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BUREAU OF FISHERIES DOCUMENT NO. 670

Issued April, 1910

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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[Translated from the French.]

One of the greatest glories of the nineteenth century undoubtedly will be its patient, persevering, and methodical exploitation of nature's resources. It must be acknowledged, however, that not everything has as yet been obtained from the sea that may well be expected. Great progress may be looked for in the propagation of useful species inhabiting its depths, although in this field of work, by its excessive mobility, the limits of exploited areas must be determined in a very arbitrary way.

Great anxiety has prevailed for a long time among those interested in the sponge fishing and sponge trade because of the improvidence with which the sponge grounds were being worked. It has been the most productive methods of fishing that were being sought, without any thought of the morrow. It is important to combat these unfortunate tendencies, and several procedures, of which each has many partisans, have been presented: One is the regulation of the number of fishing appliances (for example, the limitation of the number of divers, as in Tunis); another, the complete prohibition of certain means (the prohibition of divers, as temporarily promulgated in Tunis and elsewhere); another, the fixing of a minimum size for the sponges taken; another, applying to the fishing of sponges the principle of regulated cutting, with alternation of rest and fishing for each of the banks visited by the fishermen; the temporary prohibition of fishing (several months a year) in order to allow the larvæ to leave the sponges and to take root; and, lastly, the propagation of sponges by methods of culture.

DEFINITION OF SPONGE CULTURE.

The term "sponge culture" must be understood in the widest sense possible. It comprises all the methods which man may adopt in order to obtain under his direct supervision or by his intervention an increase in the output of commercial sponges from any given locality. It would be sponge culture to carry sponges

from one locality to another, either to increase the number of individuals in an already sponge-bearing region, to improve their production, or to make a barren region yield. It would be sponge culture to take young sponges from a natural bed and transplant them to a given area of the sea, a parc, where they might acquire a good commercial size under the supervision of a caretaker. It would be sponge culture to gather sponge larvæ on appropriate collectors and rear them in a suitable place. It would be sponge culture to break a sponge in several pieces and develop separately the individual cuttings.

It is thus possible for us to conceive various methods of sponge culture, each of which merits individual study, for we feel more or less strongly the lack of knowledge concerning the physiology of the sponge species when we take up the different methods. We shall call the first method sponge culture by sowing, the second sponge culture by parcage, then sponge culture by means of collectors, and lastly sponge culture by cuttings.

GENERAL CONSIDERATIONS.

The first question to be considered, as it belongs to all the methods, concerns the choice of the locality in which sponge culture is to be attempted. As a general rule, it is necessary to provide surroundings identical with those in which sponges naturally live as regards the depth and the quality of the water. It is, consequently, unnecessary to insist on the fact that the salinity of the water must be similar to that in which the sponges prefer to propagate; for example, care should be taken not to repeat the error of Lamiral, who attempted to introduce sponges from the Levant into the brackish ponds of the Mediterranean Sea.

Delage said that the sponges of commerce require somewhat rough water, which keeps in suspension the grains of sand, the remnants of *Foraminifera*, and the spicules of sponges which accumulate in the primary fibers of their skeletons. This, however, is an exact theoretical consideration which may be entirely overlooked in practice. The entire volume of mineral débris which a toilet sponge keeps inclosed in its spongeous sheath is never very large; it does not exist near the coasts where sponge culture is possible; there are probably few localities far from the coast where the purity of water is so great that sponges might suffer from a want of material for the formation of their skeletons.

The authors reporting experiments in sponge culture almost all agree on one point, i. e., that the results of these experiments are always remarkable when made in waters where there exists a certain current. Buccich and O. Schmidt[a] advise localities but little exposed to waves coming in from the open sea, the bottom lined with highly colored algæ, and a certain current present.

[a] In Marenzeller.

Fogarty[a] has observed that the presence of a moderate current is most useful. These results are evidently explained by the simple fact, known to all, that the waters of a current are better aerated and contain a richer fauna. In such places, consequently, a more abundant supply of nourishment is available and from it the bottom animals, like the sponges, profit more or less directly. It may be easily understood that the presence of a certain current improves the conditions of the surroundings in which the sponges grow and facilitates thus the success of experiments in sponge culture. However, too swift currents should be avoided. The aim of sponge culture is the furnishing of skeletons of sponges easy to sell, hence we must not forget that the sponges grown in very agitated waters have a coarse skeleton and that this diminishes their commercial value. This observation was made a long time ago; Aristotle says that sponges differ according to their place of growth, "the ones by their softness and the others by their coarseness," and he thus explains this fact: "The softest sponges are those which come from deep, always quiet, waters." Similar observations have been made by modern fishers of sponges,[b] and the reason is easily found. We meet here one of the applications of the principle of Lamarck concerning adaptation to surroundings. The rôle of the spongeous skeleton of a *Euspongia* or a *Hippospongia* is to insure a relative rigidity to the body of the animal; it is quite natural that there should be established a certain automatic balance between the firmness of the skeleton and the shocks or pressure which the sponge has to bear. This is a hypothesis which Keller[c] has very well elucidated. It might not be quite wise to accept all the deductions he made from it, but the primary idea of his work seems to me perfectly correct. We can not as yet properly orient the phylogenic tree of the spongeous species. In certain kinds the spongeous matter is doubtless in part an ancestral persistence; in others it may have been acquired more recently, and we have no means of distinguishing between these two species. Hence, the ideas of Keller should not be discredited, because species generally inhabiting relatively deep and calm waters are provided with rather firm spongeous skeletons.

It would be interesting to know, also, without departing from this question, whether the individuals developed in agitated waters owe the firmness of their skeleton to a difference in the nature of their spongeous matter (greater impregnation of salts, for example, different physical condition, etc.) to a greater quantity of solid particles in their primary fibers, to a greater thickness of these fibers, or to a lesser flexibility of secondary fibers. We know that Len-

[a] In Rathbun.

[b] See observations of M. Crozat, made on the coasts of Provence, in: L'Industrie des pêches aux Colonies, by Darboux, Stephan, Cotte, and Van Gaver, p. 220, vol. I.

[c] Zeitschrift für die wissenschaftliche Zoologie, vol. LII, and Festschrift der Universität Zürich, Nägeli and Kölliker, 1890–91.

denfled has shown us the rôle played in the suppleness of sponges by the flexibility of their secondary fibers; it would be necessary to determine whether this flexibility is closely dependent upon the conditions of the surroundings and whether it is immediately modified by the latter, beginning with the first generation of cultivated sponges.

A detail which the cultivators of sponges must not lose sight of is the very great care with which the sponges should be manipulated. They thrive well only in running water, and the aquarium of a laboratory is not a favorable place for their development, unless the water be constantly renewed. Moreover, they very quickly die out of water, especially in summer. We do not find any commercial sponges in shallow areas not covered by water at low tide, which is a fact to be taken into account. Preference should be given, consequently, as far as possible, to methods of work in which the sponges shall not be taken out of their natural element, or in which they shall be taken out for the shortest period possible. We find in bibliography some information on the duration of sojourn in the air compatible with the submerged life and the normal development of individuals experimented with. Allemand has made numerous experiments on this point. He has found that sponges left ten hours in the shade (at 12° to 14° C.) may revive and continue to grow.

It might be said that, on the whole, experiments in the culture of sponges so far have not been conducted by the method which ought to characterize scientific work; they have been mostly empirical and lacking the substratum of knowledge which preliminary research and observations would have furnished. It seems hardly credible that the partisans for and against sponge culture should have spent so much time in discussion, debating whether sponges propagated from cuttings develop more or less rapidly than those derived from larvæ, without any research to ascertain the period of growth of a normal sponge. This is, nevertheless, the fundamental information, the key to all undertakings in sponge culture, which requires a fixed capital in order to withstand the fluctuations in market prices. If a sponge needs ten years to acquire an adequate size, or if ten months are sufficient for this, sponge culture has to be abandoned a priori, or deserves to be studied. Investigation as to the rapidity of growth of sponges derived from larvæ is the first thing to be done before sponge culture can be considered, and this research ought to be conducted methodically in each sponge-bearing country and for each of the species utilized. It is not possible to maintain that *Hippospongia equina elastica* develops in various countries with exactly equal rapidity, nor can it be said any more justly that the rate of its growth may be compared to that of the American sheepswool. Each variety may have its particular rate of development; we have already seen that in regions where there is a certain current the cuttings

of sponges grow more rapidly. It is consequently impossible to establish any general rule, and definite conclusions may be arrived at only after numerous observations. Yet, scientific observations in this line are not numerous and can not be superposed; infrequent endeavors have been made to throw some light on the legends current in this question.

We know nothing precise in regard to the most highly prized variety, *Euspongia officinalis mollissima*. Masse says that at Rhodes it reaches an average size within three to four years. As to *Hippospongia equina elastica*, Servonnet and Laffitte fix upon a few months, according to the statements of fishermen, as being the time necessary for this sponge to obtain commercial size in the Gulf of Gabesa. This idea continues to be applied to the Sfaxian region, where Servonnet and Laffitte have gleaned part of their information. The fishermen and the merchants of sponges determine the age of individuals (one, two, three years) by the dimensions. Bouchon-Brandely and Berthoule report that in the month of June a diver had observed carefully on a rock in the environs of Benghazi the existence of 57 very young sponges, lately out of their larval stage; the following year he dived at the same place and found the same sponges still alive, their number being almost the same, but their diameter about 10 centimeters. This observation deserves attention, as it has been confirmed by researches made by Allemand. This author has noticed that for *Hippospongia equina elastica* about two years, beginning with the time when the larvæ gets fixed, were required for the circumference to reach 30 to 40 centimeters.

The researches made in the laboratory of Sfax were more successful than those made by the Administration des Travaux Publics of Tunis. The latter had three parcs constructed in March, 1897, at Sfax, at Kerkennah, and at Djerba, and sponges were carried there with all desirable precautions. The sponges had not increased in size by September, and they were invaded by algæ, which shows to what an extent their vitality had been weakened. Experiments were made with still less success, as may be easily understood, with sponges brought to Tunis in August, 1898, and held in glass jars. At Kerkennah eight living sponges were isolated under water by means of metallic gratings; development in size was noticed throughout the months of October, November, and December, but ceased later on.

The American species grow very rapidly, if we are to believe the accounts. The velvet acquires a commercial size in one year, and the sheepswool and the glove are said to grow faster still. Sawyer fixes[a] at ten months the time necessary for a sheepswool to weigh 45 grains. At Nassau the time is fixed at four months,

[a] In Brice.

and even three months[a] (Nye) is given for the same variety; for Arapian[b] this period varies according to localities, from four to six months. If this information is correct, which even Bidder doubts, it is easy to understand the optimism of the fishermen who do not fear any serious decrease of wealth of growth; it would seem, however, that if the impoverishment does not take place so rapidly in all sponge-bearing countries it yet threatens them all, for in none of the commercial species is development so extremely rapid as might be expected from some of the opinions I have mentioned here.

CULTURE OF SPONGES BY PLANTING.

It was by planting that the culture of sponges was first undertaken by Lamiral. Being one of the members of the Société d'Acclimatation, he prevailed upon the latter to intrust him with the mission of transplanting to the western coast of the Mediterranean Sea *Euspongia officinalis mollissima*, which inhabits the eastern region of this sea. The knowledge of Lamiral concerning the biology of sponges was elementary, and among the localities in which he proposed to introduce them were, as I have already mentioned, brackish ponds along the shores of the Mediterranean Sea. The Société d'Acclimatation had intrusted the study of the propositions of Lamiral to a commission, the reporter of which was Loubeiran. The report was very sensible and contained excellent advice as to the conduct of such work. The brackish ponds were to be abandoned, and advice was given in favor of localities along the shores of Africa. Lamiral had been given a sum of 5,000 francs, of which 1,000 francs were donated by the governor-general of Algeria, Marshal Pélissier.

Lamiral neglected one of the most important precautions indicated in the report of Loubeiran. Instead of keeping the boxes containing sponges submerged in the sea, he disposed them on the deck of the steamer. The water was changed, it is true. The period of transportation was likewise badly selected—in June the temperature is much too high. Attempts were made with ice to cool the water flowing on the sponges, but the effect of these adverse conditions did not fail to show. Tank water is alive with bacteria; Lamiral thinks that they are sexual products:

> The water flows out of the tanks, leaving on deck a fatty and white substance which must be the substance of the larvæ * * *. The difference in temperature of the water in the tanks has advanced the period of swarming of the sponges. They are ill from the parturition excited before its time.

Arrived on the coast of France the sponges were placed in cement boxes and deposited in the roadstead of Toulon, at Bandol, at Pomegues, and at Port-

[a] Cited by Thomas Lee in Report on the work of the U. S. Fish Commission steamer *Albatross*, by Z. L. Tanner. Report U. S. Commission of Fish and Fisheries, 1886 (1889).

[b] In Brice.

Cros. Those placed at the latter point had traveled a whole month; it may be easily understood in what condition they were. At the end of the same year, the sponges in the roadstead of Toulon were said to be still living and even to have increased in number (?). But at the close of the following year nothing remained of them anywhere. Such was the end of the enterprise. The transplantation of these 123 sponges from Syria cost 4,993.20 francs.

Lamiral later organized at Marseille a committee of aquiculture, which had only a few meetings and did not have the time to produce any useful work. The culture of sponges was on its program, but no attempt in this direction was made.

General Garibaldi[a] had thought at Caprera to make an experiment similar to that of Lamiral. In vain have I endeavored to obtain information as to whether Garibaldi's project was put into execution. It is more than probable that no attempt was made.

The projects of Espina, French consul at Sousse,[b] who wished to attempt dissemination of sponges on the coasts of Algeria, were not brought into effect, neither were those of Salse and Deel,[c] members of the Société d'Acclimatation of Nice, who proposed to transplant sponges from Syria to the shores of the island of Ste. Marguerite.

In 1896, at the request of the Colonial Office of Great Britain, Bidder indicated his opinion as to the mode of proceeding in experiments of this kind. He advised placing stones bearing the sponges in wooden cars with lateral apertures and having pointed extremities; these cars were to be towed in the rear of steamers, barely floating and letting the water flow through, which would be useful in case of an accident. But Bidder did not deem this experiment advisable; it would be "an experiment in the dark." He concurred in the opinion of Hyatt that the American sponges were simply varieties of the European species, produced under the action of a higher temperature and of coral sands; sponges introduced from the Mediterranean Sea to the Bahamas would probably undergo the same adaptations, and would thus become identical with the native varieties.

Lendenfeld does not admit, and not without reason, such plasticity in the sponge family, but he does not believe any more than Bidder in the success of attempts to transplant sponges long distances; he holds as a principle that transplanted sponges are less suited to their surroundings than the native ones and consequently not so well fitted for the struggle, a fact which will cause them to disappear in time. Expressed in such a form, this conclusion is some-

[a] Bulletin de la Société d'Acclimatation, vol. VIII, 1861.

[b] Ibid., vol. X, 1863.

[c] Ibid., 2d s., vol. I, 1864.

what too arbitrary. The density of the population of sponges on the banks is not so great that new individuals might not live in unoccupied spaces. It seems that the deterioration and degeneration of imported species is more to be feared than their entire disappearance, if the choice of the varieties and of the localities destined to receive them be made with sufficient care.

All this obviously pertains to transportation at long distances. There should be no hesitation whatever where short distances are concerned. All naturalists know that such transplantation is possible and, taken all in all, quite easy. All those who have attempted it have succeeded, no matter what species of the sponge family was experimented with, and experiments have several times been made with the commercial varieties. As to the *Hippospongia equina elastica*, Allemand transported in April and May, 1906, 67 sponges obtained at Sfax, which he immersed and made to live in the Lake of Tunis; on June 15 of the same year 44 remained alive, some of them, however, in a rather bad condition.

There is a reason for asking whether the culture of sponges from seed is worth the effort. It may answer two purposes—that of introducing sponges and establishing fishing grounds in regions naturally without this industry, or that of improving the production of a region having sponges of inferior quality by renewing the varieties existing there. Whatever the object in view, it is necessary to make the attempt with the greatest possible number of individuals and to be content to wait for results in a distant future. For the dissemination of the introduced varieties, we must depend upon the swarming of the larvæ around the centers of dispersion formed by the transplanted individuals, and it is only after a sufficiently long time that a group of these individuals may be seen to form an oily spot around the place where they were deposited. It is, consequently, an undertaking demanding much time and much money; we can not expect private persons to risk the undertaking for the purpose of profit; only powerful organizations can afford to take the initiative in this matter.

The rapidity with which the diffusion of the acclimated colony occurs depends upon a large number of factors. Account should be taken of the strength of the current at the given point to carry the larvæ along and, moreover, of the active movement of the larvæ themselves. We know very little concerning this latter question, however. I do not think that much has been learned as to the rapidity of movement of larvæ of the utilized species. I have, however, demonstrated that in the monaxid *Reniera simulans* the larvæ move at an average rapidity of 0.10 meter per minute. Under the combined action of the beatings of their lashes and the force of the current, the larvæ of sponges may make quite long distances, though these distances in actuality

seem to be rather limited. On the one hand, the movement of larvæ does not occur constantly in a clearly determined direction, but in a most irregular zigzag. On the other hand, the larvæ pass but a short time in a free condition, not over a few hours; hence they generally are fixed near their parent. Consequently the extension of transplanted colonies takes place very slowly. On the exploited points off the coast of Tunis observation showed that the maximum density of groups of sponges varies each year in a direction determined by the currents and the tide, but that the area of these displacements is not extensive.

If it is desired to sow sponges in an almost barren region or in a region situated a short distance from cultivable banks, it is necessary to ascertain that there are no special conditions adverse to a spontaneous growth on these bottoms which might interfere with the success of the proposed attempt. Let us take as an example the coast of Provence[a]: There may be found the *Hippospongia equina elastica* and the *Euspongia officinalis lamella*, but the individuals are not numerous in general, so few in fact that their presence was for a long time unperceived. Shall these be considered as the scarce descendants of former colonies which have disappeared almost entirely? It is certain that these sponges have a difficult struggle against unfavorable external conditions, and it would not be logical at the present stage of our knowledge to bring here at large expense the same varieties of sponges as the native ones in an attempt to disseminate them where sponges a long time acclimated show so little vitality.

Allemand noticed that the bottoms of the cantonment in the vicinity of the laboratory of Sfax are not everywhere favorable to the life of the sponges. In one part of the bottom "invaded by light yellow algæ, which probably harmed the sponges," all the individuals planted there perished. This is one more proof of what I assert, i. e., that the biological study of sponges is as yet not sufficiently advanced for the success of an undertaking in sponge culture to be determined in advance.

In short, sponge culture by seed may be compared to the replanting of forests on mountains by setting out a certain number of adult trees, the fate of the enterprise resting solely on the spontaneous dissemination of seeds from the latter. The results obtained might be excellent in some cases, while in others only failures would be registered. The seeds of the transplanted specimens might be inferior in the struggle for existence as compared to the neighboring specimens of vegetation; herds of cattle, if they were allowed, might destroy a quantity of young plants, and, similarly, the larvæ of sponges might in certain places be pursued by active enemies. Lastly, imagine the

[a] See J. Cotte: La pêche des éponges en Provence, Comptes rendus des Sociétés savantes de Provence. Marseille, 1906.

disappointment awaiting the sylviculturist who should attempt to grow chestnut trees on soil permeated with lime. Compared to our knowledge of sylviculture, our knowledge of sponge culture is most uncertain, and it is therefore difficult to foresee the future of sponge culture from seed. There arises in this instance the question of species; each individual case ought to be studied separately and only one general rule may here be given—that recommending the greatest prudence.

SPONGE CULTURE BY PARCAGE.

This method might give more immediate results than the former. Undertaken by a private individual in a limited and well-defined area of the sea, it would consist in preserving sponges of small dimensions, brought up in fishing, by placing them in favorable localities, whence they would be taken out at the desired time to be prepared and sold. The fisherman would not neglect the small specimens, the skeleton of which can be sold only at a loss. If the legislation of his country is wisely protective, if it forbids the fishing, sale, and exportation of small sponges, the fisherman will preserve them in parcs, awaiting the time when they will be sufficiently developed.

Such an enterprise is theoretically possible, but this does not mean that it would be remunerative. Sponges which it is desired to preserve must be gathered and transported with the greatest precautions, for which there are no facilities in practical fishing and which would render the latter quite expensive. In spite of the greatest care individual sponges would suffer fatally; the death of some would be unavoidable and the survival of the others would demand a certain period of time to recuperate and regain their former health before growing. "A fixed fragment, or an entire sponge transplanted and fixed like a fragment, will exhibit a rapidity of development much inferior to sponges coming up spontaneously." Such is the opinion of a convinced sponge culturist, Allemand.

The installation of a parc would probably be subjected to an annual tax which we might suppose to be quite negligible; but expenditures of maintenance would not be at all negligible. Sponges are a commodity which it is very easy to steal, and it would be necessary not only to supervise the parc but even to inclose it. It has been observed that sponges do not develop so rapidly when they are subjected to too much thinning. This was noticed by O. Schmidt and Buccich in regard to *Euspongia officinalis adriatica*, and it was likewise observed by Allemand in regard to *Hippospongia equina elastica*. Sponges can not, consequently, be kept in very shallow water; the inclosing of the parc would then be very expensive if it were done with a wall; it would be necessary to content one's self with determining the boundaries by means of floating beams.

However it might be effected, this expense would have to be added to that involved in taking up the sponges with which to stock the parcs. It remains to be seen whether these expenditures would be covered or exceeded by the profit from this enterprise.

Everything depends upon the rapidity of growth of the sponges. We have already noticed the data obtained. In Tunis, for example, we may expect from what we have learned that specimens of *Hippospongia equina elastica*, too small to be sold immediately, may be placed in parcs and would be ready for preparation beginning with the following year. Profit would be rapidly obtained from the difference in price for small sponges, which must be sold at a loss, and that of sponges of commercial size. It is difficult to calculate, however, whether this difference in price would counterbalance the expenditures involved. This is a question to be solved by experience alone. So far, we have the right to have a limited confidence in the future of this method of culture, but not to believe in its importance, since it seems that it can never be adopted on a very large scale.

SPONGE CULTURE BY MEANS OF COLLECTORS FOR LARVÆ.

This method, which might be considered as the most perfect theoretically, consists of parcage, not of the small sponges obtained by difficult and very expensive fishing, but very young sponges, fixed on adequate collectors. This method was neglected by most of the experimentors in spite of the advantages which it presents theoretically; this comes from the fact that the authors hesitated to undertake observations on larvæ of sponges, the average length of which is of about half a millimeter.

Ralph M. Monroe,[a] after having stated the results obtained by sponge culture by cuttings, says:

> It is quite possible that with state protection to the planters, and better methods to be determined upon by further experiments, sponge culture might be quite profitable. My belief is, gained in oyster culture from spawn, that a similar method with sponges will eventually prove the correct one, but until more is known of sponge biology it would be useless to suggest methods, notwithstanding the fact that several points in connection with it have been to my mind quite clearly demonstrated.[b]

In "L'Industrie des Pêches aux Colonies" we read:

> The desired aim might be more easily reached, perhaps, in operating on methods similar to oyster culture and clam culture, by receiving on suitable collectors the larvæ given out by sexually mature sponges in closed spaces. * * * It should not be forgotten, however, that it would be a very difficult attempt.

[a] H. V. Wilson has studied the reproduction of sponges "by means of eggs, by means of the gemmules, and by cuttings." (Report Commission of Fish and Fisheries 1889–91 (1893).) Wilson's works have been published, but he is not engaged in sponge culture.

[b] In Allen. 1896a.

Allemand announces practical experiments in this matter. The information published by him on this subject is, however, quite elementary:

A larva, fixed to a support which we afterwards immersed in flowing water in May, 1905, has developed this summer, but gave in September only a large spot with an oscule, not a completely formed sponge; this fact ought to be ascribed to the manipulations necessary in the transportation of the larva.

Evidently we can not deduce anything from this solitary failure.

In view of the absence of positively established facts, we are forced to study this method in a purely theoretical manner. The choice of the collectors deserves first consideration. Breeding effected in aquaria shows that collectors of various kinds may be utilized for the larvæ of sponges, and we know that such is the case in nature, the larvæ of commercial species attaching themselves to plants (branches of *Posidonias*) as well as to shells and stones. It should not be forgotten, on the other hand, that these collectors must be easy to manipulate and very inexpensive. We need not expect such a number of sponges to attach to these collectors as might be observed on oyster collectors. Are there not found in Arcachon over 300 young ones on one tile? After the young sponges are attached they should be preserved, and we know that they must adhere to a support. If small stones or shells have been utilized as collectors this support will not be of a sufficient size to be considered permanent, and it will have, in its turn, to be attached to another support. Should tiles be used? Tiles would be durable, as there could be no question of disintegration, but the use of tiles would be expensive. It seems that a good collector might consist of wooden branches tied in fagots and immersed in the vicinity of sponges that have attained their sexual maturity. The branches possess great resistance to sea water, and by using them, as is being done in Italy in deep-water oyster culture, it would be possible to divide them and to tie them to ropes or to apparatus similar to that used for sponge culture by means of cuttings.

The use of fagots presents another advantage. It is generally admitted that the larvæ of sponges possess a marked negative phototropism. My observations, made on *Reniera simulans*, do not concur with those of other authors in this respect, and I found, on the whole, that the larvæ of this species are quite indifferent to light. Allemand has stated that the larvæ of a commercial species, *Hippospongia equina elastica*, seek a feeble light. It is certain that a negative tropism theoretically may be very useful to the species by impeding the larvæ from rising to the surface and by making them descend to less lighted regions, i. e., to the bottom, where they may find supports in great numbers; the opinion of a sponge diver would be quite useful, and it would be wise to ask him whether young sponges are not often attached above their mother to vertical walls of rocks. Should there really exist a negative phototropism the fagots would present the advantage of offering in their lower

region a zone of lesser light, where a greater number of larvæ would attach themselves; these would be attracted at this point less imperiously by the darkness of the bottom.

Supports for young sponges would be attached with advantage to bodies which the waves might put in motion—ropes treated so as to resist putrefaction, etc. Bidder luckily demonstrated the advantage derived by sponges living on mobile supports. Thanks to the renewing of food and aerated water, a consequence of their oscillations, the rapidity of growth of young sponges is increased. It should not be lost from view that in such cases the skeleton is coarser, as stated by several authors; the advantage gained on the one hand is decreased by the diminution in value of the product obtained.

The sponge cutting should be immersed at a certain depth, and it seems rational from this point of view to choose the depth preferred by the spontaneously grown sponges of the species it is desired to cultivate. Experimenters have noticed that sponge cuttings seem to fear too intense a light; this is a thing to be remembered and may find its application.

Sponge culture appears to us then as an operation fraught with difficulties, which can be attempted, without involving too high expenditure, only in localities offering an exceptional combination of favorable conditions. It should not be forgotten that if the sponges are to be immersed at a sufficient depth they must be attached so firmly that a wave shock can not detach them. They should also be protected against marauders, and the question of guarding the parcs and inclosing these arises again in connection with the expenditure involved.

It is possible to attempt the combination of this method of sponge culture with that undertaken in parcs by placing the collectors in the parcs themselves where the adult sponges are kept. There would thus be no interruption in the future gathering of sponges, since those maintained in the parcs would furnish the larvæ before being garnered, and the young sponges attached to the collectors would be taken care of until the time when, in their turn, they would emit larvæ and reach the necessary size.

It is to be regretted that this method has not been the object of serious study and has been neglected by the cultivators of sponges.[a] In the meanwhile we are reduced to simple hypotheses where it is concerned, and it is impossible to know whether it is indeed a practical method for purposes of profit. It might be possible that, at the present state of our knowledge, such an operation would not pay nor cover not only the expenditures involved by

[a] It will shortly be attempted along the French coast of the Mediterranean. I have been asked for information on this subject. Without concealing my skepticism from my interviewer, I told him that sponge culture by collectors alone or combined with parcage was the only method worth attempting.

the concession, the construction of parcs, the guarding mentioned above, but even the cost of manipulation of collectors and larvæ attached to these. Experience shows, in fact, that even on the richest of banks sponges grow at considerable distances the one from the other; this fact shows us that a great number of larvæ are lost to reproduction, as the sponges emit larvæ in considerable numbers, and if the majority of these came out victorious from their struggle for existence we might see among the sponges themselves intense vital competition. Such is not the case. Are the larvæ destroyed because only few of them find a favorable spot to which they may attach themselves; are few of them capable of living; or is their greater number the prey of their enemies? Let us study these three hypotheses separately.

In regard to the first, it must be observed that the larvæ possess very imperfect means for the seeking of a support; they have no organ of direction. When sponge larvæ are kept in a glass jar their fixing is retarded because glass is not a very suitable support; it is accelerated by placing in the jar solid objects to which the larvæ attach themselves readily, as fragments of shells, or even by covering the interior of the jar with a coating of collodion.[a] At the moment of the physiological crisis, which acts so radically on their anatomical structure, it seems that each larva which does not meet a solid body to which it might cling is destined to perish; it must attach itself or die. Do we not see at times, in our laboratories, sponge larvæ spread useless on the surface of the water of the jars against the upper layer as they would do against a solid body? If our hypothesis is well founded it seems to us that collectors with a large surface, disposed around the sponges, would save a great number of larvæ which in their normal course would not meet any bodies to which they could attach.

We know nothing at all of any of the enemies of the sponge larvæ. Among animals widely utilized by man the sponges are perhaps those the ethology of whose larvæ is least known. We know that adult sponges are respected, ordinarily, by almost all marine animals; I saw accidentally, in an aquarium, blennies attack *Suberites domuncula* and serranids come and bite the parts wounded by the blennies. But these are exceptional cases. The immunity may be due to the great amount of organic ammonia contained by the sponges. How far are their larvæ left unmolested by other animals? This we do not know at all. We see that on bottoms of geological structure and flora identical in appearance there are banks rich in sponges separated by zones almost completely barren. We have every reason to seek to know why the distribution of these sedentary animals is so unequal, and we must observe that the interrelations of animals have not been sufficiently studied from this point of view.

[a] I have made this observation quite frequently. This question of the nature of supports offered to the larvæ is of the greatest importance to sponge culture.

This is a question of the greatest importance; if we knew that some animal species were greedy for sponge larvæ the presence of these species at given points would be a warning against the choice of such localities for sponge culture. Such a series of experiments, easily conducted and absolutely necessary, should be made as a preliminary by those who wish to encourage capital to take an interest in sponge culture. I intend to publish in the near future the results of research of this character.

We are completely ignorant of the reasons why in nature the number of larvæ that survive transformation is so very greatly limited. It is probable that there is a frequent combination of the two reasons on which I have insisted and that a certain number of larvæ after having escaped the attacks of active enemies succumb later because they fail to find suitable support at the moment when the transformation must occur.

We are obliged to consider these questions and to revert to them insistently, for experiments in sponge culture by cuttings the results of which are known to us seem to discourage us entirely from attempting sponge culture by means of collectors. The authors who made them mention but very superficially the attachment of sponges derived from larvæ on their apparatus. It seems, however, that a maximum of favorable conditions was combined there. A considerable number of sponges was assembled at a given point constituting a kind of parc; the apparatus of sponge culture consisted of collectors, and yet these collectors gathered almost nothing. Shall it be assumed that the sponges held in the parcs to be divided into sections had scarcely ever any mature larvæ or larvæ capable of living? This might be possible, although somewhat strange. Do cuttings habitually fail to reach sexual maturity under cultivation? Such a conclusion would annihilate certain hopes of sponge culture which shall be mentioned later. Shall it be admitted that the larvæ were emitted and that they died in the parcs? This would be a very grave deduction for the future of sponge culture by means of collectors if we did not observe that sponge cultivators have generally made their experiments by immersing the cuttings at a very slight depth.

However this may be, it will be noticed that there remain many obscure points by the solution of which alone can we foresee the chances of success of sponge culture by means of collectors. We may appraise the amount of capital needed for a venture of this kind, but it is absolutely impossible to know how many sponges may be garnered and, consequently, to what extent the capital engaged might be remunerated. From a purely theoretical point of view, sponge culture by means of collectors seems to us the ideal method, as being the most rational of all; but, on the other hand, it is the one which possesses the least number of scientific data. It would be lack of conscience to advise at pres-

ent the owners of capital to take a rush into the unknown by embarking on a venture of this kind before patient investigations had thrown some scientific light on the principal obscure points.

SPONGE CULTURE BY MEANS OF CUTTINGS.

This is the only method of sponge culture on which we possess any precise information, as this is the only one which has been seriously experimented with. In early antiquity observations were made on the facility with which sponges could regenerate. Aristotle affirms that "when a sponge is torn off it may be regenerated from the fragment left and become complete." The fishermen of the Mediterranean Sea continue to believe this. Hennique says that four years are necessary for a torn-off sponge to regain a good size. Masse likewise believes that the root of torn-off sponges grows up again, and he supposes also that the skeleton of the new sponge is less fine than that which it succeeds. This latter opinion can not be accepted without being tested, for it seems that if it were true the commercial varieties of sponges would have degenerated long since.

The first really scientific observations on the regeneration of sponges are due to Cavolini. This author demonstrated that a sponge which was detached from its support could adhere to a new support and continue to grow. Vaillant remarked that after isolating the cortex and the central part of *Tethya lyncurium* these two regions were susceptible of reproducing a complete individual; he also succeeded in grafting, the one on the other, two individuals of the same species.

But O. Schmidt had already undertaken research in this line on *Euspongia officinalis adriatica*, the soft fine sponge of the Adriatic Sea. In "Die Spongien des Adriatischen Meeres" he announces his first attempts and complains of lack of capital. He was soon assisted as to the financial difficulty by the Deputation de la Bourse of Trieste; he met likewise in Buccich a valuable collaborator, thanks to whom he could continue at Socolizza, northeast of Lesina, a long series of experiments (1863–1872). The results obtained by Schmidt and Buccich were studied and commented upon in an excellent report by Marenzeller.

O. Schmidt and Buccich observed that the best season for operation was winter, as during this time it was possible to manipulate the sponges in the open air and thus cause a minimum of injury to them; they may be kept several hours in the open air in winter, whereas their exposure in summer would be fatal after a few minutes' time. It was possible to secure the survival and development of fragments of sponges that had remained eight hours in the shade in February with a temperature of 7° Réaumur. On the other hand, the growth of the cuttings is slower in winter.

The sponges should be gathered by experienced men by means of the drag net rather than the hook. As soon as they are taken they are rid of their impaired parts, then fastened by wooden pegs, and, kept in water, towed astern of a boat. They are cut by means of a very fine saw into fragments measuring 26 millimeters longitudinally, and care is taken that each of the fragments retain as much as possible of the ectotome. It was observed in the experiments made at Lesina that if the sea remained calm for twenty-four hours fragments placed directly on the rocks adhered and were susceptible of further development. In practice it would be better to attach these fragments to suitable supports. Attempts of this character with wooden or metal pegs in cavities dug in flat stones or on the walls of wooden boxes did not give any favorable results. The greatest difficulty presented by metal pegs comes from their oxidation. Moreover, these first attempts were greatly interfered with because the supports became covered with sand and ooze. It may likewise be that the too intense action of light impeded the growth of the cuttings.

The apparatus constructed by Buccich gave far better results. The fragments of sponges, 72 in number for each apparatus, were perforated with a trepanning instrument, then threaded on bamboo sticks between two parallel horizontal boards. The apparatus was weighted down with stones and could be raised for examination by means of a handle attached to the upper board. The fragments were thus disposed beyond all risk of being covered with ooze and without any impediment to the free circulation of water, while the upper board of the apparatus served as a screen against the rays of light. The silicate varnish of the bamboo also protected the sticks most effectually against the action of boring insects, but the latter entirely destroyed the boards in a number of installations.

The place chosen for these experiments was a bay in which a certain current was felt, but which was well sheltered against the waves, and where the algæ at the bottom were highly colored. The operation may be considered as having succeeded when at the end of three to four weeks it is possible to ascertain that the cuttings have adhered to their supports. Beginning from this moment the growth is quite rapid; the cuttings reach a double or treble size during the first year; the growth is more marked during the first and fourth (?) years than during the second and third. This result can but surprise, and it seems to show that the observations were made on a limited number of cuttings for the whole, and that the influence of some untoward accidents has falsified the results. But however this may be, the cuttings had reached quite a considerable size at the end of five years, and the experimenters were able to conclude that a commercial size could be attained within seven years, showing the method to be a practical one.

A certain number of cuttings die, while others continue to live indefinitely without increasing in size; the materials of attachment deteriorate; but Schmidt and Buccich admit that in the hands of a careful operator not more than 10 per cent of loss need be expected. Applying these results, we see that 5,000 cuttings, the cost of which is 735 francs, would give at the end of seven years 4,500 sponges, valued at 2,205 francs, and thus an average increase in value of 210 francs. In a regular enterprise in which 5,000 cuttings were put out every year a lump sum of 5,880 francs would have been expended at the end of seven years, and from this on a profit of 1,470 francs would be obtained annually. Marenzeller deems the estimate of the price of sponges exaggerated, observing that the sale of such planted sponges would be difficult on account of the central perforation left by the bamboo sticks. The valuation would be correct if each sponge weighed 25 grams and could be sold at 20 francs per kilogram.

In the Bulletin de la Société d'Acclimatation (1879, p. 372) it is said that Schmidt and Buccich advise not to allow the cuttings to reach the current size; the cuttings might be allowed to develop only for three years, at the end of which period sponges would be gathered at a smaller size but would be sold at 0.10 franc. Four thousand sponges would cost 225 francs, including the interest of the capital for three years (which would be far from the valuation given above); the sale price being 400 francs (without deduction of the 10 per cent), we would have a profit of 175 francs. We must observe that the sale price of small sponges might fall below 0.10 franc if sponge culture, understood as above, became a current practice and flooded the market with small sponges.

In spite of the optimism of O. Schmidt and Buccich, they were obliged to interrupt their work. The Dalmatian fishermen crossed themselves as in the presence of a miracle when they saw the cuttings growing on the devices of sponge culture; later on, becoming more bold, they continually disturbed the apparatus with their nets and more than once they even stole it. In short, these classical researches had to be abandoned entirely on account of lack of protection against the fishermen.

Fogarty, agent of the firm of MacKesson & Robbins, has made similar experiments at Key West. The localities where the sponges were placed were not very happily chosen and the growth of the cuttings was not as rapid at it might have been. The cuttings of sheepswool were about 2½ inches thick; they were maintained at the bottom under about 2½ feet of water by means of wire or sticks put through them. Four months were required by the sponges to complete the healing of their wounds, and they did not grow during this time. One cutting was placed in a creek where there was no current, or very little, and its growth was very slow; the others developed very rapidly, and four months after they had been placed they had grown to four and six times their size. A total

of 216 specimens were planted; lack of protection against the fishermen here obliged Fogarty also to abandon his attempts. The result of his observations, however, was found sufficiently conclusive for Rathbun to demand that special laws be promulgated by Florida for the protection of future undertakings in sponge culture.

In 1896 there appeared a report by Allen, director of the Laboratory of Plymouth. This report was made at the request of the colonial office of Great Britain with the desire of introducing sponge culture in the Bahamas. We find in this report, in addition to accounts of the experiments of Schmidt and Buccich, and of Fogarty, information, though not detailed, on experiments made in Florida by Benedict. The latter divided the sponges under water; he wanted simply to prove that cuttings attached to favorable localities grew rapidly. The fishermen were greatly opposed to these experiments, fearing that they might be conducive to the creation of monopolies which would deprive them of their means of livelihood.

In 1889–90 Ralph Monroe likewise experimented in Biscayne Bay at a point where the most varied conditions existed. He used for supports trunks of white wood, about 12 feet in length, provided with a cross-piece at one end so as to hinder them from rolling. The cuttings were affixed to these in various manner; the method most quickly executed, but far from the best, consisted in making use of small pieces of double copper wire which were pushed into the wood by means of a special instrument. Galvanized iron can not be used in any form whatever, as it corrodes too rapidly; brass wire must likewise be eliminated on account of the deleterious action on the sponges of the salts formed by the chemical action induced. The sponges with which Monroe operated, solely sheepswool, readily endure being in the open air for several hours, though they die very quickly in stagnant water. They were cut on a cutting board with a very thin and sharp knife, the pieces being about 1 inch in length. Each whole sponge gave an average of 25 cuttings. The cuttings were immersed to depths varying from 8 feet to less than 1 foot at a distance of 12 inches apart. It would be easy to plant, with the aid of two assistants and a good boat, from 600 to 800 cuttings per day. The sponges, with a few exceptions, survived the operation and began to grow well. Later, they were destroyed or lost in various ways; nevertheless a lot, planted at Elliott's Key under 4 feet of water, gave at the end of six months 75 per cent of living cuttings which had doubled their size. In some of the other lots individual sponges were brought to maturity, but the average loss was considerable on account of insufficient adherence to the supports, or from other causes. The author concludes by saying that satisfactory means of attaching the cuttings is still to be found; the localities selected should be in bays and lagoons sheltered from the high sea, the too rapid currents, and too agitated

water; the cuttings should be immersed at a moderate depth in order that it may be easy to manipulate and observe them. The growth is more rapid when the current is strong, but the shape is then more frequently bad and the skeleton hard. This point, however, is not quite elucidated by the author. Under favorable conditions the cuttings double their size in six months, consequently eighteen months to two years would suffice to produce a sponge of commercial size. "It is quite possible that with state protection to the planters and better methods to be determined upon by further experiment, sponge culture might be profitable." Nevertheless, the author comes finally to the conclusion, mentioned above, that the most rational method in his opinion is the one closest to oyster culture. Let us observe that the estimates of Monroe as to the time necessary for a sponge to attain a commercial size are based on the results of one single experiment which was especially lucky and extended over only six months.

At the request of sponge merchants of Sfax, the Direction Générale des Travaux Publics (of Tunis) undertook researches on the biology of commercial sponges, and erected for this purpose a laboratory on piles in the open in the harbor of Sfax. This laboratory was intrusted to the supervision of Raphael Dubois. Allemand was appointed assistant director and made a series of experiments in sponge culture by cuttings, which he continued for two years and the results of which he published in 1906. He tells us that the sponges to be divided should be gathered with great care and utilized as quickly as possible after being taken, or they should be allowed to heal entirely in running water before cutting them up. He divided them with a very sharp blade previously immersed in boiling water for each cutting. The operation is successful when it takes place at a temperature of about 15°. If made at this temperature the healing of the cuttings rarely took more than three months, while in winter it is very slow, as is also the growth of the cuttings in this season.[a] On the other hand, the vivid light was, as in the experiments of Schmidt, detrimental to the healing as well as to the development of the cuttings. It is, consequently, of great advantage to shelter them.

In some ten months the cuttings grow to three times their original size. "In proportion to the growth observed, a fragment can form a sponge of commercial size (0.30 meter in circumference) only in four or five years." In short, the *Hippospongia equina elastica* developed somewhat more rapidly than the *Euspongia officinalis adriatica* of Schmidt. The author remarks that the apparatus of sponge culture must be very resistant and especially well sheltered. It is necessary to discontinue wooden materials, which suffered from the boring in-

[a] This concurs entirely with the results obtained by Schmidt and Buccich. The healing and growth of the cuttings is more rapid when they are not kept at the bottom of the water. Bidder, as we have seen, called attention to this fact.

sects, as did those of Lesina, and select "durable bodies of clay (pyramids, cones, or perforated amphoras)" or reenforced cement. Allemand forgets, however, to tell us how these clay attachments may be sheltered from light, for all the experimenters will not have the advantage of suspending their apparatus under a laboratory, as was done in Sfax. The author advised, a few pages earlier, the use of baskets or boxes to preserve the sponges precisely for the purpose of shielding them from too strong a light.

Allemand, agreeing on this subject with his predecessors, concludes from these researches that sponge culture has a real industrial and commercial value. But what he published, no more than what was published by the others, is of a nature to lead to this conviction. There is a great distance between laboratory experiments and the founding of an industrial enterprise. It should not be forgotten that the experimenters unconsciously pass very lightly over their failures and insist only on the encouraging facts, forgetting that industry must take everything in account, success as well as failure. Schmidt and Buccich discount 10 per cent of loss for undertakings in sponge culture; nevertheless, during the course of researches made by them during ten years they were unable to follow their most promising cultures for a longer period than five years; after this they became discouraged. In their hands, skillful by long practice, the final loss came near to 100 per cent. Monroe admits that the average loss in his researches was quite considerable. Allemand, evidently alluding to his own experiments, says that an undertaking in sponge culture, if well conducted, will suffer but a very small loss. We must, unfortunately, ask how he computed the mortality of his cuttings. It seems that he took into account only the mortality which occurred during the first weeks after the cutting of the sponges. We find information like the following in his table of experiments:

Mortality, 7 per cent; at the end of February there remained two sponges. Mortality, 5 per cent; at the end of February almost all the fragments were dead. Mortality, 20 per cent; on June 29, 1906, the apparatus was entirely dislodged.

On the whole, the mortality in the work at Sfax seems to have been quite considerable; it must also be remembered that the experiments were carried on during a maximum period of two or three years, and it is impossible for us to foresee what supplementary losses might have taken place during the two or three years that would have to elapse before the sponges could have been garnered. This is information which a merchant ought necessarily to have.

With the exception of Schmidt, the sponge cultivators do not give the cost of their cuttings. "The cost of the installation will not be high," says Allemand. On the contrary, the cost would be considerable. Shall I repeat what I have already said about the other methods of sponge culture? The

fishing of sponges destined to be divided into cuttings must be effected with greatest care, thus the cost of fishing would be considerably greater than that of sponges destined for the trade. The transportation, the care of the sponges, the division into cuttings, the purchase and manipulation of the apparatus of sponge culture will involve supplementary expenditures, as will also the installation and the concession of the parc where the plants are to be made. It should not be forgotten that this parc must be established in deep water as far as this is possible, so that the cuttings shall not be kept too close to the surface, where the light would be too intense for them. It is necessary to inclose this parc and to guard it carefully; it was the theft of apparatus and in general the lack of protection which forced Schmidt, Fogarty, and Benedict to abandon their researches, and it would have been the same with the experiments at Sfax if the Direction des Travaux Publics of Tunis had not provided most efficient guard. A private individual could not count on so vigilant an assistance as that of the fishing guards and the custodian of the laboratory of Sfax, and would himself have to insure, in a permanent manner, both day and night, the guarding of his installations. Schmidt and Buccich seem to have neglected these various factors of expense in sponge culture in the estimate of the cost of their cuttings. The other sponge cultivators keep silent on this subject as if it were a secondary one. This may be so from a scientific point of view, but from an industrial one it is of vital importance.

In spite of all that has been published on this subject, it is as yet impossible for us to foresee at the present time what is to be gained from an undertaking in sponge culture. It is even to be admitted that the result of the enterprise would be a considerable loss. I do not mean Buccich's diminution of value of the sponges on account of the central perforation left by the bamboo stick; these are small details easily corrected by improvements in technique. We must notice that the time needed for healing was always considerable for the species with which experiments were made. This loss of time is not a negligible quantity. Moreover, the growth of the cuttings is slow. Allemand says that they would have to grow four to five years to attain the size reached in two years by sponges coming from larvæ. It is, consequently, not possible to see how the products of sponges, obtained at a great cost and bred at a great cost likewise, can compete economically with the sponges at present brought to market. As long as sponge banks are sufficiently supplied to permit normal fishing, until the value of sponge skeletons has increased considerably, it will be impossible to adopt any other conclusion than the one here expressed.

Such could be the case, however, if the yearly increase in size of the cuttings were far in excess of the size that would have been attained by the original sponge had it not been divided. Schmidt thinks that this is so, without, however,

having verified this statement. Allemand is far more convinced, for he has observed that "the whole of the cuttings taken from a small sponge gave a greater volume than that obtained from an identical sponge placed whole at the same time and under the same conditions." It is rather difficult to have this statement agree with another of the same author, i. e., "the growth of a fragment or of a sponge derived from a fragment is much slower than that of a sponge growing spontaneously and not coming from a fragment." We might conclude, perhaps, that the sponge "placed under the same conditions," the term of the comparison, had not a normal subsequent development. An accident in experimentation can not serve as a basis for generalization. It is, moreover, to be regretted that the most of the authors who have given us information on the culture of sponges do not give any precise definition of what they mean by size and volume; it seems to me that what they mean by doubling or trebling the size is the diameter, and not the size or volume.

Marenzeller, taking into consideration the results reported by Schmidt and Buccich, seemed to be skeptical as to the future of sponge culture. He finally raised the question whether this method of culture ought not to be applied only to the cutting up of flat and worthless sponges, the pieces of which would give sponges of rounded shape, or to the grafting together of badly shaped and consequently cheap sponges. Such application would be of very small importance. The fishermen garner sponges haphazard, without taking pains to give the care and minute precautions demanded for the manipulation of individuals destined for cuttings. When the sponge brought up by the harpoon is of little worth it is not reasonable to expect the fisherman to lose time in manipulating and preserving this worthless piece, which might be utilized in a more advantageous manner if he continued his fishing. Supposing that the fisherman followed scrupulously the directions given him, the worthless sponges thus gathered would cost the breeder of sponges much more than the sponges to be had on the market. He would then have to continue with them a series of procedures involving expenditures the history of which has been given here. And all this to bring about what results? To obtain at the end of several years sponges which also might be worthless, fit only to be thrown aside, like their parent.

The project of fusing badly shaped sponges into one does not deserve to be considered. It is only a pastime for the naturalist, not a procedure for daily practice, and only the virtuosi of sponge culture might attempt it with some hope of a modest remuneration for their day's work. But we have not yet gone so far, and there is no dean in sponge culture. Moreover, there is nothing to prove that the final result of these operations would always be perfect. Should I judge by what I obtained from attempts of grafting halves of different

individuals of *Tethya lyncurium*, ultimate disappointment may be frequently met, arising after premature cicatrizations.

Buccich questioned, on the other hand, whether no senile degeneration took place on cuttings obtained from senile sponges; the growth of these would be slower than that of a sponge of the same dimensions but developed spontaneously. This last proposition was entirely confirmed by facts, as we have already seen; but it should not be deduced thence that the opinion of Bidder on the senility of sponges has been verified. It is impossible to compare experiments made on intact sponges with cuttings attached to apparatus. Let us observe, however, as an accessory consideration, that Allemand thinks to have observed that cuttings taken from large sponges do not develop as well as those from small-sized sponges; but his information on this subject is quite meager. As far as the senility of sponges is concerned, our knowledge, I believe, is limited as yet to some measurements which Allemand made at Sfax. He noticed that in some fifteen months the circumference of certain sponges increased from 40 to 45 centimeters and of others from 50 to 54 centimeters, while some increased from 60 to 63 centimeters, which means an increase in volume of 455 cubic centimeters in the first case, of 544 in the second, and 580 in the third. It can not be said that these observations constitute a definite demonstration of the fact that the sponges had their vitality weakened as they advanced in age.

These are questions, moreover, the importance of which is purely theoretical, since sponge culture by cuttings can not be the subject of practical application. The methodical study which I have given here leads us inevitably to the conclusion which sponge culturists themselves were obliged to accept. We see that Monroe says doubtfully: "It is quite possible that * * * sponge culture might be profitable;" yet, after all, he thinks that the most rational method is sponge culture by means of collectors. The last experimenter who took up this question could not answer against the argument arising from these observations. After having said that sponge culture by cuttings possesses real industrial value, which I expressly deny, he ends, nevertheless, by preferring to it a mixed method in which, unfortunately, he has no personal experience. He considers as being "the true method of culture in the future" a combination of sponge culture by cuttings and sponge culture by planting; the cuttings would produce larvæ which would stock the parc. There would thus be every four or five years a harvest from the cuttings which had grown and every two years another from the sponges spawned in the parc. This mode of operating does not seem at all justified. It is difficult to understand why the author does not advise sponge culture by means of collectors as previously studied; why he insists upon utilizing, in spite of everything, the method proposed by Schmidt. Since the cuttings require five years to reach the size which the sponges reach normally in two years, it is very probable that the emission of

larvæ would be retarded or diminished in such individuals in similar proportion. It would then be quite illogical to use sponge cuttings even for this purpose. What opinion should we have of a horse breeder who would use only sick, crippled, or deformed stallions with which to increase his stock?

From whatever standpoint it be considered, sponge culture by cuttings seems to us only a scientific amusement which can not have any practical application.

CONCLUSION.

We see from the preceding that experiments in sponge culture so far made forbid all hope of ever seeing in current practice methods like the above, and command us most imperiously to warn those desiring to undertake this industry against imprudent advice which they might receive on this subject. There remain, however, other methods which have not been attempted or which were not tried seriously enough and on which our opinion must remain provisionally pending. Let us wait before expressing it definitely; let us await carefully conducted experiments to enlighten us. It would be unfortunate for the fame of applied natural science if industrial attempts at sponge culture, after having been lauded by naturalists, brought about failure from a financial point of view or ended in insignificant results, as when the mountain gave birth to a mouse.

Thorough consideration ought to be given to the matter before engaging capital in an enterprise that might be dangerous. Since the gradual exhaustion of the banks threatens all sponge-bearing countries, however, those interested in this question should be reminded that more important and more easily solved problems urgently claim their attention. There should be as uniform legislation as possible, promulgated after international agreement, regulating in various countries (1) the period for sponge fishing, so as to allow the swarming of the mature larvæ; (2) the minimum size of individual sponges fished and offered for sale; (3) the fishing apparatus, either in regard to character or number; and (4) the security of banks situated in neutral waters.

This is the first programme to be considered. When this is done, let us hope that precise researches during the interval shall have carried the question of sponge culture a few steps further, and that we shall have then a new basis for appreciation in thorough knowledge.

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