RICHARD J. NEVES

Grier 1920

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Sexual Dimorphism and Some of Its Correlations in the Shells of Certain Species of Najades.

BY N. M. GRIER, PH. D.

I.—INTRODUCTORY.

Before Ortmann's discovery that the sex of Najades could be readily learned from associated peculiarities of gill structure, (4, 5,), systematists had only general information—of the type later to be compared in this paper—from which to identify the sex of a mussel when glochidia were absent. Hazy, (2), and Israel, (3), were able to distinguish the sexes of certain European species by such characters as relative length, height, and inflation. Israel, particularly, found associated with sex, certain colors of the epidermis of the shell. The investigations of these latter writers extended only to 3 species, none of which are closely related to those dealt with in this paper, and their original work never seems to have been followed up. In addition there occur in the papers of American investigators from time to time, scattered references to the sexual dimorphism of certain species based on some morphological feature of the shell. Such, however, are either not concerned with the species we are interested in, or are already summarized by Simpson, (6), or Walker, (8), whose information later will be brought out.

II.—PROBLEM, METHOD, AND MATERIAL.

While pursuing another investigation on the comparative morphological characteristics of certain mussel shells inhabiting the Upper Ohio Drainage and their corresponding ones in Lake Erie, (1) the writer obtained data of the type indicated, which he proposes in this paper to associate as far as possible with the sex of the shells examined.

The material used was Dr. A. E. Ortmann's splendid collection of shells in the Carnegie Museum at Pittsburgh, Pa., and while the most complete account of how these measurements were taken is reserved until the publication of the research spoken of, the method of making them is described to what is believed to be a comprehensible extent in the accompaning table dealing with sexual dimorphism. Here it may suffice to state that the dimensions taken were 7 in number and included the measurement of,

1.—Relative degree of inflation.
2.—Height.
3.—Posterior length of shell.
4.—Anterior length of shell.
5.—Length of posterior hinge line.
6.—Length of anterior hinge line.
7.—Thickness of shell—in this investigation taken just superior to the pallial line in the region directly beneath the umbo

In making these measurements an ordinary metric caliper and rule were used, the values obtained reduced to convenient factors by division into the length, with the exception of that of thickness, which it seemed desirable to compare with the height.

Measurements were made on the following genera and species, viz.,

Fusconija flava, Raf.
Amblema costata, Raf.
Pleurobema obliquum coccineum, Con.
Elliptio dilatatus, Raf.
Symphynota costata, Raf.
Anodonta grandis, Say.
Paraptera fragilis, Raf.
Proptera alata, Say.
Anodontoides ferussacianus, Lea
Eurynia recta latissima, Raf.
Lampsilis luteola, Lam.
Lampilis ovata ventricosa, Lam.

The factors above described having been obtained, it was the practice while making comparisons in the endeavor to associate any of the 7 measured morphological dimensions with the sex of the shell, to compare equal numbers of both sexes of the species. An average was made of the values obtained by calculation for each dimension of the shell, and then this result compared with that similarly obtained from the other sex of the animal. A table (I) showing the averages for each dimension of that sex of each species is appended, and from the comparison of its values, the table on Sexual Dimorphism (II) is obtained.

III.—
(*a.*) Co

In more condensed form the expressed as follows.

1. *Males of Pleurobema, F possess a greater height and deg relatively shorter. The females L. luteola, and L. ovata show opp of females representing the first f going, height correlates with the a of Anodonta, Anodontoides whil than females, have a less height.*

2. *Males of Elliptio, Anodon and L. ovata have a relatively gre shell, and consequently less of th this condition is reversed.*

3. *The one outstanding morp derating extent with maleness i greater length of posterior hinge l in the females). These facts co posterior length in ½ the species*

4. *Thickness of shell, as asso indifferent as all the other dimen the hinge lines).*

(*b.*)

There is now given from Si (7), all descriptive material of shells usually held to be associ rule, emphasis is placed on Wall desire to show the relation of obtained.

Utterback believed female possess a greater degree of infla only with the former in this res species listed in the order give to be no accredited descriptive Dimorphism), until we come to

Simpson: *Paraptera.* "Fe sometimes a little rhomboid or a sociate as far as possible with the sex

Dr. A. E. Ortmann's splendid collection
Museum at Pittsburgh, Pa., and while
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f shell.
f shell.
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ell—in this investigation taken just
in the region directly beneath the umbo
asurements an ordinary metric caliper
values obtained reduced to convenient
he length, with the exception of that of
d desirable to compare with the height.
made on the following genera and species,

Paraptera fragilis, Raf.
Proptera alata, Say.
neum, Con. *Anodontoides ferussacianus, Lea*
Eurynia recta latissima, Raf.
Lampsilis luteola, Lam.
Lampilis ovata ventricosa, Lam.

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ual numbers of both sexes of the species.
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hell, and then this result compared with
om the other sex of the animal. A table (I)
each dimension of that sex of each species
he comparison of its values, the table on
is obtained.

III.—Results.

(*a.*) *Conclusions.*

In more condensed form the results given in the tables may be expressed as follows.

1. *Males of Pleurobema, Elliptio, Symphynota, and Proptera possess a greater height and degree of inflation than females and are relatively shorter. The females of Fusconaja, Amblema, Eurynia, L. luteola, and L. ovata show opposite characters in this respect to those of females representing the first four named species. Also in the foregoing, height correlates with the degree of inflation of the shell. Males of Anodonta, Anodontoides while having a greater degree of inflation than females, have a less height.*

2. *Males of Elliptio, Anodonta, Paraptera, Anodontoides, Eurynia and L. ovata have a relatively greater length of the posterior part of the shell, and consequently less of the anterior. In the remaining shells this condition is reversed.*

3. *The one outstanding morphological feature associated to preponderating extent with maleness in the Najades dealt with, was the greater length of posterior hinge line, (the anterior seems best developed in the females). These facts correlate with values for anterior and posterior length in ½ the species only.*

4. *Thickness of shell, as associated with sex, seems to be as equally indifferent as all the other dimensions, (with the exception of those of the hinge lines).*

(*b.*) *Remarks.*

There is now given from Simpson, (6), Walker, (8), Utterback, (7), all descriptive material of the external morphology of these shells usually held to be associated with the different sexes. As a rule, emphasis is placed on Walker's late work, and it is the writer's desire to show the relation of this material to the results he has obtained.

Utterback believed females of *Fusconaja* and *Symphynota* to possess a greater degree of inflation of the shell. My results check only with the former in this respect. We must pass over the other species listed in the order given (for the reason that there seems to be no accredited descriptive material concerning their Sexual Dimorphism), until we come to *Paraptera*.

Simpson: *Paraptera.* "Female and male much alike, former sometimes a little rhomboid or again it ends in a wide rounded point

TABLE II.

SEXUAL DIMORPHISM IN NAYADES.

(Dextro-sinistral diameter $\frac{DSD}{L}$ or convexity of valve divided by length giving *degree* of *inflqtion*)

Male Greater this Respect in	No. spec. meas-ured of each		Female Greater this Respect in
Pleurobema coccineum	15	27	Fusconajo flava
Elliptia dilatatus	15	19	Amblema plicata
Symphynota costata	5	33	Eurynia recta
Anodonta grandis	8	94	Lampsilis luteola
Paraptera fragilis	5	84	Lampsilis ovata
Proptera alata	6		
Anadontoides ferussacianus	3		

(Dorso-ventral diameter of $\frac{DVD}{L}$ value divided by length giving *relative height.*)

Male Greater this Respect in	No. spec. meas-ured of each		Female Greater this Respect in
Pleurobema	15	27	Fusconaja
Symphynota	5	19	Amblema
Elliptio	15	8	Anodonta
Proptera	6	5	Paraptera
Eurynia	33	8	Anodontoides
		94	L. luteola
		84	L. ovata

(Distance posterior to extremity $\frac{PD}{L}$ from aline passing through median dorsal plane of valve expressing *relative;degree posterior development shell.*)

Male Greater this Respect in	No. spec. meas-ured of each		Female Greater this Respect in
Elliptio	15	27	Fusconaja
Anodonta	8	19	Amblema
Paraptera	5	15	Pleurobema
Anodontoides	3	5	Symphynota
Eurynia	33	6	Proptera
L. ovata	84	94	L. luteola

(Distance anterior to extremity $\frac{AD}{L}$ from a line passing through median dorsal plane of valve expressing *relative degree anterior development shell.*)

Male Greater this Respect in	No. spec. meas-ured of each		Female Greater this Respect in
Fusconaja	27	15	Elliptio
Amblema	19	8	Anodonta
Pleurobema	15	5	Paraptera
Symphynota	5	3	Anadontoides
Proptera	6	33	Eurynia
L. luteola	94	84	L. ovata

(Length of shell compared $\frac{PHL}{L}$ with th

Male Greater this Respect in	No. spec. meas-ured of each	
Fusconaja	27	5
Amblema	19	6
Pleurobema	15	5
Elliptio	15	
Anodonta	8	
Anodontoides	3	
Eurynia	33	
L. luteola	94	
L. ovata	84	

(Length of shell compared $\frac{AHL}{L}$ with the

Male Greater this Respect in	No. spec. meas-ured of each	
Symphynota	5	27
Proptera	6	19
Paraptera	5	15
		15
		8
		3
		33
		94
		84

(Thickness of shell divided $\frac{TH}{DVD}$ by do

Male Greater this Respect in	No. spec. meas-ured of each	
Pleurobema	15	27
Elliptio	8	19
Anodonta	8	5
Proptera	6	5
Anodontoides	3	94
Eurynia	33	
L. ovata	84	

about in the median line. Female shell
rounded in the post-basal region." Spec
not abundant, but if in this species "rho
imply a greater height compared with th
agreement on the part of my results. In
region was not measured.

Proptera: "Female shell with long ro
at extreme post-basal part, generally sub
shell less full in post basal region, nearly

ABLE II.

PHISM IN NAYADES.

$\frac{LSD}{L}$ or convexity of valve divided

ng degree of *inflqtion*)

	No. spec. measured of each	Female Greater this Respect in
1?	27	Fusconajo flava
1?	19	Amblema plicata
[illegible]	33	Eurynia recta
[illegible]	94	Lampsilis luteola
[illegible]	84	Lampsilis ovata
6		
[illegible]		

r of $\frac{DVD}{L}$ value divided by length

relative height.)

	No. spec. measured of each	Female Greater this Respect in
15	27	Fusconaja
5	19	Amblema
15	8	Anodonta
6	5	Paraptera
33	8	Anodontoides
	94	L. luteola
	84	L. ovata

$\frac{PD}{L}$ from aline passing through median dor-

relative degree posterior development shell.)

	No. spec. measured of each	Female Greater this Respect in
15	27	Fusconaja
8	19	Amblema
5	15	Pleurobema
3	5	Symphynota
33	6	Proptera
84	94	L. luteola

$\frac{AD}{L}$ from a line passing through median dor-

relative degree anterior development shell.)

	No. spec. measured of each	Female Greater this Respect in
27	15	Elliptio
19	8	Anodonta
15	5	Paraptera
5	3	Anadontoides
6	33	Eurynia
94	84	L. ovata

(Length of shell compared $\frac{PHL}{L}$ with that of posterior hinge line.)

Male Greater this Respect in	No. spec. measured of each		Female Greater this Respect in
Fusconaja	27	5	Symphynota
Amblema	19	6	Proptera
Pleurobema	15	5	Paraptera
Elliptio	15		
Anodonta	8		
Anodontoides	3		
Eurynia	33		
L. luteola	94		
L. ovata	84		

(Length of shell compared $\frac{AHL}{L}$ with that of anterior hinge line.)

Male Greater this Respect in	No. spec. measured of each		Female Greater this Respect in
Symphynota	5	27	Fusconaja
Proptera	6	19	Amblema
Paraptera	5	15	Pleurobema
		15	Elliptio
		8	Anodonta
		3	Anodontoides
		33	Eurynia
		94	L. luteola
		84	L. ovata

(Thickness of shell divided $\frac{TH}{DVD}$ by dorso-ventral diameter.)

Male Greater this Respect in	No. spec. measured of each		Female Greater this Respect in
leurobema	15	27	Fusconaja
lliptio	8	19	Amblema
nodonta	8	5	Symphynota
roptera	6	5	Paraptera
nodontoides	3	94	L. luteola
arynia	33		
ovata	84		

out in the median line. Female shell a little fuller and more unded in the post-basal region." Specimens of Paraptera were ot abundant, but if in this species "rhomboidal" may generally aply a greater height compared with the length, there is some greement on the part of my results. Inflation of the post-basal gion was not measured.

Proptera: "Female shell with long rounded marsupial swelling extreme post-basal part, generally sub-truncate behind. Male ell less full in post basal region, nearly rounded behind." My observations do not agree with calculations from Walker's illustration of this species which shows the female to be relatively higher. They do agree in assigning the female a greater posterior length of shell.

Eurynia: "Male shell drawn out behind and ends in a blunt point about midway up from the base. Female shell has long rounded marsupial swelling, ending in a blunt point ⅔ way up from the base." This data agrees with my measurements, as it may be inferred the male is longer, the marsupial swelling may be in evidence from the inflation of the shell at the point measured.

L. luteola: "Female shell with most decided marsupial swelling here blunt posterior point is somewhat higher up, (⅔), of height than that of male, (about halfway), and is usually more inflated." My results show the female as a higher degree of inflation, and is besides relatively longer.

L. ovata: "Female shell slightly inflated post-basal region," etc. As the recorded dimorphism for this genus is practically the same as for these last 2 species, I need only point out the full accord with my results.

The value of quantitative studies of the morphological characteristics of shells is best appreciated when cases are brought back to mind where new genera and species had to be founded on the anatomy of soft parts alone so great was the superficial resemblance in some cases between what turn out to be entirely different animals. If as a general proposition, it be admitted that the systematist should be able to find in any organism *specific characters* distributed from the most minute anatomy to the coarsest features of morphology, any such convergent phenomena as described above could be eleminated as each species of shell could be expected to vary in morphological characters around its own mean. It is to be hoped that the practice of publishing the more usual dimensions for *both* sexes of shells will be continued, that the ultimate philosophic trend of all Biological Science may have ample data for the consideration of the never-dying and always-puzzling question of the environment.

(*c*.) *Source of Error.*

Paucity of material compelled me to use in some species a few shells from Lake Erie, (most were from the Upper Ohio Drainage), although it is in some of the measured shell characteristics, as I expect to show, that the Lake Erie shells differ from those of the

pper Ohio. I do not feel, how
is greatly impaired thereby
th sexes from Lake Erie was i
ides the reduction to factors
oportion of the part concern
ssibly evens up any great diff

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TAB

GIVING AVERAGE D
AND FEMA

NO. SPECIMENS	MUSSEL	SEX	DSD/L
7	Fusconaja flava	♀	.529
7	Fusconaja flava	♂	.483
9	Amblema plicata	♀	.40
9	Amblema plicata	♂	.43
5	Pleurobema obliquumcoc	♀	.43
5	Pleurobema obliquumcoc	♂	.44
5	Elliptio dilatatus	♀	.29
5	Elliptio dilatatus	♂	.304
5	Symphynota costata	♀	.26
5	Symphynota costata	♂	.287

ations from Walker's illustra
emale to be relatively higher
ale a greater posterior length

it behind and ends in a blunt
ase. Female shell has long
a blunt point $\frac{2}{3}$ way up from
measurements, as it may be
arsupial swelling may be in
ll at the point measured.
st decided marsupial swelling
hat higher up, $(\frac{3}{8})$, of height
and is usually more inflated
her degree of inflation, and is

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s of the morphological charac
when cases are brought back
ies had to be founded on the
at was the superficial resem
urn out to be entirely different
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organism *specific characters*
tomy to the coarsest features
phenomena as described above
of shell could be expected to
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med, that the ultimate philo
may have ample data for the
and always-puzzling question

Error.

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m the Upper Ohio Drainage),
red shell characteristics, as I
shells differ from those of the

per Ohio. I do not feel, however, that the value of my conclus-
on is greatly impaired thereby, as an equal number of shells of
oth sexes from Lake Erie was included when this had to be done.
sides the reduction to factors apparently expresses the relative
portion of the part concerned, and, by the law of averages,
ably evens up any great differences.

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TABLE I.

GIVING AVERAGE DIMENSIONS OF MALE AND FEMALE SHELLS.

NO. ...MENS	MUSSEL	SEX	DSD / L	DVD / L	PD / L	AD / L	PHL / L	AHL / L	TH. / DVD
	Fusconaja flava	♀	.5294	.7756	.7749	.2315	.4867	.2499	.119
	Fusconaja flava	♂	.4838	.7710	.7550	.2308	.544	.2001	.1181
	Amblema plicata	♀	.409	.710	.806	.198	.574	.184	.1398
	Amblema plicata	♂	.437	.7680	.813	.1892	.565	.184	.1699
	Pleurobema obliquumcoc	♀	.436	.796	.845	.1552	.594	.1987	.43
	Pleurobema obliquumcoc	♂	.442	.821	.78	.2145	.575	.1973	.27
	Elliptio dilatatus	♀	.297	.494	.774	.2115	.509	.1830	.24
	Elliptio dilatatus	♂	.304	.505	.796	.2026	.544	.1615	.22
	Symphynota costata	♀	.260	.566	.744	.256	.490	.1924	.24
	Symphynota costata	♂	.287	.586	.729	.270	.497	.253	.26

8	Anodonto grandis	♀	.372	.567	.716	.277	.418	.216
8	Anodonto grandis	♂	.382	.561	.709	.288	.419	.243
3	Anodontoides ferussac	♀	.373	.517	.763	.306	.472	.242
3	Anodontoides ferussac	♂	.357	.518	.754	.248	.436	.182
5	Paraptera fragilis	♀	.355	.751	.734	.268	.502	.2081
5	Paraptera fragilis	♂	.304	.696	.737	.267	.491	.2215
6	Proptera alata	♀	.361	.775	.684	.315	.539	.219
6	Proptera alata	♂	.373	.825	.708	.292	.561	.2185
33	Eurynia recta	♀	.2740	.412	.774	.2229	.540	.1676
33	Eurynia recta	♂	.2703	.4177	.798	.207	.560	.1616
94	Lampsilis luteola	♀	.4027	.6036	.7603	.2739	.5184	.2478
94	Lampsilis luteola	♂	.3708	.5617	.7319	.2593	.4878	.2191
84	Lampsilis ovata vent.	♀	.4780	.7375	.6885	.3105	.4490	.2314
84	Lampsilis ovata vent.	♂	.4660	.716	.706	.297	.451	.2319

Hollins College, Hollins, Va.

The Prairie Mirage.

BY HOWARD C. BROWN.

Strange is it indeed, that to so many persons who have spent the lives upon the prairie, a mirage is something which is far distan a thing entirely unrelated to their life. Many persons associate th mirage only with the desert. This seems odd enough when o considers the many beautiful mirages which appear in the prair skies when a reflected grass area seems only a further extension the vast, real stretch, which, in great, gentle waves of Titan magnitude, roll, of a prairie morning, in undulating green, wi responsiveness, under the lifting sun. Few things can inspire o with more sincere thoughts of the greatness of the universe, th can the wide stretches of prairie of our land. And the mirages ar interesting to me in that they were often so thoroughly linked, the past, with the life of the pioneer.

If he loved beauty, the pioneer never ceased to revel in th wondrous reflections. But the mirage was not alone a thing beauty. If it mirrored an enemy's camp, in time of hostiliti it served a utilitarian purpose. But to those who did not love for its beauty, and for whom it served no real purpose, still it becam

object of wonder, and they never ce
phenomenon.

Mrs. Maude A. Fenton, a membe
Club, is a thorough lover of beau
lived near Indian Head, Canad
said that her most pleasant memo
out her enjoyment of the wild flow
mirages. Speaking of the last me
me seven miles from Indian Head,
of which was a very large spring
Indian Head had its water piped
sty morning in the spring of 1907,
be about half a mile away this hi
the place where the spring was,
aking to others about it, they said
en the mirage was on, for it is over

"Another time in November, 190
thought that some one had been mov
ner of the pasture land, about one-f
Fenton and I were deceived into
use which had been moved during
had not been there the day before.
ond it to be our neighbor's house s
th-east. It stayed there about tw
ded away, back to the place where it

"During the same winter, we had
autiful one of all, the Katepwa val
me fourteen miles from Indian He
where we lived. Lake Katepwa is in t
rrounding it are quite high hills wi
ed roads. Also, a few houses. Snow
ad been there a couple of times it di
place. It looked very natural. Th
out a mile away. The Hills lay to
use to the north-east, and the va
ng showed right side up. These m
morning, just about sunrise. V
ening."

One of the most interesting refer
which I have yet found, is in J. W. V