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ORIGINAL ARTICLES.

I.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

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(WITH 13 TEXT-FIGURES.)

(*Concluded from the March Number, p.* 131.)

BEFORE proceeding to the description of new species it may perhaps be well to make a few remarks on the classification of the Cretaceous Polyzoa and in particular of the Cheilostomata, the suborder which embraces all the species I propose to describe.

The main features of D'Orbigny's classification of the Cyclostomata have been generally accepted, but his classification of the Cheilostomata has suffered very severely at the hands of subsequent authors both in principle and in detail. It was based very largely on two principles, one the generic importance of habits of growth, and the other the generic importance of variations in the number and position of the dwarfed avicularian appendages which he called 'pores spéciaux.' The latter principle has been entirely discarded by recent authors, and with undoubted justice, as it involves the assumption of the perfect regularity of the most irregular feature of the Cheilostomatous cell. The application of the other principle and the importance attributed to it have been gradually more and more restricted, until we have reached a stage where it is still generally admitted to hold good in the case of the Lunulitidæ and Hippothoidæ, but on the strength of the behaviour of certain recent and Tertiary species has been denied even specific importance in the other Cheilostomatous families. It is time that a protest was entered against this rigid application of conclusions drawn from Tertiary and recent forms to the classification of Cretaceous forms. It is unfortunately the case that D'Orbigny, by an oversight in applying his principle in detail, laid it unnecessarily open to attack. It must be obvious that even if the principle be fully accepted, the separation which D'Orbigny made between the free and encrusting unilamellate species, e.g., *Semieschara* and *Cellepora*, *Semiflustrella* and *Reptoflustrella*, must be unsound. It is quite impossible to say that any of the free unilamellate forms found in the Chalk *grew* free. Seaweeds

and other perishable bodies must have been fairly plentiful in the Chalk sea—in the zone of *B. quadrata* we find great numbers of free small *Serpulæ* (*ampullacea* and *granulata*) whose bases show clearly that they grew attached to some long slender body, no doubt a seaweed—and any specimens which had grown attached to such perishable bodies would now be indistinguishable from those which had never been encrusting. These two forms of growth are, in fact, not unfrequently shared by Cretaceous species, e.g., *Homalostega vespertilio* and *Cribrilina Gregoryi*, though the majority of encrusting forms are practically never found free, and some free forms, e.g. *Semieschara Canui* (*post*), are never found encrusting. If D'Orbigny's unilamellate genera, which are separated only by this point of growth, be merged, we have left a number of genera based on habits of growth which constitute for the Cretaceous forms convenient and often natural groups which do not seriously overlap. No doubt they are artificial, but that is not yet a destructive criticism of any classification of the Polyzoa.

But though it may well remain a matter of individual opinion whether habits of growth are of any value in the definition of genera, I do not think that any field student of the Cretaceous Cheilostomata would deny them great value in the definition of species. It is very rare in the English Chalk for any species to occur in more than one habit of growth (treating the free and encrusting unilamellate forms of growth as identical). A better test could hardly be offered than the two very similar Onychocellæ figured respectively by D'Orbigny as *Cellepora Parisiensis* and by Beissel as *Eschara galeata* (the latter species is the one commonly identified as *E. Lamarcki*, but which corresponds only to Beissel's figure of *E. galeata*). *E. galeata* is a bilamellate form and the most abundant Cheilostome at all horizons above the zone of *M. cortestudinarium*. The specimens which have passed through my hands must run well into tens of thousands, yet I have only one encrusting specimen and no mature free unilamellate specimen, notwithstanding that it commonly grows from an unilamellate base. *Cellepora Parisiensis*, on the other hand, is one of the commonest encrusting species, and I must have seen thousands of specimens, yet I have no bilamellate specimen (and only one free unilamellate specimen). Stronger testimony to the fidelity of these species at any rate to a certain habit of growth can hardly be possible, and nearly all species of Cretaceous Cheilostomata show equal or nearly equal fidelity. Here, then, we have a point of considerable importance, in which the rigid application to Cretaceous forms of canons of classification derived from the study of Tertiary and recent forms is very undesirable.

Another such point is to be found in the prevailing tendency to unite Cretaceous, Tertiary, and recent specimens in one species. This involves the general assumption that polyps which produce skeletons which cannot be distinguished *must* be identical in organisation. We can admit the absolute propriety of this assumption in the case of specimens more or less contemporaneous and yet

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be free to doubt whether it must necessarily hold good in the case of specimens of widely differing age. The Polyzoa are a particularly good group in which to test this alleged persistence of Cretaceous forms into recent seas, for the complexity of their skeletons, at any rate in the Cheilostomata, makes it possible to define an enormous number of species, in fact all but the most primitive, with clearness and certainty in a way unattainable in other groups. Now it is not strongly marked species that are identified both in recent seas and the Chalk, but primitive forms such as *Stomatopora granulata* and *Membranipora reticulum*. I am not inclined to admit that the presence in the Chalk of *Membraniporæ* whose skeleton cannot be distinguished by any absolute character from that of the recent *M. reticulum* is conclusive or even presumptive evidence that polyps identical with those of the recent *M. reticulum* lived in the Chalk sea. It is not necessarily the case that because we habitually assume that a simple polyp did not have a specialised skeleton we are entitled to assume the converse that a specialised polyp did have a specialised skeleton, or in other words that a simple cell like that of *M. reticulum* could not be sufficient for the requirements of two or more differently organised polyps. There is nothing that I can see to warrant this assumption, and until it can be supported by stronger evidence it seems more prudent to continue to recognise the great physical break between the Cretaceous and Tertiary epochs as a justification for refusing to admit the identity of primitive Cretaceous forms with recent species.

From the foregoing it will be gathered that I desire to see it recognised as a principle that in dealing with the Cretaceous Polyzoa we are not bound by the Tertiary and recent forms, and any strict assimilation would be *a priori* injudicious, for it must be remembered that the recent Cheilostomata with hard skeletons, the only ones which can be compared with the Cretaceous Cheilostomata, may fairly be considered to form a group in which the general lines of development have long been settled, a middle-aged group. They are, from the geological standpoint, absolutely contemporaneous, but represent almost every possible variety of surrounding conditions. The Cretaceous Cheilostomata, on the other hand, represent the vigorous youth of the group when all sorts of experiments in development were taking place, not only those which resulted in the formation of stable families and genera which still exist, but also those which produced such unstable and shortlived families as the Melicertitidæ. They represent a long period, but on the whole only one set of conditions. Under these circumstances it is only to be expected that rules which apply to one fauna will not always apply satisfactorily to the other. Differences which in one case were of genuine specific importance might well in the other indicate merely variations of a single species under the influence of distance in space and variety of surroundings, and capable of being proved to be such by a chain of intermediate forms. The importance of taking such considerations into account is exemplified by the history of Hagenow's species *Onychocella* (*Cellepora*) *Koninckiana*. Hagenow gave two

figures of this species, and at first sight it would seem impossible that they should belong to the same species. Gregory accordingly gave to the second figure the specific name of *Hagenowi*. This involved the attribution to Hagenow of a careless blunder, but would have been justifiable, as far as the creation of species from published figures only can be justifiable, if Hagenow's specimens had come from the settled conditions of ordinary Chalk. But they came from the unsettled shallow-water conditions of the Maestricht Beds, where unprogressive variation, as well as the progressive variation which we call evolution, would be particularly likely to occur in the Cheilostomata, and I have little doubt that Hagenow united his figures in one species for the reason that I reunite them, namely, that he had seen specimens responding accurately in different parts to both figures. The species is evidently a variation which did not prove advantageous and so did not lead to further developments, and to which as a species from Maestricht we need not attach any importance, but which, if it were to appear in recent seas, would be a bombshell indeed.

The recent genera *Mucronella* and *Cribrilina* do not give satisfactory results when applied to the Cretaceous Polyzoa. In the first place, the accepted definition of *Cribrilina* excludes species with radiating or transverse furrows which are not punctured. There does not, however, seem to be good ground for treating the presence or absence of pores in the furrows (a point often very obscure in fossil forms) as necessarily generic, and I propose for convenience to treat the definition of the genus as extended accordingly. In the second place, the two genera cover an enormous number of Cretaceous species, and a study of these indicates that many of them possess characters which would, if their front walls were not furrowed, place them in entirely different genera and even families. Can such forms be logically retained in a single genus? Certainly *Cribrilina* and *Membraniporella* are not for the Cretaceous forms genera in the same sense that, say, *Mucronella* and *Porina* are, but rather agglomerations of the early stages of development of other families and genera, while the family and generic peculiarities were coming into existence, and after they had come into existence, but while the development of a fully calcified front wall was still incomplete. If the two genera were dismembered a large number of species could be successfully grouped with other families; indeed, I think additions out of the Cribrilinidæ would be made to nearly all the important groups except the Celleporidæ, Porinidæ, and Hippothoidæ, and it is interesting to note that Jullien puts the two latter groups in a separate suborder. Even if the Cribrilinidæ are not dealt with in this way the Cretaceous forms suggest that they are the product of two totally distinct lines of development from the primitive Membraniporidan cell. One of these lines is the commonly recognised one, the arching over and fusion in the middle line of marginal spines. But this will not satisfactorily account for the very large number of species in which the front wall is attached to the side of the side walls and does not rest on their surface.

Here the front wall must have arisen by symmetrical calcification of the membranous covering, starting no doubt from points along its junction with the side walls and proceeding inwards. There would therefore, on this hypothesis, be a morphological distinction of the greatest importance in the Cribrilinidæ (and through them in the majority of the Cheilostomata) between cells with a distinct rim and those without a distinct rim, a distinction which would make it impossible to retain the family Cribrilinidæ. It is distinctly favourable to this hypothesis that Marsson has on other grounds given great prominence to the question of rim or no rim in classifying the Cheilostomata. The Cretaceous forms also suggest a third line of development of the calcified front wall through such forms as *Membranipora Trimminghamensis* (*post*). The cell in these forms is clearly an ordinary Membraniporidan cell tilted forwards, and by the squaring of the lower part of the aperture and pressing downwards of the straight lower lip thus formed, we pass by easy stages represented by the Cretaceous forms of *Pyripora* to a *Micropora* practically indistinguishable from one developed through Cribrilinid forms, but with a front wall morphologically quite distinct in its origin from those developed through Cribrilinid forms.

DESCRIPTION OF SPECIES.

A. *Trimmingham Species.*

Membranipora Griffithi,[1] sp. nov. (Fig. 1.)

Colony adherent, normally growing equally in all directions with almost the regularity of a *Lunulites*, and possessing a common crust out of which the cells stand sharply. Cell nearly circular, with a sharp-edged, narrow, smooth wall. The mature cells almost invariably have both an ovicell and an avicularium. Ovicell immediately above the cell, about half the width of the zoœcium,

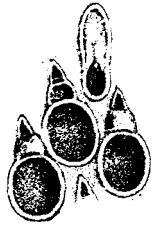

Fig. 1.

and of the usual semi-globose shape. In a large number there is a triangular incision in the rounded end, apparently giving double access to the interior, and the sides of the ovicell are extended along the side wall of the avicularium as far as the crossbar. Avicularium sharply triangular, placed immediately above the ovicell. It is spanned close to its base by a very slender bar, which is often

[1] Dedicated to Mr. C. Griffith, of Winchester, a friend of long standing, who first introduced me to the study of geology.

preserved. Large vicarious specialised cells, possibly vibracularia, occur scantily but regularly. They are long, rather narrow, and constricted towards the lower end. The aperture is situate at the lower end, and is round below and pointed above. The lower two-thirds of it are enclosed by the cell-wall, and the upper one-third by a depressed front wall, which occupies the rest of the area.

MEMBRANIPORA TRIMMINGHAMENSIS, sp. nov. (Fig. 2.)

Colony adherent, growing as a rule in one direction only. Cell elongated and pear-shaped, with an oval aperture occupying with its marginal wall (which has its edges bevelled off) rather more than half the cell, the lower part forming an external area and tapering away. On the marginal wall is a single row of denticles. At the upper end the marginal wall is exceedingly thin, which is easily

FIG. 2.

seen, owing to the free edge of the ovicell being concave. Ovicell globose, narrower than in the preceding species, but similarly placed at the head of the aperture. Avicularium placed above the ovicell, oval with an oval aperture, divided into two lobes (the upper being slightly the larger) by two lateral denticles, which were joined by a slender bar, which is generally destroyed. This species can almost be constructed from the preceding one by rounding and smoothing all sharp angles and corners.

MEMBRANIPORA BRITANNICA, sp. nov. (Fig. 3.)

Colony adherent. Cell subcircular to oval, the marginal wall chiefly a common wall. On the foot of practically every cell is placed either the ovicell or the avicularium of the cell below. The ovicell is of the semi-globose type, but wide, flattened, and steep-sided, so as to appear almost rectangular. Its free edge

FIG. 3.

a. Group of cells showing ovicells and perfectly preserved avicularium.
b. Cell with usual type of avicularium.

coincides exactly with the outline of the cell-wall beneath. Avicularium mandibular and placed transversely with the point of the mandible indifferently to the right or left. It is generally stumpy (*b*), but in well-preserved specimens the point is long and

slender and projects over the adjacent cell (*a*). The point being raised much higher than the rounded end, the aperture is in an inclined plane facing the cell adjacent to the base of the avicularium. It is an almost invariable rule that every cell (except the very early ones) has either an ovicell *or* an avicularium. The species is very characteristic of the Trimmingham Chalk, but is recognisable in the zone of *M. cor-anguinum*, though rare below the zone of *B. mucronata*.

SEMIESCHARA MUNDESLEIENSIS, sp. nov. (Fig. 4.)

Colony always adherent. Cell large and subpyriform, with the external area of the pyriform type occupying usually about one-third of the cell, but only tapering very slightly as a rule. Where the marginal wall divides the internal and external area it is very faint. The aperture is very large and occupies nearly the whole of the space within the marginal wall, and is slightly heart-shaped, its lower margin being indented by a blunt denticle projecting from the internal area. The internal area is usually very insignificant, but is

FIG. 4.

very variable in extent, and may absorb almost the whole external area. It slopes forwards and downwards. The ovicells are not at all prominent, and are little more than swellings of the foot of the succeeding cell, but have a very remarkable thickened broad rim to the aperture. Avicularia rare and very irregular in occurrence. They are narrow elongated membraniporine cells, with a slight area at the foot sloping gently towards the aperture, which is slightly constricted rather above the middle. The size of the aperture makes the species easily recognisable.

SEMIESCHARA CANUI,[1] sp. nov. (Fig. 5.)

Colony always free, but unilamellate. Cells relatively broad, aperture placed in the upper third, small, trifoliate, upper lobe semi-

FIG. 5.

circular, other lobes narrow and exactly alike. No ovicell observed. Avicularium an elongated cell, slightly constricted rather above the

[1] Named in honour of my friend M. F. Canu, the French authority on Polyzoa.

middle at a point on a line with the upper edge of the aperture, which is small and transversely oval, with a strongly denticulated lower lip.

ESCHARA ROWEI, sp. nov. (Fig. 6.)

Colony free, bilamellate, growing in expanding fronds, which are very fragile. Cell long and narrow, aperture occupying quite half the cell, heel-shaped, and elongated, with sides constricted close to the lower lip, and a strongly projecting lower lip. No ovicell. Avicularium an elongated cell with pointed ends, broad in the middle,

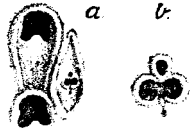

FIG. 6.

tapering more rapidly below than above. Aperture rather below the middle, appearing under a low power as a transverse oblong with rounded corners, and a distinct pore above and a faint pore below (*a*). Under higher powers the structure shown in (*b*) is revealed. This structure is rarely preserved, the specimens generally presenting it in varying degrees of ruin.

CRIBRILINA SHERBORNI, sp. nov. (Fig. 7.)

Colony always adherent. Cell widely oval, apparently based on a primitive form (*a*), with an elongated heel-shaped aperture in a plane at a slight angle to the horizontal, a front wall rising from all sides to a central circular platform in which are cut a series of radiating furrows, two long lateral slits in the front wall commencing between the aperture and the margin and running outwards close to the margin, and a globose ovicell at the top of the cell some distance above the aperture. The first stage of development appears to be that the lower lip of the aperture rises slightly, and the rest of the

FIG. 7.

margin of the aperture rises considerably to form with the upper edge of the aperture of the ovicell an oval secondary aperture (*b*). Next there are developed over the lateral slits lateral avicularia, set on legs so as to allow free access of water to the slits (*c*). These avicularia are very faintly mandibular, with the point of the mandible on the inner side, but the least attrition makes them circular. At the same time the sides and base of the secondary aperture are further raised, and the sides are produced up the sloping surface of the ovicell to meet at the central crown. In the final stage (*d*) the

avicularia develop very decided beaks, connected by a thin, almost horizontal plate into a barrier right across the cell which overhangs and entirely conceals the primary aperture, while even the area between the primary aperture and the ovicell is now so deep set as to be visible only in special lights. It is the rule for every cell to attain this stage, but the fragility of the plate between the avicularia produces many variations in the shape of the secondary aperture when the specimen is handled at all roughly. *Cellepora pinguis*, Hag., appears to be a relation.

CRIBRILINA DIBLEYI, sp. nov. (Fig. 8.)

Colony always adherent. Cell elongated. Aperture heel-shaped, surrounded by a flat raised margin, the lower lip being triangular, with the apex directed down the front wall. The upper lip bears four or five hollow denticles (when there are five the fifth is a small one between the two at the head of the cell). Ovicell large and globose, with faint radial markings, and covers the two (or three) upper denticles. Front wall marked by about 17 lines of fine

FIG. 8.

pores, increasing slightly in size towards the margin. These lines do not (except the topmost pair) meet in the middle, but leave an imperforate bar down the centre. Nearly every cell has one avicularium, many have two. They are either mandibular and slender, with thin marginal walls connected by a slender rod near the base, or broadly oval. The latter are probably decayed or worn specimens.

CRIBRILINA JUKES-BROWNEI, sp. nov. (Fig. 9.)

Colony always adherent, generally growing in narrow ribbons. Cell based on a primitive form like *Repteschavella inæqualis*, D'Orb., but with a decided rim. It has a long globose ovicell, up the front of which two slender ridges run diagonally from each corner of the aperture, meeting in an angle at nearly the highest point of the ovicell. The lower lip of the aperture is produced forwards and upwards into a broad band in three sections. The lowest of these is bluntly triangular, with the apex pointing downwards. At the sides of the cell it rises gently to the second section, which is, however, strongly arched in the middle, and so leaves there an opening between it and the first section. The third section is at a higher level still, more or less flattened and buttressed, apparently not against the side walls but against two lateral tubes (presumably

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avicularian), which rest on the side walls and open just beside the aperture. In the centre this third section rests on the second section, and its lower edge having a deep sinus an inlier of the second section is exposed. At the sides the third section rises considerably above the second section, and so there is a well-marked opening left. The upper edge of this third section carries two very minute and slender beak-shaped avicularia lying transversely with their beaks directed inwards. These constitute the apparent lower lip of the aperture, and according as they do not quite meet, just meet, or rather more than meet, in the middle line, the apparent lip has

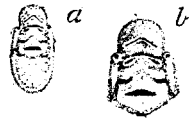

Fig. 9.

a central sinus, is quite straight, or has a central denticle. This apparent lip is on the same vertical plane as the deep-set aperture of the ovicell, and entirely conceals the aperture of the cell, and leaves only a small space between itself and the sloping surface of the ovicell. Below the transverse band is seen the normal front wall with five pairs of radiating furrows, and a single unpaired one in the middle line at the foot. The ovicell and transverse band are practically always present, and the species, which is quite small, is easily recognisable with a pocket magnifier, though the details are hardly discernible under the microscope.

Mucronella Batheri, sp. nov. (Fig. 10.)

Colony always adherent, small and very prominent, partly owing to the compactness of its surface and partly apparently to its being bilamellate. The cells of the lower lamella are wide, but very shallow, and some of them may generally be seen round the edge of the colony. They rarely exhibit more than the marginal wall, but occasionally one may be seen with a front wall consisting apparently of a number of irregular plates with a round pore in the centre. On

Fig. 10.

the foundation afforded by these cells is built a layer of cells of normal depth. Here the primitive cell is a simple lepralian cell with an oval aperture in a sloping plane. But as the cell matures the lower lip of the aperture is produced in the plane of the surface of the colony into a broad square mucro overhanging the greater part of the aperture and leaving only a very narrow space on either side of it and between it and the broad ovicell. The latter is nearly

always present, and is set on the base of the succeeding cell, and so deeply sunk that its rather flattened upper surface is practically flush with the general surface of the colony. This gives the colony its uniquely compact appearance. Every cell bears one or two avicularia, consisting of long slender tubes lying on the front wall with the wider and open end a short way below the mucro, and tapering away posteriorly and sinking gradually into the front wall. Cells which carry at the foot the ovicell of a preceding cell have two lateral avicularia; those which do not carry such an ovicell (e.g. the first of an intercalated series) have one median avicularium.

B. *Senonian Species.*

SEMIESCHARA WOODSI, sp. nov. (Fig. 11.)

Colony usually adherent, occasionally free and unilamellate. Cells hexagonal and arranged quincuncially. Aperture approximately oblong and transverse, the upper lip being sometimes rather shorter than the lower, and sometimes slightly convex. This upper lip slopes sharply inwards, and may therefore be overlooked unless the light is thrown from the *foot* of the cell. Ovicell very rare, merely a swelling of the foot of the succeeding cell. Avicularia fairly but

FIG. 11.

variably plentiful. They are separate cells, but not vicarious. They are more or less shuttle-shaped, with a small round aperture in the point of the shuttle. The species appears at least as low as the Marsupite zone, but attains its zenith in the base of the *B. mucronata* zone. It is probably lineally related to *Cellepora Michaudiana*, D'O., but easily distinguished by the shape of the apertures both of cell and avicularium.

SEMIESCHARA PERGENSI, sp. nov. (Fig. 12.)

Colony adherent. Cells hexagonal, of varying dimensions, arranged more or less quincuncially with a very broad and ill-defined common wall. Front wall arched from side to side, and also sinking slightly

FIG. 12.

from the foot (where it is almost on a level with the top of the cell-wall) towards the aperture. The aperture is semicircular and large,

with rounded basal angles, and stretches from side wall to side wall, but its apparent breadth is restricted by a very slight infold of the inner edge of the side walls. The lower lip is almost straight, but the very slight curve is often accentuated by the arching of the front wall from side to side. The avicularium is an elongated cell with an oval aperture occupying two-thirds of the area, and touching the cell-walls at its widest, but separated from them above that point by a very slight deep-seated front wall, and below that point by a considerable front wall rising towards the foot of the cell to the plane of the top of the cell-wall. The species is very characteristic of the upper part of the zone of *B. quadrata*.

CRIBRILINA GREGORYI, sp. nov. (Fig. 13.)

Colony either adherent or free and unilamellate. Cells large, with walls on the whole common, though often showing signs of separation. Aperture large and semicircular, surrounded by a broad smooth border, which extends between the upper edge of the aperture and the foot of the next cell for a distance equal to or greater than the height of the aperture. From the upper part of this band two prominent denticles project out over the aperture. The front wall springs from slightly below the surface of the side walls, and is gently arched. It bears about seven rows of punctures, running straight across from side to side, the two punctures next the side walls being much larger than the others. There are usually two avicularia, always one, to each cell, closely associated with the

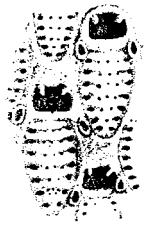

FIG. 13.

lower corners of the band round the aperture. They are small and mandibular, but except in well-preserved specimens from the zone of *B. quadrata*, where this species reaches its zenith, the mandible is poorly or not at all developed, and the avicularia present themselves as very small circular perforate denticles. No ovicell has yet been observed, though many thousands of specimens have been seen. The species most nearly resembles *Semiescharipora dentata*, D'Orb. (which is, however, near the *Membraniporellæ*), but is easily distinguished from that and all other species by the two imperforate denticles overhanging the aperture. It appears in the zone of *M. cor-testudinarium* (at Seaford), and becomes steadily more prevalent until in the upper part of the zone of *B. quadrata* it is the dominant form; above the base of the zone of *B. mucronata* it soon becomes comparatively rare.