that without doubt all biologists, myself included, will take great pleasure and satisfaction in welcoming to this field all careful workers, whose services should be much appreciated where there is such a vast amount of labor waiting to be performed.

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PIURA, PERÚ,
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SPECIAL ARTICLES

METAMORPHOSIS WITHOUT PARASITISM IN THE UNIONIDÆ

IT has been known for a long time that in the genus *Strophitus* Rafinesque the embryos and glochidia are embedded in short cylindrical cords which are composed of a semi-translucent gelatinous substance, and that these cords, which are closely packed together, like chalk crayons in a box, lie transversely in the water-tubes of the marsupium. The blunt ends of the cords are seen through the thin lamella of the outer gill, which in this genus, as in *Anodonta* and others, constitutes the marsupium. The position of the masses of embryos, while contained within the gill, is so unusual that Simpson in his "Synopsis of the Naiades" established a special group, the Diagenæ, for *Strophitus*—the only genus of the family in which this peculiarity exists. In other genera the embryos are conglutinated more or less closely to form flat plates or cylindrical masses, each one of which is contained in a separate water-tube and lies vertically in the marsupium.

So far as we are aware, Isaac Lea[1] was the first to observe this interesting arrangement which he described and figured, rather crudely to be sure, in *Strophitus undulatus* (*Anodonta undulata*). In several subsequent communications[2] he added further details and illustrations, and also mentioned the occurrence of the transversely placed cords, or "sacks" as he called them, in *S. edentulus*. He recorded the former species as being gravid from September until March, and described the extrusion of the cords from the female, as well as the remarkable emergence of the glochidia from the interior of the cords after the latter have been discharged. "The sacks were discharged into the water by the parent," he says, "from day to day, for about a month in the middle of winter. Eight or ten young were generally in each sack, but some were so short as only to have room for one or two. . . . Immediately when the sacks came out from between the valves of the parent, most of the young were seen to be attached by the dorsal margin to the outer portion of the sack, as if it were a placenta."

The essential points in these observations have since been verified by other investigators. Sterki,[3] following the suggestion of Lea, has called the cords, which differ strikingly from the conglutinated masses of *Unio* and other genera, "placentæ"—thus indicating that he considered them to have a nutritive function. He also described the extrusion of the glochidia, when placed in water, and their attachment to the cord "by a short byssus thread whose proximal end is attached to the soft parts of the young." He further states that the glochidia are enclosed in the placentæ when the latter are first discharged, and that after their extrusion they remain attached for some time.

Ortmann,[4] in a paper on the breeding seasons of the Unionidæ of Pennsylvania, says of *S. undulatus*, which he regards as identical with *edentulus*:

> I found this species gravid in the months of July, August, September, October; also in May. The latest date is May 22, 1908 (one out of eleven individuals). Among numerous specimens collected on May 14 and May 27, 1908, no gravid females were present, and during the month of June such were never found, although a good number of specimens were collected. The earliest date again is July 11. This gives an "interim" from the end of May to about the middle of July.

In a later paper Ortmann[5] states that the discharge of the cords, which he proposes to

[1] "Observations on the Genus *Unio*," Vol. II., 1838.

[2] *Ibid.*, Vols. VI., X., 1858, 1863.

[3] *Nautilus*, Vol. XII., 1898.

[4] *Ibid.*, Vol. XXII., 1909.

[5] *Ibid.*, Vol. XXIII., 1910.

call "placentulæ," is not through the lamellæ of the gills, as Simpson has maintained, but that it occurs in the usual manner through the suprabranchial chambers.

Strophitus edentulus is a rare species in all of the localities in which we have collected mussels, and we have obtained, until recently, only the following records of its breeding from individuals taken in the Mississippi River near La Crosse, Wis., during the summer of 1908:

Date	Number of Individuals	Stage of Gravidity
June 10	1	glochidia fully formed.
July 6	1	glochidia fully formed.
July 9	3	glochidia fully formed.
July 10	1	glochidia fully formed.
July 9	2	not gravid.
July 17	1	not gravid.
July 18	2	not gravid.
July 29	1	not gravid.
July 29	4	young embryos.
August 11	1	young embryos.
August 11	3	late embryos.

Since these records include the interim between the breeding seasons, they confirm the statement of Ortmann and others that *Strophitus edentulus* is one of the so-called "winter breeders," or those species which have the long period of gravidity. The interval between the seasons, however, as indicated in the above records, is seen to be a much shorter one than that observed by Ortmann.

After verifying the main observations of Lea and Sterki, so far as was possible at that season of the year, we examined the glochidia carefully with a view to determining whether their subsequent life-history would exhibit any peculiarities, as might be suspected from their relation to the cords. At that time we did not observe the normal discharge of the cords by the female; but we removed them from the marsupium, placed them in water, and, after the glochidia had emerged, employed various means to bring about their attachment to fish. None of these attempts, however, was successful, although the fish were left in small dishes containing many cords for as long a time as twelve hours. In the light of these results, which indicated the inability of this glochidium to attach itself to fish, and in view of the fact that the cords so evidently seemed to be a nutritive device, we felt it to be highly probable that in this species the metamorphosis would be found to occur in the absence of parasitism—a prediction which has been recently verified.

On February 6, 1911, a single female of *Strophitus edentulus,* which had been under observation in the laboratory since last November, was seen discharging its cords from the exhalent siphon. The discharge has continued to the present date, March 25, and during this time the cords have been thrown out in varying numbers from day to day. They measure from 2 to 10 mm. in length and about 1 mm. in diameter, although they become more or less swollen after lying in the water for a time. Each cord contains from 10 to 24 glochidia arranged in an irregular row. In many cases the glochidia emerge from the cords in a few minutes after the latter are discharged, and then usually remain attached by the thread in essentially the same manner as has been described by Lea and Sterki. The thread, which is apparently a modified larval thread, is continuous at its distal end with the egg-membrane, which generally remains embedded in the cord; so intimate, in fact, is the union between the two, that at times the membrane, adhering to the thread, is dragged out of the cord when the glochidium is extruded—in which case, of course, the glochidium becomes entirely detached from the cord.

All attempts to infect fish with these fully formed glochidia have again been unsuccessful, even when the exposure has been of long duration. Within a few days, the extruded glochidia die in spite of every effort to provide the most favorable conditions for their maintenance.

When the cords first began to be discharged, one of our students, Miss Daisy Young, happened to notice that not all of the larvæ were extruded, and that among those which remained in the cords some had lost the larval adductor muscle, possessed a protrusible foot, and showed other signs of having undergone the metamorphosis. Upon careful examina-

tion this was found to be true, and it was discovered that these young mussels—for such they undoubtedly are—are subsequently liberated by the disintegration of the cord after *having passed through the metamorphosis in the entire absence of a parasitic period.* We, therefore, have concluded that the emergence from the cords in the glochidial stage is premature—due possibly to some change which has taken place in the gelatinous substance surrounding them as a result of free contact with the water or to release from the pressure to which they are subjected while in the marsupium. It is perfectly evident that these glochidia neither become attached to fish nor undergo any further development; they have simply come out too soon and are lost.

The young mussels, on the other hand, which have developed inside the cords, when liberated by the disintegration of the latter or removed directly by teasing, are found to have reached as advanced a stage of development as is attained by any unionid at the time it leaves the fish. They closely resemble the young of *Anodonta* at the close of the parasitic period, and upon examination have been found to possess the following structures: the anterior and posterior adductor muscles; the ciliated foot; two gill buds on each side; a completely differentiated digestive tract, including mouth, œsophagus, stomach, intestine and anus; liver; the cerebral, pedal and visceral ganglia; otocysts; the rudiments of the kidneys, heart and pericardium; and also a slight growth of the permanent shell around the margin of the shell of the glochidium. The larval muscle has completely disappeared, although some of the mantle-cells of the glochidium, as well as the hooks of the shell, are still present. They crawl slowly on the bottom of the dish by the characteristic jerking movements of the foot, after the manner of the young of other species at a corresponding stage, although the valves of the shell gape more widely apart and the foot is shorter and less extensible. We have not succeeded as yet in keeping them alive for more than ten days, but it is difficult in the case of any species to maintain young mussels of this age under laboratory conditions.

Since these young mussels do not respond to the stimuli which cause glochidia to close the shell and all attempts to bring about their attachment to fish have failed, and, furthermore, since their behavior in creeping on the bottom is characteristic of post-parasitic life, it would seem clear that no subsequent parasitism is possible. The conclusion is, therefore, inevitable that we have here to do with a species which has no parasitism in its life-history, although the presence of hooks and other typical glochidial structures would indicate that it has originated from ancestors which possessed the parasitic stage like other fresh-water mussels. The cord is undoubtedly to be interpreted as a nutritive adaptation which arises in the marsupium during the early stages of gravidity, since the young embryos are at first contained in an unformed viscid matrix and the cords are a later product.

The whole history of this exceptional species warrants a more detailed study, and Miss Young is now engaged in such an investigation. When her work is completed, we hope that it may include the entire course of development, the method of formation of the cords, and the rearing of the young mussels during a much longer period than has thus far been possible.

GEORGE LEFEVRE,
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March 25, 1911

THE SCALES OF THE ALBULID FISHES

Albula has long been regarded with unusual interest by ichthyologists, being an isolated type standing near the base of the Teleostean series. It is exceptional among all teleosteans, Boulenger remarks, in having two transverse series of valves to the bulbus arteriosus instead of one; an approach to the condition of the "Ganoids," in which there are three. Gill admits the "Ganoids" into the teleostean series, and according to his arrangement *Amia* falls in the order Cycloganoidei, just before or below the Malacopterygii, of which *Albula* is a primitive member. In Smithsonian Misc. Coll., Vol. 56, No. 3, p. 2, I have