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BREEDING RECORD OF MISSOURI MUSSELS.

BY W. I. UTTERBACK.

The following record includes twenty-six of the most representative species of the different subfamilies of *Naiades* for Missouri. Actual numbers of mussels are recorded for those collected in north and northwest Missouri but no definite record of numbers of sterile and gravid individuals could be kept by the author in his survey of the Osage River from the latter part of June to the middle of August while under the direction of the U. S. Fisheries Biological Station, Fairport, Iowa.¹ The revised nomenclature for the *Naiades* is followed in this report since the revival of *Rafinesque*² has been accepted by the leading students, and since, too, it has been found that the glochidial and marsupial characters are the best bases for classification;³ however, for the sake of clearness, the more familiar names appear as synonyms in parentheses after the revised names.

In the following tables the kinds of glochidia are indicated thus:

Lamp. = *Lampsilis* type (i. e., suboval-subelliptic, spineless glochidia).

An. = *Anodonta* type (i. e., subtriangular, spined glochidia).

Prop. = *Proptera* type (i. e., axe-shaped, spined-spineless glochidia).

¹ U. S. Bu. Fish., Econ. Cir., No. 10, 1914.

² L. S. Frierson, 1914 a, (NAUTILUS, xxviii, pp. 6-8; E. G. Vanatta, 1915 a, (Proc. Acad. Nat. Sci. Phila., pp. 549-559).

³ Dr. A. E. Ortmann, 1911 b, (Mem. Carnegie Mus., iv, pp. 279-339; 1912 b, (An. Car. Mus., viii, pp. 222-365).

tion to our knowl-

MODICATA. By
J. H. Dec. 1915).
fulva arkansensis,
from the
Missouri.

By S. S. Berry.
Vol. 16, No. 9.
P. sulcularis affi-
new from the San
of Pacific Grove,

(Brug.) was
in THE NAUTI-
p. 120 (1898).
by Mr. Robert
"P. philadelphicum" (Pir.)
of Philadelphia"
1898, volume viii,
of The Acad-
y No. 113421.
collection from a
being A. N. S. P.
1906; also No.
E. Lehnert many

th, on the 26th
ished German

vol. 29, p. 53.

TABLE I
BREEDING RECORD OF SHORT (OR "SUMMER") PERIOD BREEDERS (BENTHIC SPECIES)

MUSSEL SPECIES	MONTHS WHEN BEARING GLOCHIDIA												Kind of Glochidia	
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
1. <i>PECCONATA UNDATA</i> (Barneis).....						X		X						Lamp.
<i>Quadrula trigona</i> (Lea)						X								"
2. <i>AMBLEMA PYCATA</i> (Say).....						X								"
<i>Quadrula plicata</i>														"
3. <i>MEGALONAIAS HEROS</i> (Say).....	X												X	"
<i>Quadrula heros</i>														"
4. <i>QUADRULA FESUULOSA</i> (Lea).....						X								"
5. <i>QUADRULA QUADRATA</i> (Raf.).....						X								"
<i>Quadrula quadrata</i> (Lea)						X								"
6. <i>QUADRULA VEREPROSA</i> (Raf.).....						X								"
<i>Phrygonia vereprosa</i> (Simp.)														"
7. <i>ROTUNDALIA TVERCTIATA</i> (Raf.).....							X	X						"
<i>Quadrula tverctiata</i> (Simp.)														"
8. <i>ELLIPTIC FILIATA</i> (Raf.).....							X	X						"
<i>Fila filata</i> (Barneis)														"
9. <i>UNIONIDUS TETRALISMA</i> (Say).....					X			X						"
<i>Ung. tetralisma</i> (Say)														"
10. <i>OBLIQUARIA DEPLEXA</i> (Raf.).....						X	X	X						"

TABLE II.—BREEDING RECORD OF LONG (OR "WINTER") PERIOD BREEDERS (EPIBENTHIC SPECIES)

MUSSEL SPECIES	MONTHS WHEN BEARING GLOCHIDIA												Kind of Glochidia	
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
1. <i>LAMIGONA COMPLANATA</i> (Barneis).....	X												X	Ab.
<i>Strophomena complanata</i>													X	"
2. <i>AMBYLUS GYRFALCIS</i> (Say).....	X													"
3. <i>LARINA SUBRECTILATA</i> (Say).....	X													"
<i>Ambylus subrectilata</i> (Say)														"
4. <i>LARINA GIBBOSA</i> (Raf.).....	X										X			"
<i>Larina gibbosa</i> (Say)														"
5. <i>AMBYLUS GIBBOSA</i> (Say).....	X													"

Special attention would be directed to the fact that this record includes four instances of the male discharging sperm, one in case of *Lasmigona complanata* (Say), two instances of *Lastena suborbiculata* (Say) and one of *Lampsilis cardia* (Raf.), all observed in the laboratory aquarium. In case of both *complanata* and *suborbiculata* this physiologic fact disproves the report that, like their nearest allies, *Lasmigona compressa* (Lea) and *Lastena ohioensis* (Raf.), are hermaphroditic. Another instance of sperm discharge for *Lampsilis cardia* was observed in nature. This discharge was observed as a tiny stream of milky white cysts. Upon examination with a lens, magnifying 385 diameters, these cysts were observed to be hollow globular masses of sperm, each cyst revolving through the water by means of the flagella of hundreds of sperm cells thrust out through the matrix. It was the pleasure of the author to verify the observations of Dr. A. E. Ortmann, (1911a, p. 319), in discovering on several instances the female of this same species, (*cardia*), buried in the gravel with only the siphons, mantle flaps and two blackish ovisacs exposed. The ribbon-like flaps waved to and fro in an undulating manner and occasionally a white leaf-like conglutinate would be discharged. It was noted that the marsupia of this species were sterile and receptive on occasion of the sperm discharge.

Another physiologic observation, made in the laboratory, should be mentioned here in connection with the reproductive functions of the *Naiades* and that was in case of the rotary motion of the late embryos of *Pleurobema obliquum coccineum* (Conrad) and of *Lastena ohioensis* (Raf.). These are noted to be revolving clock-wise around one axis at the rate of about fifty times per minute. This phenomenon may be common with all species of *Naiades* and the reason why only seldom seen may be because of the short duration of this embryonic activity which may be necessary in the final development into the glochidial stage, for it was only in this structural stage that this rotary motion was seen.

The most prolific and continuous breeder, found by the writer, is *Lasmonos fragilis*. This mussel, being the predominant form in northwest Missouri and thus being the most

accessible, ample opportunity for a complete record and in every month of the year. However, high water prevents any species during the month of glochidia throughout the year. These species were found in immediately preceding months. Hence, we would conclude that a long-period breeder (*Lastena ohioensis* and *Strophodontia*) because of the same habits of breeding season. The habit of these last mentioned of breeding season. We would conclude that the marsupial structures of the *Naiades* metamorphosis of its larva (*Naiades*), except the last mentioned as their natural distribution of both *S. edentulus* and *S. edentulus* due to the buoyancy of the glochidia), discharged glochidia, papery shells of both juvenile and adult.

Probably this account is on record. On March 10, 1914, bearing mature glochidia. Contrary, St. Joseph, Mo., September 10, 1914, 64 were found gravid with glochidia. *female shells were all smooth and none in this collection only 39 mm. long.* Of these so-called *lacrissim* occurrence of smaller shells in case of *Obliquaria* (= *P. securis* [Lea]).

The Breeding Record

to the fact that this male discharging sperm, (May), two instances of *Lampisilis cardia* (Raf.), In case of both complete fact disproves the *Plagiola compressa* (Lea) dirotitic. Another instance was observed in a tiny stream of milky lens, magnifying 385 to be hollow globular through the water by sperm cells thrust out of the author to vermann, (1911a, p. 319), the female of this same with only the siphons, exposed. The ribbon-like manner and occasional be discharged. It species were sterile and large.

made in the laboratory, with the reproductive in case of the rotary *Obliquaria obliquum coccineum* (L.). These are noted to at the rate of about fifty may be common with all only seldom seen may this embryonic activity development into the structural stage that this

breeder, found by theessel, being the predominant thus being the most

accessible, ample opportunity was given to obtain the most complete record and has been found gravid with ripe glochidia every month of the year except for March and August. However, high water prevented the keeping of a complete record for any species during March. In all probability *fragilis* bears glochidia throughout this month also as more individuals of this species were found in glochidial gravidity during the month immediately preceding than at any other time of the year. Hence, we would conclude that this species is bradytictic (i. e., a long-period breeder) with an overlapping breeding season. *Lastena ohioensis* and *Strophitus edentulus* may be classed likewise because of the same character in that they also overlap in their breeding season. The fact of non-parasitism as the normal habit of these last mentioned may account for their eccentricities of breeding season. We may also account for the very peculiar marsupial structures of *S. edentulus* because of this independent metamorphosis of its larva. As far as now known all species of *Naiades*, except the last named, are dependent upon fish-hosts as their natural distributors; however, the wide distribution of both *S. edentulus* and *L. ohioensis* has been considered to be due to the buoyancy of the *placentulae*, (gelatinous cords holding glochidia), discharged by the former and also to the very light papery shells of both juvenile and adult of the latter.

Probably this account will show the *smallest gravid individual* on record. On March 3, 1913, a gravid *Proptera laevissima*, bearing mature glochidia, was collected by the writer in Lake Contrary, St. Joseph, Mo., measuring 39 mm. in length, and on September 10, 1914, 61 *laevissima* were collected, 32 of which were found gravid with ripe glochidia. Strange to say, these female shells were all smaller than the other 29 males; however, none in this collection exceeded 43 mm. in length, two being only 39 mm. long. Upon further study it may be found that these so-called *laevissima* are really distinct species and that the occurrence of smaller shells may be found to be normal, as seen in case of *Obliquaria reflexa* and of *Plagiola lineolata* (Raf.) (= *P. securis* [Lea]).

The Breeding Record kept herein corresponds with those of

Ortmann, Sterki,¹ Surber,² Howard,³ Lefevre and Curtis⁴ in the exceptions which these authors make for the general rule that the species of the sub-family *Unioninae* are short-period breeders (tachytictic) and those of the sub-families *Anodontinae* and *Lampsilinae* are long-period breeders (bradytictic). The writer agrees with Surber² and Howard³ that *Megalonia heros* should be classed as doubtfully bradytictic. Probably it would be more nearly correct to consider *heros* as tachytictic with the latest breeding season known. Another case of eccentricity of breeding season is that of *Obliquaria reflexa*. Although this species belongs to the sub-family possessing long period of gravidity as the rule, yet the writer has only found it sterile during every month of the winter season. *Amygdalonia donaciformis* has also been found to be sterile in a few instances throughout the winter months, yet this knowledge may be too meagre to establish it as a short-period breeder. However, being found gravid with mature glochidia the early part of June may be partial evidence that this species is bradytictic. The writer is able to verify Surber's discovery that *donaciformis* produces the *smallest glochidium* (0.060x0.063 mm.) on record,² and also that, in its metamorphosis, the encysted young shows the unusual growth of adult shell beyond the margin of the glochidial shell.

In keeping this record it was occasionally noted that in a few cases, especially as found in *Lasmigona complanata* and *Lasmonos fragilis*, that the marsupia would contain early and late embryos, and even mature glochidia, at the same time. However, this irregularity is doubtless abnormal since uniformity of development and maturity is the rule for all species.

It may be of interest here to state how the author has been enabled to distinguish sterile females from males of those species which have no sexual dimorphism of shell and no definite differentiation of marsupium and of post-ventral mantle margin as seen in the *Unioninae* and *Anodontinae*. In most cases, as

¹ 1903a (American Nat., xxvii, pp. 103-113).

² 1912a (U. S. Bu. Fish., Doc. 771).

³ 1915 (Nautilus, xxix, pp. 4-11).

⁴ 1912 (U. S. Bu. Fish., xxx, Doc. No. 756).

pointed out by Dr. will enable one to no ovisacs) of the sterile than those that sepe A histologic study sl cepta of the sterile m

Tables 2 and 3 are plete individual recor U. S. Bureau of Fish ividual accounts of the females as well as th mature-immature gloe still holds in his poss- gravid with glochidia and late embryos. T shells, the latter hav carbonate (Na₂CO₃) : chemical in five gull preserved in the mat loose and temporarily can be made before by the preservative.

mens has been found alcohol, since such p so much free acid that reaction upon the limy

While the writer wa ing data for his illus *Naiades* of Missouri¹ i glochidia, which follo first on actual record. for his acknowledgem cation of measurement

The author is confi place in the suprabran hand this determinati

¹ American Midland Natu

and Curtis⁴ in the general rule that short-period breeders (*Aquadantinae* and *Urosalpinx*). The writer thinks *Nautilus heros* should probably it would be consistent with the latest strictness of breeding through this species and of gravidity as sterile during every *Nautilus heros* has been throughout the season to establish being found gravid one may be partial the writer is able to produces the *smallest* and also that, in its the unusual growth of the shell.

pointed out by Dr. Ortmann, even a macroscopic examination will enable one to note that the septa (vertical partitions for the ovisacs) of the sterile marsupium are distinctly more crowded than those that separate the gill chambers of the male gills. A histologic study shows five or ten gill filaments between the septa of the sterile marsupium or brood pouch.

Tables 2 and 3 are summarized accounts made out from complete individual records kept on the regular form issued by the U. S. Bureau of Fisheries for Biological Stations. These individual accounts of the different species comprehended the sterile females as well as those gravid with early-late embryos and mature-immature glochidia. As proof of this record the author still holds in his possession the preserved anatomical material, gravid with glochidia and also much that is gravid with early and late embryos. The soft parts have been preserved with the shells, the latter having been cleaned in a solution of sodium carbonate (Na_2CO_3) made by dissolving five pounds of this chemical in five gallons of water. Then the soft parts were preserved in the marked shells after the right valves were cut loose and temporarily examined afield when the best studies can be made before the tissues are contracted or discolored by the preservative. The best preservative for the whole specimens has been found by the author to be 70 or 80 per cent. alcohol, since such preserving fluids as formaldehyde contain so much free acid that the shell is deteriorated by the chemical reaction upon the limy composition.

While the writer was engaged for over three years in procuring data for his illustrated and descriptive catalogue of the *Nautilus* of Missouri¹ it was his good fortune to discover a few glochidia, which follow in the descriptive table here, as the first on actual record. The author is indebted to Dr. T. Surber for his acknowledgement of the novelty and also for his verification of measurements of these glochidia.

The author is confident that fertilization of the ova takes place in the suprabranchial canals and when more data is at hand this determination may be set forth as a well-proven phe-

¹American Midland Naturalist, Vol. iv, 1915-1916, Plates I-XXVIII.

TABLE III
NEW GLOCHIDIA

Mussel Species	Description of Glochidia						Locality in Missouri
	Kinds	Min. Long	Min. Wide	General Outline	Ventral Margin	Hinge Line	
1. <i>Amblyema perplicata quintardii</i> (Cragin).	Lamp.	.205	.215	Suboval	Spineless	Straight	Osage R., Warsaw.
2. <i>Rotundaria tuberculata</i> (Rafinesque).	"	.267	.325	Subelliptic	Spineless	Straight	Osage R., Osceola.
3. <i>Pleurobema obliquum solidum</i> (Lea)	"	.170	.180	Suboval	Spineless	Straight	Osage R., Schell City.
4. <i>Unionensis tetractema</i> (Say)	"	.160	.210	Subelliptic	Spineless	Straight	Lost Cr., Maysville.
5. <i>Lastena suborbiculata</i> (Say)	Ab.	.325	.320	Subtriangular	Spined	Undulate	Lake Contrary, St. Joseph.
6. <i>Cercoclitma parva</i> (Bar.)	Lamp.	.175	.200	Semi-circular	Spineless	Evenly curved	Flat Cr., Sedalia.
7. <i>Erycinia brevicula britsii</i> (Simp.)	"	.250	.305	Semi-elliptic	Spineless	Undulate	Niangua R., Hahaionka.

nomenon. The physiological studies of two most accessible found that the ovisacs were before being filled with eggs be necessary in all species. injured, that greater number laminae may be stretched to aeration of the embryos.

A NEW GYVELL

BY S. S. SUTHERLAND

NEOSIMNIA CATALINENSIS, NEW

Shell very thin, fusiform, maximum diameter contained almost pure porcelain or porcelain with brownish yellow for a polished and glossy; closely the striae readily visible to the being somewhat coarser than comprising some 20-25 laminae, utely wavy as they are indicated indications of an extremely fine rest of the shell are discovered at both ends, but distinctly in base. Outer lip not greatly white callos; retracted at the obscure angle. Columella in channel at the summit oblique. Length 23 mm.; maximum Type: Cat. No. 1224 of the Type Locality: 50 fathoms, California (Avalon Aquarium). Remarks: The type and a locality taken by J. H. Paine *linensis* does not seem to be a

nomenon. The physiologic preliminaries for ovulation have been noted by the writer on many instances in his detailed studies of two most accessible species of this State. It was found that the ovisacs were frequently distended with water before being filled with eggs, a reproductive function that may be necessary in all species in order that the ova may not be injured, that greater numbers may be admitted and that the laminae may be stretched to a thinness more suitable for the aëration of the embryos.

A NEW OVULA FROM CALIFORNIA.

BY S. STILLMAN BERRY.

NEOSIMNIA CATALINENSIS, new species.

Shell very thin, fusiform, swollen above the middle, maximum diameter contained about $2\frac{1}{2}$ times in the length; color a nearly pure porcelain or pearly white, the extreme ends tinted with brownish yellow for a distance of 2 to 3 mm. Surface polished and glossy; closely and finely longitudinally striate, the striae readily visible to the eye and rather irregular, a few being somewhat coarser than the remainder. Spiral sculpture comprising some 20-25 low cords at each end, becoming minutely wavy as they are intersected by the longitudinal striae; indications of an extremely faint wavy spiral striation over the rest of the shell are discovered by a strong lens. Shell pointed at both ends, but distinctly more produced at the apex than the base. Outer lip not greatly thickened, bordered by a narrow white callus; retracted at both ends, in each instance with an obscure angle. Columella sinuous; a low spiral fold and channel at the summit obliquely encircling the axis.

Length 23 mm.; maximum diameter $8\frac{1}{2}$ mm.

Type: Cat. No. 1224 of the writer's collection.

Type Locality: 50 fathoms, off Avalon, Santa Catalina Island, California (Avalon Aquarium, August 1906).

Remarks: The type and a young specimen from the same locality taken by J. H. Paine in 1903 are before me. *N. catalinensis* does not seem to be very similar to any of the related