of the radial canals. Death is thus extremely gradual. All these points are clearly important in considering the systematic position of any medusa that exhibits the slightest signs of degeneracy.

II.—LIFE HISTORY OF THE HYDROID AND MEDUSA.

By R. E. LLOYD.

In July 1915, Dr. Annandale informed me of the occurrence of the Medusa, *Irene ceylonensis* (Browne), in the brackish water of a canal in the neighbourhood of Calcutta and suggested that I should enquire into its life-history as his own observations on the subject had to be discontinued. He also kindly lent me a stained permanent preparation showing several planulae, some with budding hydroids and stolons. This preparation was made by Mr. F. H. Gravely from material gathered from the bottom of a glass bowl in which a number of the medusae with ripe gonads had been confined for observation.

About the middle of July, the medusae were plentiful throughout the canal so that I was able to obtain a large number, varying in diameter from about 2·5 mm. to 2·5 cm. By the end of the month however none were to be found. No doubt they were killed by the heavy monsoon rain, which greatly diminishes the salinity of the water.

I was unsuccessful in again raising the planulae in captivity but was fortunate in obtaining some colonies of the hydroid growing in the canal attached to stones. Some were kept alive for ten days, affording good opportunity for observation. Several gonosomes were obtained from these colonies. These were stained and mounted in Canada balsam. They show certain stages in the development of the medusa, especially the early and late stages, in a satisfactory manner.

The Hydroid Colony.

The hydroid was defined by Dr. Annandale from material taken in brackish water at Port Canning, but as I had the opportunity of examining the living animal from day to day in the laboratory a few further remarks on its structure will be made.

The hydroid varies considerably in size Only the larger and older individuals can be discerned by the naked eye. The colony as a whole is much less conspicuous than most hydroid colonies. The stolon seldom divides, so that it is easy to strip off as much as an inch from the substratum without meeting any outgrowths except the hydrothecae. The stolon however does occasionally branch, the growing point dividing in a simple dichotomous manner.

The coenosarc of the stolon has a different appearance from the coenosarc of the hydroid, due principally to the fact that the endoderm cells of the stolon are granular and opaque while those of the hydroid are clear, vacuolated and much larger. The hydroid is not set directly upon the stolon but upon short intermediate branches which have the same structure as the stolon. The line of attachment of the hydroid to these intermediate branches is most conspicuous when the hydroid is contracted, but it is visible at all times as a sudden change in the character of the endoderm cells.

The intermediate branch as well as the hydroid lies in the hydrothecae.

The Hydrotheca.

As a rule the hydrothecae arise directly from the perisarc of the stolon. Occasionally, however, they arise from short lateral branches which are common to them and to a gonotheca. They measure ·45 mm. by ·15 mm. (*Annandale*). They terminate in a conical pointed operculum consisting of a number of acute converging projections of the perisarc which together closely resemble the peristome of a moss capsule. The number of these processes is about twelve but they are difficult to count owing to their transparent delicacy.

The method of the opening and closing of the hydrotheca is simple and effective, depending as it does upon the elasticity of the marginal projections and upon a slight upturning of their points. Because of their elasticity they tend to converge so that they are always in contact with the stalk of the hydroid even when it is fully extended. At first sight it seems that in this condition the converging points would hinder the withdrawal of the hydroid by catching in rugosities projecting from the surface of the stalk during contraction, and it also seems likely that the points would strangle the neck and so prevent the entry of the head into the theca. Such possibilities are prevented by the slight upturning of the points. The act of withdrawal is not easy to observe. Low degrees of magnification are insufficient for the purpose, but when using the high power it is of course necessary to cover the object which causes immediate and lasting contraction of the hydroid. The difficulty was overcome by using an ocular of very high power with a low power lens. Ocular No. 18 such as is supplied with Zeiss' oil immersion lens combined with an objective 2/3 in. focus gave good results. A portion of a colony living undisturbed in a capsule of water was thus magnified about 200 times so that the act of withdrawal could be observed.

The Hydroid.

The principal features of the hydroid are well known. The web or membrane uniting the bases of the tentacles being the chief characteristic. The fully extended stalk of a large individual measures about 2 mm. in length by ·06 mm. in thickness. In the living animal the ectoderm of the stalk is a very thin layer devoid of cell outlines or nematocysts. The outlines of the endoderm cells on the other hand are plainly visible even under the low power of the microscope In the expanded state each endoderm cell appears to contain a single vacuole, so large that the protoplasm is reduced to a delicate peripheral layer in which nuclei are scarcely visible. Except for the granular contents of the gut cavity the stalk is transparent. The appearance of transverse lines in it is due to protoplasmic septa composed of the peripheral layers of adjacent endoderm cells which separate the vacuoles.

Since the diameter of the hydrotheca is not much more than twice the diameter of the extended stalk, it is evident that the cubic content of the stalk must be very much reduced before it can be accommodated by the hydrotheca during contraction. This reduction must be brought about by evacuation of fluid from the vacuoles of the endoderm cells. The process however was not observed. As mentioned before, the endoderm cells of the stalk present a very different appearance from those of the stolon and intermediate branches, the latter being granular and not vacuolated. The transition from the one to the other is sudden. When extended the stalk is straight and stiff. It usually appears to be motionless but on attempting to draw the outline with the Camera lucida, it becomes evident that the animal is seldom quite motionless. In the largest individuals the tentacles are constantly sixteen in number. When extended they measure about ·5 mm. in length and they are usually held in two series, eight of them springing from the base of the hypostome at an angle somewhat less than a right angle, while the other eight which alternate with them project more downwards. When the tentacles are in this position the margin of the web forms a characteristic zig-zag outline. The web measures about ·06 mm. from its margin to the angle between adjacent tentacles. The tentacles are as usual in the Calyptoplastica devoid of a central cavity, the outline between the endoderm cells being plainly visible in the living animal. That part of the base of the tentacles which lies in the web usually includes three endoderm cells and bears a few scattered nematocysts. Throughout the length of the tentacles the nematocysts are disposed somewhat irregularly in rings, one ring corresponding roughly to each endoderm cell.

Habits.

The hydroid first found at Port Canning was living in association with the protozoon *Folliculina* and this organism also occurred among the colonies taken from the canal. A species of small Polychaet worm (Spioniformia), however, was found more plentifully in association with the hydroid at Calcutta. The delicate sandy tube of the Polychaet was frequently interwoven with the stolon of the hydroid. On one occasion I was able to observe the hydroid preying upon the worm. Three fully expanded hydroids which happened to be adjacent were under observation in a capsule of water. An immature worm measuring about a millimetre in length came within reach of their tentacles and was soon fast entangled and paralysed. One hydroid attached itself to the mouth of the worm another to the anus, while the third which apparently obtained no nourishment helped to subdue the struggles of the victim. A yellowish granular stream, the blood and coelomic fluid of the worm was seen pouring slowly into the two hydroids which were attached terminally. The enteron of the hydroids became considerably expanded for a short distance below the tentacles and this expansion was no doubt the means of suction. A lesser expansion at this point is frequently visible even in the resting condition (plate v, fig. 1). The nourishment was not retained by the hydroids but passed on rapidly into the general coenosarc of the colony. Within five minutes from the commencement of the operations, the stems of the hydroids which remained extended throughout had regained their usual glassy appearance. The body of the worm, motionless and shrunken, was released in less than five minutes after capture.

The Gonosome.

The gonosome was found in various stages of development (plate vi). Although the series illustrated is not complete the earliest and later stages are well represented. In the latest the young medusa can be seen lying within the gonotheca provided with tentacles and sense vesicles. Although the manubrium is still imperforate, the medusa is evidently almost ready to be liberated. As estimated from the drawing to scale, the convexity of the bell of the medusa lying within the gonotheca measures about ·7 mm. in the specimen figured The diameter of the bell in the smallest medusa caught swimming freely was at least 2 mm. There is therefore an interval in the life-history including the liberation of the medusa and the first part of its free life which was not observed.

There are usually two medusae in each gonosome, a proximal and a distal, the latter being always the more developed. Sometimes only one medusa occurs which probably represents the proximal member of the pair after the liberation of the distal member. About 1 in 5 of the mature gonosomes were in this condition.

The gonosome of *Campanulina* was described by Hincks as growing from the stolon and containing one medusa. In this species, however, the gonosome usually grows from the base of a hydrosome and contains two medusoid buds.

In its earliest phase the gonosome appears as a tubular outgrowth from the coenosarc which sometimes arises from the main stolon but more often from the intermediate branches near the base of the hydrosome. This tubular outgrowth is a blastostyle which gives rise to the two medusae by budding. Before any buds have appeared upon it, the blastostyle has a characteristic appearance. It is, we have seen, a tubular outgrowth of the coenosarc and throughout most of its length it appears to have the same structure as the coenosarc of the stolon, the cells of both ectoderm and endoderm being opaque and finely granular. Close to the extremity, however, the cells have a different appearance, being translucent and vacuolated, having indeed the same appearance as the cells of the hydrosome. It has been mentioned that the change in the appearance of the cells at the base of the hydrosome is characteristic and sudden. The junction between the translucent end of the blastostyle and the opaque proximal portion has exactly the same appearance (plate vi, fig 1). The translucent end of the blastostyle therefore perhaps represents a reduced hydrosome. Be that as it may, it is a conspicuous feature of the gonosome visible from first to last, forming in the later stages a kind of lid closing in the gonotheca. It may be referred to as the operculum.

The medusae arise from buds which spring from the stem of the blastostyle below the operculum. They appear to arise in the usual manner by the sinking in of an entocodon. A conspicuous feature of the development is the early formation of four large lappets, placed radially on the margin of the bell. Upon these the tentacles appear at a later stage.

At the time when the first bud appears upon the blastostyle, it is evident that the cavity of the operculum is in open communication with the cavity of the cylindrical stem But later when the development of the medusae is more advanced, the stem of the blastostyle becomes flattened out and can scarcely be traced. But even at a comparatively late stage the endodermal cavity of the two growing medusae may be seen communicating with one another through the cavity of the blastostyle. One specimen shows a similar communication between the cavity of a medusa and that of the operculum. Though much compressed and rendered inconspicuous by the growing medusae, it is probable that the stem of the blastostyle preserves its status until the end. Thus, in the oldest gonosome met with, the stem of the blastostyle can plainly be seen between the two medusae, and its communication with the cavity of the operculum may be inferred owing to an interesting circumstance. The cavity of the stem of the blastostyle contains a number of irregular nucleated cells which have much the appearance of phagocytes and the same kind of cells are to be seen in the cavity of the operculum. This fact indicates that the communication between the stem of the blastostyle and the operculum persists to a late stage. Little seems to be known of phagocytesis among the Coelenterata but it is unlikely that a process so general in the animal kingdom should not occur in this group. It is possible that the presence of these cells, which, as I have said, have the appearance of phagocytes, indicate the approaching dissolution of the distal part of the gonosome and the liberation of the mature medusa.

The Gonotheca.

In the early stages of its development the gonosome is completely enclosed by a delicate perisarc. The later history of this layer, as to how and when it allows the liberation of the medusae, was not ascertained.

The Free Medusa.

The medusa was described by Browne from specimens taken in the sea off Ceylon, and its systematic position has been discussed by Dr. Annandale in the first part of this paper. It is therefore unnecessary to say much more beyond reference to the peculiar condition under which the organism was found in Calcutta. The unusual and sudden appearance of a swarm of medusae in a brackish canal—far removed from the sea though connected at one point with the tidal waters of the Hooghly—make it most likely that the medusae were all of one species. An examination showed beyond doubt that the many hundreds of specimens taken by the tow-net were indeed of one species though varying very much in appearance according to age and state of activity. Plate vii, fig. 1 gives some idea of the appearance presented by a number of the medusae at the time of capture. At first sight one might suppose that they included several distinct species. The largest, bearing ripe gonads, measured about 2·5 cm. in diameter, the height of the bell during relaxation being about two-thirds of the diameter, but specimens preserved in formalin are usually flatter than this. Half-grown specimens, especially when swimming actively, appear higher than they are broad and in this condition the tentacles may stream out to a length two or three times greater than the height of the bell. When resting they assume a flatter shape and the tentacles are considerably contracted. In this condition the peduncle and manubrium together can often be seen revolving about the fixed base. While so engaged the mouth and lips appear to clean the tentacles and search the groove between the velum and inner wall of the bell for adherent food particles.

The smallest specimens, measuring 2-3 mm., show certain differences from the mature form. The peduncles of the manubrium, which is a characteristic feature of the adult, is scarcely represented. The sense vesicles are less numerous than the tentacles, nor are they so regularly disposed in alternation with the tentacles as in the adult; but this is only to be expected at a time when the tentacles are rapidly increasing in number. Plate vii, fig. 4 shows a young medusa with eight tentacles, six sense vesicles and a number of tentacular buds. At this time the primitive germ cells are distinctly visible and they can be seen even before the medusa has left the gonosome.

In the mature condition the generativé cells are disposed along the radial canals from the base of the peduncle to the margin of the bell. They form prominent ridges with a somewhat contorted edge which projects from the lower surface of the bell. A section across one of these ridges shows the radial canal lined by attenuated columnar cells between which and the very delicate ectoderm the generative cells lie.