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# CONTRIBUTED PAPERS PRESENTED AT THE 1981 MEETING

## CORRELATIONS OF SHELL SHAPE OF *ELLIPTIO WACCAMAWENSIS*, *LEPTODEA OCHRACEA* AND *LAMPSILIS* SP. (BIVALVIA, UNIONIDAE) WITH ENVIRONMENTAL FACTORS IN LAKE WACCAMAW, COLUMBUS COUNTY, NORTH CAROLINA.

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### ABSTRACT

Obesity (shell width/shell length) values for *Elliptio waccamawensis*, *Leptodea ochracea*, and *Lampsilis* sp. from Lake Waccamaw, Columbus County, North Carolina were analyzed for correlations with sediment characteristics and for regional variation. *E waccamawensis* and *L. ochracea* showed no significant correlations with mean sediment size, percent organic matter, or percent $CaCO_3$ in the sediment. *Lampsilis* sp. was positively correlated with percent organic matter in the sediment. The uniformity of obesity of these three indigenous species of naiads does not coincide with regional habitat variability within Lake Waccmaw.

### INTRODUCTION

Observations of the effects of stream size and stream flow on shell form have been made by Ortmann (1920), Ball (1922), and Mueller (1926). The subject was expanded upon by Grier (1920), Eagar (1948), and Clarke (1973) to include comparisons of lake and flowing water forms of common species. Emphasis was then placed on factors within a habitat instead of the habitat in general. Correlations were established between shell form and the environmental variables: temperature, substrate type, trophic level, latitude, and water chemistry by Howard (1922), Brown, Clark, and Gleissner (1938), Agrell (1949), Cvancara (1969), and Green (1972).

Lake Waccamaw, the largest natural lake in North Carolina, located in Columbus County, belongs to a group called the North Carolina bay lakes. Physical descriptions of Lake Waccamaw and the other bay lakes are found in Frey (1948, 1949) and Louder (1958). The known molluscan fauna of Lake Waccamaw in 1978 was ten bivalve species and three species of gastropods, several endemic to the lake (Stanbery and Clench, 1978). A 1978 - 1980 survey of the molluscan fauna of Lake Waccamaw by the authors included quantitative observations of the lake habitat. Statistical analyses of effects the environment has on the native fauna have been made from these observations.

This paper discusses correlations between specific sediment characteristics and obesity of three native bivalve species living in Lake Waccamaw. Also examined is the variability of obesity between various regions with the lake.

### METHODS

Benthic samples (700+) were taken from throughout Lake Waccamaw using a diver-operated suction-type dredge. Samples were collected from within 1/16 and 1/4 $m^2$ sampling frames and screened through 1.6 and 6.4 mm mesh screening bags attached to the dredge. Dredge samples were taken at quarterly intervals throughout the year. Additional samples were collected monthly by hand-screening samples from within a 1/8 $m^2$ sampling frame through a 1.6 mm sieve screen. For further information on sampling methods see Porter and Horn (1980).

Bivalves were pegged open and preserved in "AGW", a mixture of 90% ethly alcohol, glycerin, and water (16:3:1), shortly after collection. In the laboratory, bivalves were opened and sex and gravid condition were determined. Measurements of length and width used a dial calipers.

Sediment samples were collected, to a maximum depth of 12 cm, at the site of each dredge or hand-screen sample and analyzed using a loss-on-ignition procedure to determine percent organic matter and percent $CaCO_3$ by weight. Measurements of mean sediment size utilized a series of U.S.A. Standard Testing Sieve Screens and a portable sieve shaker. The lake was divided by the authors into regions based on lake orientation, depth, and sediment characteristics.

Bivalve names are those used by Dr. D.H. Stansbery of the Ohio State University Natural History Museum (pers. comm.) and identifications were authenticated by Dr. Stansbery. Considered in the study are three native Lake Waccamaw bivalves, *Elliptio waccamawensis* (Lea, 1863), *Leptodea ochracea* (Say, 1817), and *Lampsilis* sp.[1]

### RESULTS

The term obesity (shell width divided by shell length) has been used by Ortmann (1920), Grier and Mueller (1922), and Brown, Clark, and Gleissner (1938) to compare the shell form of individual bivalves. In Lake Waccamaw, obesity was not correlated with shell length ($r=0.033$, $N=150$).

Obesity of the Lake Waccamaw bivalves and the relationship of it to examined variables is presented in Table I. *Elliptio waccamawensis* and *Leptodea ochracea* were not significantly correlated with either mean sediment size or percent $CaCO_3$ in the sediment. A slight positive correlation (95% significance level) did exist between obesity and the percent organic matter in the sediment for both species. Obesity of *Lampsilis* sp. was positively correlated with percent organic matter at both 95% and 99% levels. No correlations were evident with mean sediment size or percent $CaCO_3$ in the sediment.

Analysis of variance was used to compare the obesity of bivalves found in various regions of the lake (Table II). Analysis of the four major regions (shallow sand, intermediate sand, deep sand, and peat) (Fig. 1) for significant differences in shell obesity resulted in F-values of 0.131, 0.296, and 0.129 for *E. waccamawensis, L. ochracea*, and *Lampsilis* sp. respectively, all nonsignificant. Division of the lake into subregions is shown on Fig. I. No F-value was significant except that of *E. waccamawensis* in the peat region and *L. ochracea* in the intermediate sand region (Table II). Both of these values were sig-

[1] *Lampsilis* sp. is currently being studied by Dr. D.H. Stansbery, Ohio State University. Description and species name are forthcoming.

Table I. Correlations of Mean Obesity With Sediment Characteristics

| Species | Mean Sediment Size | | Percent Organic Matter | | Percent $CaCO_3$ | |
|---|---|---|---|---|---|---|
| | | *d.f.* | *r* | *d.f.* | *r* | *d.f.* |
| *E. waccamawensis* | -0.006 | 1564 | 0.157* | 1522 | 0.018 | 1522 |
| *L. ochracea* | 0.013 | 214 | 0.149* | 217 | 0.022 | 217 |
| *Lampsilis* sp. | 0.053 | 110 | 0.322** | 111 | -0.017 | 111 |

* significant at the 95% level

** significant at the 95% and 99% levels

nificant at the 95% and 99% levels.

Table III contains the mean obesity of the three bivalve species subdivided into the categories: males, gravid females, and non-gravid females. Mean values showed no significant variation in obesity between sexual categories for each species.

## DISCUSSION

The majority of previous research has dealt with the comparison of shell form in different environments. Ortmann (1920) established that the "more obese form is found farther down in the large rivers, and passes gradually, in the upstream direction, into a less obese form." Findings by Ball (1922) and Eagar (1948) substantiated this statement. Grier and Mueller (1926) noticed the tendency of three species of naiads to become more convex in the lower reaches of rivers. Increasing convexity carried with it an increase in obesity. Comparison of flowing water and lake forms of the same species was treated by Grier (1920) in Lake Erie and the Upper Ohio River, Grier and Mueller (1926) in the Mississippi River, and Clarke (1973) in the rivers and lakes of the interior Canadian basin. Both the Mississippi River and Ohio River studies showed a greater degree of inflation in the lake environment. In Canada, however, Clarke observed just the opposite. The more inflated forms were found in rivers.

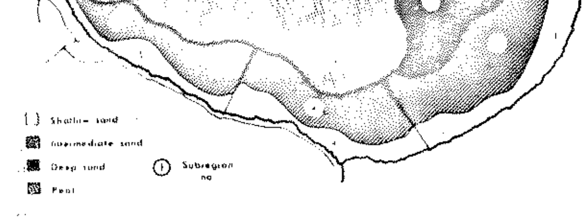

Figure I. Regions and subregions of Lake Waccamaw

Other individual factors that may influence shell form have also been examined by others. Agrell (1949) stated "ecological shell variation is essentially a function of trophic degree". Certain shell proportions show an increase with increasing eutrophication. Through the use of scatter diagrams, Cvancara (1963) noted that at lower latitudes, obesity tended to increase. Brown, Clark, and Gleissner (1938) specifically selected sampling sites with different degrees of shoal exposure. More exposure resulted in a greater degree of shell stunting. Both Allen (1922) and Eagar (1948) conclude that the type of bottom is more important in determining shell shape.

The three species used in this study showed a surprising lack of variability in obesity throughout the lake. None of the F-values between regions showed significant differences. Although there was sufficient habitat variability to delineate these regions, apparently it was not sufficient to affect shell form. Division of the habitat regions into subregions (Fig. I) was an attempt to separate effects of wave action due to prevailing winds and effects of varying shoreline development. Shoreline development includes lakefront housing, boat docks, some beach bulkheading, and recreational activities (i.e. boating, swimming, water-skiing, etc.). Greatest areas of wave disturbance is in subregions one, two, and six. The prevailing winds are usually from the southwest; only storms cause winds from the north. Shoreline development was heaviest in subregions one, five, and six. Subregions two and four were only moderately developed. Subregion three was undeveloped. Analysis shows significant variation for *E. waccamawensis* only between the two peat subregions. This was variability was probably due to factors not considered in this study. *L. ochracea* had a significant F-value in the intermediate sand subregions. Areas of greatest difference appeared to be subregions two and five. Region five was an area of heavier recreational use and higher disturbance, however, evidence is insufficient to suggest that this is the cause of the variability. Examination of sediment components showed no correlation with *E. waccamawensis*. *L. ochracea* was correlated with percent organic matter. This was only a slight positive correlation at the 95% level. No direct relationships can be drawn from these data. A positive correlation did exist between *Lampsilis* sp. and percent organic matter (significant at both the 95% and 99% levels). This may be a good relationship to pursue when establishing a distribution pattern for this species. Distribution patterns within the lake will be published later by the authors as part of the total findings of a

Table II. Mean Obesity Values in Various Subregions and Analysis of Variance of Major Regions of Lake Waccamaw.

| | Subregions 1 | 2 | 3 | 4 | 5 | 6 | F | d.f. |
|---|---|---|---|---|---|---|---|---|
| *Elliptio waccamawensis* $\overline{X} = 0.38$ N = 1593 | | | | | | | | |
| Shallow Sand | 0.38 | 0.37 | 0.39 | 0.37 | 0.38 | 0.38 | 0.52 | 5,268 |
| Intermediate Sand | 0.38 | 0.38 | 0.38 | 0.38 | 0.37 | 0.37 | 1.01 | 5,620 |
| Deep Sand | 0.37 | 0.37 | 0.38 | | | | 2.53 | 2,402 |
| Peat | 0.37 | 0.39 | | | | | 9.20* | 1,278 |
| *Leptodea ochracea* $\overline{X} = 0.46$ N = 226 | | | | | | | | |
| Shallow Sand | 0.44 | 0.46 | 0.46 | 0.42 | 0.45 | 0.45 | 0.41 | 5,72 |
| Intermediate Sand | 0.44 | 0.51 | 0.47 | 0.45 | 0.42 | 0.45 | 3.87* | 5,54 |
| Deep Sand | 0.43 | 0.47 | 0.46 | | | 0.40 | 1.48 | 3,25 |
| Peat | 0.45 | 0.45 | | | | | 0.02 | 1,60 |
| *Lampsilis* sp. $\overline{X} = 0.39$ N = 113 | | | | | | | | |
| Shallow Sand | | | 0.38 | | 0.38 | 0.41 | 0.58 | 2,6 |
| Intermediate Sand | 0.37 | | 0.45 | 0.39 | 0.36 | 0.38 | 2.25 | 4,32 |
| Deep Sand | 0.39 | 0.39 | 0.39 | | | 0.38 | 0.27 | 3,40 |
| Peat | 0.39 | 0.39 | | | | | 0.01 | 1,22 |

* significant at the 95% and 99% levels

study of the Lake Waccamaw molluscan fauna.

Table III lists mean obesities for the three species when divided by sex and gravid condition. There was no significant difference in obesity values between the sexes. For this reason, all analyses were carried out using total bivalves, regardless of their category. This allowed for larger, and perhaps, more responsive sample sizes.

## SUMMARY

*E. waccamawensis, L. ochracea,* and *Lampsilis* sp. showed a general lack of variability between the major regions of Lake Waccamaw. *E. waccamawensis* and *L. ochracea* were significantly different within the peat and intermediate sand regions respectively. At this time, no reason is apparent for this variability. Obesity of the three species was not correlated with either mean sediment size or percent $CaCo_3$ in the sediment. Some positive correlation was evident with percent organic matter, especially for *Lampsilis* sp. There was no difference in obesity due to sex or gravid condition among the three species.

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Table III. Comparison of Mean Obesity Among Sexual Categories

| *Species* | Males (m) | | | Females (f) | | | *Gravid Females (gf)* | | | *t-values* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | $\overline{X}$ | $S^2$ | *N* | $\overline{X}$ | $S^2$ | *N* | $\overline{X}$ | $S^2$ | *m vs f* | *f vs gf* | *m vs gf* |
| *E. waccamawensis* | 1070 | 0.375 | 0.062 | 408 | 0.371 | 0.057 | 115 | 0.371 | 0.072 | 0.29 | 0.004 | 0.16 |
| *L. ochracea* | 146 | 0.453 | 0.0019 | 50 | 0.463 | 0.001 | 30 | 0.452 | 0.0027 | -1.49 | 1.18 | 0.11 |
| *Lampsilis* sp. | 84 | 0.391 | 0.002 | 21 | 0.382 | 0.0005 | 8 | 0.395 | 0.0006 | 0.90 | -1.37 | 0.25 |

## THE MOLLUSCAN FAUNA OF COPPER CREEK (CLINCH RIVER SYSTEM) IN SOUTHWESTERN VIRGINIA

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Twenty species of freshwater mussels and three species of freshwater snails were found living in a 60-mile reach of Copper Creek. This survey is a continuing effort to document the Cumberlandian mussel fauna from tributary streams located in the southern Appalachian Mountains and the Cumberland Plateau region.

In general, the molluscan fauna of the tributary streams in the upper Clinch River system have been poorly studied. The most recent information concerning the mussel fauna of the Clinch River is contained in published and unpublished reports by Neves (1980), the Tennessee Valley Authority (1979), Bogan and Parmalee (1979), Bates and Dennis (1978), and Stansbery (1973, 1976a, 1976b, and 1976c). An excellent historical account of the mussel fauna from the upper Tennessee River drainage including the Clinch River was done by Ortmann (1918), and later by Cahn (1936), and Hickman (1937).

Copper Creek, located in southwestern Virginia, flows from Moccasin and Copper Ridges in Russell County westward into Scott County where it joins the Clinch River near Speer's Ferry, Virginia (Clinch River Mile 211.6). Copper Creek is approximately 60 miles long and has a drainage basin of 133 square miles.

This Clinch River tributary drains a small part of the Ridge and Valley physiographic province. The topography of this region consists of parallel ridges and valleys comprised mainly of folded shale and limestone formations which contain numerous sinkholes and extensive underground drainage channels (Masnik, 1975).

Copper Creek was surveyed to provide comprehensive, up-to-date information on the status of Cumberlandian species and present or potential habitats as part of our Cumberlandian Mollusk Conservation Program (Jenkinson, 1981). The habitats necessary to support Cumberlandian species in many of the larger tributary streams have been reduced to a few isolated populations in the upper Tennessee drainage (Ahlstedt 1981; Ahlstedt and Brown 1980). Copper Creek remains relatively free from extensive human impacts except for some agricultural development in the watershed. In this respect, Copper Creek is perhaps one of many smaller tributary streams in the upper Tennessee River drainage system which contain unknown populations of mussels including Cumberlandian species.

During May 1980, TVA biologists surveyed the mollusk fauna of Copper Creek. The lower 13.8 miles of Copper Creek were surveyed by floating the entire reach in canoes. The upper reach was sampled at points of access because this reach of the stream was too shallow for canoes.

Collections were made at 36 sites over this 60-mile reach (Figure 1) using wading, snorkeling, and scuba diving sampling techniques. These collections document the existence of 20 species of freshwater mussels and three species of river snails in this stream (Tables 1 and 2). Eleven of the mussel species are Cumberlandian forms including two species (*Fusconaia cuneolus* and *Fusconaia edgariana*) listed as endangered by the U.S. Fish and Wildlife Service.

While mussels occurred throughout the 60-mile reach of Copper Creek, most species were found only between Copper Creek Mile (CCM) 1.4 (site 3) and CCM 5.9 (site 11). Most of the Cumberlandian species occurred at CCM 1.8 and CCM 2.1 (sites 4 and 5); however, four Cumberlandian species were relatively common throughout the length of Copper Creek (*Medionidus conradicus, Pleurobema oviforme, Villosa nebulosa,* and *Villosa perpurpurea*). While *Villosa perpurpurea* is common in Copper Creek, this species appears to be rare in much of the rest of the upper Tennessee River system. Recent TVA surveys have only revealed a few live specimens of this species in the upper Clinch River and in Beech Creek, a tributary to the Holston River near Rogersville, Tennessee. In addition, five Cumberlandian species are rare in Copper Creek: