AUSTRALASIAN ANTARCTIC EXPEDITION
1911-14.
UNDER THE LEADERSHIP OF SIR DOUGLAS MAWSON, D.Sc., B.E.

SCIENTIFIC REPORTS.
SERIES C.—ZOOLOGY AND BOTANY.
VOL. III. PART 2.

PTEROBRANCHIA

BY

W. G. RIDEWOOD, D.Sc.,
BRITISH MUSEUM (NATURAL HISTORY).

WITH TWO PLATES AND THREE TEXT-FIGURES.

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CONTENTS.

THE PTEROBRANCHIA.

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With Two Plates and Three Text-figures.

INTRODUCTION.

The genus *Cephalodiscus* was founded by McIntosh (8) in 1882, for specimens which he described as *Cephalodiscus dodecalophus*, dredged by the "Challenger" in 1876 in the Straits of Magellan, from a depth of 245 fathoms. These specimens, described more fully in 1887 (9), remained for a long time the only known material of *Cephalodiscus*.

In 1903 Andersson (1) announced that *Cephalodiscus* had been re-discovered on the Swedish South-Polar Expedition, and since that date no less than fourteen new species have been described.

The report by Harmer (5) upon the Pterobranchia of the "Siboga" Expedition of 1899–1900, published in 1905, furnished descriptions of three new species. Two of these were obtained on the expedition itself:—*C. gracilis*, from the east coast of Borneo, between tide-marks, and *C. sibogae*, from the South-east of Celebes, from a depth of 41–51 fathoms; the third species, *C. levinseni*, was based upon a specimen belonging to the Copenhagen Museum, obtained off the West coast of Japan, from a depth of 100 fathoms.

The National Antarctic ("Discovery") Expedition of 1901–1904 obtained two new species from Ross Sea, one of which, *C. nigrescens*, from off Coulman Island, at a depth of 100 fathoms, was described briefly by Lankester (7) in 1905, and more fully by Ridewood in the report on the Pterobranchia of that expedition (11).

There is reason to believe that material of *C. nigrescens* was obtained from Ross Sea as far back as 1841 or 1842 on the "Erebus" and "Terror" Antarctic Expedition, but the material remained in the British Museum, unidentified until it was described by Ridewood in 1912 (13). *C. nigrescens* has since the "Discovery" Expedition been obtained from the Graham Region at a depth of 137 fathoms by the second French Antarctic ("Pourquoi Pas?") Expedition of 1908–1910, and is described by Gravier (4) in the reports of that expedition; also from Ross Sea by the British Antarctic ("Terra Nova") Expedition of 1910–1913, at depths varying from 190 to 300 fathoms, and

described by Ridewood (*report not yet published.*—W.G.R., 2nd September, 1917); and on the Australasian Antarctic Expedition of 1911–1914 from off Queen Mary Land, at a depth of 120 fathoms (*vide infra*, p. 00).

The other new species obtained on the "Discovery" expedition was described under the name *C. hodgsoni* by Ridewood (11). The material was dredged from three localities in Ross Sea at depths of 100, 130 and 300 fathoms. More material of the same species has since been obtained on the British Antarctic ("Terra Nova") Expedition of 1910–1913 from Ross Sea, at depths of 140 to 300 fathoms (Ridewood, *vide supra*); also on the Australasian Antarctic Expedition of 1911–1914 from off Adelie Land, at a depth of 354 fathoms, and from off Queen Mary Land at depths of 110 and 120 fathoms (*vide infra*, p. 13).

From the South Coast of the Cape of Good Hope Dr. Gilchrist collected during the years 1900–1904, from depths of 29 to 130 fathoms, material of *Cephalodiscus* which proved to be of a new species, and was described by Ridewood in 1906 (10) as *C. gilchristi*.

In 1907 Andersson (2) published in the Report on the Pterobranchia of the Swedish South-Polar ("Antarctic") Expedition of 1901–1903, descriptions of the re-discovered *C. dodecalophus*, and five new species, two of them, *C. aequatus* and *C. inaequatus*, bearing a general resemblance to *C. dodecalophus* and *C. hodgsoni*,* while the other three, *C. solidus*, *C. densus* and *C. rarus*, were markedly different from any of the species at that time known. This material was obtained from six localities in the Graham Region, the Falkland Islands and the Beagle Channel, from depths ranging between 44 and 128 fathoms.

Specimens of *C. densus* have since been obtained in Ross Sea, and are described by Ridewood in the Report on the Pterobranchia of the British Antarctic ("Terra Nova") Expedition of 1910–1913, and a piece was obtained on the Australasian Antarctic Expedition of 1911–1914 from off Queen Mary Land at a depth of 120 fathoms (*vide infra*, p. 22). *C. solidus* was also re-discovered on the latter expedition (p. 15), the material being secured off Adelie Land at a depth of 318 fathoms.

An Indian species was discovered by Schepotieff in 1908 off the Malabar Coast and off Ceylon, at depths of 5 to 11 fathoms, and in 1909 was described by him (14) as *C. indicus*.

Another new species was obtained on the Scottish National Antarctic ("Scotia") Expedition of 1902–1904, from the Burdwood Bank, Falkland Islands, at a depth of 56 fathoms. This was described in 1913 as *C. agglutinans* by Harmer and Ridewood (6).

The last new species is one obtained from the North of New Zealand at a depth of 100 fathoms on the British Antarctic ("Terra Nova") Expedition of 1910–1913; the description of this will appear in the report on the Pterobranchia of the expedition.

* There is reason to believe that *C. inæquatus* is not specifically distinct from *C. hodgsoni*. (See 6, pp. 559–563.)

LOCALITIES.

The material of *Cephalodiscus* obtained on the Australasian Antarctic Expedition of 1911–1914 under the leadership of Sir Douglas Mawson was dredged off Adelie Land and off Queen Mary Land from the four Stations enumerated below.

Station I—In Commonwealth Bay, Adelie Land; Lat. 66° 50′ S.; Long. 142° 6′ E.; 22nd December, 1913; 354 fathoms; temperature, 1·85° C.

Station II—Off Mertz Glacier; Lat. 66° 55′ S.; Long. 145° 21′ E.; 28th December, 1913; 318 fathoms; temperature, 1·84° C.

Station VIII—Lat. 66° 8′ S.; Long. 94° 17′ E.; 27th January, 1914; 120 fathoms; temperature not taken.

Station XII—Off Shackleton Glacier; Lat. 64° 32′ S.; Long. 97° 20′ E.; 31st January, 1914; 110 fathoms; temperature not taken.

At Stations I and II there was a bottom of thick ooze; at Stations VIII and XII the bottom was clear with no evidence of any ooze.

MATERIAL OBTAINED.

The material of *Cephalodiscus* obtained on the Expedition includes no new species. Four species are represented—*C. hodgsoni*, *C. nigrescens*, *C. solidus*, and *C. densus*. More than half of the bulk of the material consists of *C. hodgsoni*, dredged from Stations I, VII, and XII; but all that came from Stations I and VIII is "dead"—that is to say, it consists of coenœcium only, with no zooids. The dredge at Station VIII yielded also *C. nigrescens* and *C. densus*, one piece of each. *C. solidus* was obtained from Station II.

The collection occupies seven bottles, each of a capacity of about 900 cc. Denoting these bottles by the letters A—G, bottle A (from Station I), and bottle C (from Station VIII) contain "dead" *C. hodgsoni* only. Bottle D (also from Station VIII) contains *C. densus* and *C. nigrescens* and some "dead" *C. hodgsoni*. Bottles E, F, and G (from Station XII) contain *C. hodgsoni* only, and bottle B (from Station II) *C. solidus* only.

The material was fixed either in corrosive sublimate solution, or corrosive sublimate acetic acid solution, or 5 per cent. chromic acid solution, and subsequently transferred to alcohol. The preservation of the zooids of *C. hodgsoni* is good, but in the case of the other three species, in which the zooids live in separate tubes closed at the bottom, the appearances suggest that the zooids had withdrawn into the deeper parts of the tubes, and had undergone a certain amount of disintegration before the fixing fluid had diffused down the tubes to reach them in a sufficiently undiluted form to be effective.

Genus CEPHALODISCUS.

Genus *Cephalodiscus* M'Intosh. Zooids small, living as a social community within a secreted coenœcium, from the orifices or ostia of which they can emerge at will; coenœcium with a common branching cavity, or with a separate tubular cavity for each zooid and its buds. Body of the zooid consisting of three parts, with separate divisions of cœlom—first part a shield, in the form of a flattened preoral disc, with a curved red line, used for crawling and for secreting the coenœcium, containing a single cœlomic cavity, which opens to the exterior by a pair of pores; second part a collar-region, with a paired cœlomic cavity, which opens to the exterior on each side by a ciliated canal; collar produced antero-dorsally into a lophophore of several pairs of arms, each arm with two rows of tentacles; collar produced postero-ventrally into an oral lamella; central nervous system situated in the ectoderm at the bases of the arms; third part, the largest, a trunk-region, with closed cœlomic cavity, primarily paired, containing the alimentary canal and gonads. Alimentary canal U-shaped, mouth ventral, behind the stalk of the shield; anus on the antero-dorsal surface of the trunk, near the bases of the arms. One pair of pharyngeal pores or gill-slits near the collar-canals. A more or less tubular notochord projecting from the antero-dorsal wall of the pharynx; below it, in the shield, a pericardial sac, with heart. Gonads simple, one pair, opening by short ducts near the anus. Trunk prolonged posteriorly or ventrally, according to the degree of extension of the zooid, into a stalk, with a terminal sucker, around the edge of which buds are produced.

Sub-genera of CEPHALODISCUS.

Subgenus *Demiothecia* Ridewood.—Colony branching. Each ostium of the coenoecium leading into a cavity which is continuous through the colony, and is occupied in common by the zooids and their buds. Transverse sections of the branches showing the central cavity surrounded by a wall of coenœcial substamce, usually of irregular thickness, and sometimes with inwardly projecting bars and ridges.

Subgenus *Idiothecia* Ridewood.—Colony branching. Each ostium of the coenœcium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common coenœcial substance, and disposed at a more or less constant angle to the surface; the tubes either blind at their inner ends, or connected up by intercommunicating tubes in the middle of the branch.

Sub-genus *Orthœcus* Andersson.—Colony not branching, but in the form of a cake, or cone, or mass of irregular shape. Each ostium of the coenœcium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common coenœcial substance, either for their whole length or towards their lower, blinds ends only; the tubes more or less vertical, either closely set and parallel, or irregularly bent and straggling.

CEPHALODISCUS HODGSONI.

(Plate VI.)

Cephalodiscus (*Demiothecia*) *hodgsoni* Ridewood (11).

Colony irregularly branched, without cross-bars connecting up the branches. Maximum size of known specimens 250 mm. high, 150 mm. wide. Width of a branch, not including spines, mostly 4 to 6 mm., but some terminal branches as narrow as 3 mm., and some basal stems as thick as 9 mm. Cavity of coenœcium irregular, continuous, and occupied in common by the zooids and their buds, inner surface smooth, cavity sometimes traversed by solid bars. Older parts of the coenœcium of a deep amber colour, younger parts colourless. Ostia numerous, irregularly placed, oval, lateral or terminal; terminal ostia rather funnel-shaped, about 3 by 2 mm., lateral ostia smaller, mostly sessile; each ostium with from two to five long, more or less radiating spines, simple, forked, or branched; length of spines up to 20 or 25 mm., but the spines of rapidly growing terminal branches commonly shorter (8 to 12 mm); spines frequently connected by crossbars, forming an imperfect meshwork; width of spines 0·6 to 1·0 mm., in terminal branches sometimes not more than 0·4 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid 2·4 to 3·2 mm.; length from bases of arms to end of body 1·0 to 1·8 mm.; width of body 0·6 to 1·0 mm. Colour (of preserved zooids) crimson-brown or pale brown, fading to ochreous and cream-colour; male zooids commonly redder in tint than female. On the assumption that *C. inæquatus* is synonymous with *C. hodgsoni* (6, pp. 559–563), colour of living zooids red or crimson, the body darker and more brown than the arms. Arms five or six pairs, axis of each arm with an end-swelling, with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony, but males or females usually preponderating. Testes short. Free ova measuring 0·45 by 0·33 mm., attached by a stalk. Buds two, sometimes three or four, to each zooid.

Material of *Cephalodiscus hodgsoni* was obtained from Stations I, VIII and XII, but that from Stations I and VIII is "dead," consisting of coenœcium only, with no zooids. The coenœcial substance of *Cephalodiscus*, although shown in Andersson's report (2, p. 20) to be albuminoid in character, seems to be remarkably resistant, and probably remains more or less unaltered at the bottom of the sea for many years after it has ceased to be inhabited. That some sort of change, however, does take place is apparent from the fact that the "dead" material in bottles A, C and D (see p. 7) has suffered more in transit from Australia to London than has the material, with zooids, in bottles E, F and G. The "dead" material is more brittle, and has broken up to a greater extent, in consequence of the unavoidable shaking of the bottles, than the rest of the material.

The specimens (*i.e.*, pieces of colony) of *C. hodgsoni* with zooids still within (bottles E, F and G, from Station XII), although brought up together, present considerable differences in appearance that are not likely to be attributable to the fact that some of the pieces of material were fixed in chromic acid solution and others

in corrosive sublimate solution. At first glance one might hesitate to say that the two colonies represented in figs, 1 and 5 in plate VI belonged to the same species. The former is pale in colour, of an amber tint, fading off in places to lighter shades; the latter is very dark in colour, a dark brown, verging on black. The former is a characteristic piece of *C. hodgsoni*, showing forking of the spines, and cross-connections forming a coarse network, the latter shows forking of the spines, but only occasional cross-connections. The appearance, moreover, of the latter rather suggests that the colony was allowed to dry partially before being plunged into the fixing fluid, for some of the spines, while of normal dimensions in their basal parts are much thinner and of a shrivelled appearance distally, and there is a certain matting of the spines which is clearly unnatural.

No differences between the two colonies are to be noted in the structure of their zooids, so that the arguments must be based upon the coenœcial characters alone. In the same bottle (bottle G) with the specimen shown in fig. 1 are other fragments (*e.g.*, fig. 2) of a much deeper tint, and with the coenœcial substance and spines firmer and less flexible. This firmness and dark amber colour are known to be characteristics of the older parts of colonies of *C. hodgsoni*; such parts rarely have zooids, and in the abundant material of *C. hodgsoni* obtained on the "Terra Nova" Expedition large colonies are commonly met with in which the basal parts are as shown in fig. 2 and the upper parts, full of zooids, as in fig. 1, with an even gradation from one to the other extending over a distance of several inches. Fragments of colony of intermediate character are also found in bottle G of the Australasian Expedition, and one such piece is shown in fig. 3. It is less "brambly" than that represented in fig. 2, and intermediate in colour between the pieces shown in figs. 2 and 1; it has numerous zooids.

Another piece from the same bottle (fig. 4) shows an abrupt transition from the basal, brambly, dark-tinted, stiff, empty coenœcium to the terminal, pale, delicate, flexible part, full of zooids. While it is known, from a study of the material collected by the "Terra Nova," that a colony of one species of *Cephalodiscus* may grow upon a base of another species—the cases in point are *C. hodgsoni* growing on *C. nigrescens*—yet there can be little doubt in the present instance that there is here a new growth of *C. hodgsoni* upon an old and rather damaged basal piece of colony of the same species.

Continuing the argument with regard to the piece of colony represented in fig. 5, there are found in the same bottle with it (bottle E) basal pieces of the brambly kind. One of these (fig. 6) is of special interest in that, while most of it is of the deep amber tint characteristic of basal parts of colonies of *C. hodgsoni*, its upper part merges into a very dark brown or blackish part exactly resembling that which forms the bulk of the piece shown in fig. 5.

Other pieces of colony in bottle E are growing upon the skeletal axis of a kind of *Isidella*, probably *Ceratoisis*, and the general character of the branching of the colony is determined by that of the Alcyonarian; in many places the calcareous axis is but thinly coated over with coenœcial material, there being no cavity occupied by zooids.

Disregarding the differences in the colour of the colonies shown in figs. 1 and 5, the differences in general facies would seem to be attributable to differences in the rate of growth; one would conclude, that is to say, that the former has been built up rapidly, whereas the latter is a slowly-grown colony.

The specimens in bottle F call for no particular comment. The largest piece of colony is a little smaller than that shown in fig. 5; it has the appearance of being a slowly-grown colony, and is more characteristic, both in tint and general facies, of *C. hodgsoni* than is the material of bottle E.

The zooids in bottles F and G are well preserved—the material in bottle F was fixed in 5 per cent. chromic acid solution, and transferred to alcohol, and the fixation of the material of bottle G is not stated. The material in bottle E was fixed in corrosive sublimate solution, and transferred to alcohol, and the zooids are not in good condition; they are darker in colour than those of bottles F and G, and a little smaller. They have not been actually dried up, but their appearance and the shrunken look of the coenœcium suggest that the material had been allowed to become partially dry before being put into the fixing fluid. The zooids are extremely brittle, and the epithelium of the free portions of the tentacles of the arms is to a large extent missing, probably scoured off by the shaking of the bottles in transit, so that only the basement membrane remains, as a kind of skeletal axis.

As regards size, the zooids agree fairly well with one another, and with the typical material obtained on the National Antarctic ("Discovery") Expedition (11). In taking measurements it is only the fairly extended zooids that are considered; fourteen zooids were measured from the principal piece of colony of bottle E (fig. 5), fifteen from the largest piece in bottle F, and sixteen from that in bottle G (fig. 1). The first measurement given in the table below is the average of the measurements in millimetres from the tips of the arms to the caecal end of the body, the second is that from the bases of the arms to the end of the body, and the third is the width of the body.

Bottle E	—	2·4	—	0·95	—	0·53
Bottle F	—	2·4	—	1·1	—	0·57
Bottle G	—	2·9	—	1·4	—	0·66

The arms are mostly ten in number, sometimes nine, eleven or twelve; the axis of each has an end-swelling with highly refractive beads. It is not possible to decide whether the zooids in the material now under consideration show sexual dimorphism in the occurrence of five pairs of arms in females and six pairs in males, as is stated to be regularly the case in the material obtained on the Swedish South-Polar Expedition (Andersson, 2; *C. inaequatus* is regarded as the same as *C. hodgsoni*, see 6, pp. 559–563), for the whole of the material proves to be immature. Of the sixteen zooids examined from bottle G only one had gonads large enough to dissect out, and these were too small to enable one to judge the sex; of the fourteen zooids from bottle E, two had small ovaries, the others had gonads extremely minute, and too young to

enable one to decide whether they were ovaries or testes; the fifteen zooids examined from bottle F had no recognisable gonads at all; one might almost be tempted to call these neuter zooids, were it not for the fact that in the other material minute gonads were found, and in two of the zooids they were definitely recognisable as young ovaries.

In the zooids of bottle E the oral lamella has a much more even margin than is usual, and shows scarcely any scalloping, although the five lobes on each side can still be recognised. If, as is possible, the zooids were moribund when plunged into the fixing fluid, the conclusion may be drawn that the intensity of the scalloping in the oral lamella of *Cephalodiscus* is to a large extent a matter of muscular contraction at the time of death. That the zooids in bottle E were no longer vigorous when fixed is indicated by the fact that the stalk arises almost from the extremity of the trunk and not from the ventral surface. Andersson (2, plate 4) has observed that in living zooids there is no cæcal end to the body, but the stalk is terminal at the end of the trunk. The common appearance, in preserved material, of the stalk arising from some part of the ventral surface of the zooid, is in all probability due to the violent contraction, on death, of the great tract of ventral muscle that runs forward in the body from the root or origin of the stalk.

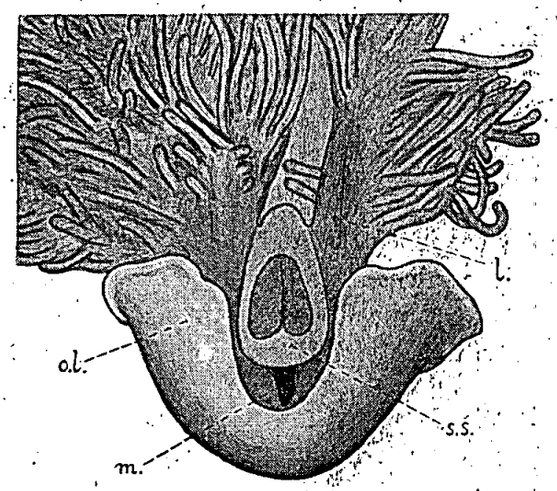

Fig. 1.

Text-fig. 1.—Oral region of a zooid of *C. hodysoni* showing the oral lamella turned forward so as to direct the food-current into the mouth. *l*, base of lophophore; *m*, mouth; *o.l.*, oral lamella; *s.s.*, stalk of the shield cut across, showing the cavity within. Drawn by *camera lucida*. (× 90.)

The conclusion seems to be justified that the function of the oral lamella is to continue the system of ciliated grooves of the arm-axes and the basal parts of the lophophore towards the mouth. Andersson has stated it as his opinion that in living zooids the oral lamella is forwardly directed, so as to form a channel on each side leading from the base of the lophophore to the mouth (2, pp. 5 and 57); it is of considerable interest, therefore, to find, in preserved material, zooids having the oral lamella forwardly directed in a manner that would achieve this end (text-fig. 1). Only

two such zooids have been found in the present material, but confirmatory evidence is forthcoming from the abundant material collected on the British Antarctic ("Terra Nova") Expedition.

The buds in the material collected occur usually two, sometimes three, to each zooid. All stages are found, from minute pear-shaped projections from the edge of the extremity of the parent stalk, up to well-developed buds, with fully-grown arms, ready to separate off as independent zooids.

Cephalodiscus nigrescens.

(Plate VII, Fig. 2.)

Cephalodiscus (*Idiothecia*) *nigrescens* Lankester (7).

Colony massive branching; maximum size of known specimens—190 by 115 mm., with twelve branches; maximum width of a single branch—32 mm.; minimum width of a branch—5 to 9 mm.; branches roughly cylindrical, stout branches with rounded or tapering apices. Colour greyish, translucent. Ostia at the ends of short, tubular peristomes, but in main stems of the colony frequently sessile; abaxial edge of the peristome produced into a blunt lip, but with no prominent ridge continued downward from the lip. No spines. Each ostium leading into a tube that ends blindly in the middle part of the branch. Width of cavity of the tubes—1·2 to 1·3 mm.; length—12 to 17 mm. on an average, but longer (20 to 26 mm.) in thick stems, and very short (4 to 5 mm.) at the tips of the branches; the deeper parts of the longest tubes shut off by curved septa so that the habitable part of the tube is reduced (commonly 8 to 14 mm. in length). Zooids—length from free ends of the arms to end of body of a fairly extended zooid—4 to 6 mm.; length from bases of arms to end of body—2·5 to 3·5 mm.; width of body—about 0·9 mm. Colour (of preserved zooids) blackish. Arms usually 7 pairs, sometimes 6 or 8 pairs; in well preserved material fixed in formalin or in alcohol the tentacles pale and the axis rather broad, with two longitudinal black bands, but in material fixed in picric acid, and in badly fixed alcoholic material the tentacles and axis of a uniform dark brown or black colour; no end-swellings with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony. Testes long. Free ova—0·6 by 0·5 up to 0·9 by 0·7 mm, not stalked. Buds from 2 to 9 to each zooid.

Material of *Cephalodiscus nigrescens* was dredged from Station VIII. (Lat. 66° 8′ S.; Long. 94° 17′ E.; 120 fathoms; 27th January, 1914). It consists of three pieces, obviously portions of the same colony, for the broken surfaces can be so adjusted as to fit accurately the one against the other. The pieces were lightly sewn together before the photograph reproduced in Plate VII, fig. 2 was taken. The height is 65 mm., and the greatest width 50 mm.

The colony is not altogether typical of *C. nigrescens*. It is not possible to say whether the material under consideration is an upper portion of a large colony, or a colony complete in itself, for the base is missing; the probabilities are in favour of the latter alternative. Three places where growth is proceeding can be recognised, and these later on might have developed into branches; they are scarcely long enough yet to be designated by that term.

The tubes in the middle of the mass are long, as much as 30 mm. from the blind end to the extremity of the lip of the peristomial tube in some cases, and while their upper halves radiate, and stand out obliquely to the vertical axis, their inner and lower parts are nearly parallel to one another, and vertical, thus giving a section of the lower part of the mass somewhat the appearance that one associates with the coenœcium of *C. solidus*. The basal part of the mass being missing, many of the long tubes are broken across. Curved septa occur at irregular intervals in the basal parts of the longest tubes, reducing the inhabited part of the tube to 20 mm. or less.

On comparing with typical material of *C. nigrescens* one is struck by the remarkable length and thinness of the lip of the peristomial tube; the length of the lip is frequently as much as 4·5 mm. The average internal diameter of the tubes of the coenœcium is 1·0 mm.; the diameter near the ostium is 1·2 to 1·4 mm. Some of the blind ends of the tubes are much more bulbous than those of the type material dredged by the "Discovery" (11), and have an internal width of 1·7 mm.

The lip of the peristomial tube being unilateral, the thickness of the tube on the side on which the lip is situated is greater than that of the opposite side, and this thickening can be traced down the side of the tube for a considerable distance into the interior of the common mass of the coenœcium, even occasionally as far as 20 mm.

The peristomial tube itself, not including the lip, is short, the distance from the lowest part of the ostial aperture to the general surface of common coenœcial substance being only 1 or 2 mm.; but at the three growing apices of the colony the distance is as much as 4 mm., that is to say, the intervals between the bases of the peristomial tubes have not yet been filled up with common coenœcial substance to the same extent as in the older parts of the colony. The coenœcial substance is fairly free from inclusions, but there can be recognised a few minute sand-grains and a number of irregular murky bodies that seem to be decalcified Foraminifera. There are also in the coenœcial substance a considerable number of extremely minute cruciform crystals that disappear when a piece of the coenœcium is transferred from alcohol to water, and may be presumed to have developed since the specimen was removed from the sea.

The zooids are black, and of the same size as those of typical material obtained by the "Discovery" (11). The arms are mostly fourteen in number, and the axes have the characteristic double black band running longitudinally. Of interest, as bearing upon the question of the disappearance of the pigment in imperfectly preserved material, dealt with at some length in the report on the British Antarctic ("Terra

Nova") Expedition, and in the section of the present report dealing with *C. solidus*, it is to be noted that in the serial sections of a zooid of the present material, cut transversely to the length, the arm-axes towards the outer side of the bunch show the double black mass distinctly, but those in the middle of the bunch do not; the preservative fluid apparently did not reach the latter in time to prevent the dissolution of the pigment.

The majority of the zooids seem to be young males. The mean diameter of a transverse section of the middle part of the notochord is in one zooid 0·033 mm., and in another 0·050 mm. Many buds are found, and of all stages; one fairly old bud has as many as 12 arms, which show the first appearance of the two rows of tentacles.

Cephalodiscus solidus.

(Plate VII, Figs. 3–5.)

Cephalodiscus (*Orthœcus*) *solidus* Andersson (2).

Colony not branching, in the form of a bulky mass or cake, measuring up to 250 or 300 mm. across, and 100 mm. high; the mass consisting of closely set, vertically disposed tubes of uniform diameter, each with an ostium at the upper end, and terminating blindly below; the tubes pale brown, united, except for a short distance at their upper ends, by common coenœcial substance, which may contain sand-grains, fine sponge-spicules and diatoms. The common coenœcial substance moderately firm, like that of *C. nigrescens*, not soft and spongy like that of *C. densus*. Upper end of each tube produced on one side into a short, thick, upright lip. Tubes in the middle of the colony measuring up to 100 mm., those at the sides shorter; width of cavity of tube about 1·2 mm.; near the ostium—1·4 mm., in narrowest parts—1·0 mm. Zooids—length from free ends of the arms to the end of body of a fairly extended zooid—4 to 5 mm.; length from bases of arms to end of body—3·0 to 3·5 mm.; width of body—1·0 mm. Colour (of preserved zooids), blackish; but colour of zooids removed from their tubes and preserved in 70 per cent. alcohol, not kept in the dark, fading to raw umber or yellow ochre. Arms usually eight pairs, axes not known to possess the two black bands seen in arms of *C. nigrescens*; no end-swellimgs with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony. Testes long. Free ova—0·9 by 0·7 mm., not stalked. Buds many to each zooid, up to fourteen.

Material of *Cephalodiscus solidus* was obtained from Station II (Lat. 66° 55′ S.; long. 145° 21′ E.; 318 fathoms; temperature 1·84° C.; 28th December, 1913), and consists of five colonies of approximately uniform size, much smaller than the type material of *C. solidus* obtained on the Swedish Expedition (2). The tallest colony (Plate 2, fig. 5) is roughly conical in shape, with a height of 40 mm., and a base of 60 mm., whereas the largest of the Swedish Expedition was a roundish cake, 100 mm. high and 300 mm. across (2, p. 11).

The largest colony, which for convenience of subsequent reference may be termed Specimen A, was subjected to a critical examination, and a vertical slice of a thickness of 10 mm. was cut from the middle of it in order to study the course of the tubes. A photograph of the section is given in Plate VII, fig. 3, and a diagrammatic representation of it in text-figure 2. The longest tubes (30 mm.) are those that reach the summit of the cone; the tubes seen on the left of fig. 3 are about 16 mm. long, and are set obliquely, those on the right are more vertical, and measure about 9 or 10 mm. The appearances suggest that the part on the right is the growing edge of the colony, although the zooids found in the tubes of that part cannot be recognised as younger than those in the longer tubes of the colony.

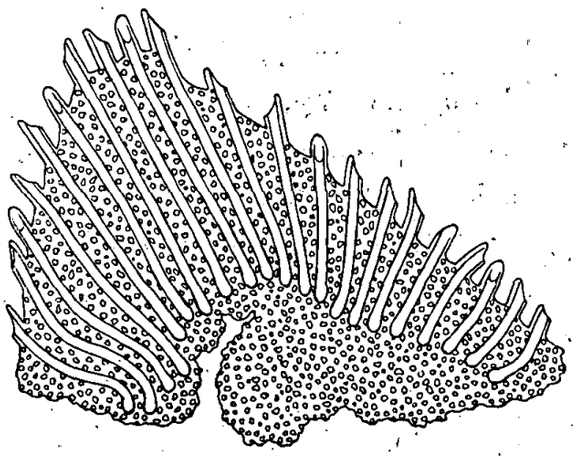

Fig. 2.

Text-fig. 2.—*C. solidus;* diagrammatic representation of a vertical section through the middle of a colony—Specimen A; Station II; × 1½. Compare with the photographic reproduction of the same slice in Plate VII, fig 3. The tubes are the cavities occupied by the zooids; the irregular, hollow marks between and below the tubes represent sand-grains.

The cavity of each tube has a fairly uniform diameter of 1·00 to 1·05 mm., unless the tube is contracted and wrinkled, as it frequently is in certain parts. The blind ends of the tubes are very slightly dilated (1·1 mm.), and show septa. Some of the tubes have curved septa along their course, and not solely at the blind end. The substance of which the tube is composed is very thin and tough; it consists of numerous extremely thin layers, and is of a darker tint than the common coenœcial substance.

Each tube has an ostium at the upper end, and the free extremity of the tube is continued on one side into a short blunt lip, closely resembling that of *C. nigrescens.* The situation of the lip with reference to the middle and peripheral parts of the colony is very inconstant; the lip may be on the side of the tube nearest the summit of the colony, on the side remote from the summit, or on one of the two sides that are radially disposed with reference to the colony as a whole (text-fig. 2).

The part of the tube that projects beyond the general surface of the colony, the peristomial tube, is from 4 to 6 mm. in length, measuring to the end of the lip.

A peristomial tube consists of a tough, dark-coloured lining, a continuation of the "tube" of the deeper part of the colony, surrounded by paler substance, which is thicker on the side where the lip is than elsewhere. The external diameter of a peristomial tube is about 2·0 mm. The internal diameter near the ostium is about 1·05 to 1·10 mm. A peristomial tube seen from the side shows the layers of growth, running around the tube and up into the lip. The layers are distinct near the extremity, but they fade away below, and at the general level of the surface above which the peristomial tubes project the substance external to the dark-coloured tube-lining merges into the soft, colourless common coenœcial substance of the colony.

A feature of interest seen in material of *C. solidus* at the British Museum (Natural History) obtained at Station 94 on the Swedish South-Polar Expedition is that certain tubes of the coenœcium, still inhabited, are sealed up by a little circular operculum of coenœcial substance set transversely across the ostium. Being transverse to the axis of the tube, the disc is level with the lowest part of the opening, but on the opposite side of the ostium it is some little distance from the extremity of the lip. It is loosely attached at its edges, and is readily removable, and it is evidently only employed by the zooid as a temporary means of closing the tube. In the material of the Australasian Antarctic Expedition there are no precise equivalents of these discs, but some of the tubes have a small quantity of very soft coenœcial substance choking up the ostia. In both cases it may be that in the unnatural conditions prevailing from the time that the colony was caught in the trawl up to the time when it was dropped into the fixing fluid, the zooids made an effort at self-preservation by a rapid secretion of coenœcial substance at the mouth of the tube. Closed ostia have already been noticed in the case of *C. nigrescens* (11, p. 22; plate 4, fig. 13), but in those cases the tubes were empty and in basal parts of the branches; a general strengthening of the uninhabited basal part of the colony was apparently in progress, and the ostia became closed in the general deposit of new coenœcial material.

In plate VII, fig. 4, is shown the top view of a rather hemispherical colony (Specimen B); the height is about 35 mm. and the greatest width 43 mm.

In four of the five colonies obtained, the common coenœcial substance that occurs between the tubes, and consolidates the whole into a rather firm mass, is densely impregnated with fine, colourless sand, and is continued as a basal layer or lump below the level of the blind ends of the tubes (text-fig. 2). The only other inclusions besides the sand-grains are some pale brown sandy tubes, ranging from 4 to 9 mm. in length, and from 0·4 to 0·8 mm. in external width. Mr. C. D. Sherborn has been good enough to examine these, and informs me that they are the tubes of arenaceous Foraminifera, probably some species of *Rhabdammina*.

One of the colonies (Specimen E) is much less sandy than the others, and is more squat in shape; it differs, moreover, in that the lower ends of the tubes project

freely below the general under-surface of the coenœcium, some of them to the extent of 10 mm. These free blind ends are mostly collapsed and wrinkled, in a manner suggesting that the distortion has occurred subsequently to the separation of the colony from the sea-bottom. The under surface of this colony is in the preserved state deeply concave, but the probabilities are that in natural conditions it was more or less flat, and that the freely projecting, blind parts of the tubes were lodged in a substratum of mud or fine sand which has not been agglutinated and incorporated into the coenœcium. The sea-bottom at Station II is stated by Mr. J. G. Hunter, the Biologist of the Expedition, to be "thick ooze," but since the four sandy colonies and the single non-arenaceous colony were obtained from the same Station, it is not easy to account for their differences, unless by the supposition of local differences in the sea-floor.

The non-arenaceous, leathery colony, if spread out, would have a superficial area of 75 by 40 mm.; it is not more than 15 mm. high in the middle, not including the parts of the tubes that project above and below. On one side it spreads out into a thin film of common coenœcial substance, transparent and not more than 1 mm. in thickness, with a few scattered tubes projecting 6 to 10 mm. below the surface, and rising about 4 to 6 mm. above the surface, some vertically, others obliquely directed towards the highest part of the colony. In the thickest part of this colony the peristomial tubes attain a length of 8 mm., measured up to the extremity of the lip; in the four other colonies they rarely exceed 6 mm.

So far as the zooids are concerned the material is not well preserved. The method of preservation is not stated, but the material is now in alcohol, and was probably fixed in that fluid. Zooids found in the deep parts of the tubes are not in a suitable condition for investigation; they are but a black powdery mass. Disintegration had evidently set in before the preservative fluid had diffused down the tube.

In the case of future expeditions it would be well, on dredging specimens of *Orthœcus* or *Idiothecia*, to extract some of the zooids immediately, and to fix them by modern preservative methods. In the case of species of *Demiothecia* such precautions, though desirable, are not so essential; it is remarkable how well-preserved are the zooids of *C. dodecalophus* obtained on the "Challenger" Expedition.

Zooids of the present material that are found in the upper parts of the tubes are sufficiently well-preserved to enable the following points to be made out. They agree in size with those of *C. solidus* described by Andersson (2, p. 11), who puts the total length at 4 to 5 mm. One zooid with arms in a state of extension measured 6·6 mm. from the tips of the arms to the cæcal end of the body, 4·5 mm. from the bases of the arms to the end of the body, and 0·9 mm. across the body. In six other zooids the corresponding measurements were:—6·0, 3·9, 0·9; 5·1, 3·4, 0·9; 5·0, 3·6, 0·8; 4·6, 3·1, 0·8; 3·7, 2·4, 0·8; 3·2, 1·6, 0·8.

Although most of the zooids in the coenœcium of Specimen A are males, with a long testis and a shorter one, two zooids were found having each two ovaries; it is

established, therefore, that in this material male and female zooids occur in tubes of the same colony. No hermaphrodite individuals were found. The ovaries are about three times as long as they are broad, and have the form of an elongated pear.

The shield of full-grown zooids is roughly circular in outline, and calls for no special comment. There are eight pairs of arms, of the same uniform blackish, or dark greenish brown tint as the rest of the zooid. When mounted in dilute glycerine the depth of colour is slightly reduced, and the more transparent parts show of a raw sienna colour. The epithelial cells of the neural surface of the arm-axis are taller than those of the aponeural, grooved surface, but they have not the bloated and swollen appearance of those in the material of the Swedish Expedition (Andersson, 2. pl. 3, fig. 10), so that one rather suspects that in the latter material the size of the cells is to some extent due to a swelling caused by the fixing reagent employed (corrosive sublimate acetic acid alcohol). The fixing reagent of the material of the Australasian Expedition at present under consideration is presumed to be alcohol alone (*supra*).

It is singularly difficult in badly preserved zooids to distinguish between the arms of *C. solidus* and *C. nigrescens*. The two species, although relegated to different sub-genera on account of coenœcial differences, are very closely allied. The zooids in both are blackish, of approximately the same size, and the internal structure is practically identical; the only difference that one can point to with any degree of confidence is that in *C. solidus* the arms are mostly sixteen in number, whereas in the great majority of zooids of *C. nigrescens* they are fourteen.

In well preserved zooids of the latter species there are clearly recognisable in the arms a pair of rather broad black bands, separated by a narrow pale band, extending along the axis of the arm, and running together into a single band at the tip. The pigmented epithelium of these bands consists of tall cells, and is confined to the neural surface of the arm-axis; a few smaller pigment-cells are to be seen scattered along the distal halves of the tentacles of the arms.

In typical material of *C. solidus* from Station 94 of the Swedish South-Polar Expedition there is tall epithelium on the neural surface of the arm-axis, with just a suspicion of black pigment; the material is well preserved, and was mercurially fixed, as above explained, and it may be that the fixing fluid has had the effect of swelling and bleaching the tall pigmented cells, much in the same way as picric acid does the pigment-cells in *C. nigrescens* (11, p. 25). There is no indication that these tall cells of *C. solidus*, if pigmented, were disposed in the form of two longitudinal bands, but the possibility is not excluded.

In badly preserved, alcohol-fixed material of *C. nigrescens* the paired black band on the arm-axis is not distinguishable, but the whole arm, indeed the whole zooid, is stained a uniform black tint. If the arms of such a zooid are dissociated and soaked for three hours in weak Eau de Javelle (1 in 30), a general and uniform bleaching takes

place; the paired black band does not reappear. The jet-black tint of the arm (axis and tentacles alike) gradually gives place to a deep greenish brown,* then to a pale brown, and finally the arm becomes colourless. The arms of the zooids of the specimens of *C. nigrescens* supposed to have been dredged by the "Erebus" and "Terror" in 1841 or 1842 (13) are uniformly black in colour, and although the coenœcial characters of the material are so obviously those of *C. nigrescens*, I was not a little puzzled by the failure to discern the paired black band of the arm-axis.

A recent inspection of abundant material obtained on the British Antarctic ("Terra Nova") Expedition shows that different portions of material of *C. nigrescens* from the same Station, and presumably brought up in the same trawl, may show differences in the colour and condition of the arms. From one Station, for instance, a very large amount of *C. nigrescens* was obtained. Some of it was fixed and preserved in formalin solution, and some in alcohol. In the formalin-fixed material and in some of the alcohol-fixed material the paired black band of the arm-axis is well marked, and the other parts of the arm are pale; but in some of the alcohol-fixed material the zooids are in a very poor condition, and the arms are stained of a uniform black tint. Why there should be this difference between the two lots of alcohol-fixed material is difficult to comprehend; the only suggestion that I can offer is that the amount of material brought up in the trawl was so great that a considerable time elapsed before the last portions of it received attention, and that the badly preserved alcoholic material consists of some of the pieces of colony that were practically dead before they were placed in the spirit. The question has its bearing upon the zooids of *C. solidus* now under consideration, for they show a uniform black staining, and the general condition of preservation is not good.

Whether, therefore, in living zooids of *C. solidus*, and in preserved material fixed by some other methods than those adopted on the Swedish and Australasian Expeditions, the arm-axes show a paired black band, must for the present be left undecided. No features of the arms beyond the difference in their number in the two species are sufficiently definite to be really trustworthy as a means of distinction, but a study of a large number of zooids enables one to say that, on the whole, the arms of *C. solidus* are longer than those of *C. nigrescens*, the axis is rather narrower, and has a more slender and tapering extremity; but the distinction is not final, for arms of *C. nigrescens* in a state of extension can show a narrow axis, with tapering extremity (*e.g.* 11, pl. 5, fig. 24).

It is worthy of note that in material of *C. solidus* from the Swedish Station 94, now at the British Museum (Natural History), the zooids tend to become paler in time, presumably by the action of light, for the fading of the black colour is most marked in the zooids in the more superficial tubes, whereas those in the deeper parts of the colony remain dark in tint. The pigment in *C. solidus* and *C. nigrescens* is probably not identical

* Schepotieff has observed that Eau de Javelle turns the black pigment of *Rhabdopleura* greenish (Zool. Jahrb. Abth. f. Anat., vol. xxiii, pt. 3, 1906, p. 477).

with that in *C. gilchristi*, the zooids of which yield up their colour readily to the fixing and preserving fluids (3 p. 239). Reduction of black colour by the action of alcohol is also suspected in the case of *C. agglutinans* (6, p. 544).

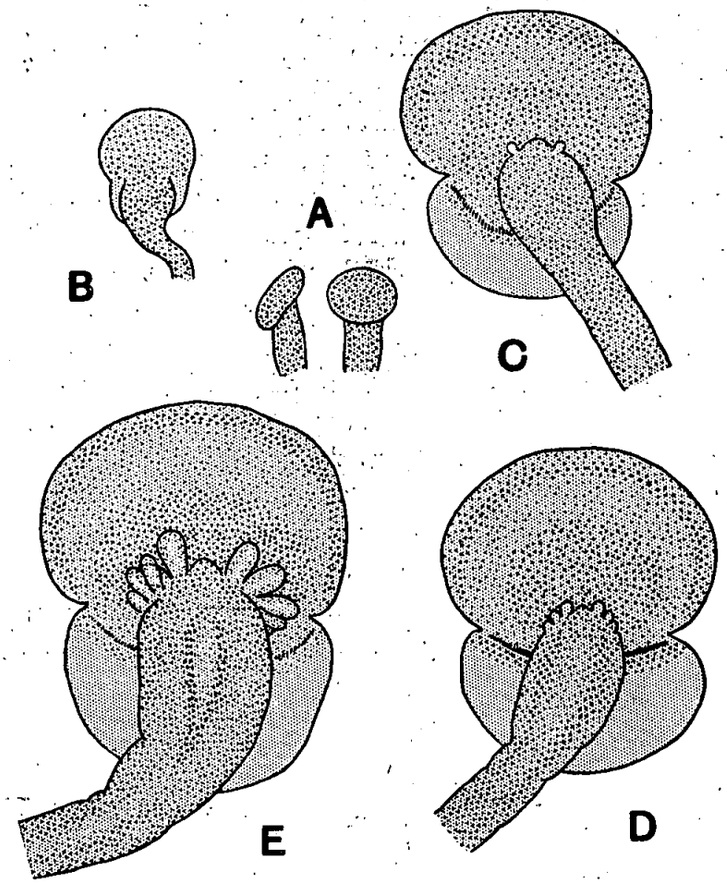

Fig. 3.

Text-fig. 3.—*C. solidus;* buds of material collected at Station 94 of the Swedish South-Polar Expedition of 1901-1903. (× 54).—A, two views of an extremely small bud; B, a bud showing first differentiation of the posterior lobe of the shield; C, a bud with the first pair of arms developing; D, a bud with three pairs of arms developing; E, a bud with five pairs of arms developing.

The buds are numerous, mostly from four to nine on each zooid; one zooid was found with as many as thirteen buds. Most of the buds found are of a stage a little younger than that shown in text-fig. 3, C. They show a fairly large shield, and no traces of arms, and they agree with the buds of the Swedish specimens of *C. solidus* in the late development of the arms, as well as in size, colour, and other respects. Since the Swedish material available furnishes a more complete developmental series than that obtained on the Australasian Antarctic Expedition, text-fig. 3 was drawn from selected buds of the type-material of *C. solidus* obtained from Station 94 of the Swedish South-Polar Expedition.

Cephalodiscus densus.

(Plate VII, fig. 1.)

Cephalodiscus (*Orthœcus*) *densus* Andersson (2).

Colony not branching, in the form of a bulky mass or cake, measuring up to 95 mm. across and 70 mm. high (Swedish Expedition material), and 130 mm. across and 100 mm. high ("Terra Nova" Expedition material); the mass consisting of closely set, vertically disposed tubes of uniform diameter, each with an ostium at the upper end, and terminating blindly below; the tubes sometimes straggling, not closely set, nor straight; the tubes united by very soft coenœcial substance for a part of their length, particularly near their bases, but in places standing free for a considerable proportion of their length. Ostium set transversely, rarely obliquely, to the end of the tube, the margin without lip, uniform, thin, sometimes with irregular external flanges. Tubes colourless, or pale brown, sometimes encrusted with sand-grains or diatoms; measuring up to 60 or 70 mm. in the middle of the colony, towards the edges gradually shorter; width of cavity of tube 1·0 to 1·2 mm., slightly greater near the ostia; external diameter of free part of a tube 1·6 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid, 4 to 7 mm.; length from bases of arms to end of body—2 to 4 mm.; width of body—0·8 to 1·0 mm. Colour (of zooids preserved in alcohol) greyish white, ochreous, orange or brown. Arms usually 8 pairs; no end-swellings with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony. Testes long, elongate, pyriform. Free ova—0·8 by 0·7 mm., not stalked. Buds many to each zooid, from five to fourteen.

Material of *Cephalodiscus densus* was dredged from Station VIII (lat. 66° 8′ S., long. 94° 17′ E., 120 fathoms, 27th January, 1914). This material consists of a fragment of a large colony (pl. 2, fig. 1), and measures 55 mm. high and 80 mm. wide; it is in a ragged condition, and is poorly preserved so far as the coenœcial substance is concerned, although the condition of the zooids is very fair.

The tubes are about 30 to 50 mm. long, with an internal width of 1·1 mm., except near the ostium, where the width increases slightly. The ostial ends of the tubes are squarely truncated, without any lip. Some of the tubes are united side by side to within 2 or 3 mm. of the ostia, others have free portions up to 20 mm. in length. There are a fair number of small sand-grains embedded in the common coenœcial substance.

The colour of the zooids is pale—raw umber to cream colour. The zooids in the deeper parts are darker in colour (burnt umber), rather suggesting that exposure to light has caused the colour to fade in the case of the zooids more superficially situated. The zooids are smaller than those of the type of the Swedish Expedition (2), and an average of eight selected zooids yielded the following results:—total length 4·4 mm.; length from bases of arms to cæcal end of the body 2·0 mm.; width of body 1·0 mm.

The arms are mostly 16 in number, sometimes less. Although the piece of colony collected is so small, both males, females and hermaphrodites are found in it. One of the hermaphrodite zooids is of interest as having both ovary and testis in a fully ripe condition, and among the buds in the basal end of the tube from which the zooid was extracted was a free ovum, presumably extruded by the zooid in question. The ova measure 0·8 by 0·65 mm. Buds are numerous; one zooid was found possessing seven, and another eight buds.

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EXPLANATION OF THE PLATES.

Plate VI.

Figs. 1–4.—*Cephalodiscus hodgsoni* Ridewood; Stat. XII, Bottle G. Nat. size.

Figs. 5 and 6.—*C. hodgsoni* Ridewood; Stat. XII, Bottle E. Nat. size.

(Photographs by Mr. J. H. Leonard.)

Plate VII.

Fig. 1.—*Cephalodiscus densus* Andersson; Stat. VIII, Bottle D. Nat. size.

Fig. 2.—*C. nigrescens* Lankester; Stat. VIII, Bottle D. Nat. size.

Fig. 3.—*C. solidus* Andersson; Stat. II, Bottle B. Nat. size. Vertical section through the colony of which the external view is shown in fig. 5. A diagrammatic representation of this section is shown in text-fig. 2.

Fig. 4.—*C. solidus* Andersson; Stat. II, Bottle B. Nat. size. Top view of a hemispherical colony, Specimen B.

Fig. 5.—*C. solidus* Andersson; Stat. II, Bottle B. Nat. size. Side view of a conical colony, Specimen A. A median section of this colony is shown in fig. 3.

(Photographs by C. Butterworth.)

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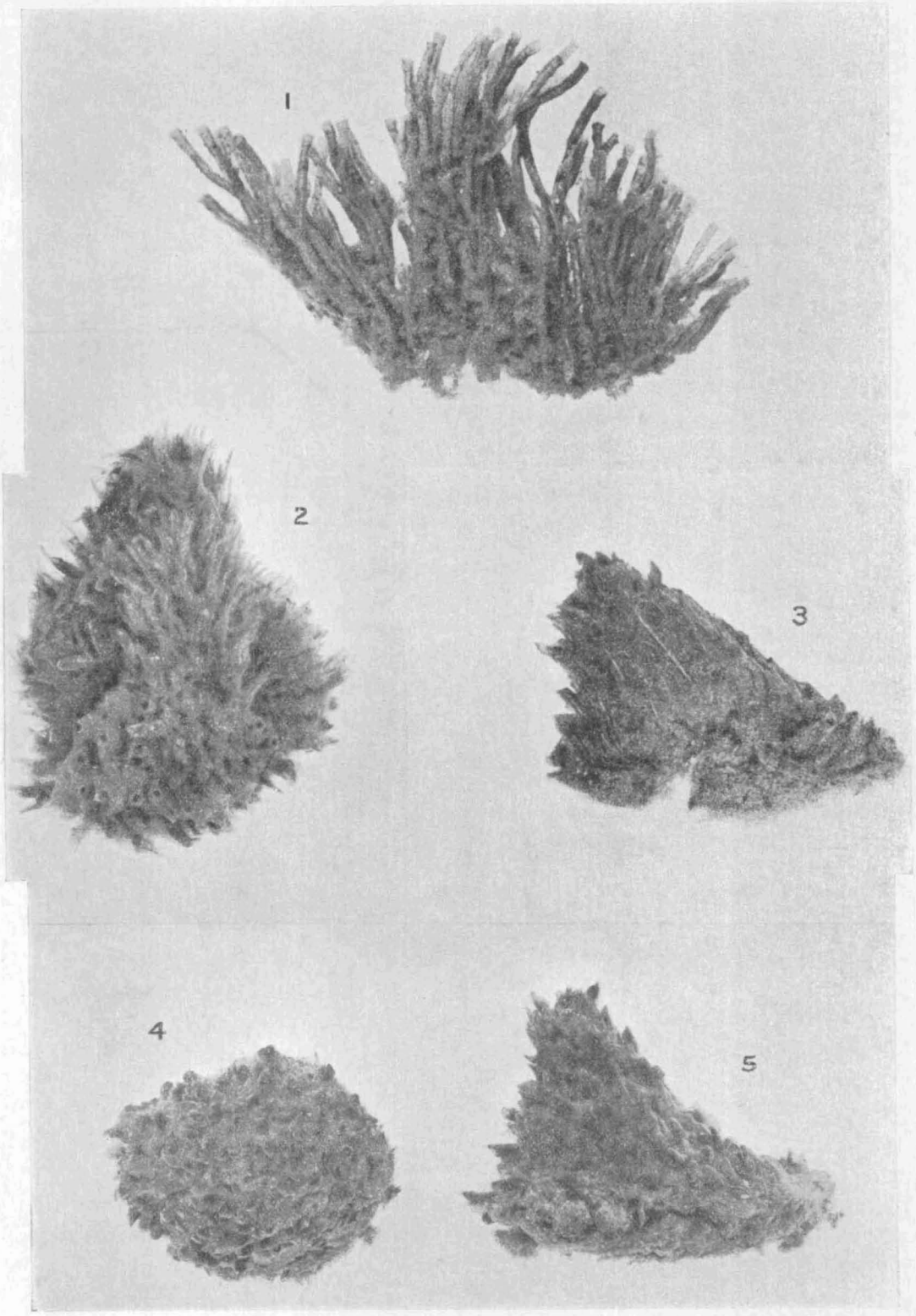
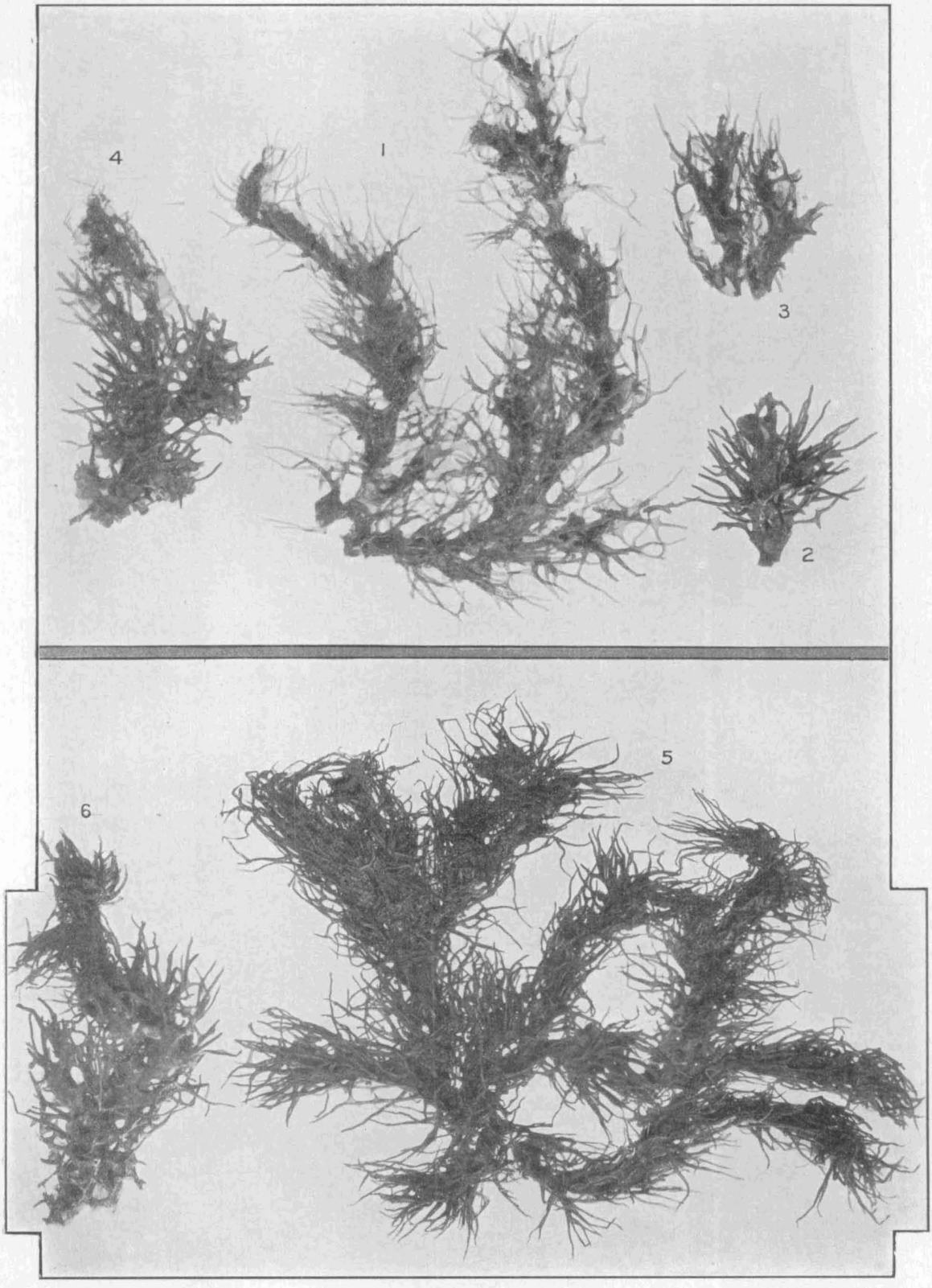


CEPHALODISCUS DENSUS (Fig. 1), C. NIGRESCENS (Fig. 2), C. SOLIDUS (Figs. 3-5). Nat. Size.



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ASTEROIDEA AND OPHIUROIDEA	Prof. R. Koehler, Université, Lyon, France.
CRINOIDEA AND HOLOTHUROIDEA ...	Prof. M. Vaney, Université, Lyon, France.
ANNULATA (EXCEPT LEECHES)	Prof. W. B. Benham, M.A., D.Sc., F.R.S., University of Otago, Dunedin, New Zealand.
LEECHES	Chas. Badham, B.Sc., University of Sydney.
CRUSTACEA CUMACEA	Dr. W. T. Calman, British Museum, London.
CRUSTACEA AMPHIPODA AND C. ISOPODA	Prof. C. Chilton, M.A., D.Sc., F.L.S., Canterbury College, Christchurch, New Zealand.
CRUSTACEA MACRURA AND C. CIRRIPEDA	Miss F. Bage, M.Sc., F.L.S., University, Brisbane.
MALLOPHAGA	Dr. T. Harvey Johnston, University, Brisbane, and Mr. L. Harrison, B.Sc., Sydney.
TICKS	Mr. L. Harrison, B.Sc., Sydney.
PYCNOGONIDA	Prof. T. T. Flynn, B.Sc., University of Tasmania, Hobart.
BRACHIOPODA	Dr. J. A. Thomson, Dominion Museum, Wellington, N.Z.
TUNICATES	Prof. W. A. Herdman, F.R.S., University, Liverpool, England.
CEPHALODISCUS	Mr. R. Ridewood, B.Sc., British Museum.
BIRDS	Mr. H. Hamilton, Dominion Museum, Wellington, N.Z., and Mr. R. Basset Hull, Sydney.
MAMMALS	Mr. H. Hamilton, Dominion Museum, Wellington, N.Z.

BOTANY.

MOSSES	Rev. W. W. Watts, Sydney.
PHYTOPLANKTON AND FRESH-WATER ALGÆ.	Prof. F. E. Fritsch, University of London.
LICHENS AND FUNGI	Mr. E. Cheel, Botanic Gardens, Sydney.
MARINE ALGÆ	Mr. A. H. S. Lucas, M.A., B.Sc., Grammar School, Sydney.
VASCULAR PLANTS	Mr. T. F. Cheeseman, F.L.S., F.Z.S., Auckland Museum, N.Z.