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Behavioral Temperature Regulation in Freshwater Mussels (Mollusca: Unionidae).

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ABSTRACT

Behavioral temperature regulation in the freshwater unionid mussel *Elliptio buckleyi* was examined in controlled laboratory experiments. The dark coloration of the periostracum in this species did not facilitate heat gain from an artificial radiation source. Heat gain was achieved by conduction from the surrounding water. Exposure of external surfaces to the water by vertical movement of the organisms out of the substrate accelerated conductive heat gain.

INTRODUCTION

Many poikilotherms are known to behaviorally regulate their body temperature by selecting microhabitats and exhibiting behaviors that permit them to attain and remain at preferred temperatures. Fish and amphibians thermoregulate by seeking out preferred water temperatures whereas reptiles regulate body temperatures by differentially selecting solar radiation inputs. Many lizards spend varying periods in the sun and shade, thereby controlling absorption and emission of radiant energy. Radiational heat gain may also be affected by modification of the surface area of an organism exposed to the sun and by integumental albedo.

While extensive research has addressed behavioral thermoregulation in poikilothermic vertebrates, no investigations of possible temperature regulation in aquatic molluscs have been conducted. This study was formulated to investigate the possibility of this phenomenon in Elliptio buckleyi, a common freshwater unionid mussel in Florida streams. Interest in this topic was sparked on two accounts; firstly, the unexplainable dark coloration of the periostracum of these and many other species of mussels, and second, the observation that mussels exhibit vertical movement in the substrate. The greenish-black valves of E. buckleyi obviously afford little in the way of crypsis, considering the sandy substrate they inhabit. It was hypothesized that this dark pigmentation may possibly facilitate heat gain in these organisms, as in many terrestrial organisms, by increasing absorption of solar radiation. Wetzel (1975) noted that in shallow water significant quantities of solar radiation may penetrate to, and be absorbed by sediments. A majority of the visible light and a considerable fraction of the infrared radiation not reflected by the surface of the water may penetrate to a depth of one meter in clear natural waters (Hutchinson 1975). Therefore it is conceivable that solar radiation is being absorbed by these organisms, which are often found at depths of but a few centimeters. To take advantage of this heat gain a mussel would have to position itself such that it could absorb solar radiation. Typically though, unionids burrow into the substrate with only the extreme posterior of their valves exposed. However, on frequent occasions I have observed mussels largely raised out of the substrate, exposing over half of the surface area of their valves. The occurrence of this behavior appears to be correlated to periods of intense sunlight. Therefore it was hypothesized that the mussels were basking in the sun to increase heat gain. My study, utilizing controlled laboratory experiments, investigated this hypothesis.

MATERIALS AND METHODS

Specimens of Elliptio buckleyi were collected from the New River, a major tributary of the Santa Fe River, in Union and Bradford counties, north central Florida. Experiments were conducted in a 38 liter glass aquarium filled to a depth of 10 cm with sand procured at the mussel collection site. Water level was maintained at a depth of 10 cm over the substrate. Water circulation and aeration were supplied with an airstone. Mussels were allowed to acclimate to laboratory conditions prior to experimentation. Pulverized fish food was introduced to provide subsistence for the organisms. A Westinghouse 125 watt infrared sunlamp suspended 15 cm above the surface of the water was utilized as the radiation source. Temperatures were measured with a YSI 43TD Tele-thermometer thermistor unit. Each trial was run for three hours with temperatures recorded every 30 minutes. Probes were inserted into the mantle cavities of the mussels, proximal to the gills. Water and substrate temperatures were concurrently recorded. All experimental animals were approximately 50 mm long.

The effect of periostracum coloration on heat gain was investigated in the first experiment. Temperatures of two mussels were monitored; one enclosed in aluminum foil except at the valve edges, the other unencumbered. Both individuals were placed directly below the sunlamp in a natural position with approximately two-thirds of their surface areas protruding above the substrate (Fig. 1).

In the second experiment the effect of the position of the mussels in the substrate was examined. One individual was positioned such that two-thirds of its external surface area was exposed as in the first experiment. The other mussel was inserted into the sand with only the extreme posterior of its valves and siphons protruding (Fig. 2).

RESULTS

Water, substrate and mussel temperatures recorded during the first experiment are tabulated in Table 1 and depicted graphically in Figure 3. Water temperatures increased more rapidly than substrate temperatures with an eventual difference of approximately 1.5 ° C. Temperatures of both mussels increased equally, lagging slightly behind water temperature.

Results from the second experiment are reported in Table 2 and shown in Figure 4. Temperatures of the exposed mussel approximated corresponding water temperatures and maintained an approximately 2.0 ° C difference with the mussel inserted in the substrate.

DISCUSSION

Results of the first experiment clearly show that the dark periostracum of Elliptio buckleyi does not facilitate heat gain in this mussel species. Not only did temperatures in the exposed mussel approximate ambient water temperatures, but no difference was observed with the mussel shrouded in aluminum foil. If the dark periostracum was functioning as a mechanism to promote heat gain, temperatures in the foil-clad mussel would have lagged significantly. Thus heat gain by freshwater mussels is primarily achieved by conduction from the surrounding water. The periostracum does not differentially absorb any solar radiation penetrating the water column. However, substrate temperatures lagged significantly behind those of the water. A similar phenomenon may be expected in streams as water temperatures rise daily after cooling at night. The difference should be even greater under natural conditions, as the closed system afforded by the experimental aquarium tended to promote heating of the sand. Results of the second experiment therefore indicate that a mussel which increases its exposure to the water, and consequently reduces contact with the cooler substrate, would warm more rapidly as water temperatures rose. Reducing contact with the substrate would correspondingly decrease conductive heat loss to the sand. The observed vertical movement of unionids under natural conditions may therefore serve to increase heat gain by these organisms.

The significance of the coloration of the periostracum in _Elliptio_ _buckleyi_ remains unresolved. Whereas dark coloration appears to be cryptic in species inhabiting streams underlain by cobble and gravel, freshwater mussels are readily apparent to a visual predator (or collector) in the sandy streams of peninsular Florida. Body temperature measurement in this study was obviously rather inexact with observations made only in the mantle cavity. Possibly, local temperature differentials are attained by mussels when exposed to sunlight. For example, radiative heat gain of the valves could be conducted only to the underlying mantle tissue, promoting growth of the valves. Perhaps circulation of water within the mantle cavity attenuates the transmission of this heat to other parts of the organism, therby relegating it unmeasurable by my thermistor probes.

LITERATURE CITED

Hutchinson, G.E. 1975. A treatise on limnology. Volume 1, Part 1 - Geography and physics of lakes. John Wiley and Sons, New York, 540 p.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co. Philadelphia; 743 p.

Table 1. Water, substrate and mussel temperatures recorded during the first experiment, investigating the effect of coloration of the periostracum of *Elliptio buckleyi* on radiative heat gain. Temperatures were recorded every 30 minutes. Approximately two-thirds of both mussels protruded above the substrate into the water column; one enclosed in aluminum foil except at the valve edges, the other unencumbered.

	Temperature (° C)			
t (hours)	water	substrate	exposed mussel	foil-clad mussel
0.0	19.50	19.50	19.50	19.50
0.5	21.00	20.00	20.75	20.50
1.0	22.50	21.00	22.25	22.00
1.5	24.00	22.75	23.50	23.50
2.0	25.00	23.25	24.75	24.50
2.5	25.75	24.50	25.50	25.50
3.0	26.50	25.25	26.25	26.25

Table 2. Water, substrate and mussel temperatures recorded during the second experiment, investigating the effect of mussel position on conductive heat gain. Temperatures were recorded every 30 minutes. Only the extreme posterior of the 'inserted' mussel was exposed above the substrate. Approximately two-thirds of the exposed mussel protruded above the substrate into the water column.

	Temperature (°C)			
t (hours)	water	substrate	exposed mussel	inserted mussel
0.0	20.00	20.00	20.00	20.00
0.5	21.00	20.25	21.00	20.00
1.0	23.75	21.75	24.00	21.75
1.5	24.75	22.75	25.00	22.50
2.0	25.50	23.75	26.00	23.50
2.5	26.25	24.00	26.25	24.25
3.0	27.00	24.50	27.25	25.00

Figure 1. Position of both mussels in the first experiment in relation to the water-substrate interface.

Figure 2. Position of the two mussels in the second experiment in relation to the water-substrate interface.

Fig. 1

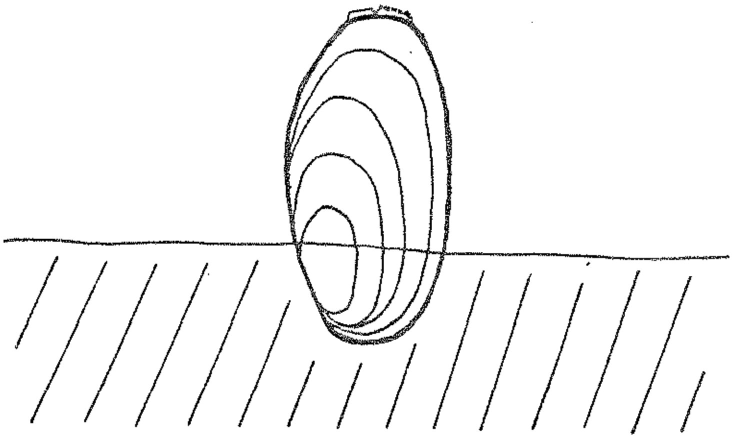


Fig. 2

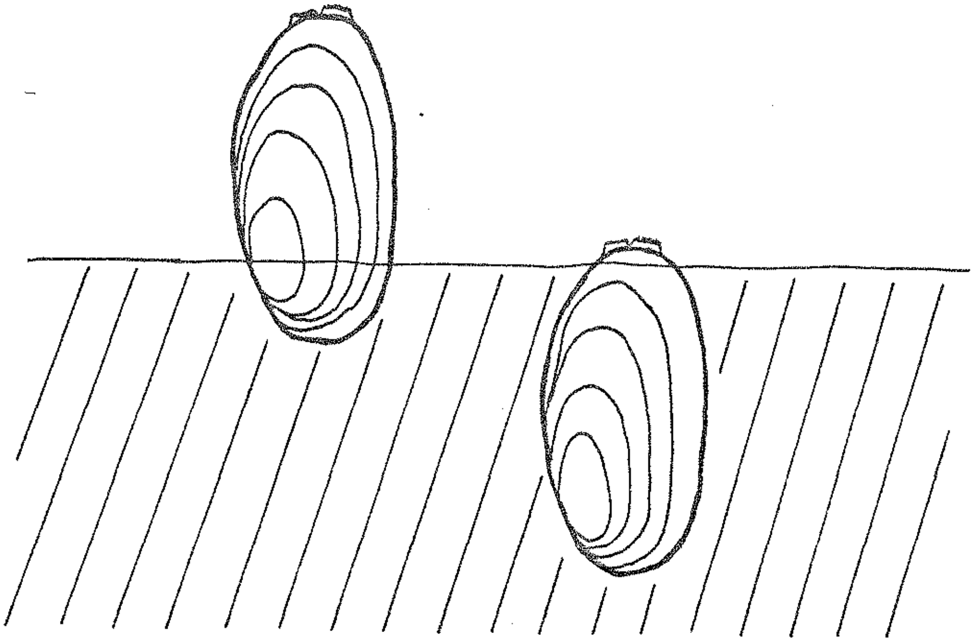


Figure 3. Water, substrate and mussel temperatures recorded during the first experiment, investigating the effect of coloration of the periostracum of _Elliptio buckleyi_ on radiative heat gain. Solid line represents water temperature; dashed line represents substrate temperature; closed circles represent unencumbered mussel temperatures; open circles represent aluminum foil clad mussel temperatures.

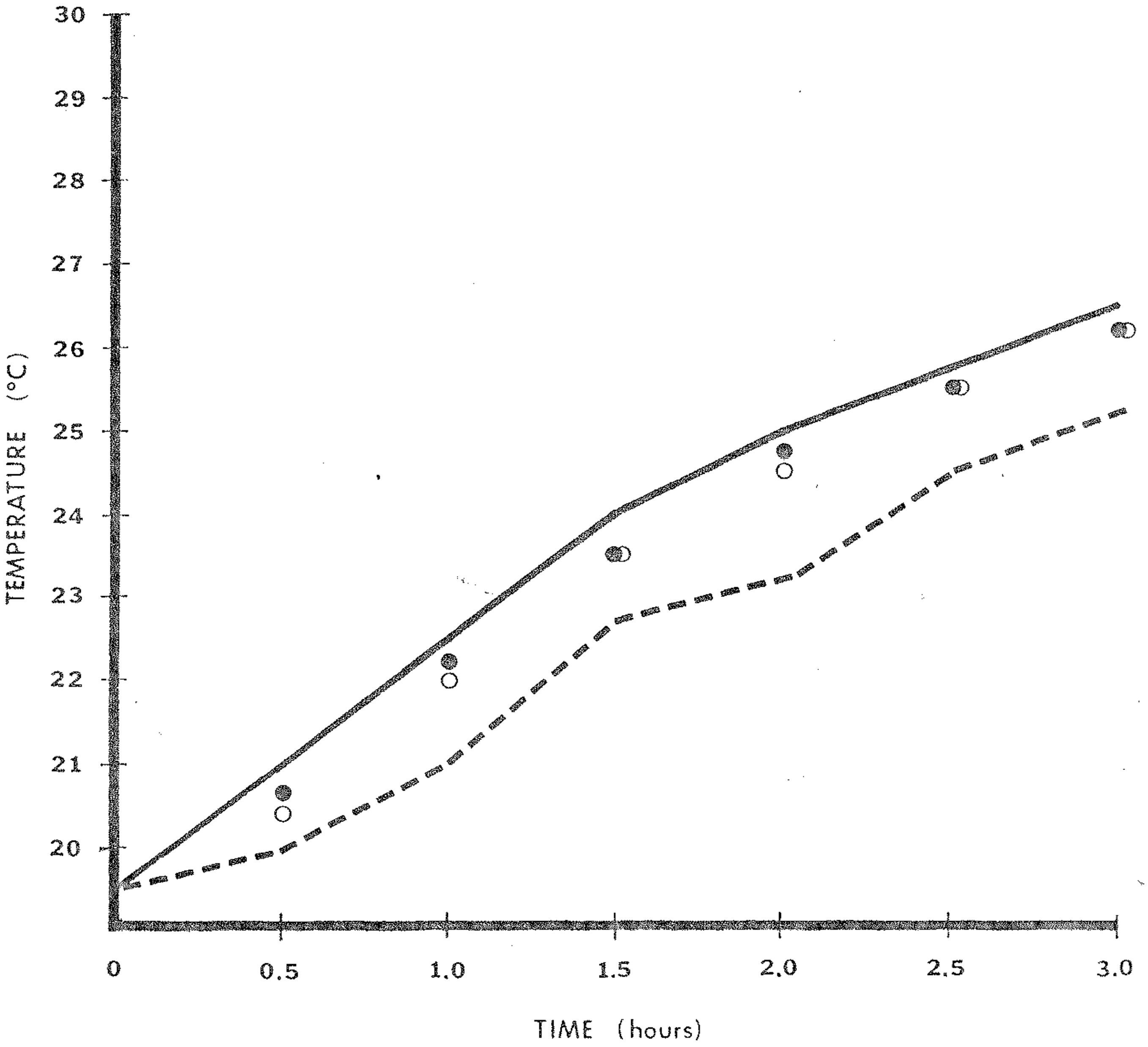
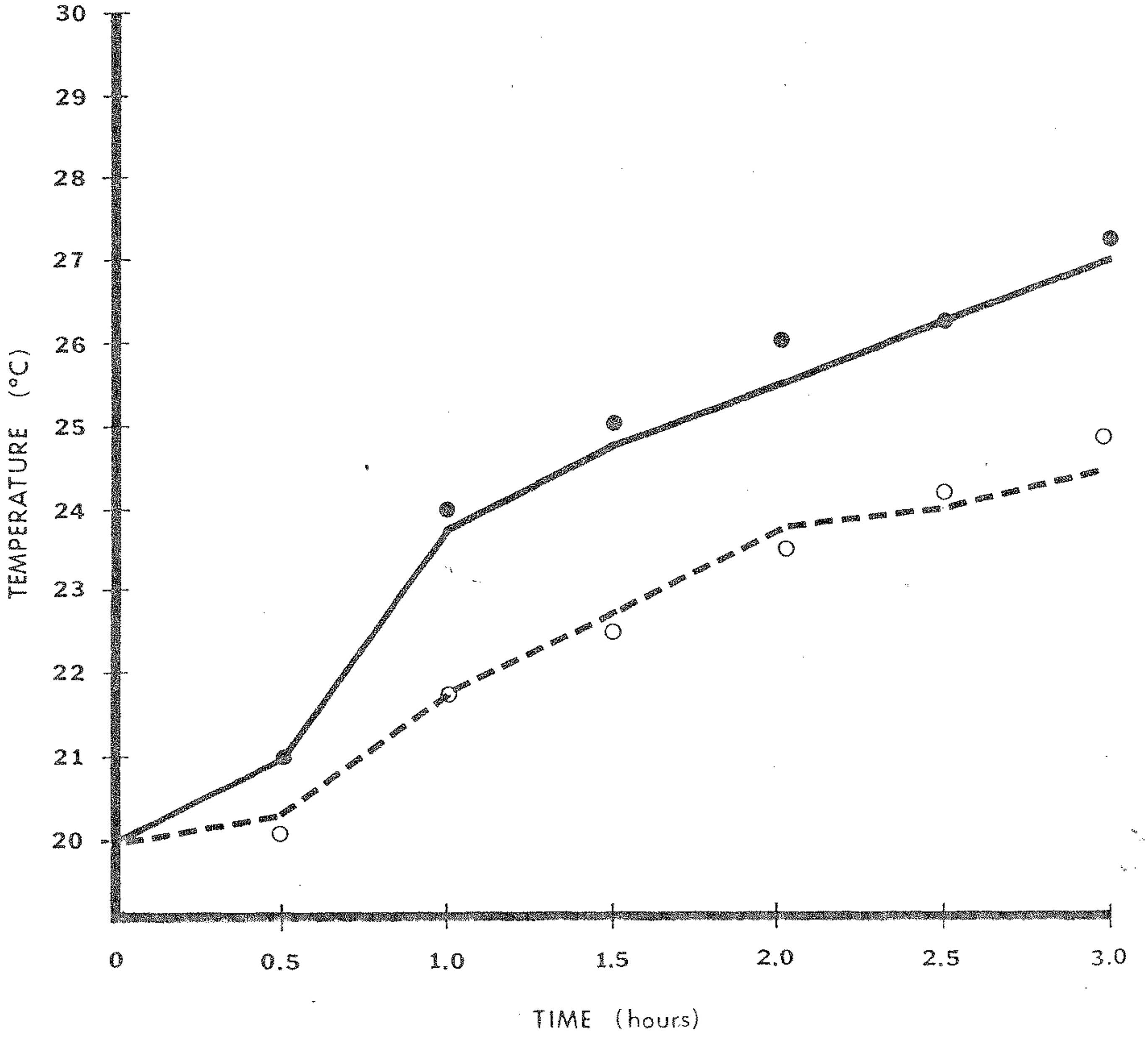

30
29
28
27
26
25
24
23
22
21
20
TEMPERATURE (°C)
0
0.5
1.0
1.5
2.0
2.5
3.0
TIME (hours)

Figure 4. Water, substrate and mussel temperatures recorded during the second experiment, investigating the effect of mussel position on conductive heat gain. Solid line represents water temperature; dashed line represents substrate temperature; closed circles represent exposed mussel temperatures; open circles represent temperatures of the mussel inserted into the substrate.


30
29
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26
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24
23
22
21
20
TEMPERATURE (°C)
0
0.5
1.0
1.5
2.0
2.5
3.0
TIME (hours)