VII.—The Pterobranchia of the Scottish National Antarctic Expedition (1902 to 1904). By S. F. Harmer, Sc.D., F.R.S., Keeper of the Department of Zoology in the British Museum; and W. G. Ridewood, D.Sc., Lecturer on Biology in the Medical School of St Mary's Hospital, University of London. *Communicated by* Dr J. H. ASHWORTH. (With Five Text-Figures and Two Plates.)*

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INTRODUCTION.

The genus *Cephalodiscus* was instituted by M'INTOSH for a species, *C. dodecalophus*, which had been obtained by the *Challenger* Expedition. After the publication of the full account of this species, by M'INTOSH and HARMER (87) in the *Challenger Report*, succeeding papers for nearly twenty years were all based on the original *Challenger* material. The subject was in particular re-investigated by MASTERMAN in a series of papers (97¹, 97², 98, 99, 03). The *Siboga* report, published by HARMER (05) in 1905, added three Oriental species to the genus. SCHEPOTIEFF (05, 07, 08) devoted several papers to a further description of the *Challenger* material; while, more recently (09), he has described an interesting new species, *C. indicus*, from Ceylon. In 1906 RIDEWOOD (06) described *C. gilchristi* from South Africa; and in the following year he gave an account (07¹) of the two species which had been dredged by the *Discovery* Expedition; and (07²) of the development of the plumes in four species of *Cephalodiscus*. One of the *Discovery* species, *C. nigrescens*, had been described two years earlier by LANKESTER (05), in a preliminary paper; and RIDEWOOD (12) has recently brought forward evidence to show that this species had been dredged by the *Erebus* and *Terror* Expedition in 1841 or 1842. In 1907 ANDERSSON (07) added no less than six species to the genus, in describing the results of the Swedish South Polar Expedition, though we give some evidence (pp. 559–563) to show that one of them, *C. inæquatus*, is synonymous with *C. hodgsoni*, which had been described by RIDEWOOD (07¹) earlier in the same year, from the *Discovery* collection. The most recent addition to the list of species has been given by GRAVIER (12), who has published an account of *C. anderssoni*, a new species which was obtained by the second French Antarctic Expedition.

Full references to the literature of the subject, up to the dates of the respective publications, have been given in the works of HARMER (05), RIDEWOOD (07¹), and ANDERSSON (07). A general account of the group has more recently been given by SPENGLER (12).

The characters of the cœnoecium are so well marked that it appears justifiable to

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use them, as a rule, as a ready means of distinguishing one species of *Cephalodiscus* from another. It is remarkable that what one would suppose to be the uncorrelated efforts of the numerous zooids of a colony do in fact produce so uniform a result. The comparison of larger series of specimens may perhaps show in the future that the cœnœcial characters are less reliable than they appear to be at present; but the fact remains that the common house of the colony has, as a rule, so distinct a character of its own that it is difficult to believe that it cannot be used for systematic purposes. It has thus been possible to distinguish the following subgenera of *Cephalodiscus*:—

(1) *Demiothecia*, Ridewood (07¹), in which the cœnœcial cavity is continuous and the zooids occur separately or in groups in any part of it, being free to wander about in it.

(2) *Idiothecia*, Ridewood (07¹), in which each zooid, with a certain number of its buds, occupies an independent tube-like cavity in the cœnœcium.

(3) *Orthoëcus*, Andersson (07), in which each zooid has a tube of its own, but the tubes are free for the greater part of their length, instead of being embedded in the common cœnœcial mass as in *Idiothecia*.

The descriptions which have been published by the observers who have been referred to above show that there is a singular uniformity of structure in the zooid throughout the genus. In such fundamental characters as the three divisions of the body, and their associated cœlomic cavities, the notochord, the proboscis-canals, the collar-canals, and the gill-slits, there is practically no variation. The remarkable character of the male *C. sibogæ*, as described by HARMER (05), indicates that in that species at least there is a striking sexual dimorphism. In those other species in which both sexes are known there appears to be no essential difference between the two sexes except as regards their gonads. An exception must, however, be made in the case of *C. inæquatus* (probably = *C. hodgsoni*), where most of the female zooids have five pairs of arms, while most of the males have six pairs (see pp. 560–562).

Making use of the cœnœcial characters which have been mentioned above, it appears to be possible to distribute the known species of *Cephalodiscus* among the three subgenera there indicated, and in this way to separate species which it might be hard to characterise from the structure of their zooids. But within a single subgenus it becomes necessary to rely more largely on the characters of the zooid; and the discrimination of species on anatomical grounds may offer considerable difficulty.

In the earlier accounts of species of *Cephalodiscus* some stress was laid on the proportions of the zooid and of its stalk. This procedure has been criticised by ANDERSSON (07), who has had the unique opportunity of examining certain species in the living state. When account is taken of the highly muscular character of the zooid, and of the evidences of contraction afforded by wrinkling of the skin of the stalk and other parts, it is easy to believe that ANDERSSON'S criticism is to a large extent well founded. It may, nevertheless, be true that some weight may be ascribed in certain cases, as in discriminating between zooids in a similar degree of contraction, to features of this kind.

The difficulty of finding reliable specific characters in the structure of the zooid is increased by the fact that the material has as a rule not been preserved with any special refinements of technique. The study would be greatly facilitated by being able to make use of specimens which had been preserved in a fully extended condition. It would then be comparatively easy to ascertain the number of the arms or plumes with certainty. Under other circumstances this point, for instance, cannot always be made out without the possibility of mistake. Even in a well-prepared series of sections it is sometimes excessively difficult to count the arms, which may be cut in planes most unfavourable for study. The method of dissection is capable of giving valuable evidence; but here, too, mistakes are not out of the question. There is reason to believe that in some species of the genus the number of arms is variable (*cf.* RIDGEWOOD, 07¹). It must also be remembered that in some cases the number of the arms has been given as the result of the study of sections of a very small number of individuals. The comparison of series of sections of the same species might suggest differences which are really due to the degree of maturity or of contraction, or to the planes in which the sections are cut. Some caution is thus necessary both in making statements and in accepting those which have been made by other observers.

It can hardly be doubted, however, that the number of pairs of arms does provide a character which is of value systematically. Other characters which can be specially relied on are probably:—the number of buds, whether few or many, which are borne at any one time by the budding region of the stalk; the presence of one or three nerve-tracts in the stalk, as pointed out by HARMER (05) and ANDERSSON (07); the presence or absence of deep pigmentation of the skin; the shape of the operculum or postoral lamella; the size of the free ova and the structure of the embryos; and the mode of development of the arms in the buds.

Using some of these characters, the single species dredged by the *Scotia* may be thus characterised:—

Cephalodiscus agglutinans, n. sp. Colony massive, branching, somewhat resembling that of *C. nigrescens* in the size of its branches, but the material of the coenecium includes large quantities of shells of Foraminifera, small fragments of shells of Mollusca and spines of Echinoids, and rounded particles of slate. The pieces of colony vary in size up to 100 or 115 mm. in greatest length, and 45 or 55 mm. in greatest breadth. Cavity of the coenecium in the form of a tubular labyrinth continuous throughout (except for a few isolated septa), much branched in the interior, but the superficial parts of the tubes are radially set, and open at a fairly definite angle (about 80°) to the surface. Diameter of the peripheral tubes 1 mm. Ostia elliptical, size 1·2 by ·8 mm., each with a single thick lip or spine* projecting about 3 mm. beyond the general surface. No peristomial tubes. Mean distance from the middle of an ostium to the middle of the ostium nearest to it, 3 or 4 mm.; at the free extremity of the

* The spines are broken off in the greater part of the material examined.

branch, however, the ostia are more crowded. Length of zooids from the free ends of the arms to the end of a fairly extended body, 4.5 mm.; length from base of arms to end of body, 3.2 mm.; width of body, .8 mm., but if the body is much contracted its width is that of the tubes, *i.e.* 1 mm. Arms usually nine pairs, but often fewer and exceptionally more; no end-bulbs with refractive beads. Stomach and the succeeding U-shaped intestinal loop long. Females not known; and no buds having more than five pairs of arms have been found.

MATERIAL.

The specimens of *Cephalodiscus* submitted to us for study were sent in six bottles, five of which were of 2½ litres capacity, and the sixth of about half that size. This material was dredged on December 1, 1903, and was obtained in a single haul on the Burdwood Bank, to the south of the Falkland Isles (Station 346; lat. 54° 25' south; long. 57° 32' west; fathoms 56). The contents of the trawl on this occasion amounted to about half a ton,* the largest and richest catch of the expedition; and the members of the staff worked up to two o'clock in the morning sorting and bottling the specimens. All the *Cephalodiscus* material was preserved in alcohol, and no special measures were taken for killing the zooids in an extended condition.

CŒNŒCIUM.

The distinguishing feature of the present species, the agglutination of foreign particles in the soft substance of the cœnœcium, is apparent at a glance, and the semitransparent or translucent appearance of the cœnœcium of other species of *Cephalodiscus* is only to be detected in certain parts of branches where the inclusions are more scanty than usual. The general appearance of pieces of colony is whitish or whitish yellow, with dark spots which mark the ostia or openings of the tubular cavities inhabited by the zooids (text-fig. 1, A and B). The branches are massive, resembling those of *C. nigrescens* in size and bulk. The substance of the branch is weak and easily crumbled, the included shelly particles adding to the weight and not adding to the strength of the cœnœcium. A branch taken out of alcohol and held horizontally in the hand by one end breaks across by its own weight.

The majority of the pieces of colony are about 80 to 90 mm. in length, and oval in cross section, measuring about 30 mm. in the long diameter and 20 mm. in the short diameter. Some of the small pieces measure about 70 mm. by 20 mm. by 15 mm. The largest pieces measure about 100 to 115 mm. long, and have three or even four branches. The total width of such branching pieces of colony is 45 or 55 mm. On Plate I. are represented five pieces which are the largest in the whole collection and best suited for showing the characters of the branching. Since these are drawn of the natural size, a detailed description of them individually is

* Report of the Scientific Results of the Voyage of the S.Y. "Scotia," 1902-4, vol. iv., Zoology, part i., Zoological Log, 1908, p. 61.

unnecessary. Most of the pieces of material show no branching, but resemble the piece of which a photographic reproduction is shown in text-fig. 1, A.

The surface of the colony appears rough, and, if the ostia or openings of the tubes are not clearly visible, does not differ much from the surface presented when a piece is broken across (text-fig. 1, D and E). But in sheltered situations, as between the branches of a piece of colony, such as is shown in Pl. I. figs. 1, 4, there are blunt

TEXT-FIG. 1.—Photographic reproduction of pieces of colony of *C. agglutinans*; of the natural size. A, a piece broader at the free end (uppermost in the figure) than at the basal end, showing no branches; B, a piece showing a branching into two; C, a longitudinal median section of a piece of colony; D and E, transverse sections through a piece of colony. The darker areas are the tubular spaces occupied by the zooids, the white specks are small pieces of shell included in the coenocelial substance.

brownish processes or "spines" projecting to an extent of 3 mm. beyond the general surface. Inspection shows that these are really the projecting lips of the inhabited tubes, one to each tube, similar to the lips that occur on the surface of a piece of *C. nigrescens* (07, pl. iv. fig. 11), but differing in being less regular in form. These spines are built up by the superposition of solid caps of coenocelial substance upon the summit of pre-existing spines, just as are the long spines of species of *Cephalodiscus* such as *C. dodecalophus*, *C. hodgsoni* (07, pl. iv. fig. 21), and *C. gilchristi* (06, pl. iii. figs. 9, 10, 11), but they differ in not exceeding a length of 3 mm., and in being restricted in

number, one to each ostium. They further differ in that they include shelly particles (see text-fig. 3), although these are present to a less extent than in the general substance of the coenœcium. They are fairly pointed at the extremities, although the actual shape may be the result of the size and form of the included shelly particles, and they broaden out at the base and curve round the ostium for about one-third of its margin. In protected situations the inhabited tubes are seen to widen out suddenly as they reach the surface, and resemble very short funnels, and it is from the rim of the funnel that the lip projects. This accounts for the distance between the spine and the tube in the surface-view of the branch shown in text-fig. 2, B.

A careful examination of the outer surface of a piece of colony and a dissection into the substance of the coenœcium between the tubes reveals the presence of broken spines in association with the several ostia, and leads to the conclusion that the whole of the surface of the colony is in the natural state provided with short lips or spines, but that, owing to the rough treatment which the specimens must have experienced in coming up in the trawl with a great weight of other specimens, their surface has been scoured and deprived of the projecting spines, which are now only to be seen in their full development in protected situations between branches which have not been broken apart, as in Pl. I. fig. 1.

Of particular interest in this connection is the fact that although in *C. agglutinans* the zooids do not live in isolated tubes, but in tubes forming parts of a common tubular system, the single lip or spine to each ostium is in other known species of *Cephalodiscus* only met with in species of the subgenus *Idiothecia* (*C. gilchristi*, *C. nigrescens*, and *C. levinseni*) and *Orthoëcus* (*C. solidus*), whereas in the known species of *Demiothecia* the spines are multiple, four or five being present around each ostium in the case of *C. hodgsoni*, for instance.

The tubular cavities which open to the exterior, and in which the zooids occur, are approximately 1 mm. across, and the average distance from the middle of the orifice of a tube to the middle of that nearest to it is 3 or 4 mm., except at the free end of a branch, where the tubes are more crowded. The walls immediately bounding these cavities are composed of a thin layer of yellowish-brown coenœcial substance, much tougher than the jelly-like albuminoid that fills in the intervals between the tubes and makes the whole so compact. The tubes proper do not include in their walls any of the foreign bodies that give to the coenœcium of this species its characteristic appearance; but some of the shelly particles of the softer material of the coenœcium are so tightly fixed to the outer surface of the tubes that in dissecting a branch the tubes are liable to be torn in the attempt to remove the particles.

The tubes in the outer part of a piece of colony are fairly uniform in diameter (one millimetre), except at the junction of two tubes, where irregularities in shape and size may occur. A longitudinal section of a branch shows that the peripheral parts of the tubes are not set at right angles to the surface, but slope somewhat towards the free end of the branch (see text-fig. 1, C). In the middle of the piece the tubes are very

irregular in their disposition, but the cavities may still be termed tubular in spite of irregularities in their shape.

The internal tubular system is continuous throughout the whole branch, and if it were not for probable resistance offered by other zooids one could conceive of a zooid travelling internally from any one part to any other part of the system. In the middle portion or core of a branch the tubes not only exhibit branching, but here and there a complete tubular circuit can be seen, as is shown at *b, b, b, b* in the diagrammatic text-fig. 2, A. The existence of such continuous circuits is explained by the part of the circuit nearest the base of the branch being due to the bifurcation of a tube during an early stage of the growth of the branch, when this part occupied an apical position; whereas the part of the circuit farthest from the base of the branch is due to the burying of a superficial groove that connected two young ostia at a time when this part of the branch constituted the apex. There can be no doubt, from a study of the apex of a branch, that growth is apical. The tubes that open to the surface at the apex are much shorter and closer together than in other parts of the branch, although of the same diameter. Evidence of the branching of a tube at the apex is forthcoming, and also evidence of the enclosure of a superficial groove between two young ostia, such as produces the continuous circuits above referred to.

The ostia show on the surface of a piece of colony as dark areas, due partly to the fact that one is looking into a tubular cavity, and partly to the fact that the actual wall of the tube does not contain the shelly particles that make the softer substance of the cœnœcium so white in colour. In rare cases in the material studied the zooid occupying a peripheral tube could be seen without cutting into the branch, but in most cases the zooids had all retreated into the middle parts of the tubular system, and had become entangled and intertwined with one another. The ostia proper are slightly funnel-shaped and oval, measuring about 1.2 mm. in long diameter and .8 mm. in short diameter, whereas the tube itself is roughly circular in section, and of about 1 mm. diameter.

So far as can be seen from the study of the surface in protected parts between two branches that have not broken apart, the tubes do not project beyond the general surface, as "peristomial tubes," in the manner of the tubes of *C. levinseni* (05, pl. ii. fig. 11) and the tubes in certain parts of the colony of *C. nigrescens* (07, pl. iii. fig. 5), and this conclusion is supported by a study of the short tubes at the free extremity of a branch. The filling up of the intervals between the new tubes seems to take place *pari passu* with the additions made to the mouths of the tubes themselves. (Incidentally it may here be mentioned that the "habit" or "facies" of a colony of *Orthoëcus* differs from that of a colony of *Idiothecia* owing to the peristomial tubes of the former being of extraordinary length; indeed, in *C. rarus* the whole colony consists of peristomial tubes with only a small amount of softer cœnœcial substance binding the blind ends of the tubes together.)

The distinction between the sub-genera *Idiothecia* and *Demiothecia* was drawn in 1907 (07¹, p. 7) because the isolation of the zooids in separate tubes in the cœnœcium

of the species grouped in the former subgenus appeared to be of systematic importance. The study of the present material, however, goes some way to break down the distinction. In *Cephalodiscus agglutinans* the internal system of spaces in the cœnœcium is continuous throughout (except for occasional septa, see below), and zooids can move fairly freely through the system, as may be seen by the manner in which they have retreated to the internal parts of the branches in the material under consideration. So far as one can judge from a study of pieces of colony preserved in alcohol, the growth of a branch in a species of *Idiothecia* is by the buds (or possibly larvæ) settling at the apex of the branch, and each secreting a tube of its own, independent of those already existing, whereas in the present species the (presumably young) zooids at the apex secrete tubes continuous with the existing system of spaces within the branch. But *C. agglutinans* differs from all known species of *Demiothecia* in having long tubes, i.e. spaces of approximately even calibre extending for considerable distances; for in the recorded species of *Demiothecia* there is a single irregular branching cavity in the interior of the piece of colony, and this opens abruptly to the exterior here and there on the surface of the branch, or by means of very short tubular passages (see *C. hodgsoni*, 07¹, pl. iv. fig. 22).

The disposition of the tubes within a branch of the colony may be studied by dissecting away the soft part of the cœnœcium and the included shelly particles, but the process is laborious and not altogether satisfactory in other respects. Much better results can be obtained by decalcifying a branch in a 1 per cent. solution of nitric acid for ten days or a fortnight, and then bisecting the branch lengthwise and dissecting out such of the tubes as are laid bare. The process of decalcification removes all the shelly particles, and leaves only the grains of slate (see p. 542), which are not numerous and can be easily picked out. The piece of colony after decalcification is of a dirty brown colour, and is translucent, without the opacity and whiteness which is such a marked feature of the cœnœcium before it is placed in acid. In text-fig. 2, A, is shown a diagrammatic representation of the cut surface of such a bisected branch. (Compare this with the diagrammatic longitudinal section of a branch of *C. nigrescens*, in 07¹, pl. iv. fig. 10.)

This diagram (text-fig. 2, A) explains the main features of the tubular passages of the cœnœcium. It shows that in the most superficial parts the tubes are fairly straight, and of uniform diameter, and that they slope more or less radially outwards and incline somewhat towards the apex. The tubes in the middle are irregular in their arrangement, but on the whole are set at a uniform distance from one another. What appear to be blind ends of tubes at *d* and *d'* are merely parts of tubes that are cut across obliquely because they are leaving the plane of section.

In some of the passages, especially in the more basal parts of a branch, as at *s* and *s'*, there are thin concavo-convex partitions or septa, sometimes two or three in close succession. These septa, however, are not common. Their concave faces may be directed towards the apex of the branch, as at *s'*, or away from it, as at *s*.

In the apical region of a branch, as shown in the upper part of text-fig. 2, A, the ostia are closer together than on the sides of the branch, and the tubes that open to the exterior are much shorter than elsewhere; but the tubes are of the same calibre as in the other parts of the branch. The substance of the cœnocœcium is more delicate and the lining of the tubes thinner and less brown in colour than in other parts, and the tubes have no spines. These circumstances lead to the conclusion that the growth in the length of a branch takes place at the apex.

TEXT-FIG. 2.—A, a diagrammatic longitudinal section of a branch of *C. agglutinans*. *a*, a short peripheral tube at the apex of the branch; *b, b, b, b*, a part of the inner tubular system showing a complete open circuit; *c*, cœnocœcial substance, a soft albuminoid with shelly particles included; *d, d'*, parts of tubular passages cut obliquely: they are not blind ends; *l*, lip or spine set at the opening of a peripheral tube; *s, s'*, thin concavo-convex septa set across the tubes. Approximately $\times 1\frac{1}{2}$. For further explanation see the text, page 538.

B, a stout branch of *C. agglutinans* with the ostia and their spines or lips indicated over a portion of the surface. The tube-openings are shown in black: the oval and crescentic areas represent the broken bases of spines. *a, a'*, spines situated on the side of the tube towards the apex of the branch; *b, b'*, spines situated towards the basal side of the tube; *c, c'*, spines more or less lateral in position; *s, s'*, spines with no tubes alongside them. Approximately $\times 1\frac{1}{2}$. See text, p. 541.

In the case of species of *Idiothecia* and *Orthoëcus* it may be surmised from a study of the characters of the tubes of the cœnocœcium that young zooids, on separating from the stalk of the parent zooids, migrate over the surface, and settle down, in the case of species of *Idiothecia** at the apex of the branch, and in the case of species of *Orthoëcus* at the margin of the colony-mass. In *C. (Demiothecia) inæquatus*,

* Except in *C. indicus* (SCHEPOTIEFF, 09), about which we know too little to be able to speculate upon the mode of growth of the colony.

ANDERSSON has actually seen living zooids creeping over the surface of the cœnocœcium (07, p. 7).

In the case of *C. agglutinans* the state of preservation of the material does not enable us to conclude with certainty that each superficial tube opening to the surface was inhabited by a single zooid and its set of buds, but the probabilities are much in favour of this. The even calibre of each tube that opens to the surface points to its gradual growth outwards, as the branch thickens, being the work of a single zooid, as in the case of species of *Idiothecia* and *Orthoëcus*. There would, therefore, be in any one piece of colony approximately as many fully formed zooids as there are ostia. What occurs in the middle part of the tubular system it is not easy to conjecture; these parts can scarcely be inhabited in the ordinary sense of the term, since there is probably in the deeper tubes no circulation of sea-water such as would suffice for nutrition and respiration of zooids living there. One must conclude that these internal tubes are rather in the nature of deep retreats for the zooids in time of danger, and that when conditions of life are favourable and all the full-grown zooids have their proboscis and arms, and perhaps the whole of their body except the stalk, projecting out of the mouth of the tube, the inner part of the tubular system is empty, or serves only as a safe situation in which the young buds may grow.

When a bud is so far grown that it severs its connection with the parent and wanders off on its own account towards the apex of the branch to settle down as an independent zooid with a peripheral tube of its own, it may possibly reach the apex by the internal tubes, where, as suggested above, it would meet with but little resistance from other zooids; but it is much more likely that the young zooid takes a superficial route to the end of the branch, as one must suppose a young zooid of *C. nigrescens* does. But in the present case the young zooid on arriving at the apex does not commence to form a new short cœcal tube for itself, as is the case in *C. nigrescens*, but, in conjunction with other young zooids like itself, elaborates the tubular labyrinth already existing. At any one time one must suppose that every tube that opens upon the apex has in it a single young zooid which is adding to the mouth of the tube to increase its length, and is filling up with softer cœnocœcial material and shelly fragments the interval between its tube and those around. A newly arrived young zooid would therefore have to contend with some other zooid for the possession of a tube, and what seems to happen is that a *modus vivendi* is arrived at by the two agreeing upon a branching in an apical direction of what is at present a single tube. This, of course, is but speculation, but it seems to be the most plausible conclusion from a careful study of the form and disposition of the tubes at the free extremity of a branch.

In the older parts of a branch it would be interesting to know what happens to a peripheral tube when the adult zooid dies. The probability is that the vacant tube would soon be appropriated by some newly liberated bud or young zooid, either from within or from without. In some cases, as is shown on p. 542, the vacant tube is sealed up, but this is very exceptional.

The life of a colony is apparently not indefinite, for some of the pieces of the *Scotia* collection are "dead," i.e. no zooids at all are to be found in them. The tubes are either empty, or are occupied by a powdery brownish black mass, which, judging from its colour, may possibly consist of the products of decomposition of zooids. Among this débris are numerous specimens of a Tanaid Crustacean, of which no adult males have been found, so that the determination of the species is difficult. The specimens have been submitted to Mr T. V. HODGSON, who will doubtless refer to them in his report upon the Tanaidacea obtained on the *Scotia* Expedition.

The spines represented in text-fig. 3 show the mode of their construction by the superposition of successive caps of cœnoecial substance and the inclusion of foreign particles in these caps. Each fragment of shell is, of course, embedded in the particular increment that was being applied at the time that the fragment was picked up, and consequently it may cause a distortion of the surface of that particular cap, and the

TEXT-FIG. 3. —Three spines showing the successive caps of cœnoecial substance and the foreign particles included.

subsequent one, but it does not project into the preceding, more basally placed cap. In text-fig. 3 it might appear in certain places as though the particle were projecting into the cap below it, but this effect is produced by the particle and the optical section of the cap drawn in the figure being in different planes; the particle is more or less behind or in front of the median longitudinal section of the spine.

The diagrammatic text-fig. 2, A, shows that, except at the apex of a branch, the lip or spine at the edge of the ostium may be situated towards the apex or towards the base of the branch, or more or less laterally, and that it has not the regularly basal position that it has in *C. nigrescens* (07¹, pl. iv. fig. 10). This irregularity is illustrated further in text-fig. 2, B, which represents the carefully drawn details of a part of the surface of a stout branch. Owing to the fact that most of the spines on the surface of a piece of colony are broken off short, it is necessary to dissect into the substance of the cœnoecium to see the relation of the spine to the ostium. In the portion dissected it will be noticed that the spine is situated towards the apical end of the branch at *a* and *a'*, but towards the basal side of the ostium at *b* and *b'*, and it is laterally placed at *c* and *c'*. The spines broaden out as one dissects into the branch, and can be traced along the tubes for about a centimetre, when they cease to be distinguishable

from the soft general material of the cœnœcium. This is in conformity with what one sees at the apex of a branch, where the very young tubes have no spines (text-fig. 2, A).

The part drawn in text-fig. 2, B, shows four spines which have no ostia alongside (e.g. s). Three of these spines did not reach the surface, but had been buried over during the increase in the thickness of the branch. Occasionally, but rarely, a buried spine is found to have a closed-up tube by its side. Such an occluded tube is closed by a thin, curved partition, such as is seen in some of the inner tubes (as at s and s' in text-fig. 2, A), the convexity in the present case being towards the outer surface; and over this and also over the spine the soft material of the cœnœcium is deposited uniformly. One must suppose that in this case the tube was not occupied at the time that the zooids in the immediate vicinity were lengthening their tubes and filling in the intervals between them, and that the septum was formed subsequently from within. The relations of the spine alongside the occluded tube, and the succession of caps composing the spine, prove that the blind end of the tube is a closed-up ostium, and is not the initial end of a tube, blind from the commencement, such as one sees in the middle part of a branch of *C. nigrescens* (07¹, pl. iv. fig. 10).

Although the present species is denominated *C. agglutinans*, from the manner in which the zooids have embedded great quantities of shelly fragments in the material of the cœnœcium, the habit is not peculiar to this species, for HARMER has stated in his account of the new species which were obtained on the *Siboga* Expedition (05, p. 8), that the cœnœcium includes foreign particles as a rule, and that they are specially obvious in *C. sibogæ* (05, pl. ii. fig. 17, 18). ANDERSSON quotes as one of the characters by which *C. solidus* is distinguishable from *C. rarus*, that the tubes are encrusted with sand, diatoms, etc. (07, pp. 11, 12); and he further states that the tubes of *C. densus* are covered with sand-grains. GRAVIER, again (12, p. 2), says that in *C. anderssoni* (which, if not synonymous with *C. densus*, is very closely allied to it) sand-grains and shells of Foraminifera resembling *Polystomella* adhere to the outer face of the tubes, and are even incorporated in the substance of the wall. The basal parts of the pieces of colony of *C. nigrescens* are also known to contain fragments of shells (RIDEWOOD, 12, p. 551, Specimen C).

The inclusions in the cœnœcium of *C. agglutinans* are present in such quantity as to make the branches of the colony much more readily crumbled and broken than are those of *C. nigrescens*, which in general massiveness bear some resemblance to the branches of the present species. The particles included are mostly calcareous, and disappear when a branch is soaked in a 1 per cent. solution of nitric acid for ten days or a fortnight. The only foreign particles remaining after this treatment are some rounded, dark grey, or blackish grains, which Dr J. W. EVANS, Mineralogist of the Imperial Institute, has been good enough to examine for us. He reports that they are water-worn grains of slate. They mostly vary in size from .3 to 1 mm. in diameter, but one was found as large as 6 mm. across. A few of them are paler in colour, and softer,

than the majority, and are nearly white when dry; these are grains of slate more decomposed than the others.

While the slate-grains are all rounded and water-worn, the calcareous inclusions are remarkably free from signs of attrition. Delicate shells of Foraminifera, minute bivalve Molluscs, extremely thin, and with the two valves still in their natural relation, pieces of Echinid spines, and portions of Polyzoan colonies occur in a remarkably fresh and undamaged state, and can be picked out clean from the soft albuminoid material of the cœnœcium. Among the other inclusions one can recognise pieces of fairly large Lamellibranch shells, fragments of Gastropod shells, and pieces of Serpulid tubes. These broken pieces of shell show sharp edges in the great majority of cases, but a few are rounded. The fragments are, many of them, but little larger than the shells of the Foraminifera, but most are from .5 to 1 mm. in longest diameter. The largest pieces picked out were 8, 10, or 12 mm. long.

The included particles are all clean and free from mud, and from their even disposition in the cœnœcium one is tempted to conclude that they have not drifted by accident against newly secreted cœnœcial material which has not yet "set" or hardened, but that the particles are definitely selected by the zooids and built into the wall of their colonial residence, somewhat in the manner in which the arenaceous Foraminifera form their shells, and the larvæ of the Caddis-flies their tubes; and similar instances might also be quoted from among the tubicolous Polychæt Worms and the Rotifers.

The inclusion of foreign particles is not always uniform in the same piece of colony. It frequently happens that one side of a branch is whiter than the other, and a longitudinal section shows that the whiter half has more calcareous particles embedded than the other, and fewer tubes.

The pieces of colony brought home by the *Scotia* are too fragmentary to enable us to draw any conclusions as to the total dimensions of a colony of *C. agglutinans*. None of the pieces show at their basal ends any signs of an area of attachment to a solid substratum, and while each of the larger pieces, such as are figured in Pl. I., may be a separate colony, it is just possible that they may be portions of a large branching colony. This is rather suggested by all the zooids found being males, and by the fact that all the buds are in about the same stage of development—namely, very young buds, up to buds with four pairs of arms: only two buds were found having as many as five pairs of arms. There is, however, no evidence of the existence of stouter branches than those shown in Pl. I., such as would be capable of sustaining the great weight of the specimens in question, and, further, it must not be overlooked that the shelly fragments in the cœnœcium add to the weight of the branches without adding to their strength, and this may impose a limit to the size of an individual colony.

There is yet, however, a further possibility that the whole colony may consist of a broad, plate-like part closely adherent to some other object, and that from this there may stand up a forest of pieces such as are figured in Pl. I. The trawl in passing over

such a colony would snap off several of the upright pieces, but would not dislodge the basal plate. This view of the constitution of the colony is supported by the fact that the diminutive colony of *C. sibogæ* is composed of a basal encrustation growing on a stone, and a series of upstanding pieces (05, p. 13, and pl. i. fig. 2).

EXTERNAL APPEARANCE OF THE ZOOIDS.

The *Scotia* specimens are, unfortunately, in a rather poor state of preservation. In many cases the zooids had obviously retreated, on being killed, into the deeper recesses of the cœnœcium, where they did not come properly into contact with the preserving fluid. The result is that they are usually in a highly and often very irregularly contracted state, and their tissues are a good deal macerated. They are frequently in closely aggregated and deeply pigmented masses, which have somewhat the appearance of the zooid with its buds of *C. nigrescens* shown by RIDEWOOD (07¹, pl. iii. fig. 7). They are, in fact, more similar in external appearance to the zooids of that species than to those of any of the species of *Demiothecia* previously described. In well-extended and fairly straight individuals the average length from the end of the metasome to the free ends of the arms is 4.5 mm., the length from the end of the metasome to the bases of the arms about 3.2 mm. The thickness of a zooid is about .8 mm.

The zooids are, however, probably all shorter than they would have been in their fully extended condition, since the wrinkling of the skin indicates a strong contraction of the muscles, particularly of the longitudinal muscles of the anterior side of the metasome and of their continuation into the stalk.

All parts of the epidermis contain a dark pigment, so that the zooids have a deep brown or black colour in the preserved material. It is obvious that the pigment is not completely dissolved out by alcohol; but it is probable that its diffuse arrangement, as seen in the preserved specimens, does not represent the exact disposition during life. This is suggested by the comparison of sections of certain individuals of *C. nigrescens* (*Discovery* Expedition) which had been preserved with special care with sections of zooids which had not been so treated (see also p. 550). The former series show pigment-granules in sharply restricted areas (*cf.* RIDEWOOD, 07¹, pl. v. fig. 28), while the latter show a diffuse arrangement, suggesting that the pigment had been partially dissolved out, and then redeposited as a general staining of the tissues.

PROBOSCS.

The proboscis or buccal shield of the zooids in the material brought back by the *Scotia* is in such a poor state of preservation that it is not possible to make a statement as to its average shape and size. By an examination of whole zooids under a dissecting microscope, sufficient can be seen to show that the proboscis offers no exceptional features; there is a main lobe, and a lower lobe, thinner than the main

portion, and possessing the red line which is so curiously constant a feature in the various species of *Cephalodiscus*. But the epidermis is hopelessly disintegrated in most cases, and it is only in the buds that the proboscis is sufficiently well preserved for its form and proportions to be adequately determined (Pl. II. figs. 1-4; and text-fig. 5).

As in other species of *Cephalodiscus*, the proboscis is a highly mobile organ, and its parts appear in very varying positions in different individuals. It is shown in the sagittal section, fig. 15, and in the frontal sections, figs. 6-10, of Pl. II.

Pl. II. fig. 14 represents a section which has cut the proboscis-stalk at its narrowest region, and it demonstrates the two proboscis-canals (*p.p.*) in their usual relation to the pericardium (*per.*) and the anterior dorsal horns (*b.c.²a*) of the collar-cavity.

COLLAR-REGION.

The principal parts of the collar are the arms or plumes, dorsally; and the operculum or postoral lamella, ventrally.

(i.) *Tentacle-bearing Arms or Plumes.*

The number of these structures is greater than in any of the species previously described, since the full number appears to be nine pairs. This number is, however, not quite constant, as is indicated below. The species which most nearly resemble it in the number of their arms are the three species of *Orthoëcus* (*C. densus*, *C. rarus*, *C. solidus*), which were described by ANDERSSON (07), in which the number is stated to be constantly eight pairs; and *C. nigrescens*, in which the number is usually seven pairs, although it may rise to eight pairs (RIDEWOOD, 07¹). None of the species of *Demiothecia* which have been previously described have more than six pairs; and this is the commonest number in the subgenus in question.

The sections shown in figs. 6-11 of Pl. II. are chosen to demonstrate that nine pairs of arms may really be present. They have been cut at right angles to the long axis of the zooid, and therefore in a plane which has been described in the *Siboga* report (HARMER, 05) as "frontal."

Fig. 6 shows the first seven and the ninth arms of the left side, and the first seven arms of the right side. The study of the entire series of sections shows that all these arms except L.⁹ and R.¹ are directed dorsally, in a line prolonging the main axis of the zooid. The eighth and ninth pairs of arms could probably have assumed the same general direction during life; but they are actually lying in a position which makes their interpretation more difficult than in the case of the first seven pairs.

In fig. 7, which is the eighth section from that represented in fig. 6, the first seven arms of the left side are connected with one another. The lophophoral region of the collar has, in this section, not yet split up into the separate arms. Four of the membranous partitions which separate the arm-cavities for a short distance at their

bases, and are formed by the "Grenzmembran,"* are seen in this section. On the right side the first five arms are similarly connected, but R.⁶ and R.⁷ are already free. A comparison of this figure with fig. 8 will show that the first right arm has its axis directed more or less horizontally (or backwards) at the base, and that the arm then curves dorsally to assume the position in which it was seen in fig. 6. On the left side of fig. 7 the lophophore is about to separate from the rest of the collar, and the anterior dorsal horn of the collar-cavity is cut nearly at its tip. On the right side most of the lophophore is separated, in the section, from the rest of the collar, but the first arm is cut in a plane parallel to its food-groove, at its base. As the two sides of the groove are continuous with one another in an adjacent section, the difference between the two halves of the lophophore is thus not so great as it appears to be at first sight. The food-grooves are obvious in all the arms except in L.⁶, where the groove has opened out.

Fig. 8, which is eight sections further on, shows the dorsal parts of the collar-cavity (*b.c.*²) separated by a well-marked dorsal mesentery, at the ventral end of which lies the notochord (*nch.*), followed by the pericardium (*per.*) containing the heart. Some of the arm-grooves have disappeared. The eighth arm (L.⁸) is visible on the left side, and the ninth arm (L.⁹) of the same side shows indications of joining the lophophore. The relations of the first right arm (R.¹) have been explained in describing the previous section. The sixth right arm has joined the lophophore, but the seventh arm of that side is still distinct.

Fig. 9 represents the tenth section from that shown in the preceding figure. The eighth arm of the left side is now separate and is cut longitudinally, while the ninth arm of the same side is cut in a plane parallel to its long axis, so that its two sides are completely separated by the food-groove. It will be noticed that this arm, the last of the series, is closely related at its base to the opercular lobe (*op.l.*) of the same side. On the right side, R.⁷ has joined the lophophore; R.⁸ is beginning to appear, although still separated from the lophophore; and the tentacles of R.⁹ are commencing to be visible.

Fig. 10, which is four sections further on, shows the last two arms of both sides, both ninth arms being connected with the corresponding opercular lobe at their base.

In fig. 11, which is seventeen sections nearer the aboral end of the animal, the eighth left arm has passed across the dorsal side to the right of the metasome, where it lies close to the eighth right arm; while the ninth right arm has passed across the ventral side of the zooid. The section passes through the region of the gill-slits and collar-canals. Parts of the gill-slits (*g.s.*) are seen, in the region of their external openings and of their origin from the pharynx (*ph.*), on both sides of the section. The left collar-canal appears as a single cavity, but the right canal is cut twice, the two parts being connected by the strong muscle of the canal. The reason for this appearance is that the organ has a concave outline on its dorsal side, where the section

* SPENGLER, J. W., "Die Enteropneusten d. Golfes v. Neapel," *Fauna u. Flora d. Golfes v. Neapel*, 18 Monogr., 1893, p. 452.

passes. Part of the coelomic opening (*c.c.i.*) is visible in the figure, while a line crossing the epidermis just outside the canal indicates the commencement of the external orifice. On the dorsal side of the section are visible the two testes (*t.l.*, *t.r.*), with the genital mesenteries passing from the median dorsal mesentery (*d.m.³*) of the metasome to the gonads. The left testis (*t.l.*) of this individual is large and functional, but the right testis (*t.r.*), which is cut close to its external opening, has remained undeveloped. It appears in only a few sections of the series, and it does not anywhere reach a size much larger than is shown in the section under consideration. The asymmetry of the gonads is to be regarded as an individual peculiarity of this zooid (see also p. 553).

The demonstration of the number of arms, beyond the possibility of doubt, being a matter of some importance, a plasticine reconstruction of this individual was made according to the method described on p. 21 of the *Siboga* report (HARMER, 05). A slight improvement was, however, introduced by drawing the sections on thin drawing card ("Bristol board"). After cutting out the outlines drawn, the card was covered with a layer of plasticine and was attached to the part of the model already made. The cards representing the sections were left *in situ* in the model. The special advantage of this mode of procedure is that the cut edges of the cards remain in the model as a record of the outlines of the sections from which it has been constructed. This obviates the danger of destroying the outlines of the sections when smoothing out the intervals between two successive sections. If it should appear, moreover, that two sections have not been fitted together in correct "registration," it is easy to separate them at any time and to fit them together more accurately without losing the evidence on which the model was built up. The study of this reconstructed model has enabled us to obtain a clear idea of the position of the individual arms, of the parts of the operculum, and of the arrangement of the gill-slits and collar-canals, with other features of the zooid.

Making use of this evidence, the correctness of which can be estimated from the figures (figs. 11-6), the following description of the arms may be given. It will, of course, be understood that their position in the individual under consideration is to a large extent fortuitous, and that during life the arms could undoubtedly have assumed many other positions.

The first seven arms of both sides are directed dorsally, in line with the long axis of the zooid. On the right side, however, the first arm passes at first posteriorly, at right angles to the long axis, and then curves dorsally. On both sides the eighth and ninth arms are in the main directed ventrally. The ninth right arm passes ventrally from its origin, but soon curves across the ventral or anterior side of the zooid to assume the position shown in fig. 11. The eighth arm begins by passing dorsally for a short distance, and then doubles back sharply in a ventral direction. Fig. 10 represents the arm at the point where this flexure is taking place. It will be seen that the food-groove faces posteriorly. The part which is marked R.⁸ represents the arm after the

flexure has taken place; and in the later sections of the series (fig. 11), the arm is seen in transverse section as a continuation of the part marked R.⁸ The elongated part which stretches from this region towards the ninth arm shows the food-groove (R.^{8*}) opened out and cut obliquely at or near its flexure.

The eighth left arm (figs. 11-8) also has its food-groove directed posteriorly; but it lies in such a position that it is cut almost longitudinally as it passes across the dorsal side of the principal part of the collar. The ninth left arm (figs. 10-6) at first lies between the eighth arm of the same side and the region of the central nervous system (figs. 10-8). It runs more or less horizontally near its base, but soon curves dorsally, so as to appear even in the first section (fig. 6) which has been represented.

Although there are eighteen arms in the zooid which has thus been described in detail, this number is not constant in the species. A series of selected zooids were dissected and were found to give the results set forth below. It is possible, however, that arms may have been lost in some of the zooids examined, either by accident during life or as the result of violent contraction at the moment of preservation, and that some margin of error may thus have been introduced into the table. The facts as observed are as follow:—

12 arms :	3 individuals .	.	.	.	3
13 " :	1 " .	.	.	.	4
14 " :	3 " .	.	.	.	
15 " :	4 " .	.	.	.	15
16 " :	11 " .	.	.	.	
17 " :	11 " .	.	.	.	17
18 " :	6 " .	.	.	.	
19 " :	1 " .	.	.	.	1
Total	40 individuals .	.	.	.	40

If it may be inferred that in a zooid with thirteen arms, for instance, there were seven arms on one side and six on the other, it follows that of the forty individuals dissected there were only three which had less than seven arms on one side at least, and these appear to have had six pairs. In four cases there were seven arms on one or both sides; in fifteen cases there were eight arms on one or both sides; in seventeen cases there were nine arms on one or both sides; and in one case there were ten arms on one side. Representing these as percentages, it follows that the observations indicate:—

Total Number of Arms.	Maximum Number of Arms on One Side.	Individuals.	Percentages.
17 or 18	9	17	42·5
15 or 16	8	15	37·5
13 or 14	7	4	10·0
12	6	3	7·5
19	10	1	2·5
Total . .		40 .	100·0

It results from these figures that 42·5 per cent. of the zooids had nine arms on one side at least; while 80 per cent. had either eight or nine arms on one side at least. We accordingly draw the conclusion that the typical number of arms, in this species, is nine pairs, but that more than a third of the cases observed had a pair less; while a smaller percentage had seven, six or even ten arms as the maximum number on one side.

TEXT-FIG. 4.—Arms of *Cephalodiscus agglutinans*. A, an arm well extended; B, an arm in a moderate state of contraction; C-E, terminal portions of arms.

The number of tentacles or pinnules on an arm of a full-grown zooid is usually between thirty-five and forty-five pairs, but in some instances the number may be fifty pairs, and in younger zooids the number is less than thirty-five pairs.

It is difficult to say with certainty whether the dorsal epidermis of the axis of the arm is thick and black in *C. agglutinans*, as it is in *C. nigrescens*, because in most cases the epidermis has disintegrated, and there is more than a suspicion that in those cases in which the epidermis is still present the pigment-granules, which might have been present in them, have become bleached. This suspicion is founded upon the fact

that in the *Discovery* material some of the pieces of *C. nigrescens* were carefully fixed in Perenyi's fluid and some in picric acid solution, but most of the material was preserved in 5 per cent. formalin; and in slides made from the former material (fixed in Perenyi's fluid), the pigment is strongly marked (RIDEWOOD, 07¹, pl. v. fig. 28), whereas in sections prepared from the formalin-preserved material, the thick dorsal epidermis is not darker than the other parts of the section. The material of *C. agglutinans* was preserved in alcohol and not in formalin, it is true, but the preservation is not good, and the appearance of the large cells on the dorsal surface of the axis of the arms seen in paraffin-prepared serial sections is remarkably like that in the sections of the formalin-preserved zooids of *C. nigrescens*.

The dorsal epidermis of the arms of *C. agglutinans* is least disintegrated in contracted arms, and in the arms of fairly young zooids having but twenty-five to thirty-five pairs of tentacles. Text-fig. 4, A shows the appearance of a well-extended arm, and B an arm in a moderate state of contraction. The terminal part of the arm has no end-bulb with highly refractive beads such as distinguish the arms of *C. dodecalophus* (M'INTOSH, 87, pl. iv. fig. 1; pl. v. fig. 1; and RIDEWOOD, 07¹, text-fig. 1, p. 4) and *C. hodgei* (07¹, pl. v. fig. 32). In extended arms the extremity is bluntly pointed; in contracted arms it is rounded and even hemispherical. Some terminations better preserved than usual are shown in text-fig. 4, C-E (cf. *C. nigrescens*, 07¹, Pl. v. figs. 23-27).

(ii.) *Operculum or Postoral Lamella.*

The interpretation of the sections shown in figs. 8-11 is at first sight by no means easy, so far as the operculum is concerned. The study of the plasticine reconstruction has, however, enabled us to come to a clear conclusion as to its general form. It is seen to be deeply emarginate in the middle line, and the median sagittal sections examined thus show only a feebly developed lower lip (e.g. fig. 15, *op.*). On either side of the mouth, however, the operculum is produced into a large lateral lobe, a great part of which is free. The comparison of this series with other series of sections, and with what is known of other species of *Cephalodiscus*, shows that the operculum is a highly mobile organ, the parts of which can assume very different positions at the will of the zooid. In the specimen under consideration the right lobe (*op.r.*) is directed in the main dorsally (figs. 10-8), while the left lobe is sharply reflected ventrally, close to its origin from the collar. Figs. 10 and 9 cut this left lobe at or near the point where the flexure takes place. A consideration of fig. 9 will show that if the lobe of the left operculum (*op.l.*) nearer to the proboscis be imagined to have been unbent, so as to pass in a dorsal direction as a prolongation of the part of the operculum of the same side which is nearer the central nervous system, it would not have appeared in fig. 9; and the two sides of the section would have been fundamentally similar. If the zooid had died with the left lobe in the position indicated, both lobes would have appeared in fig. 8 in the position actually

seen on the right side. This section shows the large right lobe of the operculum in a region where it is free from the rest of the collar. The species appears to be characterised by having these free lateral lobes of the operculum well developed. It may be supposed that the size of the lateral lobes is to some extent correlated with the number of the arms; since it can hardly be doubted that one of the most important functions of the operculum is to help to convert the ventral grooves of the arms into channels leading the food to the mouth. A large development of the arms would accordingly require a corresponding development of the opercular lobes, which, during the act of feeding, would presumably be thrown into the position seen on the right side in fig. 8.

Comparison with other species of *Cephalodiscus* in this respect cannot be attempted very satisfactorily, but it may be noted that the operculum of *C. hodgsoni*, figured by RIDGEWOOD (07¹, pl. vi. fig. 53), has a close resemblance to that of *C. agglutinans*, here described. Except with the aid of solid reconstructions, which have not been made in many cases, it is often difficult to ascertain the exact form of this organ; but it may be remarked that in *C. gracilis*, of which a plasticine reconstruction has been figured in pl. iii. fig. 25, of the *Siboga* report (HARMER, 05), the operculum is hardly emarginate in the middle line, and has no special development of its lateral lobes. The arms in that species are comparatively few, only five being present on each side.

Two further points may be noted with regard to the operculum of *C. agglutinans* :—

(a) The last arm of each side is continuous with the corresponding opercular lobe, as in other species of *Cephalodiscus* (cf. HARMER, 05, pp. 31, 36; and RIDGEWOOD, 07², p. 229). This is sufficiently illustrated by fig. 10.

(b) The free edge of the operculum is more or less scalloped, as is indicated by fig. 11, where two of the end-lobes are cut separately. Evidence that the edge has this form has also been obtained in some of the dissected specimens. The same character has been figured by RIDGEWOOD (07¹, pl. vi. fig. 53) in *C. hodgsoni*.

(iii.) Collar-canals.

These structures agree in general form and position with those of other species of the genus. Seen in side view the ventral outline is very convex, while the dorsal outline may be concave. In a frontal section of the zooid (fig. 11), a collar-canal which is cut near its dorsal side may appear as two separate parts. The inner part (c.c.i.) opens into the collar-cavity, while the two parts of the tube are connected by the strong collar-muscle. The epithelium of the canal is much thinner on the dorsal side than it is ventrally; and it is reasonable to suppose that it is more flexible there. The muscle would thus seem to have the function partly of dilating the coelomic opening and partly of acting in antagonism to the prolongation of the principal muscular mass of the metasome; which, as shown in the sagittal section, fig. 16, *ms.*,

ends in close relation with the collar-canal (*c.c.i.*). The *modus operandi* of the collar-canals has previously been discussed by both of us (HARMER, 05, pp. 41-46 ; RIDEWOOD, 07, pp. 41-43).

GILL-SLITS.

The gill-slits (Pl. II. figs. 5, 11, *g.s.*) agree closely with those of other species of the genus. In the individual represented in figs. 6-11, the external openings of the gill-slits are seen from the plasticine reconstruction to lie in strongly marked longitudinal grooves, each of which occurs nearer to the middle line of the anterior wall of the metasome than the external opening of the corresponding collar-canal. These grooves are, however, probably the result of contraction at the moment of death. They can be traced along the metasome for a considerable distance, in an aboral direction, beyond the collar-pores. The walls of the gill-slits are composed of vacuolated epithelium (MASTERMAN'S "pleurochords"), as in other species of *Cephalodiscus*.

ALIMENTARY CANAL AND NOTOCHORD.

The great length of the intestinal loop, which commences at the stomach and is situated in the caecal end* of the metasome has been alluded to above in describing the distinctive features of this species. It is well seen in the dissected specimen, fig. 12, and in the sagittal section, fig. 16. In both figures the metasome is probably shortened by muscular contraction; and in its full state of extension the folds seen in the figures would have probably disappeared. Owing to the length of this part of the alimentary canal, the stomach (*stom.*) is separated by a considerable interval from the caecal end of the metasome—a character in which the present species resembles *C. levinseni*. In one individual which has been examined, the intestinal loop contains a number of Diatoms and other microscopic organisms, and many Sponge-spicules.

The notochord (*nch.*) is seen in sagittal section in fig. 15; and as shown by this figure, as well as by figs. 8-10, it has a well-developed lumen.

GONADS.

Every individual in which the gonads have been examined has proved to be of the male sex. Although the amount of material at our disposal has been large, it was all dredged at one time, and there is nothing to forbid the assumption that all the pieces brought back by the *Scotia* were parts of a single large male colony.

The testes vary a good deal in size in the different individuals examined. In their highest development (figs. 5, 12) they are elongated organs, which may be simple tubular structures, or may be marked by several constrictions extending transversely to

* ANDERSSON (07, p. 7) has pointed out, from observations on living zooids, that the "caecal end" of the metasome disappears in fully extended zooids, where the stalk appears as a direct continuation of the body. The appearance of a caecal end is none the less very characteristic of the majority of the contracted zooids.

their main axis. These are probably in part the result of the contraction of the zooid. The aboral end of the testis may extend at least as far as the origin of the stalk from the metasome.

In some cases, though not in all, we have noticed the appearance indicated at the aboral end of the testis in fig. 12. A tube, which seems to end blindly, extends into the cavity of the organ as an invagination of the aboral end. The most probable interpretation of this structure is that it is merely part of the wall of the testis which has been invaginated, and that it has no special morphological significance. Its walls are sometimes more pigmented than those of the rest of the testis, so that it may be a conspicuous structure in entire preparations.

When both testes are fully developed, as in fig. 5, *t.l.*, *t.r.*, they appear symmetrically disposed on either side of the median dorsal mesentery of the metasome. The central part of the testis is occupied by a mass of fully developed spermatozoa, while there is a peripheral zone, of varying width, which contains very numerous nuclei, indicating stages in spermatogenesis. In other cases, as in fig. 11, the two testes are very different in size; and in this particular case the left testis (*t.l.*) is fully developed, while the right testis (*t.r.*) has remained vestigial. The figure shows the two transverse genital mesenteries which run from the dorsal mesentery of the metasome, near the region where the testes open to the exterior, to the two gonads. These transverse mesenteries are no doubt the bearers of blood-vessels which pass from the dorsal vessel to the gonads.

NERVOUS SYSTEM.

We have no new observations of importance with regard to this part of the anatomy, and it will be sufficient to note that the nervous system of *C. agglutinans* agrees in essential respects with that of other species of the genus.

ANDERSSON has, however, stated (07, pp. 7, 8, 32) that while in the subgenus *Orthoëcus* the lateral nerves unite ventrally on the metasome to give rise to a nerve-tract which has a single median thickening, *Demiothecia* differs from it in having a subsidiary thickening on each side of this median one. The occurrence of the three nerve-tracts in the ventral region of the metasome and in the stalk was first pointed out by MASTERMAN (98, p. 513) in *C. dodecalophus*; but it is not certain that the character in question can be used to discriminate the subgenera of *Cephalodiscus*. Thus in *C. levinseni* (HARMER, 05, p. 51, pl. xi. fig. 132), which belongs to *Idiothecia*, a single nerve-tract is present in the stalk, while in *C. nigrescens* (RIDEWOOD, 07¹, p. 40, text-fig. 15), belonging to the same subgenus, there are three nerve-tracts. ANDERSSON has, moreover, not sufficiently taken into account the fact that in *C. gracilis* and *C. sibogæ* (HARMER, 05, pp. 52, 53), which belong to *Demiothecia*, only a single nerve-tract is present; while, on the other hand, *C. dodecalophus*, *C. hodgsoni*, and *C. æquatus*, belonging to the same subgenus, have three nerve-tracts. *C. agglutinans* (fig. 13, *n.t.*) agrees with the species of *Orthoëcus* described by ANDERSSON, and with *C. (Idiothecia)*

levinseni, *C. (Demiothecia) gracilis*, and *C. (D.) sibogæ* in having a single nerve-tract in the stalk.

The number of the nerve-tracts in the region in question is no doubt correlated with the way in which the metasomatic muscles are arranged at the point where they pass into the stalk. In *C. agglutinans*, as in *C. levinseni*, *C. gracilis*, and *C. sibogæ*, the layer of metasomatic muscles forms a single fold extending deeply into the cavity of the stalk, round the single nerve-tract, in the region where the stalk is separating from the body. In *C. dodecalophus*, *C. hodgsoni*, and *C. æquatus*, in which three nerve-tracts are present, there is, in addition, a pair of muscular folds similarly related to the lateral nerve-tracts.

BUDS.

The buds seem to be produced in exceptionally large numbers in the present species, and an examination of the budding disc at the end of the stalk of full-grown zooids shows that in some cases as many as seven pair of buds are present at the same time. As in other species, the free surface of the disc is of the nature of a sucker for adhering to foreign objects; the disc is wider than the end of the parental stalk, and the buds develop in pairs in the groove between the stalk and the disc. The youngest buds cannot be said to have any stalks; they are merely clavate or pyriform outgrowths, which soon show a transverse groove when the proboscis differentiates from the rest of the bud. The stalks of the other buds are remarkably long; that of one bud with two pairs of arms developing, of the stage shown in text-fig. 5, C, measured 3.9 mm.; another of the same stage of development measured 4.3 mm.

There is a remarkable uniformity to be noticed in the size of the stalked buds present. The proboscis of a bud in which the first pair of arms are just about to develop, such as is represented in text-fig. 5, A, is not very much smaller than that of a bud in which five pairs of arms can be recognised—and it is the proboscis which practically determines the size of the bud. Buds intermediate in size and development between minute stalkless buds just forming from the disc and buds like that shown in text-fig. 5, A, are scarce; and no buds have been found older than that shown in text-fig. 5, F. Indeed, only two buds of the latter stage were discovered. It would seem, therefore, that buds develop very rapidly up to the time when the first pair of arms make their appearance, and that their subsequent growth is slower. What happens after the stage with five pairs of arms it is impossible to say. The buds of this age seem to be too young to separate off as independent zooids and to leave the colony—their alimentary canal is still cæcal, and the ten arms have not yet produced any tentacles (text-fig. 5, F)—and in some other species of *Cephalodiscus* (e.g. *C. hodgsoni* and *C. nigrescens*, RIDEWOOD, 07²) buds may be found still attached by their stalk to the parent having the full number of arms characteristic of the adult zooids. The absence of old buds in the present material may perhaps be accounted for by some seasonal cause; or buds may only begin to be produced when the development of the gonads has reached a certain stage.

In text-fig. 5 are shown composite figures of buds based upon thirty-five *camera lucida* drawings. The proboscis is reproduced in the successive figures as gradually increasing in size; this is correct in the main, but buds with the same number of arms may have

TEXT-FIG. 5.—Figures illustrating the development of the arms or plumes in the buds of *Cephalodiscus agglutinans*, for comparison with the figures of *C. gilchristi* and *C. nigrescens* in RIDGEWOOD, 07², pp. 243 and 236. The lettering is the same as before, namely:—1, 2, 3, 4, 5, the first, second, third, fourth, and fifth arms of the buds; *b.*, the “body” or metasome of the bud; *b.s.*, main portion of the proboscis or buccal shield; *m.*, mouth; *p.l.*, lower lobe of the proboscis; *po.l.*, operculum or postoral lamella; *s.*, stalk of the bud.

A, aboral view of a bud in which no arms have yet developed; B, a bud with one pair of arms; C, a bud with two pairs; D, a bud with three pairs; E, a bud with four pairs; F, a bud with five pairs of arms; G, the oral surface of the body of a bud in which the lower lobe of the proboscis was turned well upward, and has been cut away. The operculum is seen to be continuous with the last developed (fourth) arm, and is as yet incomplete below the mouth. Approximately $\times 60$.

the proboscis of different sizes, and there are many buds with three pairs of arms which have a smaller proboscis than others with two pairs or even one pair only. This irregularity may be partly accounted for by disparity in the rates of growth of the proboscis and the collar-region, but is to a large extent also to be explained by the fact that the

proboscis is not only a very mobile organ, but is evidently also capable of considerable change in superficial extent; a large proboscis on a bud with three pairs of arms is thinner than a smaller proboscis on another bud with the same number of arms.

In buds with three, four, or five pairs of arms the first portion of the gut can be seen in the interior of the "body" in clarified preparations; it appears as a cæcal tube, connected with the mouth, and with a slender cord passing from the blind extremity towards the stalk. The state of preservation of the material is so poor that the study of the internal structure of the buds by means of serial sections did not seem advisable. The development of the internal organs in buds of *Cephalodiscus* is not likely to differ much among the various species, and any time and energy spent upon a study of these parts is most profitably expended by restricting oneself to material that is specially suited to the methods of microscopical technique.

On comparing the buds of *C. agglutinans* with those of other species of *Cephalodiscus*, one is struck by the fact that in the relatively late appearance of the arms this species more closely resembles *C. gilchristi*, a species of the subgenus *Idiothecia*, than it resembles species of the subgenus *Demiothecia*, such as *C. dodecalophus* and *C. hodgsoni* (RIDEWOOD, 07², pp. 231 and 225). Incidentally it may be mentioned that the buds of *C. æquatus* and *C. inæquatus*, examined by us in material collected on the Swedish South-Polar Expedition, agree very closely with those of *C. dodecalophus* and *C. hodgsoni*. In *C. dodecalophus*, *C. hodgsoni*, *C. inæquatus* (which we regard as synonymous with *C. hodgsoni*, see p. 560), and *C. æquatus* the first pair of arms reach the end of the proboscis at a stage when three pairs of arms are recognisable (07², p. 231, text-fig. 4, G and H, and p. 225, text-fig. 2, G); whereas in *C. agglutinans*, as also in *C. nigrescens* and *C. gilchristi* (07², pp. 236 and 243), the arms at the three-pair stage (text-fig. 5, D) are but insignificant bead-like outgrowths from the sides of the collar, and are very remote from the edge of the proboscis.

SYSTEMATIC POSITION OF *C. AGGLUTINANS*.

We have not found it an easy matter to come to a definite conclusion with regard to the affinities of the *Scotia* species of *Cephalodiscus*. In the present state of our knowledge it is probably best to accept provisionally the subdivision of the genus into the three subgenera mentioned on p. 532. We may remark, however, in passing that it is surprising that a crowd of independent zooids should be able to build up a cœnœcium, by their united efforts, which has a definite character of its own. But, on the other hand, there is sufficient resemblance between the cœnœcia of *C. levinseni*, *C. nigrescens*, and *C. gilchristi* to justify their inclusion in a single subgenus, *Idiothecia*; and this becomes the more significant when it is remembered that these species have been recorded from such widely distant localities as between Japan and Corea, the Antarctic Ocean, and South Africa respectively. There is, moreover, a considerable amount of resemblance in anatomical structure between the zooids of species which

have been referred to *Demiothecia*, as well as between those which have been placed in *Orthoëcus*.

According to the subgeneric diagnoses which have previously been given, *C. agglutinans* should come in *Demiothecia*, since the cavity of the cœnœcium is continuous throughout (as distinguished from *Idiothecia*, in which each zooid inhabits a separate tube of its own), while the tubes are not in the main distinct from one another and with separate cavities, as in *Orthoëcus*. But in other respects the cœnœcium of *C. agglutinans* shows a greater resemblance to *Idiothecia*, to which we are inclined to refer it, in spite of the continuity of the cœnœcial cavity.

The cœnœcium of the known species of *Demiothecia* consists of a more or less branching system traversed by a continuous cavity, which is of such a kind that a transverse section of a branch shows a central cavity surrounded by a layer of the cœnœcial substance, irregularly thickened in various places. A transverse section of the cœnœcium of *C. agglutinans* does not show this simple arrangement; but it exhibits a massive cœnœcial substance, crammed with foreign inclusions, and traversed here and there by the relatively small tubes inhabited by the zooids. The arrangement of these tubes is shown diagrammatically in text-fig. 2, A, on p. 539. In its massive character and in the disposition of the outer parts of the tubes this has considerable resemblance to the cœnœcium of *C. (Idiothecia) nigrescens*, as figured by RIDGEWOOD (07¹, pl. iv. fig. 10). It differs from it in the fact that the tubes which lead to the external ostia do not end blindly at their lower ends, but are connected together by a complicated system of branching tubes which occupy the axial part of the branch. But the fact must be emphasised that the arrangement of the outer parts of the tubes agrees substantially with that of the entire tubes of *C. nigrescens*, and that no species of *Demiothecia* yet described possesses a system of regularly arranged long tubes leading from the interior to the ostia. The ostia of *Demiothecia* are little more than perforations of the common cœnœcial wall, so that the central cavity may be described as opening directly to the exterior by means of the ostia. We think, therefore, that there is much to be said for the view that *C. agglutinans* may be regarded as an *Idiothecia* in which the inner parts of the tubes of the zooids are connected by a set of tubes, branching in the axial region of the cœnœcium and placing all the cavities in communication with one another.

A further argument in favour of this view may be obtained from a consideration of the mode of growth which appears to be indicated by a study of the cœnœcium (*cf.* p. 539). We have given reasons for believing that the growth of the branches is to a large extent apical, as appears to be the case in *C. nigrescens* and *C. levinseni*, both of which belong to *Idiothecia*. This may be inferred by the regular arrangement of the outer parts of the tubes, in all parts of the colony, as well as by the fact that the apical tubes are shorter than the others, and apparently younger.

The occasional occurrence of septa across the tubes of *C. agglutinans* (p. 538) may indicate some approach to the more typical species of *Idiothecia* in which each tube

is completely cut off from its neighbours (compare the septa in *C. nigrescens*, RIDEWOOD, 07¹, pl. iv. fig. 10).

The single short spine or lip at the side of each ostium in *C. agglutinans* finds a parallel in *C. (I.) nigrescens*, *C. (I.) levinseni*, and *C. (O.) solidus*. In *C. (I.) gilchristi* there are long spines, about as numerous as the ostia, but not very distinctly related to them; whereas in *C. (I.) indicus*, *C. (O.) densus*, and *C. (O.) rarus* there are no lips to the tubes. In *C. (D.) dodecalophus*, *C. (D.) hodgsoni*, and *C. (D.) æquatus*, however, the spines are long and numerous, usually four or five to each ostium.

The study of the zooids may be held to give some support to the view that the nearest ally of *C. agglutinans* is to be found in the subgenus *Idiothecia*. There is considerable resemblance between the zooids of *C. agglutinans* and *C. nigrescens* in their relatively large size, in the general proportions of the body, in the large number of arms, and in the dense pigmentation of the skin. Too much weight, however, must not be attached to this last character, since the pigmentation may not really be an indication of affinity, but may be of a purely physiological nature, as seems to be the case in certain deep-water pelagic Fishes.* *C. sibogæ*, a species of *Demiothecia*, has, moreover, a deeply pigmented epidermis (HARMER, 05, p. 8).

In the absence of end-bulbs with refractive beads at the ends of the arms, *C. agglutinans* agrees with the species of *Idiothecia* and *Orthoëcus*, and differs from those of *Demiothecia*.

Attention has already been drawn (p. 556) to the fact that, in the relatively late appearance of the arms in the buds of *C. agglutinans*, this species more closely resembles *C. gilchristi* and *C. nigrescens* than species of *Demiothecia* such as *C. dodecalophus*, *C. hodgsoni*, and *C. æquatus*.

The special characters of the cœnœcium of *C. agglutinans* might be taken to justify the institution of a new subgenus for the reception of this species. We think it unnecessary to adopt this course; but it is obvious that, if the species is rightly referred to *Idiothecia*, the original diagnosis of that subgenus (RIDEWOOD, 07¹, p. 10) must be amended by adding to the statement, "tubular cavity . . . having no connection with the other cavities of the tubarium," some statement to the effect that the tubes may be connected with one another. The following amended diagnosis is suggested:—

Subgenus *Idiothecia*. Each ostium leading into a long tube lodged in a common cœnœcial substance; the tubes definitely arranged at a more or less constant angle to the surface, usually completely separated from one another, and each containing a single zooid with its buds, but sometimes connected with one another by an intercommunicating system of tubes.

It may be pointed out in conclusion that the name *Idiothecia* would not be less strictly applicable in consequence of the extension of the scope of the subgenus,

* Cf. Sir JOHN MURRAY and J. HJORT, *The Depths of the Ocean*, London (Macmillan & Co.), 1912, pp. 618, 624, 677, and elsewhere.

for the derivation of the word (*idios*, one's own, personal, private; and *theke*, a case, box, vault) refers to the zooids, with their buds, having each their own tubes; and this appears to be the case in *C. agglutinans*, in spite of the fact that the tubes communicate with one another in the axial part of the cœnœcium (see p. 540).

ADDENDUM ON THE SYNONYMY OF *C. HODGSONI*.

Through the kindness of Dr H. THÉEL, the British Museum has received from the Riksmuseum at Stockholm duplicate specimens of all the species of *Cephalodiscus* which were described by ANDERSSON in the report (07) on the Pterobranchia of the Swedish South-Polar Expedition. We have been much interested in comparing this material with the other specimens which have been available for study.

The species of *Cephalodiscus* which have previously been described from Southern localities are as follows:—*C. dodecalophus* (*Challenger* and Swedish Expedition); *C. æquatus* and *C. inæquatus* (Swedish Expedition); *C. nigrescens* and *C. hodgsoni* (*Discovery* Expedition); *C. gilchristi* (Cape Colony, Dr J. D. F. GILCHRIST); *C. densus*, *C. rarus*, and *C. solidus* (Swedish Expedition); and *C. anderssoni* (second French Antarctic Expedition). With the exception of the three Oriental species described in the "*Siboga*" report, and of *C. indicus*, from Ceylon, more recently described by SCHEPOTIEFF (09), this list accounts for all the species of *Cephalodiscus* hitherto recorded. ANDERSSON (07, p. 16) has stated that within the Antarctic area *Cephalodiscus* is one of the most characteristic members of the marine fauna, in the neighbourhood of Graham's Land at least; and that it occurs there, as a rule, in depths of 100 to 150 metres, wherever the bottom has a firm consistency and consists of gravel ("Kies") and small stones. We may agree with him, in view of these facts, in thinking that the headquarters of the genus lie in Antarctic and Subantarctic waters.

Of the species already mentioned, *C. densus*, *C. rarus*, and *C. solidus* were placed by ANDERSSON in his subgenus *Orthoëcus*; and *C. anderssoni*, more recently described by GRAVIER (12), clearly belongs to the same assemblage. None of these species have at present been found a second time, and we have no criticism to make with regard to them, except that *C. anderssoni* may perhaps prove to be a synonym of either *C. densus* or *C. rarus*.

C. nigrescens and *C. gilchristi* are two very distinct species of the subgenus *Idiothecia*.

The rest of the Antarctic or Subantarctic species, namely, *C. dodecalophus*, *C. æquatus*, *C. inæquatus*, and *C. hodgsoni*, belong to the subgenus *Demiothecia*, in which the cœnœcial cavity is continuous and is not represented by a number of distinct tubes, each belonging to one zooid. According to the diagnoses originally given, all these species are characterised by the possession of six pairs of arms in each sex, with the exception of *C. inæquatus*, in which ANDERSSON states that there are five

pairs in the female and six pairs in the male. According to this observer (p. 8), *C. æquatus* is closely related to *C. hodgsoni*, but on p. 9 he says that it is nearly allied to *C. dodecalophus*.

At the first examination of the cœnœcium of the specimens obtained by the Swedish Expedition it appeared to us that there was an even closer resemblance—amounting, in fact, to a practical identity of characters—between *C. hodgsoni* and *C. inæquatus*. Since the latter is said to be characterised by a difference between the two sexes in respect of the number of arms (female five pairs, male six pairs), it became important to make a new examination of *C. hodgsoni* to ascertain whether any difference could be detected between the two sexes in that form. Although the number of male individuals examined was but small, the result of this inquiry was to confirm the conclusion, suggested by the appearance of the cœnœcium, that *C. inæquatus* is a synonym of *C. hodgsoni*. It may be noted in passing that although the memoirs containing the accounts of the two species in question were published in the same year (1907), the name *C. hodgsoni* has the priority, as is shown by the inclusion of the title of RIDEWOOD's paper in the bibliography given by ANDERSSON on p. 115.

In the original description of *C. hodgsoni* it is stated (RIDEWOOD, 07¹, p. 55) that “the normal number of plumes is twelve, but the sixth pair develop late, and a full-sized polypide, with buds of its own, and with well-developed ovaries, may have only ten fully-grown plumes.” It is further remarked, however, that a vestigial sixth pair can “usually” be detected in such cases, but that no individual has more than six pairs. In his later paper (07², p. 230) the same author states that “some polypides of *Cephalodiscus hodgsoni* of full size and with mature gonads have five pairs of plumes only.” He does not discuss, in either place, the possibility that the difference to which he alludes might be correlated with a difference in sex.

We are in a position to confirm the substantial accuracy of ANDERSSON's statement with regard to the number of arms or plumes in the specimens described by him as *C. inæquatus*, though we think he has gone rather too far in asserting (07, p. 6) that the number is invariable, in each sex, in the species examined by him. The following is the result of an examination of 38 zooids in which the arms were dissected from one another sufficiently to enable them to be counted when the zooid was mounted on a slide. There is no doubt some element of uncertainty in some of these estimations, particularly with regard to the presence or absence of vestigial sixth arms; but in the main the results can probably be accepted as trustworthy.

The material examined consisted principally of female zooids; since, when the gonads were sufficiently advanced in development to be recognisable as to their sex, 19 specimens were female and 3 were male. The remaining 16 specimens were mostly advanced buds or quite young zooids in which the sex was not certainly distinguishable.

The evidence as to the number of arms may be given in a tabular form, as follows:—

Sex.	Number of Arms.	Number of Individuals.			Remarks.
		Stat. 5.	Stat. 94.	Total.	
Female	10	13	2	15	In one of these cases the evidence for the occurrence of more than ten arms was not conclusive.
"	11	3	...	3	
"	9	1	...	1	Perhaps not more than ten arms. " "
Unknown	10	5	9	14	
"	11	...	1	1	
"	12	...	1	1	
Male	12	...	2	2	
"	11	...	1	1	
				38	

It is thus clear that the majority (29 out of 38) of the zooids examined have ten arms; that of this number 15 were proved to be female, while the remaining 14 may have belonged to that sex; and that no individual proved to be male has ten arms. It should be noted, however, that we are assuming, with ANDERSSON, that the specimens from Stations 5 and 94 belong to the same species. Of three zooids in which twelve arms are certainly or doubtfully present, two were ascertained to be male. There is evidence that the female may occasionally have eleven or nine arms instead of the normal number (ten), and that the male may have only eleven arms instead of the number (twelve) stated by ANDERSSON to be characteristic of that sex. The evidence of the occurrence of eleven arms in two female specimens appears to be quite satisfactory. In counting the arms, an arm-bud has been reckoned as an arm even though, as in one of these two, it is very small and but little developed.

Evidence of a similar nature was obtained from sections of the material received from Stockholm. In six series of sections of female zooids, five arms could be counted on one or both sides; while in a single series of sections through a male zooid twelve arms were ascertained to be present.

Turning to the *Discovery* specimens described by RIDGEWOOD as *C. hodgsoni*, the number of the arms has been re-examined in eight series of sections, with the following result:—

Ten arms are present in 2 female zooids, and in 2 others in which the gonads are too minute to be certainly distinguishable as ovaries. Ten is probably the number of the arms in 1 other case in which the sex is not determinable. Three zooids are male; and of these 1 has twelve arms, 1 has not less than eleven arms, and 1 has not less than ten arms, while the possibility of the occurrence of twelve arms is not excluded.

In six individuals of *C. hodgsoni* which were partially dissected and in which ovaries could be identified with certainty the results were somewhat less uniform. Two of these zooids had ten arms each; 1 had eleven; and 3 had twelve arms. But even here there is a sufficient amount of correspondence with the results arrived at by ANDERSSON to give some support to the conclusion that *C. inæquatus* is synonymous with *C. hodgsoni*, on the assumption that the number of arms is not invariable.

CŒNŒCIUM.

It can hardly be doubted, from the published figures, that there is at least a considerable resemblance between the cœnœcium of *C. hodgsoni* and that of *C. inæquatus*. ANDERSSON's figure (07, pl. ii. fig. 1) of the latter closely resembles RIDEWOOD's (07¹, pl. ii. fig. 1) of the former. It may be noted that both figures represent the natural size of the object. In both cases the general appearance of the cœnœcium and its mode of branching are substantially the same; and the same result is arrived at by a comparison of the actual specimens. RIDEWOOD states (p. 51) that the spines are simple, forked, or trifid, and that the length of their free part is variable, usually within the limits 5 to 15 mm. ANDERSSON states (p. 10) that the length of the "Ausläufer," by which we understand the free parts of the spines, may reach 20 mm.; and (p. 19) that they may be divided into two or three branches. Although this latter statement is made in a paragraph which refers to two other species as well as to *C. inæquatus*, an inspection of his figure shows that it really refers to the species under consideration.

We may add that the comparison of the actual specimens shows that *C. inæquatus* resembles *C. hodgsoni* in general size and proportions of the colony, in the colour of the cœnœcium, and in the length and thickness of the spines. In both forms the ostia are elliptical and their average long diameter is 3 mm.; while in both the number of spines associated with each ostium is about four or five.

MEASUREMENTS OF ZOOIDS.

According to RIDEWOOD (07¹, p. 53), the zooids of *C. hodgsoni* measure about 2 mm. from the cæcal end of the body to the dorsal border of the proboscis. ANDERSSON (07, p. 10) gives the length of a zooid of *C. inæquatus* which is not too strongly contracted as about 3 mm. It must be remembered, however, that no special care had been taken, in preserving the *Discovery* material, to obtain well-extended zooids; and that ANDERSSON had the opportunity of examining the zooids of the form described by him in the living condition. It is, moreover, not quite clear how his measurement was taken.

We have ourselves measured several zooids of both forms in more or less median sagittal sections, the measurement being taken in each case from the extremity of the cæcal end of the metasome to the dorsal border of the proboscis. According to these measure-

ments, four individuals of *C. hodgsoni*, of both sexes and in varying degrees of contraction, measured from 1.568 to 1.856 mm. Four individuals of *C. inæquatus*, similarly measured, fell within the limits 1.760 to 2.240 mm. The longest of these zooids in particular was obviously well extended. It may accordingly be concluded that while, on the whole, the zooids of the material collected by the Swedish Expedition are rather larger than those obtained by the *Discovery*, there is no essential difference in size between the zooids of the two forms under consideration.

Similar results were obtained by a study of the length and thickness of the notochord, the size of which ANDERSSON claims to be of some taxonomic value (07, p. 60). The measurements taken from sections of *C. inæquatus* are on the whole greater than those of *C. hodgsoni*, but the two series of measurements overlap.

The buds of *C. inæquatus* were examined to see if there is any appreciable difference between them and those of *C. hodgsoni* (RIDEWOOD, 07², p. 225), particularly in respect of the mode of development of the arms. In size and general proportions, and in the mode of development of the arms, the two sets of preparations are in very close agreement.

We are accordingly of opinion that *C. inæquatus* should be regarded as a synonym of *C. hodgsoni*.

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LIST OF REFERENCE-LETTERS.

<i>an.</i> , anus.	<i>nch.</i> , notochord.
<i>b.c.</i> ¹ , proboscis-cavity.	<i>n.t.</i> , nerve-tract.
<i>b.c.</i> ² , collar-cavity.	<i>op.</i> , operculum or postoral lamella.
<i>b.c.</i> ^{2a} , anterior dorsal horn of collar-cavity.	<i>op.l.</i> , left lobe of operculum.
<i>b.c.</i> ³ , metasomatic cavity.	<i>op.r.</i> , right lobe of operculum.
<i>b.c.</i> ^{3b} , part of metasomatic cavity in loop of alimentary canal.	<i>op.rec.</i> , recess at base of operculum.
<i>c.c.</i> , collar-canal.	<i>p.</i> , proboscis.
<i>c.c.i.</i> , internal opening of collar-canal.	<i>per.</i> , peristome.
<i>c.n.s.</i> , central nervous system.	<i>ph.</i> , pharynx.
<i>d.m.</i> ² , dorsal mesentery of collar.	<i>p.p.</i> , proboscis-pore.
<i>d.m.</i> ³ , dorsal mesentery of metasome.	<i>r.</i> , rectum.
<i>g.s.</i> , gill-slit.	R. ¹ -R. ⁹ , right arms.
<i>int.</i> , intestine.	<i>st.</i> , stalk.
L. ¹ -L. ⁹ , left arms.	<i>stom.</i> , stomach.
<i>l.n.</i> , lateral nerve.	<i>t.</i> , testis.
<i>m.</i> , mouth.	<i>t.l.</i> , left testis.
<i>ms.</i> , longitudinal muscles of metasome.	<i>t.r.</i> , right testis.
	<i>v.m.</i> ² , ventral mesentery of collar.

EXPLANATION OF PLATES.

PLATE I.

Figs. 1-5. Selected pieces of colony of *Cephalodiscus agglutinans*, n. sp., drawn by Miss G. M. WOODWARD. Natural size. The specimen drawn in fig. 1 is selected as the type-specimen of the species.

PLATE II.

Cephalodiscus agglutinans, n. sp.

The figures were drawn with the Zeiss objectives severally indicated, and were then reduced to two-fifths linear. The scale for the two objectives used in drawing the figures is given, in hundredths of a millimetre, at the bottom of the plate.

Fig. 1. A young bud. Obj. A.

Fig. 2. A slightly older bud. Obj. A.

Fig. 3. An older bud. Obj. A.

Fig. 4. A still older bud. Obj. A.

Fig. 5. Obliquely frontal section, showing both testes (*t.l.*, *t.r.*), parts of both gill-slits (*g.s.*), and the left collar-canal (*c.c.*). Obj. C.

Figs. 6-11. Frontal sections of one zooid.

Fig. 6. Showing eight of the left arms (as numbered) and seven of the right arms. Obj. C.

Fig. 7. Showing the same fifteen arms, the anterior dorsal horns of the collar-cavities (*b.c.²a.*), the pericardium (*per.*) enclosing the pericardial sinus or heart, and the internal openings of the proboscis-pores (*p.p.*). Obj. C.

Fig. 8. Showing the anterior end of the notochord (*nch.*) and of the right lobe (*op.r.*) of the operculum. Obj. C.

Fig. 9. Through the mouth (*m.*). The double appearance of the left lobe (*op.l.*) of the operculum is due to the fact that the organ in question is folded ventrally. To see the correspondence between the two sides of the section, the part of the left lobe which is nearer the proboscis (*p.*) must be imagined to have been folded dorsally. It would then not have appeared in the section, and the left lobe of the operculum would have had much the same appearance as the right lobe. Obj. C.

Fig. 10. The mouth (*m.*) is still visible. The reflected part of the left lobe (*op.l.*) of the operculum is almost separate from the rest of the organ. Obj. C.

Fig. 11. Through the region of the collar-canals (*c.c.*) and gill-slits (*g.s.*). The right testis (*t.r.*) is very small in this zooid. Two of the terminal lobes of the scalloped edge of the right half (*op.r.*) of the operculum are visible. Obj. C.

Fig. 12. Stomach (*stom.*), intestine (*int.*), rectum (*r.*), and one testis (*t.*) of an old zooid. Obj. A.

Fig. 13. Stalk, in transverse section. Obj. C.

Fig. 14. Proboscis-stalk, in transverse section, showing both proboscis-pores (*p.p.*), the anterior dorsal horns (*b.c.²a.*) of the collar-cavities, the anterior end of the central nervous system (*c.n.s.*), and the pericardium (*per.*) with the included pericardial sinus. Obj. C.

Fig. 15. Median sagittal section of the anterior end of a zooid, showing the notochord (*nch.*). Obj. C.

Fig. 16. Nearly median sagittal section of another zooid, showing the alimentary canal. Obj. C.

N.B.—In several of the sections, figured parts of the epithelia were somewhat macerated, as the result of imperfect preservation. The epithelium of the stomach in fig. 16, part of the anterior epidermis of the proboscis in figs. 6-9, and part of the epidermis containing the central nervous system in figs. 10 and 11 have accordingly been restored where necessary.

HARMER AND RIDEWOOD: "SCOTIA" PTEROBRANCHIA—PLATE I.

HARMER AND RIDWOOD: "SCOTIA" PTEROBRANCHIA—PLATE II.