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ARTICLE IV.—*Description of Lymnæa (Bulimnæa) megasoma*, Say, *with an account of changes produced in the offspring by unfavorable conditions of life.* By R. P. WHITFIELD.

During the meeting of the Am. Assoc. for the Adv. of Science, held at Burlington, Vt., in 1867, Mr. Chittenden, of New York, exhibited living specimens of *Lymnæa megasoma*, Say, procured near that city, at a locality formerly well known to naturalists, but at which, for many years previous to that time, the species was supposed to have become extinct. The individuals exhibited were obtained from the stream which formerly supplied the pond where they had previously been found.

After the adjournment of the meeting the shells were distributed among members of the Society, from one of whom, Prof. James Hall, of Albany, N. Y., I obtained three individuals, two adults and one partially grown. One of the adults I succeeded in preserving alive until the following summer, the others died soon after I received them.

The species has been recognized at only a very few localities. Say's types were collected by Dr. Bigsby at Bois-blanc Lake, north of Lake Superior. Prof. Hall also collected it near Lake Superior. W. G. Binney cites also W. Stimpson as having collected it at that locality, and it was well known from Burlington, Vt., from a small pond between the town and the Lake shore, (long since filled up,) but I believe has never been recognized in the waters of the Lake itself. I have seen the shells in collections marked "Michigan," and "Near Montreal," but I think these latter localities have not been authenticated. In Long's Expedition, p. 263, 1824, Mr. Say gives the following description of the shell: "Large, dilated subovaL; spire short, rapidly diminishing, acute; whorls about five, rounded, obtusely wrinkled across; body whorl large, the wrinkles very obvious, suture deeply impressed; aperture subovate, much longer than the spire, within chestnut-brown; columella white."

* * * "The color is brownish, sometimes lineated across the body whorl with dull greenish and pale ochraceous;" The color of the interior of the shell is chestnut-brown to purplish-brown. Say gives the length as more than one and six-tenths of

an inch, but the Vermont shells often attain a length of two inches. In Prof. S. S. Haldeman's monograph (page 6, Genus Lymnæa) he proposes the generic name BULIMNÆA for this shell.

There is considerable difference in the form and texture of the shell between the Western specimens and those from Vermont; the latter being more ventricose, especially in the last volution, and the shell less regular in form and in the growth lines and texture of the suface; neither is it so bright in color. In comparing nearly three hundred individuals from the Vermont locality with about fifty individuals from the Lake Superior region, some years ago, these differences were seen to be very marked. As I have not been able to find any description of the animal of this species, I give the following, which was taken from that of the adult Vermont specimen above referred to, the shell of which is one inch and seven-eighths long.

Animal blackish, the head and tentacles marked with small yellow spots which give a brownish color on close inspection; and when the animal is in motion the surface has the appearance of being covered with a superficial bloom of a russet color. Foot blackish grey, lighter beneath; mantle bluish grey, slightly tinged with yellow towards the posterior angle of the shell aperture. Head broadly semicircular, spreading below, obtusely angular at the posterior lateral margins and slightly emarginate in front. Foot disc broadly rounded in front and tapering behind to an obtusely rounded point; about five-eighths of an inch wide near the anterior end, and together with the head measures about one inch and five-eighths in length when the animal is in motion. Tentacles broad and thin, more than half an inch long, slightly curving inward and irregularly tapering to an obtuse point. Eye spots small, situated at the inner base of the tentacles; yellow in color with a black centre. Respiratory orifice of the pulmonary sac situated a little less than half an inch from the posterior angle of the shell aperture, and when fully dilated, as in the act of receiving air, is about one-fourth of an inch in its greatest diameter, and regularly oval in outline. The portion of the pulmonary sac near the respiratory orifice is very flexible, and is often protruded fully half an inch beyond the margin of the shell in the form of a long, slender, siphonal process, in the efforts of

the animal to reach the surface of the water for the purposes of respiration.

In examining the internal features of the animal there are a few prominent points of difference noticeable, as compared with the internal parts of any of the species of Lymnæa which I have been able to examine. These were, however, all of small or medium sized forms, *L. elodes* being as large as any I could obtain. I shall mention only a few of these features, without attempting an elaborate description of their entire characters. In tracing the features of the alimentary canal the oral aperture is found to be surrounded by five plates. The jaw, or horizontal plate is curved and armed with a small beak or central projection. The lateral plates are two on each side in adult individuals, instead of one only as in most Lymnæidæ. The upper one is very elongate-triangular, widest above, slightly truncated at the lower end, to which is articulated a second very much smaller triangular piece, pointed at the lower end. The pharynx or buccal mass is very large, and the radula or lingual membrane quadrangular in form when separated and spread out, with the antero lateral angles slightly truncated from wearing. It is about three-sixteenths of an inch long and about one-tenth wide. The denticles are arranged in about one hundred and thirty transverse rows, of one hundred and one in each row. They are of three kinds on each side of the central one, and are arranged in the following order: 10–25–15–1–15–25–10. The central series consists of a simple point or granule. The next fifteen on each side are similar to each other, except a general increase in obliquity from the centre outward, being short, broad and tricuspid, or occasionally having a fourth point on the sides of the central one, which is the longest. The first series of uncinæ, twenty-five in number, are long, oblique and narrowed above, forming a neck and again expanding toward the end; the serrated edge is oblique to the axis, and divided into three, four, or occasionally five serrations. The second kind of uncinæ, ten in number on each side, are small and slender, tricuspid, irregularly curved and loosely arranged. All the denticles become narrower and more oblique to the axis of the membrane as they recede from the central line, and their serrated faces directed more and more outward.

The salivary gland is situated at a very short distance below the pharynx, and surrounds the œsophagus. It is of a bright lemon yellow color and forms a rather conspicuous feature.

The most noticeable feature in the anatomy of the soft parts, is an organ which is situated immediately in front of the stomach, in connection with the dilatation of the œsophagus usually referred to as the "*crop*." In the ordinary forms of the Lymnæidæ this crop forms a fleshy expansion of the canal, but is of a soft texture and similar in character and color to the adjoining parts, but in this species there is a distinct organ presenting all the features of a true gizzard. This body is of about the size of a small pea, of a bright salmon color, and composed of two concavo-convex parts, somewhat elliptical in outline, placed on one side of the dilated portion of the œsophagus so as to half surround it. They are attached at their extremities by firm ligaments of a silvery white lustre, very similar in appearance to those on the outside of the gizzard of the commom barn-yard fowl. The interior of the gizzard is hard and firm, and somewhat wrinkled transversely. There is usually more or less sand found in the interior; that taken from the original Vermont specimen, when cleansed from foreign matter, was sufficient to have made a pellet one-twelfth of an inch in diameter. The true stomach is quite large and curved, opening from the lower side of the gizzard and gradually contracting behind to the diameter of the intestine.

The other organs do not differ essentially in form or position from the corresponding parts of other Lymnæidæ. In size and distinctness however, they are remarkable. The hepatic gland is very large, and with the hermaphrodite gland, which is imbedded in its substance, occupies all the upper part of the shell. The hermaphrodite gland exists as several small tufts of a deep flesh-color; the extremities of the tufts or bunches projecting to the surface of the hepatic gland are readily discernable from its dark greenish brown substance.

Some very curious changes were produced in the offspring of this species by the confinement and other unnatural conditions under which they were kept, during several years, in aquaria of limited size. The adult individual of the three original ones obtained, I succeeded in preserving alive until the summer follow-

ing. On the second of February, 1868, about seven months after I received it, I observed a nidamentum filled with eggs adhering to the plants in the aquarium. I had examined the vessel the previous evening, and as I had not observed it at that time I inferred it had been deposited within the preceding eighteen hours. The nidamentum measured one and one-quarter inches in length and about one quarter of an inch in width, reniform in outline, and contained seventy-two perfect ova, and a few without germinal spots. The ova were about one-twenty-fourth of an inch in their longest diameter, and of a broad oval form. A rather curious transformation was noticed to be taking place in the form of the germinal vesicle. In some of the ova it was already spherical, in several it was composed of two flattened spheres in close contact, as is described to be the case in the ova of Anodonta (Balfour Treat., Comp. Emb., Vol. 1, p. 31.), and in several it was seen to have the form of two discs united by a curved ligature of similar substance. The following day the germinal vesicles were each composed of a single spherical body. On the fourth day after their deposition, motion was first observed of the germinal vesicle. At this time a second nidamentum was observed, filled with ova. In the germinal spots of these the same changes were observed as in the others, and as it was detected at an earlier period, some of the spots consisted of a spiral thread, loosely coiled, but with the ends more closely coiled, forming discs, which gradually increased in size and approached each other as the thread between shortened, until they assumed the form of depressed spheres, and finally became united into a single spherical body.

With the instruments then at my command I was not able to trace all the changes of the embryos, but on the fifth day after their deposition I noticed a rapid revolving motion in those of the first nidamentum, and for several days they continued to increase in size and were very active, but on the fourteenth and fifteenth days they became inactive and soon died.

In the ova of the second nidamentum the same changes were observed as in those of the first, and on the twelfth day the form of the animal was distinctly visible, the shell having a little more than one volution; the foot, head and eyes were clearly dis-

tinguishable, and the position of the heart distinctly observed. On the fifteenth day the pulsations of the heart were counted and found to be forty-five in thirty seconds. On the fourteenth and fifteenth days the tentacles were observable with a low power glass, and the ocular lobes very prominent. The embryos escaped from the ova and nidamentum on the twentieth day, and were observed on the surface of the water obtaining air in the ordinary manner of the adult animal, and apparently feeding upon the slimy coating of the plants and glass.

In the spring of 1868 I placed several of the young shells when about half an inch in length, in various ponds and small streams in the vicinity of Albany, N. Y., where the conditions seemed favorable for their preservation, and retained others in a small aquarium at home.

I had been somewhat surprised to find that the ova deposited by the Vermont shell were fertile, as the animals of this group of molluscs are said to be dicœcious, requiring the congress of two individuals for fertility. The Vermont shell having been kept solitary from September 1867 until February 1868, the time when it deposited the nidamentæ, would seem to prove that this is not necessarily the case, unless, as Capt. W. H. Dall suggests, it had been in copula before I received it, and the semen had been retained in the *receptacula seminis* during the entire period without loss of its properties. From the young shells placed in various localities in the vicinity of Albany I obtained no results, except in one instance. In this case I found about thirty individuals two-thirds grown in June 1869, and large individuals in September of the same year, also a nidamentum nearly three inches in length filled with ova, lying loose upon the sandy bottom of the pond. I also found fully grown individuals, of large size, in 1870. From my observations upon these specimens I inferred that hybernation began early in September and ended in the spring, during the middle or latter part of May. All the individuals obtained from this pond have the exact form, size and characters of the original stock as obtained from their native locality in Vermont. But the changes that were produced in those kept in aquaria were so remarkable that I have thought them worthy of being recorded.

The specimens retained in aquaria were the larger and more

thrifty specimens from the second nidamentum deposited by the Vermont shell, being of the same brood as those transplanted to the aforementioned pond. They were carefully treated and observed almost daily during the entire time required for the observations recorded below. These young shells had acquired a little more than half the size of the parent shell in February of the following year (1869), being then nearly a year old. During this month several of them deposited nidamenta containing fertile ova. Those first observed were carefully separated from all others and cared for. A second nidamentum was deposited by some of these same specimens during the early part of the summer. Those of the winter brood deposited nidamenta in the spring of 1870. From one of these last, when grown and about eleven months old, being the fourth generation, or the third removed from the parent shell, the figure 10, Plate 1, was made.

Each generation of those kept in confinement differs in the form of the shell from the original type; the first only in size; the second in size and very slightly also in the degree of ventricosity, especially of the earlier volutions; but the third very markedly in the slender form of the earlier volutions; and in the narrow aperture as well as in the dimished size. This was not only the case in a few individuals, but in all of the brood, eight of which I succeeded in preserving until they were about seventeen months old. This peculiar change in the form of the spire interested me greatly, and I became anxious to ascertain its cause.

The previous generations had invariably produced nidamentæ during February or March; but the individuals of this slender spired brood failed to produce any during the spring or early summer months. When in the early summer one of the specimens died I examined the soft parts of the animal and failed to find any trace of the hermaphrodite gland, which should be imbedded in the substance of the hepatic gland in the apical volutions of the spire. I had made a constant practice of examining the soft parts of the animals, using Dr. Joseph Leidy's excellent memoir, published in Binney's Terrestrial Mollusca as a guide, and had become familiar with the different organs. After failing to trace this organ in the dead individual, I tried a living specimen with equally poor success; even when attempting to trace the organs

by following up the hermaphrodite duct from below, it was lost in the thinnest film of membrane before reaching the seat of the gland itself. Although I made the attempt on several specimens of the brood, I obtained only the same result in each case.

Late in June of that year (1871), I visited the pond previously mentioned and procured a single adult individual, which was placed in an aquarium containing a number of the slender spired individuals. On the fourth day after I found it paired with one of them, and carefully removed both to another vessel, together with the plants among which they rested. That evening I found that each individual had deposited a nidamentum containing ova; that of the small individual being attached to the shell of the other, and that of the large introduced specimen fastened to the plants in the water, the animals being still paired. The nidamentum of the shell with slender spire was removed to a separate vessel, and in due time the young individuals escaped from the eggs, and were preserved until they attained a length of more than an eighth of an inch, when they were destroyed by an accident to the aquarium during my absence from home. None of the other individuals of this brood (*i. e.*, those with slender spires) deposited fertile ova, although several of them formed nidamenta containing ova, but which were entirely destitute of germinal vesicles.

From the foregoing facts it would appear that the slender spire of the shells of the fourth generation might be the result of the atrophy of a portion of the organs usually occupying that part of the shell, namely the hermaphrodite gland; and that this change in the anatomical features of the individuals of this generation was in some way the result of, or dependent upon the changed conditions under which they had existed during their confinement in the aquaria; resulting in the production of a monœcious animal from a diœcious one of the most perfect kind. Also in changing the specific characters, as far as the form of the shell can be considered, to such an extent that when shown to a good working conchologist (Dr. James Lewis) he gave it as his opinion that they could have no specific relations to each other.

That these changes were the result of the adverse circumstances under which they existed is distinctly proved by the fact that

those of the second generation which were reared in the pond near Albany under very favorable conditions not only retained their dicœcious character, but also the same specific features as those of the original locality, and in many instances attained an unusually large size.

One peculiar feature attending the changes produced in these animals, is that all those of the fourth generation which attained maturity were apparently of the same sex, which would as a matter of course, without the introduction of individuals of more perfect character, have resulted in the extinction of the species. But had the experiment been conducted upon a large number of individuals both sexes might have been produced, but in different individuals, which might have resulted in the establishment of a moncœcious species. In discussing this subject Mr. Dall suggests that perhaps the changes which took place in the animals and shells might have been due to *close breeding*, resulting in sterility in the later generations; but in this connection states that in plants, under such conditions, the male organs are the ones usually retained, probably owing to their requiring less nutriment. In this case, however, the female organs retained their vitality in all the individuals of the fourth generation, and no males appeared to be developed.

NOTE.—The series of shells representing the changes and modifications above described, are now in the collection of the Museum.

Since the above article has been in type I have received from Dr. L. Johnson, of New York, a specimen of *Lymnæa stagnalis*, from near Sodus Bay, Lake Ontario, which on examination shows a gizzard-like body closely resembling that of *L. megasoma*, but of darker color and softer texture. These differences may be, to some extent, however, owing to the advanced stage of decomposition of the specimen when examined.

EXPLANATION OF PLATE 5.

LYMNÆ MEGASOMA. Page 29.

Fig. 1 View of the adult parent shell from Vermont.

Fig. 2. Shows the form of the animal when feeding on the surface of the glass of the aquarium.

Fig. 3. Shows the animal when in motion on the bottom. The opening of the pulmonary sac is shown as extended when breathing.

Fig. 4. Shows the form of the head when in rapid motion, and fig. 5 the same when at rest.

Fig. 6. Outline view of a shell of the second generation.

Fig. 7. Outline of one of the third generation.

Fig. 8. Outline of the individual of the fourth generation which produced living offspring.

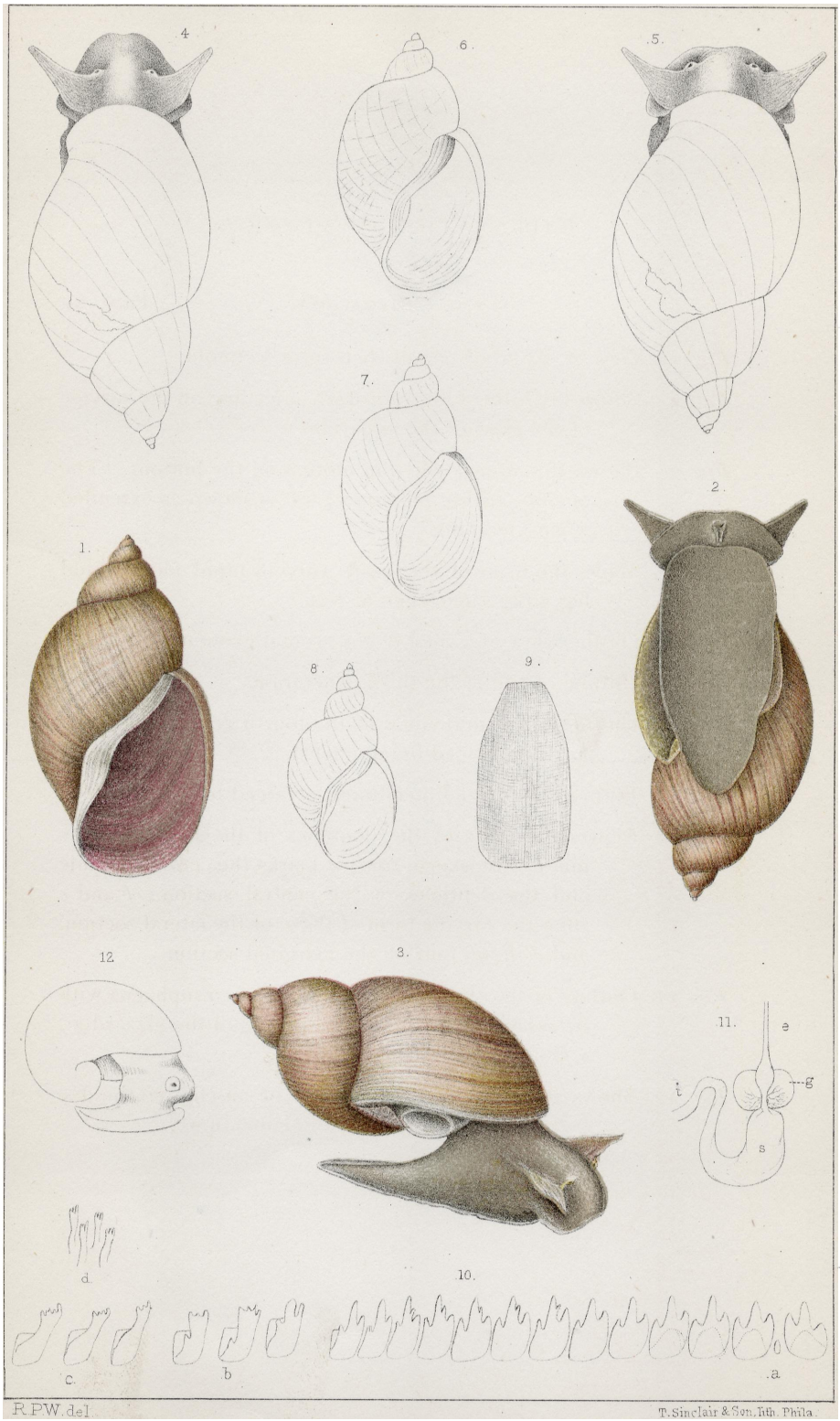
Fig. 9. Form of the lingual membrane, enlarged to six diameters.

Fig. 10. Represents parts of the denticles of the left side of a mature transverse row ; *a* marks the central granule and the denticles of the central section ; *b* and *c* show the varying form of those of the lateral section, and *d* shows four of the marginal section.

Fig. 11. Outline of the stomach, natural size ; *e*, œsophagus with its expansion below at the opening of the gizzard *g* ; *s*, stomach ; *i*, intestine.

Fig. 12. Shows the form and appearance of an embryo the day before its escape from the nidamentum.

LYMNAEA MEGASOMA.



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