

## SEX BEHAVIOR AMONG NAIADES

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While doing graduate work in the University of Missouri on the problem of preparing a descriptive and illustrated catalogue on the Naiades\* and also while collecting data as a Scientific Investigator for the benefit of the Pearl Button Industry under the direction of the U. S. Bureau of Fisheries† the writer had occasion to make some unusual observations of sex behavior among Naiades, commonly known as Freshwater Mussels.

Most of the observations mentioned in this paper are those made in the laboratory and in nature for *Lampsilis cardium* (Rafinesque), often known as *Lampsilis ventricosa* (Barnes), or in the trade as "Pocket Book". This species of Freshwater Mussel is the highest type of the next highest generic group of Naiades, the *Lampsilis*. This genus of Rafinesque is especially characterized in the female by profuse tentacles and papillae arranged around both the branchial and anal openings on the margin of the mantle which is doubled posteriorly and is extended down to the lowest post-ventral point on the mantle edges of both sides antero-ventrad to the incurrent opening as two long ribboned flaps.

This special character of fringed mantle flaps bearing eye-spots, together with unusually large marsupia with some thirty large bulging ovi-sacs, gives this type of mussel high rank in taxonomy because of its survival and minimum mortality due to the best advantage for the aeration of the embryos up to the glochidial stage. This adaptability resulting in the best advantage for the embryos is seen in all forms of life.

Because of this tentacular structure of both the incurrent and ex-current siphons and also because of the undulating ribbon-like flaps on the mantle margins below the branchial opening, together with the immense marsupia at the posterior ends of the outer gills, the shells of the female are greatly inflated and decidedly blunted at the posterior end.

Also through the action of these mantle flaps water currents are so created as to draw the sperm of the male into the branchial chamber as well as to direct an excess supply of oxygen through the thin ovi-sacs to the early embryos contained in membranous masses termed conglutinates.

These conglutinated masses in our type for study, *Lampsilis cardium*, are in the shape of in-soles and are actually discharged from the swollen

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†MUSSEL RESOURCES OF MISSOURI, U. S. Bureau of Fisheries, Economic Circular, No. 10.

beaded margins of the marsupium by processes of rupture through the thin postero-ventral walls. The writer has observed this discharge of late embryos both in the aquarium and in nature and thus has been able to verify the observations of other workers.

The writer, however, has observed the discharge of the sperm of the male and the intake by the female,—an observation not recorded before as far as he has been able to ascertain through a complete bibliography on the Naiades secured after four years of study of this very interesting group of Mollusks.

Besides making observations of this sex behavior in the laboratory and in nature for *Lampsilis cardium*, the writer has also been able to record three other instances of the male discharging sperm,—one for *Lasmigona complanata* and one for *Utterbackia ohiensis*\*,—all in the laboratory aquarium. However, in the case of *Lampsilis cardium* this behavior for both sexes was observed in both the aquarium and the clear shallow water of the river.

The sperm discharge was observed as a tiny stream of milky white cysts from the anal, or excurrent siphon. Upon examination with a lens magnifying 385 diameters these cysts were seen to be hollow globular masses of sperm revolving clock-wise in the water by means of flagella thrust through a matrix from hundreds of individual sperm-cells, much in the same manner as in the Colonial Protozoön, *Volvox globator*.

This rotary motion of the sperm masses, together with that of the late embryos of the Naiades, may not be the eccentricity as claimed by some workers in this group of Mollusks since this physiological character may be expected in all mussels,—in fact this ingrained tendency to move in circles is characteristic of all forms of life, especially in the gametes and in all stages of the embryonic development.

One of the most important revelations made in the field of Zoology at the last Meeting of the American Association for the Advancement of Science was the relation of this circling tendency to that of sex as applied alike to plants and animals.† After twelve years of research work Dr. Schaeffer, now of the Department of Zoology in the University of Kansas, has made thousands of tests for various animal and plant types,—especially for the ameba,—to find that the right and left spiraling propensities are involved in the determination of sex in that the positive, or clock-wise spiraling accompanies forms reproducing sexually and the negative, or anti-clock-wise spiraling as characteristic of forms reproducing asexually as seen among the lower forms of life.

Among the higher sexual forms, as seen among the Naiades, whatever causes the differences in this rotary motion in the germ cells, as well as in the pre- and post-embryos, we would ascribe to identical differences in sex. Be that cause what it may we know from observing

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results as seen in the globular sperm masses of mussels that the etiology for the male gamete would indicate that its sex is determined in a molecular way by the left-to-right stereoisomer, as we may term this hypothetical causation.

The presence of these right and left stereoisomers, as causal factors for male and female, would only be accompanying factors in the chromosome theory of sex determination in that the presence of the idiosome determines the male offspring and the absence of such odd chromosome predestines the female.

The writer has also observed the rotary motion in late embryos of that peculiar species of mussel, *Utterbackia ohiensis* (Raf.) These were observed to be revolving,—some right and some left,—around one axis at the rate of fifty times a minute. This phenomenon is seldom seen because of its short duration and seems to be a necessary movement in the final development into the glochidial (larval) stage.

The interesting behavior of the female *Lampsilis cardium* was noted by the writer on many instances to be buried in the gravelly bottom of clear shallow water with only the siphons, mantle flaps and two black ovi-sacs exposed. The ribbon-like flaps waved to and fro in an undulating manner and occasionally a white leaf-like conglutinate would be discharged. Not far away was another female with open siphons and waving flaps sucking in sperm from a male of the same species which was discharging milt from the anal opening in a tiny white stream making the water milky white for some distance around. Most of the other females located at this station were found at that time to have empty marsupia and receptive for the sperm of the active male *cardium*.

<sup>†</sup>From a paper, "MOLECULAR ORGANIZATION OF PROTOPLASM IN AMEBAE". By Dr. A. A. Schaeffer, Department of Zoology, University of Kansas.