

Notes on Ecology, Systematics, and Development of Some Mysidacea and Euphausiacea (Crustacea) from New Zealand

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DURING SURVEYING OPERATIONS of H.M.N. Z.S. "Lachlan" in January, February, and March, 1951, opportunities occurred for making biological and oceanographic collections. Stations were kept in eastern and southern nearshore and oceanic waters between Wellington, New Zealand, and Auckland and Campbell islands, some 400 and more miles south of South Island, New Zealand. A series of specimens was obtained which has furnished information on ecology, development, and morphology of a number of southern cool-water species. This report concerns the Crustacea of the orders Mysidacea and Euphausiacea.

Little information, other than of a systematic nature with brief ecological information, has been available on New Zealand zooplankton. In 1923 Tattersall reported on 12 species of Mysidacea from collections made by H.M.S. "Terra Nova" about New Zealand. Seven of these were new species, 6 from the genus *Tenagomysis*. He listed and discussed a total of 15 species, predominantly from the northern, subtropical waters; Chilton (1926) briefly summarised these data. *Tenagomysis*, with 9 species, was regarded by Tattersall as an endemic and characteristic genus of New Zealand, but since then Ii (1937) and Nouvel (1942) have recorded single species from Japan and the Golfe de Gascogne, respectively. Tattersall (1955) adds a further two species, *Boreomysis rostrata* Illig, and *Euchaetomera zurstrasseni* (Illig).

Mysids were absent from the majority of the 86 stations kept from "Lachlan." Two

species of *Tenagomysis* were captured, both in the shallow waters (approximately 20 m.) of Foveaux Strait, at the southern extremity of South Island. *T. macropsis* Tattersall was present at 18 and *T. tenuipes* Tattersall at 13 stations. Specimens were abundant at times, and from them it has been possible to provide additional information on the systematic morphology of *T. tenuipes* (described originally from a single male) and to give an account of the larval development of both species.

Tattersall (1924) tabulated 15 species of euphausiids according to their distribution about New Zealand. Eight had been taken by H.M.S. "Challenger" (Sars, 1885) and 7 others were among the 12 species collected by "Terra Nova," all from northern waters. The species belonged predominantly in tropical and subtropical waters.

Five species were present in "Lachlan" collections, namely *Nyctiphanes australis* Sars, *Euphausia lucens* Hansen, *E. vallentini* Stebbing, *Thysanoessa gregaria* Sars, and *Nematoscelis megalops* (?) Sars. *N. megalops* (?) is a new record for the southern Pacific (Boden, 1954), but the others have been recorded previously from New Zealand. The northernmost record of *E. vallentini* was 47° 37'S (171° 47'E) which is in keeping with its more southern range (John, 1936). *E. lucens*, a northern subantarctic species (John, 1936) did not occur south of New Zealand. *Thysanoessa gregaria* occurred sparingly in Cook Strait—between North and South islands—but was present in greater numbers in offshore, subantarctic waters, and it extended southward to Auckland and Campbell islands. *Nyctiphanes australis* occurred only in coastal water.

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Euphausiid developmental stages were captured and these have furnished the larval history of *Euphausia lucens*, a variety of instars of the three furcilia of *Nyctiphanes australis*, and notes on the early furcilia stages of *Thysanoessa gregaria*.

Salinities and temperatures of the waters in which species occurred have been used to confirm the distribution shown by conventional chart plots. Some data on diurnal variation, as indicated through changes with time in numbers taken at the surface, contribute

additional information for both mysids and euphausiids.

MATERIAL AND METHODS

Collections were made at 86 stations kept during the surveying routine of the naval frigate, H.M.N.Z.S. "Lachlan." Two series were run between Cook Strait and Dunedin, one in January and the other in March, 1951. The March, but not the January series, crossed the subtropical convergence. The bulk of the stations were situated between Dunedin and

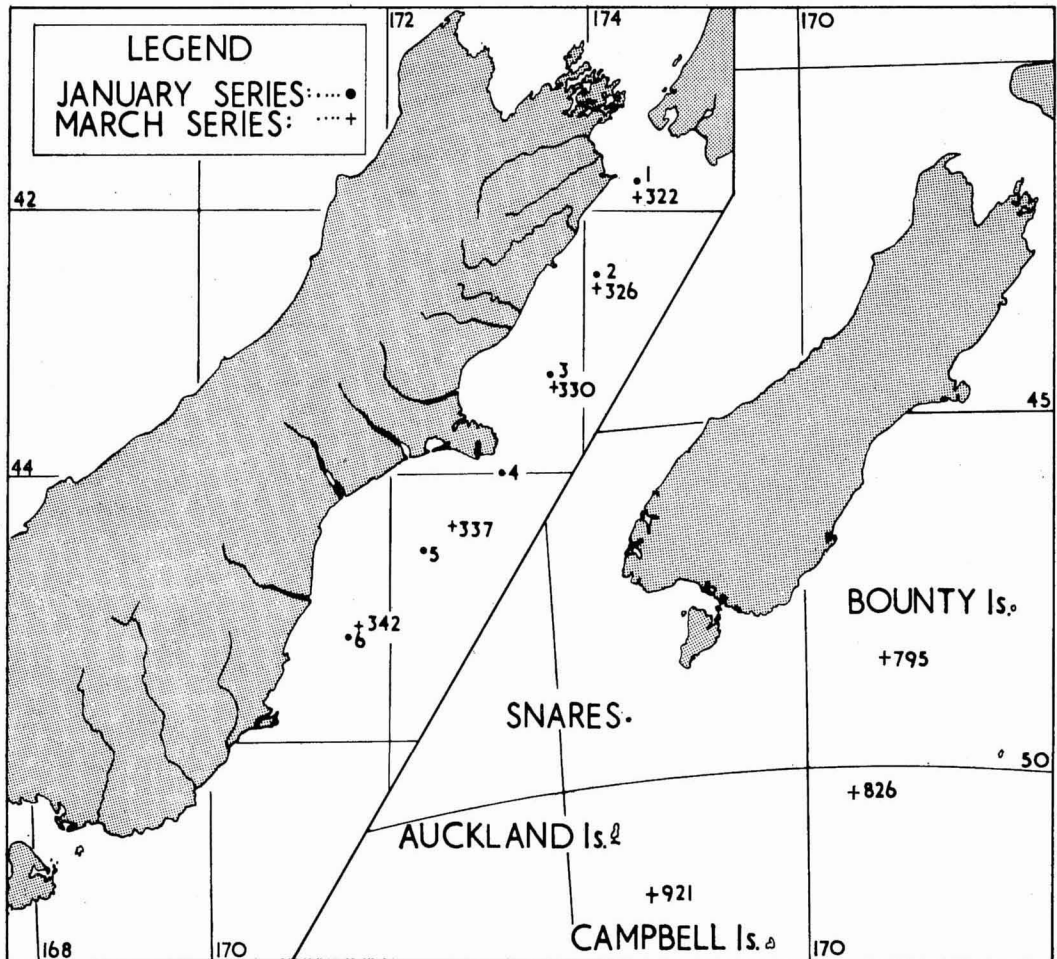


FIG. 1. The plankton stations kept by H.M.N.Z.S. "Lachlan" during January, March, and November, 1951. Left—the January (1-6) and March stations between Cook Strait and Dunedin. Right—the November stations between southern New Zealand and the Auckland-Campbell islands area.

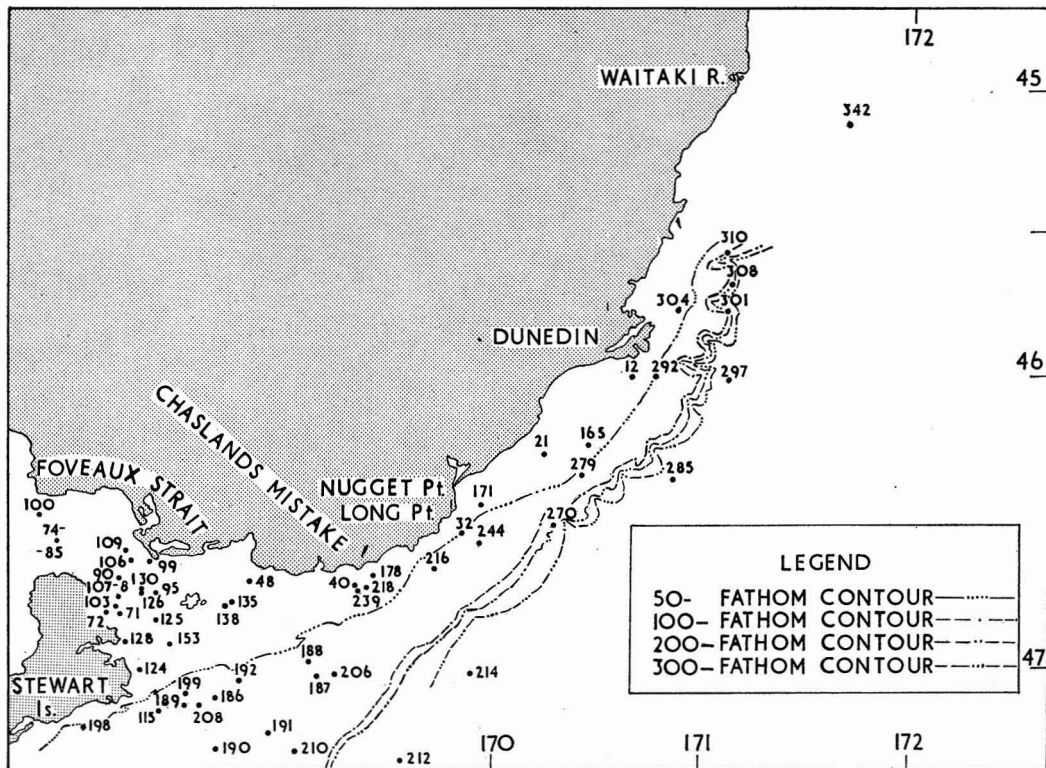


FIG. 2. The plankton stations kept by H.M.N.Z.S. "Lachlan" in and about Foveaux Strait at the southern end of New Zealand during January, February, and March, 1951.

western Foveaux Strait and were kept during January, February, and March 1951. Three were included from a series run between southern New Zealand and the Auckland-Campbell islands area in November 1951. Plankton stations are shown in Figures 1 and 2.

Day and night stations were kept as opportunity permitted. Because the ship's surveying routine could not be interrupted for lengthy tows these were restricted to 3 minutes except at stations 74 to 85 where the net was streamed for 15 minutes (see later). Most were surface hauls, supplemented on occasion with oblique tows from 75 metres to the surface when in deep waters, e.g., on passage from Wellington to Dunedin. As the ship was usually in a particular area for some time, the inadequacy of the 3-minute tow in a position

under certain conditions was largely overcome by making numbers of tows under various conditions of time and weather. The net was 50 centimeters diameter with a 16- to 18-mesh grit gauze in the outer portion, a 29-mesh middle portion and 80-mesh inner portion running to the cup. Care was taken to ensure uniform procedure during sampling: the ship's speed was maintained as nearly as possible at 2 knots, and depth of tows made within the surface 2 metres; the same net structure was used throughout the series, the materials being renewed frequently. Because of this standardisation, samples could be compared and some quantitative data obtained.

Surface temperatures and water samples were taken at each net-station, and usually at several intervening positions as well. Salinity determinations were made at the Dominion Laboratory, Wellington.

OBSERVATIONS ON THE SYSTEMATICS AND
ECOLOGY OF MYSIDS

Order MYSIDACEA

Suborder MYSIDA

Tribe LEPTOMYSINI

Genus *TENAGOMYSIS* G. M. Thomson, 1900*Tenagomysis macropsis* Tattersall

Figs. 3, 4

Tenagomysis macropsis Tattersall, 1923.

Males, females, and juveniles (one tow consisting of about 60,000 individuals) were taken in 18 samples which were confined to northern and western Foveaux Strait, southern New Zealand.

Tattersall gives a full diagnosis of this species to which reference should be made for greater detail.

Figure 3 illustrates the external appearance of an adult 8.9 mm. male and the fourth pleopod. Characteristics which aid identification are: the rounded rostral plate with anterolateral, curved spines; the elongate eye-stalk; the 3 tarsal joints of the thoracic limbs; the spination and proportional lengths of telson and inner and outer uropods, Figure 4b.

Tenagomysis tenuipes Tattersall

Fig. 5

Tenagomysis tenuipes Tattersall, 1918, 1923.

Tattersall described this species from a single male, 21 mm. long, taken in Carnley Harbour, Auckland Islands. In the present samples almost 500 specimens of both males and females were taken in 13 hauls from western Foveaux Strait (in the same area as, and often together with, *T. macropsis*) and from eastward of Stewart Island. Numerous juveniles were also captured.

Mature males reached a length of 21.3 mm. and mature females 19.9 mm. Brood-pouch juveniles, ready to be shed, were 4.2 mm. in length. Tattersall's diagnosis is adequate, but

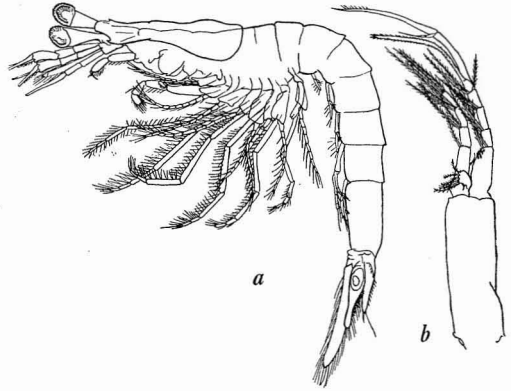


FIG. 3. *Tenagomysis macropsis* Tattersall. *a*, An 8.9 mm. adult male; *b*, fourth pleopod.

inasmuch as large numbers of both sexes were examined in the present material, and some additional information obtained, a full description is given.

Both males and females are moderately slender with large black eyes; they are often brown (preserved) with conspicuous chromatophores.

The carapace exposes the last two thoracic segments completely; it is approximately one-third the length of the body, is produced anteriorly into a broadly triangular rostral plate and has rounded anteroventral angles (Fig. 5a).

The peduncle of antenna 1 (Fig. 5a, b) is long and slender in the female, but stouter in the male with a long, densely hirsute male process. Segment 1 is slender, curves outward and dorsad, and is longer than segments 2 and 3 together; segment 2 is approximately one-third as long as segment 3 which has, distally, a stout mediodorsal spine and three or four lateral setae.

In antenna 2, the peduncle of the endopod (Fig. 5a, c) is not as long as segment 1 of antenna 1. There is a stout spine ventrally on segment 1 of the endopod, and segment 2 is longer than segments 1 or 3. The squame is 11 or 12 times as long as wide and extends from one-sixth to one-fourth of its length beyond the peduncle of antenna 1. It pos-

sesses an articulation distally at 0.9 of its length and a stout spine ventrally on its basal segment; a bluntly pointed process extends dorsad between the basal segments of the squame and endopod.

The thoracic appendages are long and slender. Each limb has a multi-jointed tarsus,

the number of joints being 5 on the first two legs, 8 or 9 on the third, 11 to 14 on the fourth to the seventh, and 9 or 10 on the eighth. There is some indication that females may have one or two fewer joints on some legs (see Table 1). Epipodial processes are pronounced, especially on the first leg (Fig.

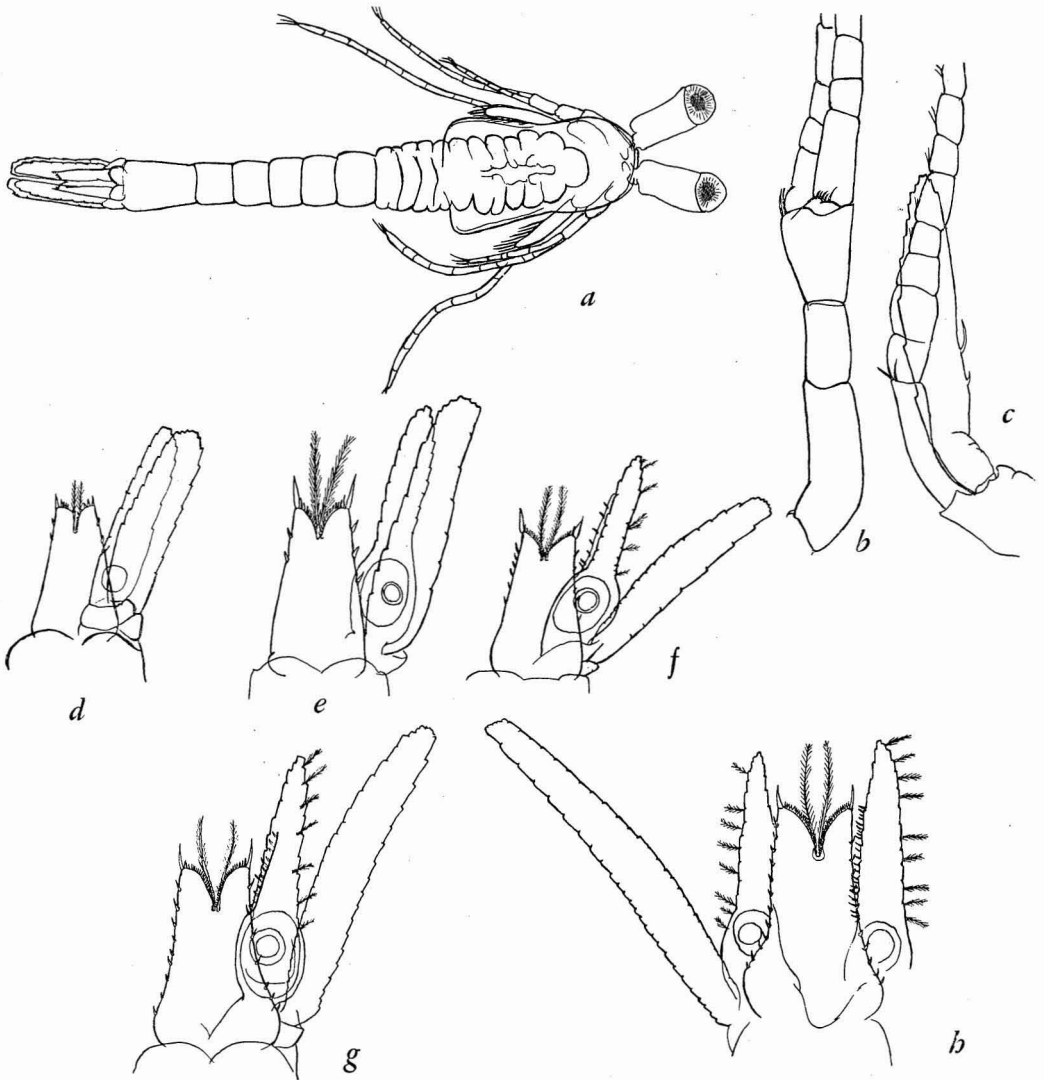


FIG. 4. *Tenagomysis macropsis*. a-g, Developmental stages: a, A 2.2 mm. specimen from the brood pouch, (thoracic limbs not shown); b, antenna 1 of same; c, antenna 2 of same, with squame developing; d, telson and uropods of same; e, telson and uropods of a 2.7 mm. (free living) specimen; f, telson and uropods of a 5.0 mm. specimen; g, telson and uropods of a 7.0 mm. specimen. h, Telson and uropods of adult, 9 mm. male. Magnification of f and g is 0.6 that of d and e.

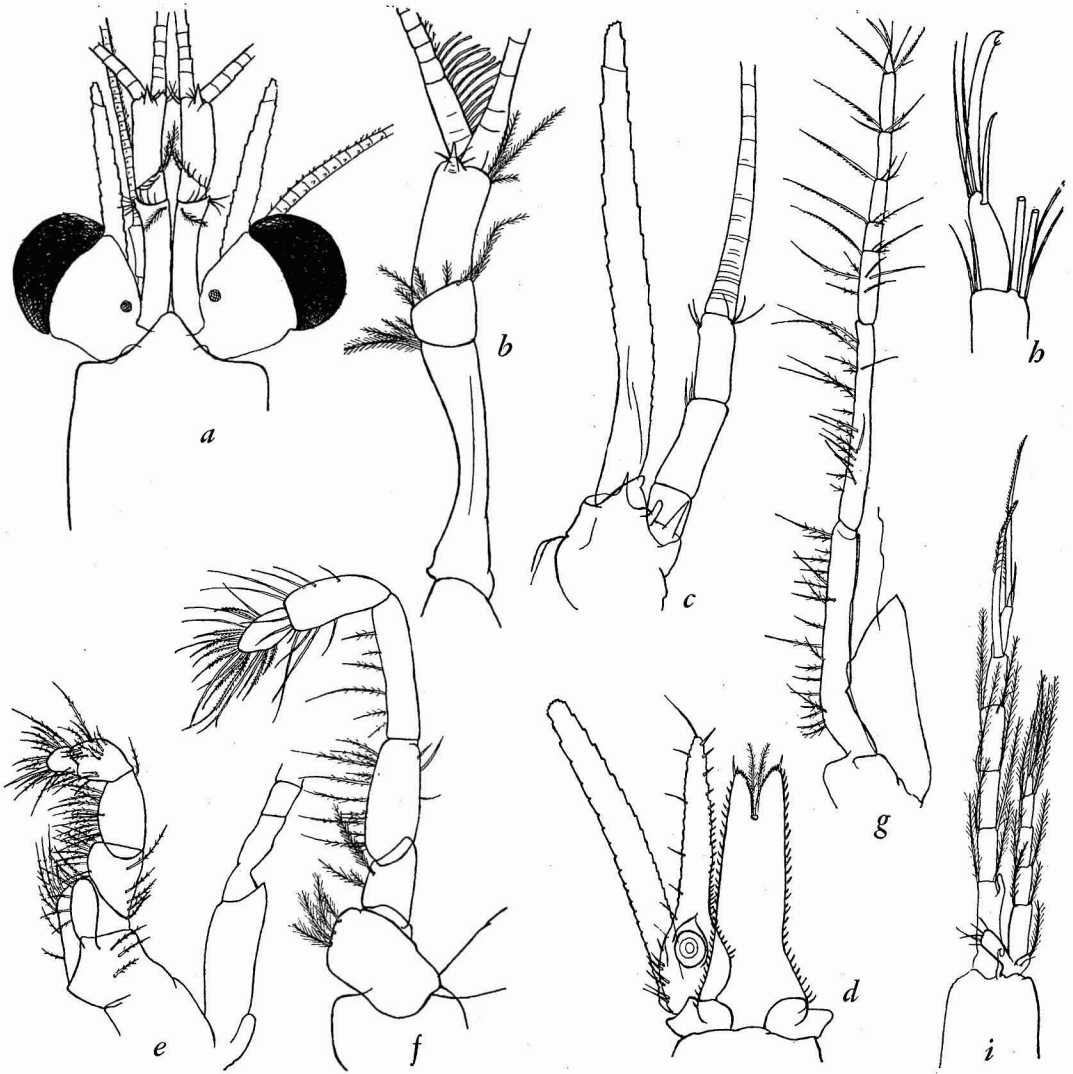


FIG. 5. *Tenagomysis tenuipes* Tattersall. *a-b*, Structure of a 9.8 mm. specimen. *a*, Anterodorsal aspect; *b*, antenna 1, dorsal; *c*, antenna 2, with squame; *d*, telson and uropods; *e*, first thoracic limb; *f*, second thoracic limb; *g*, third thoracic limb; *h*, dactyl of thoracic limb. *i*, The fourth pleopod of a 16.9 mm. male.

5*e, f*), and setose, the number of setae decreasing from leg one to leg eight which has a few only. Exopods are present on all legs; the basal segment is freely acuminate at the outer distal corner and the flagella has 9 segments on all except the first leg on which it has 8.

There are no spines on the abdomen and the sixth somite is twice as long as the fifth and as long as the telson.

The telson (Fig. 5*d* illustrates the telson and uropods of a half-grown specimen) is ventrally keeled and is cleft for one-fifth of its length; the cleft has 50 to 60 pectinations

to each margin and 2 plumose setae at its apex; the lateral margins are provided with about 36 spines and one, longer terminal one. The inner uropod is 1.25 times as long as the telson and carries 85 to 90 spines on its inner margin, often in groups of 2 to 4; for most of the length of the uropod these spines are closely spaced, but the spacing increases distally. On the outer margin are the usual long setae, and an additional series of short ones which are more densely grouped about the position of the statocyst. The outer uropod is 1.5 times as long as the inner, is narrow and more or less parallel-sided.

In pleopod 4 of the male (Fig. 5*i*) the outer ramus is almost twice the length of the inner; the penultimate and antepenultimate segments bear long spines, each with spinules which, on the penultimate spine, occur over almost its whole length and on the antepenultimate spine, over the distal half only. Proximally and medially on the first segment of the outer ramus is a short blunt process which is inclined towards the abdomen; distally on the same side of the same segment is a much longer process pointing away from the abdomen. The first segment of the inner ramus of pleopod 5 bears the usual proximal inner lamella, and there is an additional, smaller one carrying a single seta, at the distal one-third of the same segment.

Table 1 indicates that a general increase in the number of joints in the tarsal segment and some small variation in the number of joints of any one limb may occur. The latter varia-

tions may be apparent in a single specimen, e.g., in leg 7 of the 21.3 mm. male where on one side there are 13 joints and on the other, 14.

Except for secondary sexual characters, the fewer joints which appear to be present in the tarsus, and the more slender peduncle of antenna 1, there are few apparent differences between female and male.

DEVELOPMENT OF JUVENILES OF *Tenagomysis macropsis* AND *T. tenuipes*

The data which follow are additional to Tattersall's and are included in view of the frequency with which catches of juveniles were made and the initial difficulties experienced in their identification. The often large catches indicate that these larval forms make a significant contribution to the plankton of the area and therefore, should be considered in future investigations.

Development appears continuous, there being no clearly definable stages comparable with those of euphausiids. Prior to release from the brood-pouch, in both species, the cephalothorax is relatively larger than the abdomen (due to the presence of more or less yolk from the large egg), the limbs are stouter and less setose, and the proportions of telson and uropods differ from the corresponding adult structures. The changes associated with these during growth are the most noticeable features of development.

Tenagomysis macropsis juveniles of 2.2 mm. in length (Fig. 4*a*) are retained in the brood-

TABLE 1.
THE INCREASE IN NUMBER OF TARSAL JOINTS WITH INCREASE IN LENGTH IN *Tenagomysis tenuipes*

LIMB	LENGTH OF SPECIMEN				
	4.2 mm.	8.0 to 9.0 mm.	16.8 mm. (Male)	21.3 mm. (Male)	19.9 mm. (Female)
3.....	2	5	8	9	8
4.....	2	6	9	11	10
5.....	3	6	10	13	11
6.....	3	7	12	13	12
7.....	3	7	13	13-14	12
8.....	2	6	9	10	9

pouch where there may be as many as 25 present. Both antennae 1 and 2 (Fig. 4a, b) are incompletely developed; the squame of antenna 2 (Fig. 4c) is not articulated distally and has only 2 or 3 outer lateral setae; the peduncle of the endopod is not clearly segmented. In the peduncle of antenna 1 (Fig. 4b), segment 2 is slightly longer in comparison to segments 1 or 3 than it is in the adult. Both uropods (Fig. 4d) are setose; the inner is very slightly the shorter, contains the elements of a statocyst, but bears no spines on the inner margin. On the margins of the telson there are 2 or 3 lateral, and 1 terminal, spines; there are 4 to 6 spinules and 2 plumose setae in the cleft. From about 2.5 mm. the young are free in the water and there is a sturdier appearance to the appendages. The cleft of the telson has about 11 spinules (see Fig. 4e, for 2.7 mm. specimen) per side and the statocyst of the inner uropod is better differentiated; the outer uropod is slightly longer relative to the inner one. In 5.0 mm. specimens (Fig. 4f) the outer uropod is noticeably longer than the inner and the latter has developed a series of 6 to 7 spines near the inner margin and several extra setae on the outer; the statocyst is well developed. There is an increase of lateral spines on the telson to 5 or 6 and spinules in the cleft to about 17. In specimens 7.0 mm. long (Fig. 4g) the outer uropod is markedly longer than the inner and on the inside margin of the latter the number of spines has increased to 11. The telson now has 7 to 9 lateral spines and 20 or more spinules in the cleft and is developing a waisted appearance as the basal one-third or so is becoming more bulbous in outline. Between a length of 7.0 mm. and the adult size of 8 to 9 mm. (Fig. 4b) there is a further increase in the number of lateral spines on the telson to 11 or 12, of the cleft spinules to 27 to 30, and of the spines on the inner margin of the inner uropod to about 22.

In addition to these specific changes, there is a progressive lengthening of the limbs and increased definition of cephalic, thoracic, and

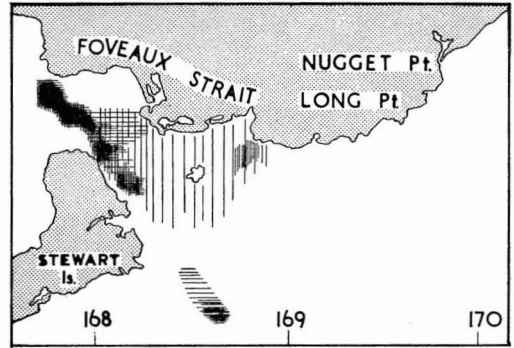


FIG. 6. The distribution of *Tenagomysis macropsis* (vertical lines) and *T. tenuipes* (horizontal lines) about southern New Zealand. Abundance is indicated by the density of the shading.

abdominal regions as adulthood is approached.

In *T. tenuipes* the differences between juvenile and adult are similar in kind to those of *T. macropsis*. In contrast to *T. macropsis* the number of joints in the tarsus of thoracic appendages increases with the age of specimens (Table 1).

Individuals of 8 to 9 mm. (Fig. 5a-g) illustrate the differences to be expected. The telson (Fig. 5d) has 29 to 30 lateral spines, which may be roughly in groups of longer and shorter spines, with the distal ones the more closely spaced and shorter. The cleft has approximately 29 pectinations. The outer uropod is 1.2 times the length of the inner and 1.3 times as long as the telson; the inner uropod has 32 to 35 spines on the inner margin and these tend to be in groups of 3 proximally and to be longer and more widely spaced distally; the outer margin bears secondary setae which are more numerous about the statocyst.

Thoracic limbs 1 and 2 (Fig. 5e, f) are essentially as in the adult. Limbs 3 (Fig. 5g) to 8 are long and slender with reduced numbers of joints in the tarsus. Table 1 indicates the progressive increase in the number of joints in these limbs in specimens ranging in length from 4.2 mm. (about to be shed from the brood pouch) to an adult male of 21.3 mm.

In other features there are slight changes in the proportions of one part with another, e.g., the eyes of smaller specimens are proportionally larger, and the limbs are stouter, but such are usually not of sufficient degree to cause confusion of identity.

The known distribution of both *T. macropsis* and *T. tenuipes* has been extended by the present collections. *T. macropsis* had previously been recorded from northern New Zealand, eastwards almost to Chatham Islands ("Terra Nova," sta. 242), to Dunedin. The present records from Foveaux Strait (Fig. 6) increase the range southward and westward and appear to be consistent with the previous ones.

The range of *T. tenuipes* has been brought 200 miles northward from the Auckland Islands to southern New Zealand, which also involves an increase in temperature of at least 6°C. Both records are from shallow, inshore waters; the species has not been collected between the two areas and may be regarded as a neritic one.

DIURNAL VARIATION OF NUMBERS
AT THE SURFACE

Tattersall (1936 *b*), in a short account of vertical distribution, showed diurnal migration occurring for two species of mysids taken by the Great Barrier Reef Expedition. This appears to be the only account of vertical distribution or diurnal movements of mysids for waters of the Southern Hemisphere. Dakin and Colefax (1940: 129) state that a rise to the surface is usual at night, and that probably they collected specimens at no other time. Hardy and Günther (1935) record neither vertical distribution nor migration for the species at South Georgia. There are no previous data for New Zealand mysids.

The data presented below are derived from surface tows and are indicative of vertical migration only through the variation, with time, of numbers at the surface. Further, they are from collections (sta. 74 to 85) made in western Foveaux Strait with the ship at anchor in a tideway wherein the net was streamed for

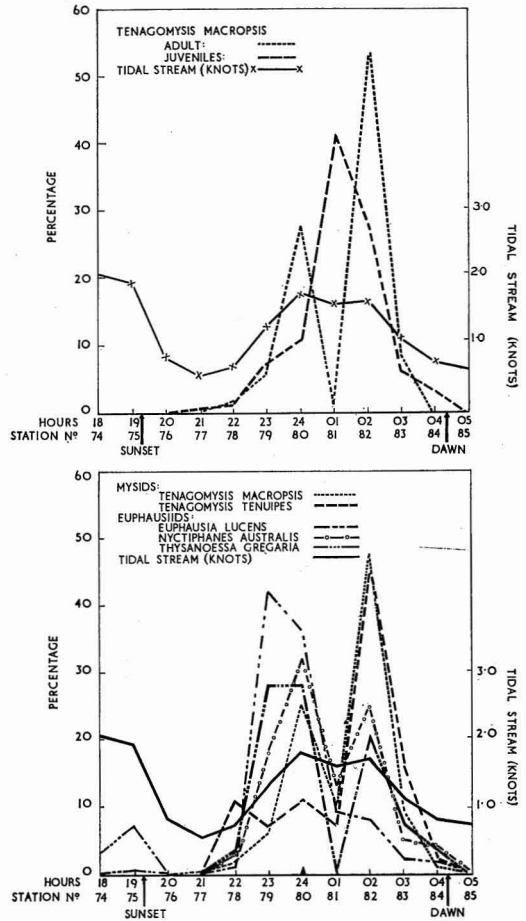


FIG. 7. The variation in numbers of mysids and euphausiids captured in surface tows in a tideway—station series 74-85, western Foveaux Strait. The catch of each species at a station is expressed as a percentage of its total catch for the series. Upper, differential movements of adult and juvenile *Tenagomysis macropsis*. Lower, diurnal variation of mysids and euphausiids.

15 minutes each hour. In this method of working, the velocity of water passing through the net may vary considerably from tow to tow, but in this instance, it was almost constant at from 1.7 to 2 knots between 2400 and 0200 hours (see Fig. 7 in which the rate of flow, computed from hourly observations made from the ship, is plotted) and under half a knot less an hour previous, or subsequent, to these times. Size of catch prob-

ably did vary over the period required to complete the station series because of the velocity changes in the tidal flow, but nevertheless, the variations in numbers taken conform in general to other diurnal migration patterns (Cushing, 1951); especially is this so between 2300 and 0200 hours.

In Figure 7 the curves express the number of specimens per haul as a percentage of all specimens of that species taken in all the hourly hauls. These curves (except for that of juvenile *T. macropsis*—see below) follow a pattern which is normal (Cushing) in that there is a "main rise" with a subsequent decline in numbers which in turn is followed by a later rise and then the descent from the surface.

Tenagomysis macropsis (Fig. 7, lower) becomes increasingly numerous from 2100 to 2400 hours when there is a sudden decline to 0100 hours; a second peak of high numbers is reached at 0200 hours followed by a rapid decrease to 0300 hours and then an easing to 0400 hours; at 0500 hours, in full daylight, no specimens were captured. *T. tenuipes* occurred irregularly and in small numbers until 0100 hours. There was no significant increase at midnight (compare with *T. macropsis*), but following a slight decrease in numbers at 0100 hours, which repeats a similar decrease at 2300 hours, there is a sudden increase, coincident with that for *T. macropsis*, to a peak at 0200 hours. The subsequent decline in numbers parallels that of *T. macropsis*.

The great increase in numbers of both species of mysids at 0200 hours coincides with a similar, but not as great, increase in two species of euphausiids, (see later and Fig. 7). As there still remain 2 hours to dawn—first light at 0410 hours—this increase would not appear to be associated with the usual pre-dawn rise, which with Copepoda was indicated by an increased catch at 0300 hours. As this behaviour accorded in the 2 mysid and 2 euphausiid species and as their subsequent reactions were similar, it would appear that for these species, under the conditions ex-

perienced, the rise at 0200 hours was a true expression of their behaviour pattern.

A possibility not to be ruled out in the circumstances is that shoals of the relevant species were being sampled, especially at the 0200 tow, in which case, the appearance of a later, small, predawn rise might be masked by the large catches made earlier. That such shoaling is a not altogether reasonable possibility is demonstrated by the independent migrations to the surface of juvenile and adult *T. macropsis*, shown in the upper graph of Figure 7, where the percentage occurrence of juveniles per haul is superimposed on that for adults from the same hauls. Juveniles increase slowly and steadily to 2400 hours when a sudden increase to a single peak at 0100 hours occurs. The subsequent decline indicates a rapid descent from the surface about the time the late rise of adults commences, although both are at the surface in moderate numbers between 0100 and 0200 hours. The juveniles are also somewhat slower at leaving the surface in this series, as is indicated by a catch of 50 as against 3 adults at station 84.

OBSERVATIONS ON THE SYSTEMATICS
AND ECOLOGY OF EUPHAUSIIDS

Order EUPHAUSIACEA

Family EUPHAUSIIDAE

Genus EUPHAUSIA Dana

Euphausia lucens Hansen

Fig. 8

Euphausia lucens Hansen, 1905, 1911; Tattersall, 1924; John, 1936.

A few of this species were taken from Cook Strait, but the majority were taken around southern New Zealand. None occurred in the subantarctic stations 795, 826, 921 (Fig. 1). In all 3,378 specimens were captured in 37 hauls.

Sub-mature males and females ranged between 10.0 and 11.0 mm. in length; mature specimens reached 16 mm. and exceptionally, 18 mm.

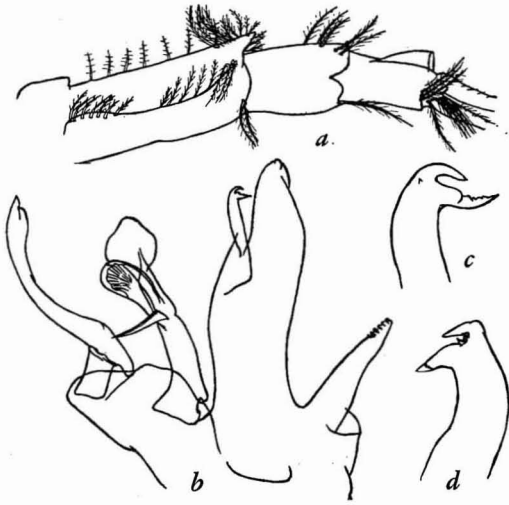


FIG. 8. *Euphausia lucens* Hansen. *a*, Lateral aspect of antenna 1, adult female; *b*, left copulatory organ of 15 mm. male, from behind; *c*, lateral process of left copulatory organ; *d*, lateral process of right copulatory organ.

Features which aid in identification of the species are the broad, triangular lappet (which is variable in size) on the distal inner margin of segment 1, and the shape and size of the keel on the terminal segment, of antenna 1 (Fig. 8*a*); the short, broadly triangular rostrum; absence of dorsal spines on the abdominal segments; and in the male, the detailed structure (Fig. 8*b-d*) of the copulatory organ (John, 1936).

There is a slight discrepancy between John's figures and the present material in the structure of the lateral processes of the copulatory organ (Fig. 8*c, d*). In the present specimens one or more minute, subsidiary spines are in association with the terminal tooth of the process. On the lateral process of the left organ there is, as well, a series of denticulations on the outer surface of the curved end (Fig. 8*c*). Probably these are little more than minor differences as the organs are otherwise identical.

According to Tattersall (1924) *E. lucens* is "a species, the centre of whose distribution lies in the south temperate zone, but which

occasionally penetrates to the subantarctic region." John regards it as primarily a subantarctic species, not found south of the antarctic convergence, and limited by the subtropical convergence in its northward extent. Both authors regard the 12° to 14°C. isotherms as delimiting its northward extension. The difference in terminology lies in Tattersall's acceptance of Regan's (1914) definition of the southern zones wherein northward of the 12°C. isotherm is south temperate, and south of it, subantarctic zones. John regards the waters between the subtropical and antarctic convergences as subantarctic, the temperature of which ranges from 14.5°C. in the north to 4.5°C. in the south over summer months (Deacon, 1937).

In the present collections *E. lucens* extends to stations 322 and 326, north of the subtropical convergence (Figs. 1, 9); at 322 it occurred only in an oblique haul, and at station 326, 10 specimens were taken in the oblique and 6 in the surface tow. At station 330, just south of the convergence, 13 specimens were present in the oblique, and 21 in the surface, hauls. It is a possibility that the oblique tows at 322 and 326 are sampling from concentrations in colder water (11°C.) which was shown by bathythermograph to be present at 40 to 60 metres, and which was a northward extension of subantarctic, overlaid by subtropical, water. The higher numbers in both hauls at 330 appear to support this. Movement northward beyond the convergence in such colder deeper water may in part explain John's statement that specimens occur in the coldest of the subtropical water along the northern edge of the convergence. Contrarily, this species has been taken in water to about 20°C. (John, 1936: 208); with the temperature tolerance which this indicates specimens could penetrate into the overlying warmer water north of the convergence.

Judging from the present collections *E. lucens* appears to be confined to more northerly subantarctic waters (see Fig. 9) than was found by the "Terra Nova" (Tattersall, 1924)

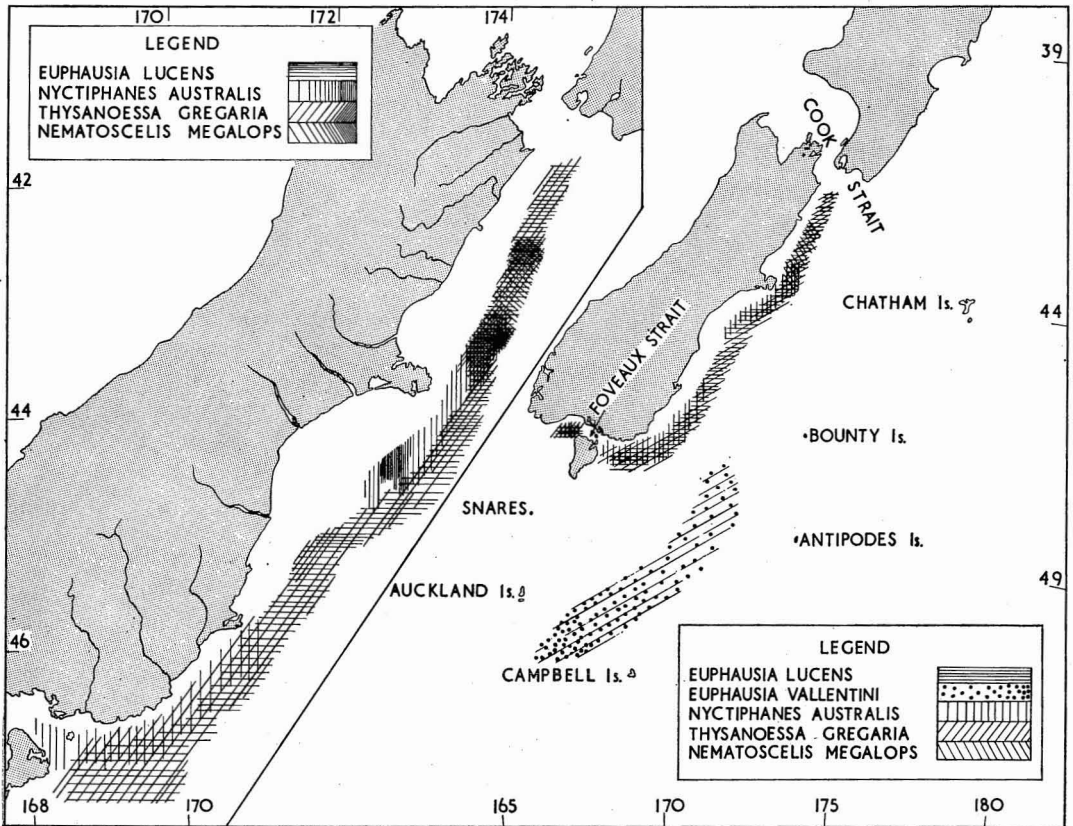


FIG. 9. The distribution of euphausiids between Cook Strait and the Auckland-Campbell Islands area. *Left*, occurrences between Cook and Foveaux Straits. *Right*, occurrences in the sub-antarctic waters in relation to those on the coast of South Island.

or "Discovery II" (John, 1936). No specimens were collected at stations 795, 826 or 921 between southern New Zealand and Auckland Islands—it was replaced by *E. vallerntini* (Fig. 9) in these hauls. John (*loc. cit.*) reports, however, that the southern limit of occurrence of *E. lucens* overlaps the northern limit of *E. vallerntini*; further sampling is required to show where this occurs to the south of New Zealand.

The pattern of the distribution of *E. lucens* in southern New Zealand waters (Fig. 10) suggests that specimens are entering coastal areas in intruding tongues of subantarctic water. Preponderant occurrence is in a narrow range of salinity between 34.25 and 34.45

parts per thousand which is within that of subantarctic water (34.2 to 34.5 parts per thousand, see Deacon, 1937). Occurrences in water of lower salinities possibly result from intrusions of subantarctic water carrying specimens into dilute coastal water. Some occurrences in waters of higher salinities may be in mixtures with subtropical waters, possibly intruding eastwards through Foveaux Strait.

Euphausia vallerntini Stebbing

Fig. 11

Euphausia vallerntini Stebbing, 1900; Holt and Tattersall, 1906. Hansen, 1911; Tattersall, 1924; John, 1936.

Euphausia splendens (part), Sars, 1885.

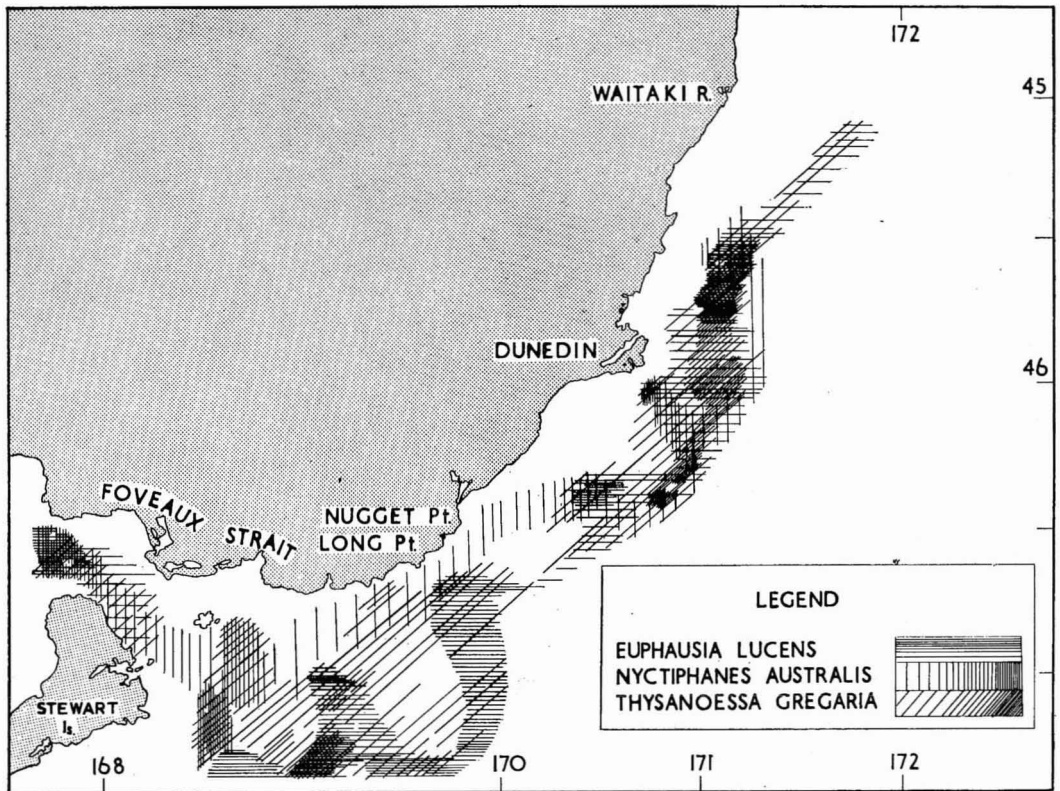


FIG. 10. The distribution of euphausiids, south-eastern New Zealand, for the period January through March, 1951. Abundance is indicated by the density of the shading.

During November 1951, single specimens were taken at each of stations 795 and 826 (at 1900 and 0300 hours respectively) and 24 specimens, including larval stages, at 921 (at 0300 hours). These occurrences (Fig. 9) are in subantarctic waters.

The length of the largest specimen, a female, was 20.5 mm. John (1936) fully describes this species, including larval stages. It is readily identifiable, and also distinguishable from *E. lucens*, by the large, broad, oval lappet distally on segment 1 and the high-arched keel dorsally on segment 3 of antenna 1 (Fig. 11*a-c*), combined with the presence of the "spine" posteriorly in the mid-dorsal line of abdominal segment 3 and the short, acutely pointed rostrum.

E. vallentini is typically associated with subantarctic waters (John). Off New Zealand,

specimens have been taken north of the 12°C. isotherm (Tattersall, 1924) and to about 45°S latitude (John, 1936: 213); both of these occurrences were south of the subtropical convergence, northward of which it has not been recorded. In the present collections, the temperature ranged between 9°C. at 47°37'S, station 795, to 8.2°C. at station 921; since the stations were all kept after nightfall, the 24 specimens collected at 921 would suggest that the species is more common in the colder waters of the higher latitudes in November (see Fig. 9). No specimens have been taken in neritic or near-oceanic waters about southern New Zealand, but it is possible that occasionally it might occur in intrusions of subantarctic water in winter months when the temperature of these waters is appreciably lower.

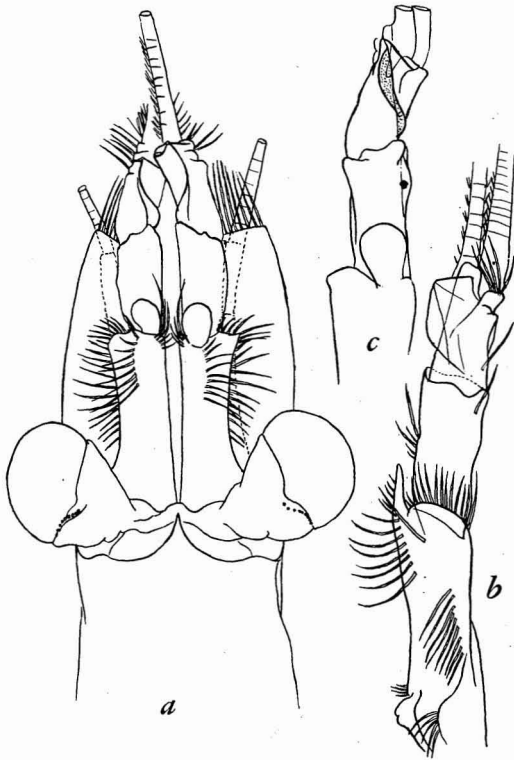


FIG. 11. *Euphausia vallentini* Stebbing. *a*, Antero-dorsal aspect, 20.5 mm. female; *b*, antenna 1, lateral aspect; *c*, antenna 1, dorsal aspect.

Genus NYCTIPHANES G. O. Sars

Nyctiphanes australis G. O. Sars

Nyctiphanes australis G. O. Sars, 1883, 1885;
G. M. Thomson, 1900; Hansen, 1911;
Dakin and Colefax, 1940.

A commonly occurring euphausiid, especially in coastal waters; a total of 3,132 specimens were taken at 28 stations.

Mature females ranged in length from 9.8 to 17.0 mm. and males from 12.0 to 16.0 mm.; thus specimens may mature over a considerable range of size. A very full diagnosis has been given by Sars, 1885; Dakin and Colefax, 1940, illustrate an adult female, a calyptopis, and a furcilia stage.

This species is confined to southeast Australian and New Zealand waters (Hansen, 1911; Tattersall, 1924; Sheard, 1953) and is

regarded as a coastal one. It was collected by "Terra Nova" only in the area about, and south of, Three Kings Islands, just north of New Zealand, but Thomson (1913) recorded it as being extremely common in Otago Harbour, where it was important as a fish food.

The distribution from the present collections is shown to be fairly consistently further inshore than the other euphausiids taken (Figs. 9, 10), although overlap along the margins of the species ranges (especially with that of *E. lucens*) is apparent. Comparatively wide salinity tolerance is demonstrated (34.05 to 34.72 parts per thousand), and preference is shown for temperatures, for the most part, above 13.5°C. These data lend support to Tattersall's claim that *N. australis* is a coastal species. The species was absent in tows north of the subtropical convergence, but the earlier records suggest that it may be common throughout our coastal waters.

Genus THYSANOESSA Brandt

Thysanoessa gregaria G. O. Sars

Fig. 12

Thysanoessa gregaria G. O. Sars, 1883, 1885;
Hansen, 1911, 1913; Dakin and Colefax,
1940; Einarsson, 1945; Boden, 1954.

A total of 1,256 specimens were taken, mostly in small numbers, at 42 stations; large catches were made only in a night series between Dunedin and Nugget Point (stations 285 to 308; Figs. 1, 9, 10).

The longest specimen was a 16.2 mm. female, but the majority of adults, which were comparatively rare, were between 10 and 13 mm. long; most specimens captured were either furcilia or cyrtopid stages.

The adult possesses a characteristic denticulate plate, the pre-anal spine (Sars, 1885), which, together with the stout form of the body, very long second leg (Fig. 12*b*), large eye, and in the male, the copulatory organ (Fig. 12*a*), contributes to ready identification of the species.

Sars reported *Th. gregaria* from "Challenger" collections made between Sydney and Wellington, Chilton (1911) found it in stomachs of fish from the Kermadec Islands, and Tattersall recorded it in "Terra Nova" catches from south of Three Kings Islands. The latter collections, some 250 specimens from 20 stations, comprised the largest catches until those of the present series. The species is regarded as typically from northern or southern temperate waters (Hansen, 1911; Tattersall, 1924; Einarsson, 1945; Boden, 1954). Although in the southern hemisphere it has several times been recorded in subantarctic waters, i.e., south of the 6°C. isotherm in Regan's (1914) terminology (see Hansen 1913, and Tattersall, 1918) Boden, following an extensive survey, regarded it as a "true temperate or subtropical form" and states that its occurrences in African subantarctic water were "probably transitory."

In the present collections specimens occurred from Cook Strait to latitude 51° 41'S (station 921 where 30 were collected; Figs. 1, 9); at only six stations were more than 50 specimens taken at one time and of these, stations 210, 297, and 308 had 195, 200, and 496 specimens, respectively. Its consistent penetration into coastal water (Fig. 10) in which temperatures of 15°C. and higher were met, and its presence in subantarctic water of as low as 8.2°C. indicate a considerable temperature tolerance. However, largest catches were made in oceanic water with salinity and temperature characteristics of the subantarctic, suggesting that the species may occur there more frequently than previously thought.

Genus NEMATOSCELIS G. O. Sars

Nematoscelis megalops (?) G. O. Sars

Fig. 13

Nematoscelis megalops G. O. Sars, 1883, 1885; Hansen, 1911, 1915; Esterley, 1914a; Banner, 1949; Boden, 1954; Boden, Johnson and Brinton, 1955.

A total of eight females was taken, two from the horizontal and five from the oblique tows at station 326, and one from the oblique tow at station 330 (Figs. 1, 9).

According to Hansen (1911), Banner (1949), Boden (1954), and Boden, *et al.* (1955), the only means of separating the Atlantic species *N. megalops* from *N. difficilis* of the northeast Pacific, is on the structure of the male copulatory organ. On the other hand Einarsson (1942), from a study of the spermathecae of the two species, regards them as identical. Most unfortunately, no male was taken here, and because of this the identification is left open; but the evidence presented in Table 2 appears to favour the specimens being identified as *N. megalops*. The notes for *N. difficilis* are derived from Esterley (1914a), Banner (1949), and Boden, *et al.* (1955).

Table 2 lists characters which vary between the two species, suggesting that differences may exist other than those found in the male

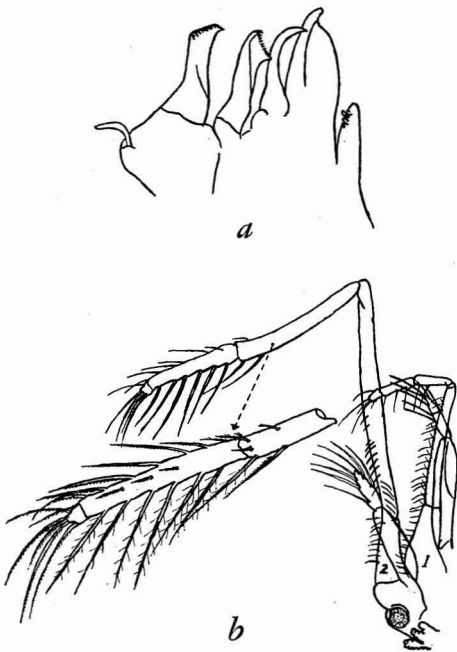


FIG. 12. *Thysanoessa gregaria* G. O. Sars, a, Left copulatory organ of adult male, from behind; b, first and second thoracic limbs.

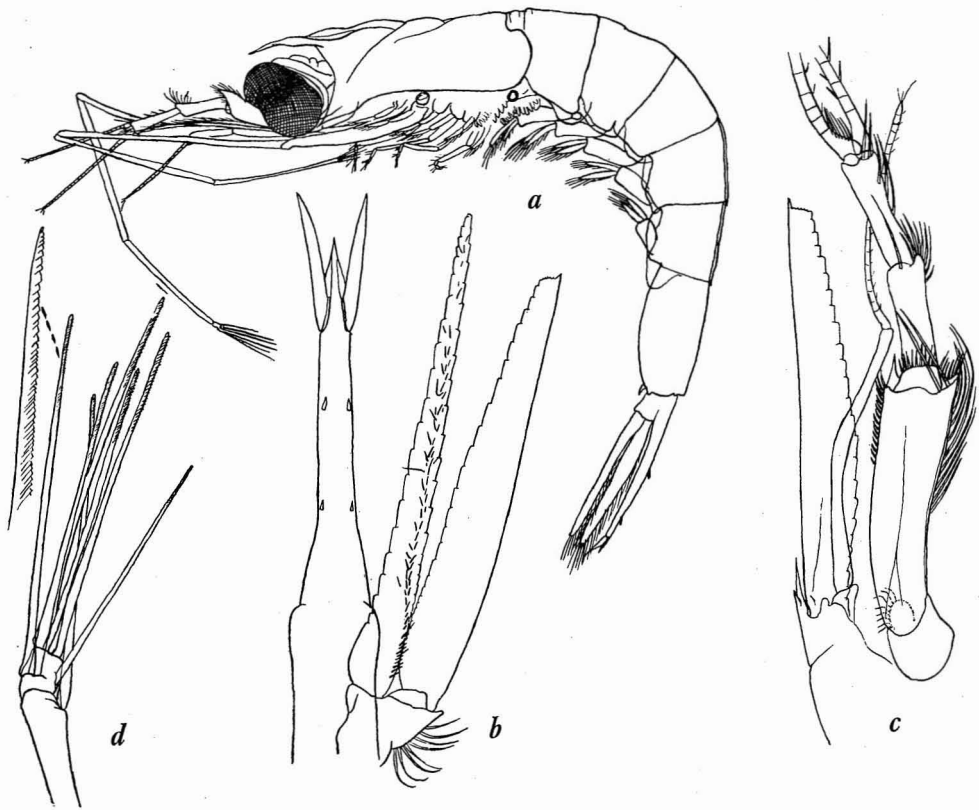


FIG. 13. *Nematoscelis megalops* (?) G. O. Sars; 20.4 mm. female. *a*, Lateral aspect; *b*, telson and uropods; *c*, antennae 1 and 2; *d*, terminal portion of limb 2.

copulatory organs. The median spine-like processes on the fourth and fifth abdominal somites, (or the median keel in the *N. Z.* specimens?) may prove a convenient distinguishing character in view of their absence (Banner) in *N. difficilis*.

Nematoscelis megalops has been described as one of the characteristic euphausiids of the northwest Atlantic according to Hansen (1911) who mentions that it has also been recorded "at some places in the southern temperate Atlantic," but that females taken in the southern Indian Ocean could not be referred to either *N. megalops* or *N. difficilis*. Boden (1954) reports that *N. megalops* is common about South Africa, but that no records exist of it from the south Pacific. On the other hand, Sheard (1953) records *N. difficilis*,

adults and larval stages, as commonly occurring in east Australian waters. He also, doubtfully, records *N. megalops* from the western Indian Ocean.

Specimens of *N. megalops* from the south Atlantic could well get caught up in the West Wind Drift and attain a sparse, subantarctic circum-global distribution, eventually reaching southern New Zealand in the subantarctic water. It is equally possible for *N. difficilis* to be carried into the area from Australia, either in the West Wind Drift, or (and more likely) across the south Tasman Sea via the western drift in that portion of the ocean.

Thus it is possible for either, or both, *N. megalops* and *N. difficilis* to be present in New Zealand waters. Recorded distributions, and more especially proximity to Australia and

direct oceanographic communication from Australia to New Zealand, suggest that the New Zealand specimens may be *N. difficilis*. The morphological features listed in Table 2, however, favour their being *N. megalops* and accordingly the species is provisionally listed as *N. megalops*.

EUPHAUSIID LIFE HISTORIES

There are numerous accounts of larval development of a wide range of species of the Euphausiacea. Einarsson (1945) has treated the historical progress in these studies and has reviewed the terminology of the developmental phases. Gurney (1947) reviews development. Sheard (1953) briefly covers historical features and theories of development; he also discusses "dominance" among larval instars and questions the validity and usefulness of the concept. Boden (1955) discusses in turn Sheard's view towards dominance and also his "lumping" of the numerous furciliars of *N. australis*, and those of other species into three furcilia stages. Boden is of the opinion that dominance is still a useful concept, and that, "under the present circumstances it is

less useful to 'lump' the furcilia stages than to 'split' them."

Some life-history stages are available from the "Lachlan" material for *Nyctiphanes australis* and *Thysanoessa gregaria*; the three calyptopis, and a complete series of furcilia stages for *Euphausia lucens*. There is little doubt that in the present material dominant instars occur for the oceanic species *E. lucens* and *T. gregaria*. For the coastal species *N. australis*, a tendency for dominant instars to occur is explained as due to the local nature of the collections (see Sheard, 1953); Sheard's grouping of the instars has been followed for this species.

Development of *Euphausia lucens*

John (1936) combines *Euphausia crystallophias*, *E. superba*, *E. frigida*, *E. vallentini*, and *E. lucens* into a group of related species (his "Southern Group"); of these, closest relationship is considered to exist between *E. lucens*, *E. vallentini* and *E. frigida*. He describes the development of *E. vallentini* and *E. frigida* (but not of *E. lucens*) and the close relationship of adults of the two species is reflected in the similarity of their development

TABLE 2

DIAGNOSTIC CHARACTERS OF *Nematoscelis difficilis* AND *N. megalops* (FROM VARIOUS AUTHORS) AND THEIR COMPARISON WITH FEMALE *Nematoscelis* FROM NEW ZEALAND

CHARACTER	<i>N. difficilis</i>	<i>N. megalops</i>	<i>N. megalops</i> (?)
Ratio of lengths of segments 1 to 3 of antenna 1	1 : 0.6 : 0.65	1 : 0.5 : 0.45	1 : 0.47 : 0.45
Squame	Reaches to half length of segment 3 of antenna 1	Reaches to end of segment 3 of antenna 1	Reaches almost to end of segment 3 of antenna 1
Ratio of length of telson to abdominal somite 6	3.8 : 2 (Boden <i>et al.</i> 1955, fig. 40a)	3 : 2	3 : 2
Dorsal armature on abdomen	Denticles not present	Small, mediadorsal spine-like processes on 4th and 5th somites	Low, mediadorsal keels on 4th and 5th abdominal somites which terminate in a short spine-like process on the posterior margin of each of the somites

TABLE 3
COMPARISON OF LARVAL CHARACTERS OF *Euphausia frigida*, *E. vallentini*, *E. lucens* AND (?) *E. lucens* FROM SOUTH AFRICA

STAGE	CHARACTER	<i>E. frigida</i>	<i>E. vallentini</i>	<i>E. lucens</i>	(?) <i>E. lucens</i>	
<i>Calyptopis</i> I-III	Carapace	Smooth, rounded frontal margin; no posterior spine; lateral denticles in Stage III.	Same as <i>E. frigida</i>	Same as <i>E. frigida</i>	Strongly spinose, very broad, rounded and medially cleft. Large postero-dorsal spine. Lateral denticles present, all stages.	
	Length, mm.	I II 1.7-1.8 III 2.5-2.9	. . . . . 1.6-1.8 2.5-2.8	0.9-1.2 1.4-1.7 2.1-2.5	0.98-1.0 1.3-1.8 2.10-2.33
<i>Furcilia</i> I.	Frontal plate	Broadly rounded, non-spinose	Angularly rounded, non-spinose	Broadly rounded, non-spinose	Very broad, strongly spinose margin, medially cleft.	
	Pleopods	4 non-setose	4 non-setose	4 non-setose	1 non-setose	
	Telson spines	7	7	7	7	
	Length, mm.	3.8-4.3	3.2-4.0	2.7-3.2	3.0	
	II.	Pleopods	4 setose, 1 non-setose	4 setose, 1 non-setose	4 setose, 1 non-setose	1 setose, 4 non-setose
	Telson spines	7	7	7	7	
Length, mm.	4.7-5.7	4.5-5.1	3.4-4.1	3.5		
III.	Pleopods	5 setose	5 setose	5 setose	5 setose	
Telson spines	7	7	7	7		
Length, mm.	5.5-6.7	5.4-6.1	4.0-5.0		
IV.	Pleopods	5 setose	5 setose	5 setose	5 setose	
Telson spines	5	5	5	5		
Endopod of antenna 2	segmented	segmented	segmented	unsegmented		
Length, mm.	6.5-7.7	5.4-6.1	4.7-5.5		
V.	Telson spines	3	3	3	3	
Endopod of antenna 2	. . . . .	. . . . .	. . . . .	segmented	
Length, mm.	7.0-8.3	6.1-7.6	5.0-6.1		
VI.	Telson spines	1	1	1	1	
Length, mm.	6.8-9.6	6.2-9.3	5.0-6.0		

(see Table 3). It might be expected that *E. lucens* would also exhibit a developmental series similar to those of *E. frigida* and *E. vallentini*, and the New Zealand material proves this to be so.

Boden (1955) has described the calyptopis and the first two furcilia stages (with brief notes on later stages) of what was believed to be *E. lucens*, from a small amount of material collected in the area of the Benguela Current. The developmental series of his material is widely at variance with the species relationship discussed above, and it would appear that the species described may be other than *E. lucens*. The New Zealand material supports such an opinion. It supplies a continual series of stages from calyptopis to adult *E. lucens* which, even though similar to *E. frigida* and *E. vallentini*, is unlikely to be confused with developmental stages of these species inasmuch as *E. frigida* is only exceptionally found north of the antarctic convergence and no adults of *E. vallentini* were captured in the waters where *E. lucens* was abundant. Further, furciliae of *E. lucens* are considerably smaller, especially in later stages, than for the other species, see Table 3.

Relevant information for comparing *E. lucens*, *E. frigida*, *E. vallentini* and Boden's material is summarised in Table 3.

The stages of *Euphausia lucens* obtained, following John's (1936) system of nomenclature, are as follows:

Calyptopis: Stages I, II, and III.

Furcilia:

- Stage I. With four pairs of non-setose pleopods.
- Stage II. With four pairs of setose, one pair of non-setose pleopods.
- Stage III. With five pairs of setose pleopods; 5 terminal spines to telson; endopod of antenna 2 unsegmented.
- Stage IV. Telson with 5 terminal spines; endopod of antenna 2 segmented; squame differentiated.

Stage V. Telson with three terminal spines.

Stage VI. Telson with one terminal spine.

FIRST CALYPTOPIS: (Fig. 14*a-e*). Length, 0.9 to 1.2 mm. (average 1.0 mm., 9 specimens measured).

The carapace (Fig. 14*a*) is rounded at frontal and posterior margins, longer by one-third than the abdomen, and without lateral denticles. The peduncle of antenna 1 is not segmented. There are indications of segmentation on the abdomen. The telson is short (Fig. 14*b*) with 7 terminal spines and 4 pairs of lateral spines of which the anterior pair is ventrolateral. The mandible, and maxillae 1 and 2 are illustrated (Fig. 14*c, d, e*). The first thoracic limb is segmented, and the terminal portion is bifurcate.

SECOND CALYPTOPIS: (Fig. 14*f, g*). Length, 1.4 to 1.7 mm. (average 1.6 mm., 15 specimens measured).

The carapace possesses a small dorsal organ and no lateral denticles; it is broadly rounded anteriorly and posteriorly (Fig. 14*f*), slightly constricted behind the eyes, widest in the posterior half and is almost as long as the abdomen. Thoracic segments 2 to 8 are visible as narrow annulations between the first thoracic limb and the abdomen which has five segments. The telson (Fig. 14*g*) is as described for the first calyptopis, but is longer and more slender; there are no uropods. The peduncle of antenna 1 (Fig. 14*f*) has 2 or 3 segments; one of the flagellae is represented by the terminal portion of the ultimate segment of the peduncle, the other by a minute segment. The eyes are rudimentary and covered by the carapace. The maxillae and limb 1 are essentially as in Stage I.

THIRD CALYPTOPIS: (Fig. 14*b, i*). Length, 2.1 to 2.5 mm. (average 2.3 mm., 14 specimens measured).

The carapace possesses a dorsal organ and a small posterolateral denticle on each ventral margin; the anterior margin is squarer, the posterior margin more rounded than in the

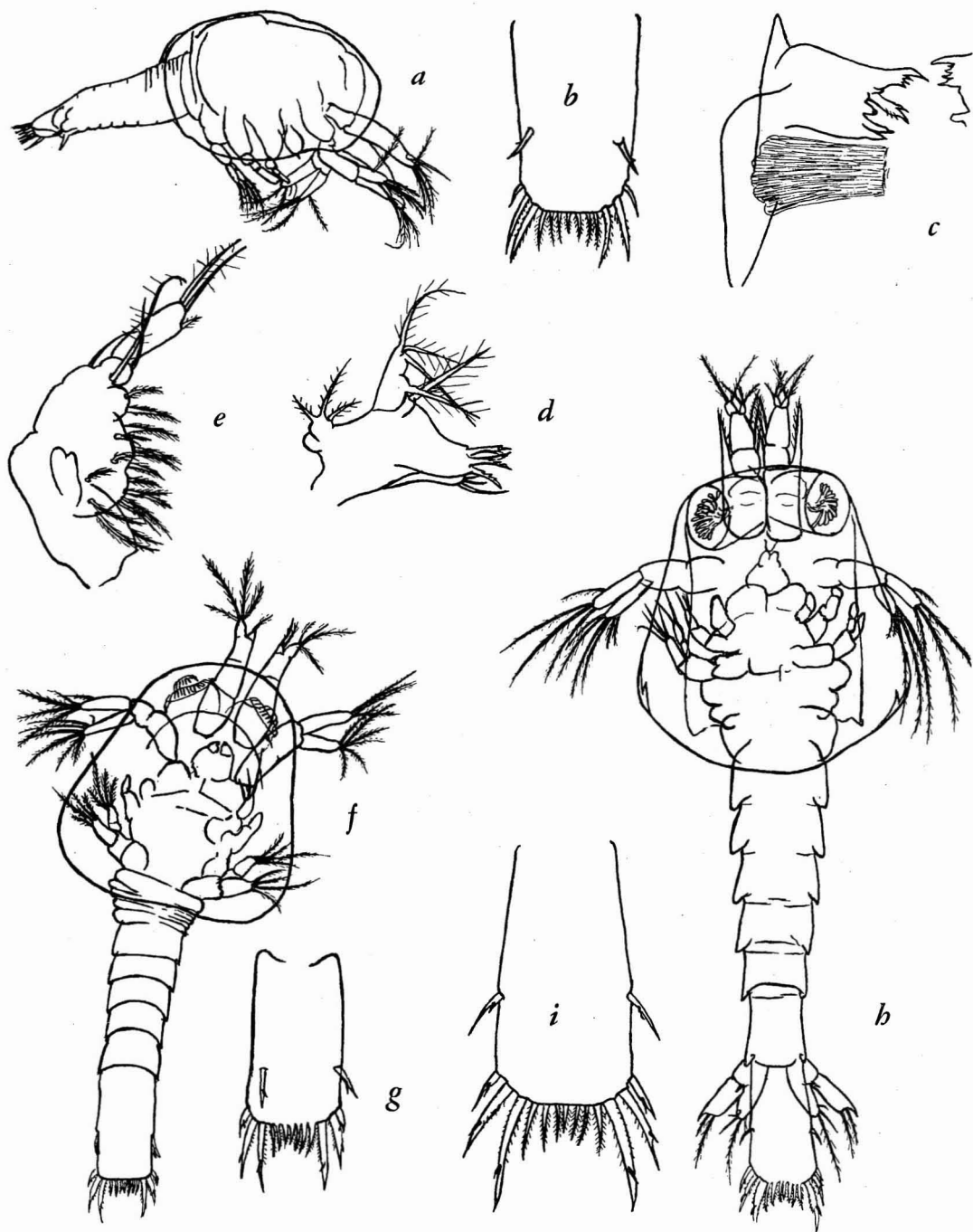


FIG. 14. Calyptopis stages of *Euphausia lucens* Hansen. *a-e*, Stage I: *a*, Lateral aspect of 1.0 mm. specimen; *b*, telson; *c*, mandible; *d, e*, first and second maxillae. *f, g*, Stage II: *f*, Dorsal aspect of 1.5 mm. specimen; *g*, telson. *h, i*, Stage III: *h*, Dorsal aspect of 2.4 mm. specimen; *i*, telson. *a, f, g*, $\times 50$.

previous stage, but the slight constriction is still present behind the eyes; it is much broadened posteriorly (Fig. 14*b*). On segment 1 of the peduncle of antenna 1 there is a well-developed lateral spine which reaches to the end of segment 3; both flagellae are segmented off from the peduncle. The eyes are well defined and becoming pigmented but are still covered by the carapace. The abdomen has 6 segments and a telson, and is 1.5 times the length of the carapace. There are 7 terminal spines on the telson (Fig. 14*i*) which is flanked by inner and outer uropods. There are rudiments of limbs enclosed in a common sheath posterior to limb 1.

Stages II and III are very similar to the corresponding stages for *E. frigida* and *E. vallentini* (see John, 1936, who does not describe Stage I). That they are not of these species must be assumed from the facts, firstly that no adults of either were taken as far north as southern New Zealand, where these calyptopids were captured, and secondly, that the furciliae with which they are continuous are smaller than those for either *E. frigida* or *E. vallentini*.

FURCILIA, STAGE I: (Fig. 15*a-d*). Length 2.7 to 3.2 mm. (average 3.0 mm., 17 specimens measured).

This stage has 4 pairs of non-setose pleopods and 7 terminal spines on the telson. The carapace (Fig. 15*a, b*) possesses a distinct dorsal organ, lateral denticles, and anteros ventral spines; the rostral plate is as wide as long, or wider, with the frontal margin slightly rounded. The spine on the outer distal corner of segment 1 of antenna 1 is usually as long as segments 2 and 3 combined, but may reach only halfway along segment 3. The first thoracic limb is bifurcate; the second (Fig. 15*c*) is rudimentary, with elements of exopodite and gill developing; other limbs are buds enclosed in a common sheath (Fig. 15*a*). Uropods reach to, or almost to the first pair of lateral spines (Fig. 15*d*) which are situated at between one-half and two-thirds the length of the telson.

FURCILIA, STAGE II: (Fig. 15*e-g*). Length, 3.4 to 4.1 mm. (average 3.8 mm., 28 specimens measured).

This stage is characterised by 4 pairs of setose and 1 pair of simple pleopods, and 7 terminal spines on the telson. The rostral plate is rounded, or angularly rounded (Fig. 15*e*), is broader at the base than long, and usually has a minute terminal spine. Thoracic limb 2 (Fig. 15*f*) comprises 3 or more segments, is setiform and possesses a rudimentary exopodite and gill; limb 3 is a kneed rudiment and has a rudimentary gill; limbs 4 to 6 exist as buds. The distolateral spine of segment 1 of antenna 1 extends to halfway or more along segment 3. The first abdominal segment has a pronounced tergal wing extending dorsally and laterally (Fig. 15*e*). The telson (Fig. 15*g*) is 4.5 times as long as wide and inner and outer uropods reach to, or a little beyond, the lateral spines.

FURCILIA, STAGE III: Length, 4.0 to 5.0 mm. (average 4.7 mm., 16 specimens measured).

There are 5 setose pleopods and 5 terminal spines (6 in two specimens) on the telson. The rostral plate is similar to that of the previous stage. The endopod of antenna 2 is unsegmented. The distal spine of segment 1 of antenna 1 extends for half, or less, of the length of segment 3; the flagellae are elongating. The endopod (inner ramus) of thoracic limb 1 is elongating; limb 2 is setiform and possesses 3 tarsal joints (sub-segments); limb 3 may have 3 joints or be indistinctly segmented in the tarsus; limb 4 is kneed, 2-segmented and with elements of gill and exopodite; limbs 5 and 6 are rudiments. The outer uropod is as long as the inner which reaches from one-third to halfway between the lateral and the first (outer) post-lateral spines; the inner has 3 or 4 setae on its outer margin. The inner pair of post-lateral spines are broadening basally.

FURCILIA, STAGE IV: (Fig. 15*b-j*). Length, 4.7 to 5.5 mm. (average, 5.2 mm., 6 specimens measured).

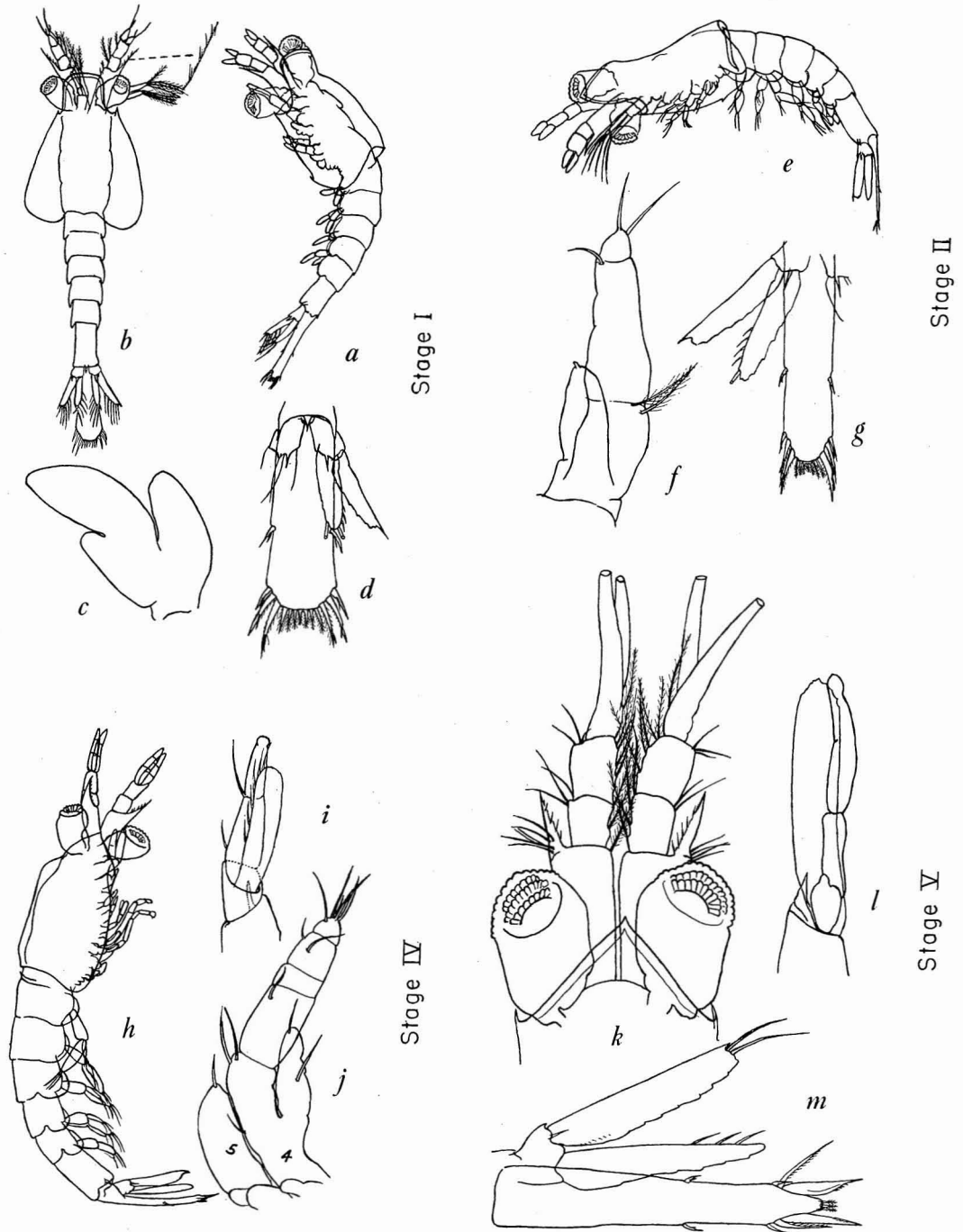


FIG. 15. Furcilia stages of *Euphausia lucens* Hansen. *a-d*, Stage I: *a*, Dorsolateral aspect of 3.2 mm. specimen; *b*, dorsal surface; *c*, second thoracic limb; *d*, telson and uropods. *e-g*, Stage II: *e*, Dorsolateral aspect of 4.0 mm. specimen; *f*, second thoracic limb; *g*, telson and uropods. *h-j*, Stage IV: *h*, Dorsolateral aspect of 4.6 mm. specimen; *i*, antenna 2 showing segmented flagella and the squame; *j*, thoracic limbs 4 and 5. *k-m*, Stage V: *k*, Antero-dorsal aspect of 5.5 mm. specimen; *l*, antenna 2, endopod and squame; *m*, telson and uropods.

There are 5 setose pleopods, 5 terminal spines on the telson, and the endopod of antenna 2 is segmented (Fig. 15*i*). The rostral plate (Fig. 15*b*) is more triangular, with less convex margins than in Stages II or III, and it has a small terminal spine. There is a pronounced dorsal organ on the carapace. The squame of antenna 2 is differentiated; it is setose on its inner margin and without a distolateral spine; the spine arising from the basal segment is present. The segmented endopod is beginning to elongate. The first abdominal somite possesses tergal wings. Thoracic limb 1 is bifurcate distally; the second and third limbs are fully segmented, and each has a setose exopodite and a gill. Limb 4 (Fig. 15*j*) is 3- or 4-segmented, with a rudimentary exopodite which has 2 setae, and a rudiment of a gill. Limb 5 (Fig. 15*j*) is short, kneed, with a terminal seta, and rudiments of gill and exopodite; limb 6 is rudimentary.

FURCILIA, STAGE V: (Fig. 15*k-m*). Length, 5.0 to 6.1 mm. (average, 5.4 mm., 15 specimens measured).

This stage has 3 (rarely 2) terminal spines on the telson. The rostral plate (Fig. 15*k*) is triangular, almost straight sided, with a minute terminal spine. The spine on segment 1 of antenna 1 is somewhat longer than the second segment of the peduncle (Fig. 15*k*). The endopodite of antenna 2 is segmented and the squame is as long as the endopod. Limbs 1 to 4 are better developed than in the previous stage; limb 5 is segmented, short and kneed; limb 6 is a kneed rudiment which may be segmented. The telson is 5 times as long as wide (Fig. 15*m*) and the inner post-lateral spines are becoming conspicuously broadened. The outer uropod is as long as the inner and they reach almost to the base of the outer pair of post-lateral spines.

FURCILIA, STAGE VI: Length, 5.0 to 6.0 mm. (average 5.6 mm., 15 specimens measured).

There is one terminal spine on the telson (rarely 2). The rostral plate is broadly triangular and acutely pointed. The spine on

segment 1 of antenna 1 is usually present and extends almost to the end of segment 2 of the peduncle. The endopod of antenna 2 has 3 segments, and there are indications of the segmentation of the flagella in the terminal segment. Thoracic limb 5 has a 3-jointed tarsus; limb 6 is kneed, with 2 segments and elements of exopodite and gill; limb 7 is a bud with a gill, and there is a single gill rudiment at the position of limb 8. The telson is slender and the outer post-lateral spines are much reduced, the middle pair are long and slender, the inner pair are broadened proximally, and curve outward in the distal half. The uropods are subequal in length and reach to the base of the post-lateral spines; the inner has 4 to 6 setae on its outer margin.

POST LARVAL STAGE: (Fig. 16). The specimen figured (Fig. 16*a*) is 7.5 mm. long and was readily identifiable as *E. lucens*. The terminal portion of the telson (Fig. 16*b*) is acutely pointed and has one pair of large latero-terminal spines which bear small secondary spines distally. Inner and outer uropods are equal in length, but are not as long as the telson. There is a pre-anal spine with 2 teeth. Antenna 1 (Fig. 16*c*) is developing a keel on segment 3 and a small, distinct, triangular lappet on segment 1. The squame of antenna 2 (Fig. 16*c*) is longer than the combined segments 1 and 2 of the peduncle of antenna 1, and has a long spine at the base. The rostrum is proportionately longer and more acutely pointed than that of the adult. The thoracic limbs are as in the adult, including the modified setae on the distal segment of limb 2 (Fig. 16*d*). The mandible has a well-developed cutting plate and palp, and maxillae 1 and 2 are similar to those in the adult.

Development of Nyctiphanes australis

Sheard (1953) reviews the state of knowledge on the development of *Nyctiphanes australis*, and presents a series of detailed diagrams illustrating variation in the order of development of pleopods, and in the loss of

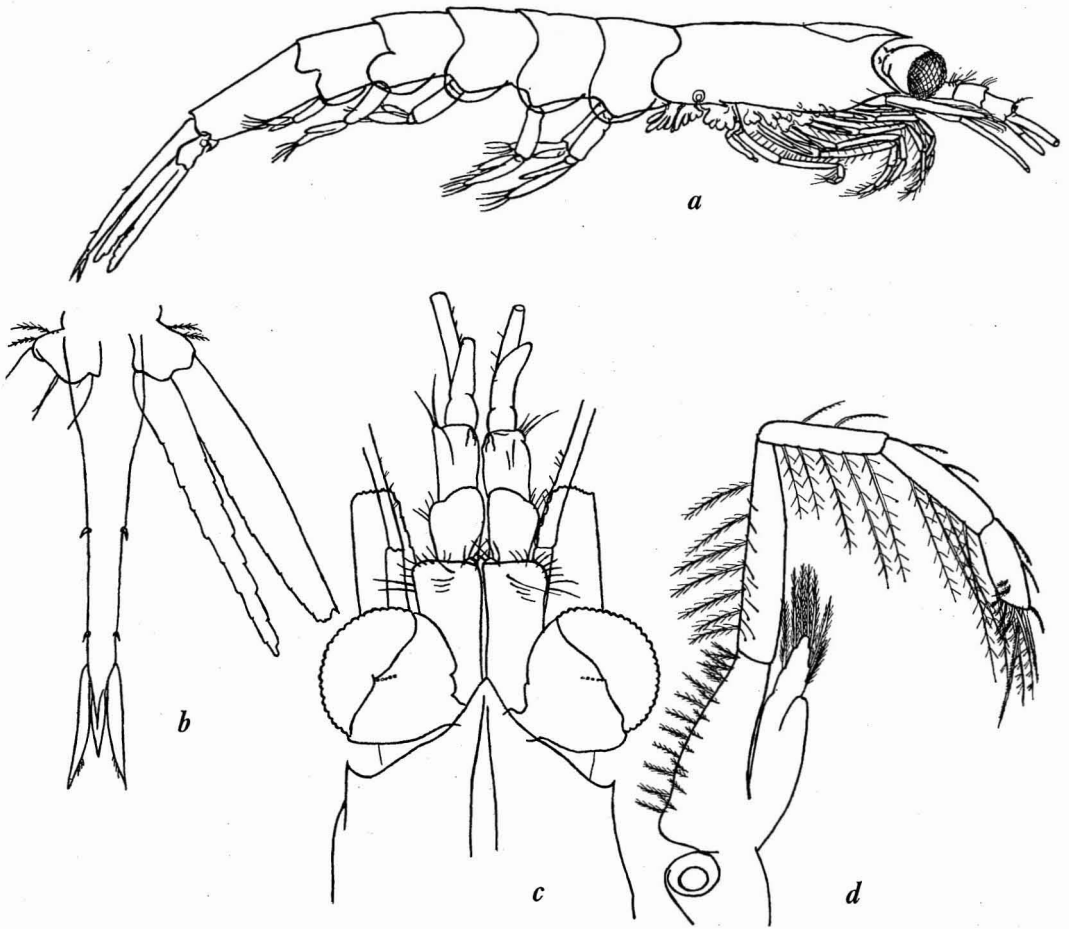


FIG. 16. Mid post-larval stage of *Euphausia lucens*. *a*, Lateral aspect of 7.5 mm. specimen; *b*, telson and uropods; *c*, anterodorsal aspect; *d*, second thoracic limb.

telsal spines. In this, as in previous accounts of development in this species, little attention has been paid to other morphological changes. Inasmuch as morphology is necessary for the certain identification of the larvae of *N. australis*, the present account deals with this, especially of the thoracic limbs and their differentiation during the furcilia stages. The account is not exhaustive, but is representative of a range of instars from each of the furcilia stages. The designation of the furcilia, and the instars composing them, are those proposed by Sheard; the present ma-

terial, although restricted in quantity, suggests that his furcilia stages meet the requirements of this species.

By means of his diagrams Sheard demonstrates that the number of instars preceding some later instar (for example, that with 5 setose pleopods and 7 terminal spines on the telson) may vary. This condition has not been otherwise commented on, although the present material suggests that it is important. It appears to lead to variations in the degree of differentiation of the thoracic limbs and antennae among specimens which have been

designated a single instar by other characters. This occurs in the later instars of Furcilia II, and in Furcilia III instars. Thus in the "Lachlan" material, the instar with 4 setose and one non-setose pleopods is composed of two groups of specimens, one of which is further advanced than the other in its limb development, probably because specimens have undergone an additional earlier ecdysis. It is possible that further groups could have been identified from more extensive material. Sheard recognises that the group of specimens with 5 setose pleopods and 7 terminal spines on the telson is comprised of individuals from two instars. One of these, in which the endopod of antenna 2 is not segmented and the inner post-lateral spine of the telson is not broadened, he identifies as belonging in Furcilia II (his 5S7Sp A); the other, wherein the endopod is segmented and the inner post-lateral spine is broadened, is assigned to Furcilia III (his 5S7Sp B). In "Lachlan" specimens a third group, belonging in Furcilia II (and which, in itself, may have been a miscellany of development stages), is present. These specimens were intermediate between Sheard's two groups in their limb and antennal development, but retained the pleopod and telson differentiation typical of this group of instars (5 setose pleopods, 7 terminal spines on the telson).

This type of complexity extends into the other instars of Furcilia III. It is convenient to identify those instars in which multiple stages of limb development are present as "instar-groups," while each of the stages composing such a group is an instar. This classification possibly has a factual basis, although insufficient material has defeated attempts to trace the development paths leading up to these complexities. However, Sheard's diagrams of development series for *N. australis* suggest possibilities which might produce such a result. More will be said of this type of parallelism in development in the discussion of Furcilia II and III in the following.

FURCILIA, STAGE I: (Fig. 17*a-d*). The number of pleopods and telson spines present and the size of all specimens in the "Lachlan" material are given in Table 4. In all instars of this stage the pleopods are non-setose.

The morphological changes between successive instars are progressive, but not extensive. The wide frontal plate of the carapace (Fig. 17*b*) covers approximately half the eye and stalk, is broader basally than long, and is squarely truncate anteriorly. The carapace is medially emarginate posteriorly and has a denticle on each lateral margin; stout antero-ventral spines are present. The telson (Fig. 17*c*) has 7 terminal spines, 1 pair of lateral and 3 pairs of post-lateral spines. The ratio of length of telson to its width ranges between 2:1 for specimens with one pair of pleopods to 7:3 for specimens with four pairs; the telson is twice the length of the sixth abdominal somite and the lateral spines are placed at between one-half and two-thirds its length.

The thoracic limbs develop progressively with each instar, and those already differentiated increase in complexity. Limb 1 is biramous throughout the instars, the inner ramus (endopod) being 2-segmented. Limb 2 develops from a stout, unsegmented, kneed rudiment to a kneed, 3-segmented structure with elements of a gill and exopodite. Limb 3 grows from a bud to an elongate rudiment with exopodite and gill as bud-like swellings; limb 4 is an elongated bud in the 4-pleopod instar. The distal spine of the basal segment of the peduncle of antenna 1 (Fig. 17*b*) reaches beyond the mid-length of segment 3; both flagellar rudiments are segmented off at instar 2, but only the inner in the first instar.

FURCILIA, STAGE II: (Fig. 17*e-l*).

Table 5 presents the data on pleopods and telson spines and size of the "Lachlan" material and demonstrates that specimens with 4 setose and 1 non-setose and those with 5 setose pleopods and with 7 terminal telson spines are 'instar-groups,' not single instars. Two instars, identified by differing states of

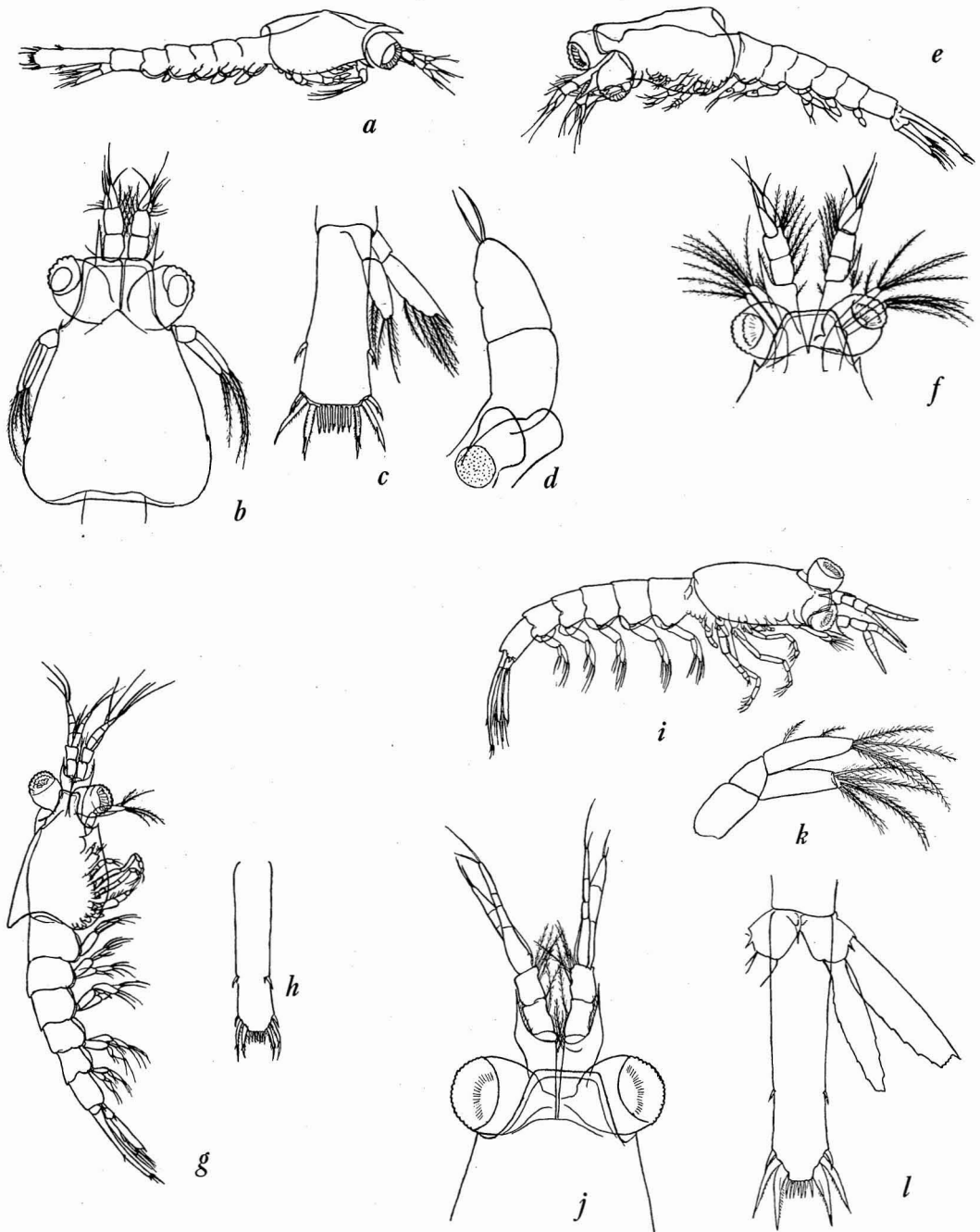


FIG. 17. Furcilia stages of *Nyctiphanes australis* G. O. Sars. *a-d*, Stage I with 4 non-setose pleopods: *a*, Lateral aspect of 2.9 mm. specimen; *b*, anterodorsal aspect; *c*, telson and uropods; *d*, rudimentary limb 2. *e, f*, Stage II with 3 setose and 2 non-setose pleopods: *e*, Dorsolateral aspect of 3.5 mm. specimen; *f*, anterodorsal aspect. *g, h*, Instar A, Stage II, from the instar-group with 5 setose pleopods and 7 terminal spines on the telson: *g*, Dorsolateral aspect of 4.2 mm. specimen; *h*, telson. *i-l*, Instar A', Stage II, from the instar-group with 5 setose pleopods and 7 terminal spines on the telson: *i*, Dorsolateral aspect of 4.3 mm. specimen; *j*, anterodorsal aspect; *k*, unsegmented antenna 2; *l*, telson and uropods, inner post lateral spines of telson broadening proximally.

TABLE 4
COUNTS AND MEASUREMENTS OF STAGE I FURCILIAS OF *Nyctiphanes australis*

NUMBER OF PLEOPODS	TELSAL SPINES	NUMBER OF SPECIMENS	RANGE OF LENGTH, MM.	AVERAGE LENGTH, MM.
1.....	7	1	2.5	....
2.....	7	2	2.5	....
3.....	7	13	2.5 to 2.8	2.7
4.....	7	33	2.7 to 3.0	2.8

TABLE 5
COUNTS AND MEASUREMENTS OF STAGE II FURCILIAS OF *Nyctiphanes australis*

NUMBER OF SETOSE(S) AND NON-SETOSE(N) PLEOPODS	TELSAL SPINES	NUMBER OF SPECIMENS	INSTAR GROUP	LENGTH RANGE, MM.	AVERAGE LENGTH, MM.
1S 3N.....	7	1	....	3.1	....
3S 2N.....	7	20	....	3.1 to 3.8	3.6
4S.....	7	1	....	3.6	....
4S 1N.....	7	} 23	1	3.4 to 3.8	3.6
			} 17	2	3.4 to 3.6	3.5
5S.....	7	} 24	A	3.6 to 4.2	3.9
			} 23	A'	4.0 to 4.7	4.3

limb development are in the first group. In the second, two of three instars are listed (Figs. 17*g, h*, instar A; 17*i-l*, instar A'); these belong in Furcilia II as in neither is the endopod of antenna 2 segmented (Fig. 17*k*), but the third instar has the segmented endopod and is listed in Furcilia III.

Throughout all instars, the frontal plate remains broad-based, more or less squarely truncate and covers a considerable portion of eye and stalk (Fig. 17*j*). The laterodistal spine on segment 1 of antenna 1 persists, reaching from two-thirds to almost the outer end of segment 3 of the peduncle; the flagellae are initially about twice the length of those in the last instar of Furcilia I, but are elongate and slender by the final instar of Furcilia II (Fig. 17*j*). A pair of dorsolateral tergal wings appear on the first abdominal segment in the first instar (Fig. 17*e*) and persist throughout the instars of this and Furcilia III. The telson (Fig. 17*b, l*) remains twice as long as the sixth abdominal segment; the ratio of length, to the width at the distal extremity, changes from 3:1 to 4:1 and that of length of telson

to the length from its base to the lateral spines changes from 5:3 to 4:3, by the end of the series. The inner uropods reach about two-thirds the way to the lateral spines in the first, and all of the way in the final, instar.

Of the thoracic limbs (Fig. 17) the endopod of limb 1 commences to elongate relative to the exopod at the instar with 4 setose pleopods. At that with 1 setose and 3 non-setose pleopods limb 2 is 3-segmented, with 2 terminal setae and clearly defined buds of gill and exopodite; by the 4 setose pleopod stage the tarsal segment is 3-jointed (i.e., with 3 subsegments) and the limb is moderately setose, has a 2-branched gill and a stout exopodite. Limb 3 progresses from an elongate rudiment to a 3-segmented, stout appendage, with 2 terminal setae, a single gill and a small, stump-like exopodite. Limb 4 becomes an elongate kneed rudiment.

The instars comprising the instar-groups with 7 telsal spines and either 4 setose and 1 non-setose or 5 setose pleopods (Fig. 17) are differentiated by the degree of development reached by the thoracic limbs; relevant data

TABLE 6
COMPARISON OF LIMB DEVELOPMENT AMONG INSTARS OF THE INSTAR-GROUPS POSSESSING 7 TERMINAL SPINES ON THE TELSON AND EITHER 4 SETOSE
AND 1 NON-SETOSE OR 5 SETOSE PAIRS OF PLEPODS IN *Nyctiphanes australis*

LIMB NUMBER	CHARACTER	FURCILIA II				FURCILIA III
		With 4 Setose and 1 Non-setose Pleopods		With 5 Setose Pleopods		With 5 Setose Pleopods
		Instar 1	Instar 2	Instar A	Instar A'	Instar B
2	Segments, general	Complete, 3 tarsal joints	Complete	Complete		
	Setae	Sparse, overall	Moderate	Moderate	Fully developed	Fully developed limb
	Exopod	Well developed bud, no setae	2 terminal setae	2 terminal setae	.....	Setose
	Gill	2-branched	2-branched	2-branched	.....	.....
3	Segments, general	3-segmented; tarsal joints indistinct	Tarsus 3-jointed	Tarsus 3-jointed	Fully developed	Fully developed, and almost as long as limb 2
	Setae	2, terminal	Moderate, overall	Moderate-strong, overall	Strongly setose	.....
	Exopod	Well developed bud	Non-setose	Non-setose	Terminal setae	.....
	Gill	2-branched	2-branched	2-branched	.....	.....
4	Segments, general	Kneed, indistinct 2 segments	Stout, 3-segmented	3-segmented	Tarsus 3-jointed	Fully segmented, well developed; about half as long as 2
	Setae	.....	Terminal	Terminal	Moderate, overall	Moderate-strong
	Exopod	Rudiment	Large bud	Large (elongate) bud	Non-setose	With single terminal seta
	Gill	Well developed bud	2-branched	2-branched	2-branched	.....
5	Segments, general	Elongate bud	Elongating, kneed rudiment	Elongate, kneed rudiment	2-3 segmented	3-segmented
	Setae	.....	.....	.....	2, terminal	Sparse on terminal segment
	Exopod	.....	Large bud	Large bud	Elongate bud	Elongate, rudimentary
	Gill	Bud	2-branched	2-branched	2-branched	2-branched
6	Segments, general	Bud	Elongating rudiment	Elongate rudiment	Unsegmented, kneed rudiment	Elongate, kneed rudiment
	Setae	.....	.....	.....	.....	Non-setose
	Exopod	.....	.....	.....	.....	.....
	Gill	.....	Bud	Elongate bud	Single	2-branched
7	General	Bud	Bud	Bud	Bud, increasing in length	Elongate bud; 2-branched gill

are summarised in Table 6 (see also Table 9). It is seen that the degree of differentiation in instar 2 and instar A (Fig. 17g, b) is similar. This is possibly due to the same number of ecdyses having been passed in the development paths of these two (different) instars. Contrarily, several degrees of development in each of the two instar-groups suggest that additional ecdyses are necessary during the course of development of some specimens, to attain this end.

FURCILIA, STAGE III: (Fig. 18).

Table 7 presents data on the "Lachlan" specimens of this stage.

The tergal wings (Fig. 18a, g) on the first abdominal segment persist throughout the series of instars. The frontal plate of the carapace gradually narrows at the base, but is still comparatively broad; the front margin becomes broadly rounded in the later instars. The uropods elongate and become slender and reach a little beyond the lateral spines. The telson length to width (at the tip) attains the ratio of 6:1; by the last instar the outer post-lateral spines are much reduced, the middle pair are slender and beginning to reduce and the inner are long and broad; the telson is round ended with a short, acute spine.

The squame (Fig. 18f, b) is strongly setose on its inner margin and develops a disto-

lateral spine. The flagellae of antennae 1 and 2 increase in length until they are about three times the length of the peduncles. The distolateral spine of segment 1 of antenna 1 persists. At the stage of instar E, a wing-like expansion begins to develop dorsolaterally on the distal end of segment 1, antenna 1; this has increased in size by instar F, and from instar K onwards is a conspicuous, triangular lappet.

As in Furcilia II the individual instars of the instar-groups are identifiable by the state of differentiation of the limbs; and again there is duplication in the degree of limb development between one or more instars of one group and some of the following (except that no overlap was apparent between the groups with 5 and 3 telson spines).

The stage of development of limbs 5, 6 (Fig. 18d, e), and 7 are of chief concern for identifying the instars of each group, and data are tabulated in Table 8 for those instar-groups with 5, 3 and 1 telson spines.

The interrelationships between instars of one group and those of another are illustrated in Table 9. In this, those instars of one group which show identical limb development with those in another are linked by dashed lines; as well, an instar arising directly from a previous one is connected to it by a solid line. It is apparent that relationships are complex,

TABLE 7
COUNTS AND MEASUREMENTS OF STAGE III FURCILIAS OF *Nyctiphanes australis*

NUMBER OF SETOSE PLEOPODS	NUMBER OF TELSAL SPINES	NUMBER OF SPECIMENS	INSTAR	LENGTH RANGE, MM.	AVERAGE LENGTH, MM.
5.....	7	17	B	4.3 to 4.8	4.5
5.....	6	2	....	.....	....
5.....	5	13	C	4.4 to 5.0	4.6
			D	4.4 to 4.6	4.6
			E	4.3 to 5.2	4.9
5.....	4	2	....	.....	....
5.....	3	13	F	4.9	4.9
			G	5.0 to 5.7	5.2
5.....	2	6	....	.....	....
5.....	1	13	H	4.4 to 5.0	4.8
			J	5.3 to 5.7	5.4
			K	5.4 to 6.5	5.9

TABLE 8
LIMB DIFFERENTIATION OF INDIVIDUAL INSTARS OF FURCILIA III, *Nyctiphanes australis*

INSTAR	NUMBER OF TELSAL SPINES	THORACIC LIMB			OTHER CHARACTERS
		5	6	7	
B.	7	See instar B, Table 6			
C.	5	Limb development as for instar B, Table 6			
D.	5	Stout, sparsely setose; tarsus 3-jointed; exp. non-setose; 3-branched gill	Kneed, 2-3 segments, non-setose. No exp.; 2-branched gill	Bud; 2-branched gill	
E.	5	Fully developed; $\frac{2}{3}$ length of limb 4; exp. non-setose	Tarsus 3-jointed; limb sparsely setose; small bud-like exp. occasionally; 2-branched gill	Elongate, kneed rudiment; 2-branched gill	Wing-like extension dorso-laterally on distal end seg. 1 of antenna 1
*F.	3	Exopodite with terminal seta	Limb 3-segmented, sparsely setose; 2-branched gill	Elongate bud; 2-branched gill	Extension on seg. 1, ant. 1, more advanced than E; stout, forwardly curving protrusion
†G.	3	Exopodite with terminal setae	Tarsus 3-jointed; limb moderately setose; 3-branched gill	2-segmented, single terminal seta; 2-3-branched gill	Extension on seg. 1, ant. 1, becomes a triangular, forwardly curving flap-like protrusion
*H.	1	Twice length of limb 6; exopodite with terminal seta	3-segmented, sparsely setose, 2-branched gill	Elongate bud; gill 2-branched	Ant. 1, segment 1 as for instar F
†J.	1		Tarsus 3-jointed; limb moderately setose; 3-branched gill; (exp. in young males)	2-segmented with or without setae; 2-3-branched gill	Ant. 1 segment 1 as for instar G
K.	1		Fully developed, strongly setose; no exp., or exp. with terminal setae (males)	Moderately setose, half length of limb 6; no exopodite	Extension on seg. 1, ant. 1, now a conspicuous lappet

*Denotes identity in limb development between instars F and H.

†Denotes identity in limb development between instars G and J.

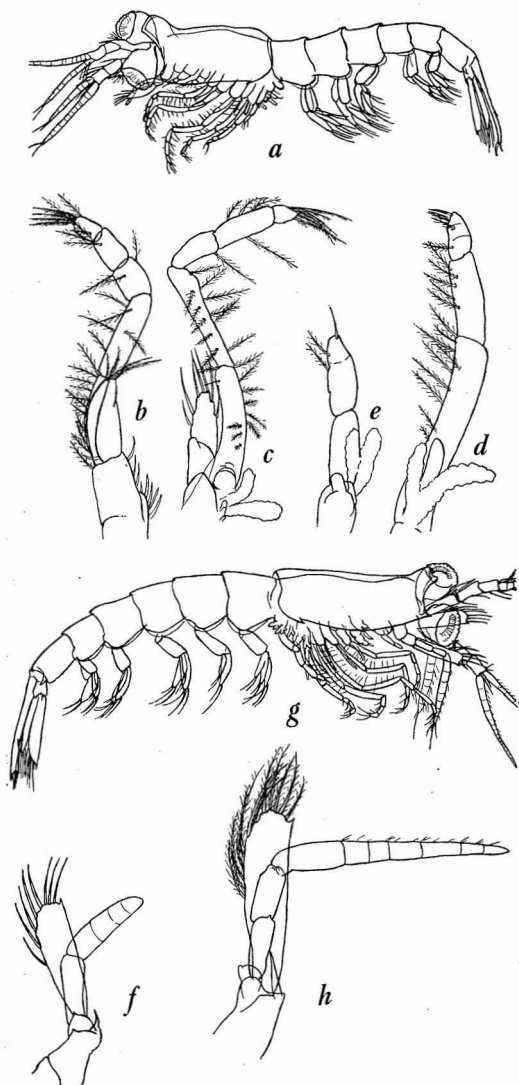


FIG. 18. Two instars of Furcilia Stage III of *Nyctiphanes australis* G. O. Sars. *a-f*, Instar D, from the instar-group with 5 telson spines: *a*, Dorsolateral aspect of 4.5 mm. specimen; *b, c, d, e*, thoracic limbs 1, 2, 5, 6; *f*, antenna 2. *g, h*, Instar F, from the instar-group with 3 telson spines: *g*, lateral aspect of 4.9 mm. specimen; *h*, antenna 2.

but that the table illustrates only a portion of the picture. For example there is no indication of the origin of either instars B or E, or of the fates of instars A or C. Much more material than was available to me is necessary

to complete the developmental paths indicated by the table. Sheard's (1953) diagrams again demonstrate possible paths.

It seems probable that the instar-groups, with their instars having differing degrees of limb development, must arise from specimens undergoing additional ecdyses in Furcilia I or early in Furcilia II. It is perhaps noteworthy that the first indication of an instar-group is among specimens with 4 setose and 1 non-setose pleopods at a later stage of Furcilia II. It is probable that developmental paths following different courses (i.e., paths involving different combinations of setose and non-setose pleopods) first come together in this late stage of Furcilia II. Thenceforth specimens of the several instars would develop along parallel lines until maturity is reached.

Development of Thysanoessa gregaria

Gurney (1947) described the development of *Th. gregaria* from the first furcilia to the fifth cyrtopia from material collected around Bermuda. The first three of Gurney's five furciliae were obtained in the New Zealand material. A detailed comparison of these with the descriptions of those from Bermuda reveals only slight differences in the proportion of length to breadth of the telson and in the lengths of the second to fourth lateral spines (the post-laterals) on the telson. In Furcilia I, Gurney states the telson is three times as long as wide, and "spine 4 not generally longer than spine 3, and rarely as long as the telson is wide"; in the New Zealand specimens the telson may be 3.5 times as long as wide and the spines are longer than the width of the telson. In other characters such as the form and extent of the rostral plate, number and position of spines on the telson, degree of limb development, proportional lengths of segments of antenna 1, and in the pleopod development, there are no discernible differences.

According to Gurney, *Thysanoessa gregaria* differs from the other species of the genus in

TABLE 9
 RELATIONSHIPS OF INSTARS IN THE 'INSTAR-GROUPS' OF FURCILIA STAGES II AND III, *Nyctiphanes australis*
 (Explanation in Text)

FURCILIA CHARACTERS	FURCILIA STAGES AND CHARACTERS					
	II 4S 1N	II and III 5S 7Sp	III 5Sp	III 3Sp	III 1Sp	Post Larval*
Instars	1 → A		C	F	H →	+2 extra moults
	2 → A'		D	G	J →	+1 extra moult
	?	B	E	?	K →	

*Post larval stage: the number of extra moults that are considered necessary for specimens to undergo in order to reach a stage of development comparable with those of instar K (the most advanced) are indicated.
 Abbreviations of characters: S—setose pleopods; N—non-setose pleopods; Sp—terminal telson spines.

having the rostral plate pointed from Furcilia Stage I and in the reduction in number of telson spines during Stage IV. Appropriate furcilia stages were not available from the local collections to check the latter character, but the form of the rostral plate was similar in the earlier stages.

There was no morphological variation among the specimens examined.

Einarsson (1945) has summarised previous expressions of opinion on and added considerably more evidence towards the view that neritic euphausiid species show much greater variation in the morphological features of the larval instars than do oceanic species. The large range of instars so far demonstrated for the typically neritic species of *Nyctiphanes* (Sheard, 1953; Boden, 1951, 1955; and others) concurs in this, as do the small numbers of well-defined (dominant) instars for the southern and oceanic *Euphausia* species (John, 1936; Fraser, 1936). However, Sheard maintains that dominant instars do not necessarily obtain in either neritic species, e.g., *N. australis*, where there may be numerous instars, or in

oceanic species, e.g., *Euphausia simplex*, where there are fewer instars. He regards the so-called dominant instars of *N. australis* as being significant only in local stocks, with the distinguishing characteristics of such dominants varying from place to place as environmental conditions change. By studying collections covering the ecological range of the species these locally occurring 'dominants' become submerged in a life-history series which in overall view is characterised by a diffuse variety of instars. Boden (1955) questions this viewpoint of indeterminate dominants.

The "Lachlan" collections of *N. australis* are small. Nevertheless, a variety of the instars which may occur were available. In that the material is from a restricted environmental range and, therefore, is essentially a local stock, the apparent dominant instars in Furcilia I, II, and III could conform to Sheard's view of the local origin of such dominants. The New Zealand material exhibits the additional complexity of the 'instar-group' wherein characters, which have been regarded as signifying a particular instar, are found to

include what appears to be a number of instars; these are separable on the several degrees of differentiation reached by the thoracic appendages. The orderliness, and interrelationships between the instars of these instar-groups (Table 9), seem to preclude the possibility that the instars are composed of specimens in which morphological variations have arisen due to changes in such environmental factors as temperature.

The larval development of two oceanic species, *Euphausia lucens* and *Thysanoessa gregaria*, presents an opposing view to that expressed by Sheard (1953) from his studies of *N. australis* and *E. simplex*. In *E. lucens* morphological variants were recorded only as rare exceptions in an orderly series of closely diagnosed instars; nor were there any indications of the instar-groups of *N. australis*. There were no variants in the material for *T. gregaria*. Dominant stages were undoubtedly present in both (see Table 10 for *E. lucens*). This may have been due to inadequate sampling (Sheard, 1953); nevertheless, there is general conformity in the larval histories of a number of oceanic species, in that there are small numbers of well defined instars. This suggests that those instars deviating from the usual expression of an oceanic species' life history may be regarded as exceptional to the dominant instars.

DIURNAL VARIATION IN NUMBERS OF
EUPHAUSIIDS AT THE SURFACE

Little information on the diurnal movements of southern euphausiids is available.

Tattersall (1924) reported of "Terra Nova" samples that numbers taken at night were much greater; he also (1936a) described the vertical distribution during daylight of one species at two stations near the Great Barrier Reef. Hardy and Gunther (1935) discuss and illustrate vertical movements for various developmental stages of *Euphausia superba* and for *E. frigida*, *E. triacantha*, *E. vallentini*, and species of *Thysanoessa* from South Georgia. For the Northern Hemisphere, Esterly (1914b) discusses vertical distribution and movements of euphausiids in the Californian area; Leavitt (1935, 1938) extensively discusses vertical distribution of species, and Moore (1949, 1950) illustrates vertical distribution and migration for the Bermuda area.

Vertical distribution cannot be demonstrated for the present collections since no vertical hauls were taken. The fact of diurnal migration is apparent, however, through the diurnal variation of numbers taken in surface tows, both in the station series 74 to 85 in western Foveaux Strait, and the curves constructed for all other surface tows. In Figure 7 the catch per tow for *Euphausia lucens*, *Nyctiphanes australis*, and *Thysanoessa gregaria* is expressed as a percentage of the whole catch of each species for stations 74 to 85 (see also for mysids, the curves for two species of which are included). Both *E. lucens* and *T. gregaria* arrive at the surface in large numbers at 2300 hours, an hour before *N. australis*, and more or less maintain these numbers until 2400 hours when they, together with *N. australis* disperse, leaving many fewer specimens

TABLE 10
DOMINANCE IN FURCILLA STAGES OF *Euphausia lucens*

PLEOPOD DEVELOPMENT	TELSAL SPINES	ANTENNA 2, ENDOPODITE	NUMBER OF SPECIMENS	AVERAGE LENGTH, MM.	FURCILLA STAGE
4 non-setose	7	Unsegmented	43	3.0	I
4 setose, 1 non-setose	7	Unsegmented	70	3.8	II
5 setose	5	Unsegmented	44	4.7	III
5 setose	6	Unsegmented	2	....	III
5 setose	5	Segmented	16	5.2	IV
5 setose	3	Segmented	17	5.4	V
5 setose	1	Segmented	16	5.6	VI
5 setose	2	Segmented	2	....	VI

to be taken in the tow at 0100 hours. At 0200 hours, and accompanying a similar rise for mysids, there is a sharp increase in numbers of *N. australis* and *T. gregaria*, but for *E. lucens* there is only a check to the rate of decrease of numbers being taken. As was discussed for the mysids, the factors contributing towards this second rise (at 0200 hours) are not understood. Nevertheless, there are similarities between this curve and that obtained for all other stations (Fig. 19). The main rise commences at 2100 hours and reaches a peak at 2300 hours in both; an absence of specimens at 2400 hours (in Fig. 19) probably corresponds with the 0100 hours decrease in collections from stations 74 to 85. This is succeeded by a rapid increase over the next hour to 0100 hours, an hour earlier than for stations 74 to 85, when again there is a fairly rapid decrease, then a check at 0300 hours (corresponding to the pre-dawn rise?) and the final dispersion due to the dawn descent. A catch of 732 specimens at station 308 at 0500 hours (indicated in Fig. 19 by the dashed line) falls outside the normal pattern and may be the result of sampling a swarm which has persisted through to daylight.

SUMMARY

Collections were made from the survey frigate, H.M.N.Z.S. "Lachlan," between Wellington and the southern extremity of South Island during January, February, and March, 1951, and between southern New Zealand and Auckland and Campbell islands in November, 1951. In all, 86 stations representative of this coverage have been examined and the mysid and euphausiid fauna reported on.

Two species of mysid, *Tenagomysis macropsis* and *T. tenuipes* were collected about Foveaux Strait; this extends the range of *T. tenuipes* 200 miles northward from Auckland Islands. The collections of *T. macropsis* slightly extend the area from which it has been taken previously. *T. tenuipes* was originally described from a single male from the Auckland Islands; the present material has afforded the opportunity

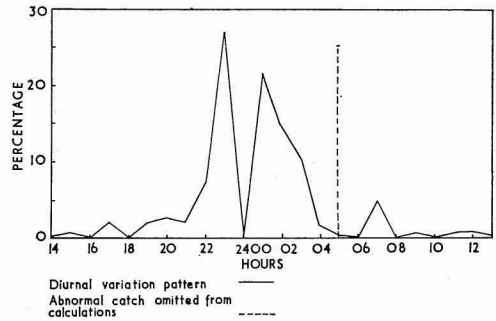


FIG. 19. Diurnal variation in surface waters for all species of euphausiid for the period January through March, 1951. The catch for each hour is expressed as a percentage of the total of all specimens captured.

of reporting on and adding to the systematic morphology of males and females. For both species the larval development, which is continuous, has been described.

Five species of euphausiid were taken; four, namely *Euphausia lucens*, *E. valleritini*, *Thysanoessa gregaria*, and *Nyctiphanes australis* had been recorded previously, but one, *Nematoscelis megalops* (?) is a new record for the southern Pacific.

The larval development stages of *Euphausia lucens* have been described. From a comparison of these with early stages described as *E. lucens* from South Africa, the writer concludes that the latter account is of another species. Instars of the three furcilia stages of *Nyctiphanes australis* are described. It has been found that some of the 'instars,' previously designated by certain morphological characters, in reality appear to be groups of instars in which the individual instars are identifiable by the degree of differentiation reached in the thoracic appendages. The first three stages obtained for *Thysanoessa gregaria* show that its development in New Zealand waters closely parallels that of Bermudan material.

Data are presented on the distribution of both the mysids and euphausiids about New Zealand.

The diurnal variation of numbers at the surface indicates that a vertical migration oc-

curs for mysids and euphausiids which follows the pattern for other zooplanktonic organisms. Differential migration between adults and larval *Tenagomysis macropsis* has been recorded.

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