global distribution of the F1-F9 and Juvenile in this study (Fig. 4) corresponds with the previously described distribution of the adults, showing a cosmopolitan distribution in waters mainly equator-ward of the subpolar ocean provinces.

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