HYDROID ZOOPHYTES.*

STUDIES IN MARINE LIFE.

BY G. E. BULLEN.

TO THE student of marine invertebrate biology there is, perhaps, no other group of lowly organisms which present a greater variety of exquisite forms or offer more bionomic interest than do the hydroid zoophytes with their offspring the Hydromedusæ or jellyfishes.

Hidden within the dark recesses of rock pools, and discarded in bunches from the fisherman's trawl, are to be found numerous examples, which rival in beauty of form, if not always color, the choicest blossoms of a hothouse.

It is needless to remark, however, that it is not until the microscope is brought into use that the delicate structure of these "flower animals" is revealed. For the various common species which are to be met with on any sandy beach among seaweed and other debris appear at first sight to be of no particular interest. These, however, as a rule, are but the mere skeletons of former living colonies, and to view them in all their beauty the naturalist's dredge must be employed, or for certain littoral species diligent search should be made in the rock pools. Often these latter are so completely covered with foreign matter—algæ, diatoms, protista, etc.—that they are indistinguishable to any but the most practised eye. A specimen of this description, *Bourgainvillia ramosa*, is shown in Fig. 1, which has been sufficiently enlarged to show a certain amount of the investing matter.

In order to understand something of the habits of "hydroids," it is necessary to investigate their structure, and the following microphotographs have been taken from specimens exhibiting certain particular morphological characters.

In Fig. 2 is seen an example of a hydroid, *Clava multicornis*, in a simple form nearly approaching the text-book type, *Hydra viridis*. Here it will be seen that the "head" is furnished with a number of cylindrical tentacles similar somewhat to those of a sea anemone.

These are the means by which the animal procures its food. This consists of animalcules often of a fair size, microscopically speaking, for these creatures have an insatiable appetite and prey upon anything which comes in their way and is minute enough for them to swallow whole.

The tentacles themselves are, indeed, formidable "breadwinners." They are, more or less, hollow throughout their length, and the outer skin is studded thickly with minute cavities. Within each of these "thread cells," as they are called, is contained a formidable battery of minute darts or harpoons, each attached to the side of the cell by a long, slender thread.

When some unwary victim happens to come in contact with one of the outspread tentacles, the darts are instantly expelled from the cells and enter the unfortunate's body, completely paralyzing it. It is then drawn by means of the thread toward the tentacle which, in turn, passes it toward the mouth, situated in the center of the flower-like head. The arrangement of these thread cells on the tentacles of another species, *Coryne vaginata*, common in many

is passed into the body cavity of the hydroid it is rapidly digested, and by a number of vibratile cirri with which the endoderm is furnished, the digestible and alimentary matter is circulated throughout the entire colony; the rejectamenta are expelled from the mouth. The word "colony" has been used, for, in the majority of species, the animal does not remain solitary, but by sending out roots from the base, the

The calyces are to be seen in the illustration (Fig. 9) depicting a small colony of *Clytia Johnstoni* having the polypites themselves contracted.

These appendages may either be borne upon ringed stems, which allow a certain degree of free movement, or else they are supported in rows upon the branches of the colony. In this style of growth there is much diversity in arrangement in different forms.

Fig. 5.—Polypite (Coryne). Much Enlarged to Show Thread Cells.

Fig. 6.—Polypites (Syncoryne). Much Enlarged to Show Attached Embryos.

stolons, or by branching in its upward growth develops into numerous "heads" or polypites, each provided with a crown of tentacles, a condition which is shown in certain of the illustrations.

It is, however, in the propagation of a certain form over a wider area that the hydroid offers the greatest interest. This brings us to a consideration of the second important aspect of the zoophytes' morphological economy, viz., the reproductive system. In the majority of cases propagation consists in the liberation of free-swimming embryos, either as medusæ (i. e., jellyfishes), or in another form, termed planulæ. In Fig. 6 are shown a number of undeveloped embryos still attached to the parent stock. Before these were developed the several heads presented an appearance somewhat similar to that seen in Fig. 5, but during the growth of these gourd-like, as they are termed, the tentacles atrophied. The body cavity and alimentary system being common to the entire colony, nutrition to these developing embryos is derived from the labors of other polypites, still furnished with tentacles.

The classification of the hydroid zoophytes is based largely upon the form presented by the caenosarc or the hard chitinous ectoderm. Those in which the flower-like heads, or polypites, and developing embryos are protected by special growths of this substance, to form calyces, or cups, and embryo capsules, are termed the Thecophora, in contradistinction to the Aethecata, in which this protection is lacking.

The types hitherto touched upon, together with that

Sometimes the cups are distributed in regular alternate intervals on each side of the stem (as in Figs. 3 and 4); less frequently on one side of the branch only (Fig. 8) in the same plane; and in a few forms they are closely clustered with the lips of the cup pointing in alternate directions. In certain types there is a jointed lid to the top of the embryo capsule and calyx, which affords perfect protection to the animal within.

The capsules show a still wider variety of forms, each more or less elegant, and suggestive of ancient Greek vases. A fair example of the less ornate type is shown in Fig. 3, the capsule of a species of *Diphasia*, and in the following illustration (Fig. 4) are seen several *in situ* upon the branches of the colony of another kind, *Sertularella tricuspidata*. An entirely different form of embryo case—it can scarcely be termed capsule—exists in all species of the germs *Aglaophenia*, an example of which is shown in Fig. 8. This is termed the corbula, within the wide ribs of which the developing young are contained in a thin enveloping sac.

The early life and growth of the liberated medusa is too deep a subject to be discussed even superficially here. Certain forms are shown in the next illustration (Fig. 5). It may be mentioned, however, that, despite the apparent total dissimilarity of form presented by these embryos from the parent hydroid, a certain analogy exists between them in several morphological characters.

Fig. 1.—A Colony of Zoophytes (*Bourgainvillia*). Microphotograph x 10.

Fig. 3.—Embryo Capsule of Zoophyte (*Diphasia*). Much Enlarged.

Fig. 2.—Single Individual of the Club Zoophyte (*Clava*). Much Enlarged Microphotograph.

Fig. 4.—Portion of Zoophyte (*Sertularella*). Much Enlarged, Showing Embryo Capsules.

STUDIES IN MARINE LIFE.

rock pools, is well seen in the next illustration (Fig. 5). Returning to our original example, however, it may be mentioned that the body consists throughout of two principal layers of chitin, the ectoderm, and endoderm; a third middle layer, the mesoderm, is recognized by histologists, but no reference will be made to it in the present description. When the food

interesting species, *Hydractinia echinata* (Fig. 7) which lack of space forbids us to describe, belong to this latter group. In the other main division the elegant cup-like expansions of the caenosarc, to form protection for the fragile polypites, and the highly ornate form of the urn-like embryo capsules, add considerably to the exquisite beauty of these interesting organisms.

Medusæ, in common with hydroid colonies, are highly phosphorescent. On a dark night, when these creatures are plentiful, the sea often appears to be lit up with a myriad of tiny stars. Wherever sudden disturbance occurs, such as the rapid passing of a shoal of drift fish across the bows of an approaching vessel, the sea fairly glares with luminosity. In a few forms, however, the embryo is never freed from

* Knowledge and Scientific News.

the capsule, but remains attached to the top of the rim throughout its existence. An instance of this is shown in Fig. 10, a specimen of *Gonothyrea loveni*, where two, three, and even four embryos are shown crowded together outside with more to follow within the capsule.

In conclusion it may be said that we have desecrated more upon the beauty of these "flowers of the sea" than their representation by microphotographs justify. This is, perhaps, only too true; yet it should be remembered that there can be no comparison between fresh living specimens and those prepared, however carefully, for microscopic examination.

HISTORY OF THE WHALE INDUSTRY.

CONTRARY to a very prevalent opinion that obtains among a vast number of our fellow men whose occupations and environments are in no wise connected with seafaring life, the whale is a true mammal, and in no respect is it a species of the piscatorial family, except in so far as it finds its home and nourishment in the waters of the sea instead of on land. In general structure it is much like our ordinary quadruped, having well-defined shoulder and hip joints, though they are only partially developed. Owing to its tremendous size, averaging about fifty feet in length and twenty-four feet in girth and weighing from seventy to one hundred tons, it is manifest that it could never have been intended for a land resident, the utter impossibility of such a huge mass locomoting over the uneven topography of the earth's surface being at once apparent, even though food of suitable character to sustain life could be secured. Being a true mammal, it is possessed of a circulatory system identically similar to that of farm animals. Warm blood courses through its veins; it breathes air and can remain submerged for as long a period as fifteen minutes, a much greater time than it is possible for any other inhabitant of the earth to go without replenishing its air supply.

Another marked similarity exists in its procreative functions. The young whale is calved alive and nourished with a rich milk from the udder of its female progenitor. In rare instances twins are born. These facts have been revealed through embryology.

The whale inhabits every sea of the globe, and the supply seems undiminished. Man is its only enemy, and hence its depopulation has been immensely smaller than that of any other of the earth's living beings. Its most prolific breeding and feeding area is the waters of the North Pacific Ocean. This is accounted for by the action of the Japan current, which gives a variety of water temperature nowhere else to be found. Ships from every whaling port in the world have in the past made annual cruises to this region in search of these profitable monsters of commerce.

The principal member or group of the whale family is the bowhead, the most valuable of all, from which as much as \$2,000 worth of balena, the whalebone of commerce, and whale oil alone are extracted. This species will average 3,000 pounds of whalebone. The right whale, next in importance, contains about one-half as much whalebone and equally as much oil and other by-products. The sperm variety is chiefly valuable for its contents in sperm oil, as much as fifty-five barrels of the pure fluid being pumped from the head alone, the latter appearing to be fully one-third the size of the whale. These three members of the whale family are of historical fame, the ones up-

tom, grampus, finback, and humpback, were not sought or taken; but latterly with modern methods of capture, as exemplified by the harpoon gun, swivel mounted on the bow of a fast steamer, their day of security from the destroying hand of man is at an end, and they too must sacrifice their lives to the lust for wealth. The value of the whale as an article of commerce was first discovered by finding the carcass of an extinct whale, which had been washed ashore on the coast of the Mediterranean Sea. The residents were jubilant to find that it contained vast quantities of oil, with which the dip lamps, used in their holy worship services, might be kept lighted. Since then the whale has been hunted in a more or less desultory way. Not until the fifteenth century had the industry assumed large or international importance. At that period many European governments came near to

Fig. 7.—A Small Colony of Zoophytes (Hydractinia). Much Enlarged.

serious complications through an arbitrary division of the fishing grounds, and acts of piracy upon the part of their citizens. In some instances companies were organized solely to prey upon the cargo of returning whalers, this being a cheaper and easier method of securing the product than by engaging in the hunt for the mammal direct. Happily, however, the discovery that whales were abundant in all waters led to amicable treaties of division being arranged, and peace was brought to the industry. The American whale fisheries began in colonial days, as early as 1614. The colonists along the New England coast took up the business with avidity, and from 1660 to 1765 it was the most important of all the industries engaged in by our early fathers, and from Cape Cod and New Bedford several sloops were sent on their voyages with great success. The war of independence and the war of 1812 caused temporary cessations of the business. It was revived with the declaration of peace, and grew rapidly until 1854. The American whalers had 678 ships and barks, 35 brigs, and 2 schooners actively engaged, giving employment to over 25,000 men. During the twenty-six years from 1835 to 1861 the American whalers produced 3,671,772 barrels of sperm oil, 6,553,014 barrels of whale oil, and 66,687,500 pounds of whalebone. The total cash value of this product was \$272,274,916.27. It required the capture of 100,000 whales to furnish this great amount, and all these were taken by the primitive hand method of harpooning. The business had grown to such large propor-

was fully as great as that recovered, and represents a net loss of over \$275,000,000 to the industry during that time, as compared with the methods now employed, whereby all of these products are turned to profitable account. The civil war effectually placed an embargo on the business, except for the few vessels that left San Francisco during that time for Northern Pacific waters. It also practically sounded the death knell of whaling as then conducted for the oil and bone only, as in 1876 Capt. Sven Foyn, of Norway, invented the harpoon gun for attacking the whale, and by this method a mechanism succeeds the old and dangerous system. He built a steamer equipped with this powerful machine gun, capable of firing into the body of the whale a bomb-laden steel harpoon over six feet in length, to which is attached a 4½-inch Russian hemp line of the finest quality and by which the mammal is drawn alongside the steamer, to be towed later to the packing and rendering plants on shore. By this means the capture of the whale is made cheaply, harmlessly, and expeditiously as compared with hand harpooning from the bow of a small lifeboat.

When landed at the modern whaling stations, the huge carcass is drawn up an inclined plane to the slaughtering department, and there its various products are reduced to marketable shape. Immediately the enterprise proved again most successful, and within a few years Foyn had established twenty-five different stations along the coast line of his country and became immensely wealthy. In 1898 some of his fellow countrymen, seeing the big profits to be earned, embarked in the business along the Newfoundland coast; their success was so immediate and marked as to attract the attention of Boston and Canadian capitalists, who in 1901 established the first modern whaling station in those waters. In 1901 they capitalized their venture for \$100,000, and they are now employing a capital of over two and one-quarter million dollars, and have declared annual dividends as high as eighty per cent on that amount. Within four years from the date of their entry into Newfoundland they had established no less than twenty-one stations, and have now invaded the greatest of all whaling grounds, the North Pacific Ocean.

About two years ago in December, 1906, the first modern whaling station on the entire Pacific was erected and in the first seven and one-half months of operations 176 whales were captured, whose products netted \$257,110, being 145 per cent on the money invested in steamers, station, and expense of business to that date.

Readers who are not familiar with conditions should understand that a whale consists in part of ninety barrels of oil, sperm, blubber, and carcass, valued at \$14 per barrel; from 250 to 3,000 pounds of whalebone worth over \$400 per ton; over ten tons of whale meat, a cheap nutritious food, which sells for \$65 per ton. About 800 square feet of leather is obtained, and is well adapted for use in the upholstery and book-binding industries. Four tons of whale guano, made from the contents of the stomach, blood, and refuse pieces of flesh, is another of the many merchantable products, now worth \$40 per ton and used by the sugar planters of Hawaii. Three tons of bone fertilizer, valued at \$40 per ton ground, finds a ready market in this country. Upward of 600 pounds of tallow furnishes the raw material for soap and candle making, and a like amount of glue goes to our furniture factories. Whale amber, the finest leather pre-

Fig. 8.—Part of Zoophyte (Aglaophenia). Much Enlarged, Showing Corbula.

Fig. 9.—Small colony of Zoophytes (Clytia). Much Enlarged, Showing the Calyces.

Fig. 10.—Portion of Zoophyte (Gonothyrea). Much Enlarged, Showing Embryos Attached to Top of Capsules.

STUDIES IN MARINE LIFE.

on which the industry in its earlier history was founded, and in whose quest countless lives have been sacrificed, so that their immensely rich products might be recovered for the comfort and convenience of our advancing civilization.

In former times, and before the introduction of the permanent whaling stations on shore, the other or lesser valued varieties, consisting of the sulphur bot-

tions that over \$70,000,000 was invested by American whalers, and employment was given to over 70,000 people.

It must be mentioned that during this period of great prosperity all of the now valuable by-products, such as whale meat, leather, tallow, guano, bone fertilizer, glue, and whale amber or leather preservative, were not utilized at all, though their aggregate value

servative known, is used by our tanners and harness makers. Ambergris, the base of high-grade French perfumes, is one of the very valuable by-products of the whale, and even the tail, which averages a ton in weight, is eagerly sought by the Japanese at \$50 per ton. Here is an array of by-products taken from the whale of every variety, every one of which is of great value and with an ever-increasing market at hand in