Letters from New Guinea on Nautilus and some other Organisms.

By

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RALUM (NEW BRITAIN), GERMAN NEW GUINEA,
viâ SINGAPORE;
April 5th, 1895.

DEAR PROFESSOR LANKESTER,—Although I have not seen any mature ova of the pearly Nautilus since my last letter to you, yet I have made some further observations on the adult, which may be of interest.

1. Ectoparasites.—In my previous note[1] I accidentally omitted to mention the occurrence of numerous Copepod parasites in the mantle chamber of the Nautilus. They are present in nearly every individual that I have examined, and are found attached to the branchiæ, the internal surface of the funnel, and in other regions of the pallial chamber.

The parasites are a species of the genus Caligus,[2] and possess the characteristic semilunar suckers on the first pair of antennæ.

When Nautili are placed in jars the Caligids emerge in large numbers from the mantle chamber, and swim about actively in the water, usually in close proximity to the sides of the vessels, from which they can be removed only with some difficulty, owing to the great adhering power of the above-mentioned suckers.

2. Movements.—I send you a photograph of a Nautilus in its ordinary swimming attitude,—such a figure, I believe,

[1] 'Natural Science,' May, 1894.

[2] C. nautili, pending a more detailed description.

not having been previously published.[1] From the photograph it will be seen that in swimming the animal elevates itself to such an extent that the eyes are raised above the free margin of the mouth of the shell. As to its movements on the surface of the water, there is very little to add to the excellent account given by the late Professor Moseley in his 'Notes by a Naturalist on H.M.S. Challenger.'

I can emphatically confirm Moseley when he says that "it is probably a mistake to suppose that it ever comes to the surface voluntarily to swim about." Nevertheless a Nautilus is not necessarily ruined by being brought up from the bottom in a fish basket. If liberated within a reasonable time it is capable of returning to its natural habitat. I have proved this experimentally.

When freshly captured Nautili are placed in aquaria they rise to the surface and sink to the bottom with the greatest facility. The rising to the surface, according to my observations, is effected solely by the muscular activity of the animal, and is in no way dependent on any physical modification of the gas in the air-chambers. The presence of the latter renders the shell extremely light and buoyant, so that it is, under normal circumstances, completely under the control of the muscles of the animal. I say "under normal circumstances" advisedly, because there is one thing which the Nautilus cannot do, namely, turn upside down. It is necessary to insist on this, because Moseley gives a translation of the account given by Rumphius at the beginning of last century, which, I regret to say, so far as my experience has gone, is very wide of the mark. Always remembering that Rumphius was the first to demonstrate the cephalopodous character of the pearly Nautilus, the suspicion is forced upon me that he derived his account of its habits from the narrative of an ill-informed and imaginative Malay fisherman. Natives are so often remarkably well informed about the habits of animals, that the above supposition can by no means be taken as conveying a reproach to the old master.

[1] This photograph is reproduced as Fig. 24 at the end of this article.

"On the bottom," says Rumphius, according to Moseley's translation, "the animal creeps with the other side[1] uppermost, with the head and tentacles on the bottom, and makes tolerably fast progress." The only comment I can make on this statement is that it is inconceivable. I wish I had the work of Rumphius to refer to, in order to find out how he succeeded in seeing the Nautilus at all on the bottom. He goes on to say, "The animals remain mostly at the bottom, creeping sometimes into hoop-nets set for fish and lobster-pots; but after a storm, when the weather becomes calm, they are to be seen floating in troops on the surface of the water. . . . The floating, however, does not last long, for, drawing in all their tentacles, the animals turn their boats over and go down again to the bottom."

The Nautilus can no more turn its boat over than a successful balloon ascent can end by the cage coming down uppermost. Anyone can convince himself of this by placing an empty Nautilus shell in water. A remarkably small weight is sufficient to sink such an empty shell; and when the living animal retracts itself and ceases all muscular action, thereby converting itself, as it were, into a dead weight, it is heavy enough to sink several shells in addition to its own.

There is a slight error in Moseley's account of the movements of the Nautilus, which may as well be corrected. He says, "On either side of the base of the membranous operculum-like headfold . . . the fold of the mantle closing the gill-cavity was to be seen rising and falling, with a regular pulsating motion, as the animal in breathing took in the water, to be expelled by the siphon." It is not a fold of the mantle which is thus seen to pulsate, but the posterior free membrane-like expansion of the funnel on either side.

Besides observing the movements of the Nautilus in the narrow limits of jars and buckets, I have also placed them in the sea in shallow water, and will briefly describe one such experiment.

On March 16th a Kanaka brought me six Nautili. All of them sank to the bottom of the buckets except one, which

[1] That is, the ventral side.

swam about on the top all the time. About an hour afterwards I took the latter out in a canoe to observe its movements in one to three fathoms of water. On placing it in the sea it remained at first on the surface, swimming actively backwards, i. e. with the shell directed forwards. It frequently swam to the bottom and back again to the surface—often also swimming in the middle stratum of water. I have never found any necessity for framing an elaborate theory as to the rising and sinking of the shell.

3. The Position of the Spadix or Hectocotylus.—I was surprised to find that the spadix in the male developed variably on the right and left sides of the cephalic system. Out of thirty-seven males which were examined *ad hoc*, twenty-three had the spadix on the left side, and fourteen had it on the right side.

4. Pallial Arteries.—I will say a few words about the pallial arteries, in order to refer to the arterial blood-supply of the siphuncular pedicle. Anatomical evidence seems to point to the conclusion that the latter structure has more of a vestigial than of an actively functional physiological importance. Embryology will show whether or not it has any original relation to the primitive shell-gland.

The so-called lesser aorta of Owen, arising from the anterior slightly incurved margin of the heart, divides immediately, as is known, into two branches. These are respectively the anterior and posterior pallial arteries.

The anterior pallial artery bends inwards and somewhat downwards to the middle line, and then runs forwards below the skin on the surface of the renal sacs. At the point where it turns forwards a small intestinal branch is given off. Arrived at the anterior limit of the renal sacs, the anterior pallial artery passes into the substance of the mantle, and runs towards the free margin of the mantle, shortly before reaching which it bifurcates into two main marginal arteries, from which numerous radial arteries are given off (see Fig. 1).

Exactly at the point where the anterior pallial artery passes into the substance of the mantle a pair of branches, right and left, arise from it almost at right angles to it. These may be called the branchio-osphradial branches of the anterior pallial

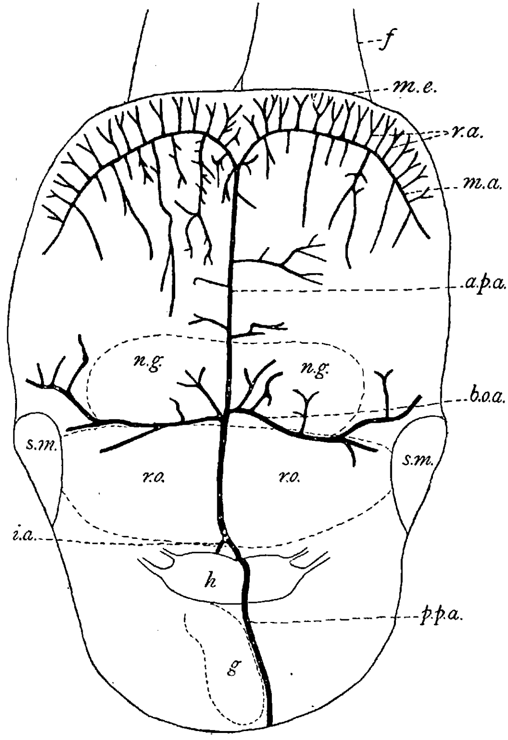


Fig. 1.—N. pompilius, ♀. View of ventral surface of pallial and visceral regions, to show the course of the pallial arteries. *f.* Funnel. *m. e.* Free edge of mantle. *r. a.* Radial pallial arteries. *m. a.* Marginal pallial artery. *a. p. a.* Anterior pallial artery. *n. g.* Region of nidamental gland. *b. o. a.* Branchio-osphradial artery. *s. m.* Shell-muscle. *r. o.* Region of renal organs. *h.* Heart. *p. p. a.* Posterior pallial artery. *g.* Gonad. *i. a.* Intestinal branch of anterior pallial artery.

artery, since among their minor ramifications they send up branches to the tips of the branchiæ supplying the integument of the latter, and also a small branch into each of the osphradia (i. e. into the osphradia of Lankester and Bourne, and into those which I described in my last letter). In the female they also supply the nidamental gland.

The posterior pallial artery runs backwards over the ventral surface of the heart, leaves the pericardium through the orifice described by Owen, and then passes onwards below the skin to the left of the genital gland, between the latter and the gizzard. Upon reaching approximately the middle point of the posterior rounded surface of the body it, too, passes into the integument, and immediately divides into two main branches, right and left, which supply the dorsal and posterior regions of the mantle, including the siphuncular pedicle. A variable number of small secondary or tertiary branches go up into the siphuncular pedicle, but there is one branch which is essentially the siphuncular artery (see Figs. 2 and 3). But even the definite siphuncular artery is not constant in its origin, but arises now from the right and now from the left of the two main branches of the posterior pallial artery. The siphuncular artery is therefore a minor ramification of the posterior pallial artery.

Owen, followed by Vrolik, described the latter as passing *in toto* into the siphuncle. Keferstein, whose figure is more accurate in this respect, says that it passes "nach hinten zur Körperhaut und besonders zum Sipho."

Injection indicates that the arteries which supply the siphuncle are homodynamous with the other ramifications of the posterior pallial artery.

5. *Pallial Veins.*—It is not now necessary to go into details with regard to the pallial veins, but I will point out how they may be seen to great advantage.

When a Nautilus becomes moribund it usually rises to the surface, owing to an abundant production of gas in the interior of the body. If it is allowed to die, and is then removed from the shell, the veins are found to be injected with gas of some sort, and the finest ramifications of the veins, in the mantle at least, are displayed with a clearness which could be hardly attained by artificial injection.

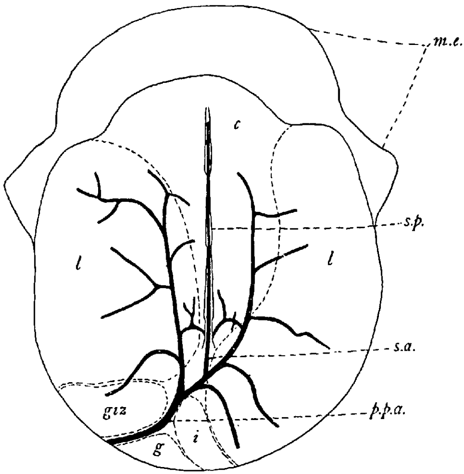


FIG. 2.—N. pompilius, ♂. View of dorsal surface of pallio-visceral region, to show the principal ramifications of the posterior pallial artery. *m. e.* Free mantle edge. *c.* Region of crop. *s. p.* Siphuncular pedicle. *l.* Region of liver. *s. a.* Siphuncular artery arising from the right of the two main branches of posterior pallial artery. *p. p. a.* Posterior pallial artery. *giz.* Region of gizzard. *g.* Region of gonad. *i.* Region of intestine.

N.B.—In front of siphuncular artery are seen two small branches which bend backwards and enter the siphuncular pedicle on its dorsal aspect. The pedicle is here represented turned forwards to expose its ventral surface.

The mantle is simply riddled by these veins in a manner which defies one's powers of draughtsmanship. The veins are collected into two main trunks, which lie on either side of the anterior pallial artery, and proceed backwards to open into the afferent branchial vessels. At the sides of the mantle there are also a number of lateral pallial veins, which open into a large sinus situated over the shell muscle.

6. Miscellaneous.—In New Hanover and New Ireland the Nautilus shell is called "Togol," and is used as a decoration on the outriggers of the canoes and on the houses, and also as a drinking vessel and for baling out canoes. Occasionally the

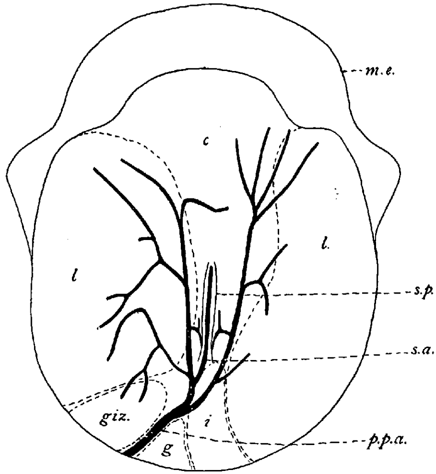


FIG. 3.—N. pompilius, ♂. Similar view as in Fig. B, to show the siphuncular artery arising from the left of the two main branches of the posterior pallial artery. Letters as in Fig. B.

shell of Nautilus umbilicatus is obtained, and the new-comer then acquires the useful information that that is the male of the Nautilus! This seems to be the idea of the Kanakas as well as of the outlying white men.

In New Hanover, where primitive institutions still largely flourish undisturbed (including cannibalism), a curious custom prevails, of which I became aware while engaged in collecting finger-prints. The natives employ the cheiromantic creases for the purpose of creating factitious social groups or families, within the limits of which marriage is tabooed. They trace a fancied resemblance between the creases of the hand and the form of the wings of a given bird, and name accordingly. All those whose hand-creases are referable to the same bird constitute one family or "tā-uk," apart from any question of blood relationship. Thus a man of the "kanai ta-uk," or family of the sea-gull, cannot marry a woman of that "ta-uk."

It is also tabu to eat bird-flesh, but they all eat pork—exactly the reverse of what occurs in New Britain, at least as far as the men are concerned.

Probably most of the fighting in New Hanover is due to the complicated relations of the sexes. "Plenty fight belong Mary."

Finally, I may conclude these brief notes by adding that if a Kanaka kills another Kanaka of his own ta-uk he does not eat him, according to my information.—Yours very truly,

Arthur Willey.

Ralum, New Britain,
viâ Singapore;
June 4th, 1895.

Dear Professor Lankester,—The following are a few zoological observations, relating chiefly to the fauna of Blanche Bay, which I have incidentally made during the last few months.

1. Polyclades.—The Polyclade fauna is rich both in species and individuals. Most of those that I have hitherto had any opportunity of observing have been taken close to the shore of the island of Rakaiya (or Raluan), in Blanche Bay, from the lower surfaces or in the crevices of volcanic stones.

I have, however, on several occasions also obtained them from the reef opposite Ralum. Although a fact of no absolute value proceeding from so limited an experience, it is nevertheless worth mentioning that the Polyclades from the reef off Ralum have all belonged to the subdivision Cotylea, and included a very fine Thysanozoon, attaining a length of 66 mm.; whereas those from the stones off Rakaiya, which I have collected in much larger numbers, have all been representatives of the subdivision Acotylea.

Several of the latter have laid their egg-plates in my jars. There are, among others, two well-marked species of Stylochus, both characterised by their uniformly pitted or granular appearance, but in one case of an opaque dark ashy colour, and in the other of a light brown sandy complexion. As I cannot match these with any descriptions in the literature at my command, it will do no great harm to refer to the former as S. cinereus and to the latter as S. arenosus.

Stylochus cinereus has a length of 24 to 27 mm., and a width of 10 mm.; tentacles brownish yellow, covered with eyes, and 3·5 mm. from anterior margin of body; cerebral eyes extending over proximal portion of outgoing nerves; anterior marginal eyes extending backwards to level of tentacles; margin of body cloudy, but light and unpigmented.

S. arenosus has a length of 41 to 45 mm., and a width of 16 mm.; tentacles covered with eyes except the tip, which is orange-coloured; tentacles 5·5 mm. from anterior margin; cerebral and marginal eyes as in S. cinereus; margin of body nearly colourless and translucent; about twelve pairs of intestinal diverticula.

It is difficult to obtain uninjured examples of S. cinereus, as it tears with the greatest readiness while being detached from the stones on which it lives. Lacerated examples presenting a ragged appearance thrive well in aquaria. The tendency to laceration seems to be a characteristic of the species as much as any anatomical feature. There is a species of Cryptocelis (marginal eyes all round body) common here, which practises deliberate autotomy, this being one of its most characteristic peculiarities.

S. cinereus laid several irregular patches of eggs on April 27th. The eggs were disposed in no particular order in a somewhat granular gelatinous matrix, each ovum being surrounded by its own membrane, and measuring 12 to 13 μ in diameter. Before the commencement of segmentation the ova of this species pass through a pronounced amœboid stage (Figs. 4 and 5), subsequently becoming round again. It is also a favorable species for observing amœboid movements of the polar bodies. The movements are sluggish but unmistakable, and sometimes the polar bodies become widely separated from one another (Fig. 6).

Fig. 4.

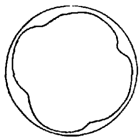
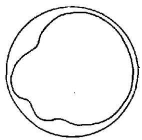


Fig. 5.



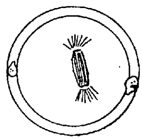


Fig. 6.

Figs. 4 and 5.—Ova of Stylochus cinereus before commencement of segmentation, to show the amœboid phase. Zeiss, 3 c, cam. luc.

Fig. 6.—Ovum of S. cinereus preparing for the first division, to show the amœboid character of the polar bodies. Zeiss, 3 c, cam. luc.

Stylochus arenosus laid one irregularly contoured plate of eggs on May 6th. The ova were arranged in distinct rows, each ovum surrounded by its own proper membrane, and measuring 9 to 10 μ.

The egg-discs of two species of Planocera, occurring like the above species in shallow water off Rakaiya, offer a strong contrast to the egg-plates of Stylochus. I am under the necessity of naming these, at least provisionally, on the same principle as the above-described species of Stylochus.

Planocera discus (mihi) attains a length of 45·5 mm., with a width of 28 mm. The dorsal surface is coloured with delicate yellowish-brown (umber) reticulated markings, on which are scattered black nodal spots; interspaces whitish;

margin of body of the delicate brown ground colour interrupted by narrow white streaks; mid-dorsal region pitted with numerous minute black spots; tentacles brown with rose-yellow tip, 13 mm. from anterior margin; large tentacular eyes at base of tentacles, more numerous than the smaller cerebral eyes; latter numbering about twenty-two to twenty-five on each side; female genital aperture about same distance from posterior end as the tentacles are from the anterior end; pharyngeal bursæ, seen from below, dense white; intestinal diverticula six or seven pairs.

The margin of the body is always sinuous or skirt-like, and when at rest the animal is capable of assuming a nearly circular form. Both this and the following species can be handled with impunity, neither of them evincing the slightest disposition to laceration.

Planocera discoides (mihi) is, for a Polyclade, an object of great beauty. I obtained two specimens of it from the bottom of a volcanic stone, on the top of which corals and sponges were growing off the south-west shore of Rakaiya, in some two or three feet of water at low tide.

It reaches the length of 75 mm., with a width of 36 mm., always with a sinuous margin. Like the preceding species, it can assume an almost circular form. The body is remarkably transparent; intestinal rami, seen from above, light brown, moniliform, anastomosing; interspaces beset with numerous minute rubiginous spots; larger dark brown nodal spots scattered about dorsal surface; margin of body light, pellucid; tentacles pellucid, 22 mm. from anterior margin; female aperture same distance from posterior margin; large dense white shell-gland between the two genital orifices; eyes about twice as numerous as in P. discus; cerebrum in a clear pellucid area, which is deeply indented or excavated ventrally; seven or eight pairs of intestinal diverticula, which present a dull greyish-white colour from below.

P. discus laid a circular disc of egg-capsules on April 30th. The disc had the appearance of consisting of a series of concentric circles, but closer examination showed that the rows were arranged spirally, the spirals being here and there interrupted (Fig. 7). The egg-disc measured 15 mm. in diameter.

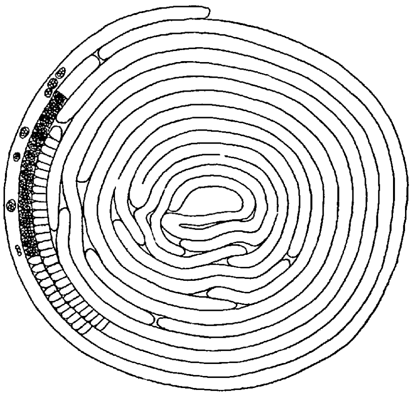


FIG. 7.—Enlarged view of the egg-disc of Planocera discus. Only a few of the egg-capsules have been inserted in the drawing.

Each row consists of numerous capsules packed closely together in what amounts to a common gelatinous tube. The spirals can be unwound. In the outermost spiral were a few irregularly dispersed capsules. The normal capsules contained each from eight to eleven ova, and the latter had no other membrane round them individually.

On May 4th the same individual, which had been kept isolated all the time, laid another much smaller disc of egg-capsules. I left these undisturbed, and in the course of time many of the ova developed into ciliated embryos with a pair of large primary eyes. The embryos swim about actively in the capsules, three or four to seven or eight in each capsule, surrounded by the fragments of those eggs which had not developed. Many of the embryos had developed abnormally, owing probably to the fact that the water in which they were kept had not been changed frequently enough. Before segmentation commences, some of the ova in each capsule present an appearance of approaching fragmentation, and it is probable that this is a regular occurrence. Here also the polar bodies execute amœboid movements.

In the case of P. discoides I found two egg-discs on May 27th on the same stone on which the adults were living. To the unaided eye they were not to be distinguished from those of P. discus, but microscopic examination showed that the gelatinous matrix[1] in which the egg-capsules were

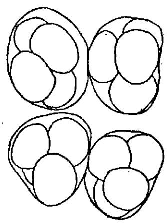


Fig. 8.—Four egg-capsules from an egg-disc of Planocera discoides each capsule contains four ova. Zeiss, 3 A, cam. luc.

arranged in concentric rows was more continuous, and not divisible into concentrically disposed tubes; and, above all, that in each egg-capsule there were only four ova (Fig. 8).

Of the four ova in each capsule, as a rule, only two develop into ciliated embryos; frequently, however, three, and rarely only one. I have in no instance found four ciliated embryos in a capsule. Those ova which do not develop undergo fragmentation. I think the particles of the fragmented ova must be dissolved in the fluid contained in the capsules, and not absorbed by the remaining ova in the solid form. When two or three embryos are revolving in a capsule, there is usually no trace whatever of the previous existence of other ova in the same capsule; and when there is only one embryo in a capsule it is no larger than other embryos.

It is chiefly before the embryos begin to revolve that the

[1] A large number of amœboid bodies may be observed in the matrix in which the egg-capsules are embedded in this species.

actual evidence of fragmentation is to be obtained (Figs. 9—11). Only rarely are the rounded particles derived from the

FIG. 9.

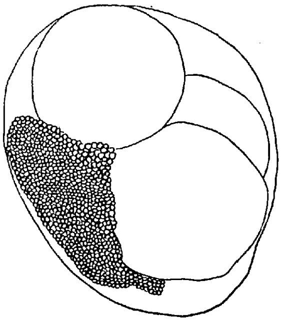


FIG. 10.

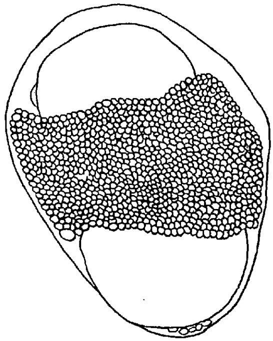
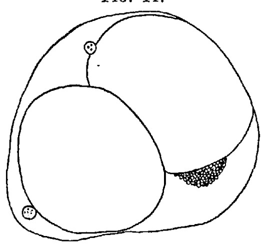


FIG. 11.



FIGS. 9, 10, and 11.—Planocera discoides. Egg-capsules. In Fig. 9 one ovum has undergone fragmentation; in Fig. 10 two ova have undergone fragmentation; in Fig. 11 the remains of the fragmented particles are seen lying against an embryo which had already acquired cilia, but had not commenced to rotate. Zeiss, 3 c, cam. luc.

fragmentation of the original ova, to be seen floating about in those capsules in which the embryos are revolving.

2. Cirripathes anguina.—From the reef off Ralum I obtained a fine specimen of this unbranched Antipatharian, upwards of 9 feet in length. It reached up close to the surface

at low water. The natives here call it "a pada ur-a-ta," or simply "a ur-a-ta," which means "the bones of the sea."

3. Nudibranchiata.—The Nudibranch molluscs, particularly the Dorididæ, are represented here by a great wealth of species of all sizes up to 60 mm. by 45 mm., many of them being brilliantly coloured. Their spiral egg-bands may be obtained without difficulty. Several species, including two Æolids, have laid their eggs in my dishes.

On the reef off Ralum, and in Blanche Bay too, there are to be found large numbers of very long spirally coiled ribbons, so thickly encrusted with sand that they appear to consist of nothing but sand. The natives call these "a pipia," which means "earth" or "ground." Some are tough and elastic, others brittle. They are the egg-bands either of species of Dorididæ, or of other Opisthobranchiate Mollusca, but I have not yet been able to identify them.

4. Onchidium.—One of the commonest Mollusca in the shallow water off the south-west shore of Rakaiya is a species of Onchidium. It is often found in the very heart of large friable stones, approximately at low-water mark, but sometimes further out. It occurs in other parts of Blanche Bay as well. What service the dorsal eyes can be to it is not easy to imagine. Semper supposed it was to enable the Onchidium to perceive and escape from what he says is its chief enemy, Periophthalmus. But although I have seen a small species of Periophthalmus at Rakaiya, on the muddy shore of the so-called lagoon, it is difficult to accept Semper's view.

The papillæ which carry the eyes are obviously homologous with the retractile branched respiratory papillæ in the posterior dorsal region, and every transition can be observed between them.

When kept in confinement in jars, Onchidium asserts its pulmonate qualities by often creeping out of the jars for long distances.

5. Larvæ of Polygordius and Squilla.—It is worth recording the presence of larvæ of Polygordius in the "Auftrieb" in Blanche Bay. In the narrow strait which separates

Rakaiya from the mainland I have taken one larva of Polygordius in an advanced stage of metamorphosis, when the long body has grown out behind the trochophore. On the same occasion the "Auftrieb" contained also larvæ of Squilla.

6. Phosphorescence.—The astonishing phosphorescence which is to be observed when fishing with the tow-net at night in Blanche Bay is in large measure due to Copepods and Ostracods.

7. Ascidians.—The Ascidian fauna here is richer than I expected to find it, since, as Herdman has pointed out, the tropics are not the metropolis of the Ascidians.

The Didemnidæ, which form one of the most difficult groups of compound Ascidians from a systematic point of view, are strongly represented by red, white, yellow, and green varieties.

Botryllus also occurs, though not common. I only know at present of two species—one very thin and white, attached to the lower surface of corals; the other thicker and purple, found growing on a Tridacna shell.

In regard to the compound Ascidians, I have been struck by the apparent absence of any member of the Polyclinidæ.

The simple Ascidians are represented by numerous species, one of which especially has peculiarities of such a nature that I will describe it at some length, reserving an account of the other Ascidians for a future occasion.

8. Styeloides eviscerans, n. sp.—In 1885, Sluiter described, in the 'Natuurkundig Tijdschrift voor Ned-Indie,' Bd. xlv, a simple Ascidian, under the name of Styeloides abranchiata, n. gen. et sp., in which the branchial sac and intestine were absent. Such was the condition of the animal in other respects that Sluiter was led to suppose that this must be the normal state of things, and founded the new genus accordingly.

In his extremely useful "Revised Classification of the Tunicata" ('Journ. Linn. Soc. Zool.,' vol. xxiii), Herdman, commenting on this species of Sluiter's, says, "This is such an exceptional and remarkable case that I cannot help suspecting that the single specimen examined by Sluiter was merely an individual abnormality."

I venture to hope that I have found the solution to this enigma in the species about to be described.

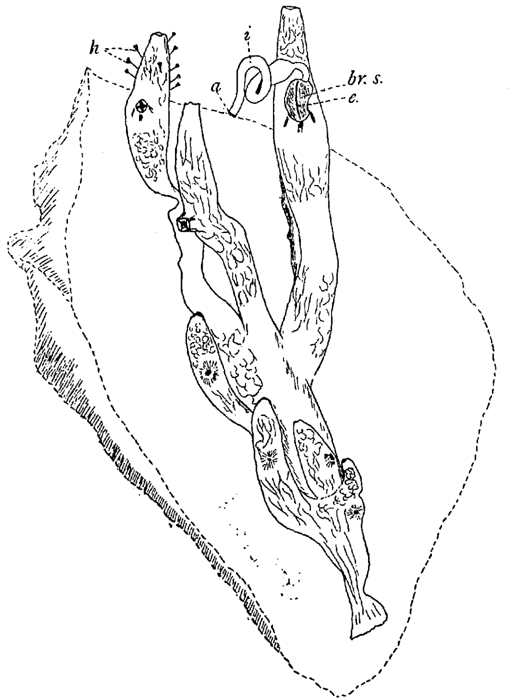


FIG. 12.—Group of seven individuals of Styeloides eviscerans, n. sp. represented as lying attached to the surface of a fragment of stone. In the large individual to the right the digestive tract is indicated in process of extrusion through the atrial aperture. *a*. Anus with frilled margin. *i*. Intestine. *br. s.* Branchial sac. *e*. Endostyle. *h*. Foreign organisms attached to test.

The species is not common, but I have obtained three or four examples of it from the lower surface of stones off the south-west shore of Rakaiya, in one half to one fathom of water.

The accompanying sketch (Fig. 12) represents a fine and typical group of individuals of this species. The members of the group are so intimately connected together by the mutual fusion of their tests that one would at once suppose that they had arisen from a parent stock by budding. Such, however, is not the case, since by making incisions it is found that it is only a fusion of test-substance, and not a true organic union. Moreover sometimes isolated individuals are to be found, as in Fig. 13.

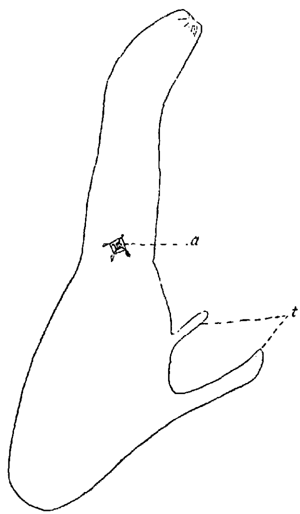


FIG. 13.—Styeloides eviscerans. Outline of isolated specimen. *a*. Atrial siphon. *t*. Processes of test.

The general colour of the animal or group of animals is a characteristic dull reddish brown, the colour being more pronounced in the neighbourhood of the apertures, while the lips of the latter are a pure dark red, interrupted by four light streaks which indicate the quadripartite character both of the buccal and atrial orifices.

As seen in the figures, the individuals are not always attached to the rock by the same side, but sometimes by the ventral side, sometimes by the right, and sometimes again by the left side (Fig. 12).

The total length of the group represented in Fig. 12 was 91·5 mm., and the greatest breadth of the group 31 mm. The animal of which an outline is given in Fig. 13 measured 51·5 mm. in length, and the atrial opening was 20·5 mm. removed from the buccal aperture. By its external appearance alone it is an extremely well-marked species. The surface of the coriaceous test is in some places wrinkled and in other places smooth.

The most remarkable peculiarity of the new species, however, is the faculty which it possesses of evisceration.

After I had had them for a short time in a vessel where everything was fresh and in good condition, I suddenly discovered a number of digestive tracts lying at the bottom. On then inspecting the Ascidians, of which there were several species present at the time, I found that they were all living and in a healthy condition.

Eventually I actually observed the process of evisceration taking place (cf. large individual to the right in Fig. 12). It takes a rather long time before the process is completed. It is effected by violent periodic contractions of the atrial siphon. After it is over the animal presents a perfectly normal and healthy appearance, opens and closes its siphons, and is susceptible to irritation and to the influence of cocaine. So constant is this ejection of the digestive tract that if it is desired to preserve specimens intact, they must be placed in alcohol immediately after capture.

The dissection of an individual which has ejected its branchial sac and intestine discovers no laceration whatever; and undoubtedly, in ignorance of the habit of evisceration, one would be tempted to suppose, as Sluiter did, that the absence of an alimentary canal was the normal condition.

In adopting Sluiter's generic name the diagnosis must of course be amended.

Before evisceration takes place the branchial sac is found to have the usual vascular connections with the mantle, but the endostylar area seems to have a very loose attachment to the mantle, and can be readily detached. When the branchial sac is ejected the dorsal tubercle (Figs. 14 and 15) and peripharyngeal groove are left behind, and there is a corresponding triangular excision in the wall of the ejected branchial sac.

FIG. 14.

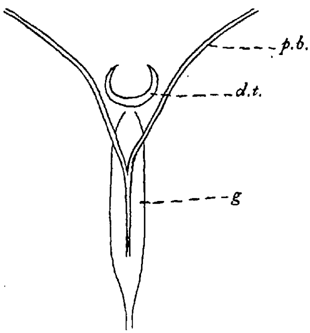


FIG. 15.

FIG. 14.—Styeloides eviscerans. Dorsal tubercle. *p. b.* Peripharyngeal band. *d. t.* Dorsal tubercle. *g.* Ganglion.

FIG. 15.—Dorsal tubercle of another individual of S. eviscerans.

The dorsal lamina is a simple undulating or crumpled membrane, and there are four folds of the wall of the branchial sac on each side.

The genital saccules have the characteristic subcylindrical form, and occur on both sides attached to the mantle. Curious bodies called endocarps, whose nature I do not understand, also occur on the inner surface of the mantle as in Sluiter's species.

The latter is probably a distinct species from the one I have described, although there are many features common to them both, particularly the external form and mode of attachment.

I am a little puzzled to understand what Sluiter says about the endostyle, and am inclined to think there must be some mistake about it, as there is no trace of a typical endostylar epithelium in the section figured by him. I have even observed a line or ridge in the ventral surface of the mantle corresponding very closely to his Taf. viii, fig. 2, but this possibly represents the former line of contact between the endostyle and the mantle.

There are naturally a great many more questions to be answered in connection with this remarkable Ascidian, but I have probably said enough to show that its property of evisceration is its most distinguishing peculiarity, and thus to afford an explanation for an otherwise inexplicable anomaly.

Yours very truly,
ARTHUR WILLEY.

RALUM, GERMAN NEW GUINEA,
viâ SINGAPORE;
September 24th, 1895.

DEAR PROFESSOR LANKESTER,

1. Significance of the Siphuncle in Nautilus pompilius.

Being desirous of obtaining, if possible, experimental evidence as to the physiological significance of the siphuncle in the pearly Nautilus, I have made several successful attempts to cut the siphuncle without otherwise injuring the animal. The evidence supplied by the experiment cannot be regarded as conclusive, on account of the altered conditions of depth and temperature to which the Nautilus is exposed by being brought up to the surface, but it may be well to consider what the results indicate.

At first I sawed through the shell into one of the chambers, and then cut the siphuncle. This method has the disadvantages of injuriously affecting the efficiency of the chambers, and of causing a more or less considerable loss of blood to the animal. The latter will, however, live in confinement about as long as untouched individuals.

A young Nautilus operated upon in this way on June 26th was placed in the sea in shallow water, for its movements to be watched. It sank slowly to the bottom, and then for a long time made active revolving motions about the vertical axis, but scarcely made any progressive movements.

On another occasion (July 10th), after several trials, I found that the best way of performing the operation is to saw through the shell in the neighbourhood of the posterior portion of the body of the animal, over the cardiac region, and not to tamper with the chambers. If the shell be held mouth downwards, this point lies approximately in the same vertical and transverse plane with the points where the free margin of the mouth of the shell merges into the umbilicus. When a large enough hole has been made in the shell to admit the scissors, the shell being still held upside down, the ventral visceral portion of the body usually detaches itself from the shell, or can be readily caused to do so, and, sinking inwards, exposes the root of the siphuncle, which can then be severed. On returning the shell to its normal position the body immediately resumes its normal intimate contact with the wall of the cavity in which it lives, and the pressure so exerted prevents any extensive loss of blood. Under these conditions the operation does not, as a rule, appear to affect the vitality of the animal in any degree.

A Nautilus[1] which was treated in this way on July 10th, on being placed in the sea swam about very vigorously for some time in the middle stratum of water, but most of the time at a little distance from the bottom. On September 13th I operated on four more individuals taken in Talli Bay, on

[1] It should perhaps be mentioned that in this particular individual I accidentally cut into the last chamber, and plugged the opening with wax.

the north coast of the Gazelle peninsula. One of them showed a tendency to sink to the bottom, which it always performed very gradually. In this one I had accidentally punctured the mantle over the heart. The others remained floating and swimming about on the surface during the whole time of observation. They did not go far in one steady direction, but tended to go in circles, as in fact did another one whose siphuncle was uncut. If one of the individuals floating at the surface was forced down to the bottom with a hand-net, it would slowly rise to the surface again. This also often happens with a Nautilus that has not been operated on.

The results indicated by the above experiments, which, it may be added, are worth repeating, may be summarised as follows:

The cutting of the siphuncle (α) does not temporarily affect the vitality of the animal; (β) does not prevent it from making movements of translation;[1] (γ) does not prevent it from floating at the surface; (δ) does not prevent it from sinking to the bottom.

It still remains to be ascertained whether a Nautilus whose siphuncle has been cut, having sunk to the bottom of the sea in shallow water, will undertake a journey to the surface. My experiment of July 10th would seem to indicate that this might be expected to occur.

The above experiments do not appear to oppose the view which I expressed in a former communication—that the siphuncle of Nautilus pompilius is, in some measure, of the nature of a vestigial structure.

It might indeed be legitimate to suppose, on the principle of the correlation of organs, that in the Nautiloidea the course of evolution has led to a reduction of the siphuncle pari passu with an increase in the efficiency of the chambers as hydrostatic organs.

[1] In speaking above of progressive movements I mean, of course, in the usual backward direction.

2. Some Features in the Arterial System of N. pompilius, as determined by Injection.

(1) Circulus Pallialis.—After successful injections a singular feature in the circulatory system is to be observed. The marginal pallial artery, which I described and figured in a former note, is found to pass on each side, dorso-laterally, into a branch of the dorsal aorta, so that a complete arterial circuit is produced.

I have even partially injected the marginal pallial arteries from the dorsal aorta itself, but the injection fluid did not proceed very far in this centripetal direction, owing no doubt to the resistance it met with from the action of the heart.

For this remarkable arterial circuit, produced by the confluence of the marginal pallial arteries, which arise ultimately as branches from the so-called "lesser aorta," with a pair of branches[1] from the great aorta, I propose the above name of "circulus pallialis." It is illustrated in the accompanying sketches (Figs. 16 and 17).

In Fig. 16 the posterior convex extremity of the body is supposed to be somewhat tilted up, in order to show the whole outline of the septum-producing area of the mantle. This outline is very distinct in fresh specimens, and the region of the mantle enclosed by it is distinguished from the surrounding portions of the mantle by its greater thickness and opacity. As already stated, this is the portion of the mantle which manufactures the septa, and it has an abundant arterial supply through the ramifications of the two main branches of the posterior pallial artery. These ramifications may be grouped together as the pallio-septal arteries; and it is surprising to see how rigidly they are confined within the septal contour.

It will be noticed that the latter makes on each side a

[1] For reasons which will presently appear, these may be called the pallio-nuchal arteries.

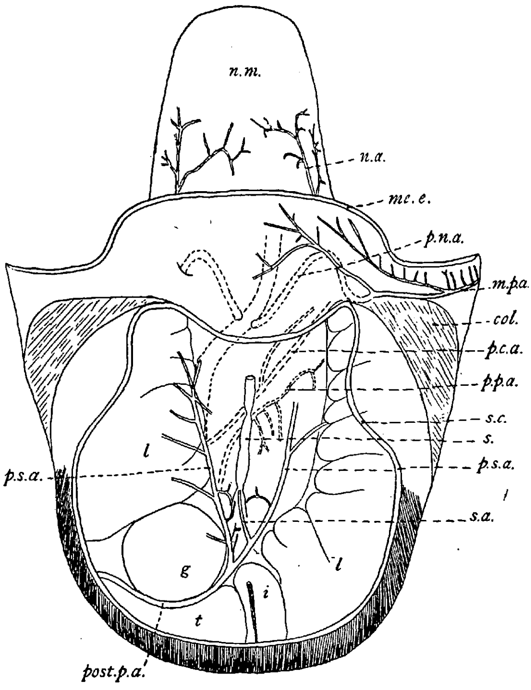


FIG. 16.—N. pompilius, ♂. Dorso-posterior aspect of visceral region, to illustrate the circulus pallialis and the septal contour. *n. m.* Nuchal membrane. *n. a.* Nuchal artery. *m. e.* Free mantle-edge. *p. n. a.* Pallio-nuchal artery. *m. p. a.* Marginal pallial artery. *col.* Columellar or shell muscle. *p. c. a.* Posterior columellar artery. *p. p. a.* Posterior proventricular artery. *s. c.* Septal contour. *s.* Siphuncle. *p. s. a.* Pallio-septal arteries. *s. a.* Siphuncular artery. *l.* Liver. *i.* Intestine. *t.* Testis. *post. p. a.* Posterior pallial artery. *g.* Gizzard.

N.B.—The dorsal aorta and its branches are indicated by dotted lines. They show dimly through the skin when injected.

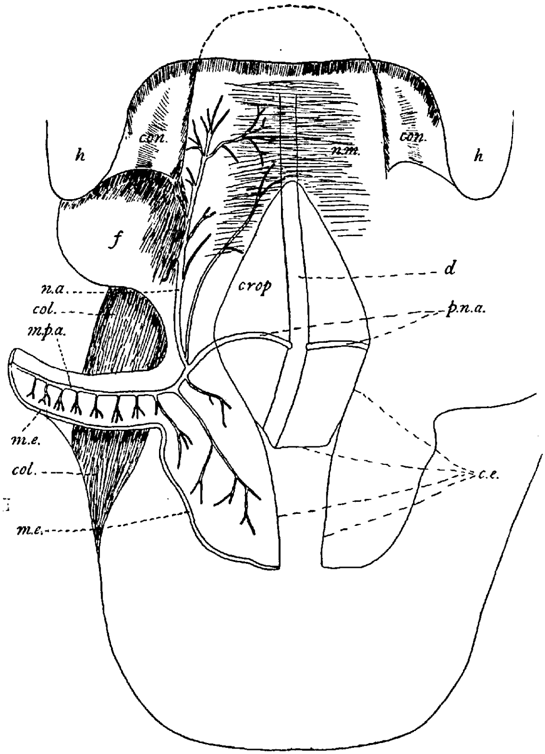


Fig. 17.—N. pompilius, ♂. View of nuchal region, to further illustrate the circulus pallialis. The dorsal free mantle-edge is reflected and a median incision made. *h.* Hood. *con.* Concavity at base of hood, in which the nuchal membrane (*n. m.*) lies. *f.* Dorso-posterior portion of funnel. *n. a.* Nuchal artery. *col.* Columellar muscle. *m. p. a.* Marginal pallial artery. *p. n. a.* Pallio-nuchal arteries. *d. a.* Dorsal aorta. *m. e.* Free mantle-edge. *c. e.* Cut edges of mantle and body-wall.

N.B.—The dorsal aorta shapes its course in this region in accordance with the state of repletion of the crop.

symmetrical figure with the outline of the great shell-muscles[1] where the latter abut on the shell.

In Fig. 17 the union of the marginal pallial artery with the left pallio-nuchal artery is represented from the inner surface of the mantle. Here it is seen that the two arteries unite in the dorso-lateral angle where the mantle and the funnel-flap fuse with the body-wall; and furthermore, that from the same point an artery is given off which passes forwards and gives off branches to the nuchal membrane. The latter structure was accurately described by Owen as a "semilunar ridge" lying in the concavity at the base of the hood, and applied to the involute convexity of the shell.

Owen thought it might serve to prevent the shell from encroaching too much upon the hood "in the act of creeping." We now know that the animal does not creep on its hood with reversed shell.

The nuchal membrane would seem to be responsible for the dense black colour of the involute portion of the shell, and possibly also exerts a lubricating influence. Keferstein calls it the "Nackenlappen."

(2) Genital Arteries (Fig. 18).—No less than three arteries arise directly from the heart which, to my knowledge, have hitherto escaped attention. They are (*a*) the artery of the genital duct or gonaducal artery; (*b*) the artery of the genital gland or genital artery; (*c*) the artery of the pear-shaped gland.

The accompanying sketch (Fig. 18) obviates the necessity of a detailed description. The genital artery is submedian, and the main trunk lies on the dorsal side of the genital gland.

Both the gonaducal artery and the artery of the pear-shaped gland give off a branch which passes into the perigonadial membrane, and this apparently trifling fact, combined with the subsymmetrical relations of the gonaduct and the pear-shaped gland, may indicate that the latter is the metamorphosed genital duct of the left side, and not, as I believe has been

[1] For purposes of nomenclature it will be found convenient to speak of the great shell-muscles as the columellar muscles.

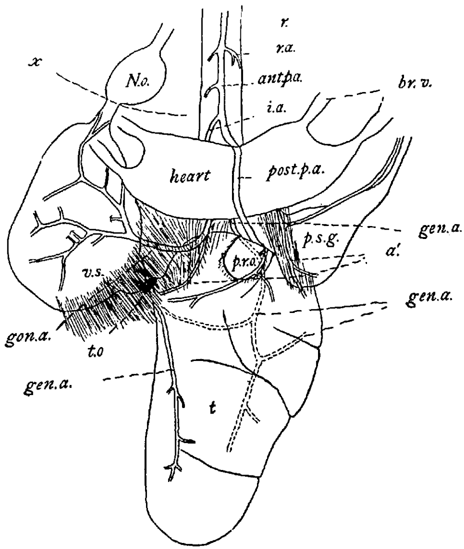


FIG. 18.—N. pompilius, ♂. Genital arteries from below. *r.* Rectum. *r. a.* Rectal artery. (N.B.—The rectal arteries are very variable.) *ant. p. a.* Anterior pallial artery. *i. a.* Intestinal artery. (N.B.—This artery usually passes to the right of the rectum, as shown in this figure; but in one instance I have observed it to pass down to the left of the rectum.) *br. v.* Branchial veins. *post. p. a.* Posterior pallial artery. *p. s. g.* Pear-shaped gland with its artery. *a'.* Branches of the preceding artery and of the gonaducal artery, which supply the superjacent perigonoidal membrane. *gen. a.* Genital artery and its branches. *t.* Testis. *t. o.* Aperture of testis. *p. v. o.* Orifice of communication between the pericardial and visceral portions of body-cavity, through which the posterior pallial artery passes. *gon. a.* Gonaducal artery. *v. s.* Vesicula seminalis. (N.B.—This structure, the testis and pear-shaped gland are closely united to the heart by a membrane.) *N. v.* Needhamian vesicle or spermatophore sac. *x.* Dotted line to indicate where the pallial duplicature merges into the body-wall ventrally.

suggested, the morphological equivalent of an entire left genital apparatus.

In the female the ramifications of the genital artery pass up on to the surface of the individual ova, and form a kind of capillary system, the finer branches following, but not always confined to, the reticular markings formed by the ridges of the follicular membrane which project into the yolk (Figs. 4 and 5).

The meshes formed on the surface of the ova by the intersection of the follicular ridges or plications are much wider in submature ova than in the less mature, and the ridges would presumably be found to flatten out in completely ripe eggs, although it has not been my good fortune hitherto to have found any such. At the animal pole of the egg the ridges are absent, and those which lie at the margin of this area form incomplete meshes as described by Kölliker in the ovarian ova of other Cephalopods (Fig. 19).

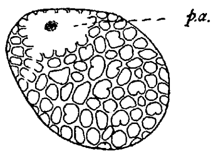


FIG. 19.—Fresh ovarian ovum of N. pompilius, to show the reticular markings produced by the plications of the follicle. *p. a.* Clear polar area, in the centre of which lies the germinal tract.

The clear polar area of the ovum has usually a subtriangular shape, and from each of the corners of the triangle what may be called a line of weakness occurs in the follicular wall, bound on either side by incomplete meshes (Fig. 19).

The arteries which traverse the surface of the ova give off minute branches which pass inwards, as it were, into the depths of the follicular ridges; and these deep-lying vessels anastomose with one another, while the superficial branches appear, as a rule, not to form anastomoses. It may be added that the impression of anastomoses is much more readily conveyed by examination with a hand-lens than it is by the use of the compound microscope.

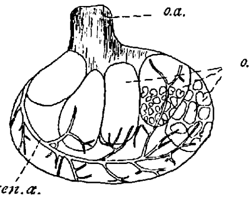


FIG. 20.—Ovary removed from body, and seen from dorsal aspect. On the right of the figure the follicular meshes of a submature and a half-mature ovum are partially inserted to show difference in size. *o. a.* Neck of ovarian sac, which bears the aperture. *o.* Ova. *gen. a.* Genital artery. Only the more superficial branches are indicated.

The germinal tract appears in the centre of the clear polar area as a faint whitish spot, and is turned towards the ventral aspect of the ovary (Fig. 20). The older ovarian ova are rendered shapeless by mutual pressure, with, however, a roughly oval outline. In this condition an ovum may measure 15·5 mm. in length, with a breadth of 11·5 mm. When the pressure is released by slitting open the ovary the ova round up, and those which are submature have an average diameter of some 10 mm. The yolk is viscous and glutinous, and possesses a translucent brownish tinge. The nearly ripe ova rupture with the utmost facility.

From a consideration of the size and relative states of maturity of the ova, it might be expected that they are laid singly. Every month, from December to September inclusive, I have been able to obtain over-ripe males (with spermatophores in the dorsal buccal recess and in the Needhamian vesicle) and submature females. Once in July I obtained a male with a discharged spermatophore capsule in the buccal recess; in fact, I have found this more than once.

From these facts, and from the fact which I have previously mentioned of the relative scarcity of the females in comparison with the males, I draw three provisional conclusions: firstly, that during the process of reproduction (fecundation

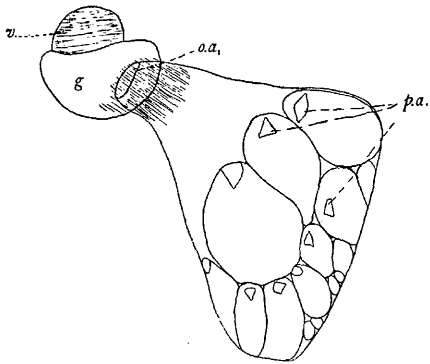


FIG. 21.—Female genital organs of N. pompilius, seen from below, to show the direction in which the polar areas of the ova lie. *p. a.* Polar areas of ovarian ova. *o. a.* Aperture of ovarian sac. *g.* Uterine portion of oviduct. *v.* Vaginal portion of oviduct.

and spawning) the females live in retirement; secondly, that the females practise what the Germans call "Brutpflege;" and lastly (what I regard as almost certain), that reproduction takes place all the year round.

(3) Cephalic Arteries (Figs. 22 and 23).—For a description of these arteries it will suffice to refer to the explanation of the figures. I will, however, call attention to the variability of the right and left anterior proventricular arteries; the latter was absent from the individual represented in fig. 7. The two main trunks into which the dorsal aorta divides behind the brain may be called the right and left innominate arteries.

It is a singular fact that the great median buccal artery always springs from the right innominate artery. The constancy of this origin would seem to indicate that it is potentially a paired structure.

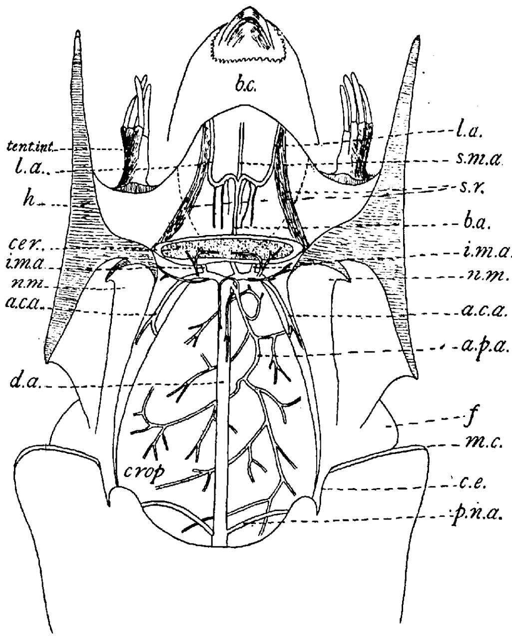


FIG. 22.—N. pompilius, ♂. Dissection, from above, of the cephalic region to show the cephalic arteries. An incision has been made through the nuchal membrane, the hood, and the buccal membrane. The brain-capsule has been opened, and the median portion of the mantle behind the nuchal region has been removed. *b. c.* Buccal cone. *tent. int.* Dorso-lateral inner row of tentacles (the superior labial processes of Owen). *l. a.* Labial arteries supplying the buccal membrane and fringe. *s. m. a.* Superior mandibular artery. *s. r.* Superior retractor muscles of the jaws (Owen). *b. a.* Buccal artery. *i. m. a.* Paired inferior mandibular arteries. *n. m.* Nuchal membrane. *a. c. a.* Anterior columellar artery. *a. p. a.* Anterior proventricular artery. *f.* Dorso-posterior portion of funnel. *m. e.* Free mantle-edges *c. e.* Cut edge of mantle. *p. n. a.* Pallio-nuchal artery. *d. a.* Dorsal aorta. *cer.* Brain with cerebral arteries. *h.* Cut edge of hood.

N.B.—Apart from the cerebral arteries, all the anteriorly directed branches of the innominate arteries pass below the cerebral capsule.

Attention may also be drawn to the two arterioles which arise from the base of the right proventricular artery and supply the wall of the dorsal aorta.

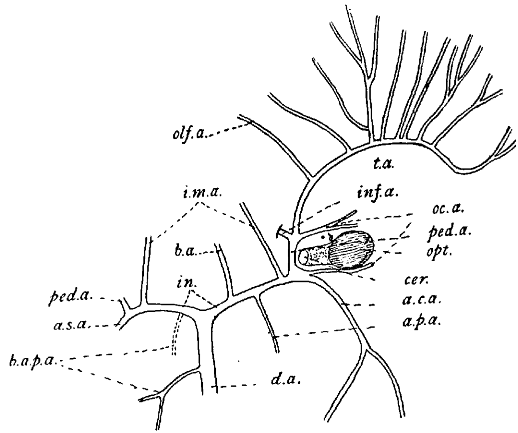


Fig. 23.—N. pompilius, ♂. Sketch to show the arteries which arise from the innominate arteries after the brain has been cut through. *t. a.* Right tentacular artery, which gives off branches to all the tentacles of its side. The innermost or mesiad branch (*olf. a.*) supplies the bipartite laminated organ of van der Hœven, which possibly represents a pair of inferior labial processes, and may have an olfactory function. *inf. a.* Infundibular artery, which passes through the cartilage into the funnel. The latter also receives minor branches from the columellar arteries. *oc. a.* Arteries to the eye. *ped. a.* Pedal artery, a convenient name for the common trunk from which the infundibular and tentacular arteries arise. *opt.* Optic ganglion. *cer.* Brain cut across and drawn aside. *a. c. a.* Anterior columellar artery. *a. p. a.* Right anterior proventricular artery. Compare its origin in Fig. 7, where it arises from the aorta. *d. a.* Dorsal aorta. *l. a. p. a.* Left anterior proventricular artery, usually but not invariably present; it sometimes arises from the left innominate artery, as indicated by the dotted lines; and sometimes, as in this example, from the dorsal aorta. *in.* Innominate arteries. *b. a.* Buccal artery. *i. m. a.* Inferior mandibular arteries.

3. Further Remarks.

(1) Capillaries.—As far as I have been able to observe, there seems to be a true capillary system in the free portion of the mantle, that is to say, in the pallial duplicature. I have previously described the pallial arteries and veins. There may be another system of capillaries in the funnel, which has

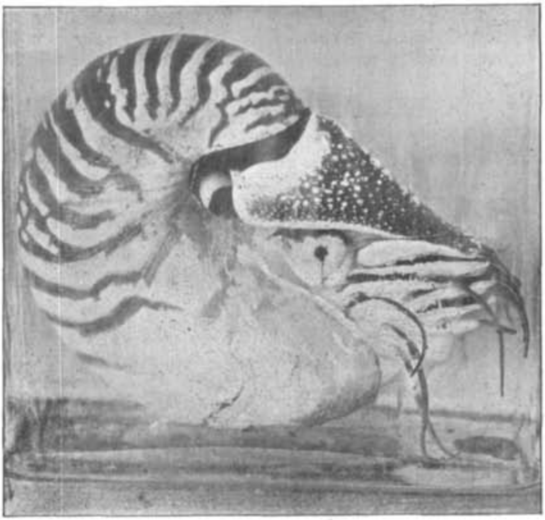


Fig. 24.—Photograph of a living specimen of Nautilus pompilius, taken by A. Willey at Ralum in 1895.

an astonishingly rich vascular supply, and at whose base two large veins, the infundibular veins, may be observed to pass into the vena cava. But I have observed no veins in connection with the genital organs, and I gathered from microscopic examination that the follicular arteries on the surface of the ova possessed free openings.

(2) Blood.—I will here only mention that the blood is a syrupy fluid with a pronounced blue tint, which becomes very dark on exposure to the air. The corpuscles comprise amœboid and fusiform cells, the latter being somewhat Gregarina-like in appearance.

Yours very truly,

Arthur Willey.