

teraliter suspensa, anatropa. *Stylus* cum *stigmatē* confusus, demum subreniformi-discoideus, parvus, subconcavus. *Fructus* ignotus.—*Frutex Guianensis*; folia alterna, oblonga, majuscula, glaberrima, petiolata; racemi axillares, divaricatim ramosi; flores parvi, cum pedicellis articulati.

1. *Discophora Guianensis*;—omnino glaberrima, ramulis teretibus, substriatis; foliis oblongis, utrinque acuminatis, apice lineari-angustatis, coriaceis, supra nitidis, nervis sulcatis, venis immersis, subtus fuscis, nervis rubentibus cum venis transversis prominentibus, punctis minutis resinosis notatis, margine revolutis, petiolo incurvo canaliculato; racemis axillaribus petiolo 2–3-plo longioribus, dichotome et divaricatim ramosis, pedicellis bracteatis, bractea oblonga obtusa crassiuscula pubescenti, floribus cum pedicello articulatis.—Deme-rara.—v. s. in herb. Hook. (Parker).

The branches are terete with a smooth bark; the axils are $1\frac{1}{2}$ to 2 inches apart; the leaves are quite smooth, thick, and coriaceous, 8 inches long, $2\frac{1}{2}$ inches broad, on a petiole of $\frac{1}{2}$ to $\frac{3}{4}$ inch in length: a raceme about $1\frac{1}{2}$ inch long springs out of each axil, sending out from the base upwards several alternate branches at nearly right angles, which are again divided; the branchlets and pedicels are slightly pubescent and furnished at their base with a short, obtuse, fleshy bract, covered with short fine hairs; the ovarium is 4 lines long, $1\frac{1}{2}$ line diameter; the stigmatiferous disk is about one-third of the diameter of the ovarium; the calyx and petals are quite glabrous; the latter are linear, submembranaceous, marked with three parallel nervures, and are of a reddish yellow colour when dry*.

XIII.—Upon the genus *Doliolum* and its species.

By Dr. A. KROHN†.

[With a Plate.]

Quoy and Gaimard describe and figure in their work, the 'Voyage of the Astrolabe' (p. 599. pl. 89. figs. 25–28), a small crystalline Tunicary not 2 lines long, which they first discovered at Amboyna, and subsequently found again on the coast of Vanikoro. For this animal they created a genus, to which they gave the very appropriate name of *Doliolum*, placing it in the near

* A representation of this species, with analytical details, will be seen in plate 20 of the 'Contributions to Botany.'

† Wiegmann's Archiv für Naturgeschichte, 1852. — Translated by Thomas H. Huxley, F.R.S., Assistant Surgeon R.N.

neighbourhood of *Salpa*. The species was called *D. denticulatum*. I am not aware whether this animal has been since examined by other naturalists, although it occurs not unfrequently in the Mediterranean.

Once, on a previous occasion, I found it at Messina; but in the course of last spring I took it frequently at Naples, and persuaded myself that not only in point of structure (not very perfectly made out by Quoy and Gaimard), but also in development, it is decidedly an Ascidian. It is a free swimming Ascidian, which in many respects closely resembles the *Salpæ*, and so far forms an interesting transition between the two orders of the Tunicata. The genus, however, is not limited to this one species, as I discovered three other kinds at the same place and time.

Before proceeding to describe the different species, it will be desirable to consider what they all have in common.

The genus *Doliolum* is mainly characterized by the circumstance, that the body of the animal (as the name indeed indicates) resembles a cask open at each end. The anterior somewhat broader end is prolonged into a very short, often hardly perceptible tube, which answers to the ingestive or respiratory siphon of other Ascidians, and, like this, has its lip divided into a number of segments. These lobes, generally about ten in number, are somewhat pointed. At the opposite end, whose aperture represents the cloacal aperture of other Ascidians, the body becomes gradually narrower*.

The mantle is relatively very thin, and contains scattered granules in its substance. The second layer of the body (*Leibes-schicht*) is, as in all Tunicata, that which supports the nerves and muscles.

The nervous centre consists of a round ganglion placed in the middle of the dorsal surface; from it three anterior and as many posterior branches proceed. Two of these pass divergingly to the sides of the body, the third runs along the median line. The muscular apparatus closely agrees with that of *Salpa* in its arrangement. It consists, according to the species, of either eight or nine flat bands, which, like hoops, encircle the body at tolerably regular intervals, and so give it a still stronger resemblance to a little cask.

The anterior band surrounds the base of the respiratory siphon, the posterior immediately encircles the margin of the posterior aperture. Both are less strongly marked than the other bands.

With regard to the internal organs, the respiratory apparatus

* The two apertures are diametrically opposite likewise in the *Pyrosomata*; and here also the cloacal aperture, which opens into the cavity of the common mass, has a smooth edge (see Savigny, Mém. sur les Anim. sans Vertèbres),

presents the most striking deviation from the ordinary arrangement. Instead of a sac, it forms a partition stretched across the cavity of the body, flat in one species, bent at an angle in another; and dividing the space into an anterior and a posterior compartment.

Its structure is much simpler than that of the compound Ascidians, since it is pierced by only two series of symmetrical, transverse, or somewhat oblique clefts ("*stigmata branchiaux*," Milne-Edwards), the edges of which are, as in all Ascidians, beset with cilia. In the median portion of the branchial membrane the clefts are wider, beyond it they narrow again.

These clefts then are the only means of communication of the anterior and posterior divisions of the cavity of the body with one another.

Upon the walls of the anterior division, the ciliary apparatus for conducting food to the mouth is arranged; *i. e.* the well-known ventral groove and its prolongations, which are less known, and may be here more minutely described. The anterior end of the relatively short ventral groove gives off two narrow ciliary bands, which diverge from one another and run up at the base of the respiratory siphon, along the parietes of the cavity of the body to the dorsal surface; here, converging towards one another, they become united in front of the nervous ganglion. A third ciliated band runs from the posterior extremity of the ventral groove to the mouth*.

Upon the wall of the posterior space lie the reproductive organs and the alimentary canal; and anteriorly to the latter, in its pericardial cavity, the heart, which pulsates very rapidly, and is, as in the *Salpæ*, a short sac. The circulation and the course of the blood are not to be perceived, as the blood is pellucid and contains no granules.

The alimentary canal is but moderately developed in proportion to the size of the body. The mouth is placed upon the branchial membrane, upon the great longitudinal ridge between the lateral clefts. It leads into a short œsophagus, to which the rounded stomach with the intestines bent into a loop succeeds.

Like the compound Ascidians and the genus *Clavelina* among the simple forms, *Doliolum* propagates both by ova and by buds.

* A similarly constructed ciliary apparatus is to be found in all Tunicata, according to my investigations. The anterior ciliated band, forming a complete circle, has been described by some zoologists as a vascular ring, sometimes as a nervous ring. So also an accessory part of the same apparatus, especially frequent in the *Cynthiæ* as a rounded prominence, has been regarded sometimes as a nervous centre, sometimes as an organ of peculiar structure and doubtful function (see Siebold, *Vergleichende Anatomie*, p. 260). This elevation is distinguished, however, by no other circumstance, than by being marked upon its surface by a spiral ciliated groove.

But while in the former this double means of multiplication is allowed to each single creature, in the latter each generation possesses only a single mode; so that, as in the *Salpæ*, the first generation propagates by ova, and the second multiplies by budding, the third again producing ova, and so on in a continual alternation. In support of this view I may adduce the fact, that on examining a certain number of adult individuals of the same kind, in some, generative organs are always found, in others only a *stolo prolifer*—the producer and bearer of the gemmæ. Further evidence will be adduced in the section upon Development.

In the sexual generation the male and female organs are sometimes united in the same, sometimes carried by different individuals. The gemmarium (*keim-stock*) of the asexual individuals is a short, cylindrical, somewhat curved, posterior process, which arises close in front of the posterior aperture and exactly in the middle line; in some species upon the dorsal, in others upon the ventral side. It can be moved to a slight extent, by one of the posterior muscular bands, which appears to be peculiarly modified for this purpose in all asexual individuals; of which more by and by. The buds, whose number is but small, are developed only from the extremity of the gemmarium, along which we find them arranged one behind the other as more or less projecting prominences.

The asexual generation, developed from ova, has to undergo a metamorphosis. As in other Ascidians the larva is Cercariform.

All the species move by jerks, as Quoy and Gaimard state; by a sudden contraction they dart forwards, and then remain at rest for awhile.

Description of Species.

A. Species with eight muscular bands and the gemmarium ventral.

1. *Doliolum denticulatum** (Q. & G.).

The branchial membrane is bent into a sharp angle projecting backwards, and extends further than in the succeeding species. Its upper half reaches as far as the second muscular band, and at times beyond it; the lower half extends as far as the third muscular band only.

The mouth is placed upon the lower half of the branchial membrane; from it the œsophagus passes in a curved direction backwards and downwards to the deeper-seated stomach. The intestine describes a wide arc, passing at first backwards and

* This specific denomination is unfitting, since in the other species the anterior aperture is toothed. I propose therefore for this species the name of *D. Ehrenbergii*.

eventually upwards upon the right side of the cavity of the body.

In the sexual individuals of this species I have only been able to discover the males, and I thence presume that the sexes are separate. The male apparatus lies upon the left lateral wall of the posterior cavity, and consists of a testis and a relatively long and wide seminal canal. This canal is commonly distended with spermatozoa, and extends as far as the fourth muscular band. The testis is composed of single rounded lobes, which, like the folioles of a rosette, are grouped round the commencement of the seminal canal.

As to the asexual individuals, the change in the arrangement of their muscular bands produced by the development of the gemmarium, consists in the separation of the ends of the penultimate band; the narrow and pointed extremities of which run for some distance upon the base of the gemmarium. Fully developed individuals of this kind attain the length of 2 lines or a little more.

2. *Doliolum Mülleri* (Krohn).

This species is wider in the middle, and thence resembles a more squat cask. The mantle is very soft and almost mucilaginous, so that foreign bodies readily become imbedded in it. The branchial membrane has the form of a vertical partition placed in the posterior part of the cavity of the body and slightly convex behind; there are about twelve pair of clefts. The mouth seemed to be nearer the lower half. The alimentary canal, on the other hand, is in the middle of the cavity, remote from either wall. The œsophagus descends towards the stomach, to which the short intestine succeeds, descending at first and then curving upwards in a loop.

The sexual individuals of this species are hermaphrodite. Close to the stomach and intestine we distinguish three structures closely applied to one another. The largest, the testis, is pyriform, and lies with its narrower end near the anus. The two other bodies are spherical; the one is filled with clear nucleated vesicles, which I consider to be germs; whence the whole must be regarded as an ovarium. The other body is unquestionably a fully developed ovum, in which we easily recognize the outer investment, the granular yolk and the germinal vesicle with its spot. In some individuals I found it free, in the posterior cavity of the body.

With regard to the asexual individuals I will only observe, that their penultimate muscular band is arranged similarly to that of the preceding species.

Varieties of this very common species, which is often met with

in swarms in March and April, have a red-spotted body, and the alimentary canal blue or pale red.

Fully grown individuals reach the dimensions of $1\frac{1}{2}$ line in length.

B. Species with nine muscular bands, and with the gemmarium upon the dorsal surface.

1. *Doliolum Nordmanni* (Krohn).

In form this species appears at first so nearly to approach *D. denticulatum*, that they may be readily confounded together. It is only upon more close examination that the characteristic differences in the branchial membrane and the number of the bands become obvious. The branchial membrane in this species forms a flat septum stretched obliquely from above and behind, downwards and forwards across the cavity of the body, with only four pair of clefts. The mouth is exactly in the centre of the branchial membrane. The alimentary canal in all respects resembles that of *D. Müllerii*.

I have nothing to say about the generative organs and the sexual relations, since all the individuals observed were asexual. With respect to the gemmarium I must observe, that a peculiar filiform, transversely annulated, or rather wrinkled appendage is attached to its free extremity, which is found in no other species. The modification of the arrangement of the muscular bands, which has been already referred to, affects here the ante-penultimate band, which, in consequence of the position of the gemmarium, is open above.

This is the smallest of the species, since in its full-grown state it is not more than 1 line in length.

2. *Doliolum Troschelii* (Krohn).

I have but rarely observed this species. It is much larger than that just described, as I have met with individuals more than 3 lines in length. Upon the whole it resembles *D. denticulatum* and *Nordmanni*, only that the body is more elongated. It is especially remarkable from its singularly broad muscular bands*. The alimentary canal is quite similar to that of the preceding species; but of the branchial membrane I can say nothing, since it was accidentally absent in all the specimens, having been probably injured and torn off in some manner.

* Upon superficial examination, this species, on account of its broad muscular bands, might readily be taken for a very young *proles solitaria* of *Salpa punctata* (Forskahl). Among the *Salpæ* observed by me at Messina (Annales des Sciences Nat. 1846), this solitary *Salpa*-form is the only one all whose muscular bands form complete and relatively very broad circles.

Sexual individuals were not seen. In the asexual ones the ante-penultimate muscular band has the same arrangement as in *D. Nordmanni**.

Development and Metamorphosis.

The development of the buds was observed in *D. Mülleri*, but presented no remarkable feature. The buds shoot one after another, as it seems, from the gemmarium, for the outermost is always the largest, and often already changed into a young Ascidian, whilst the others are far behind in their development, and indeed the more, the greater their distance from it. Buds which are so far developed as to allow the majority of the organs, and among the rest the swiftly pulsating heart, to be distinguished, are placed vertically (like those of the Compound Ascidians and Clavelinidæ according to Milne-Edwards), with the anterior extremity forwards, and are attached to the gemmarium by a short pedicle. This pedicle is inserted upon the abdominal surface close below the alimentary canal; when the bud is detached it falls with it, and subsequently wholly disappears. Such recently detached budded forms may be so far confounded with young asexual individuals, inasmuch as their pedicle may be readily taken for the little-developed and as yet budless gemmarium, which has the same form and position. More close examination, however, will eliminate this error, since all free bud-forms already exhibit the rudiments of the sexual organs.

The asexual individuals developed from ova are born, as has been said, in the form of Cercaria-like larvæ, and therefore undergo a metamorphosis. This metamorphosis is characterized, however, by many peculiarities, whose explanation is only to be found in the mode of life of the adult animal. It is well known that in the larvæ of the fixed Ascidians, the tail very soon disappears, as an organ which has become useless, when the larva has found a fitting locality in which to fix itself. Only after this has taken place does its body become gradually changed into the perfect animal.

In *Doliolum*, on the other hand, which, as we have seen, is a free swimmer, there is no need for the tail to disappear so soon;

* I must leave it undecided whether the cask-like Tunicary with eight muscular bands, but much larger than *D. denticulatum*, which is described by Quoy and Gaimard as *D. caudatum* (l. c. p. 601, pl. 89. fig. 29. & 30), really belongs to this genus. In the figure the one end of the body is indeed siphon-like, but its lip is without lobes. From the opposite extremity a dense pyramidal process projects, like the processes of many associated *Salpæ*. I should be inclined to regard the animal rather as a *Salpa* than as a *Doliolum*, especially since the completely circular muscular bands which it possesses, are, as we have seen above, no decisive criterion of the genus *Doliolum*.

it persists during almost the whole period of development of the new creature, serves as an organ of locomotion, and begins to wither away only when the young has reached its perfect development and independence*.

The tail, however, dies away quite as Milne-Edwards has already observed in the course of metamorphosis of *Amouroucium proliferum*, and as I a short time since observed in larvæ of *Phallusia mammillata* obtained by artificial fecundation.

The contractile central portion or axis of the tail, composed of a simple series of rectangular, nucleated cells, is gradually retracted from its sheath into the body of the young animal and so becomes gradually shorter and shorter. Soon the young animal casts off its larval investment, and only slight traces of the tail are left upon its ventral surface, close under the digestive canal, in the form of a round body which soon disappears.

The following observations will afford more detailed evidence of the above view; they were made upon separate, not yet fully developed individuals of *D. Nordmanni*.

To all these individuals the tail was still attached; in some it remained in all its integrity, while in others it had begun to disappear. The whole, tail and animal, was surrounded by the larval tegument, a very thick, glassy membrane, which must not be confounded with the mantle, which is closely applied to the body of the young animal. This could be readily distinguished from the homogeneous larval tegument by the granules imbedded in its substance. The larval tegument was about a line long, and drawn out at each end into a tolerably acute point. The relatively short and very thin tail, or rather its wasted axis, appeared articulated from the presence of the above-mentioned cubical cells, and external to these a thin muscular layer was perceptible, whose fibres ran longitudinally from the root to the point†. The root projects far into a vesicular appendage attached close under the intestinal canal, and filled with a clear fluid, which is probably only a dilatation of the second tunic (*Leibes-schicht*), and diminishing *pari passu* with the tail, collapses, and at length disappears. The young animal appears in most specimens to be already so far developed, that all the organs and the lobes of the anterior aperture (which are at first turned inwards, and only

* The animal described by Joh. Müller as *Vexillaria flabellum* (Archiv, 1846), and considered by him to be probably the larva of *Amouroucium proliferum*, is, according to my observations, an incompletely developed Ascidian, whose tail, as in *Doliolum*, appears to persist until the perfect form is nearly assumed. The perfect, as yet unknown animal will probably be found to agree with *Doliolum* in its mode of life.

† This layer of fibres seems to be wanting in no Ascidian larva. In the tail of the *Vexillariæ* it has been already quite correctly described by J. Müller. It perfectly accounts for the rapid movements of the tail.

subsequently unfold themselves and project) are visible. Upon the dorsal surface the rudimentary gemmarium had already made its appearance in the form of a conical projection. The young animal was not capable of any independent movement, and its tail was only seen at intervals slightly twitching and vibrating.

Final Remarks.

In the course of the preceding observations, the analogies which connect the genus *Doliolum* with the *Salpæ* have been referred to. These analogies consist not only in the similar mode of life, the similar diametrical opposition of the apertures, and especially in the similar muscular apparatus of each, but also, as I have endeavoured to show, in the similar mode of propagation, according to the laws of the Alternation of Generations, by which, as in the *Salpæ*, sexual and asexual generations occur in regular succession. Yet, in the genus *Doliolum* the typical characters by which the Ascidian is separated from the *Salpa* predominate; such are distinctly seen in the absence of the respiratory siphon, in the structure of the respiratory apparatus, and in the metamorphosis.

By their approximation to the *Salpæ*, and by the simpler structure of their branchiæ, however, *Doliolum* seems to me to stand lower than the Compound Ascidians; although, like the higher Ascidians, it is solitary, and, unlike them, it is free.

The Ascidians then, according to their mode of life, may be divided into fixed and free. To the former belong the numerous genera of simple and compound or aggregated Ascidians, to the latter the solitary genus *Doliolum* and the aggregate genus *Pyrosoma*.

Note by the Translator.

Dr. Krohn does not appear to have met with a memoir upon *Doliolum* and *Appendicularia* (*Vexillaria*) published in the 'Philosophical Transactions' for 1851. I have there described and figured *D. denticulatum*, and I am delighted to find that in all essential points, what I have stated is confirmed by one of the most accurate and careful of the German observers.

Dr. Krohn does not seem to have been more successful than myself in making out the ovaries of *D. denticulatum*; but I should hardly be inclined to adopt his supposition, that this species, in opposition to its immediate congeners, is dioecious; the explanation I have suggested (*loc. cit.* p. 601) seems to me still to be the more plausible.

It will be observed that Dr. Krohn considers what I have called the testis to be the *vas deferens*, and *vice versa*. I feel quite

sure, however, that in the specimens I examined the relations of the organ were as I have described and figured them.

From the excellent description of the development of *Doliolum* given in Dr. Krohn's memoir, it seems highly probable that my guess as to the nature of the "shrivelled tubular process," p. 601, is correct, viz. that it is the remains of a pedicle of attachment.

In common with all previous observers, Dr. Krohn appears to have confounded what I have called the "endostyle" with the true "dorsal folds" of Savigny. Recent careful examinations of many species of Ascidians have convinced me that the distinction which I drew between these structures (on *Salpa* and *Pyrosoma*, 'Phil. Trans.' 1851, p. 572) is well founded. The "endostyle" invariably exists at the base of the "dorsal folds" in ordinary Ascidians, and consists essentially of a band of thick, cylindrical, elongated cells, arranged round a common axis. Two similar accessory bands are in the ordinary Ascidians developed upon the folds on each side of the "endostyle."

Dr. Krohn does not seem to have noticed the ciliated sac, or the peculiar manner in which the anterior ciliary bands terminate at this part. I have described similar bands in *Salpa* and *Pyrosoma* (*loc. cit.* § 17-52), and I find that such exist in all Ascidians. The "accessory part of the same apparatus" mentioned by Dr. Krohn is the "tubercule antérieure" of Savigny. It is not, as Dr. Krohn supposes, a mere appendage of the ciliated bands, but it is a very peculiar structure placed in the space between the ciliated bands and the tentacular circlet (in ordinary Ascidians), and is always in more or less close connexion with the ganglion. It is the same organ as the "ciliated sac" of *Salpa*, *Pyrosoma*, and *Doliolum*, and is, I think, very probably an organ of sense. I have found it varying very remarkably in shape and size in species of *Boltenia*, *Cynthia*, *Molgula*, and *Phallusia*.

The existence of a well-developed testis in *Appendicularia* (*Vexillaria*) (*loc. cit.* § 84) appears to me to present an insuperable difficulty to Dr. Krohn's hypothesis, that this creature is an incompletely developed Ascidian; and in addition to this circumstance, there is the absence of a cloaca (the anus opening directly on the dorsal surface (§ 82)), which stamps the form as altogether peculiar.

With regard to the muscular apparatus of the tail of Ascidian larvæ, I may here state as a fact, which I believe to be altogether new, that it is composed of a layer of large, elongated, thick walled cells applied end to end. The cells contain a large clear nucleus with a nucleolus. Their walls present a delicate fibrillation, which is continued from one cell to another, so that it appears at first as if the cells were inclosed within a bundle of

fibres; resembling exactly the embryonic muscular fibres of the frog described by Kölliker. The larvæ in which I observed this belonged to a very peculiar small *Cynthia*, in the Collection of the British Museum. Contrary to the usual course, the larvæ had attained a very considerable degree of development in the space between the inner tunic and the outer wall of the branchial sac, and had so become preserved with their parent.

Another point of great interest about the larvæ may be mentioned here. *The integument of the tail and of the body of young larvæ, in which the body contains nothing but a mass of cells, and offers no trace of any organs or apertures, presents clear and unmistakeable signs of the presence of cellulose.* The determination of this point is one of the desiderata left by Löwig and Kölliker (*Annales des Sciences*, 1846), and it shows, I think, very clearly that the Ascidians do not necessarily get their cellulose, as they suppose, from the *Diatomaceæ* or other ingesta. Do the cells of the tail of the foetal Ascidian secrete cellulose as the "Primordialschlauch" in plants secretes it? If so, they must fix carbon; and the physiological distinction between animals and plants will disappear, as the anatomical ones have already disappeared.

In referring to the analogies between the *Salpæ* and *Doliolum*, Dr. Krohn appears to uphold the doctrine of the fundamental difference between the *Salpæ* and other Ascidians. In the memoirs referred to, I have endeavoured to show, on the contrary, that there is but one type of Ascidian structure, and that the variations upon this type pass insensibly into one another. Subsequent investigations, which I hope to make public at no distant period, have to my mind demonstrated the truth of this proposition. The great difficulty I have found among the Ascidians has been, indeed, to discover *any* good anatomical distinctions among the genera.

DESCRIPTION OF PLATE III. B.

Fig. 1. *Doliolum Mülleri*, asexual individual, from the ventral side: *a*, gemmiferous tube or "gemmarium;" *b*, penultimate muscular band with its ends inserted into the gemmarium.

Fig. 2. Larva of *D. Nordmanni*: *c*, larval tegument; *d*, young *Doliolum*; *e*, vesicular appendage; *f*, axis of the tail.

Fig. 3. The same further developed and more magnified. Letters as before.

XIV.—On the genus *Lepton*. By WILLIAM CLARK, Esq.

To the Editors of the *Annals of Natural History*.

GENTLEMEN,

Exmouth, July 5, 1852.

I HAVE stated in the July 'Annals' for 1852, that the discovery of the animal of the *Lepton convexum* has put it in my power to



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