Notes on Plymouth Sponges.

By

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(1) Sycon compressum:

On a Specific Character.

Sycon compressum is one of the long-recognised sponges, that stand refreshingly conspicuous in a group made difficult with doubtful definitions. The unique dermal spicules, and the striking outward form, divide it from other species in a way quite different from that in which *Sycon raphanus* is divided from *S. villosum* or *Reniera cinerea* from *Reniera permollis.*

From the doctrine of evolution it would appear the logical deduction that the constant and striking differences which *S. compressum* shows from its next allies are important to its existence, while the varying differences shown among other so-called species are nearly, or quite, uninfluential. It therefore seems worth while to examine whether we can find circumstances in the life of the sponge which can lift this statement from the deductive to the empirical standpoint, by showing that there are exceptional facts in the environment, to which the unusually marked specific characters exceptionally fit the animal.

Walking on the low-tide rocks immediately under the Laboratory at Plymouth, it will be found that there occur in abundance *S. compressum, S. ciliatum, Leucosolenia botryoides, Guancha coriacea, Halichondria panicea,* and *Hymeniacidon sanguineum.*

In the tide-pools all four calcareous sponges occur in quantity, and under heavy masses of weed both the Sycons are equally abundant. But on the tops of all the naked rocks we find able to support existence only the green tufts of *Halichondria*, the red smears of *Hymeniacidon*, and the crisp little white leaves of *S. compressum.*

Both the siliceous species are comparatively massive incrusting sponges, and therefore exist under completely different conditions to the delicate, bag-like, Calcarea. Leaving them, therefore, for the present, we find, with respect to two closely allied sponges, that *S. compressum* and *S. ciliatum* live side by side in every sheltered cranny, but on the working tops of the rocks *S. compressum* is alone—

often with little even of seaweed hardy enough to bear company—exposed for hours every day to sun, rain, or wind.

I made some tentative experiments as to the endurance of *S. compressum*, a brief summary of which, with figures of the metamorphosed collar-cells, appeared in "The Collar-cells of Heterocœla," *Q. J. M. S.*, vol. 38. Though they would have been better if comparative with studies on other species, the results by themselves are fairly striking.

(1) Several sponges were gathered at 1 p.m. on February 6th at low neap tide. They were taken from positions on the tops of rocks, free from all water or seaweed, and placed, without more water than they contained, in a small empty corked bottle. On February 7th, at 1 p.m., a section from a large specimen was examined under the microscope; though twenty-six hours out of the water, flagella were moving everywhere (though not quite on all cells). The absence of collars and hemispherical outline of the cells has been described in the paper referred to. The remainder of the sponge was placed in the aquarium circulation, and on February 8th, at 6 p.m., was found in the most healthy life, most of the cells being collared and perfectly normal in shape, while the flagella were in active motion.

(2) Some of the same collection were taken from the bottle at 8.30 p.m. on February 7th and placed in sea-water, having endured some thirty-four hours' sojourn in air. Another experiment being designed, the sea-water was saturated with indigo-carmine, was out of the circulation, and through a disconnection of the tubes was most of the time entirely without aeration. Notwithstanding that these circumstances were most unfavourable to recuperation, one of the sponges examined at 4 p.m. on February 8th showed a fair proportion of collars, had very active flagella all over, and looked exceedingly healthy; another examined on February 10th, though having no collars, showed healthy flagellate action everywhere. Of the four other specimens treated in the same way and examined on these two days, only one (on February 10th) was found to be completely dead.

(3) Some sponges were collected from the upper and exposed surfaces of rocks, where rain had been falling on them for three hours. They were placed in a dry bottle and, after a further three hours, examined with the following results:—

(*a*) Possibly dead; no changes recognisable; all the cells amœboid in form.

(*b*) Flagellar action observed and (?) the regeneration of a collar.

(*c*) *Violent* flagellar action. This sponge was only just dipped in the sea-water before cutting, (*a*) and (*b*) had lain in sea-water some minutes.

(*d*) Held under a stream of fresh water some minutes, tissues all destroyed.

(*e*) One minute lying in fresh water, of which for thirty seconds it was entirely submerged; a few flagella were found moving, in most parts they were not visible, in most places the cells had thrown out strings of protoplasm, and were in other ways altered.

Though improbable, it was logically conceivable that the comparative immunity to rain and other fresh water was due to modification of the naked protoplasm itself. While (*e*) was in full action, therefore, a drop of fresh water was introduced under the cover-slip. For a moment the flagella quickened, almost instantly stopped, and within a few seconds the cells successively became transparent, then ovoid, then disappeared.

It appears to be fairly certain, therefore, that this apparently fragile member of a singularly delicate group of animals must have some exceptional provisions, (1) to resist evaporation, (2) to withstand injury from such evaporation as still takes place, (3) to resist the entrance of noxious fluids, *videlicet* pure water.

To meet (1) and (3) I propose at once the spicules. Dendy, in his masterly review of the Heterocœla,* pointed out the anomalous position of *S. compressum*, in having a highly developed cortex and yet retaining what may be called the "conal acerates," that is, the centrifugal bunch of unbranched spicules which surmounts the end of each radial tube. The first, as he shows, is a Grantiad character; but the second is typically Syconid.

Now I suggest that the thick, continuous, cortex, set with its dense mass of club-shaped radial spicules, enables the sponge to pursue its daring existence; clothing it with a deep armour of calcareous mosaic through which, when the skin is contracted on its pores, a minimum amount of permeation or evaporation can take place. The shillelagh-like outer ends of the spicules serve, like the heads of iron nails set in a pile at sea, to cover and protect the surface of the substance in which their points are embedded.

As to (2). The danger to a sponge from evaporation of the contained water comes at a stage short of desiccation. If we suppose a rigid, cylindrical, Sycon to be exposed to the sun and wind for two or three hours between tides, the returning water would find it—though perhaps damp, and still in cellular life—with its gastral cavity empty; evaporation having replaced the liquid reservoir by a bubble. Such a sponge is doomed. It has occurred to me again and again, when measuring the oscular currents, to be surprised at the sudden quietude

* *Q. J. M. S.*, vol. 35.

of a *Leucandra* or other sponge employed, after being transferred from one basin to another; a quietude at once replaced by the accustomed stream when the obstructing bubble was removed. This was accomplished in very wide-mouthed sponges by merely raising the osculum, but in most of those dealt with, the bubble could not escape without the aid of pressure.

Hence the flat form of *S. compressum*. In its cloaca a bubble is never formed. The tide leaves it with rounded outline, so that in a sponge a centimetre wide, its shorter axis may be nearly half as much. As there occurs evaporation, even from its protected surface, into the air round it, and the fine capillaries of its walls suck in fresh supplies of water from the central drop, the sides gradually come nearer, like the capsule surfaces of an aneroid barometer, until the cloacal cavity may attain itself such capillary dimensions that only very dry air can further extract the moisture.*

As a matter of observation, above the rising tide it is easy to observe on every side flat, yellowish, sponges, like oval pieces of whitey-brown paper, which swell out at once in water to their natural rounded form; and if a sponge in the rounded form be taken from the water and laid on blotting paper, it becomes flat. On the other hand, in tide-pools which never dry I have found several specimens of *S. compressum* with the oscular part of the cloaca cylindrical, and this observation only corroborates one noted long ago by Grant.

The cylindrical form is never met with on exposed sites. One such specimen was found, not in a pool, but hanging under a large rock, down which, from weeds and growth of all sorts, a trickling of sea-water kept up through the whole period between tides. There was a constantly renewed drop falling from the open cylindrical mouth, and when this was dried away with a handkerchief the sponge could not flatten, like those accustomed to be dry in every ebb, but its stiff round tube remained open and empty.

Among all the Calcarea, the only sponge that I know described of absolutely comparable shape is *Sycortis lingua*, Haeckel (Newfoundland), which appears to me a near connection of *S. ciliatum*. Haeckel notes that only two sponges have dermal spicules at all comparable with *S. compressum* for size and arrangement; the one is *Leucandra lunulata* (Cape of Good Hope), which takes the form of "plattgedrückte langliche Schlaüche"; the other is *Ascandra falcata* (Adriatic), apparently cylindrical.

As to the siliceous companions of *S. compressum*, their complicated,

* In the drying of marine organisms the external deposit of salt, and internal concentration of brine, must considerably retard ultimate desiccation; though probably with injurious results to organisms whose protoplasm is not adapted to withstand such salinity.

and massively "spongy," structure opens up a totally different series of needs and adaptations, not comparable with the delicate simplicity of the Sycon. One point only may be noted; that for *Halichondria* with its few wide oscula, the difficulty with the contained bubble is slight, and when the oscula point upwards it will escape at once. I am somewhat of opinion that the hairy coat of *S. ciliatum* may assist it in another way to retain moisture, when, in its intermediate situation, hanging under sheltering masses of damp seaweed; it is worth noting that *S. lingua*, from Haeckel's description, has no cortex, but a very long fur.

It would involve far more space and detailed discussion than are here convenient to endeavour to assign the exact importance of the few facts above narrated, nor until associated with many parallel observations is it worth while. The subservience of a "marked species characteristic" to outward circumstances, shown in the partly cylindrical form of tide-pool specimens, may be due to the fact that only here such varieties can survive, may indicate a power of individual adaptation. Probably it means merely that mobility, never exercised, is lost; and that the spicules which are never called on to slide over one another become locked and plaited to the rigidity of other Sycons. I have before now endeavoured to show* that the definite series of changes in canal-system and outward form, with which homoplasy presents us again and again in every group of Porifera, bring definite increasing mechanical advantage. Here I have attempted to argue that the most definitely characterised common species of sponge has the most definite use for its species characters. I hope later to be able to show, in the case of *Reniera*, that the minute spicular changes which fill our classifications, and to which it appears impossible to ascribe utilitarian value, are not characteristic of species, but merely the direct consequence in the individual of some altered physical conditions of the nutrient medium.

(2) Halichondria panicea; Suberites domunculus: Variation and Metampy.

The specimen of *H. panicea* given me from Exmouth (*vide* p. 317) differs markedly from a Plymouth specimen, or from Bowerbank's figures, in having the interior skeleton far looser and more fibrous in character. The Exmouth specimen shows, even in the innermost mass, numerous well-marked bundles, three or four spicules in thickness, branching, but having a general tendency to parallelism. The Plymouth specimen shows the confused skeleton recognised as characteristic by all authors; and the far more numerous spicules form, in the interior of

* *Loc. cit.*, p. 18, and *Proc. R. S.*, vol. 64, p. 61.

the sponge, an irregular criss-cross, rarely showing well-marked fibres; looking like a felt of pine-needles, and well represented in Bowerbank's figure (Fig. 300, *Mon.*, vol. i.).

This difference is explained when we consider the difference in conditions of life: the Exmouth specimen living some fifteen feet below low-water mark, removed from the possibility of any shock or jar; the Plymouth specimen between tidemarks, exposed to what is often a very violent surf. Such a loose framework as is found in the Exmouth specimen, being very slightly bound together, will dislocate under shocks, and the (sharply pointed) needles drive over one another to form the smaller, and denser, skeleton which is best known to shore-collectors.

I have found a difference, closely comparable to that between the deep-water *Halichondria* of Exmouth and the surf *Halichondria* of Plymouth, in *Suberites domunculus*. In this species the individuals carried on the back of a hermit-crab have a dense skeleton, like the surf-beaten *Halichondria*, and justify their name with a consistency almost of cork; while the individuals found growing on rock in the deep waters of Millbay Channel (Plymouth Sound) are much larger, supported by a skeleton of precisely similar elements, but much looser, giving the sponge the soft consistency of a ripe plum.

If the above explanation be correct of the differences between the soft and hard specimens of *Suberites* and *Halichondria*, the soft *Suberites domunculus* is not a "variety" in the sense that an albino rabbit, or a six-toed cat, is a variety. I am not aware of any word applicable to describe a definite difference from the type, frequently encountered, but known to be due to post-natal influences. It appears useful, in instances where such a history can be proved, to have a word to distinguish the phenomena from those of congenital difference—to distinguish conditional from germinal variation. I suggest the unscholarly, but manageable word, "metamp," suggested by the Greek μεταμπέχομαι = "to put on a different dress." Thus we shall speak of "*Suberites domunculus* met. *mollis*"; and distinguish the inherited darkness of the Cinghalese from the metampic brown of the tropical Englishman. Holding, as I do, that the sizes and forms of sponge spicules are largely influenced by the temperature and constitution of the sea in which they grow, I believe that not only varieties, but many so-called species of sponges, are merely metamps of each other.

To speak of "abnormal forms" does not meet the case—neither the tidal nor the deep-water *Halichondria* can be considered abnormal. The determination of a normal form would, on the view here put forward, mean merely the determination of a normal depth, a normal salinity, or a normal temperature. In the case of littoral and sub-

littoral species such a determination would in many cases be quite meaningless.

The cylindrical *Sycon compressum*, referred to in the previous note, may be considered a metamp of the flat *Sycon compressum*. In this case the flat form may be considered normal, since according to present knowledge it is a thousand times more frequent. Vosmaer (*Mitt. aus d. Zool. Stat. z. Neapel*, vol. v. part 3) has put forward the view that *Leucandra aspera* is extraordinarily diverse according to its habitat, and my own work has caused me to take the same view of *Sycon raphanus* (cf. the papers cited in previous note); these are cases of mutual and probably continuous metampy, where a normal form is difficult to select.

The skin of *H. panicea*, with its net of spicules, is well represented in Bowerbank's figure (*Monograph*, vol. i. Fig. 505). It is coherent and easily detachable, and, as Ridley and Dendy remark (*Challenger Mon.*, p. 15), Schmidt's definition of his genus *Pellina* is completely fulfilled by this species. Topsent, however, has since (*Réforme dans la Classification des Halichondrina*) revived the genus *Pellina*, with a Renieran instead of a Halichondrian skeleton.

The skin is considerably thicker and more spicular in the Plymouth than in the Exmouth specimen, being conspicuous in spirit as a white veil over the sponge, showing as a hard white line when the sponge is cut. It is tempting to connect this denser spicule-sheathing of the tidal sponge with the restraint of evaporation and protection of soft tissues against brine and rain-water, as suggested in regard to the club-spicules of *S. compressum;* but it must be remembered also that far denser crusts are well known in other siliceous genera which are not tidal.

Bowerbank's Fig. 300 does little justice to the subdermal space. This is not a series of spherical lacunæ in the tangle of spicules; the spicules in the ectosome of *H. panicea* are as definitely arranged as in an *Axinella*. The skin is only connected with the body by spicule-fibres, which traverse the subdermal space like the columns in a Norman crypt, expanding above to support the tangential spicules of the skin, and below to root in the body.