

ON THE OCCURRENCE AND BEHAVIOUR OF
TWO LITTLE-KNOWN BARNACLES,
HEXELASMA HIRSUTUM AND
VERRUCA RECTA, FROM THE
CONTINENTAL SLOPE

By A. J. and EVE C. SOUTHWARD
with an appendix by L. H. N. COOPER
The Plymouth Laboratory

(Plate I and Text-figs. 1-5)

The fauna of the continental shelf and slope between Ireland and Spain has been described by Le Danois (1948), but very little faunistic work has been carried out in the area recently. Since R.V. 'Sarsia' was brought into service at Plymouth there have been several opportunities of investigating that part of the slope lying to the south-west of the British Isles. It has been found that, in addition to beds of coral, quite extensive exposures of rocks, stones and gravel occur between 200 and 1000 fathoms. There is a rich epifauna in this area and barnacles are one of the dominant groups.

Only two species of barnacles are abundant. Both of them have been found, either as live specimens or dead shells, at many of the stations investigated. They are *Hexelasma hirsutum* (Hoek) and *Verruca recta* Aurivillius. We will first describe these species and their associated fauna, and then discuss their behaviour, as observed in the laboratory.

We are indebted to Dr L. H. N. Cooper for advice in this work, and to Dr J. P. Harding for facilities at the British Museum (Natural History). Thanks are due to Captain C. A. Hoodless and the crew of R.V. 'Sarsia', for their patience during many days of fruitless dredging, and to Dr D. Atkins, whose request for dredging on the slope led to the discovery of the barnacles.

Hexelasma hirsutum (Hoek)

Balanus sp. undescribed, Jeffreys, 1878.

B. hirsutus Hoek, 1883.

B. hirsutus Hoek, Gruvel, 1920.

Hexelasma hirsutum was first described by Hoek from material collected by H.M.S. 'Triton' in the Faroë-Shetland Channel, Station 10, 1882. The two specimens are now in the British Museum. Hoek assigned the species to the genus *Balanus*, and it was not until other related species were found that their

TABLE 1

Collection	Station	Depth	No. of specimens	Substratum	Author, or present location of material
<i>Hexelasma hirsutum</i>					
'Porcupine'	48° 31' N., 10° 03' W.	690 fm	1	Shell of living brachiopod	Jeffreys, 1878 (as <i>Balanus</i> sp.)
'Triton'	59° 40' N., 7° 21' W.	516 fm.	2	<i>Cidaris</i> spine	Hoek, 1883 (as <i>B. hirsutus</i>)
Monaco	38° 31' N., 26° 49' W.	845 m	2	—	Gruvel, 1920 (as <i>B. hirsutus</i>)
Monaco	Azores area	—	3	Telegraph cable	Gruvel, 1920 (as <i>B. hirsutus</i>)
'Monarch'	48° 04' N., 9° 23' W.	1000 fm.	24	Telegraph cable	} Specimens in British Museum
'Monarch'	48° 02' N., 9° 25' W.	930 fm.	6	Telegraph cable	
'Monarch'	48° 02' N., 9° 27' W.	900 fm.	10	Telegraph cable	
'Marie-Louise Mackay'	51° 23' N., 11° 32' W.	210 fm.	3	Telegraph cable	
'Sarsia' 1956/4	48° 33' N., 10° 05' W.	570-770 fm.	>60 and old shells	Rocks, gravel, dead coral, living brachiopod	} Specimens in authors' possession
'Sarsia' 1956/8	47° 30' N., 7° 20' W.	870-970 fm.	Old shells only	—	
'Sarsia' 1957/1	48° 34' N., 10° 0' W.	570-700 fm.	>90 and old shells	Rocks, gravel, antler	
'Sarsia' 1957/1	48° 33' N., 10° 01' W.	580-680 fm.	Old shells only	—	
'Sarsia' 1957/1	48° 31' N., 10° 11' W.	520-680 fm.	Old shells only	—	
<i>Verruca recta</i>					
Monaco	Azores area (8)	861-1385 m	10	Stones, rocks, coal and dead coral	Aurivillius, 1898; Gruvel, 1920
'Talisman'	Azores area (1)	960-990 m	1	Coral	Gruvel, 1902
'Travailleur'	—	2018 m	1	Coral	Gruvel, 1902
Monaco	28° 04' N., 16° 49' W.	1340-1530 m	1	—	Gruvel, 1920
'Sarsia' 1956/4	48° 33' N., 10° 05' W.	570-770 fm.	13	Stones, dead coral, shell fragments	} Specimens in authors' possession
'Sarsia' 1956/8	47° 30' N., 7° 28' W.	550-600 fm.	1	Coral	
'Sarsia' 1956/8	47° 38' N., 7° 28' W.	710-750 fm.	8	Small stones, coral, clinker	
'Sarsia' 1956/8	47° 30' N., 7° 20' W.	870-970 fm.	2	Coal, coral	
'Sarsia' 1957/1	48° 42' N., 9° 48' W.	180-200 fm.	1	Shell	}
'Sarsia' 1957/1	48° 33' N., 10° 01' W.	580-680 fm.	Old shells only	Stones, coral	
'Sarsia' 1957/1	48° 34' N., 10° 00' W.	570-700 fm.	12	Stones, coral	

affinity with the Chthamalidae was recognized, and the new genus *Hexelasma* erected (Hoek, 1913). Table I shows the older and the more recent records of *H. hirsutum*. Jeffreys's record is almost certainly this species, even though the specimen was not described (Jeffreys, 1878, p. 414). Its occurrence at the 'Porcupine' station on the shell of a living brachiopod (*Hispanirhynchia cornea* (Davidson), recorded by Jeffreys as *Rhynchonella sicula* Seguenza) has been repeated in one of the 'Sarsia' hauls; a living specimen of the same brachiopod was taken with a live *H. hirsutum* on one valve and a live *Verruca recta* on the other valve.

The known range of *Hexelasma hirsutum* is from the Faroë-Shetland ridge to the Azores. A related species, *H. americanum* Pilsbry, found on the western side of the Atlantic, appears to differ in external features and in the shape of the tergum (Pilsbry, 1916).

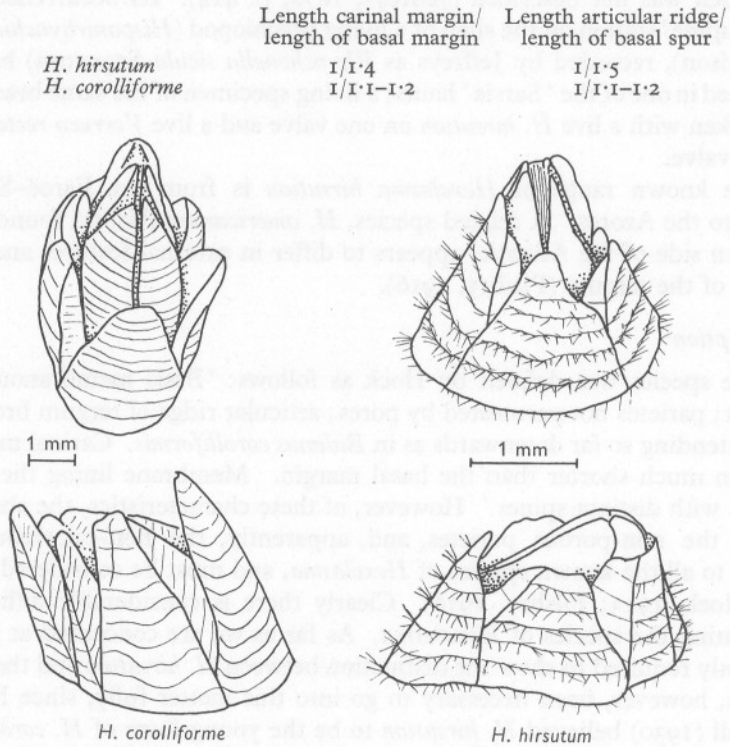
Description

The species was defined by Hoek as follows: 'Basis membranous; radii absent; parietes not permeated by pores; articular ridge of tergum broad, but not extending so far downwards as in *Balanus corolliformis*. Carinal margin of tergum much shorter than the basal margin. Membrane lining the growth ridges with distinct spines.' However, of these characteristics, the absence of radii, the non-porous parietes, and, apparently, the non-calcareous basis apply to all the known species of *Hexelasma*, and must be considered generic (cf. Hoek, 1913; Pilsbry, 1916). Clearly there is considerable difficulty in separating the species of *Hexelasma*. As far as we are concerned at present, it is only required to show the distinction between *H. hirsutum* and the others. It has, however, been necessary to go into this matter fully, since Nilsson-Cantell (1930) believed *H. hirsutum* to be the young form of *H. corolliforme*. We have therefore re-examined the type specimens of *B. corolliformis* and *B. hirsutus* in the British Museum, as well as Nilsson-Cantell's specimens of *H. corolliforme* in the 'Discovery' collection.

H. hirsutum can be distinguished from other species by its markedly conical or tent-like shape (Pl. 1, fig. 1). Even on restricted substrata, such as sea-urchin spines and branches of coral, the diameter of the orifice is much smaller than the maximum diameter of the specimen (usually less than half). In normal uncrowded specimens from stones the diameter of the orifice is about two-fifths to one-third of that of the base, and the compartments do not diverge from one another. In these characters this species differs strongly from *H. corolliforme*. We have examined small specimens of both species (down to 1 to 2 mm in diameter in *H. hirsutum*) and find the shape still distinctive (Text-fig. 1).

The difference in shell form is clearly demonstrated by the rostral compartment, which is triangular in *H. hirsutum* and elongate in *H. corolliforme* (Text-fig. 2). The rostra of both old and young *H. hirsutum* have an index

(height/width) of 0.8–0.9, while the type and other specimens of *H. corolliforme* have an index of 1.2–3.1. The other main character distinguishing *H. hirsutum* from *H. corolliforme* and most other species is the shape of the tergum.



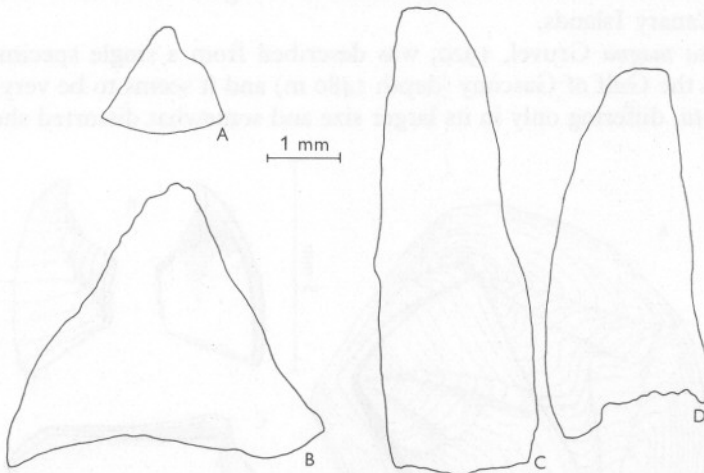
Text-fig. 1. Small specimens of *Hexelasma corolliforme* and *H. hirsutum*. Above, oblique view from rostral aspect; below, side views with rostra adjacent.

These measurements show that, in *H. hirsutum*, as reported by Hoek, the tergum is more elongate from apex to spur and the articular ridge is relatively shorter (Text-fig. 3).

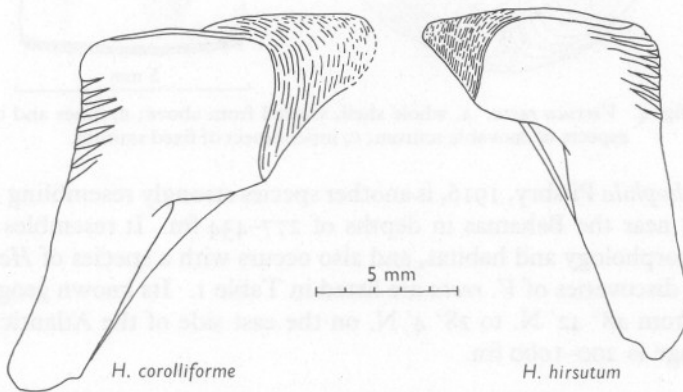
There appear to be few other differences between the species of *Hexelasma*, and we have not been able to find any differences between the mouthparts of *H. hirsutum* and *H. corolliforme*.

All our specimens are conical in shape and fully hirsute all over (Pl. I, figs. 1–5). The edges of the compartments are reflexed under the basis for 1–2 mm or less depending on size. On removal from the substratum a distinct 'scar' can be seen. This is possibly the same as the thin calcareous basis reported by Pilsbry (1916) for another species of the genus. Only the remains of the reflexed edges of the compartments show strong effervescence with acetic acid. The vaguer white patches in the middle of the scar partly

disappear in acid and may be weakly calcified. The scar shows distinct growth rings, and must therefore be formed by the reflexed margins of the compartments rather than by the basal membrane. It cannot be regarded as a true calcified basis such as is found in species of *Balanus*.



Text-fig. 2. Outline drawings of rostra of *Hexelasma hirsutum* (A and B), and *H. corolliforme* (C and D).



Text-fig. 3. Terga of large specimens of *Hexelasma*, inner side, showing articular ridge.

Verruca recta Aurivillius

Verruca recta Aurivillius, 1898.

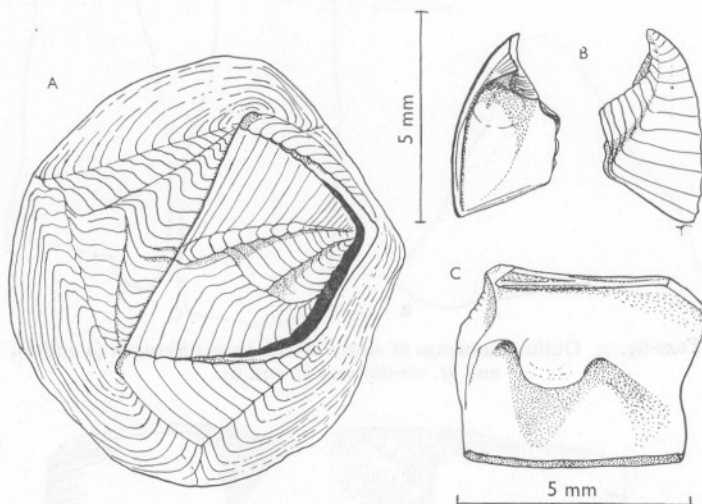
V. linearis Gruvel, 1902.

V. recta Aurivillius, Gruvel, 1920.

This species was first described by Aurivillius (1898), who found it among material from the Azores region (see Table 1). It was next encountered by

Gruvel (1902) in another collection from the Azores. He named it *V. linearis*, believing his specimens to be specifically distinct from those of Aurivillius. However, when he examined the Monaco collections he decided that his earlier specimens were, after all, *V. recta* (1920). By this time specimens had been collected at further stations in the Azores regions and also at one station off the Canary Islands.

Verruca magna Gruvel, 1920, was described from a single specimen collected in the Gulf of Gascony (depth 1480 m) and it seems to be very similar to *V. recta*, differing only in its larger size and somewhat distorted shell.



Text-fig. 4. *Verruca recta*. A, whole shell, viewed from above; B, inner and outer aspects of movable scutum; C, inner aspect of fixed scutum.

V. coraliophila Pilsbry, 1916, is another species strongly resembling *V. recta*, occurring near the Bahamas in depths of 277-434 fm. It resembles *V. recta* in both morphology and habitat, and also occurs with a species of *Hexelasma*.

Recent discoveries of *V. recta* are listed in Table 1. Its known geographical range is from 48° 42' N. to 28° 4' N. on the east side of the Atlantic, and its depth range is 200-1000 fm.

Description

The external characters of *V. recta* were described by Aurivillius (1898) and Gruvel (1902, 1920); we will here describe certain variations in these features and also some of the internal features.

The appearance of the whole animal is shown in Text-fig. 4A; the operculum is formed of either the right or left tergum and scutum, and we have about equal numbers of specimens of each type. The movable scutum (Text-fig. 4B) has two large articular ridges and a third very narrow ridge,

which is not visible from above in about half our specimens. The basal edges of the fixed plates are reflexed inwards as in *V. coraliophila* (Pilsbry, 1916), and there is a tongue-shaped adductor ridge protruding from the inner side of the fixed scutum (Text-fig. 4C). Neither of these characters was noted by Aurivillius or Gruvel; they indicate that *V. recta* belongs to the same subgroup of the genus as *V. coraliophila*, and that the two species may be synonymous.

The mouthparts are of the usual *Verruca* type, with no distinctive characters. The proportions of the rami of the first three pairs of cirri are of more help. The first cirrus has equal rami; the second has an anterior ramus about two-thirds the length of the posterior; in the third cirrus the anterior ramus is about four-fifths the length of the posterior. The caudal appendages are shorter than in other species of *Verruca*, being only one-fourteenth of the length of the sixth cirrus, and about three-quarters the length of its protopodite. In a large specimen each appendage had only seven segments. Pilsbry (1916) has recorded measurements of the cirri and caudal appendages for several species of *Verruca*, though not for *V. coraliophila*. Of these species the one with the most nearly corresponding measurements is *V. halotheca* Pilsbry, a Pacific species belonging to the same subgroup of the genus, and one which also resembles *V. recta* in both external features and habitat.

HABITAT AND ASSOCIATED FAUNA

The depths at which *Hexelasma hirsutum* and *Verruca recta* have been found, and the nature of the substrata on which they occur, are included in Table 1. Both species have been found on the same variety of substrata, including igneous and sedimentary rocks and living or dead shells of other animals, though only *Hexelasma* has been recorded from telegraph cables. Presumably they will settle on almost any exposed solid object if other conditions are favourable.

The two species differ somewhat in depth range. *Verruca* was found from just under 200 fm. to about 1000 fm., although most abundant at the 500–700 fm. level. It appears to be the more widespread, occurring alive at more of the 'Sarsia' stations than *Hexelasma*. The latter, with one exception, has been found only between 500 and 1000 fm. The exception is material from a cable, and it seems possible that the cable was hauled up from deeper water than that beneath the ship. *Hexelasma* is very abundant in the vicinity of the original 'Porcupine' station. The sea bed in this region of the continental slope is not particularly steep, but is very irregular. The echo-sounder records show the multiple criss-crossing bottom traces characteristic of submarine valleys, and it seems possible that the steep sides of these valleys may offer a very favourable habitat.

At the 500–700 fm. level, where both *Hexelasma* and *Verruca* are abundant,

there is a characteristic associated fauna. Sponges, probably *Hymedesmia* sp., cover some of the rocks and sometimes the barnacles themselves. Attached to the rocks and stones, among the barnacles, are several species of solitary corals; two or three as yet unidentified species of serpulid worms; and the holothurian *Psolus squamatus* Koren. Mobile animals found in the same dredge hauls included the polychaetes *Eunice pennata* (O. F. Müller) and *E. oerstedii* Stimpson, the decapod *Munida tenuimana* Sars*; the echinoderms *Ophiacantha* sp., *Ophiactis* sp., and *Stereocidarid ingolfiana* Mortensen; and the brachiopods† *Hispanirhynchia cornea* (Davidson) and *Dallina septigera* (Lovèn).

At one of the deeper stations (47° 30' N., 70° 20' W., 870–970 fm.) at which *Verruca* was found in the living condition, the fauna was rather different. Living and dead branches of the coral *Anisopsammia rostrata* (Pourtales) were abundant. Also present were *Munida microphthalma* A. Milne-Edwards*; the echinoderms *Ophiacantha* sp., *Ophiactis* sp., *Korethraster hispidus* Wyv. Thomson and *Hypsechinus* sp.; and the brachiopod *Platidia* sp.

At the shallower station (48° 42' N., 9° 48' W., 180–200 fm.) at which only *Verruca* was obtained, the fauna was characteristic of the coral region of Le Danois (1948), with *Lophohelia*, *Dendrophyllia*, and *Caryophyllia*, as well as several decapods and eunicid worms.

BEHAVIOUR

Some notes on the behaviour of *Hexelasma hirsutum* were made on the material collected in 1956. Regular beating of the cirri, such as occurs in most other species of barnacles, was never seen; it was found that water movement was necessary to induce extension of the cirri, which were fully protruded from the shell only within a restricted range of temperatures (Southward, 1956). These findings have been partly confirmed and partly amended by experiments on the 1957 material, as described below.

Water currents

The influence of water movement was studied at several temperatures (Table 2). Full extension of the cirri was induced only by water currents in excess of 1 cm/sec. Raising the velocity from 1 to approx. 5 cm/sec. caused a sharp increase in the number of barnacles with their cirri extended. Above 5 cm/sec up to the highest speed obtained in the apparatus (30 cm/sec) there was little or no increase in the number reacting, and in some experiments there were signs that very fast currents had an inhibiting effect.

Sensitivity to water movement was very strong. Extension of the cirri

* Identified by Dr R. B. Pike.

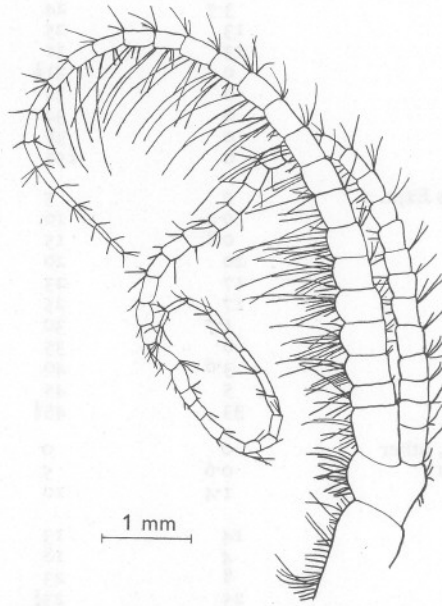
† Identified by Dr D. Atkins.

TABLE 2. EFFECT OF WATER MOVEMENT ON THE BEHAVIOUR OF *HEXELASMA HIRSUTUM*

	(Water speed cm/sec)	Min from start	No. with cirri extended, out of 47
Expt. 1. In constant temp. room at 5° C; overnight without water movement. Light for Expt. 48 W.	0	0	0
	0.8	10	0
	2.2	12	1
	2.2	17	2
	3.5	18	2
	3.5	23	5
	3.5	24	6
	13	25	6
	13	31	8
	0	31½	2
	0	32	3
	0	34	1
	0	38	3
0	158	0	
Expt. 2. Conditions as Expt. 1	0	5	0
	0.4	10	0
	0.8	15	0
	20	20	3
	17	23	8
	17	25	7
	1.7	30	2
	6	35	7
	3.6	40	5
	5	45	7
	33	45½	8
Expt. 3. Temp. 7° C, other conditions as Expt. 1	0	0	0
	0.6	5	(1 intermittent)
	1.4	10	(2 intermittent, 3 'pumping')
	14	13	9
	4	18	7
	8	23	14
	25	23½	10
	0	23½	6
	0	24	3
	0	26	1
	0	31	0
Expt. 4. Four hours without water movement; temp. 8° C; other conditions as Expt. 1	0	0	(1 intermittent)
	0.4	5	(1 intermittent)
	0.6	10	(1 intermittent)
	1.3	15	1
	3.3	20	3
	17	25	7
Expt. 5. Overnight without water movement at 4° C then temp. re- duced to 0.3° C in 2 h using cur- rent of 17 cm/sec to circulate water over cooling vessels of ice and salt	0.8	5	(2 intermittent)
	1.2	10	(3 intermittent)
	11	15	4
	17	20	6
	25	25	7
Expt. 6. Specimens kept at 10° C for 2 days, then brought into room with diffuse daylight, temp. 15.6° C.	0	5	(5 intermittent)
	0.7	10	6
	7	15	9
	10	20	6

occurred within a few seconds of starting the paddle wheel that generated the current, and most of the specimens withdrew their cirri a few seconds after the paddle wheel stopped, although one or two remained extended for 5 min or so after prolonged periods of current stimulation. Slowing down the velocity of the current from over 10 cm/sec to less than 5 cm/sec caused an immediate reduction in the number extended; an immediate increase could be obtained by speeding up the current again (Table 2, expts. 2 and 3).

Some of this sensitivity to water currents may lie in the peculiar 3rd cirri



Text-fig. 5. Third cirrus of preserved specimen of *Hexelasma hirsutum*, 9 mm diameter.

of *Hexelasma*. The rami are usually of unequal length, as in most Chthamalidae, with a ratio varying from 1.4:1 down to almost 1:1 (the latter in older specimens). The longer ramus is very flexible, and thinner than the short ramus (Text-fig. 5). When the cirri are extended in a water current (Pl. I, figs. 2, 3) the long ramus streams out and contrasts with the rest of the cirral net which is held stiffly in the current. The flexible ramus is insensitive to touching that causes bending of some of the other rami, and does not therefore appear to be part of a captorial apparatus. Possibly the long rami function as direction indicators, allowing the cirral net to be swung into the best position for capturing particles carried by the current (Pl. I, figs. 4, 5).

In contrast to *Hexelasma*, *Verruca* may extend its cirri in still water. Nevertheless, some experiments showed that water currents of 5–25 cm/sec would stimulate closed specimens of *Verruca* to full extension. Specimens of

the holothurian *Psolus squamatus*, which were present on stones with the barnacles, were also observed. Extension of the tentacles was stimulated by water movement, though the extension was very much slower than cirral extension in the barnacles.

Temperature

Experiments on the effect of temperature on extension of the cirri of *Hexelasma* are reported in Table 3. Up to one-third of the specimens under observation would extend their cirri between 7° and 12° C. Outside this

TABLE 3. EFFECT OF TEMPERATURE ON THE BEHAVIOUR OF
HEXELASMA HIRSUTUM

(Water current approx. 7-25 cm/sec.)

Temperature (° C)	Number of specimens out of 47 showing extension of cirri
-0.4	(10 intermittent)
0	(5 intermittent)
0.1	7
0.3	7
0.8	7
1.6	8
5.0	8
7.0	10-14
8.0	7
9.0	8-13
11.3	8
12.1	8-11
15.6	9
16.5	(5 intermittent)
18.0	8
19.8	3
20.5	(4 intermittent)
22.2	(2 intermittent)
24.0	(1 intermittent)
24.5	50% coma
26.5	100% coma

optimum range some extension was observed between 0° and 20° C. Some activity, but not full extension, was shown up to 24.5° C., at which temperature more than 50% succumbed to heat coma. *Verruca* also showed heat coma at this temperature. The range of temperatures over which *Hexelasma* would extend the cirri is greater than that reported previously for the 1956 material. The latter showed extension only between 3° and 8° C.

Both the 1956 and 1957 collections of *Hexelasma* were first examined 5-6 days after capture, but during this period they were treated differently. The 1956 material was brought back on the deck of R.V. 'Sarsia' under a flow of sea water from the deck supply; the specimens must have been subjected to great temperature variation during the voyage and may have suffered damage. The 1957 material was transferred immediately on capture to a

refrigerator at 5–7° C and brought back to the laboratory constant temperature room which was also at 5–7° C. Since the sea temperature at the depth the specimens came from was about 7–9° C (see Table 4), there would be much less chance of shock or damage.

Orientation of Hexelasma

The sensitivity of *Hexelasma* to water movement suggested that it might settle or grow in a position with the cirral net facing the prevailing water current in the habitat, as do many other barnacles (Crisp & Stubbings, 1957). Since the stones were very irregular, and as their original orientation on the sea bed was not known, the possibility of orientation to a current was tested by measuring the correspondence of the carino-rostral axes of barnacles on stones bearing groups of five or more. Of fifty-six barnacles measured in this way, the approximate angles subtended between them and a selected reference specimen (usually the largest in the group) were, in percentages:

0° C	45° C	90° C	135° C	180° C
48	30	9	6	7

That is, on average, three out of four specimens in each group faced the same way, or at an angle that allowed them to swing the cirral net, which easily traverses an arc of 90° (Pl. I, figs. 4, 5), to face the same way. It is not known, of course, whether all groups tested faced the same way, but it is a reasonable assumption that they did. The specimens facing away from the direction of the majority were mostly on large or irregular stones and may have been orientated to minor reverse eddies.

DISCUSSION

Barnacle communities of shallow water areas are best developed on wave-beaten rocky coasts or in estuaries with strong tidal currents, and it is a general rule that most species need water movement in their habitat to succeed in competition with other sessile organisms. This rule seems to apply to the deep-water species described here; their behaviour and orientation strongly suggest that they receive considerable water movement in their natural habitat.

These barnacles, and many other common animals in the same habitat, are sessile, and need hard substrata to grow on. Hard substrata are more likely to be exposed where water movement prevents the accumulation of fine particles. At the stations where the barnacles were most abundant the rocks and stones were partially embedded in a muddy bottom, as shown by the absence of a black deposit of manganese oxide present on the exposed parts (see Peach, 1912). Similar partly embedded rocks have been dredged elsewhere, and their position in the deposit, as deduced from the blackening, has been held as evidence that they were once buried in the deposit and more

recently exposed by water currents that carried away the fine particles (Peach, 1912).

Biologically and geologically, therefore, there is strong evidence for the existence of water currents where the barnacles occur. The velocity of the currents, judging from the behaviour of the barnacles, must be at least 1–5 cm/sec (0.9–4.3 km/day); such a current would be able to remove particles of fine sand (0.02–0.2 mm diameter) as well as the finer particles of silt and clay.

SUMMARY

Hexelasma hirsutum (Hoek) and *Verruca recta* Aurivillius are common at many stations on the continental slope to the south-west of the British Isles, the former at depths of 500–1000 fm., the latter from 200 to 1000 fm. Certain external and internal features of these species are described and their systematic status redefined. Their behaviour in the laboratory suggests that they are accustomed to considerable water movement in their natural habitat, and the significance of this inference is discussed.

REFERENCES

- AURIVILLIUS, C. W., 1898. Cirrhipèdes nouveaux provenant des campagnes scientifiques de S. A. S. le Prince de Monaco. *Bull. Soc. zool. Fr.*, T. 23, pp. 189–98.
- CRISP, D. J. & STUBBINGS, H. G., 1957. The orientation of barnacles to water currents. *J. Anim. Ecol.*, Vol. 26, pp. 179–96.
- DANOIS, E. LE, 1948. *Les Profondeurs de la Mer*. Paris: Payot.
- GRUVEL, A., 1902. *Expéditions Scientifiques du 'Travailleur' et du 'Talisman'*. Cirrhipèdes. Paris.
- 1920. Cirrhipèdes. *Result. Camp. sci. Monaco*, Fasc. 53, 88 pp.
- HOEK, P. P. C., 1883. Cirripedia. *Challenger Rep.*, Zool., Vol. 8, Part 25, 169 pp.
- 1913. The Cirripedia of the Siboga-Expedition. B. Cirripedia sessilia. *Siboga-Exped.*, Monogr. 31, pp. 129–273.
- JEFFREYS, J. G., 1878. On the Mollusca procured during the 'Lightning' and 'Porcupine' expeditions, 1868–70. (Part 1). *Proc. zool. Soc.*, 1878, pp. 393–416.
- NILSSON-CANTELL, C. A., 1930. Thoracic cirripedes collected in 1925–1927. *'Discovery' Rep.*, Vol. 2, pp. 226–60.
- PEACH, B. N., 1912. Report on rock specimens dredged by the 'Michael Sars' in 1910, by H.M.S. 'Triton' in 1882, and by H.M.S. 'Knight Errant' in 1880. *Proc. roy. Soc. Edinb.*, Vol. 32, pp. 262–91.
- PILSBRY, H. A., 1916. The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species. *Bull. U.S. nat. Mus.*, Vol. 93, 366 pp.
- SOUTHWARD, A. J., 1957. On the behaviour of barnacles. III. Further observations on the influence of temperature and age on cirral activity. *J. mar. biol. Ass. U.K.*, Vol. 36, pp. 323–334.

APPENDIX

Environmental conditions on the slope

By L. H. N. COOPER

In Table 4 an attempt is made to assess the hydrographic conditions under which the larger barnacle, *Hexelasma hirsutum*, was living. It will be seen that temperatures ranged from 4.2° to 9.4° C., salinities were between 35.1 and 35.5‰, and the water was well oxygenated. These temperatures agree with the range of temperatures over which *Hexelasma* showed most activity.

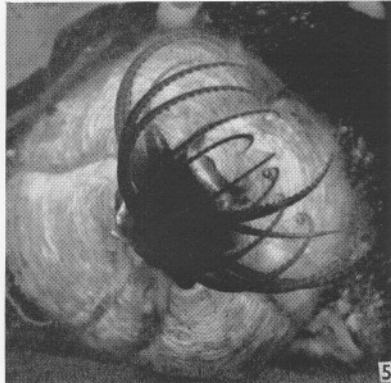
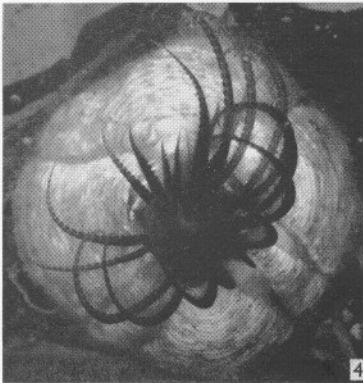
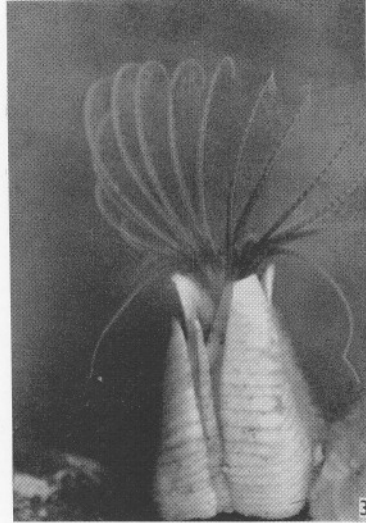
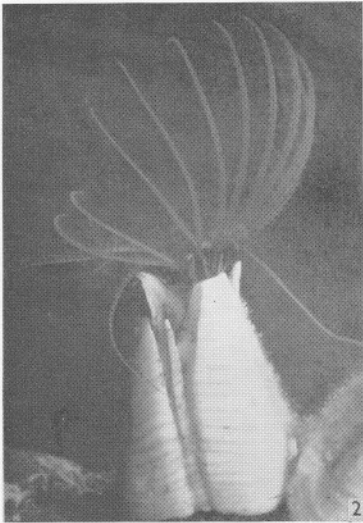
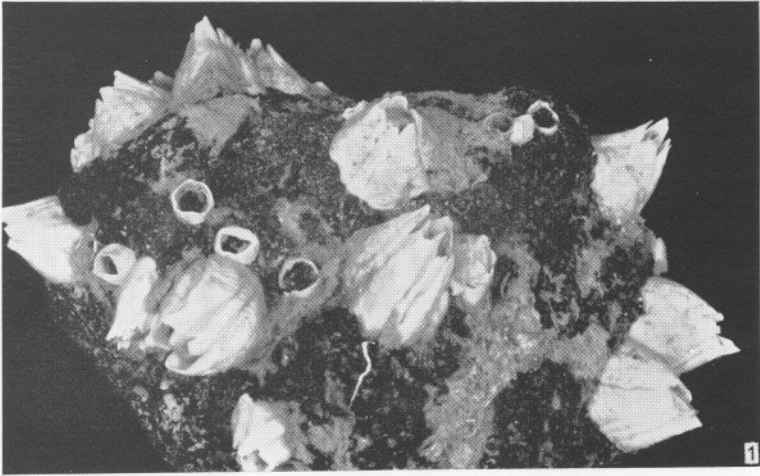
TABLE 4. HYDROGRAPHIC CONDITIONS AT STATIONS ADJACENT TO THOSE AT WHICH LIVING *HEXELASMA HIRSUTUM* WERE TAKEN

Dredge station	Depth (fm.)	Temp. (° C)	Salinity (‰)	Oxygen (ml./l.)	Silicate (µg-atom/l.)
48° 31' N., 10° 03' W.	690	6.9-7.7	35.4	4.5	13
59° 40' N., 7° 21' W.	516	8.4	35.3	—	—*
38° 31' N., 26° 49' W.	845	7.9-8.7	35.3	—	—†
48° 04' N., 9° 23' W.	1000	4.2	35.0	5.0	20
48° 02' N., 9° 25' W.	930	4.5	35.1	5.1	15
48° 02' N., 9° 27' W.	900	4.6	35.1	5.2	15
48° 33' N., 10° 05' W.	570-770	6.5-9.4	35.3-5	4.1- .8	12-14
48° 34' N., 10° 00' W.	570-700	6.7-9.4	35.3-5	4.2-5.8	11-14

* From Tait (1957). † From International Council (1944, p. 126); the remainder from unpublished data, L. H. N. Cooper.

It is probably coincidental, but water at all stations would have contained a proportion of 'Gibraltar Water' formed by mixing of warm, deep, saline water from the Mediterranean basin with deeper North Atlantic Central water. The occurrence of *Hexelasma* at the Azores suggests that the barnacle is not in need of materials which may be carried by cascading water from the continental shelf.

To the physical oceanographer the inference that the habitat of these deep-water barnacles is one of considerable water movement is of much importance. Such water movements could be oscillating surges resulting from internal waves or steady currents running along the slope, and it would be helpful if the barnacles themselves could be orientated. Dried specimens of *Hexelasma* were sent to Dr R. S. M. Nairn of Newcastle, in the hope that they might have measurable magnetic orientation, when the direction of the water current could be assumed to be the same as the carino-rostral axis (i.e. the direction which the cirral net faces). However, no deflexion of the magnetometer needle was observed. Sometimes iron objects discarded from ships are dredged up: if such an object is found in future, with barnacles growing on it, the residual magnetism may provide a measure of the direction of water movement *in situ*.



(Facing p. 646)

REFERENCES

- INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA, 1944. Observations hydrographiques de l'expédition internationale du 'Gulfstream' 1938. *Bull. Hydrogr., Copenh.*, 1938-39, pp. 113-137.
- TAIT, J. B., 1957. Hydrography of the Faroe-Shetland Channel, 1927-1952. *Mar. Res. Scot.*, No. 2, 309 pp.

EXPLANATION OF PLATE I

Fig. 1. Group of *Hexelasma hirsutum* on a piece of rock, which also bears one live and several dead specimens of *Verruca recta*, as well as patches of sponge and a serpulid tube. $\times \frac{1}{2}$.

Fig. 2. *Hexelasma* viewed from the carinal aspect, showing cirral net turned to face water current coming from the left. Note long rami of 3rd cirri streaming in current. $\times 1\frac{1}{2}$.

Fig. 3. The same specimen as fig. 2 just after water current was stopped.

Figs. 4, 5. View of larger *Hexelasma* from above showing rotation of cirral net. Current from left. In this specimen the 3rd cirri have almost equal rami. Approx. natural size.

Figs. 2-5 taken at 5° C in constant temperature room, with specimens subjected to water current of 5-20 cm/sec in apparatus described by Southward (1957). Approx. 2:1 on negative (Pan F); electronic flash tube $\frac{1}{2}$ -1 ft. away, 100-300 J; Elmar 50 mm lens at f18.