ON THE FEASIBILITY OF RAISING SPONGES FROM THE EGG.

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For the purposes of scientific investigation the problem suggested in the title of this paper presents no difficulties to the zoologist. Whether on the other hand it is practicable or even desirable to rear sponges from the egg for the purposes of the sponge-grower, is a question which can only be decided by experiments carried on continuously for some years. From the standpoint of the scientific breeder such experiments seem eminently desirable, and the probability that they would result in economic discoveries of importance is very great. It is my purpose to point out toward the end of this paper some of the advantages attainable, as I believe, by this method of breeding. I shall preface my remarks on the rearing of sponges with a brief account of the manner in which the egg development goes on.

Some sponges are known to be hermaphrodite, others have been described as of separate sexes. The probability is that sponges are in general hermaphrodite, but that the individual at one period produces chiefly male elements, and later chiefly female elements. Fertilization takes place in the body of the mother and the egg here undergoes its early development. The embryo eventually bursts the maternal tissue, and, passing into one of the canals, is caught by the current sweeping through the canal system and is discharged into the surrounding water through one of the large apertures (oscula) on the surface of the sponge.

In the great majority of sponges (horny and silicious forms) the embryo, or larva as it now should properly be called, since it leads a free life, is an oval, solid body, covered with slender hair-like processes of protoplasm, the so-called cilia. The cilia strike rhythmically to and fro, like so many minute and flexible paddles, and the sponge larva is by their means whorled through the water. Sponge larvæ, of course, vary in size, but frequently have a length in the neighborhood of 1 mm. ($\frac{1}{25}$ inch). The surface layer contains more or less pigment. Thus, in the commercial sponge, *Euspongia*, the larva is whitish, with a brown spot at one end. In *Tedania brucei*, a large red sponge, growing especially on the mangroves in parts of the Bahamas, the larva is a beautiful red.

The free-swimming life of the sponge larva is short, lasting, when bred in the laboratory, only a day or two. During this period the larva is moved along not only by its own relatively feeble motion, but, being subject to the action of currents, it may be carried a considerable distance from the spot where it was born. It eventually settles down on some firm basis and transforms. The cilia are lost, and the oval body flattens out into a disk so thin that it has the appearance of a minute incrusta-

tion. The circular outline of the disk is soon lost, the little sponge spreading in an irregular fashion over the surface to which it is now firmly attached. In two or three days the metamorphosis is complete, and we have a sponge, very small, to be sure, and without reproductive elements, but like the adult in fundamental structure. Its surface is perforated by minute apertures, the pores, through which water enters the body, and by a few larger apertures, the oscula, through which the water leaves the body. Ramifying through the interior is a system of spaces or canals which connect the pores with the oscula. Portions of this canal system form small spheroidal chambers, the walls of which are studded with cilia. It is owing to the motion of these internal unseen cilia that a current of water is constantly circulating through the sponge body, carrying to its tissues the oxygen and food (minute particles of animal and vegetable organisms) necessary for their life.

How long it takes for a sponge developed in this way to reach adult size and begin breeding is unknown. I have kept young sponges that have transformed and attached to the walls of my laboratory aquaria for days and weeks. After the first few days the increase in size has generally been imperceptible. But the unfavorable conditions incidental to such an unnatural habitat were doubtless responsible for this lack of success.

PRACTICAL SUGGESTIONS ON REARING SPONGES.

More species of sponges breed during the warm season than at other times. Yet in the Mediterranean (Naples) some sponges are found breeding at all times of the year. In the Bahama Islands and on our own coast, I have found the breeding time of many sponges to fall within the period from midsummer on through early autumn. For the inauguration of experiments I should recommend the months of July, August, and September.

It is easy to determine when one of the horny or silicious sponges is breeding. On cutting out a piece of the sponge, the developing eggs scattered through the tissues can be seen without the help of a lens. They are minute, rounded bodies, often very numerous, and sufficiently conspicuous to catch an observant eye.

The means employed for getting young sponges must always be different from those made use of in the case of animals like fish, oysters, etc., in which artificial fertilization is practicable. Since the sponge egg is fertilized and undergoes its early development in the body of the mother, artificial fertilization is here of course out of the question.

The young in numbers ample for study can, however, be obtained in the following easy manner. The sponge being raised to near the surface of the water is then dipped up in a glass aquarium or bucket, in such a way as not to expose the animal to the air. In a few minutes time the ciliated larvæ will begin to be discharged. In the study of some Bahama sponges I found it convenient to take to the sponge-grounds, in a boat, a couple of good-sized tubs. In one of these some sponges would be placed for about half an hour. At the end of that time they were transferred to the second tub. The water of the first tub was meanwhile examined for the sponge larvæ. In this I was aided by negro boys, who soon became expert. We bailed out the water in 2-gallon glass vessels in which the little larvæ could readily be seen. The latter were then picked out with glass tubes and placed in a special dish. By the time the examination of the first tub was completed, the second would be found to

contain numbers of larvæ. These were collected in the same way, the sponges being thrown overboard.

It would seem in the case of sponges, as in so many marine animals, that the stimuli arising from confinement in a limited volume of water lead to the rather sudden discharge of those embryos (or in certain forms, eggs) that have reached the proper stage for birth.

I have no doubt that if the sponge were handled carefully, it would be possible to get from the same individual, day after day during the breeding season, numbers of larvæ, precisely as several batches of eggs are got from one codfish, for example.

The swimming larvæ thus obtained may be made to attach, during the next day or two, to the walls of the dishes in which they are kept, or to pieces of wood or small stones. After attachment the young, or, as we might say, the sponge "spat," are easy to handle. In this connection, however, it will be well to bear in mind that the circulating pipe water of aquaria, even large and elaborate ones such as those at Naples and Woods Hole, has been found to be unsatisfactory for the rearing of young sponges, as indeed it is for the young stages of many marine organisms. The sponges become covered with sediment, and bacteria develop. Changing the water in the dishes twice a day is, on the whole, a better method. But this is far from an ideal environment. It will probably be much better, after the attachment of the spat to pieces of wood, shells, etc., at once to transfer the latter to some natural site known to be adapted to the growth of sponges.

I hardly think that the method of getting young sponges which I have just described can ever be adapted to the needs of the sponge-grower. And yet, for the purposes of experiment, where a few hundreds or a thousand young sponges would suffice, the method is adequate. I believe, however, that live-boxes may be devised in which the sponge may be kept imprisoned in its natural home, though at some convenient depth, and in which the discharge of larvæ may go on normally day after day. Such a box must have fine metal gauze windows on the sides and above, through which the water may pass freely, and yet with meshes sufficiently fine at any rate to hinder the passage of the larvæ through them. Projecting shelves, which must be easily removable, might be arranged one above the other. The sides and bottom of the box should, moreover, be covered with removable pieces—tiles, for instance. The larvæ settling down on the removable shelves or other pieces would attach to them, and might from time to time be taken out with as much ease as the honey stored up in the modern manufactured comb is removed from the hive.

The precise form of live-box to be used will naturally only be determined after proper experiments. To prevent as far as possible the settling of the larvæ on the body of the mother, a phenomenon very apt to occur, it will perhaps be found well to place the adult on a perforated tray near the top of the box, and a series of such trays, one above the other, may be found a good device. In planning experimental boxes of this sort, the character of the motion of the sponge larva should be borne in mind. The larva not only swims, frequently making long, shallow dives, but also creeps about over the sides and bottom of the vessel in which it is kept.

The live-box has proved itself of great use to the naturalist desirous of obtaining the young stages of animals, which are difficult to keep or breed in the laboratory. In this connection I well remember the experiences of a companion (Prof. C. L. Edwards), engaged in the study of the development of the large holothurian or sea-cucumber

(Mülleria), so common in parts of the Bahama Islands. It was with the greatest difficulty that a few embryos of this form could be got in the laboratory. When, however, the animals were confined in a large box anchored in about a fathom of water, quantities of developing eggs could be had by drawing up with a tube some of the sediment in the bottom of the box.

The "spat" once obtained in abundance, success will next depend largely on the selection of the locality in which the young sponges are to be set out. A careful study of the Florida grounds should be undertaken, with the view of investigating, among other points, this very matter of the kinds of locality best adapted to the growth of the various grades of sponges. Quiet water, a firm bottom, and an absence of muddy sediment seem essential desiderata. The question of enemies is probably of minor importance, and yet the well-known student of sponges, Vosmaer, mentions that he has several times seen the European hermit-crab (*Pagurus*) greedily eat a common silicious sponge (*Suberites*), certainly quite as unappetizing a morsel as the coarsest commercial sponge.

When it has once been accurately determined what are the physicial and biological characteristics of the Florida grounds, which produce the finest sponges—and it may be mentioned here that sponges are among the most variable of animals and seem to be peculiarly affected by their surroundings—a detailed comparison should be made between these grounds and those parts of the Mediterranean producing the finest grades. The purpose of such a comparison would be to discover whether we really lack any of the natural advantages necessary for the production of the finest sponges and, if so, whether these can be artificially reproduced—whether, for instance, it would be possible or desirable to imitate on this side a particular kind of bottom found in the Mediterranean.

Following on the investigation of the sponge-grounds, I believe it to be eminently desirable to start a series of experiments, the purpose of which shall be to discover how far, along what lines, and by what means sponges may be artificially altered by breeding. The great variability of sponges in nature leads one to believe that they would quickly respond as individuals to a change in the environment, and thus, simply by growing the animals in a superior locality, an improved variety, constant, as long as the sponges continue to grow in that locality, might be produced. It is quite likely that such improvements could be carried out on sponges propagated by cuttings as well as on those grown from eggs. In improving races, however, it has always been found that the two important means are sexual breeding from selected specimens and grafting, the latter method being commonly regarded as only applicable to plants.

In sponges, as in other organisms, increase of knowledge will in all probability confirm the belief, already fairly well grounded, that individuals developed from the fertilized eggs vary more, i. e., exhibit more differences one from the other, than individuals grown from buds or cuttings. Herein, to my mind, lies the advisability of growing sponges from eggs as well as from cuttings. The latter method, being quick, sure, and simple, can at once be made of great practical use. Breeding from the egg is more complex, and must be carefully tried by competent experimenters. In the end, however, I believe that it will lead to great improvements in the quality of our sponges.

I would suggest that, after selection of a proper locality, a small plantation of sponges developed from eggs be started and carefully watched. As the sponges grow, it would be a simple matter to pick out those individuals in which the fiber varied in

the desired direction. A small piece cut out would not seriously injure the sponge and would show the quality of fiber as well as the entire body. Selected individuals might be removed from the general ground and during the breeding season placed together in large live boxes. The "spat" collected from such individuals would doubtless develop into superior sponges. I do not know any marine animals which would seem to be so adapted to continuous rearing, with constant improvement of breed, as sponges. Their plant-like habit of growth makes it easy to handle and experiment upon them. Their variability, especially in the matter of the skeleton, would seem to insure success to selective breeding; and the very simplicity of what is desired, namely, improvement in the quality of the skeletal fiber, would at once lend a directness to the efforts of the cultivator, which should lead to comparatively early results.

In closing, I may direct your attention to a method of race improvement, so far practiced only in the cultivation of plants, but to which the vegetative character of sponges will readily lend itself. I refer to the method of grafting. The ease with which two or more individuals of the same species of sponge, irrespective of age, may be made to fuse, and become henceforth a single individual, is well known. Dr. Grant records observations on this head as far back as 1826. Among later experimenters I will only mention Vosmaer. This fusion of individuals goes on commonly in nature. An interesting account of a number of cases may be read in Johnston's British Sponges and Corallines, published 1842, page 11.

The natural tendency of sponges to grow together, coupled with the ease with which they may be propagated by cuttings, would make artificial grafting in these animals a simple matter. With a small plantation of very superior sponges at hand, the result of careful breeding from selected individuals, and other plantations consisting of sponges grown from cuttings, grafting ought to be not only a scientific but an economic success. At slight expense, large numbers of common sponges might be improved simply by pinning to the common cutting a piece of the improved variety.

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