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SEASONAL METABOLISM OF THE SPHAERIID CLAM, *MUSCULIUM PARTUMEIUM*, FROM A PERMANENT AND A TEMPORARY POND

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ABSTRACT

Seasonal metabolic rates were examined for the sphaeriid clam, Musculium partumeium (Say) from a permanent and a temporary pond. For the fall-born generation from the permanent pond and for the single generation from the temporary pond, metabolic rates peak during periods of greatest growth and reproduction. Metabolic rates were consistently higher for the permanent pond population. These rates for Musculium partumeium extend the available information on the family Sphaeriidae to the genus Musculium.

One important aspect of the ecology of an organism is its seasonal pattern of metabolism. The majority of the investigations on the metabolic rates of freshwater molluscs have dealt with gastropods (Berg et al., 1962; Berg and Jonasson, 1965; Burky, 1971; Burky, Pacheco, and Pereyra, 1972; McMahan, 1973; Calow, 1976). Metabolic studies of sphaeriid

clams have been limited. However, there are reported rates on *Pisidium* (Johnson and Brinkhurst, 1971b; Jonasson, 1972; Holopainen and Ranta, 1977a, b; Alimov, 1975; Burky and Burky, 1976) and *Sphaerium* (Alimov, 1975; Waite and Neufeld, 1977; Collins, 1967). The study of *Pisidium walkerii* by Burky and Burky (1976) is the only seasonal metabolic study in the literature. This study assessed the seasonal metabolic rates of the sphaeriid clam, *Musculium partumeium* (Say) from a permanent and a temporary pond.

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MATERIALS AND METHODS

Clams were collected from a temporary and a permanent pond in SW Ohio (see Way et al., 1980, for a description of the two ponds). The clams were sorted into 6–8 visual size categories (2–30 clams per chamber, depending on size) and oxygen consumption was measured monthly at field temperature with Clark-type O_2 electrodes (YSI Model 53 monitor, YSI Model 5331 bath stirrer and chambers) using the acrylic chamber modification described by Burky (1977). After each experiment shell lengths (SL = greatest anterior-posterior dimension) were measured. Clams were dried to constant weight at 90°C , and they were subsequently analyzed for total nitrogen using a Coleman Model 29 nitrogen analyzer. Total dry weights were converted to tissue weights using shell correction values from Burky et al. (1979). Oxygen consumption values are expressed as $Q_{O_2} = \mu\text{l } O_2/\text{mg dry tissue/hr}$ and $Q_{O_2} = \mu\text{l } O_2/\mu\text{g tissue N/hr}$. Tissue nitrogen can be assumed to represent protein and helps express the respiration rates in terms of more realistic energy equivalents.

RESULTS AND DISCUSSION

In order to consider seasonal metabolic rates it is necessary to briefly outline the life histories of the two populations (from Way et al., 1980). The ephemeral, or temporary, pond (DW) usually has a single generation per year. Clams are born (mean SL at birth = 1.4 mm) in the spring and early summer (May–July), remain dormant as juveniles in the dry substrate (August–January), begin growth in March (reaching adult SL of 5.9 to 10.1 mm in July), reproduce, and then die as the pond dries during the summer. The permanent pond (AM) has two generations per year. The first generation is born (mean SL at birth = 1.4 mm) in the spring between May and July (AM-SG). These individuals initiate growth during late August (reaching adult SL of 4.4 to 8.0 mm in November), and reproduce between September and November. Some adults of the spring generation overwinter and contribute to the next spring generation. Young of the fall, permanent pond, generation (AM-FG) overwinter as subadults (mean SL = 2.4 mm) and

experience rapid growth and reproduction in late spring (reaching adult SL of 3.8 to 7.5 mm in July). Most clams of the fall generation die by the end of July, but a few survive to contribute to the new fall generation.

For *M. partumeium* there is no inverse relationship between metabolic rate and size within size series of adults or juveniles. Thus in the metabolic rate equation, $M = \mu\text{l } O_2/\text{clam/hr} = kW^b$, $b = 1$. In this study b was not significantly different from 1 for any date. Values of b not significantly different from one have been reported for gastropods (Daniels and Armitage, 1969; McMahon, 1973; and others), and for the sphaeriid clam *Pisidium walkerii* (Burky and Burky, 1976). It is also indicated in the data of Collins (1967) for *Sphaerium occidentale* and Johnson and Brinkhurst (1971b) on several genera of *Pisidium*. One possible explanation for the absence of a size-rate relationship is the small size range of clams within a particular generation. This idea is supported by the fact that for a number of dates where the size range of clams utilized was very small, the regression of $\log M$ on \log tissue weight was not significant (prob. $F < 0.05$). Burky and Burky (1976) discuss the possible effects of brooding young on b -value (sphaeriids are ovoviviparous) and the significance of a b -value of one on energy partitioning in *P. walkerii*. Consequently, oxygen expressed as $\mu\text{l } O_2/\text{mg dry tissue/hr}$ or $\mu\text{l } O_2/\mu\text{g N/hr}$ were averaged for all individuals, regardless of size, within a generation, i.e. all adult values were averaged on a given date as were values for juveniles.

Oxygen consumption for adults of the ephemeral pond (DW) population at field temperature (FT) ranges from $0.58 \mu\text{l } O_2/\text{mg tissue/hr}$, standard error (SE) = 0.04 (or $12.31 \mu\text{l } O_2/\mu\text{g N/hr}$; SE = 0.46) for clams of mean SL = 7.57 mm in July (FT = 20°C) to $3.23 \mu\text{l } O_2/\text{mg tissue/hr}$, SE = 0.17 (or $22.65 \mu\text{l } O_2/\mu\text{g N/hr}$; SE = 1.20) for clams of mean SL = 6.54 in May (FT = 14°C). Oxygen consumption averaged $2.29 \mu\text{l } O_2/\text{mg tissue/hr}$ (or $12.81 \mu\text{l } O_2/\mu\text{g N/hr}$) for newborns (May–July) at field temperatures of 14 – 20°C .

Values for adults of the permanent pond, spring generation, (AM-SG) range from $0.49 \mu\text{l } O_2/\text{mg tissue/hr}$, SE = 0.08 (or $4.39 \mu\text{l } O_2/\mu\text{g}$

N/hr, SE = 0.78) to 1.55 $\mu\text{lO}_2/\text{mg}$ tissue/hr (or 14.14 $\mu\text{lO}_2/\mu\text{g}$ N/hr) for clams of mean SL = 6.34 in November (FT = 7.0°C) and for clams of mean SL = 5.97 in May (FT = 15°C) respectively. Newborns of AM-SG (mean SL = 1.4 mm) collected in August (FT = 20–25°C) average 2.18 $\mu\text{lO}_2/\text{mg}$ tissue/hr (or 15.56 $\mu\text{lO}_2/\mu\text{g}$ N/hr). Permanent pond, fall generation (AM-FG) juveniles (mean SL = 3.16 mm) have metabolic rates averaging 1.64 $\mu\text{lO}_2/\text{mg}$ tissue/hr (or 14.29 $\mu\text{lO}_2/\mu\text{g}$ N/hr) during November–May (FT = 7–15°C), while adults have rates ranging from 1.91 $\mu\text{lO}_2/\text{mg}$ tissue/hr, SE = 0.75 (or 19.79 $\mu\text{lO}_2/\mu\text{g}$ N/hr, SE = 7.67) for clams of mean SL = 5.43 mm in July (FT = 20°C) to 3.36 $\mu\text{lO}_2/\text{mg}$ tissue/hr, SE = 0.74 (or 35.35 $\mu\text{lO}_2/\mu\text{g}$ N/hr, SE = 8.34) for clams (mean SL = 5.35 mm) in June (FT = 18.5°C).

The comparable values reported in the literature are for the genus *Pisidium*: 0.35 to 0.87 $\mu\text{lO}_2/\text{mg}$ tissue/hr at field temperatures for *P. walkeri* (Burky and Burky, 1976); 0.09, 0.15, and 0.33 $\mu\text{lO}_2/\text{mg}$ tissue/hr at 11°C, 16°C, and 8°C for *P. casertanum* (Berg et al., 1962; Berg and Jonasson, 1965); and 0.43, 1.08, 1.15, and 1.30 $\mu\text{lO}_2/\text{mg}$ tissue/hr at 20°C for *P. casertanum*, *P. ventricosum*, *P. henslowanum*, and *P. casertanum*, respectively (calculated using a 0.5 mg standard clam for Johnson and Brinkhurst, 1971b). Values for other sphaeriids have been reported by Collins (1967), Alimov (1975), and Waite and Neufeld (1977), but oxygen consumption is expressed per tissue wet weight or total wet weight (including shell) and thus are not comparable.

Oxygen consumption for the fall generation at the permanent pond (AM) rapidly increases during the months of April and May (2.33 to 4.15 $\mu\text{lO}_2/\text{mg}$ tissue/hr), corresponding to the period of peak growth and reproduction, with a subsequent decline over the summer months (4.15 $\mu\text{lO}_2/\text{mg}$ tissue/hr in May to 1.91 $\mu\text{lO}_2/\text{mg}$ tissue/hr in late July). Patterns of growth and reproduction for overwintering clams at the ephemeral pond (DW) are similar to those of the permanent, fall generation (AM-FG) (Way et al., 1980; Hornbach et al., 1980). Therefore it is not surprising that the annual patterns of respiration of overwintering ephemeral pond (DW) clams are very similar when compared to the permanent

pond ones (AM-FG). Rates increase from April to May (1.42 to 3.23 $\mu\text{lO}_2/\text{mg}$ tissue/hr) and then decrease from May to July (3.23 to 0.58 $\mu\text{lO}_2/\text{mg}$ tissue/hr) when the pond dries. The annual respiratory pattern is the same for ephemeral (DW) and permanent (AM-FG) pond generations when the values are based on tissue nitrogen, but oxygen consumption rates are consistently higher for the latter. Clams of the permanent pond (AM-FG) partition more of the total assimilated energy to respiration than do those of the ephemeral pond (DW) (56% vs. 38% for AM-FG and DW, respectively; Burky, Hornbach and Way, unpublished data), thus ephemeral pond (DW) clams can direct a greater fraction of the total assimilated energy to growth and reproduction.

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TAXONOMIC RE-EVALUATION OF THE BIVALVE FAMILY LYONSIIDAE¹

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ABSTRACT

The taxonomy of the marine lyonsiid bivalves is reviewed and redefinitions of the family and genera are offered. These lyonsiids are divisible into three distinct genera, Lyonsia, Entodesma, and Mytilimera, based primarily upon periostracum and calcareous shell structure, umbonal length ratios, modifications of the mantle edge including the presence of arenophilic radial mantle glands, morphology of the pedal gape, comparative sizes of adductor muscles, morphology and size of the foot and byssal systems, modifications of the siphons and general habitats. Some changes in generic taxonomy are suggested. It is also recommended that the present subgeneric taxa for the marine Lyonsiidae be abandoned since these lower ranks indicate ecomorphs and not true taxonomic units.

Few modern workers have concerned themselves with the systematics of the bivalve subclass Anomalodesmata. Existing reports are

conflicting and have thrown the taxonomy of this heterogeneous group into a state of confusion and disarray. The subclass contains such diverse members as the elongated and cylindrical clavagellid watering-pot shells, the

¹College of Marine Studies, University of Delaware Contribution No. 151.

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The majority of the investigations on the metabolic rates of freshwater molluscs have dealt with gastropods (Berg et al., 1962; Berg and Jonasson, 1965; Burky, 1971; Burky,

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MATERIALS AND METHODS

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The comparable values reported in the literature are for the genus *Pisidium*,: 0.35 to 0.87 ;jI02/mg tissue/hr at field temperatures for *P. walkerii* (Burky and Burky, 1976); 0.09, 0.15, and 0.33 MI02/mg tissue/hr at 11°C, 16°C, and 8°C for *P. casertanum* (Berg et al., 1962; Berg and Jonasson, 1965); and 0.43, 1.08, 1.15, and 1.30 MI02/mg tissue/hr at 20 °C for *P. casertanum*, *P. ventricosum*, *P. henslowanum*, and *P. casertanum*, respectively (calculated using a 0.5 mg standard clam for Johnson and Brinkhurst, 1971b). Values for other sphaeriids have been

reported by Collins (1967), Alimov (1975), and Waite and Neufeld (1977), but oxygen consumption is expressed per tissue wet weight or total wet weight (including shell) and thus are not comparable.

Oxygen consumption for the fall generation at the permanent pond (AM) rapidly increases during the months of April and May (2.33 to 4.15 $\text{ml O}_2/\text{mg tissue/hr}$), corresponding to the period of peak growth and reproduction, with a subsequent decline over the summer months (4.15 $\text{ml O}_2/\text{mg tissue/hr}$ in May to 1.91 $\text{ml O}_2/\text{mg tissue/hr}$ in late July). Patterns of growth and reproduction for overwintering clams at the ephemeral pond (DW) are similar to those of the permanent, fall generation (AM-FG) (Way et al., 1980; Hornbach et al., 1980). Therefore it is not surprising that the annual patterns of respiration of overwintering ephemeral pond (DW) clams are very similar when compared to the permanent pond ones (AM-FG). Rates increase from April to May (1.42 to 3.23 $\text{ml O}_2/\text{mg tissue/hr}$) and then decrease from May to July (3.23 to 0.58 $\text{ml O}_2/\text{mg tissue/hr}$) when the pond dries. The annual respiratory pattern is the same for ephemeral (DW) and permanent (AM-FG) pond generations

when the values are based on tissue nitrogen, but oxygen consumption rates are consistently higher for the latter. Clams of the permanent pond (AM-FG) partition more of the total assimilated energy to respiration than do those of the ephemeral pond (DW) (56% vs. 38% for AM-FG and DW, respectively; Burky, Hornbach and Way, unpublished data), thus ephemeral pond (DW) clams can direct a greater fraction of the total assimilated energy to growth and reproduction.

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TAXONOMIC RE-EVALUATION OF THE BIVALVE

FAMILY LYONSIIDAE

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ABSTRACT

The taxonomy of the marine lyonsiid bivalves is reviewed and redefinitions of the family and genera are offered. These lyonsiids are divisible into three distinct genera, *Lyonsia*, *Entodesma*, and *Mytilimera*, based primarily upon periostracum and calcareous shell structure, umbonal length ratios, modifications of the mantle edge including the presence of arenophilic radial mantle glands, morphology of the pedal gape, comparative sizes of adductor muscles, morphology and size of the foot and byssal systems, modifications of the siphons and general habitats. Some changes in generic taxonomy are suggested. It is also recommended that the present subgeneric taxa for the marine Lyonsiidae be abandoned since these lower ranks indicate ecomorphs and not true taxonomic units.

Few modern workers have concerned themselves with the systematics of the bivalve subclass Anomalodesmata. Existing reports are

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conflicting and have thrown the taxonomy of this heterogeneous group into a state of confusion and disarray. The subclass contains such diverse members as the elongated and cylindrical clavagellid watering-pot shells, the