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THE FALKLAND SPECIES OF THE CRUSTACEAN GENUS *MUNIDA*

By

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INTRODUCTION

In the course of a trawling survey of the continental shelf surrounding the Falkland Islands and fringeing the Argentine Patagonian coast, carried out by the R.R.S. 'William Scoresby' during the months October 1931 to April 1932, large numbers of the Anomurans, *Munida subrugosa* (White) and *Munida gregaria* (Fabricius) were taken. This survey was complementary to the trawling surveys previously carried out by the same vessel at different seasons during the years 1927 and 1928. At the same time it was more extensive, embracing as it did a much larger area and many more observations. The two species of *Munida* were met with far more frequently than on previous occasions and at times in very much larger numbers. The great importance of these two species in the bionomics of the area surveyed was still more fully realized, and although Matthews was then publishing his report, "Lobster Krill, Anomuran Crustacea that are the food of Whales" (Matthews, 1932), which dealt with the material from the two earlier surveys together with certain taxonomical and historical aspects, it was thought that the large amount of material being obtained would provide opportunity for further investigations on their respective life histories.

Both species are of considerable economic significance on the grounds surveyed, and they occur in certain areas in very great abundance. Matthews has shown that the free-swimming post-larval form of *M. gregaria*, the so-called *Grimothea*, is of prime importance as a food supply for the whalebone whales which are to be found in this area, whilst Hamilton (1934) stresses the part played by *Munida* in the diet of the southern sea lion, *Otaria byronia*. Hake, *Merluccius gayi*, taken in the trawl, were frequently found to be subsisting entirely on these creatures, and many birds eagerly feed upon them. These two species of *Munida* fulfil in the economy of the Falkland Islands region a role similar to, but wider than, that of krill, *Euphausia superba*, in South Georgian waters.

Munida were found to be excellent eating in the ships of the expedition, and they are utilized as food in the small ports on the coasts of Chilean and Argentine Patagonia under the wide term "Camerones." It is possible that in the future they may acquire commercial importance, for more use could be made of them for human consumption.

The existence of a pelagic post-larval form in *M. gregaria* is of considerable biological interest, for, so far as we are aware, it occurs only in this one species of the genus *Munida*.

With the pelagic habit are correlated certain structural modifications of the third maxillipede, and these, as Matthews (1932) has shown, may in certain circumstances be retained until, or almost until, the attainment of sexual maturity.

Press of work in the field allowed but a cursory examination of fresh material to be made, and although many samples were preserved some hauls were discarded after only identifying, counting, sexing and examining for parasites. In the very large hauls of *M. subrugosa* which were occasionally taken only fractional samples could be handled, the rest being indiscriminately tossed overboard. The material, large as it is, was obtained incidentally in a scheme much larger in scope than the subject of this report, and it thus lacks much of the value of a collection planned with the object of obtaining information regarding the life histories of the two species. Only a few questions are solved in the following report, and the suggestions put forward must wait upon subsequent more searching investigations carried out with closer attention to the living animal.

Mention must be made here of a small but useful collection of post-larval *M. gregaria* from Otago Harbour, New Zealand, forwarded by the late Mr G. M. Thompson to Mr L. H. Matthews, through whose courtesy it came into the writer's hands.

LARVAL DEVELOPMENT

Larval forms of the genus *Munida* have been described by Sars (1890), Stephensen (1913), Williamson (1915), Stebbing (1919), Webb (1921), Gurney (1924), and Lebour (1930). Sars, Webb and Lebour describe the larva of *M. banffica*, Stephensen the larva of *M. tenuimana*, whilst Williamson deals with both these northern forms: Stebbing and Gurney are concerned with southern hemisphere forms. Stebbing describes and figures what purports to be a larval stage of *M. gregaria* collected by Vallentin at the Falkland Islands, but unfortunately the description is scanty and the figures almost useless. Gurney deals with a form taken by the 'Terra Nova' in New Zealand waters. Young (1925) mentions the hatching of larvae from the eggs of *M. gregaria* by Anderton, but only gives the hatching dates and no description.

The larval forms of *Munida* now to be discussed were collected in tow-nets and other nets during the trawling survey of 1931–2. In a series of forty-three oblique hauls with a 1 m. tow-net, taken between September 1931 and April 1932, at depths of from 139 to 29 m. to the surface, fourteen contained larval forms and three early post-larval forms. The larval forms were taken in the months September to November and in February, but the early post-larvae were limited to January. Hauls in which larvae were not present were made in every month from September to April, except December.

Graphs showing the percentage of berried females to the total number of females in the monthly catches of *M. gregaria* and *M. subrugosa* have been prepared in the hope that the spawning periods would be indicated. The graph for *M. gregaria* (Fig. 1) shows a rapid descent from a high figure in October to zero in November, and this may be taken as indicating the shedding of larvae into the plankton. This spawning time corresponds with September and October given by Young (1925) as the spawning date of New Zealand *M. gregaria* kept under observation in captivity. The catches of *M. gregaria* were, however, scanty in November and December, and the conclusion that this definite spawning season occurs would be unwarrantable were it not supported by the frequency of *Munida* larvae in the plankton during September and October and by Young's observation.

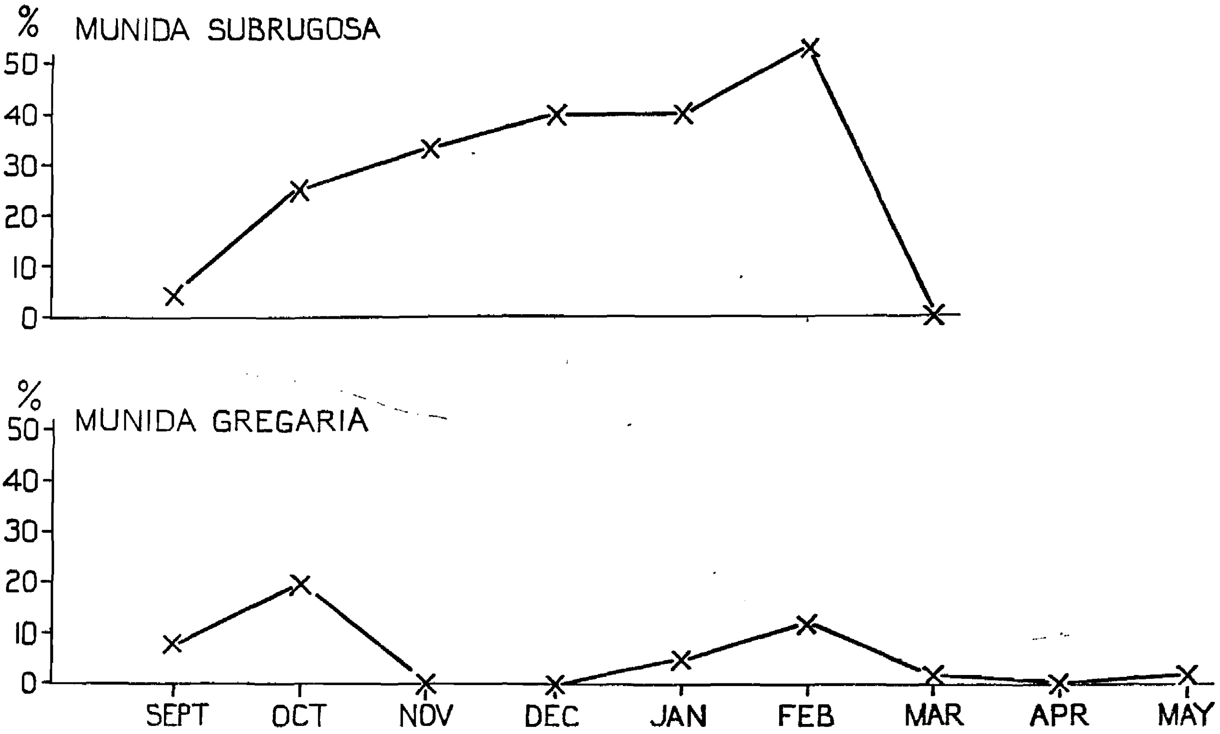

Fig. 1. Percentage of berried females to total catch of females in *Munida subrugosa* and *M. gregaria*.

Berried females again appear in the January and February catches in increasing numbers, but a fall occurs in March and April. It seems probable that females are again beginning to bear eggs after spawning in September and October, but that the hauls made in March and April, in which the catches of *M. gregaria* were only small, have failed to sample this part of the population.

Should spawning take place in September and October—which seems certain—and should eggs be extruded on to the pleopods in January and February—which seems probable—a period of eight months must be assigned to egg-carrying on the part of the female, a length of time which may be compared with ten months in the case of the American lobster, *Homarus americanus* (M.-Edw.), Herrick (1895).

In these circumstances, unless several months or a whole year are passed without breeding, the adult female can seldom, if ever, undergo more than one moult per year, the moult taking place between the time of hatching of the eggs and the resumption of egg bearing, i.e. October to January. The probability that long resting periods elapse between successive reproductive phases in the individual is upheld by the low percentage of berried females to the total population at any time. Such resting periods would enable growth and moulting to be free of the restricting egg-carrying condition for long intervals.

The spawning time of the second species, *M. subrugosa*, is less easy to determine. The graph (Fig. 1) showing the percentage of berried females in this species indicates a possible shedding of larvae in February; for after climbing to a pronounced peak in that month it shows a sudden drop to zero in March which persists in April and May. The paucity of *Munida* larvae in the plankton during February (three present in two hauls out of six) and their total absence in March and April makes spawning at this time of the year unlikely. No date, therefore, can be given for the spawning of *M. subrugosa*, but the likeliest time for this event would seem to be in early summer, in September and October, as in *M. gregaria*, a time when large numbers of *Munida* larvae are present in the plankton. Eggs obtained from ovigerous females taken on September 20 and October 13 contained well-developed embryos, but those of females captured on September 5 showed no indication of an embryo. It may be then that the spawning time of *M. subrugosa* is more variable than that of *M. gregaria*, and that larvae are shed into the plankton all through the summer.

In the series of larval *Munida* which has been examined it has not been possible to recognize two forms to correspond with the two species that are to be found in the adult condition in the area, and it is possible that the differences between the larvae of these two species are so small as to be imperceptible. Certainly the differences between the very earliest post-larvae, before the modification of the external maxillipede in *M. gregaria*, are such as to make distinction at this stage difficult or even impossible, and considering the close resemblance and relationship of the two species, a very marked similarity or even morphological identity of the two larval forms would not be surprising.

The Falkland Islands *Munida* larvae resemble the other described forms to a marked degree, but they can be distinguished by a different spinulation of the posterior dorsal margins of the abdominal segments. Five larval stages are here described, differentiated primarily by the spines of the telson.

STAGE I (Fig. 2*a*)

The two spines on the posterior dorsal margins of the second to fifth abdominal segments in the first stage of *M. banffica* are replaced in the Falkland larvae by four prominent spines, in the spaces between which are two smaller spines. Laterally to the outer larger spines are one or two smaller spines, making twelve to fourteen in all. The fourth and fifth abdominal segments each carry two strong lateral spines exactly similar to those present in *M. banffica*. The first abdominal segment carries a row of very fine spinules on its posterior dorsal margin, a feature common to the more posterior segments of the larvae of *Galathea*.

This is the stage figured by Gurney (1924) from a specimen taken north of Three Kings Islands, New Zealand. His figure shows features very much like the Falkland

Islands form, especially in the large number of spines on the abdominal segments. Differences exist in the arrangement of these spines, in the shape of the antennal scale and in the presence of spines on the whole length of the posterior margin of the carapace.

The aciculate form of the antennal scale given by Lebour (1930) as a generic character of *Munida* and stressed as such by Gurney (*loc. cit.*) is more pronounced in previously described forms than in the Falkland Islands larvae. Although approaching *Galathea* in this feature, these larvae belong indisputably to the genus *Munida*, *Galathea* not being known to occur in the area. The distinguishing character of the larvae of the two genera is the palp of the first maxilla—not the second as given by Lebour (1930)—which is composed of one segment in *Munida* and of two in *Galathea*. The aciculate form of the antennal scale, as figured by Gurney and Lebour, cannot, therefore, be looked upon as a generic feature, and it would seem probable that the two genera merge one into the other in this respect.

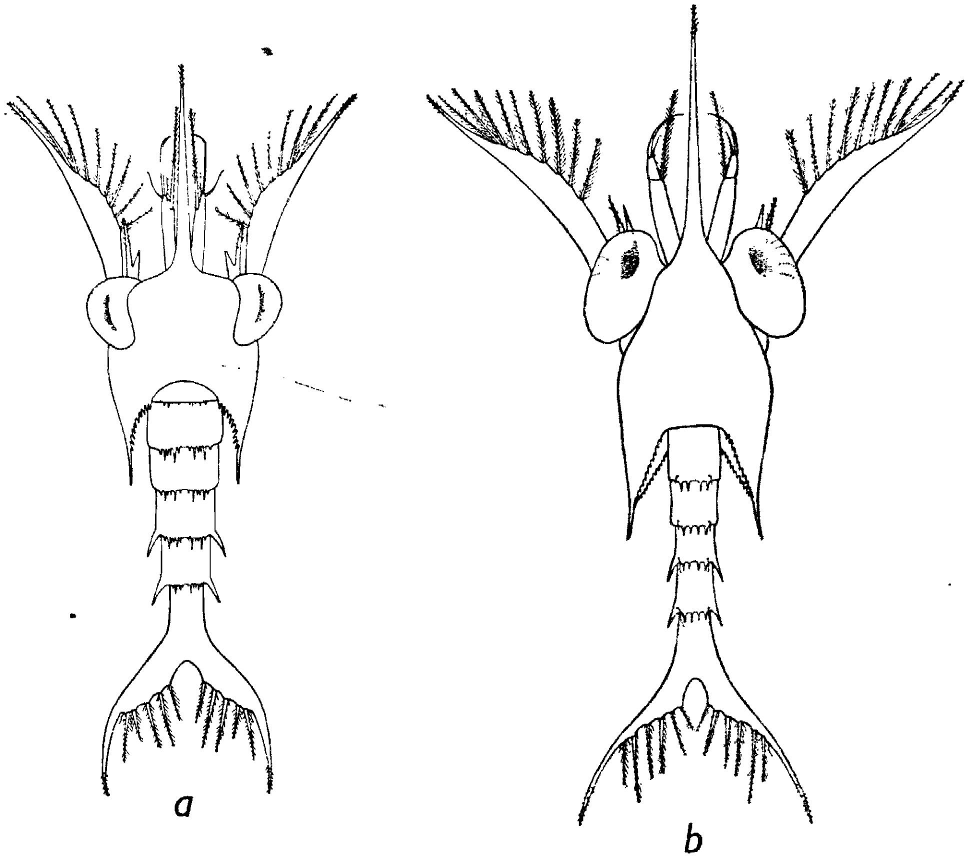

Fig. 2. Larval stages of *Munida*.

a. First stage, length 3·0 mm. *b*. Second stage, length 4·0 mm.

The rostrum and the postero-lateral spines of the carapace are not as long in the Falkland larvae as in *M. banffica* larvae, characters showing an approach to the larvae of *Galathea*. The telson remains the same as in the northern species, having seven spines on either side, the second being insignificant and hair-like. The total length from tip of rostrum to the cleft of the telson of the specimen figured was 3·0 mm., considerably smaller than the corresponding size in *M. banffica.*

STAGE II (Fig. 2*b*)

This is a stage not figured by Lebour (1930) for *M. banffica*, although described in her text; it differs from stage I and also from her second larva in the possession of eight spines on either side of the telson. A second and important change is in the spinulation of the postero-dorsal margins of the abdominal segments. The postero-dorsal margin of the first segment is now smooth, whilst only the four large spines remain in this position on the second to fifth segments. The strong lateral spines persist on the fourth and fifth abdominal segments. On each segment bearing dorsal spines small hairs arise slightly anterior to the base of the outer of these spines. The antennal scale now carries nine plumose hairs instead of eight, and the antennule is composed of two segments. The shape of the carapace has become modified, giving the eyes greater prominence, and the importance of the fourth spine of the telson is foreshadowed in its increasing size. The total length of the specimen figured was 4·0 mm.

STAGE III (Fig. 3*a*)

The division of the sixth abdominal segment from the telson and the appearance of the uropods mark a strong advance in the development of the larva. The number of spines on either side of the telson is increased to nine, the fourth equalling the first in size and now fused with the telson. The outer branch of the uropod carries ten plumose hairs, the inner branch being still non-setose. The sixth abdominal segment carries a stout mid-dorsal spine only. The dorsal spines of the preceding four segments are reduced in size, the fourth segment carrying the largest. The hairs on the antennal scale are increased to ten. The prickles previously present on the tip of the rostrum, on the tips of the antennal scales and on the tips of the first spines of the telson have disappeared. The total length of the specimen figured was 5·5 mm.

STAGE IV (Fig. 3*b*)

A great reduction in the size of the outer spines of the telson, the fourth now being predominant, and an increase in the total number to eleven, mark this stage. The inner branch of the uropod carries seven plumose setae and the terminal seta of the outer branch has become spinose and fused. The second abdominal segment has lost all spines, and those on the postero-dorsal margins of the third to the fifth segments are again reduced in size. The proximal segment of the antennule has lost the stout seta it previously carried and this has been replaced by one arising lower down. The distal segment of the antennule carries more aesthetes on its inner side. The number of hairs on the antennal scale is again increased and is now fifteen. The number of teeth on the posterior margin of the carapace is reduced. The total length of the specimen figured was 8·0 mm.

STAGE V (Fig. 3*c*)

A further increase to twelve occurs in the number of spines of the telson. The uropods are more setose and the inner branch is larger. Only two spines are present on the postero-dorsal margins of the third and fourth abdominal segments, although four still persist on the fifth. Simple biramous pleopods are present on the second to fifth abdominal segments. The teeth on the posterior border of the carapace are reduced to only four or five. Fine teeth are now present on the dorso-lateral margin of the proximal portion of the rostrum. The antennal scale carries seventeen plumose hairs and the antennule has many more aesthetes on the terminal segment. The total length of the specimen figured was 8·5 mm.

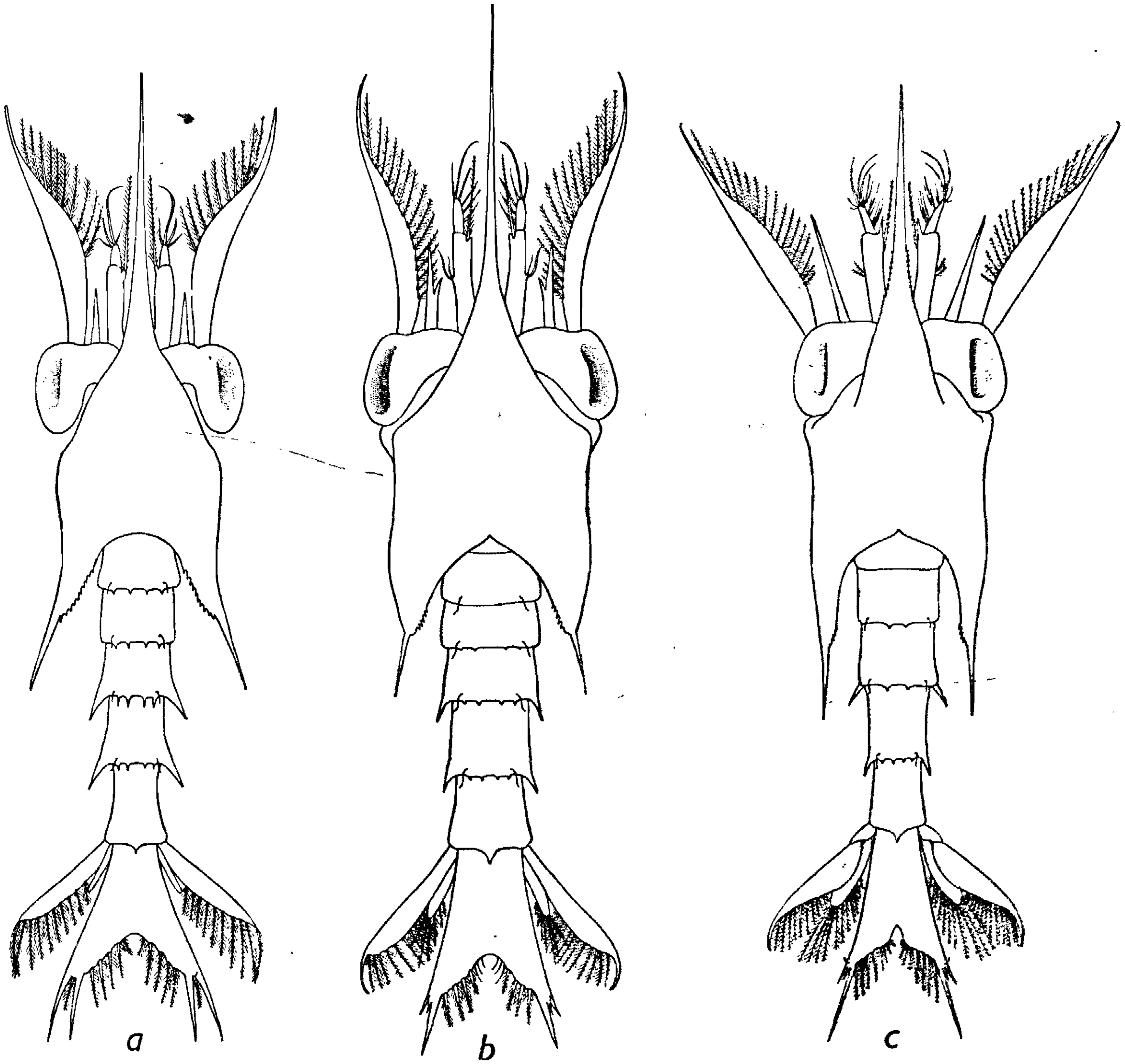

Fig. 3. Larval stages of *Munida*.
a. Third stage, length 5·5 mm. *b*. Fourth stage, length 8·0 mm.
c. Fifth stage, length 8·5 mm.

This may or may not be the last larval stage, but comparison with the last stage of *M. banffica* makes it very probable that a post-larval form follows. If the foregoing five stages can be looked upon as separate and comparable with the four stages of *M. banffica*, a further resemblance to *Galathea*, where five stages are known at times to occur, is presented. A certain amount of variation occurs within each stage, principally in the number of hairs on the antennal scale.

The post-larvae, apart from one or two structures which have yet to be modified, such as the pleopods, have the form of the adult. In consequence of their small size distinction between the two species is difficult at first, but the difference in the length of the eye stalk and the modification of the third maxillipedes in *M. gregaria* soon become apparent. The rostrum has not at first a single point as in the adult, but in the earlier post-larvae the tip of the rostrum has the appearance of a trident with the two lateral spines longer than the central spines. Later, the central spine is increased in length and the two lateral spines become subsidiaries, whilst other small spines have made their appearance along the sides of the rostrum. In the *Grimothea* stage of *M. gregaria* many more lateral spines have arisen, giving to the edges of the rostrum a toothed appearance; from the base of each tooth springs a single, short, stiff hair. These lateral teeth are retained in the adults of both species, but with the greatly increased size of the rostrum they become overshadowed and insignificant.

DEVELOPMENT OF PLEOPODS IN *MUNIDA SUBRUGOSA*

The appearance, in the fifth larval stage, of the pleopods on the abdominal segments as very simple biramous appendages has already been mentioned above. Later, in the early post-larval stage, when the young *M. subrugosa* has acquired the general adult structure, the pleopods of the second to fifth segments still display the biramous form, thus differing considerably from the adult of either sex. The typical pleopod at this stage, when the carapace has a length of 3–4 mm., consists of a large stout protopodite carrying an endopodite and an exopodite (Figs. 4*a–d*). The endopodite is a small, simple segment attached to the inner distal corner of the rectangular-shaped protopodite. The expodite, on the other hand, is much larger and carries about fourteen long, strong and heavily plumose setae. Two of these are arranged close together at the extreme tip, and of the remainder six are placed along each side; at times, five or seven may occur instead of six. The setae spring from collars articulating with the exopodite. The surface of the exopodite is sculptured with conchoidal depressions opposite these articulations, giving the body of the exopodite, with its subconical shape, the appearance of a pineapple.

In the next stage examined (Figs. 4*e–h*) the pleopods have entirely changed in character. Considerable reduction has taken place, although the size of the protopodite is greater relative to the size of the exopodite and endopodite. The inner edge of the protopodite remains straight, but the outer has become markedly convex and now carries six to ten stout plumose setae. The exopodite has changed considerably. It has

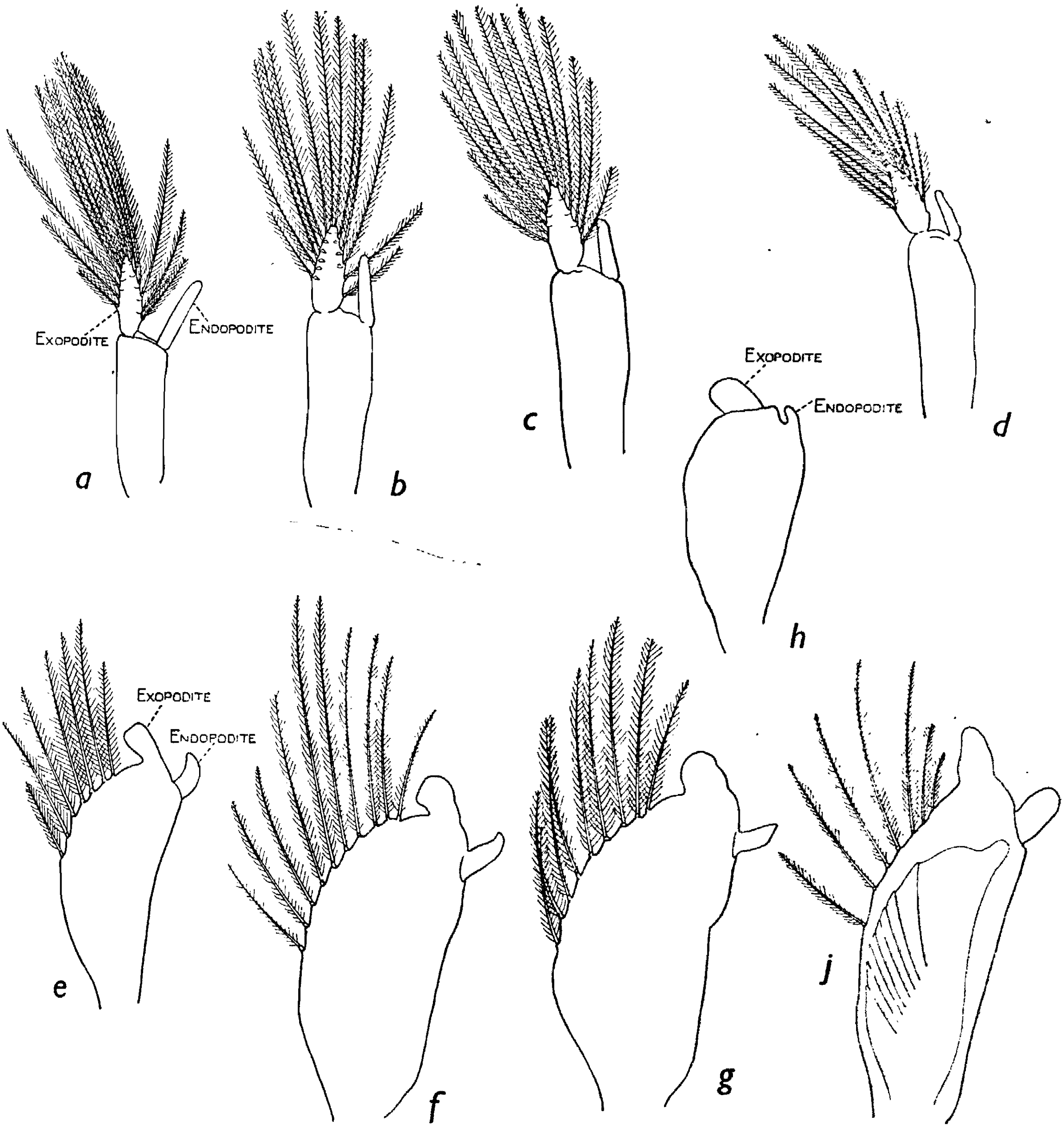

Fig. 4. Development of pleopods in *Munida subrugosa* (*a–h*) and *M. gregaria* (*j*).

a. Fifth pleopod, first stage.
b. Fourth pleopod, first stage.
c. Third pleopod, first stage.
d. Second pleopod, first stage.
e. Fifth pleopod, second stage.
f. Fourth pleopod, second stage.
g. Third pleopod, second stage.
h. Second pleopod, second stage.
j. Fourth pleopod, late second stage.

In each figure the left pleopod is shown. Figs. *e–j* are to a scale 2½ times greater than Figs. *a–d*.

shrunk to a very great extent and has lost the whole of its plumose setae. Its shape is ill defined and irregular and it appears merely as a lobe at the extremity of the protopodite. The endopodite is also very much smaller than before and it now projects like a horn a little way down the inner border of the protopodite. The pleopods of the third to fifth abdominal segments have this form, but that of the second abdominal segment has altered to a more marked degree and the ultimate simple two-segmented female form is already strongly foreshadowed. The protopodite, carrying no setae, is much smaller than in the succeeding pleopods and the endopodite and exopodite project from the end as two lobes, the exopodite being the more prominent (Fig. 4*h*). Specimens of this stage preparing for ecdysis and identified as *M. gregaria*, showed the flat, foliaceous pleopod of the next stage so outlined as to demonstrate that the original exopodite would be suppressed and the endopodite retained (Fig. 4*j*).

When this ecdysis is completed, the third, fourth and fifth pleopods are flat and expanded (Figs. 5*a–c*). The inner edge is straight or slightly concave, whilst the outer is convex and carries articulating plumose setae to the number of nine to twelve. This is the part corresponding to the protopodite of the earlier biramous pleopod. Articulated to this, at the junction of the inner straight and outer curved borders, is the relic of the endopodite appearing as a simple, short projection, the exopodite having entirely disappeared. The appendage of the second abdominal segment (Fig. 5*d*) consists merely of a two-segmented process of a very simple nature.

The foregoing account describes the course of growth in both sexes, but at this stage in the male the development of the third to fifth pleopods is arrested except for progressive increase in size. The pleopods of the second segment together with those of the first, which have yet to appear, metamorphose to become the copulatory appendages before the adult form is fully realized.

The pleopods of the female, with the exception of those of the second segment, which already have almost their final shape, have to become modified considerably in order to attain the adult egg-carrying form. This form is attained by the loss of the lobe of the protopodite, by extension of the endopodite and by a considerable lengthening and stiffening of the whole limb, together with the growth of hairs to which eggs will be attached. Pérez (1927) has described this post-larval metamorphosis of the female pleopods in *Galathea* and states that the same change takes place in *Munida*. He says that the small finger-like terminal process of the protopodite is composed of two segments in the male, whereas in *M. subrugosa* it is composed of only a single segment; and, though giving no evidence for his statement, he asserts that this is a rudimentary endopodite. The process is in fact an endopodite, but it should rather be looked upon as a degenerate endopodite, whilst the exopodite has been completely aborted. Selbie (1914) mentions male *Galathea intermedia* with this endopodite composed now of one segment and now of two.

In our species the change in the form of the female limbs takes place from the most posterior segment anteriorly, as though the centre of the metamorphic activity were situated in the fifth abdominal segment and gradually extended forward. When the

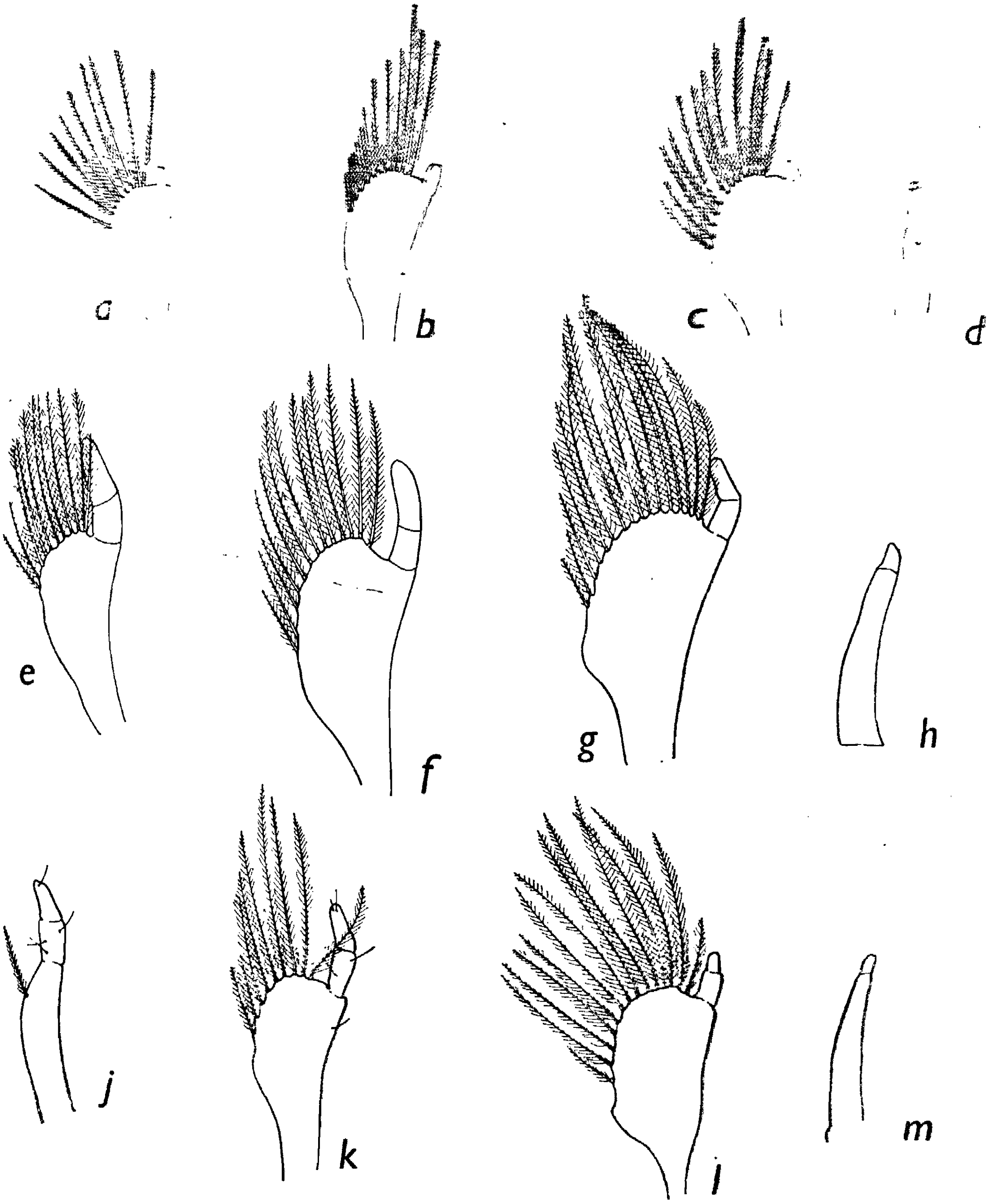

Fig. 5. Development of pleopods in *Munida subrugosa.*

a. Fifth pleopod, third stage.
b. Fourth pleopod, third stage.
c. Third pleopod, third stage.
d. Second pleopod, third stage.
e. Fifth pleopod, fourth stage, female.
f. Fourth pleopod, fourth stage, female.
g. Third pleopod, fourth stage, female.
h. Second pleopod, fourth stage, female.
j. Fifth pleopod, fifth stage, female.
k. Fourth pleopod, fifth stage, female.
l. Third pleopod, fifth stage, female.
m. Second pleopod, fifth stage, female.

In each figure the left pleopod is shown. All the figures are to the same scale.

differentiation of the female pleopods commences, at a carapace length of 10–12 mm., the small endopodite increases in size and becomes two-segmented (Figs. 5*e–g*), whilst the lobe of the protopodite of the fifth pleopod is slightly reduced (Fig. 5*e*). The following stage shows this lobe almost gone (Fig. 5*j*) and, in the specimen figured, with only a single plumose hair remaining of the dozen or so previously present. A few, short, stiff, non-plumose hairs, the rudiments of the egg-carrying hairs, are present on the two distal segments. The lobes of the pleopods of the fourth abdominal segment (Fig. 5*k*) are slightly reduced and egg-carrying hairs appear on the endopodite. The

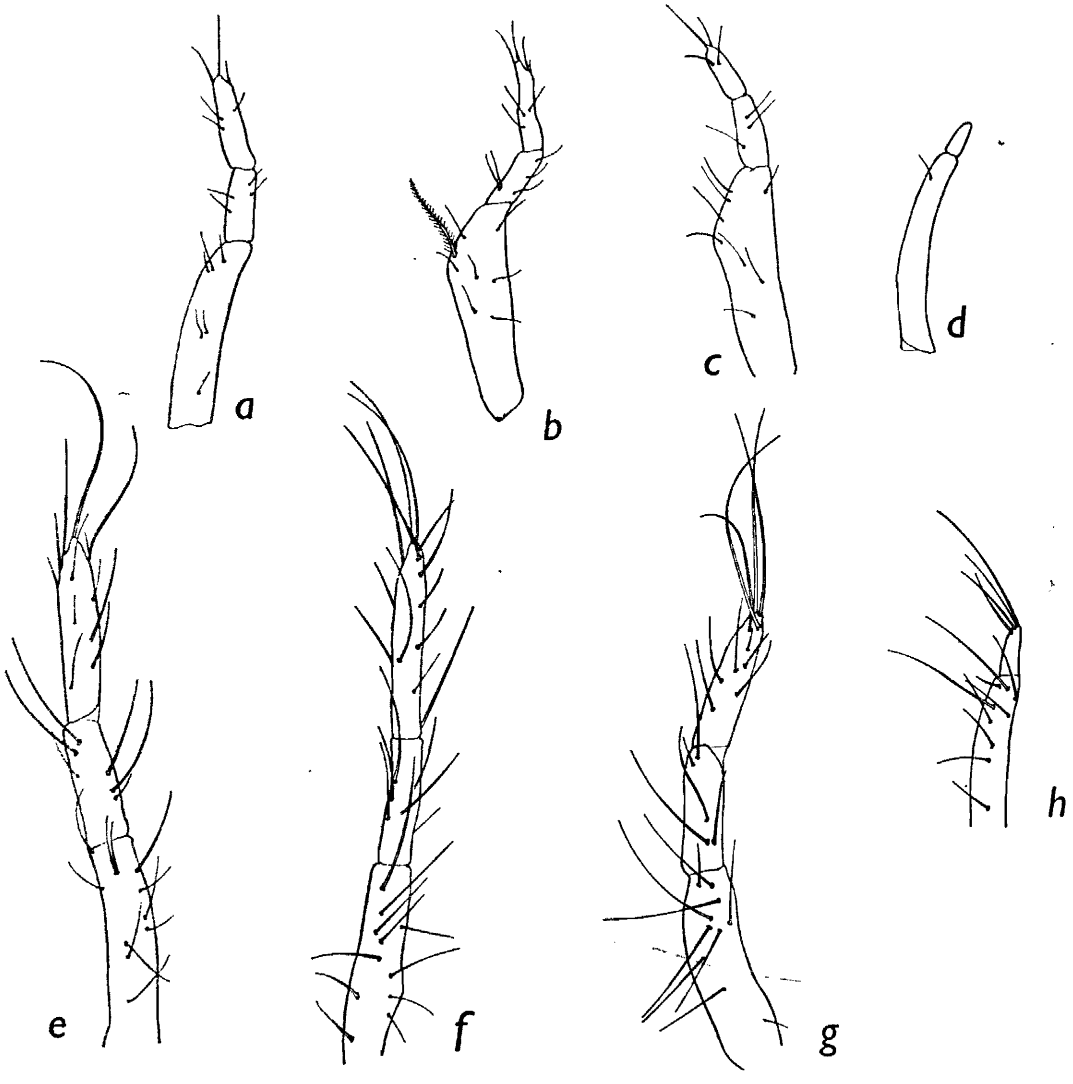

Fig. 6. Development of pleopods in *Munida subrugosa*.

a. Fifth pleopod, sixth stage, female.
b. Fourth pleopod, sixth stage, female.
c. Third pleopod, sixth stage, female.
d. Second pleopod, sixth stage, female.
e. Fifth pleopod, seventh stage, female.
f. Fourth pleopod, seventh stage, female.
g. Third pleopod, seventh stage, female.
h. Second pleopod, seventh stage, female.

In each figure the left pleopod is shown. All the figures are to the same scale.

pleopods of the third segment (Fig. 5*l*) remain as before, as do those of the preceding segment (Fig. 5*m*).

The next advance in development shows the pleopods of the fifth segment approaching the final form (Fig. 6*a*). All sign of the protopodal lobe has disappeared, the whole limb is stouter and more elongated and supports more egg-carrying hairs. The third and fourth pleopods still show a slightly lobose protopodite, and although the egg-carrying hairs are now abundant, a plumose seta still remains on the fourth pleopod which is figured (Fig. 6*b*). The pleopods of the second abdominal segment (Fig. 6*d*) are now stiffer and are beginning to carry hairs. Finally the adult form is realized (Figs. 6*e–h*) and only growth, strengthening of the limb and greater proliferation of the ovigenous hairs are required.

In the male the pleopods of the first and second segments are modified to act as copulatory appendages. In the late larval and early post-larval stages no appendage is to be found on the first abdominal segment in either sex. In the male, however, with the commencement of the modification of the second pleopods to form copulatory appendages, the supplementary copulatory appendages on the first segment make their appearance. The appendages of the second segment are present in the early post-larval stages as biramous pleopods (Fig. 4*d*), similar to those of the succeeding segments, and later they degenerate to a protopodite with two projections representing the endopodite and exopodite as already described (Fig. 4*h*). In the female, the exopodite disappears and the endopodite persists in very simple form. The degenerate exopodite, however, persists in the male, whilst the endopodite takes on a considerably modified form.

The form of the second pleopod shown in Fig. 4*h* is followed, in the male, by that depicted in Fig. 7*a*, and it consists of a simple protopodite bearing a simple styliform endopodite and a very small bud representing the exopodite. Fig. 7*c* shows further development; an increase in size has taken place; especially of the endopodite, whose distal half is now flattened and carries a border of short stiff hairs. A keel runs along the proximal half, and the flattened distal part appears to have been twisted on this portion. Development continues by the expansion of the flattened spatulate tip of the endopodite and the thickening and strengthening of the proximal stalk-like part. The exopodite increases in size and projects as a very simple, single segment. Fig. 7*e* shows what is almost the mature adult form. The whole limb is very much larger. The endopodite is large and expanded, and is bordered by short, stiff hairs, with a bunch of these covering one corner. The exopodite is rigid and acts as a stop to the free movement of the endopodite in a lateral direction.

The appendage of the first abdominal segment of the male first appears as a very simple limb of two segments (Fig. 7*b*), the proximal being long and curved with a small terminal segment. It is this terminal segment which undergoes the most modification before the limb achieves its final form. Fig. 7*d* shows it lengthening and becoming slightly turned at the tip; one or two hairs have made their appearance. The tip then expands with one side curved and one side straight, giving a prow-like termination to the limb (Fig. 7*f*). In the final form (Fig. 7*h*), the protopodite is curved and strong and from a corner at its distal extremity springs a group of particularly long setae. The prow-like shape of the distal segment is further accentuated and, indeed, exaggerated.

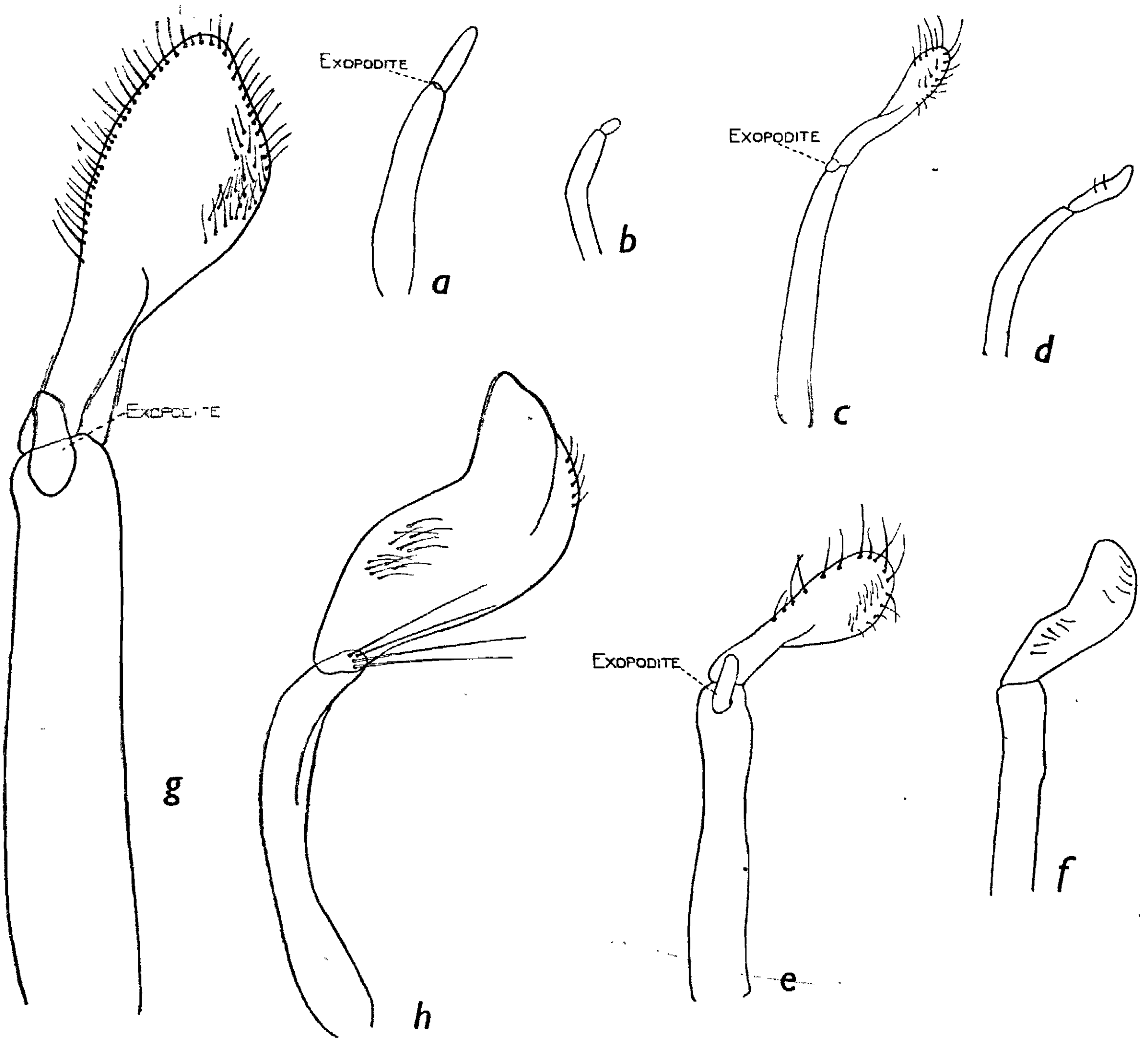

Fig. 7. Development of pleopods in *Munida subrugosa*.

a. Second pleopod, fourth stage, male.
b. First pleopod, fourth stage, male.
c. Second pleopod, fifth stage, male.
d. First pleopod, fifth stage, male.
e. Second pleopod, sixth stage, male.
f. First pleopod, sixth stage, male.
g. Second pleopod, adult male.
h. First pleopod, adult male.

In each figure the left pleopod is shown. All the figures are to the same scale.

It is not suggested that these stages described in the development of the pleopods indicate different and successive moults or hard and fast stages. Variation occurs in the combination of the different stages of development of the limbs, but invariably the more posterior the limb the farther is it advanced in development. The stage at which the limb may have arrived does not depend entirely upon the size of the animal, and although there is a general advance in size according to the stage reached, considerable overlap occurs. In the female specimens figured, for example, the most advanced stage (Figs. 6*e–h*) had a carapace length of only 9·3 mm., whereas the preceding stage figured (Figs. 6*a–d*) had a carapace length of 12·0 mm.

The course of development of the pleopod here outlined for *M. subrugosa* is followed in almost identical fashion by *M. gregaria*. In the final form of the pleopods no distinction between the two species is to be found.

GROWTH

In the hope of obtaining an indication of the growth rates of *M. subrugosa* and *M. gregaria*, measurements of the length of the carapace of all the specimens brought home and now in the Discovery collections have been made. The measurement taken was from the mid-dorsal point of the posterior margin of the carapace, where a slight indentation usually occurs, to the tip of the rostrum. The measurements were made in millimetres by means of vernier callipers, and such measurements as included fractional parts were referred to the integer immediately below. The smaller specimens (less than 15 mm. in length of carapace) were first measured in half-millimetres, but later these were grouped in millimetres so as to conform to the rest. For the purpose of drawing the frequency curves the measurements have again been grouped into two millimetre classes.

The numbers of specimens measured were *M. subrugosa* 4457, *M. gregaria* 1951 from the Falkland Islands region and, in addition, 137 immature specimens of *M. gregaria* from New Zealand waters. The material, taken during the course of three trawling surveys and at other times, was obtained over a period of several years and, although large, it is not representative of every month of the year. Tables I and II show the times at which the specimens of *M. subrugosa* and *M. gregaria* were obtained from the Falkland Islands region. Table III gives the time distribution of *M. gregaria* from New Zealand waters. It will be seen that in the Falkland Islands region scarcely any specimens of either species were taken in June, July and August, and that the numbers of *M. gregaria* in October, November and December are negligible. In the ensuing discussion of the length frequencies for *M. subrugosa* the figures have been grouped into two-monthly time intervals. The June–July period is not represented, whilst the inadequate catches in April, August and November cause the curves for the corresponding bi-monthly periods to be not wholly representative of the stock.

MUNIDA SUBRUGOSA

The bi-monthly length frequency figures of this species have been reduced to percentages, and with the values thus obtained the curves in Figs. 8 and 11 have been constructed. The principle followed in drawing these curves is that suggested by Wollaston (1929). The multimodal curve which would normally be obtained by drawing a smooth curve through the plotted points has been split up into individual "curves of error", each of which is considered to represent a distinct group in the total stock. In the figures each curve of error is shown in its entirety, and thus the catch of each bi-

Table I

Munida subrugosa

	1926		1927		1928		1929		1930		1931		1932		Totals	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	191	170	191	170
Feb.	—	—	29	28	—	—	—	—	—	—	—	—	236	327	265	355
Mar.	—	—	13	20	—	—	—	—	—	—	2	9	92	93	107	122
Apr.	—	—	20	15	—	—	—	—	—	—	12	4	—	—	32	19
May	33	38	—	—	6	5	—	—	—	—	7	9	—	—	46	52
June	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	6	4	—	—	—	—	—	—	—	—	6	4
Aug.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sept.	—	—	—	—	—	—	—	—	—	—	147	132	—	—	147	132
Oct.	—	—	—	—	—	—	—	—	—	—	951	851	—	—	951	851
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	522	485	—	—	522	485
Totals	33	38	62	63	12	9	—	—	—	—	1641	1490	519	590	2267	2190

Table II

Munida gregaria

	1926		1927		1928		1929		1930		1931		1932		Totals	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	185	304	185	304
Feb.	—	—	1	—	—	—	—	—	—	—	—	—	113	92	114	92
Mar.	—	—	30	43	—	—	11	20	—	—	—	—	1	1	42	64
Apr.	—	—	172	170	—	—	12	23	—	—	32	45	—	—	216	238
May	201	215	—	—	—	—	—	—	—	—	52	91	—	—	253	306
June	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sept.	—	—	—	—	—	—	—	—	—	—	86	29	—	—	86	29
Oct.	—	—	—	—	—	—	—	—	—	—	2	4	—	—	2	4
Nov.	—	—	—	—	—	—	—	—	—	—	4	7	—	—	4	7
Dec.	—	—	—	—	—	—	—	—	—	—	2	3	—	—	2	3
Totals	201	215	203	213	—	—	23	43	—	—	178	179	299	397	904	1047

Table III

Munida gregaria from New Zealand

	1932		1933		Totals	
	♂	♀	♂	♀	♂	♀
Jan.	—	—	17	13	17	13
Feb.	—	—	8	10	8	10
Mar.	—	—	9	10	9	10
Apr.	—	—	—	—	—	—
May	—	—	—	—	—	—
June	—	—	—	—	—	—
July	—	—	—	—	—	—
Aug.	—	—	—	—	—	—
Sept.	—	—	—	—	—	—
Oct.	—	—	—	—	—	—
Nov.	22	16	—	—	22	16
Dec.	12	20	—	—	12	20
Totals	34	36	34	33	68	69

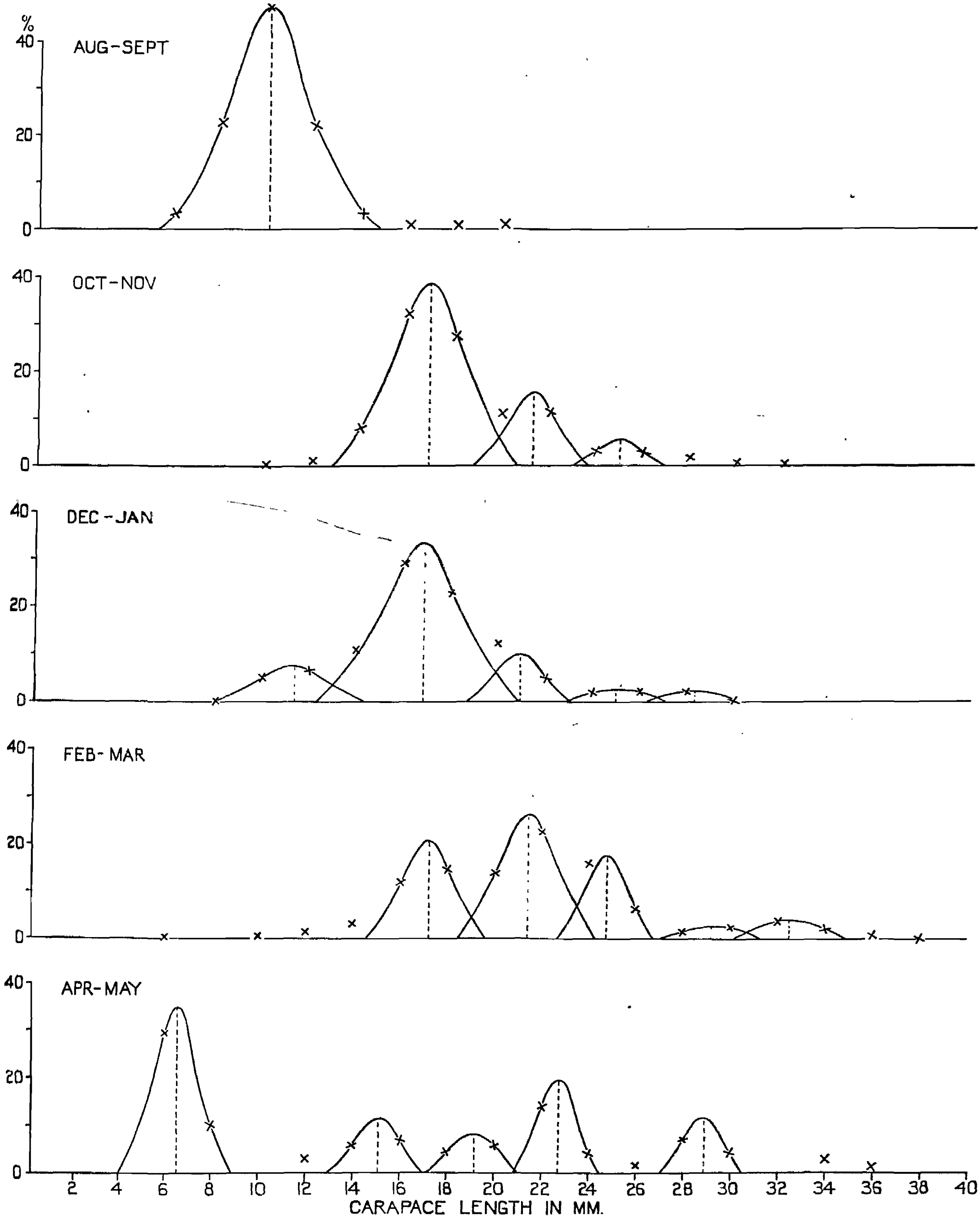

Fig. 8. *Munida subrugosa*, females. Bi-monthly graphs of carapace length frequencies reduced to percentages; each individual curve of error drawn in its entirety.

monthly period is seen to consist of a number of groups distinguished by definite modal lengths. The modal length of each separate curve of error, indicated in the figures by the perpendicular dropped from the modal point of each curve, has then been plotted on the circular graphs, Figs. 9 and 12. In these graphs the circles represent carapace lengths, the origin being at the common centre. The circles are placed 2 mm. apart and so correspond with the frequency classes of the curves of Figs. 8 and 11. The six equally spaced radii represent the six bi-monthly periods of the year, and along each radius have been plotted the modal lengths of each separate curve of error present in the corresponding bi-monthly graph. The values of these modal lengths are shown by crosses along the radii. Where a modal length is based upon less than 10 per cent of the total specimens for any period, its position is marked by a smaller cross than that employed for modal lengths based upon more than 10 per cent of the total specimens for the period. When all the modal lengths are thus plotted it is found that a smooth curve of ever-increasing radius can be drawn through the majority of the points. This curve is not a true helix, for the increase in radius is not constant; but it is a reasonably smooth curve passing through practically all the points without retrogression and may be termed subhelical. This curve illustrates the growth throughout the life of an average individual.

The curves thus obtained on the circular graph can be readily transferred to the usual rectangular form of graph as in Figs. 10 and 13. Here the bi-monthly periods are shown along one axis, carapace lengths along the other. The points on the circular graph are then plotted in the order in which they are met as one travels along the subhelical curve from the origin. In Figs. 10 and 13 no line has been drawn through these points, but they lie along a curve showing rapid growth in the early part of life, gradually slowing down until growth almost ceases. This is, of course, a reflection of the changing rate of increase of the radius of the subhelical curve in the circular graph.

Considering now the graphs for female *M. subrugosa*, the smallest specimens are seen to have been taken in the period April–May, the curve of error of this group giving a modal value of 6·5 mm. The next point occurs in August–September at 10·0 mm.; but this young group was not sampled in October–November. The point in December–January at almost 11·5 mm. is based on less than 10 per cent of the catch for that period, but lies easily on the curve leading to the point at slightly more than 15·0 mm. in April–May. The female *M. subrugosa* has now completed the first year of post-larval life and the carapace has increased in length from 6·5 to 15·0 mm. The female is now sexually mature and can be found carrying eggs at carapace lengths from 12·0 mm. The onset of sexual maturity probably accounts for the slowing down of the growth rate to a steady increment of about 4·0 mm. each year which now takes place. In the circular graph a slight regression is seen in the third year, from 21·3 mm. in October–November to 21·0 mm. in December–January. Apart from this rather trifling aberration, almost four years of growth can be traced with reasonable accuracy by this method.

The rectangular graph showing growth (Fig. 10) gives a picture of a post-larval life of some six years. During this time the carapace length of the female *M. subrugosa*

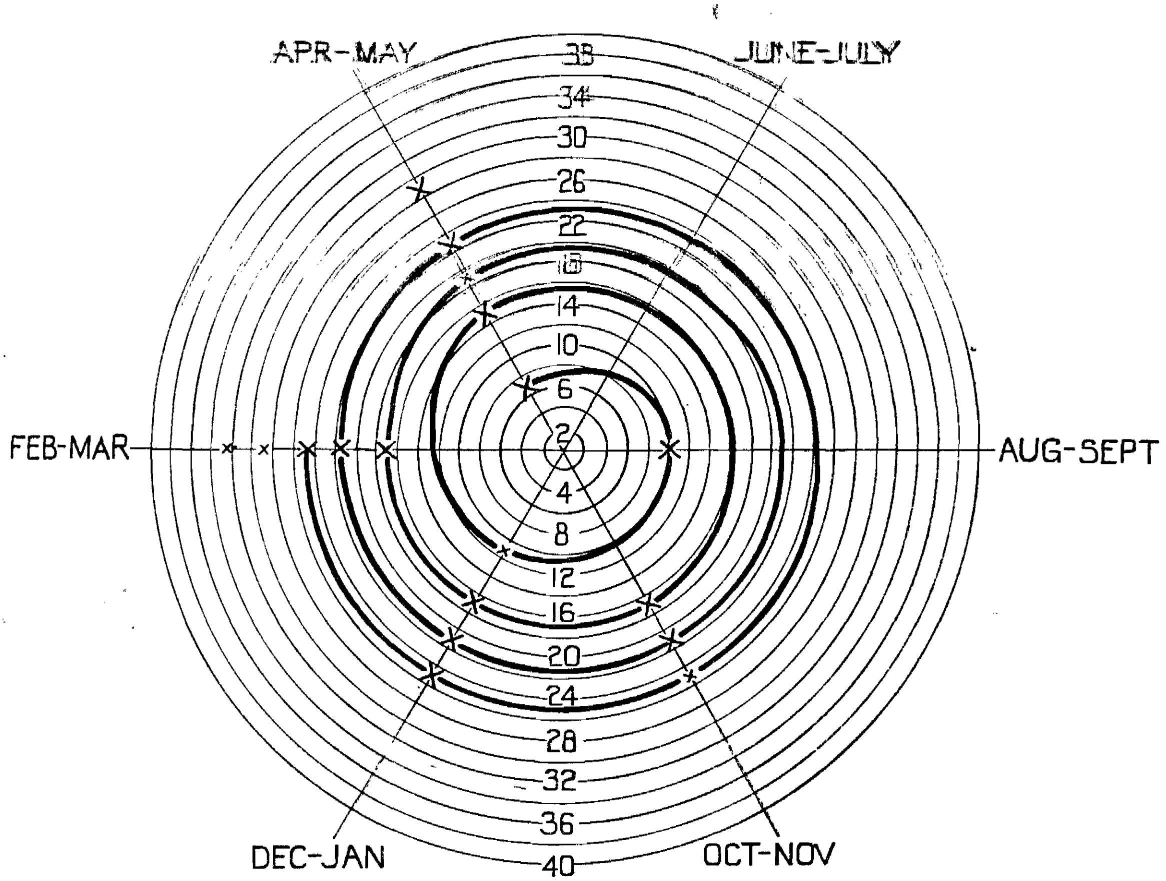

Fig. 9. *Munida subrugosa*, females. Circular graph of modal lengths of curves of error drawn in Fig. 8.

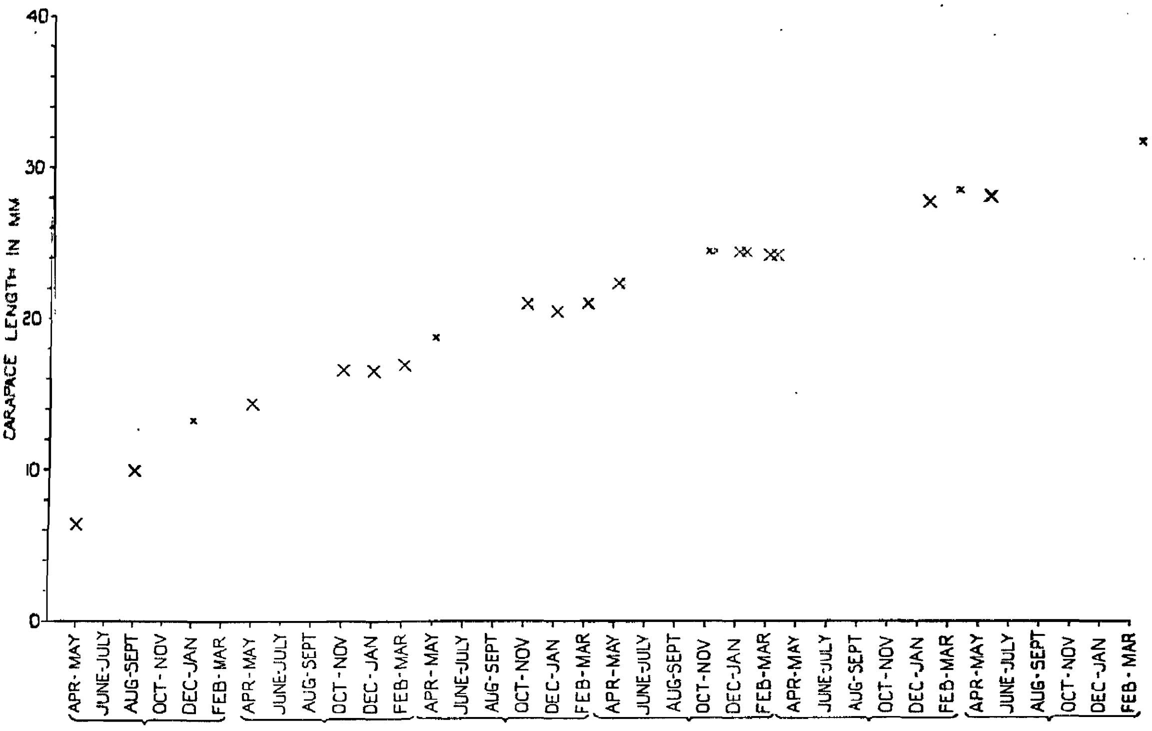

Fig. 10. *Munida subrugosa*, females. Graph of modal lengths of curves of error drawn in Fig. 8.

increases from 6·5 to 32·5 mm. This latter is by no means an extreme length, and it seems not at all unlikely that large specimens may be eight years old or even older.

The curves obtained for the male *M. subrugosa* are closely parallel to those for the female, but they indicate a slower rate of growth especially in the first year. The initial post-larval group in April–May has a slightly smaller modal length of 6·25 mm. The curve in the circular graph (Fig. 12) shows the carapace length at the end of the first year to be almost 12·0 mm., 3·0 mm. less than in the female. The second half of the curve for this year is based upon low figures, less than 10 per cent of the total catch in each period, and one point, that for February–March at 13·5 mm., does not fall on the curve and, it is felt, should be disregarded. Apart from this one point, the subhelical curve can be drawn with reasonable confidence for the first five years of life, and is shown in the figure for the first six. It shows that the male gradually overtakes the female in growth, and the two sexes are roughly of the same length in their sixth year. As in the female, growth continues after this, but the data are altogether too inadequate for discussion. It can, however, be said that the largest specimens taken are usually male, and it seems probable that the male normally lives to a greater age than the female.

MUNIDA GREGARIA

The data which can be used for inquiry into the growth of *M. gregaria* are not of such an extensive or uniform character as those employed for *M. subrugosa*. In the Falkland Islands region this species was not met with during several months of the year and the bulk of the material consists of the immature *Grimothea* stage, the adults seldom being taken in quantity. In view of this it has not been thought advantageous to employ the method used for *M. subrugosa*. The graphs of carapace length for *M. gregaria* (Figs. 14–16) have not been drawn to give each curve of error in its entirety, but they have been drawn with every attention to the form of this curve.

Before considering the curves thus obtained for the specimens taken in the Falkland Islands region an examination of those for the material from New Zealand waters will be helpful.[1] This material, comprising 137 specimens, 69 males and 68 females, was taken in Otago Harbour at intervals varying from five to twelve days during the months November 1932 to March 1933. The collections are well spaced, each month during the period being represented by three or four catches, but the numbers in each catch are small; still, in spite of this, the homogeneity of the whole material gives it a value which is lacking from the more extensive Falkland Islands material. The significance of curves drawn from small samples is discussed by Wollaston (1929) and, accepting his views, it is considered justifiable to draw conclusions even from these small samples. The material was measured in the same manner as the Falkland Islands material, but it has not been grouped into 2 mm. length classes and instead of percentages the actual numbers are shown. Curves have been drawn for each of the five calendar months in which specimens were obtained.

Examining first the curves for the females (Fig. 14, right), a well-defined group is seen

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[1] Procured by the late Mr G. M. Thompson as mentioned in the Introduction, p. 212.

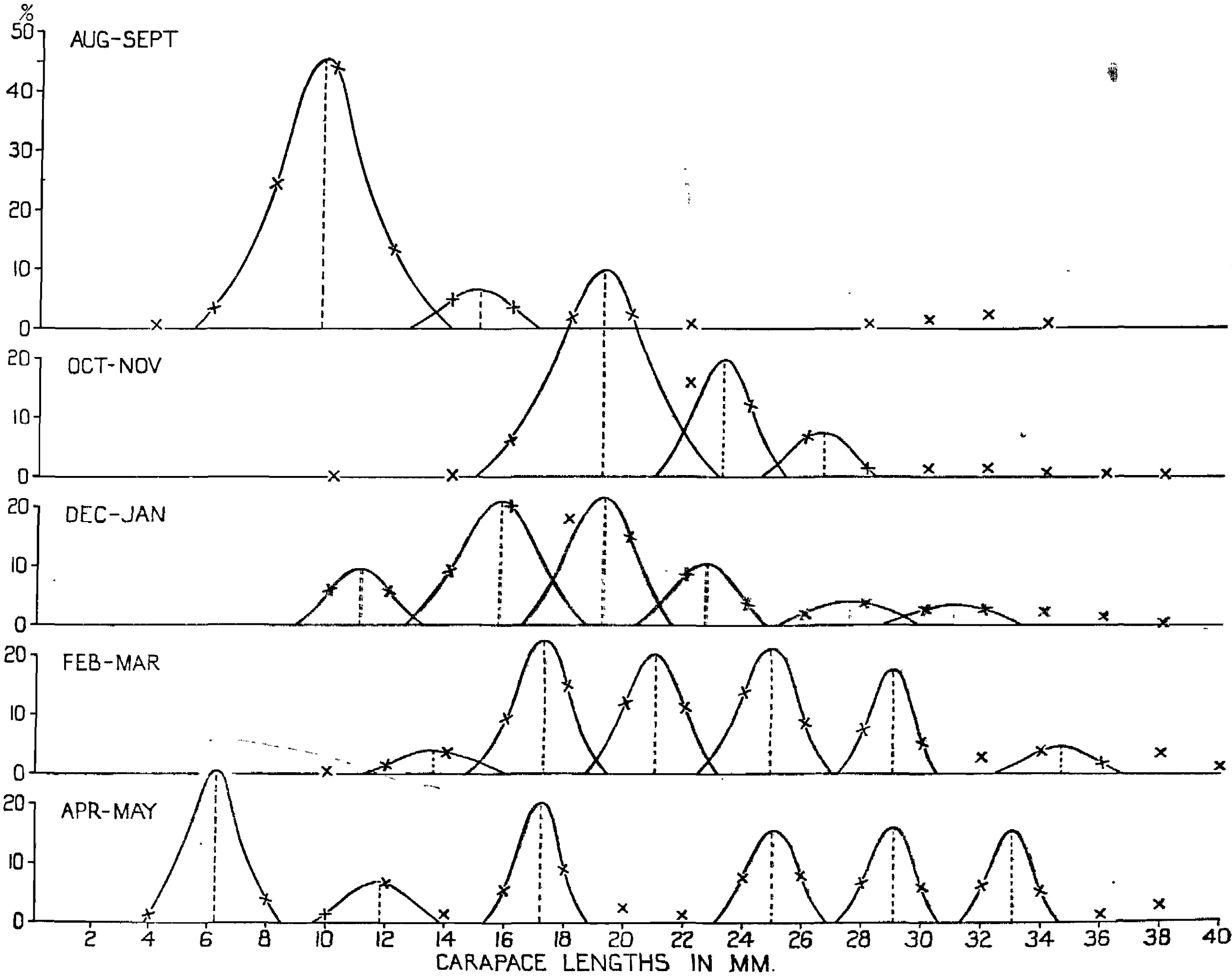

Fig. 11. *Munida subrugosa*, males. Bi-monthly graphs of carapace length frequencies reduced to percentages; each individual "curve of error" drawn in its entirety.

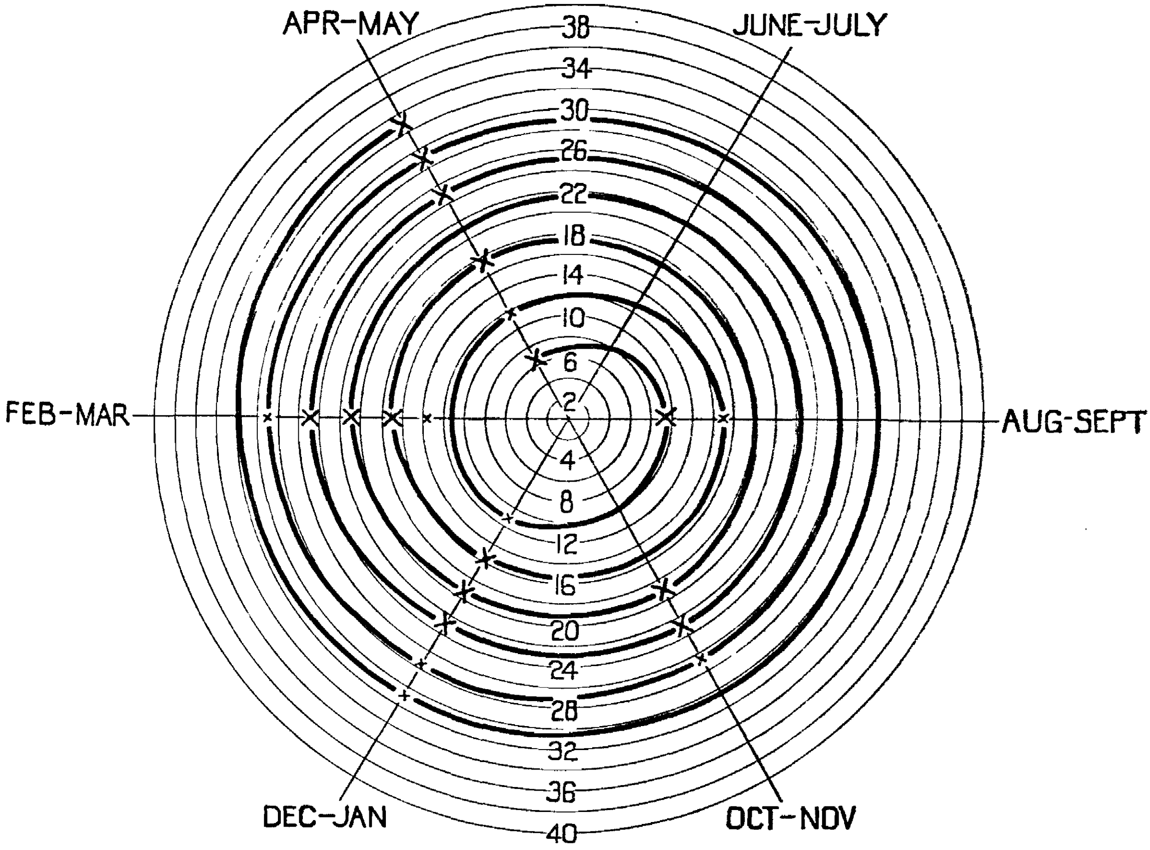

Fig. 12. *Munida subrugosa*, males. Circular graphs of modal lengths of curves of error drawn in Fig. 11.

to be present in November with a modal length of 6·3 mm. The curve for December shows two modes, but this may be due to moulting or to the sampling of a different brood, either a possible cause of this bimodality. A steady increase in modal length to 11·0 mm. in March takes place throughout the series. The curves for the males for November and December show two modes similar to those in the female curve for December and they suggest the same possible causes. The two modes, however, approach and coalesce, so that a maximum growth in the length of the carapace from 6·2 mm. in November to 11·5 mm. in March is shown.

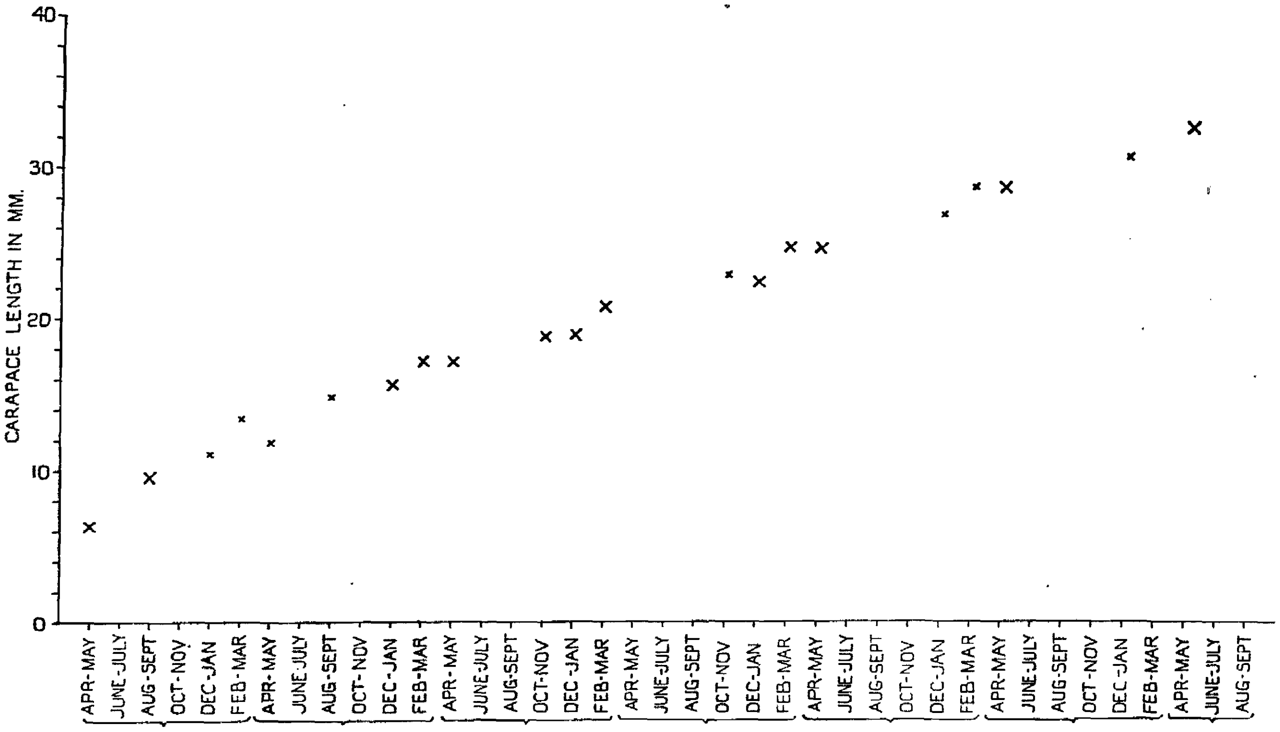

Fig. 13. *Munida subrugosa*, males. Graph of modal lengths of curves of error drawn in Fig. 11.

Turning now to the Falkland Islands material, the female *M. gregaria* makes its appearance at the smallest modal carapace length of 7·0 mm. in January (Fig. 15). The New Zealand specimens of this month have a carapace more than 2 mm. longer, but the difference in latitude of more than 6° between Otago Harbour and the north coastal waters of the Falkland Islands, whence the material was derived, explains the discrepancy. If this smallest group were hatched from the egg in October or November the larval life of this species must be much shorter than that of *M. subrugosa*, which first appear as post-larvae in May and then at a slightly smaller length. February shows this group about a mode of almost 9·0 mm., and by April it has grown to a length of slightly more than 10·0 mm. No increment of importance is added by May. This means a growth of 3·5 mm. in the five months January to May which is rather less than the growth of the New Zealand *M. gregaria* for the five months November to March. This first-year group, in which a considerable retardation of the growth rate is apparent in

April and May, evidently stops growth almost entirely during the winter months, for the mode has not advanced by September.

The April curve shows two other well-defined distributions in addition to that of the first-year group; one with a mode at 21·5 mm. and a second with a mode at 27·5 mm. These are represented in May at 22·0 mm. and 27·5 mm. respectively. For the first-year group of September, with a modal length of 10·5 mm., to reach a modal length of more than 21·0 mm. by the following April means that the length of the carapace would have to be more than doubled in seven months. This does not seem reasonable, and the absence of any records of the second-year group is indicated by the gap shown in the graphs of each month. In December, three individuals at lengths of 13, 14 and 15 mm. respectively are the only representatives of the first-year group after the age of nine months that we have examined. If it be agreed that the second-year group is absent from the material, then the modes in the April curve at 21·5 and 27·5 mm. represent respectively the third- and fourth-year groups. These year groups are indicated in March and well shown in May. In January a mode at a still greater length occurs which will represent the fourth-year group, whilst the two younger year groups were not sampled at all in this month.

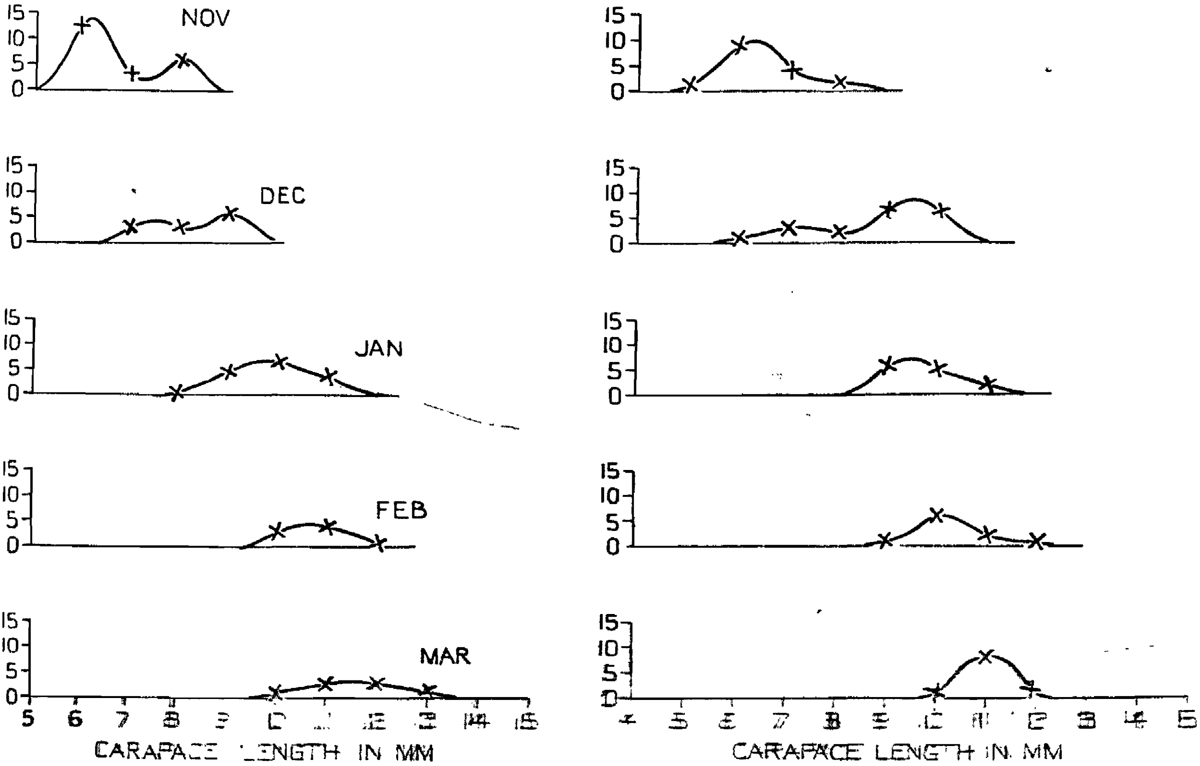

Fig. 14. *Munida gregaria.* Monthly graphs of carapace length frequencies of New Zealand specimens; males on the left, females on the right.

In the male *M. gregaria* the first-year group pursues a similar course to that in the female (Fig. 16). Commencing at the slightly greater modal length of 7·5 mm. in January, it reaches 10·0 mm. by May. An asymmetry on the upper limb of the May

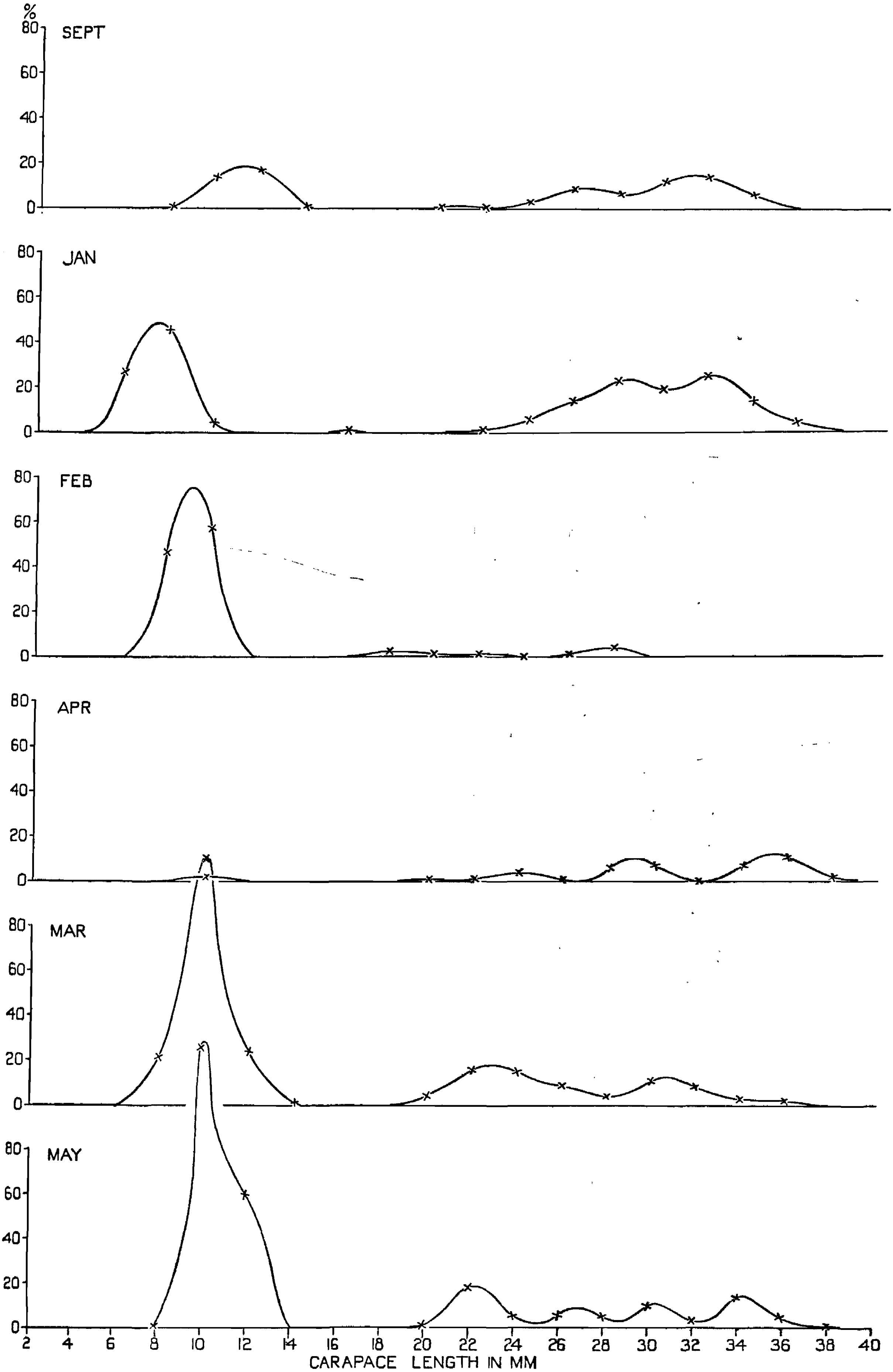

Fig. 16. *Munida gregaria*, males. Monthly graphs of carapace length frequencies of Falkland Islands specimens.

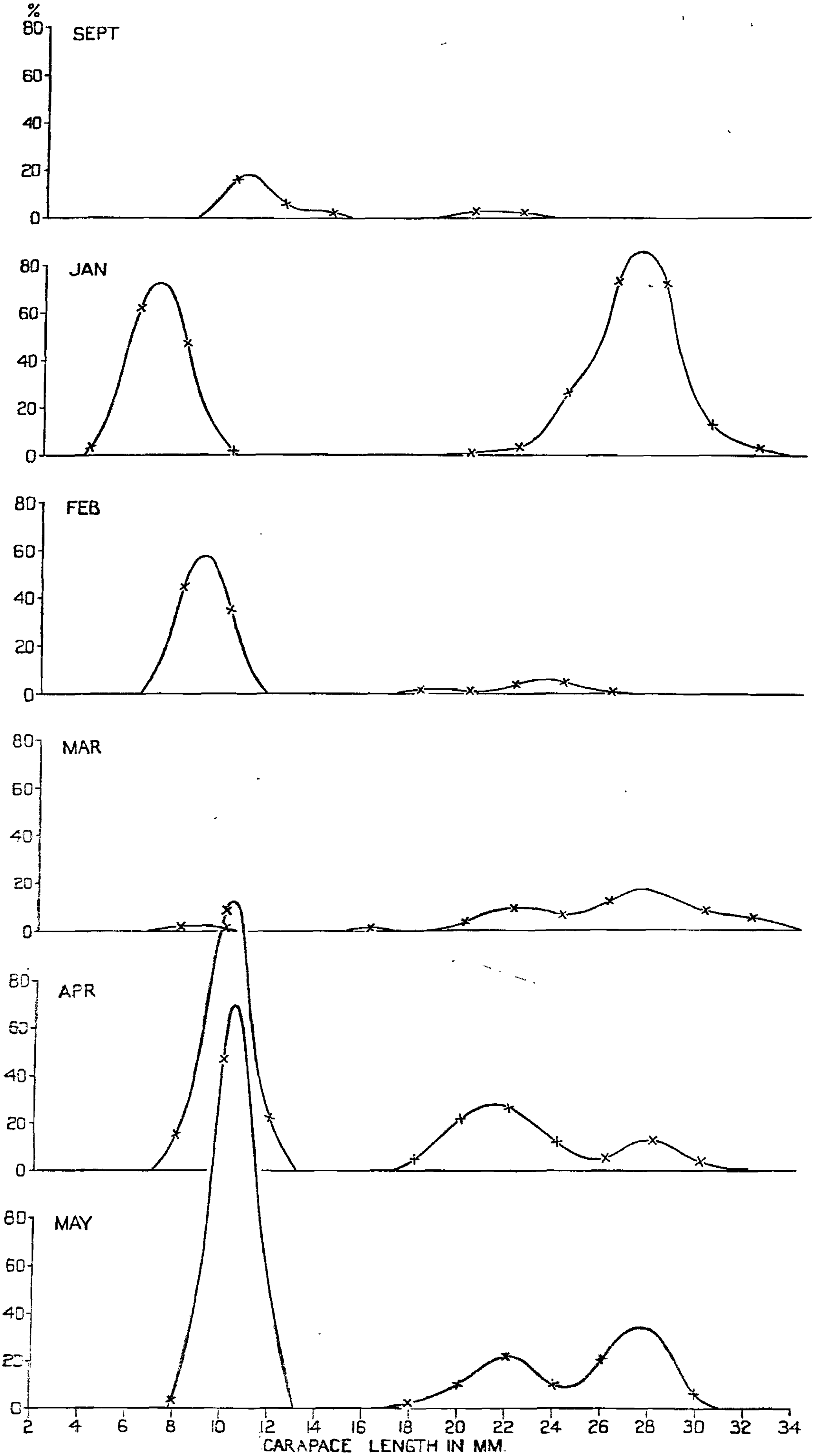

Fig. 15. *Munida gregaria*, females. Monthly graphs of carapace length frequencies of Falkland Islands specimens.

curve of this first-year group probably indicates a moult to the greater length of 11·5 mm. actually in progress. Again, no growth seems to take place during the winter months and the September first-year group is dispersed about a mode slightly above 11·0 mm. corresponding to that indicated in May as an asymmetry on the upper limb of the main curve.

The records of the older groups in the male population are inadequate or absent, and no satisfactory account of the later growth can be deduced from them. The general growth no doubt closely follows that suggested above for the female.

I wish here to acknowledge the help given to me by Mr T. Edser, of the Ministry of Agriculture and Fisheries, whilst preparing this account of the growth of the two species and particularly to thank him for the idea embodied in the circular graphs of Figs. 9 and 12.

EPIZOA AND PARASITES

The two species of *Munida*, in common with many other members of the Decapoda, often carry on their exoskeleton an epizootic fauna. Large and obviously older specimens were those most commonly infected. The commonest epizoa are Serpulid Polychaetes resembling *Spirorbis*. At times these occur very extensively, not only on the carapace, but on the tergites and pleura of the abdominal segments, on the legs, especially on the chelate limb, and even on the ocular peduncle.

M. gregaria was found carrying growth of a Polyzoon, *Alcyonidium* sp. This occurred most frequently on the tergites and pleura of the second to the fourth abdominal segments, where flexion of the abdomen occurs; but on some specimens the incrustations spread over the carapace, on the legs and in one case extend even on to the eyes, obscuring the pigmented corneal portion to such a degree as to interfere with vision. A Vorticellid was seen on the limbs of immature specimens of both *M. gregaria* and *M. subrugosa*.

The two species of *Munida* both harbour a Bopyrid parasite, *Pseudione galacanthae*, Hansen, which takes up its position in the branchial chamber. In all except the most recently infected individuals the presence of the Isopod is displayed by the bulging carapace and branchiostegite, a deformity which in older specimens assumes no mean proportions.

Pseudione galacanthae was first found in *Galacantha diomediae* var. *parvispina*, Faxon, in the Gulf of California (Hansen, 1897). It was recorded from *Munida subrugosa* taken on the east coast of Patagonia by Richardson (1904), and it has also been obtained from *Munida quadrispina*, Benedict. A rather larger size is attained by specimens from the two species of *Munida* considered here than by those first described by Hansen and obtained from *Galacantha diomediae*. The slight asymmetry shown in Hansen's figures of the type is still less marked in the specimens before us. *P. galacanthae* was always found with its head pointing posteriorly with regard to the host and with the long axis of the body lying in a diagonal position so that the anterior part of the body was more ventral in position than the mesosome.

The epicarid larva was obtained from the marsupium of a female. Cryptoniscid larvae were found in the branchial cavity of the *Grimothea* stage of *M. gregaria*; this position had evidently only just been assumed, for the larva was still free and no deformation of the host had yet occurred. These larval stages are very similar in general appearance to the corresponding stages of *Phryxus abdominalis*, Kröyer, as depicted by Sars (1899).

A striking habit of this parasite is the strong preference shown for the right side of the host. This side was usually the one infected, although infection also occurs on the left side only and on both sides. A consideration of all the hauls between September 1931 and March 1932[1] in which infected specimens were obtained, yields the following data:

Munida subrugosa

Total number examined ...	5798		
Number parasitized	429 or	7·4	per cent of the total
Parasitized on right side only ...	395 or	92·1	per cent of those parasitized
Parasitized on left side only ...	20 or	4·6	per cent of those parasitized
Parasitized on both sides ...	14 or	3·3	per cent of those parasitized

Munida gregaria

Total number examined ...	3369		
Number parasitized	125 or	3·7	per cent of the total
Parasitized on right side only ...	114 or	91·2	per cent of those parasitized
Parasitized on left side only ...	10 or	8·0	per cent of those parasitized
Parasitized on both sides ...	1 or	0·8	per cent of those parasitized

The percentage of parasitization in individual hauls varies from zero to 50 per cent in *M. subrugosa* and from zero to 100 per cent in *M. gregaria.*

It would seem that an individual of *M. subrugosa* infected on the left side has almost equal chances of being infected on the right side as well. This is not so for *M. gregaria,* in which, of the total of those parasitized on the left side, 90 per cent are infected only on the left side. The asymmetry of *Pseudione galacanthae* mentioned above is evidently impressed by the shape of the cavity of the carapace in which it lives. Specimens taken from the left side of *M. subrugosa* showed an opposite asymmetry to specimens taken from the right, those from the one side giving the appearance of a mirror image of those from the other. This was especially well seen when the parasites from a host infected on both sides were placed together. Thus no reason for the preference of *Pseudione galacanthae* for one side of its host is to be found in its superficial asymmetry.

One hundred and seventy-one specimens of a large haul of the *Grimothea* stage of *M. gregaria,* not included in the above figures, yielded five infected with the Cryptoniscid larva of *Pseudione galacanthae.* This represents only 2·9 per cent, a figure rather less than the 3·7 per cent obtained from the whole season's data. It may be that infection was only taking place at this juncture and that many more *Grimothea* would

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[1] Hauls of the *Grimothea* stage of *M. gregaria* are not included.

shortly be seized upon by Cryptoniscids. Another haul of large *Grimothea* taken later in the year yielded an even lower percentage of infected specimens (1·9 per cent).

There seems to be no evidence that great inconvenience is caused to the host by the presence of the parasite. If a certain proportion of mortality were caused by harbouring the parasite, the percentage of infection in early life should exceed that for the whole population.

DISTRIBUTION

The geographical distributions of *M. subrugosa* and *M. gregaria* have been briefly dealt with by Matthews (1932). He has given their general distribution, so far as it is known, and it remains for us to examine the more detailed distribution in the area covered by the trawling surveys, especially in the light of the large numbers obtained during the period October 1931 to April 1932.

MUNIDA SUBRUGOSA

The area covered by the trawling surveys does not extend beyond the known limits of the occurrence of this species. No station was made either as far north as 35° S, which is given as the northern limit by Matthews, or as far south as Cape Horn where the R.R.S. 'Discovery' took large numbers in 1927. The species is distributed generally over most of this area, but regions of concentration and absence can be mapped. Depth is one of the factors appearing to limit its distribution, and the increasing depth at the edge of the continental shelf forms the eastern boundary. Few hauls of the trawl were made in waters of any great depth, but *M. subrugosa* has been taken at several stations where the haul has commenced or passed into moderate depths from shallower depths, as, for example, at WS 246 and WS 772 where the hauls rose from 267 to 192 m. and 309 to 162 m. respectively. The catches at these stations were always small and the limiting depth was no doubt in the neighbourhood. Only two or three stations of a depth greater than 200 m. and with a level bottom yielded records. It seems evident that *M. subrugosa* is passing beyond its optimum depth when descending below the 200-m. contour. Henderson (1888) records this species at a depth of 600 fathoms off Monte Video; but the record is of a single specimen in a "very imperfect state of preservation", and too much importance should not be attached to it.

Certain areas of the continental shelf show very few, or an absence of, *M. subrugosa* in such a manner as to suggest some definite cause (Fig. 17). The distribution shows a heavier concentration near the coasts, especially off the north and north-west coasts of the Falkland Islands, off north-east Tierra del Fuego, and in the neighbourhood of the mouths of the Rio Gallegos and Rio Coig. Lying outside these two last-named regions comes a long strip, roughly parallel to the coast, of diminished catches and then beyond this an area of absence. Similarly, moving west and north-west from the area of concentration to the north-west of the Falkland Islands an area of scanty numbers is passed through before the same region of absence is reached and records cease. Thus a region, running roughly north and south, in which conditions may be unfavourable to the species, is seen to separate a Patagonian population and a Falkland Islands popula-

Fig. 17. Chart showing distribution of *Munida subrugosa* in the Falklands area.

tion. South and east of the Falkland Islands group there is an absence of records, but here the continental shelf is narrow and waters of a suitable depth are limited, whilst similarly the depth of the region south-west of these islands precludes the occurrence of this species. Only one station on the Burdwood Bank yields a record, but imperfect exploration of this uncongenial trawling ground makes its distribution here problematic.

In the northern part, the area of the survey is cut across by a zone of absence running east from the Gulf of San Jorge; this zone separates the southern region already described from a northern region of rich abundance where large numbers were taken in each haul of the trawl. West of this rich region can be seen indications of a northward continuation of the longitudinal barren strip running parallel to the coast.

This description of the distribution of *M. subrugosa* is, as stated above, based almost entirely on the results of the 1931–2 survey. The two previous surveys, more restricted in every way, add little to the foregoing conclusions but tend to corroborate them. On the first survey *M. subrugosa* was taken north and north-east of the Falkland Islands and off the Patagonian coast. The central barren area was indicated. The second survey, carried out with especial reference to the edge of the continental shelf, helps to show the influence of depth on the distribution.

The causes of the discontinuous distribution described above have not been ascertained. The areas of concentration or absence appear to have no relationship to the character of the substratum upon which they live. Matthews (1934) has mapped the texture of the bottom deposits obtained on the 1931–2 survey and *M. subrugosa* occurs indiscriminately on all the grades which he distinguishes. The hydrological features of the area are simple and comparatively uniform (Klaehn, 1911). Only the Falkland current has a direct influence in this region, and the only deviation from the simple northward sweep of this water is the small and insignificant counter-current moving southwards along the Patagonian coast. Again, no relationship between the hydrological element in the environment and the above outlined distribution is to be found.

MUNIDA GREGARIA

The distribution of this species is remarkable for its neritic character, and the chart (Fig. 18) shows the manner in which the species surrounds the Falkland Islands and does not occur far from shore. The northern coasts and the entrances to Falkland Sound seem to be favoured localities. Away from the Falkland Islands the species clings close to the coast of Patagonia and Tierra del Fuego. The R.R.S. 'Discovery' took large numbers in the harbours of Hermite Island and Cape Horn, and these records, no doubt, indicate the extreme southern limit.

Occurrences along the Tierra del Fuegian and Patagonian coasts are well marked and doubtless the species is to be found all along this coast, close inshore, until the northern limit is reached. The capture of *M. gregaria* at St. WS 771, 42° 40′ S, 60° 32′ W, is the most northerly record of the species in this region. In addition to the records obtained by the ships of the Discovery Committee, the observations of Captain Fagerli, of the whale factory ship 'Ernesto Tornquist', in the Gulf of San Jorge and southwards from

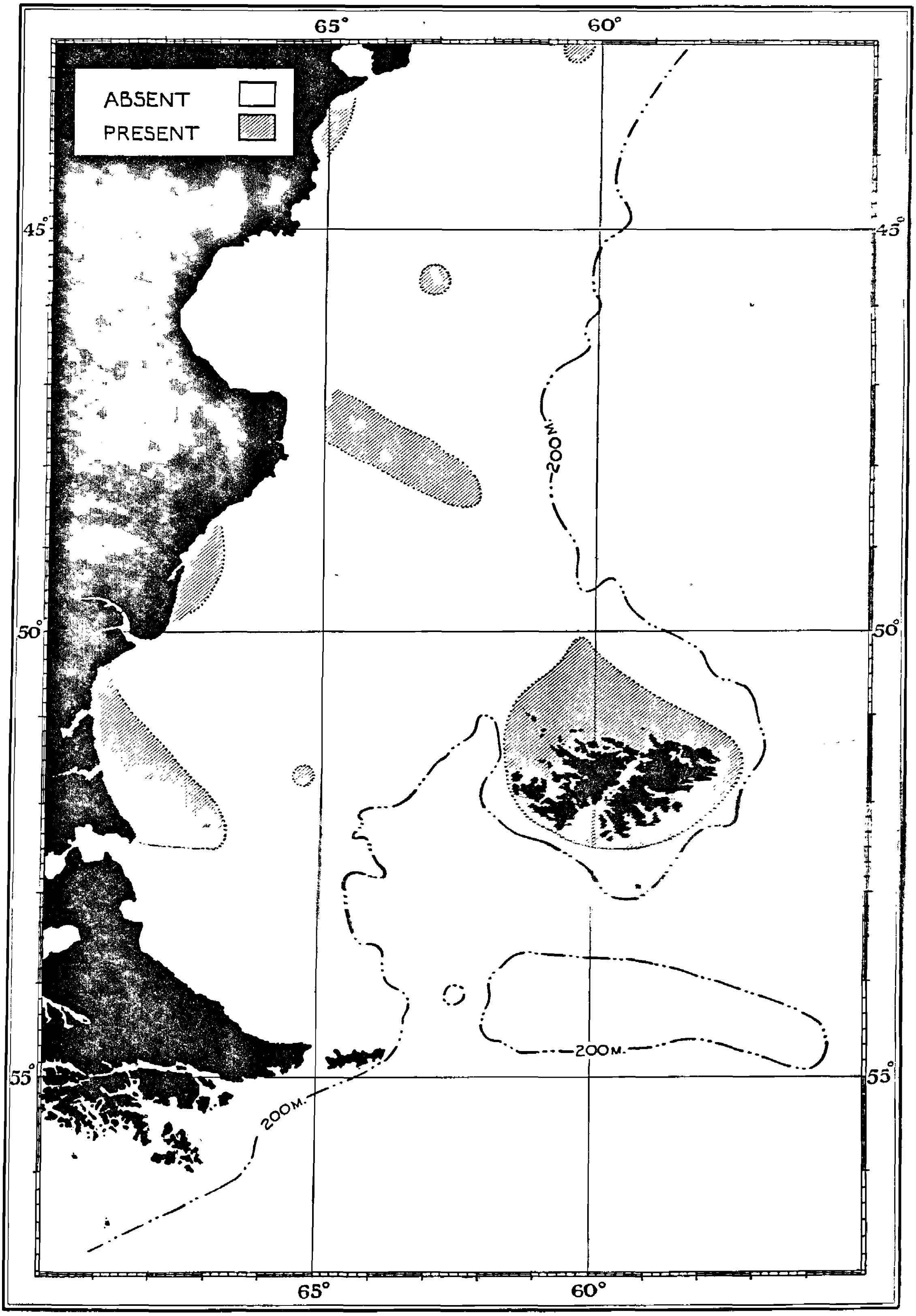

Fig. 18. Chart showing distribution of *Munida gregaria* in the Falklands area.

there, as given by Matthews (1932), must be borne in mind. That *M. gregaria* inhabits the shore waters of the Magellan Straits and the complicated channels of the adjacent regions is well known from the observations of previous expeditions in addition to records obtained by the R.R.S. 'Discovery' and 'William Scoresby'. The only occurrence of note lying offshore[1] is in an area running east-south-east from Cape Blanco. The numbers taken at the stations in this area are few and indicate a very meagre population.

Depth is probably the limiting factor in the distribution of the benthic adult; but it must be borne in mind that the adult stage may lead a pelagic life. Matthews (1932) gives Young's (1925) limit of 60 fathoms (130 m.) as the greatest recorded depth at which the adult is found. Only three or four stations with a greater depth than this have yielded *M. gregaria* in this survey, but considering the habits of the animal it is difficult to know with certainty whether the specimens were actually taken on the bottom or at intermediate depths as the net was on its way to the surface. The greatest possible depth at which adult *M. gregaria* might have been taken was at St. WS 783 with a depth of 159 m.

The *Grimothea* stage of *M. gregaria*, which is discussed in the following section, is usually found in the proximity of land, 60 miles from the Falkland Islands shores at St. WS 100 being the greatest distance out to sea at which it was taken, with the exception of certain records discussed below.

SWARMING OF THE *GRIMOTHEA* STAGE OF *MUNIDA GREGARIA*

Matthews (1932) has discussed the *Grimothea* stage of *M. gregaria* and its relations to the adult at some length. He also remarks upon its swarming habits and quotes from many accounts of old voyages to show how this feature has been remarked upon by the explorers of these regions from the earliest times. Such of these records as can be plotted on the chart show that none occur far from land, but some are placed very much farther north than any of our observations.

On January 30, 1932, the R.R.S. 'William Scoresby' met with many swarms of the *Grimothea* stage over an area some four miles in length, the swarms being so dense as to impart a reddish tinge to the colour of the sea. This area of shoals was situated about ten miles distant from the Eddystone Rock, East Falkland, and close to the position where shoals were encountered by the R.R.S. 'Discovery' on May 4, 1926.

Whilst these shoals were under observation by the R.R.S. 'William Scoresby' Mr E. R. Gunther made the following note: "The patches were either spherical or subcircular suggesting a compact swarm of bees, or were extended into bands of irregular width. One or two feet to three or four feet was the diameter of the smaller patches, but whereas a swarm of bees is very dense and surrounded by wanderers, these swarms had a well defined edge and were less dense". This description is interesting because it

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[1] In addition there are the following three isolated records: at St. WS 761, two specimens, at St. WS 771 six specimens, at St. WS 791, one specimen.

was made independently and in complete ignorance of Young's observation on the same phenomenon in New Zealand waters in 1925. His description runs: "The smaller shoals often take a circular shape like a swarm of bees, and the incessant motion of each individual tends to heighten the illusion".

On February 17, 1932, whilst the R.R.S. 'Discovery II' was lying at anchor in Port Stanley Harbour, a shoal of *Grimothea* came alongside the vessel during darkness and was seen in the water by the light of the gangway cluster lamp which seemed to be an attraction. In the laboratories of the ships the *Grimothea* stage has been observed to display a strong positive heliotropism. The light from a hand torch would cause them to back towards it with remarkable rapidity and precision. On the other hand, on May 23, 1926, specimens were taken in horizontal tow-nets used at depths down to 90 m. at Sts. 66 and 67 which do not corroborate this. St. 66 was made in the dark hours, and specimens were obtained at the surface, at 45 and at 90 m. St. 67 made during daylight hours yielded specimens at 45 and 90 m. On both occasions the largest catches were in the deepest nets. The degree of heliotropism, should any exist, in the pelagic form of *M. gregaria* may vary according to the stage in development, and a specimen positively heliotropic in February might exhibit a very different reaction to light in May.

The swarm of *M. gregaria* from which the specimens obtained at Sts. 66 and 67 were taken was evidently being swept away from suitable and favourable habitats. It was already 300 miles from the nearest land in water of a greater depth than 4000 m. and under the influence of the Falkland current which would continue to carry it to the north-east. It has been shown that *M. gregaria* is a shallow coastal water form, and it would seem that individuals of a swarm such as this, which had been swept away from the adult habitat, would fail in the normal fulfilment of their life history.

LIST OF REFERENCES

Anderton, T., 1907. *Observations on New Zealand Fishes made at the Portobello Marine Fish Hatchery.* Trans. Proc. N.Z. Inst., xxxix, pp. 485, 486.

Benedict, J. E., 1903. *Descriptions of a new genus and forty-six new species of Crustaceans of the family Galatheidae, with a list of the known marine species.* Proc. U.S. nat. Mus. xxvi, pp. 244, 308, 314.

Buchanan-Wollaston, H. J., and Hodgson, W. C., 1929. *A new method of treating Frequency curves in Fishery Statistics, with some results.* J. Cons. int. Explor. Mer, iv, 2, pp. 207–25.

Chilton, C. 1905. *Note on the function of the last pair of thoracic legs in the Whale Feed* (Grimothea gregaria). Trans. Proc. N.Z. Inst., xxxvii, p. 320.

—— 1909. *Crustacea of the Subantarctic Islands of New Zealand.* The Subantarctic Islands of New Zealand (Wellington), ii, pp. 612, 613.

—— 1911. *Scientific Results of the New Zealand Government Trawling Expedition,* 1907. *Crustacea.* Rec. Canterbury [N.Z.] Mus., i, 3, pp. 301–3.

Cunningham, R. O., 1871. *Notes on the Reptiles, Amphibia, Fishes, Mollusca and Crustacea obtained during the voyage of H.M.S. 'Nassau' in the years* 1866–69. Trans. Linn. Soc. Lond., Zool., xxvii, p. 495.

Dana, J. D., 1852. *Crustacea of the U.S. Exploring Expedition* (Philadelphia), pp. 478, 483, pl. xxx, figs. 7 *a–c*, pl. xxxi, figs. 1 *a–c*.

Gurney, R., 1924. *Decapod Larvae.* Reports of the British Antarctic ('Terra Nova') Expedition, 1910, ix, pp. 175, 176.

Hamilton, J. E., 1934. *The Southern Sea Lion,* Otaria byronia *(de Blainville).* Discovery Rep., viii, 295, 296.

Hansen, H. J., 1897. *Reports on dredging operations off the west coast of Central America...by the 'Albatross'...Isopoda.* Bull. Mus. comp. Zool. Harvard, xxxi, p. 118, pl. v, fig. 2.

Henderson, J. R., 1888. *Anomura.* Rep. Sci. Results Voyage H.M.S. 'Challenger', Zool., xxvii, p. 124.

Herrick, F. H., 1895. *The American Lobster. A study of its habits and development.* Bull. U.S. Fish. Comm. xv, pp. 1–252, 54 pls, 38 figs.

Hutton, F. W., 1878. *On collections from the Auckland and Campbell Islands.* Trans. Proc. N.Z. Inst., xi, p. 340.

Klaehn, J., 1911. *Ueber die Meeresströmungen zwischen Kap Horn und der La Plata-Mündung.* Ann. Hydrogr. Berl., pp. 647–65, 4 pls.

Lebour, M. V., 1930. *The Larvae of the Plymouth Galatheidae.* I. *Munida banffica, Galathea strigosa* and *Galathea dispersa.* J. Mar. biol. Ass. U.K., xvii, pp. 175–87, 3 pls.

Lenz, H., 1902. *Die Crustaceen der Sammlung Plate (Decapoda und Stomatopoda). Fauna Chilensis.* Zool. Jahrb., Suppl. 5, p. 744.

Matthews, L. H., 1932. *Lobster Krill, Anomuran Crustacea that are the food of Whales.* Discovery Rep., v, pp. 467–84, 1 pl., 1 fig.

—— 1934. *The Marine Deposits of the Patagonian Continental Shelf.* Discovery Rep., ix, pp. 175–206, 13 pls.

Miers, E. J., 1881. *An Account of the Crustacea collected during the Survey of H.M.S. 'Alert'.* Proc. zool. Soc. Lond., p. 73.

Milne-Edwards, D., 1891. *Crustacea.* Mission Scientifique du Cape Horn, 1882–3, vi, (F), pp. 32–7.

Nierstrasz, H. F., und Brender à Brandis, G. A., 1923. *Die Isopoden der Siboga-Expedition.* II. *Isopoda Genuina.* I. *Epicaridea.* Siboga Expeditie, xxxii *b*, p. 78.

Ortmann, A. E., 1911. *Crustacea of Southern Patagonia.* Rep. Princeton Exped. Patagonia, 1896–9, iii, Zool., 6, pp. 659, 660.

Pérez, C., 1927. *Évolution postlarvaire des pléopodes chez les Galathées.* C.R. Acad. Sci., Paris, clxxxiv, pp. 703–5, 1 fig.

Richardson, H., 1904. *Contributions to the Natural History of the Isopoda.* Proc. U.S. nat. Mus., xxvii, pp. 83, 84.

Sars, G. O., 1890. *Bidrag til Kundskaben om Decapodernes Forvandlinger.* II. Munida. Arch. Math. Naturv., xiii, pp. 132–201, 7 pls.

SARS, G. O., 1899. *An Account of the Crustacea of Norway.* II. *Isopoda.* (Bergen).

SELBIE, C. M., 1914. *The Decapoda Reptantia of the Coasts of Ireland.* Part I. *Palinura, Astacura and Anomura* (*except Paguridae*). Fisheries, Ireland, Sci. Invest., p. 68, pl. XI, figs. 11, 12.

STEBBING, T. R. R., 1914. *Crustacea from the Falkland Islands collected by Mr Rupert Vallentin.* Part II. Proc. zool. Soc. Lond., pp. 346, 347.

—— 1919. *Crustacea from the Falkland Islands.* Part III. Proc. zool. Soc. Lond., p. 331.

STEPHENSEN, K., 1913. *Report on the Malacostraca Collected by the 'Tjalfe' Expedition*, etc. Vidensk. Medd. naturh. Foren., Kbh., LXIV, pp. 130–4.

THOMSON, G. M., 1899. *A revision of the Crustacea Anomura of New Zealand.* Trans. Proc. N.Z. Inst., XXXI, pp. 193–5.

WAITE, E. R., 1911. *Scientific Results of the New Zealand Government Trawling Expedition*, 1907. *Outcome of the Expedition.* Rec. Canterbury [N.Z.] Mus., I, 3, p. 266.

WEBB, G. E., 1921. *The Larvae of the Decapoda Macrura and Anomura of Plymouth.* J. Mar. biol. Ass. U.K., XII, N.S., p. 398.

WILLIAMSON, H. C., 1915. *Decapoden.* I. Teil (*Larven*). Nord. Plankt., VI, pp. 456–66.

YOUNG, M. W., 1925. *Notes on the habits of Whale-feed* (Munida gregaria). *Marine Biological Notes.* N.Z. J. Sci. Tech., VII, pp. 318–19.