

subject. When this gentleman was last at the Museum I asked him how it was that he had obtained no male specimens of *F. Hildebrandti*, and very much to my surprise and pleasure found (though he had forgotten to mention it before) that he had not only arrived at the same conclusion as myself, but had solved the riddle long before on Kilima-njaro, and discovered that *F. Altumi* is the male and *F. Hildebrandti* the female of one and the same species.

Mr. Hunter had been considerably exercised in his mind by on the one hand never being able to obtain the male of *F. Hildebrandti*, while on the other hand all the specimens he got of *F. Altumi* proved invariably to be males. As these two birds were always obtained in company by his collectors, the truth gradually dawned on him and was subsequently proved beyond a doubt by the dissection of a large number of specimens obtained for food.

On comparing the two birds the different points of resemblance are at once seen, viz. the plumage of the upper surface and under tail-coverts and the colour of the bill and legs, which are all practically the same in both; but, so far as I know at present, the extraordinary difference in the colour of the under surface in the sexes is unique in this genus. A still more extraordinary thing is that in the two apparently closely allied forms, *F. icterorhynchus* and *F. natalensis*, the females resemble the males but are without spurs.

The name *Francolinus Hildebrandti*, Cabanis, must therefore be used in future to designate this species.

XVI.—*On Angelopsis, and its Relationship to certain Siphonophora taken by the 'Challenger.'* By J. WALTER FEWKES.

[Plate VII. figs. 1-3.]

ONE of the most interesting genera of Medusæ discovered in the depths of the Gulf-stream by the United States Fish-Commission steamer 'Albatross' is a new Physophore which was described a few years ago (1884) under the name of *Angelopsis* in my paper on the Medusæ of this region.

This genus is remarkable for its large float and the reduction in size and increase in thickness of the walls of the polyp-stem, which has the form of a semicartilaginous expansion with a cavity, and with its external walls covered with

the polypites, sexual bells, and possibly tentacles. It is also remarkable in possessing bud-like structures on the lower part of the float, near its junction with the base. These bag-like bodies recall in general appearance the form of the float itself, and somewhat resemble structures to which Hæckel has given a special name (aurophore) in certain related genera.

My original description of this strange Siphonophore was necessarily a short one, and for reasons beyond my control at that time the figures which were given of it were somewhat imperfect. Since the publication of the first notice of *Angelopsis* I have reexamined my types and have been able to make a dissection of the larger of them, from which study it is possible for me to add something to my first description, which, although superficial, is accurate as far as it goes. The present paper has in part been called forth* by Prof. Hæckel's report on the 'Challenger' Siphonophora, which contains descriptions of allied genera, the account of the anatomy of which throws considerable light on the interpretation of certain structures in *Angelopsis* the function of which was not wholly plain four years ago.

Among the interesting Siphonophora described or figured in the 'Challenger' Report already quoted are four new genera which differ from other known Siphonophora in very important particulars. Hæckel has found it necessary to form a new group for the reception of these genera, and assigns to it the name of Auronectæ. In this group he includes doubtfully my *Angelopsis*, and regards it as possibly the same as his genus *Auralia*. Although *Angelopsis* seems to be allied to *Auralia*, there are certain marked differences so far as I can make out from his meagre and unsatisfactory account of *Auralia*. Unfortunately Hæckel does not describe or figure his genus in the report † referred to, so that I am ignorant of some of the main characters of his *Auralia*. The genus *Angelopsis* is so different from other Siphonophora that there is a call for a more intimate knowledge of its anatomy.

* I have delayed my publication of the new facts embodied in this paper in the hope that it might be possible to collect *Angelopsis* alive and gather information in regard to its nectocalyces, tentacles, tentacular knobs, and other structures.

† The editor speaks of this work as a "Monograph of the whole class of Siphonophora." Any report which simply mentions the names of new genera and refers to publications yet to appear for descriptions of these novelties does not come up to the highest standard of what a "Monograph" should be.

Hæckel does not say whether his *Auralia* was taken by the 'Challenger' or not. The locality given for it, viz. "depths of the Tropical Atlantic," is also somewhat vague.

I have been able to examine but two specimens, both of which are somewhat mutilated and more or less distorted in preservation*.

Angelopsis globosa was taken by the 'Albatross' in lat. $37^{\circ} 50'$ N., long. $73^{\circ} 3' 50''$ W., from the depth of 1395 fathoms †. The remaining genera of the Auronectæ, to which group Hæckel ascribes *Auralia*, the supposed relation of *Angelopsis*, are called by him "deep-sea Siphonophoræ"; but no genus is recorded from more than 650 fathoms ‡. It will thus be seen that *Angelopsis may* have come from considerably deeper water than any other Auronectid yet described.

From the existence of the "aurophore" among the Auronectæ Hæckel regards them as preeminently deep-sea Siphonophores. He considers the aurophore to be an organ for the secretion of "air" (gas) which is emptied into the cavity of the float. It is not wholly evident, even if the aurophore is a gas-secreting organ, that on this account the Auronectæ are permanent deep-sea Siphonophores. Moreover, additional proof is necessary to demonstrate that the physiological rôle of the aurophore is to secrete air (gas). Upon this latter point more observations are needed, and it must be confessed that the large size of the float looks as if the Siphonophore *Angelopsis* is better fitted for life at or near the surface than at great depths.

Certain "striking features" of the Auronectæ, according to Hæckel, "make it very probable that the Auronectæ are permanent deep-sea Siphonophoræ, which may move up and down within certain limits of depth, but never come to the surface." Among the peculiarities referred to by him are "the extraordinary development of the swimming-apparatus,

* In the figures of *Angelopsis* which are here published accurate outlines are attempted even when there is no doubt that certain distortions are present which are due to the method of preservation. The system of "restoration" by which "semidiagrammatic" figures are constructed and "missing parts supplied from a knowledge of the form of the same in other Medusæ" does not wholly commend itself to the author. Possibly while figures not treated in this way are less effective, they are less liable to propagate erroneous ideas of the form and structure of these animals.

† Hæckel ascribes my *Angelopsis* to the "Tropical Atlantic." What he exactly means by the term is not clear to me. Lat. $37^{\circ} 50'$ is certainly outside of the tropics. *Rhodalia*, which came from lat. $37^{\circ} 17'$ S., he ascribes to the "South Atlantic."

‡ I have already elsewhere in these 'Annals' discussed the unreliability of the data of depth at which certain Medusæ are recorded. *Auralia*, according to its discoverer, came from the "depths of the Tropical Atlantic;" but as he does not mention the depth, the datum is not very reliable and does not contribute much to demonstrate that this genus is deep-sea in habitat.

the voluminous pneumatophore, the powerful horizontal corona of radially expanded nectophores, and particularly the singular aurophores, wanting in all other Siphonophoræ, and acting probably as an important gas-secreting gland or a pneumadenia." It is certainly difficult to see how any of the above-mentioned features "make it probable that the *Auronectæ* are permanent deep-sea Siphonophoræ . . . but never come to the surface." One might even suggest that exactly the reverse conclusion might be drawn and that some of these features imply life at or near the surface.

The failure to find nectocalyces in *Angelopsis* led me to suppose that these organs or individuals are wanting in this genus. I cannot now say that they are present, as they are also not found in the new specimen which I have lately studied. As Hæckel found them in the same bottles with his *Auralia** and *Rhodalia*, it is possible that they once existed in *Angelopsis*, and future studies may bring them to light.

The following general description of *Angelopsis* was given in my original account † of this Medusa:—

"This Medusa has a spherical region above, which is considered [to be] a float, on the underside of which is clustered a number of small bodies resembling tentacles. The former region (*py.cy.*) resembles the bell-like body in a Medusa; the latter a clump of tentacles closely massed together, with the form which we might suppose they would have if the entrance to the bell-cavity were closed by the velum and tentacles developed over its lower floor. The so-called float is spherical, without apical opening or protuberance, smooth on the outer surface and without radial elevations. Diameter from 7 to 10 millim. The wall of the float is thin, and in the interior is a second thin-walled sac or float, which is supposed to correspond to the pneumatocyst (*py cy.*) of *Rhizophysa*. The inner sac has no opening into the outer, and does not communicate with organs below. It is destitute of appendages. Its cavity (*cav. p.*) occupies the whole interior of the float.

"The lower floor of the float is formed of the thickened outer walls which bear the so-called tentacles. The thickened region is found to have a cavity within (*cav. b.*) and to

* Hæckel simply says that the corona of nectocalyces (nectophores) is simple in *Auralia*, but gives no more information about them in this genus. He gives no account of their anatomy, whether they were sessile or pedunculate, or any detail of any scientific value about them. His description of *Auralia* is so superficial that it is very difficult to tell whether it is the same as or different from *Angelopsis*.

† "Report on the Medusæ collected in 1883-84," Ann. Rep. U.S. Fish Comm. 1884.

be separated by a muscular floor from another cavity (*car.*) just below the inner air-sac. On the outer walls of this thickened layer (*mm.*), at the point where it joins the thin walls of the outer layer of the float, there are found spherical bag-like structures (*gm.*) of unknown function. These bodies recall in appearance the larger float, from which they hang, and suggest the possibility that they are buds from the outer walls. Whether they are new individuals, peculiar zooids, or chance swellings, I cannot determine. They are found in both specimens, and so closely resemble the larger float that the supposition that they are *new individuals budding from the thickened region* of the bell seems highly probable. The cavity of one of them was found filled with bodies resembling those found on the lower floor.

"The whole external surface of the thick walls of the lower hemisphere of the Medusa is covered with small clusters of bodies which resemble the gonophores in *Verella* or the sexual clusters of *Physalia*. These clusters have a small axis, from the sides of which hang, in grape-like clusters, small, spherical, and ovate bodies resembling tentacular knobs, fastened by a delicate peduncle to an axis. The appended bodies are of two sizes, large and small, and through the walls of the latter radial structures which arise under the peduncle can be seen. All are snugly approximated to the outer wall of the animal, and in one instance a small fragment of what appears to be an Echinoderm test (*a*) was firmly grasped by them. No *external opening* into the *cavity* of the muscular base on which they hang was found, although carefully searched for, especially at the lower pole of the Medusa. In cutting open one of the small spherical bodies (*gm.*) which arise from the side of the Medusa I found it filled with a granular mass, which had some resemblance to the botryoidal clusters on the lower hemisphere of the Medusa."

As we have no printed account of the genus *Auralia*, it is premature at present to accept Hæckel's reference * of *Angelopsis* to this genus. He promises, however, a description of *Auralia* in a work, 'Morphology of the Siphonophora,' yet to be published, which with the present account may make it possible to tell whether or not the two belong to the same genus. If on such a comparison they are found to be the same, the name *Auralia* by the laws of scientific nomenclature will have to be regarded as a synonym of the older designation *Angelopsis*.

* The author mentioned was unable "with any certainty" to identify his *Auralia* and my *Angelopsis*. I find the same difficulty, but the cause of my difficulty is not wholly the same as his.

The Rhodalidæ, according to Hæckel, have the following characters:—"Trunk of the siphosome without permanent central canal and distinct primary mouth." It includes, according to him, two genera, *Auralia* and *Rhodalia*. Looking now at his synopsis, we find that *Auralia* has the "trunk of the siphosome *with* a large central cavity," which would seem to throw it out of the family; and if his definition of the family is followed it would include *Rhodalia* only. It is certainly desirable that his diagnosis of a new family should be broad enough to include the characters of the genera embraced in it, and that one description should not be the negative of the other. Several other instances of a similar kind * might be mentioned which detract very greatly from the value of the Report on the 'Challenger' Siphonophoræ.

I cannot accept Hæckel's interpretation of the "spherical bag-like structures" of *Angelopsis* given on p. 301, where he says they are probably "nectophores," nectocalyces. There are two reasons which lead me to doubt the validity of his conclusions. First, it is very difficult to detach them from their connexion with the float, and, secondly, they have neither bell-openings nor radial tubes so far as can be discovered. It is also to be noted that they arise in a different position from the nectocalyces on the float and nectostem. When we recollect with what ease the nectocalyces ordinarily separate from the "corn" in Siphonophoræ, and the same is true in Aurnectæ, the persistency with which these buds cling to the "corn" is significant. Moreover in their general appearance they are unlike nectocalyces. It is not impossible that they are homologous with the organs which he calls aurophores, but unlike them they have *no external opening* so far as could be discovered. I have searched in vain for these openings; if they exist, they are rendered invisible by the contraction of the walls of the orifice.

My remark that these bodies are buds from the floats, which was ventured not as a dogmatic assertion but as a

* As will be seen, for example, on pp. 242, 243, in his account of a genus of Forskaliadæ, Fewk., called *Strobalia*. He speaks of a *Strobalia*, *S. cupola*, sp. nov., which will be described in his 'Morphology of the Siphonophoræ.' One is disappointed not to find a description of it in the 'Report,' and has good reason to expect a description of a second species, for Hæckel mentions a species of his *Strobalia*, *S. conifera*, as collected by the 'Challenger,' but does not describe it. He does not even promise to describe it in his 'Morphology of the Siphonophoræ.' It is unfortunate that species collected by the 'Challenger' should not be described in a report on them, but simply mentioned by name; and the statement made that they are similar to other species, also undescr^{ibed}, adds very little to our knowledge.

suggestion, does not seem to have been shown to be false by Hæckel's criticism. I cannot agree with him that they are "probably nectophores," and that if they are aurophores they may still be "new individuals * budding from the thickened region" &c. as suggested.

Float.—The float of *Angelopsis* is spheroidal, the longer diameter being situated in a horizontal plane. The upper portion is somewhat flattened and convex. There is no apical external opening. The longer diameters of the two specimens examined are respectively 5 and 7 millim.

No variation in colour was observed in the external walls. The float is whitish in alcohol †.

When the external surface of the float is examined with a hand-lens there are observed scattered over its surface clear spaces, *c*, resembling nematocysts. Similar structures are recorded and figured by me in *Rhizophysa gracilis* from Florida ‡.

Nectocalyces.—No nectocalyces were observed, although the characteristic elevations from which they are said by Hæckel to arise in related genera are prominent. The structures *gm*, *gmm*, *gm'*, which Hæckel says "are probably nectophores," are not "nectophores," and have no anatomical features of the nectophores of other Siphonophora. The case with which nectocalyces are dropped renders it possible that they once existed in *Angelopsis*; but as I have not found them they are not described or figured §.

Polyp-stem.—The portion of the *Angelopsis* corresponding to the polyp-stem (siphosome) of other Siphonophores is enlarged into a thick-walled, bulbous, more or less cartilaginous structure, which forms the lower or basal region of the animal. In one specimen this portion is contracted into a globular base of about the same size as the float, and in it forms a dish-like cavity, the diameter of the rim of which is

* Hæckel in one place (p. 283) considers the aurophore an "organ," in another, two lines below, a "peculiar Medusoid person." I am unable to tell which opinion he holds as to its character.

† The marked reddish pigment, which in *Athorybia* and other genera is found at the apex of the float, retains some of its colour even after specimens have been in alcohol several years.

‡ "Notes on *Acalephæ* from the Tortugas, with a Description of new Genera and Species," Bull. Mus. Comp. Zool. vol. ix. no. 7.

§ Hæckel gives a beautiful figure of *Stephalia* with a circle of nectocalyces. Unfortunately he does not describe the nectocalyces in his specific diagnosis. He also gives figures of *Rhodulia*, the nectocalyces of which are "semidiagrammatic," and says in his text, "Of course the form and position of the detached nectophores could not be recognized in the spirit specimens with full certainty, the soft jelly substance being much contracted by the action of the alcohol."

somewhat larger than that of the float. This region is more or less distorted by the alcohol, as shown in my figure. It is crossed by radial elevations similar to the peduncles of the siphosome (nectostem) of *Rhodalia*, which are more or less torn, especially at one extremity (distal). There is no external opening into the interior of this dish, and covering its surface there are clusters of sexual bodies, and here and there pyriform organs, which are possibly polypites. The tentacles are not sufficiently well preserved to determine their relationship, and the tentacular knobs, if such exist, were not recognized.

The two bodies (*gm*, *gmm*) which hang from the neighbourhood of the base of the float bear some resemblance to an organ called the aurophore * by Hæckel. As neither of them has external openings they do not resemble aurophores in this particular. It is also an important fact that there is no external opening in the external walls of the polyp-stem †.

One of these "buds" is larger than the other, but both are very much shrunken and too poorly preserved for their internal structure to be definitely made out.

The contents of these "buds" show the falsity of regarding them as the same as true nectophores or nectocalyces, although there is nothing to prevent their being homologized with these structures. From the imperfection of the material at my command it was not possible for me to give an accurate account of their anatomy; but enough was seen to show that they are not true swimming-bells.

One of the most characteristic and interesting features, morphologically speaking, of the anatomical structure of *Angelopsis* is the fact that the polyp-stem is thickened and its walls penetrated by a network of canals, which seem to ramify in all directions through it. This bulbous, thickened polyp-stem is peculiar to genera belonging to the Auronectæ.

* Hæckel regards the aurophore as "adapted to the production and emission of the gas contained in the large pneumatophore." The reasons which he gives for this conclusion are not all that might be desired. One reason seems to be "the great internal surface of the endodermal epithelium, thus produced, together with the extraordinary size and glandular appearance of its high cylindrical cells, make it probable that the great mass of air contained in the pneumatophore is secreted by the lacunar system of the aurophore and conducted into the cavity of the pneumatocyst by pores which pierce the inner wall of the aurophore." One is tempted to ask, Why regard the contents as air rather than some other gas?

† The "lacunar systems" of irregular canals in the aurophore closely resemble the "gastral canals" of the cartilaginous polyp-stem. See Hæckel's section of the aurophore of *Rhodalia* (pl. v. fig. 24). In the one case he seems to regard these lacunæ as gas-secreting. Why not ascribe the same function to the gastric canals?

The interior is hollow, forming a cavity which is destitute of an external orifice. This cavity is divided into regions and is lined by a more or less cartilaginous * plate. *Auralia* alone of the Auronectæ resembles *Angelopsis* in the absence of an external orifice to this cavity.

Directly below the air-float the cavity of the polyp-stem forms a thin disk-shaped recess, the upper walls of which are formed by the float, the lower by lamellar folds of the cartilaginous plate which lines the cavity of the polyp-stem. A large orifice or communication leads from this vestibule into the main cavity (*cav. b.*) of the polyp-stem. There is no opening from the cavity of the float into the vestibule (*cav.*) of the cavity of the polyp-stem.

Cormidia.—The clusters of sexual bodies (*p*) and polypites dot the whole underside and skirt the margin of the external surface of the polyp-stem of *Angelopsis*. They are in a very poor state of preservation, so that I am unable to recognize with certainty their different parts. I have supposed that each cluster consists of a central axis, with clusters of male and female sexual bells arising from its external walls. Some of these are much larger than the others, and those are interpreted as polypites; but of this interpretation I have some doubt. Tentacles were not observed, and if they once existed have been ruptured from their connexion with the cormidia. Hæckel finds tentacles and tentacular knobs or like structures in several genera which he regards as closely related to *Angelopsis*; but I have not been able to find them in this genus. A small fragment of the shell † (test) of a sea-urchin was found clinging to the underside of the polyp-stem, and I have supposed that it was held there by the tentacles; but the only structures observed were those which looked like immature tentacular knobs.

After calling attention to the possibility that *Angelopsis* is the same as another genus (*Auralia*), Hæckel speaks of the "inaccuracy" of my description and the "superficiality" of my examination of *Angelopsis*.

So far as inaccuracy goes this criticism is believed to be unjust, although the poor character of my material rendered it difficult to make out many details of structure. My descrip-

* The use of the word cartilaginous here and elsewhere refers rather to the tough nature of this plate than to its histological characters. It recalls closely the "shell" of *Velella* in its general characters and differs very strikingly from the soft gelatinous body of most Medusæ.

† In the original figure of *Angelopsis* this little fragment was represented; but when my second drawing was made this foreign body had dropped off and was found in the bottom of the bottle containing the type.

tion, which was the first printed account of an Auronectid, the revelation * of which group Hæckel styles "one of the most splendid discoveries of the 'Challenger,'" was the first account of these strange Medusæ. It was made from poorly preserved material and was not intended to be histological or anatomical.

EXPLANATION OF PLATE VII. FIGS. 1-3.

The following letters have the same signification in the three figures:—

- c. Clusters of transparent bodies found in the walls of the float and easily seen in alcoholic specimens. They consist of clear spaces or "cells" arranged in clusters, rows, or irregular figures.
- cav. Lens-shaped cavity of the nectostem below the float.
- cav. p. Cavity of the float.
- cav. b. Cavity of the polyp-stem.
- f. Floor of the float, separating the cavity of the pneumatocyst (cav. p.) from cav. b., the cavity of the polyp-stem.
- gm. Globular bodies resembling nectocalyces in position, but unlike them in structure. *gmm.* is very much shrunken in preservation, *gm.* is less so and somewhat resembles an "aurophore."
- gm'. Small immature "buds," which may be undeveloped nectocalyces. Their true character is not known.
- l. Folds of a cartilaginous plate separating the cavity of the nectostem, cav., and that of the polyp-stem, cav. b. The figure of these folds is a little too regular, and in nature they are more plicated.
- mm. Thickened wall of the polyp-stem through which ramifying tubes extend. Several of these tubes are seen longitudinally, others, as at *t*, in cross section.
- o. Opening of the bud *gm.* into the cavity of the float.
- p. Cluster of sexual bells and a single polypite. In fig. 3 a sexual bell, *s*, and a single polypite is shown.
- py. cy. Pneumatocyst or float.
- rn. Ridges or elevations, possibly remnants of the attachment of nectocalyces.

Fig. 1. Side view of the larger specimen of *Angelopsis*. The want of symmetry is mainly due to contraction in preservation. The specimen is distorted, and probably some of the organs which exist in the live animal are lost.

Fig. 2. Section through the float and enlarged polyp-stem, vertically, showing the cavities of the float and body. Two clusters of sexual bodies are shown on the left of the figure. From the shape of the larger specimen, shown in fig. 1, it is probable that the transverse diameter of the polyp-stem is relatively to that of the float somewhat larger in live specimens than here shown.

Fig. 3. A detached cluster of sexual bodies and a single polypite. This cluster was taken from the bulbous polyp-sac of fig. 2.

Boston, Mass., U.S.A.,
April 10th, 1889.

* Of the four genera regarded by Hæckel as belonging to the Auronectæ, *Stephalia* was taken by the 'Triton' Expedition, *Stephalia* and *Rhodalia* by the 'Challenger,' and the collector of *Auralia* is not mentioned. The 'Challenger' increased very greatly our knowledge of the possible allies of *Angelopsis*, which was discovered by the 'Albatross.'