U.B. BERGEN
Nr. 250

Tillates innlemmet i U.B.B.'s manuskriptsamling.
Bergen 24/4 - 68
Are Dommasnes

HOVEDFAGSOPPGAVE

I MARIN ZOOLOGI

TIL

MATEMATISK-NATURVITENSKAPELIG

EMBETSEKSAMEN

ON THE FAUNA OF *CORALLINA OFFICINALIS* L.

by

Are Dommasnes

CONTENTS

ABSTRACT

The fauna of *Corallina officinalis* has been studied at three localities south of Bergen, Norway. A list of species is given. A distinct distribution pattern is shown for some species, and this is discussed with reference to the wave exposure. The feeding-biology of the fauna is also discussed and some suggestions are given for future research on the fauna of *Corallina officinalis*.

INTRODUCTION

When this research work started, my intention was to find (1) which animals lived in the *Corallina* growths (2) how the fauna varied with wave exposure (3) how the fauna varied with depth and (4) the seasonal variations during the year. Actually, point (4) was the main purpose of the work, and it also proved to be the most troublesome.

When I started taking samples in January 1965, I had not yet finished the obligatory studies in town, and had little time to sit at Espegrend looking at animals. In the autumn of 1965, when I started sorting samples and identifying animals, I soon encountered the first difficulty: There was "too much" variation in the results from samples taken at the same place: In one sample there could be relatively high numbers of a particular species, in the next none - and then it reappeared in a third sample. The samples obviously were not comparable - one could not safely draw conclusions from the differences between two samples taken from the same place at different times. The remedy for this could be to take larger samples - or to take many small samples from each place. Both alternatives involved more work - and the examination of each of the samples I already had took more than one week. I chose a variation of the second alternative: I examined several of the samples I already had and combined all samples from one place. This meant that I could not find out anything about the seasonal variations because the samples, uncombined, were too small, and combined they could of course not give any such information. But I should still be able to work with points (1), (2), and (3). Later it turned out that, with samples only at two depths at the same place, I could not find out much about how the fauna varied with depth either.

What appears here is then (1) an account of which animals were found in the _Corallina_ growths and (2) an attempt to explain differences in the faunas of the localities out from differences in wave exposure. In a few cases I can also show seasonal variations and depth preferences.

Previous studies of the fauna of _Corallina_ have mostly been parts of general surveys of the algal fauna in particular regions. SLOANE et al. (1961) investigated the fauna of different algae, among them _C. officinalis_, in an area of rapids. They were able to show that some species have a preference for rapid currents and others prefer quiet water. RUFFO and WIESER (1952) sampled several algal species, among them also _C.mediterranea._ WIESER (1959) also mentioned that he had sampled _C. mediterranea_. CHAPMAN (1955) sampled _C. granifera_ from an exposed shore on the Azores, but took only one sample.

THE LOCALITIES

My samples were taken at three localities south of Bergen. The localities can be classified as "very sheltered", "semi-exposed" and "very exposed", respectively.

The innermost locality, number 1 (Fig. 1), is in Raunefjorden just outside the Biological Station. There is almost no wave exposure. No open stretch of water leads in to the locality, but some waves come from passing small boats. Because of the lack of exposure considerable quantities of sediment have accumulated. Most of it is probably humus that has come out with a small stream at the Biological Station.

Locality 2, in Fanafjorden, is considerably more exposed. The waves can travel in through Korsfjorden from the ocean, and although they lose much of their force on the way in, the surf can be very rough at this locality on stormy days. Wind from the south can also set up large waves through the fjord system. As a result, there is almost always some surf, but most of the time not very heavy.

The outermost locality, number 3, is on a small island on the open shore and there is nothing outside to lessen the force of the waves. Sampling *Corallina* from the shore there is possible only a few days a year. Sampling at 5 m is easier, but that also could be done only on calm days.

The algal zonation was not constant, with *Corallina* occupying different levels in the different localities. (Fig. 2).

At the sheltered locality 1 *Corallina* is found in a distinct zone from 0.6 m to about 1.1 m below mean tide level.

At locality 2 *Corallina* is found in two zones. Its upper zone occurs as an undergrowth in a zone of *Fucus vesiculosus* L. and *Fucus serratus* L. from mean tide level and down to about 0.5 m. Below, in the zone of *Alaria esculenta* (L.) GREV. and *Laminaria digitata* (HUDS.) LAMOUR only a few *Corallina* plants occur. Below that there is a broad zone of *Corallina* going down to at least 3 m, and then other algae take over.

At the most exposed locality, number 3, the zonation looks much simpler. Uppermost is a broad zone of *Verrucaria*. Below is a number of other algae - the species depend on the topography or on the exposure at just that spot. Then come the zones shown in Fig. 2. The upward extension of *Corallina* is also dependent on the local topography. Downwards, the

Corallina zone stops where the Alaria esculenta zone begins, at about mean tide level. In the Alaria zone there is no Corallina. Probably the Alaria plants, sweeping over the rock with the waves, prevent settling of other plants. In the zone of Laminaria hyperborea (GUNN.) FOSL., Corallina is found as an undergrowth. It goes down at least to 20-30 m, but the growth is very scattered at that depth.

The Corallina plants seem to be very sensitive to desiccation, and the rise of the upper Corallina zone at localities 2 and 3 is probably only possible because the waves keep the plants wet even at low tide. The Corallina plants in the upper zones at localities 2 and 3 grow very compactly (Fig. 3), thus gaining an extra protection against desiccation. The structure is reinforced by small Modiolus modiolus L. and Musculus discors L. with shells ranging from about 2 to 12 mm.

The different wave exposure at the three localities can be observed during sampling and deducted from a map of the area. But it is very difficult to say anything about the water movements to which the animals living among Corallina are exposed. One knows that, due to friction, water movements are slower near the bottom than higher up in the water. Probably there is also a gradient inside the Corallina growth, with swifter currents near the tops of the plants than at the roots. This gradient must to a large extent be determined by the compactness with which the plants are growing. Obviously, in a compact growth the water movements are slowed down much more than in a scattered growth.

At locality 1 samples were taken from the upper part of the Corallina zone, at about 0.6 m below Mean Tide Level. At localities 2 and 3 samples were taken from 0 m and 2.5 m and from 0 m and 5 m below MTL respectively.

For the rest of this work I will adopt the term "station" for each sampling site, although this term is not commonly used that way. The "stations" will be identified by numbers and letters like this:

Locality and depth	Station
Locality 1, 0.6 m	1
Locality 2, 0 m	2A
Locality 2, 2.5 m	2B
Locality 3, 0 m	3A
Locality 3, 5 m	3B

THE GROWTH TYPES OF *CORALLINA OFFICINALIS*

The *Corallina* plants at the different stations had different appearances, as shown in Fig. 3. The quantity and type of sediment (organic and inorganic material) deposited between the algae also varied considerably.

The characteristics of the growths at the different stations can be summarized like this:

Station 1: Moderately compact growth, normally long plants. Relatively heavy sedimentation of organic material. No macroscopic epiphytes.

Station 2A: Very compact growth, short plants. Some sedimentation of shell fragments, mostly from Mytilidae. Some macroscopic epiphytes.

Station 2B: Moderately compact growth, normally large plants. Some sedimentation of sand and shell fragments, mostly from Mytilidae. *Dichtyota dichetoma* (HUDS.) LAMOUR occurred in some samples in large quantities as an epiphyte on *Corallina.*

Station 3A: Very compact growth, short plants. Some sedimentation of shell fragments, mostly from Mytilidae. No macroscopic epiphytes.

Station 3B: Very scattered growth, with perhaps only two or three plants per square decimeter. Plants normally long, and very slender. No sedimentation. Macroscopic epiphytes in one sample.

TEMPERATURE AND SALINITY

The temperature was measured and water samples were taken at the same time as the Corallina samples - but only near the surface, as the largest variations were likely to occur there. Salinity was determined from the water samples with a gold-thread aerometer.

The variations in temperature and salinity at the three localities are shown in Fig. 4. The temperature range was about the same at all localities, but the salinity range was slightly smaller at locality 3 than at the other localities - probably due to less drain-off from land after heavy rain.

The most extreme variation in salinity, found at locality 2, was from 28 ‰ to 35 ‰. Most of the time the salinity was over 30 ‰. Even 26 ‰ is probably tolerable for most littoral and sublittoral animals if it does not last for a long time.

It is possible that the variation in temperature makes some of the animals inhabiting Corallina migrate downwards during the coldest part of the year. This can be seen at least in the case of larger animals that are easier to observe, like some fishes (Labridae) and the crab Cancer pagurus LEACH.

COLLECTION AND EXAMINATION OF THE SAMPLES

The 2.5 and 5 m samples were obtained by skin-diving, the others could be taken by wading out from the shore. The samples were taken by enclosing small tufts of Corallina in a plastic bag and then detaching them from the rock by means of a knife or by tearing them off. At station 3B where the growth was more sparse, I had to pick the plants by hand and put them into the bag a few at a time. I could see that I lost some animals in this way, but most of them probably clung to the Corallina every time there was any danger, and thus would stay with the samples.

Immediately after the samples had been brought to the laboratory, they were fixed in 4 per cent formalin, and then stored for examination.

The samples were examined under a microscope with 12X magnification. Each branch was examined separately and the deposits in the jars were examined under higher magnification to get an estimate of the quantities of smaller forms like harpacticoids and ostracods. In the samples from Steinskjær there was so much sediment that it was difficult to find the animals and make a good estimate.

To have a means of quantity reference between the samples the volume of each sample was measured (after the animals had been sorted out): a graded cylinder was filled with water to a known level; the Corallina sample, which had been lying on a filter paper for about an hour to drain off excess water, was put into the cylinder and the rise of the water surface noted. The samples usually had to be measured in two or three portions to allow the use of a small cylinder graded for every 0.1 ml. The volumes of the samples ranged from 4 to about 20 ml.

The numbers of each species found was multiplied by a factor to give the numbers for 20 ml samples.

Some species were not counted. These are all the species belonging to the groups Foraminifera, Hydrozoa, Actinia, Nematoda, Polychaeta, Ostracoda, Harpacticoida, Halacarida, Chironomida and the Bryozoa.

For these animals, where they were present, I used a system of categories, ranging from I to IV. The species or the group was placed subjectively in one of the categories according to the "general impression" of its abundance in the sample. Both the size and the numbers of the animals of course influenced the impression of the quantity. The determination of the category in which a species should be placed was made in relation to the size of the sample and was therefore not standardized together with the counted numbers to "20 ml samples".

To show my results in tables I have used a parallel system of categories for the animals I have counted; this also goes from I to IV. Category I represents 1 to 5 animals, category II represents 6 to 25, category III represents 26 to 100 and category IV represents more than a hundred animals per 20 ml algae.

For most purposes, I have combined all the samples from one site. Here again I have used the system of categories. For the animals counted, I have added up the numbers of each species found in each sample, and then divided the sum by the number of samples. If, for example, the result is in the range from 6 to 25 I place that species in category II.

For the species that had initially been placed in categories, and not counted, I had to use another method: The arithmetic means of the categories for the counted animals were: for category I (1+5)/2 = 3, for category II (6+25)/2 = ca. 16; for category III (26+100)/2 = 63; and for category IV I have taken a "mean" of 200, although there is no upper limit to the numbers incorporated in this category. I have also used these values for those animals not counted: to combine several samples I have, for each species or group, added up the means of its categories for all samples at that station, and then divided the sum by the number of samples. The category for the samples combined was then determined according to this result.

For example: For the group Nematoda at station 3B we have (see Fig. 14):

23 July 1965:	category	I	with mean	3
6 September 1965:	"	II	" "	16
29 September 1965:	"	III	" "	63
			Sum of means:	82

The "mean" for the samples combined is then 82/3=ca.27, which is just within the range for category III.

The example also gives an idea of the inexactitude of this method. On the other hand, I do not think the way I have taken the samples justifies a more exact method of estimation, because many animals fall off during sampling. The small size of the samples also makes them rather inaccurate.

One of the samples from station 2A - 1 November 1965 - has been omitted from all the tables showing the distribution of the animals. Because of too large waves I had to take this sample at a less exposed site than the other 2A sample and the 2B samples. If shows a fauna that in many respects is quite different from that of the other 2A sample, and for that very reason I think it is useful, because it illustrates the uncertainties in an investigation like this.

THE FAUNA

Foraminifera

Foraminifera were found at all the stations. They seemed usually to be adhering to the Corallina plants and their epiphytes, although some fell off during fixation.

At station 1 there were large quantities of Foraminifera, corresponding to category IV - at the other stations mostly categories II and III. The quantities showed no great variations during the year.

Cnidaria.

Hydrozoa were sparse in my samples. They were found in small numbers in some samples from stations 2B and 3B. At station 2A large numbers of hydrozoan stalks were found in the sample from 1 november 1965, but there were no living animals.

A few small Actinia were found in some samples from stations 1, 2A, 3A and 3B.

Turbellaria

When watching fresh samples where the animals were not killed, I could see some turbellarians creeping around on the algae. They occurred in samples from all sites, but were destroyed during fixation.

Nemertini.

In fresh samples from station 1 I also found some nemertines, among them Lineus longissimus GUNNERUS.

Nematoda

Nematoda were found at all stations. There was a weak tendency towards larger quantities at stations 2A, 3A and 3B, which were most exposed. This was unexpected, but is difficult to comment on without knowledge of the species involved. Also unexpected was the scarcity of Nematoda at station 1, because WIESER (1959) showed that Nematoda usually make up a much larger part of the fauna in localities with much sediment than in localities with only small amounts.

Polychaeta

Serpulids were found at every station except 3B.

Spirorbis corallinae de SILVA and KNIGHT-JONES was by far the most common polychaete in my samples. This species, which was described in 1962, has not previously been reported from the Norwegian coast - but no work on Spirorbinae from Norway has been published since then.

At station 1 S. corallinae was relatively sparse. At stations 2A, 2B and 3A it was more common - in some samples very common. At station 3B I found neither S.corallinae nor any other serpulid in any of the samples. This may have been because the much more slender Corallina plants at this station were laid flat against the rock by the currents caused by wave exposure and thus would have brought serpulids living on them in contact with the bottom. Spirorbis retreats into its tube immediately if anything larger than food particles comes in contact with its tentacles. As station 3B is subject to strong wave action almost constantly, Spirorbis living on Corallina there would have had to stay inside their tubes all the time, and would have starved to death. (I have watched by diving how the Corallina plants at station 3B were laid flat by wave currents. The time taken by the currents to shift and lay the plants flat the other way was very short, much shorter than the time Spirorbis take to get out of their tubes again after they have been disturbed, as observed in the case of animals in a petri-dish.) The very compact structure of Corallina at 0m (stations 2A and 3A) prevents the plants from being laid flat, and probably also prevents any movement of the plants and rubbing between them. Furthermore, S. corallinae sits mostly on the middle part of the plants, which is well protected against rubbing, as that would mostly affect the smaller branches near the top.

S.pagenstecheri QUATREFAGES was found in all samples from station 1, but it was always second in number to S.corallinae. It was not found at the other stations. According to de SILVA and KNIGHT-JONES (1962) S.pagenstecheri can be found "very abundantly on Corallina officinalis in rock pools in the upper half of the shore" (loc.cit. page 607). They also write that "of the various species Spirorbis pagenstecheri seems the most tolerant of turbid estuarine conditions" (loc. cit. page 605). Although the salinity at station 1 is never low enough to justify use of the term "estuarine" it can probably be quite low for short periods after heavy rain. Rain also brings turbidity from suspended sediment, so maybe S.pagenstecheri is better adapted to live here than at the other localities (although even here S.corallinae occurs in larger numbers).

S.granulatus (L.) was found in two samples from station 2B. This species is difficult to distinguish from S.corallinae without crushing the tube. It is therefore very possible that it has escaped my attention in other samples.

At station 2B one specimen of S.tridentatus (LEVINSEN) was also found.

Small numbers of Pomatoceros triqueter (L.) and Hydroides norvegica (GUNNERUS) were found in some samples from station 2B.

The group "Polychaeta non Serpulida" consists of errant polychaetes and some species that probably live in tubes but leave them when formalin is added to the samples. The species belonging to "Polychaeta non Serpulida" are either very small or represented only by very small individuals.

At station 1, in the sample from March 1965 there were only a few small non-serpulid Polychaeta, but in the samples from June and September there were much larger numbers. The increase was due to the occurrence of relatively large specimens of Nereis sp.

At station 2A there were only a few non-serpulid polychaetes in one sample but quite a number in the other, and representatives of the following families were recognised: Nereidae - 10 specimens; Syllidae - 6 specimens and Phyllodocidae - 1 specimen.

At station 2B there were also large variations in the number of non-serpulid Polychaeta with a maximum in the samples from June and September and fewer or none in the samples from January and May.

In the samples from stations 3A and 3B non-serpulid Polychaeta were relatively scarce.

Harpacticoida.

Harpacticoida were found in all samples. The quantities were mostly in categories II and III.

In the sample from station 2B, 16 June 1965, the following 11 species were found:

Zaus aurelii POPPE
Tisbe furcata (BAIRD)
Scutellidium hippolites (KRÖYER)
Parathalestris sp.
Parathalestris harpactoides (CLAUS)
Dactylopodia vulgaris var. *dessimilis* BRIAN?
Parastenhelia spinosa (FISCHER)
Amphiascus minutus (CLAUS)
Ameira longipes BOECK
Mesochra pygmaea (CLAUS)
Laophonte inopinata T.SCOTT

Ostracoda.

Ostracoda were found at all stations and in almost all samples. The quantities varied, but no regular pattern could be seen. The variation in numbers may to some extent be due to loss of animals during sampling. HAGERMAN (1966) mentions that Ostracoda close their shells and fall off the algae if they are disturbed. Although I closed the plastic bags very soon after detaching the samples, sufficient numbers may have fallen off to affect my estimates of the quantities.

Several species of Ostracoda, of different size and shape, seemed to be present.

Isopoda

Several species of Isopoda were found, and the group probably makes up an important part of the Corallina fauna.

Three species of Idotea were found. They are Idotea pelagica LEACH, Idotea baltica (PALLAS) and Idotea granulosa RATHKE. Their distribution is shown in Fig. 5.

Although no Idotea were found in the Corallina at station 1, I.granulosa is common among Ascophyllum at that locality.

The complete absence of I.granulosa and I.pelagica from the samples from station 2B is puzzling. Their presence at station 3B shows that they are able to thrive at that depth and their occurrence in the 3A samples shows that they are also able to live in Corallina growing more compactly than that found at station 2B. On the other hand, I.baltica seems to thrive at station 2B.

The occurrence of I.pelagica and I granulosa at station 3B shows that both species tolerate a high degree of exposure.

Ianiropsis breviremis G.O.SARS has been found at all the localities. Its distribution seems not to be influenced by wave exposure, which means that it must be able to cling tightly to the substrate when there is water movement. G.O. SARS (1899) writes about this species, that "at Bratholmen, it occurred in considerable numbers on the roots and stems of Laminaria overgrown by Hydroids and Polyzoa". This may indicate that I.breviremis likes to have small structures (like hydroids, Polyzoa and Corallina) to cling to.

Jaera (albifrons) praehirsuta FORSMAN was found at all three localities, - but at station 1 only in one sample and at the other two localities only in the 0m samples (stations 2A and 3A). It therefore seems that J.praehirsuta is primarily a littoral species and that it can stand a high degree of exposure (although the exposure may be reduced by the compactly growing Corallina).

BOCQUET (1953) showed that the different colour patterns of the Jaera species are genetically determined. The colour patterns found in my material agree exactly with the forms BOCQUET named uniforme and bifasciatum. Uniforme was most abundant, and at station 3A bifasciatum was not found at all.

Specimens of J. praehirsuta from two samples have been measured and their sex determined. The results are shown in histograms in Fig. 6. In March there were few very small specimens, but in July there were many, and four of the large females had eggs. This indicates that breeding had not yet started in March, but was nearly finished in July. It should, however, be noted that the two samples are from different stations - probably with different populations and maybe slightly different breeding times.

A few specimens of Munna boecki KRÖYER were found in a sample from station 1. Larger numbers were found at station 2B with a maximum of 52 per 20 ml algae in the sample from 16 June 1965. This species was not found at stations 2A, 3A or 3B - indicating that the species is sensitive to wave exposure, as one would expect. Crustaceans with long, thin legs and antennae like Munna provide so much resistance to the water that they probably can not cling to the substratum in fast-moving water. Their legs may also get entangled. Reasons for not finding M. boecki in larger numbers at station 1 are more difficult to imagine, but water movement is probably not involved. Both wave exposure and tidal currents are weak at this station.

Tanaidacea

The only tanaid found was Tanais cavolinii H. MILNE-EDWARDS, which was found in one sample from station 2A and in one sample from station 3A - only a few specimens in the latter sample. A total of 42 specimens was found, and only two of these were males.

T.cavolinii seems to prefer very compactly-growing Corallina. It seems to be very tolerant of wave exposure, with an occurrence ranging from the most extreme exposure at locality 3 to very sheltered polls. But, as mentioned previously, it is possible that most of the impact of the waves is absorbed by the Corallina, so that the animals living inside are not really subject to such strong exposure as one might expect.

Amphipoda.

Several species of amphipods were found.

Stenothoe monoculoides (SP.BATE) was present at all sites and did not seem to be affected by wave exposure (Fig. 12). It has quite strong legs and strong claws, making it well adapted to cling to the algae. It is also a good swimmer.

Two species of the genus Apherusa were found (Fig.12). Apherusa bispinosa (SP.BATE) was found at stations 1 and 2B only. These were the stations with least wave exposure. Apherusa jurinei (MILNE-EDWARDS) occurred at all stations, seemingly independent of wave exposure.

Two Dexamine species, D. spinosa (MONTAGU) and D. thea BOECK were found. It is known that D.spinosa is a detritus-feeder (ENEQUIST 1950). The two species are very alike in appearance and mouth-parts, so this is probably valid for D.thea also. D.thea was by far the more commonly found of the two, but it occurred only at stations 1 and 2B.

I found altogether three specimens of the genus, Gammarellus. At station 2B I found one specimen of Gammarellus homari (I.C.FABRICIUS) and at station 3B two specimens of Gammarellus angulosus (RATHKE).

Hyale nilssoni RATHKE and Hyale pontica RATHKE were found at locality 3 - and only there. H. nilssoni was found only once - a few specimens at station 3A. H.pontica was found in both samples from station 3A and in one sample from station 3B.

A few specimens of the two amphipods, Sympleustes glaber (BOECK) and Tryphosa sarsii (BONNIER), were found in one sample from station 2B.

Four tube-living amphipods were found. They were Ampithoe rubricata (MONTAGU), Parajassa pelagica (LEACH), Jassa falcata (MONTAGU) sensu SEXTON and REID (1951) and Corophinum bonelli (MILNE-EDWARDS). They show very different tolerances to wave exposure (Fig. 7). The least tolerant is clearly C.bonelli. This species builds its tube of mud. A mud-tube is unlikely to stand much exposure, so that C.bonelli is unable to live at stations 3A and 3B for that reason. It also has relatively weak gnathopods which will not enable it to cling as well as the other tube-living amphipods to algae when it is outside its tube. Its long 5th, 6th and 7th pereiopods also provide resistance to water currents. C.bonelli is a suspension feeder (ENEQUIST 1950).

A.rubricata, J.falcata and P.pelagica seemed to be able to stand exposure in the order shown, P.pelagica and J.falcata being the most tolerant of exposure. These three species live in tubes of "amphipod silk" secreted from their pereiopods 3 and 4.

A. rubricata is known to feed on algal fragments which drift within reach of its tube, but it also eats living algae and it may turn carnivorous (SKUTCH 1926). J.falcata and P. pelagica have been observed in petri-dishes to grasp pieces of algae and everything else brought within reach of their tubes, as does A.rubricata also. They probably feed, therefore, in the same way as A.rubricata, but it is possible that they are also suspension-feeders. P.pelagica in particular has very setose antennae that seem ideal for filtering. It cleans them often by pulling them through the half-closed claw of the first gnathopod, but I have not been able to see if anything is carried to the mouth. A. rubricata and J.falcata also make these "cleaning movements", but their antennae are less setose.

SKUTCH (1926) described how females of A.rubricata expelled their offspring very soon after they emerged from the brood-pouch, whereupon the young ones started building their own tubes. If this is usual practice for all three species, the period between the expulsion of the young and the completion of their own tubes is critical. One of the greatest dangers is that the young animals can be swept away from the coast by waves. This danger is particularly great at locality 3, where there is strong wave action practically every day in the year. At this locality, therefore, only the species that are best adapted to cling to the algae can survive.

When looking at these three species in petri-dishes (outside their tubes) I have seen that they use their gnathopods for clinging to the algae both when they are moving about and when they are sitting quietly. Animals moving from one piece of alga to another hold on to one piece of alga with their 5th, 6th and 7th pereiopods while they stretch out and grasp the other piece with their gnathopods, whereupon they pull themselves over to that piece. When they are moving on the same piece of alga or sitting quietly they also use their gnathopods to grasp whatever they can find (Figs. 8

and 10). It is therefore obvious that the strength of the gnathopods (which probably depends mostly on their size) is one of the most important factors contributing to these amphipods' ability to survive in exposed habitats. In this respect I think A.rubricata is inferior, because it has much smaller second gnathopods than J.falcata and P.pelagica. The proportional difference between juveniles of A.rubricata and P.pelagica is similar to that between females, as shown in Fig.8. Jassa falcata has gnathopods of about the same size as P.pelagica. It is therefore very possible that A. rubricata does not occur at locality 3 because the juveniles have such weak gnathopods that they are not able to cling to the algae there and build a tube. Even the adults do not always stay in their tube. The continuation of the species requires, for example, that the males leave their tubes for periods of time and seek out the females. At locality 3 this also calls for great ability to cling to the algae.

Caprella linearis (L.) was found in some of the samples from station 2B.

Phtisica marina SLABBER was found in a sample with many epiphytes from station 2B. I have on other occasions found this species in extremely large numbers on Desmarestia.

Decapoda

Three species of Anomura were found - but never more than one or two specimens in each sample.

Pagurus bernhardus (L.) was found at station 1 on 25 March 1965.

Galathea intermedia LILLJEBORG was found at station 2B on 17 January 1965.

Porcellana longicornis (L.) was found in four of the samples from station 2B.

One specimen of the brachyuran, Pirimela denticulata (MONTAGU), was found at station 2B on 23 May 1966.

Insecta

A few chironomid larvae were found at stations 1 and 2A.

Halacarida

Halacarida were found at all stations. The quantities varied much from sample to sample, even at the same station - and in some samples none were found at all. At least two species, very different in size and morphology, were found.

Pycnogonida

One species of Pycnogonida was found - Phoxichilidium femoratum (RATHKE). It occurred in large numbers only in the sample from station 2A taken on November 1965. The Corallina in this sample was woven together by a net of hydroid stalks - but I found no living hydroids. They had probably been eaten by the pycnogonids.

At locality 3 there were no pycnogonids among the Corallina - possibly because of the wave exposure.

Gastropoda

18 species of prosobranchswere found, most of them in small numbers only.

Margarites helicinus (FABRICIUS) was found at station 2B (only once) and at stations 3A and 3B.

A few juvenile specimens of Gibbula sp. were found at station 2B in the samples from June and September.

Some specimens of Lacuna vincta (MONTAGU) were found at stations 2B, 3A and 3B. It was found in all samples from station 3B, the numbers ranging from 16 to 27 per 20ml. That probably means that L.vincta occurs regularly among Corallina at this site. It is herbivorous, collecting food from the surface of weeds and from rocks and stones (FRETTER and GRAHAM 1962).

Littorina saxatilis (OLIVI) and Littorina obtusata (L.) were found in small numbers at station 2A.

Cingula semicostata (MONTAGU) was found at stations 2A (one specimen) and 2B (2 specimens).

Two specimens of Alvania punctura (MONTAGU) were found at station 2B.

Two species of Rissoa were found. Rissoa inconspicua ALDER was found at stations 2A and 2B. In a sample from 17 January 1966 at station 2B there were more than 90 specimens per 20 ml of algae. Rissoa parva (da COSTA) was found at all stations except 3B. At station 1 only one specimen was found. At station 2A there were a few specimens in each of the two samples, but at 2B R.parva was found in five of the seven samples with a maximum of 27 per 20 ml of algae in one sample. Both of these species are known to be herbivorous (FRETTER and GRAHAM 1962).

Skeneopsis planorbis (FABRICIUS) was found at all stations except 3B. The species seems to be able to survive in very exposed habitats - although the Corallina growth gives some protection. It may be absent from station 3B because the Corallina there does not form such a compact growth and thus gives less protection against water movement.

Particularly large numbers of S.planorbis were found at station 2A in the sample taken on 1 November 1965. This sample was from a relatively sheltered habitat which at very low water formed a rock-pool (15-20 m away from the place where the other 2A sample was taken). It is probable that larger quantities of sediment accumulated among the Corallina plants here than on the steeply sloping shore where the other sample from station 2A was taken. This may give an explanation of the large numbers of S.planorbis at this site because the species is known to feed on diatoms, algal fragments and detritus (FRETTER and GRAHAM 1962).

Two specimens of Omalogyra atomus (PHILIPPI) were found at station 2B, and one specimen of Ammonicera rota (FORBES and HANLEY) at station 1.

Some specimens of Rissoella opalina (JEFFREYS) (?) were found in one sample from station 2B.

Juvenile specimens of Nucella lapillus (L.) were found in small numbers at stations 2A, 3A and 3B.

A few species of opisthobranchs were found. Most of them belong to the family Pyramidellidae, known to be ectoparasites on molluscs and polychaetes with calcareous shells or tubes. No species occurred in all of the samples from one site, and no opisthobranch was found in large numbers.

The pyramidellids found were: Chrysallida spiralis (MONTAGU), 1 specimen from station 2A; Odostomia eulimoides HANLEY, a few specimens from station 2B; Odostomia scalaris MACGILLIVRAY, from stations 2A and 2B; Odostomia turrita HANLEY from station 2B. The last species occurred in relatively large numbers (18 per 20 ml algae in one sample taken on 17 January 1966).

A few specimens of the saccoglossan, Limapontia capitata (MÜLLER) were found at station 2A.

The nudibranch Doto coronata (GMELIN) (?) was found in one sample from station 3B. This species is almost unrecognizable after fixation, and it may well have escaped my notice in other samples.

A small nudibranch, not identifiable, was found in another of the samples from station 3B.

Bivalvia.

The bivalves, because of the size of some of them, made up a considerable part of the biomass, even in samples where they did not occur in large numbers.

A few very small specimens of Anomia sp. were found on Corallina from station 2B.

Small Mytilus edulis L. were found in large numbers at station 2A in the sample taken on 1 November 1965. They ranged in size from less than one to 17 mm. Most of them were 1-3 mm. A few M.edulis were also found in one of the samples from station 2B.

Modiolus modiolus L. was found in most of the samples - and at all stations, but it was less common at 2B than at the other stations. It was the only bivalve in Corallina at station 3B. It ranged in size from less than one to 11 mm. In the samples where M.modiolus was most common, all the specimens were measured. The results are shown in Fig. 11. The histograms from locality 3 show an increase in size from September to January, but most interesting is the absence of larger individuals in the September sample. This indicates that the largest animals must have migrated to other habitats between January and September. That is also natural, because M.modiolus usually grows to about 10 cm. At station 1, where Corallina was growing on stones, they only had to go down between the stones where there already lived many large M.modiolus. At the other stations they would have to migrate much farther, and many of them would perhaps never make it.

Musculus discors L. was common at all stations except 3B. This is a much smaller species than M.modiolus. According to TEBBLE (1966) its maximum size is 1/2 inch (1.27cm). Many of the animals I found were almost that size and thus were probably mature. M.discors should therefore be able to stay among Corallina for the entire life-span after the pelagic larval stages.

Hiatella sp. was also found at all sites except station 3B, but never in large numbers. The specimens found were always small, never more than 10 mm, and were attached by their byssus in between the lower parts of the Corallina plants.

Lasaea rubra (MONTAGU) was found at station 3A on 17 January 1966, but in no other sample. TEBBLE (1966) mentions that in the British Isles it is found between tide-marks, on rocky shores.

Turtonia minuta (FABRICIUS) was found at all stations except 3B. At stations 1 and 2B only a few specimens were found, but at station 2A in the sample taken on 1 November 1965 there were 1470 specimens per 20 ml algae. At station 3A the species was also common.

All the bivalves found attach themselves to the substrate with byssus threads and, except Anomia, are well able to move around if conditions become unsuitable. While kept in an aquarium, Modiolus and Musculus tended to congregate on the branches of Corallina projecting farthest upward from the bottom.

Bryozoa

At station 2B at least one species of the family Crisiidae was found, but it was not common in any of the samples. No Crisiidae were found at the other stations.

Hornera violacea M.SARS was also found at station 2B only. It was slightly more common than the Crisiidae, although it never occurred in large quantities.

A few colonies of Electra pilosa (L.) were found at stations 2B and 3B.

Serupocellaria reptans (L.) was found, very sparsely, at stations 2B and 3A.

Hippothoa hyalina (L.) was found regularly at all sites except station 1. It was found in one of the samples from station 2A (March 1966) in relatively large quantities and in all samples from station 2B in more variable quantities. H. hyalina was also found in relatively large quantities at station 3A and in very large quantities in two of the three samples from station 3B.

The colonies of H.hyalina had exactly the same red colour as the Corallina plants they were growing on, although they are usually considered to be white (MARCUS 1940; MATURO 1959).

The reason for the complete absence of bryozoans from the samples taken at station 1 may be the relatively large amount of sediment on the bottom. This probably prevents settling of the larvae or kills them by clogging soon after. MATURO (1959) considers silting a major factor in preventing the establishment of bryozoans.

Echinodermata.

Small starfish were found in a few samples - but only one or two in each.

Pedicellaster typicus M.SARS was found in one sample from station 1 and in one sample from station 2B. The specimens were very small.

Asteria rubens (L.) (small specimens with a diameter of about 1 cm) was found in three samples from station 2B.

Leptasterias mülleri M.SARS (a small specimen with a diameter of 2 mm) was found in one sample from station 2B.

The brittlestar, Amphipholis squamata (DELLE CHIAJE) was found in several samples. All specimens were small, with a maximum radius from the centre to the tip of the arms of about 6 mm. It was found in four samples from station 2B - one to four specimens in each (not corrected to 20 ml samples).

Four specimens were also found in one sample from station 3A. At least two specimens, found at station 2B on 17 January 1966, had crept into tubes of dead Hydroides norvegica.

Ascidiacea.

In a sample from station 1 I found one Ascidia sp., about 3.5 cm long. I did not find ascidians in any of the others but I could see there were a few growing on Corallina at station 1.

It is difficult to find a reason why they were not more common, but it may be that the Corallina grew too compactly at some sites and not compactly enough at others. Single plants, as at station 3B, were probably not strong enough to carry ascidians, and they would be subject to abrasion against the rock because of wave motion.

DISCUSSION

The size of the animals

The most significant factor in determining the Corallina fauna is probably the space available in between the plants. It is evident that the compact way in which Corallina usually grows severely limits the "interstitial" space between the plants, where animals can move, and thus also limits the maximum size of the animals that can live there. One should therefore expect that the fauna of Corallina is characterized, generally, by smaller forms than the fauna of the surrounding algae and rocks, all other differences apart.

That this really is so can be illustrated, perhaps rather obviously, by mentioning some animals that did not occur in the samples, and which no one would expect to find there: No large, or even "middle-sized" crustaceans were found - the largest were some small anomurans (*Pagurus bernhardus*, *Galathea intermedia* and *Porcellana longicornis*) and a small brachyuran (*Pirimela denticulata*), none of them much more than a centimetre long. Among the surrounding algae and stones one could expect to find larger specimens from both groups. (Larger pagurids were sometimes seen walking on top of the Corallina growths.) No large nudibranchs were found, although they are not uncommon on the larger algae growing nearby.

Some of the species found can grow relatively large, but only small specimens of these occurred among the Corallina. One such example is Modiolus modiolus, large specimens of which occurred in between the stones at station 1, while only small specimens were found in the Corallina growing on these stones. At the other stations also only small specimens of M.modiolus were found (see discussion on M.modiolus p.23). Another example is Nucella lapillus, which was represented by juvenile specimens only - although at stations 2A and 3A large numbers of "adult" specimens sat on the rock half a metre away. The starfish, too, were so small that they must be termed juveniles.

These examples, I think, prove the rather obvious statement: Corallina as a habitat puts strict limitations on the maximum size of the animals that live there.

The limitation on size also means that large predators cannot reach the animals living inside the Corallina growth. For this reason I thought, when I started the investigation, that perhaps Corallina served as a "kindergarten" for juveniles of some animals that did not live there as adults. This is probably the case for Modiolus modiolus, but I have not found significant numbers of any other juveniles of species that did not also live in the Corallina growths as adults.

Effects of wave exposure.

There were considerable differences between the faunas at the five stations, and these must partly be due to different wave exposure. This has already been discussed in the comments on the different species, but I will here try to point out the more general aspects.

In Fig. 12 the distribution of some selected species is given to show how, going from locality 1 to 2, and from locality 2 to 3, some species disappeared and other species appeared. One sees that the fauna can be roughly divided into three groups: species that were found only in sheltered habitats, species that were found in both unexposed and exposed habitats, and species that were found mainly in exposed habitats.

To the first group belong five species that were found only at stations 1 and 2B. They were *Corophium bonelli*, *Dexamine thea*, *Apherusa bispinosa*, *Munna boecki* and *Ampithoe rubricata*. Except for *A. rubricata* they all have relatively long, weak legs and antennae. Except for *A.rubricata* they are also at least partly detritus-feeders.

The reason for the absence of *A.rubricata* from the more exposed stations is discussed on pp.17-19. The four other species are probably affected by wave exposure in at least three ways: (1) clinging to the algae may require stronger claws than these animals have; (2) in the current induced by wave action their long, thin appendages may easily get tangled or broken; and (3) in more exposed habitats there is less detritus available to feed on.

The absence of these species from station 2A may also be a zonation phenomenon, because the *Corallina* zone from which the 2A samples were taken would be more or less dry at low tide - in calm weather perhaps only occasionally reached by a wave. (Even so it must always be moist or else the *Corallina* would have died.)

At the other extreme we have the animals that were more common at locality 3 than elsewhere, or did not occur at the other localities at all. The most typical of these were *Hyale pontica* and *Parajassa pelagica* which both occurred only at stations 3A and 3B. *Idotea pelagica* occurred at stations 2A, 3A and 3B - at station 3A in very large numbers. *Hippothoa hyalina* also occurred in largest numbers at locality 3.

Many species were found at all three localities, and must therefore be able to live under all degrees of exposure. The distribution of some is shown in the middle part of Fig. 12. The distribution pattern shown for *Spirorbis corallinae*, i.e. its presence at all stations except 3B, is discussed on p.11. This pattern was also found for several other animals, among them *Hiatella* sp., *Musculus discors*, and *Turtonia minuta*. These bivalves are filter-feeders, and the reason for their absence from station 3B may be similar to that suggested for the absence of *S.corallinae*: when the *Corallina* plants were laid flat against the rock by waves, the animals would have been disturbed and kept their valves almost constantly shut, so that they would not have got enough food.

A common characteristic of the crustaceans living at locality 3 is that they are all more strongly built and have stronger claws than those living only at localities 1 and 2. Examples are *Parajassa pelagica* as compared with *Ampithoe rubricata* (see discussion on tube-living amphipods pp.17-19), *Apherusa jurinei* as compared with *A.bispinosa*, and *Jaera praehirsuta* and *Ianiropsis breviremis* as compared with *Munna boecki*.

Food and feeding-biology

WIESER (1959) has given the following classification of the algal fauna, according to the food sources the animals depend on:

A. Predators and scavengers.

B. Nonpredators.

1. Animals feeding on the algae themselves or on the epiphytes.
   a. Animals feeding on the epiphytes.
   b. Suckers.
   c. Browsers.

2. Animals feeding on suspended or deposited material.
   a. Animals feeding on material being deposited or already deposited.
   b. Animals feeding on suspended material.

For the fauna of *Corallina* the following sources of food are available: (1) Epiphytes growing on *Corallina* and algae growing in between its thalli; (2) sediment and living organisms suspended in the water; (3) material deposited in between the thalli and (4) the fauna associated with Corallina and its epiphytes.

Corallina is very heavily calcified, and it cannot be possible for any of the animals I have found to feed on it, except perhaps between the joints. I therefore think a slightly modified version will be more useful for classifying the Corallina fauna:

A. Predators and scavengers.

B. Nonpredators.

1. Animals feeding on the epiflora of Corallina.

a. Diatom-feeders. Animals feeding on microscopic algae growing on Corallina and on its macroscopic epiphytes.

b. Suckers. Animals feeding by sucking juice from the macroscopic epiphytes.

c. Browsers. Animals browsing on the macroscopic epiphytes.

2. Animals feeding on suspended or deposited material.

a. Animals feeding on material being deposited or already deposited.

b. Animals feeding on suspended material.

Some of the species are specialized and belong to only one of these groups, but many use more than one of the available food sources and thus belong to more than one of the groups.

In the group "predators and scavengers" we find animals that live solely from predation or scavenging together with animals that occasionally take other food and all stages to animals that live mainly on other food but on occasion turn predator or scavenger.

Animals belonging to the "predators and scavengers", found in Corallina, are Foraminifera, Actinaria, Turbellaria, Nemertina. Among Nematoda several species are carnivorous

(WIESER 1953). Many of the errant Polychaeta are predators, and these probably make up most of the group "Polychaeta non Serpulida".

Among Amphipoda, the Caprellidae are predators.

Some Amphipods (and Isopods) readily eat their newly moulted cuticles, and the step from that to scavenging is not a long one.

Among Isopoda, the _Idotea_ species are omnivorous (NAYLOR 1955). This is probably also true of _Jaera praehirsuta_. The Pycnogonida are predators. The Asteroides are also predators, while the Ophiuroidea are omnivorous.

In the group "diatom-feeders" we find several of the nematodes, and also the Harpacticoida. According to WIESER (1959) all the Ostracoda found on algae except one genus belong to this group. In two Mediterranean localities he found that about 50 per cent of the ostracods fed on small algae - the other 50 per cent (gen._Paradoxostoma_) were suckers. Several Amphipoda feed on diatoms, while others are probably omnivorous (WIESER 1959). Many of the prosobranchs found also belong to this group.

To the "suckers" belong some Nematoda (WIESER 1959), the ostracod genus, _Paradoxostoma_, and some Halacarida.

Animals that live at least partly from browsing are _Jassa falcata_, _Parajassa pelagica_, _Ampithoe rubricata_, the _Idotea_ species and some prosobranchs (_Gibbula_, _Lacuna_).

Among the "animals feeding on material being deposited or already deposited" we find, again, some Nematoda (WIESER 1959). Some Amphipoda belong, at least partly, in this group: The _Apherusa_ species, the _Dexamine_ species, _Stenothoe monoculoides_ (perhaps) and _Corophium bonelli_. The isopod, _Munna boecki_, and the tanaid, _Tanais cavolinii_, also belong here.

"Animals feeding on suspended material": Many of the animals in this group are probably not selective in their choice of food, but take living planktonic animals as well as dead material - and should therefore have been mentioned with the predators as well. To the suspension-feeders belong the Serpulida, the Amphipod, Corophium bonelli, and all the Bivalvia and Bryozoa.

In Fig. 13 the distribution of the feeding categories is shown in percentages. This can be only approximate, as it is difficult to know in which category to place many species. I have combined the three categories under "Animals feeding on the epiflora of Corallina" to one category - "Herbivores". Species that belong to more than one feeding category have been included in each of the categories in question.

For the group, Nematoda, which consists of several species with different feeding patterns, I have divided the quantities like this: herbivores 60 per cent; predators 30 per cent and detritus-feeders 10 per cent. This is based on the work by WIESER (1953) where he shows that the feeding types of Nematoda in exposed localities are consistently in this proportion regardless of the geographical origin of the sample. I think that both localities 2 and 3 are sufficiently exposed to justify the use of these ratios. At locality 1 the number of Nematoda is so small that the use of this rule, even if it does not apply there, would not make any appreciable difference to the final result.

For the Ostracoda, I have made the assumption that they are all "herbivores" - either diatom-feeders or suckers.

The histograms are based on the "numbers per 20 ml" for the species that have been counted and on the "arithmetic means" of the categories for animals where the quantities have only been estimated.

The histograms show that the percentage of "predators and scavengers" is about the same at stations 1, 2A and 3A - ranging from 29 to 36 per cent. At stations 2B and 3B it is smaller - at 3B only 8 per cent.

The percentage of "herbivores" is relatively constant except at station 3B where it includes 67 per cent of the fauna - at the other sites the percentage ranges from 35 to 46. The high percentage at station 3B is mainly due to the very large numbers of *Parajassa pelagica* present there. This species must get its food from outside *Corallina*, as the *Corallina* plants at station 3B have no epiphytes. Most of the food is probably pieces of algae torn loose by the surf. At locality 1, where the amount of sediment is quite large, there is a much higher percentage of "detritus-feeders" than at the other localities, while the percentage of "suspension-feeders" is quite low. At localities 2 and 3 the percentage of suspension-feeders is higher than the percentage of detritus-feeders. The relatively low percentage of suspension-feeders at station 3B is due to the very large number of *Parajassa.* The group "detritus-feeders" at stations 2B and 3B is made up almost entirely of the amphipods, *Stenothoe*, *Apherusa* and (only at station 2B) *Dexamine*. At locality 3, where there is not much sediment, these animals probably feed mostly on diatoms, and hence should have been counted among the herbivores. Such a change in feeding habits with the food present is probably common too among other species, but little is yet known about this, and I have therefore decided not to try to compensate for it in the histograms.

Predation from animals living outside the *Corallina* growth

Most of the predators mentioned are too small to be able to catch the larger members of the *Corallina* fauna, like most of the isopods and amphipods. To keep the fauna in ecological balance, predation by animals living outside the *Corallina* is probably necessary. The most important predators are probably fishes of the families Labridae and Gobiidae, which were very common at all the localities. Where the *Corallina* grows very compactly, predation may be difficult for large fishes like the Labridae, but at station 3B *Corallina* grows in a more scattered fashion so that its fauna is easily accessible.

SOME COMMENTS, AND SUGGESTIONS FOR FUTURE RESEARCH ON THE FAUNA OF *CORALLINA OFFICINALIS*

When making an investigation like this there must be many things with which one is not satisfied. I will try to point out some ways in which this research might have been improved, and also some additional investigations which I should have liked to do.

One thing I have learnt is that, where it is not practical just to wade out from the shore and take the samples, all collecting of *Corallina* and other small algae should be done by means of SCUBA-diving. The diver can then take his time to put a plastic bag carefully over the algae to be sampled without making currents that may sweep away some of the animals. He can then equally carefully detach the algae and close the bag. A diver using only a snorkel, as I did, has to do all this while he is holding his breath. It is evident that not all operations can then be carried out equally carefully, and animals may be lost.

In two cases I have examined two samples taken at the same station and at the same time - only with different amounts of epiphytes. These two pairs of samples were both from station 2B taken on 3 September 1965 and 17 January 1966, respectively. There were some differences between the composition of the two samples in each pair, but I do not think that these four samples alone give enough information to allow reliable conclusions to be drawn about the fauna of *Corallina* with and without epiphytes.

It would be very interesting to make a comparison between the fauna of *Corallina* and that of some other algae. At station 3B *Delesseria sanguinea* (HUDS.) LAMOUR grew on the rock together with *Corallina*. On *Corallina* I found large numbers of *Parajassa pelagica* and relatively few *Jassa falcata*. On *Delesseria* I found quite the opposite: large numbers of

J.falcata and relatively few P.pelagica. As these algae grew in the same place, the environmental factors must have been the same, and any difference in the fauna of the two algal species must have been due to the animals' preference for one or other alga. I think that this particular comparison would be especially interesting to investigate further, as it would illustrate well the importance of the algal substrate to the fauna living on it.

I have not been able to tell much about the vertical distribution of the animals from my material. As Corallina often grows in two separate belts, with rather limited vertical ranges, an investigation of the variation of the fauna with depth should probably include other algae as well.

It would be of interest to obtain identifications of the species in those groups where I did not do that (Foraminifera, Nematoda, "Polychaeta non Serpulida" etc.). One would probably find a change in the species composition of these groups too as the exposure changed.

COLMAN (1940) gave "population density" in terms of number of animals per 100 grams damp weed for several algae. CHAPMAN (1955) used number of animals per square metre of sea bottom. WIESER (1959) gave numbers of animals per square centimetre of sea bottom and per gram of alga for a number of algae. It would have been interesting to have some values for the population densities in my samples also, but because I have used a combination of counts and "estimated quantities", my "population densities" would not have been comparable with those given by others. I have therefore not given any values for population densities.

Another interesting problem which I have not tried to tackle is the vertical distribution of the animals within the Corallina. It is probable that some species live mainly near the top of the plants, and others near the basal discs, while some perhaps live on all parts of the plants. I think this could be observed most easily in an aquarium, preferably with some sort of alternating artificial currents like those caused by wave exposure.

Last, but not least, it will always be interesting to get reports on the fauna of Corallina officinalis and related species from other parts of the world. Will, for example, the Corallina fauna of a tropical locality be characterized by the same small size of the animals as here? Is there a change in the relative importance of the different systematic groups - are there, for example, more small decapods? Do the isopods and amphipods living in exposed habitats always have stronger claws and are they more strongly built than their relatives living in more sheltered habitats? These, and many others, are questions to be answered by future research.

SUMMARY.

This work gives an account of the fauna of Corallina officinalis at three localities south of Bergen, one very sheltered, one semi-exposed and one very exposed.

The fauna of C.officinalis is characterized by the smallness of the animals as compared with the fauna of the surrounding larger algae and rocks.

Modiolus modiolus, which settle on C.officinalis as larvae, migrate to other habitats before they are one year old.

Wave exposure affects the form of growth and the zonation of C.officinalis. It also affects the composition of the fauna, indirectly probably through its effect on C.officinalis and directly through the effect of water motion on the species themselves; only those species able to stay in their habitat even in very strong surf occur under conditions of strong exposure. For the isopods and amphipods the result of this seems to be that the species found in the most exposed locality are more solidly built and have stronger claws than those found

only in the less exposed localities. In the case of tube-living amphipods a strong tube is necessary for survival in the most exposed locality. In the most sheltered locality lack of wave exposure results in an accumulation of sediment which prevents the settling of bryozoans.

In the most sheltered locality the percentage of detritus-feeders is much higher than in the other localities. Herbivores make up the dominating feeding category in all the localities.

ACKNOWLEDGEMENTS.

I selected this research-work on Corallina among several alternatives suggested by Professor H. BRATTSTRÖM. Although the product is somewhat different from that originally intended, I want to thank him for the suggestion, for advice and for working facilities at the Biological Station, Espegrend.

I also want to thank the staff for advice and help with literature, and Dr. J.B.L.MATTHEWS for correcting my English.

Several people have helped me identify the animals, and I particularly want to thank them: Cand. mag. T. HÖISÆTER has identified the gastropods, Dr. W.J.M.VADER has helped me identify "difficult" amphipods, Cand. mag. M.JENSEN has helped me identify the echinoderms, Cand. mag. T. SAMUELSEN has identified the Anomura, Dr. I. DRZYCIMSKI has identified Harpacticoida from one sample, Cand. real L. GREVE (JENSEN) has checked my identification of some juvenile *Tanais cavolinii*, and Dr. C.SANKARANKUTTY has identified *Pirimela denticulata*.

REFERENCES

BOCQUET, C., 1953: Recherches sur le polymorphisme naturel des Jaera marina (FABR.) (Isopodes Asellotes). Archs. Zool. exp. gen. 90: 187-450.

CHAPMAN, G., 1955: Aspects of the fauna and flora of the Azores. VI. The density of animal life in the coralline alga zone. Ann. Mag. nat. Hist. 95: 801-805.

COLMAN, J., 1940: On the faunas inhabiting intertidal seaweeds. J. mar. biol. Ass. U.K. 24: 129-183.

ENEQUIST, P., 1950: Studies on the soft-bottom amphipods of the Skagerak. Zool. Bidr. Upps. 28: 297-492.

FRETTER, V., and GRAHAM, A., 1962: British prosobranch molluscs. London. 755 pp.

HAGERMAN, L., 1966: The macro- and microfauna associated with Fucus serratus L., with some ecological remarks. Ophelia 3: 1-43.

MARCUS, E., 1940: Mosdyr. Danm. Fauna 46. 401 pp.

MATURO, F.J.S., 1959: Seasonal distribution and settling rates of estuarine Bryozoa. Ecology 40: 116-127.

NAYLOR, E., 1955: The diet and feeding mechanism of Idotea. J. mar. biol. Ass. U.K. 34: 347-355.

RUFFO, S., and WIESER, W., 1952: Osservazioni sistematiche ed ecologiche su alcuni anfipodi delle coste mediterranee italiane. Memorie Mus. civ. Stor. nat. Verona 3: 11-30.

SARS, G.O., 1895: Amphipoda. An account of the Crustacea of Norway. 1: Christiania and Copenhagen. 711 pp.

- 1899: Isopoda. Ibid. 2: Bergen. 270 pp.

SEXTON, E.W. and REID, F.L.S., 1951: The life-history of the multiform species Jassa falcata (MONTAGU)(Crustacea Amphipoda) with a review of the bibliography of the species. J. Linn. Soc. 42: 29-91.

de SILVA, P.H.D.H. and KNIGHT-JONES, E.W., 1962: Spirorbis corallinae n. sp. and some other Spirorbinae (Serpulidae) common on British shores. J. mar. biol. Ass. U.K. 42: 601-608.

SKUTCH, A.F., 1926: On the habits and ecology of the tube-building amphipod Amphithoë rubricata MONTAGU. Ecology 7: 481-502.

SLOANE, J.F., et al., 1961: The ecology of Lough Ine. IX. The flora and fauna associated with undergrowth-forming algae in the rapids area. J. Ecol. 49: 353-368.

TEBBLE, N., 1966: British bivalve seashells. A handbook for identification. London. 213 pp.

WIESER, W., 1953: Die beziehung zwischen mundhöhlengestalt, ernährungsweise und vorkommen bei freilebenden marinen nematoden. Ark. Zool. ser. 2 4: 439-484.

- 1959: Zur ökologie der fauna mariner algen mit besonderer berücksichtigung des Mittelmeeres. Int. Revue ges. Hydrobiol. Hydrogr. 44: 137- 179.

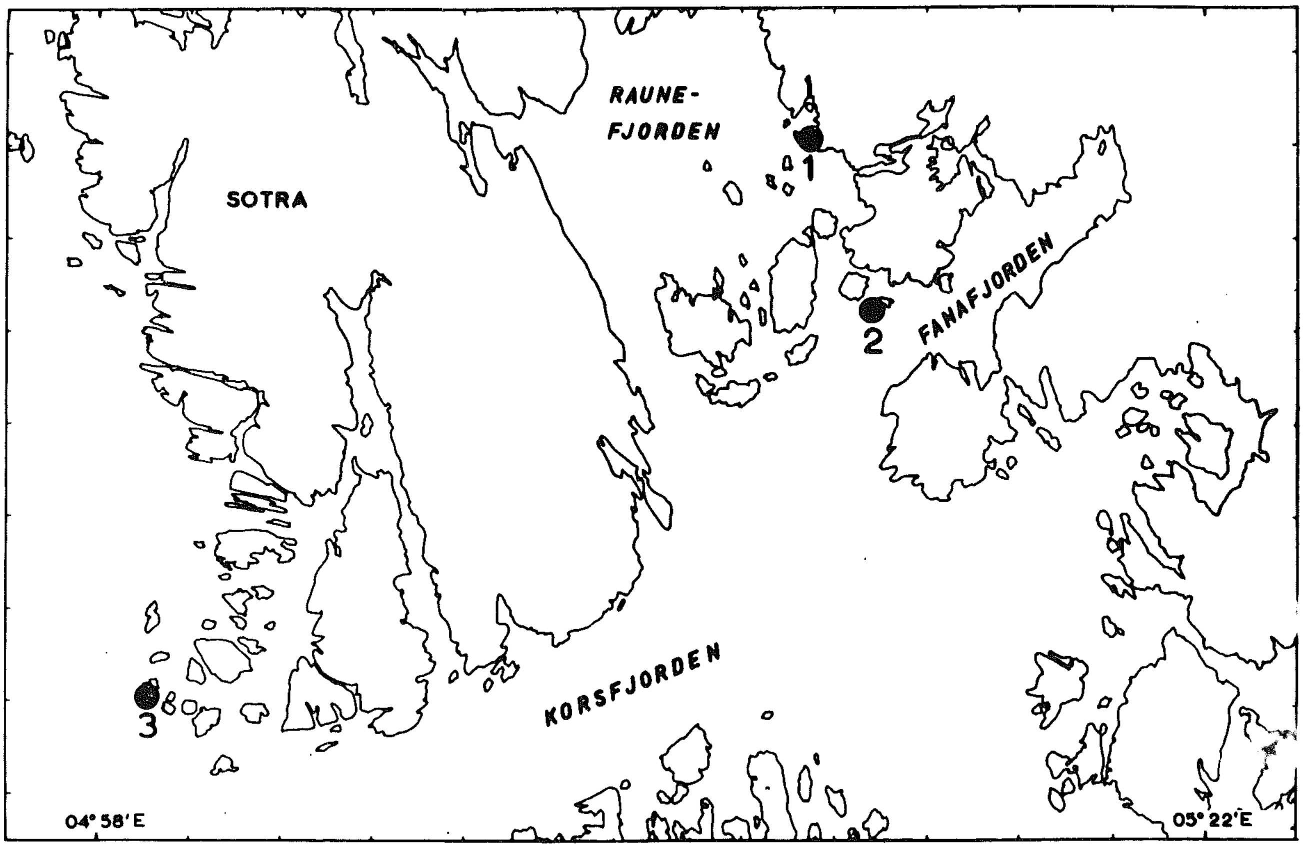


Fig. 1. Map of the area near the Biological Station, Espegrend, showing the three sampling localities.

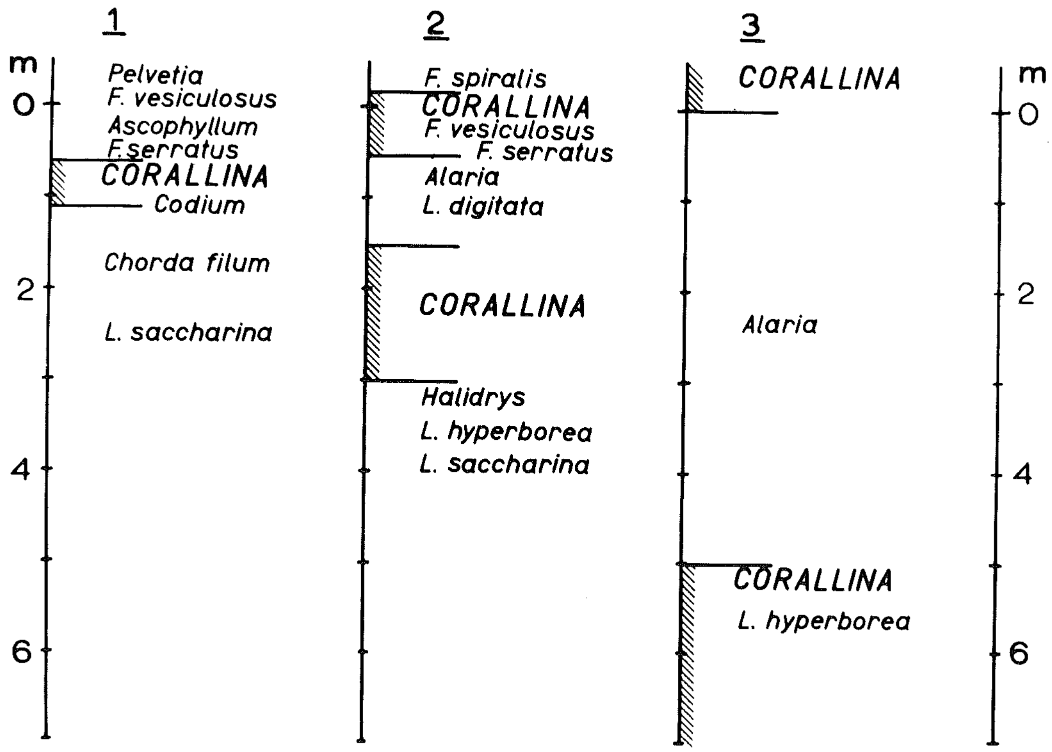


Fig. 2. The vertical distribution of Corallina officinalis (shaded) and of other large algae occurring in the same area. Mean tide level is at 0 m.

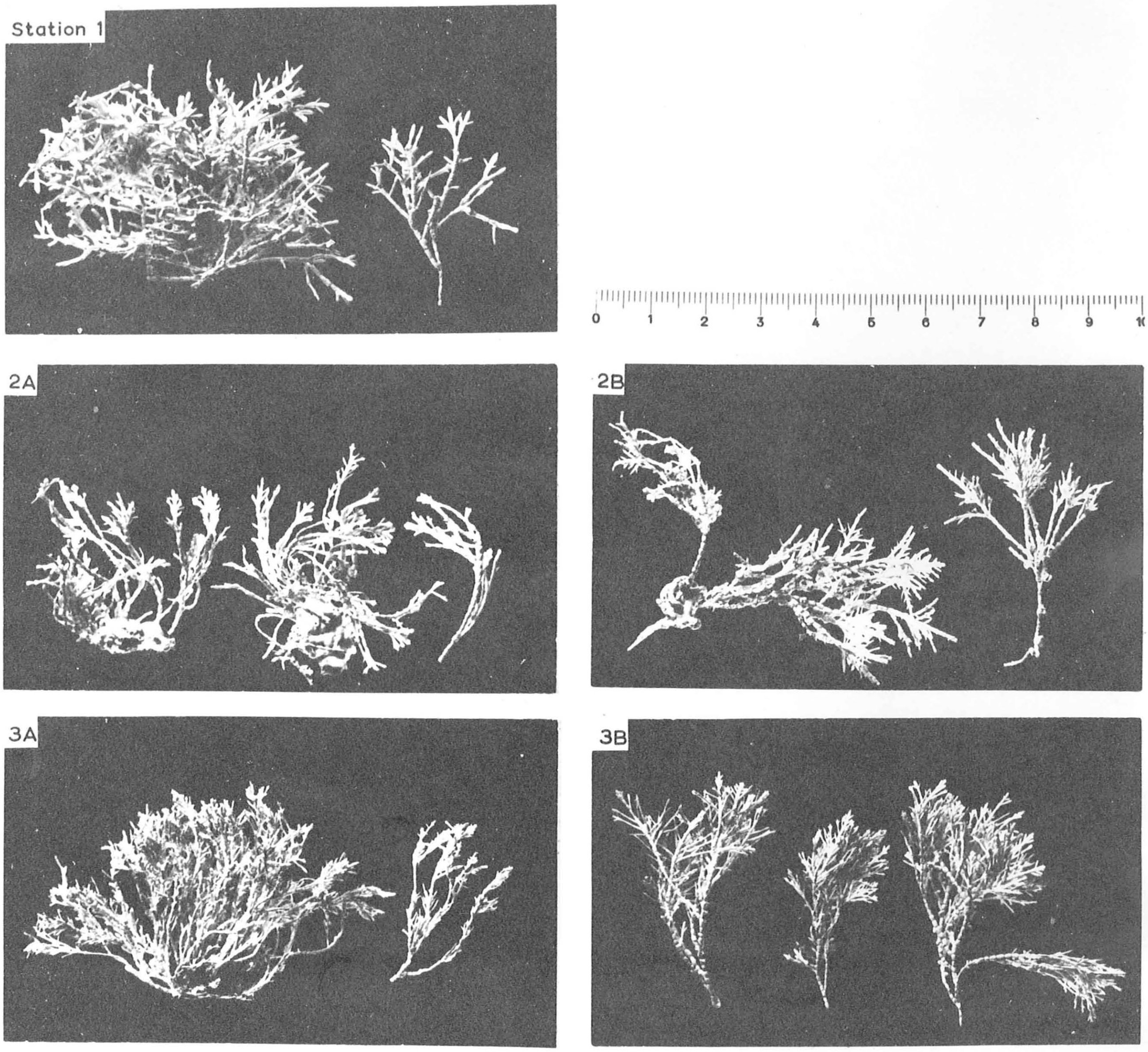


Fig. 3. Corallina from the different stations, showing the different types of growth. Scale in centimetres.

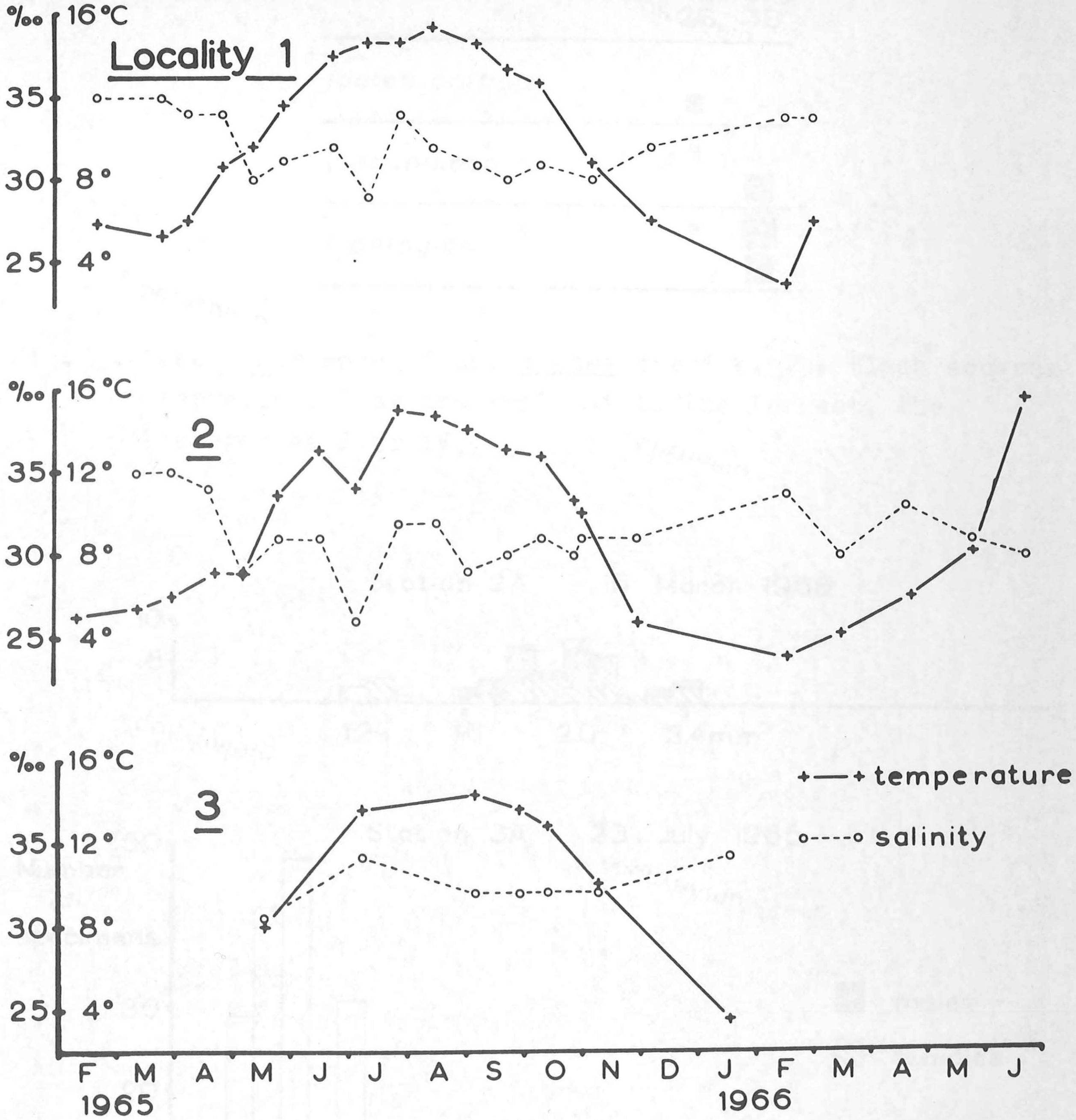


Fig. 4. Variations in salinity and temperature at the sampling localities.

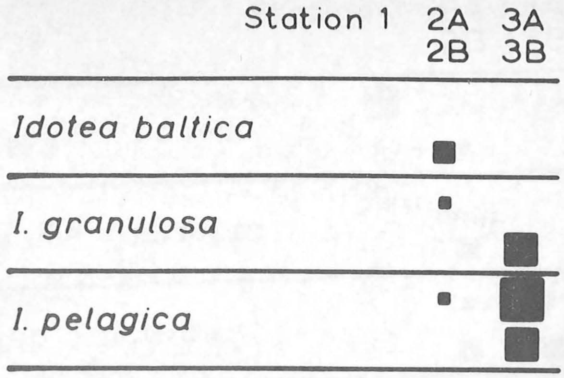


Fig. 5. The occurrence of the Idotea species. The black squares represent, from the smallest to the largest, the categories I to IV.

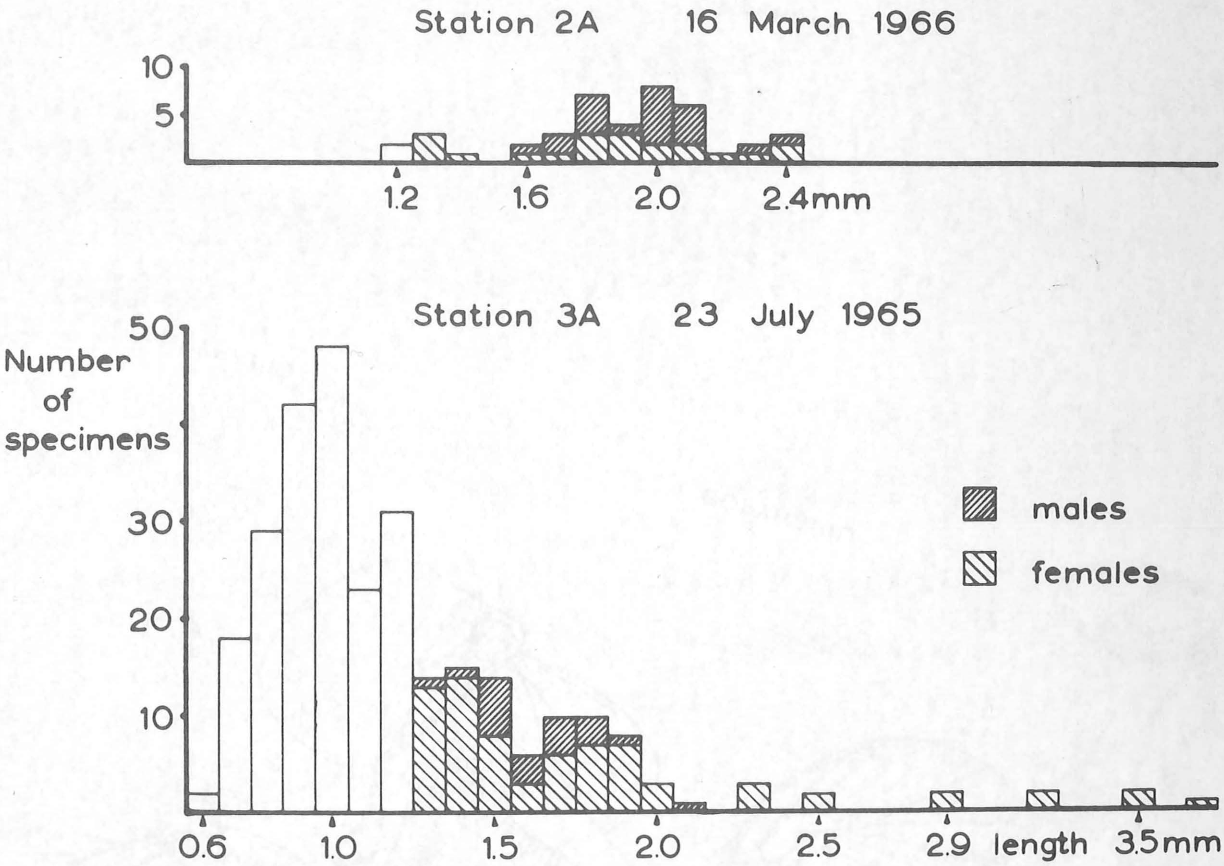


Fig. 6. Size distribution of Jaera praehirsuta from two samples.

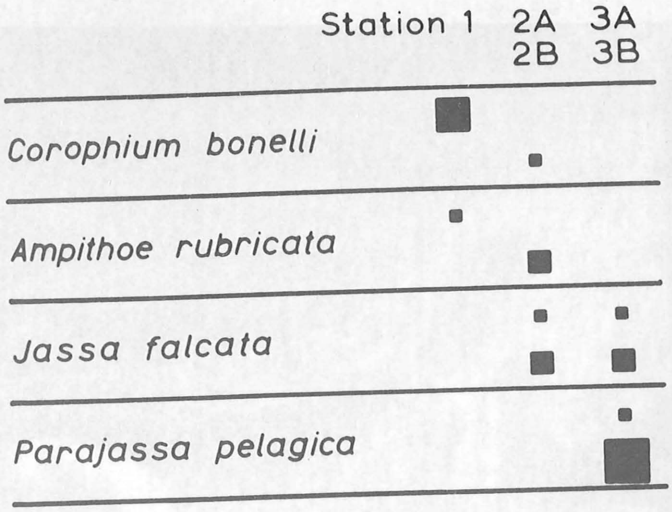


Fig. 7. The occurrence of the tube-building amphipods.

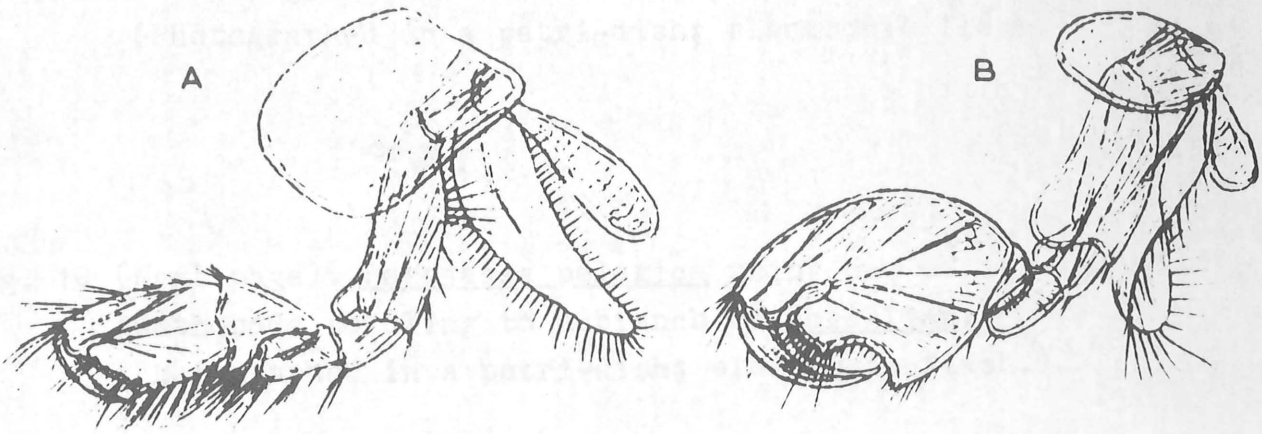


Fig. 8. Second gnathopods of Ampithoe rubricata ♀ (A) and Parajassa pelagica ♀ (B). Drawings from SARS (1895).

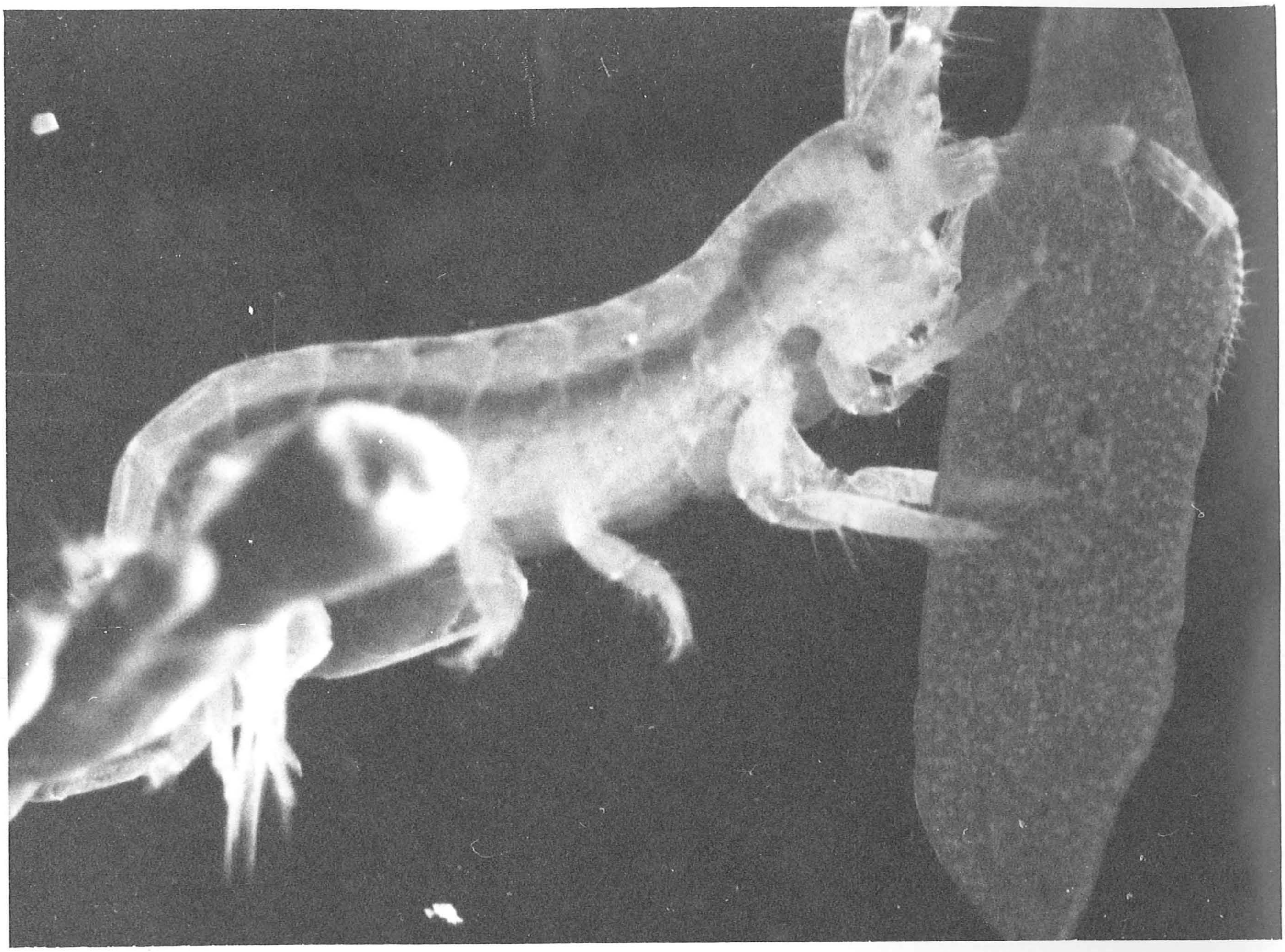
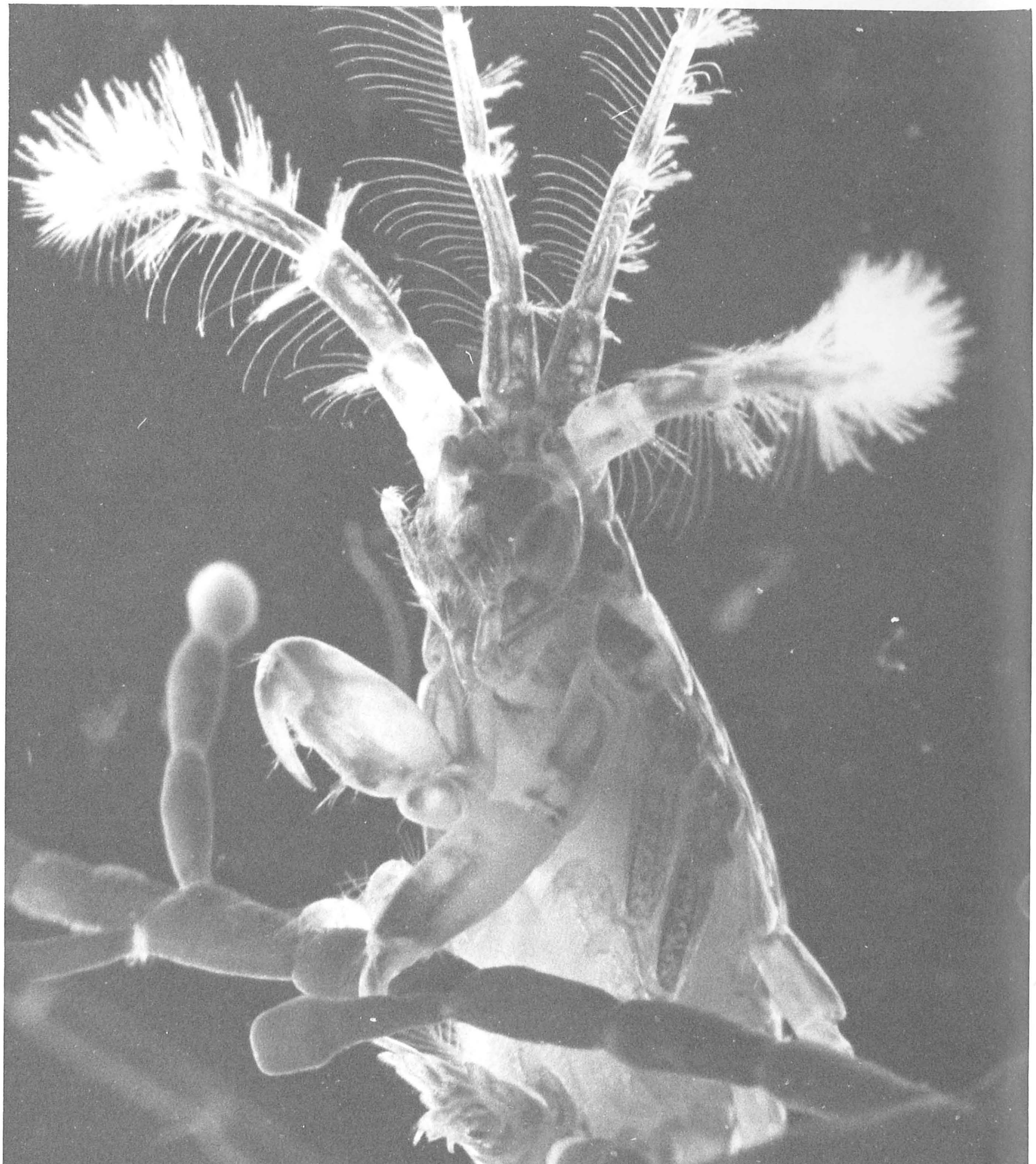


Fig. 9. Ampithoe rubricata walking from a branch of Corallina to a piece of another alga. It has just gripped the other alga with its gnathopods to pull itself over to it. (Photographed in a petri-dish; electronic flash.)

Fig. 10 (Next page). Parajassa pelagica using one of its second gnathopods to cling to a branch of Corallina. (Photographed in a petri-dish; electronic flash.)



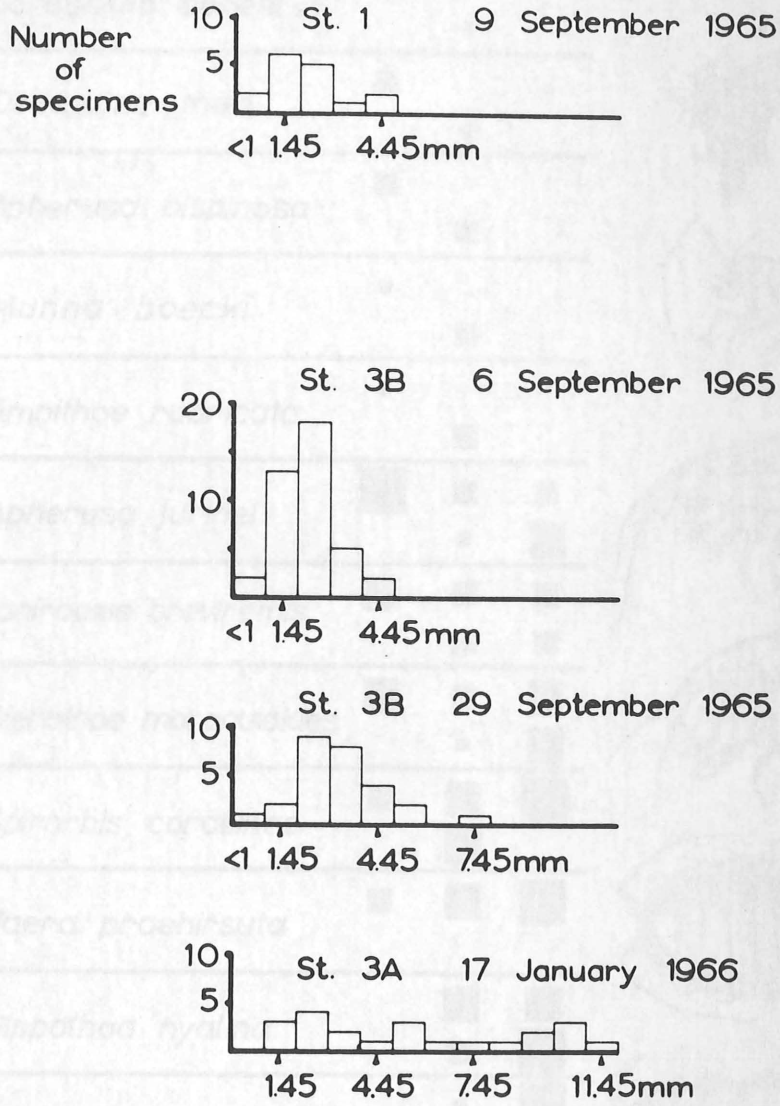


Fig. 11. Size distribution of <u>Modiolus modiolus</u> from four samples. In the column marked 4.45 mm all sizes from 4.0 mm to 4.9 mm (mean value 4.45 mm) are included.

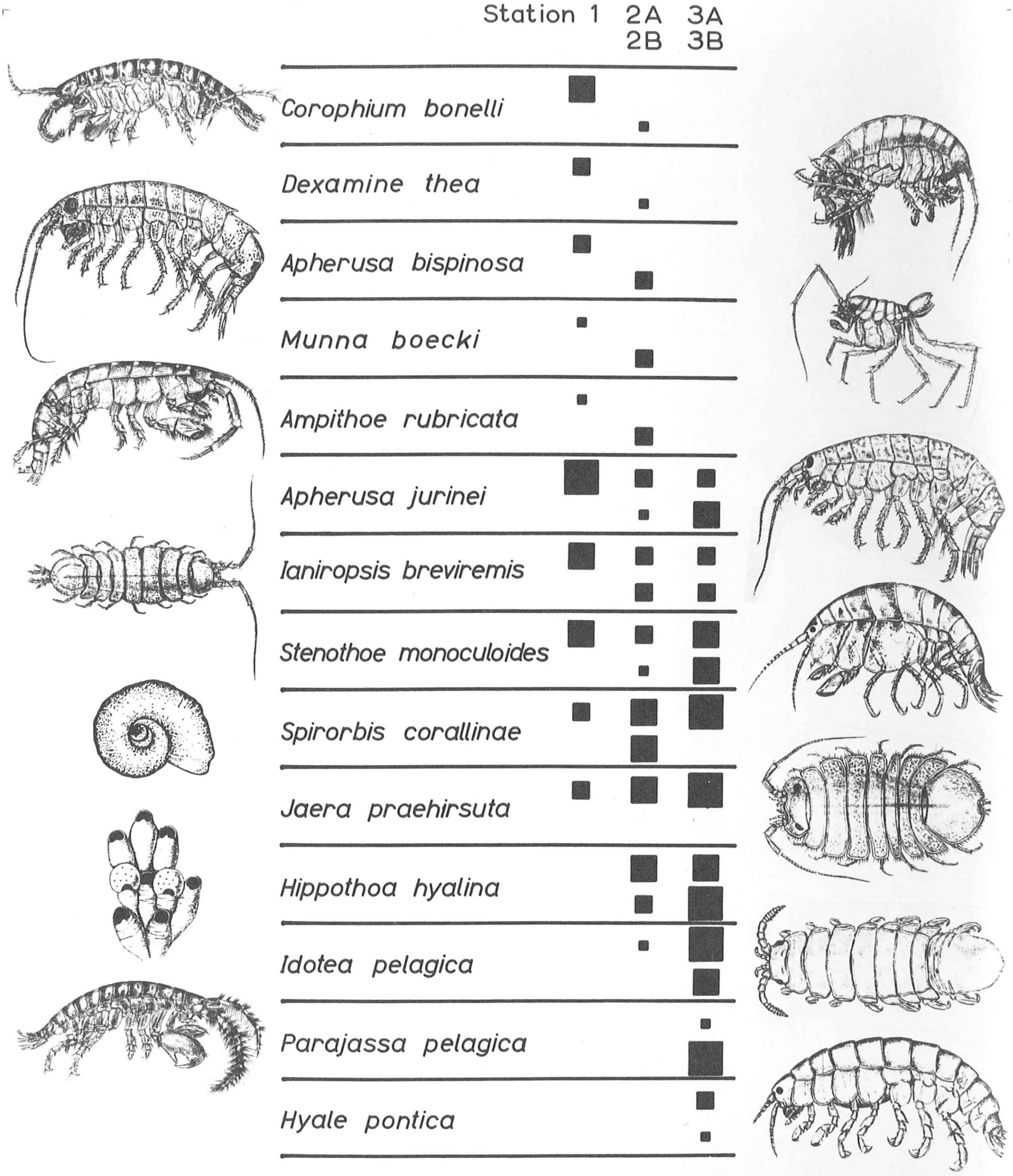


Fig. 12. The occurrence of various species. Drawings from SARS (1895, 1899), de SILVA and KNIGHT-JONES (1962) and MARCUS (1940).

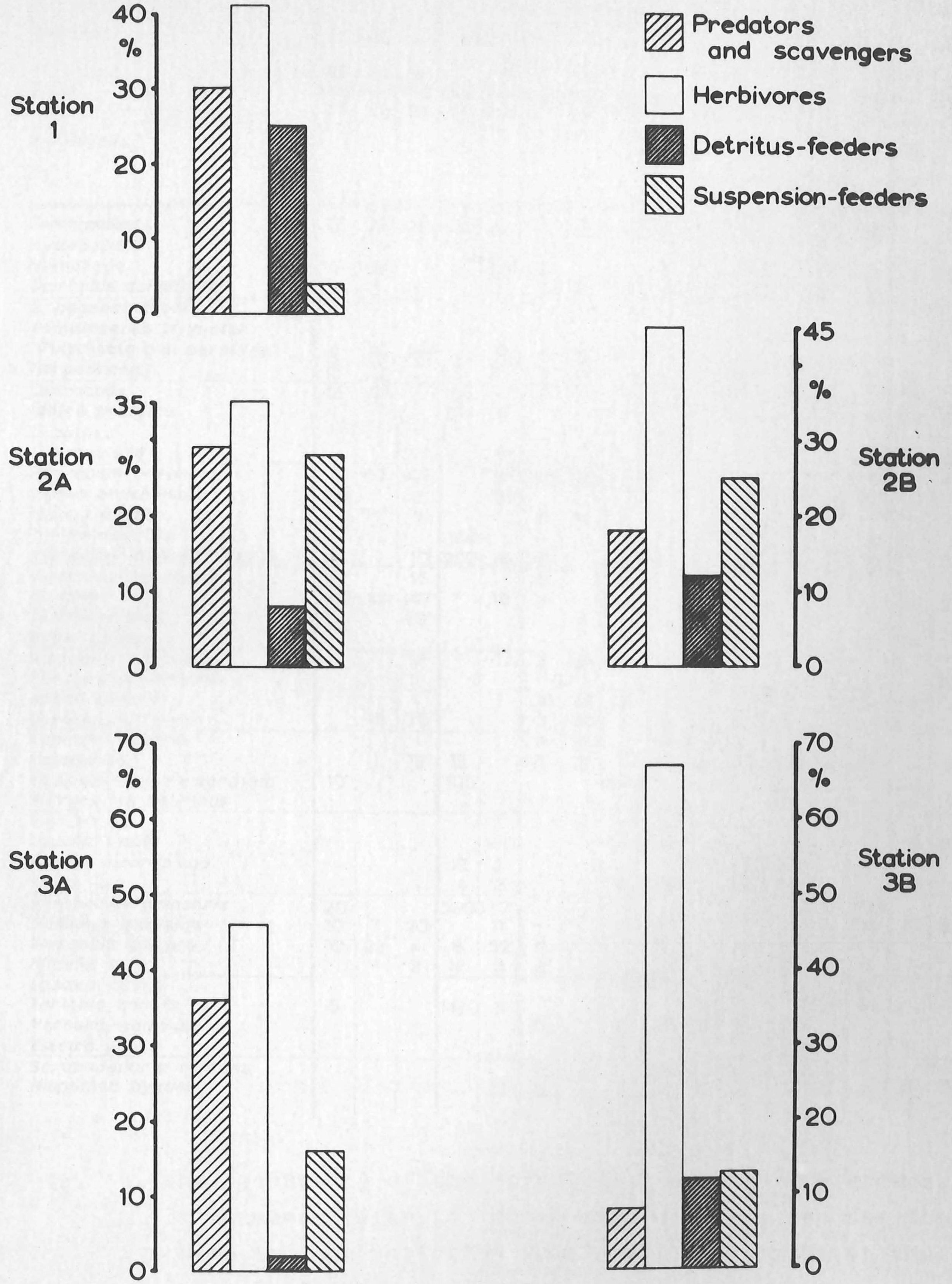


Fig. 13. Distribution of the feeding categories at the different stations.

Station	1			2A		2B							3A		3B		
Date	25 Mar 65	23 Jun 65	9 Sep 65	1 Nov 65	16 Mar 66	7 May 65	16 Jun 65	3 Sep 65	3 Sep 65	17 Jan 66	17 Jan 66	23 May 66	23 Jul 65	17 Jan 66	23 Jul 65	6 Sep 65	29 Sep 65
Epiphytes				I	I	I			III		III	II			III		
Foraminifera	IV	IV	IV	II	II	III	II	III	II	III	II	I	III	III		II	II
Hydrozoa								II	I			I					II
Nematoda	I	II		I	IV	I		I	II	II	II	I	I	III	I	II	III
Spirorbis corallinae	I	I	II		III	II	III	III	III	III	III	II	I	IV			
S. pagenstecheri	I	I	I														
Pomatoceros triqueter								I	I	II	II	II					
"Polychaeta non serpulida"	I	III	III	I	III	I	III	II	III	I	I		II			I	I
Harpacticoida	III	III	I	II	II	II	III	II	III	II	III	III	II	II	III	II	II
Ostracoda	III	III	I	IV	I	III	I	II	III	II	II	III	II		III	I	III
Idotea pelagica				98	4								308	30	82	57	
I. baltica						3			66		2						
I. granulosa					4											33	60
Ianiropsis breviremis	5	67	42		19	29	16			1			10	5	11	49	
Jaera praehirsuta	25		3		39								572	67			
Munna boecki		7	7			6	52		11	1		4					
Tanais cavolinii				159										6			
Stenothoe monoculoides	95		10	229	16	17		6	7			3	18	35		53	47
Apherusa bispinosa	15		15			23			2	4	95	3					
A. jurinei	185	13	147		18	9		6		1		3	2	10	36	20	44
Dexamine thea	5		40				4	3	2	6							
Hyale pontica													8	3	14		
Ampithoe rubricata			12			3	36	9	16								
Parajassa pelagica													2	5		708	504
Jassa falcata			1		1	39	36	24	7	1	7	7		8	11		35
Corophium bonelli		15	70			3	20		6	3		2					
Caprella linearis						6	36		7								
Halacarida		I	III	III		III	III	I	II	II	II	III	I	III	I	I	
Phoxichilidium femoratum	10			105								1					
Margarites helicinus												8	8		11		20
Gibbula sp.							12	3	5								
Lacuna vincta								3	2				6		18	27	16
Rissoa inconspicua				12	1						91	4					
R. parva			1	4	3			15	25	1	27	13	4				
Skeneopsis planorbis	20			3600	7						2		4	224			
Modiolus modiolus	10	7	20		11			9	5		2	3	6	35	4	83	55
Musculus discors	10	22	4	8	52	6			11	1	114	37	22	43			
Hiatella sp.		7	2	12	5	3		3	20	10	4	2	2	8			
Lasaea rubra														40			
Turtonia minuta	5			1470	3					2	2		14	61			
Hornera violacea						II		II	II	II	II	I					
Electra pilosa							I	I	I		I	I			I		I
Scrupocellaria reptans						I	I		I		I		I	I			
Hippothoa hyalina					III	III	I	II	II	I	I	I	III	I	II	IV	IV

Fig. 14. The occurrence of the more common species and groups. The numbers refer to "20 ml samples". One can see that there is much variation from sample to sample at the same station.