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Scientific Editors

Aquatic Ecology of the Mondego River Basin
Global Importance of Local Experience

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Coordenação editorial
Imprensa da Universidade de Coimbra

Concepção gráfica
António Barros

Infografia
António Resende
Estímulus [design] • Coimbra

Execução gráfica
GRAFIASA

Ilustração da capa
P. P. Cunha e J. Dinis

ISBN
972-8704-04-6

Depósito legal
175038/02

OBRA PUBLICADA COM O PATROCÍNIO DE:
IMAR – INSTITUTO DO MAR
IPIMAR – INSTITUTO DE INVESTIGAÇÃO DAS PESCAS E DO MAR

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SHREDDERS IN LOW ORDER STREAMS

Abstract

In low order streams the riparian vegetation canopy generally restricts light reaching the river bed and therefore primary production. Riparian vegetation also provides streams with organic matter that is decomposed by the joint action of fungi and invertebrates. The trichoptera *Sericostoma vittatum* Rambur and the diptera *Tipulla lateralis* Meig. are two common shredders present in Ribeira de S. João, a 4th order river, and at other local streams. In this chapter we integrate results of several publications (Canhoto and Graça 1995, Feio and Graça 2000, Graça et al. 2001) aiming to know important aspects of their trophic ecology: consumption rates, preferences among leaf types, importance of leaf conditioning and activity patterns.

Introduction

In low order streams the riparian vegetation canopy generally restricts light reaching the river bed and therefore primary production. On the other hand, riparian vegetation provides the stream with organic matter such as leaves, branches and berries, depending on the season (Triska et al. 1982). Consequently allochtonous organic matter is the main energy source for low order streams running through forests.

After falling into the water, leaves are leached out of soluble compounds, colonised and decomposed by microorganisms and eaten by aquatic invertebrates (Gessner et al. 1999). Animals feeding on this organic matter are known as "detritivores" and can be classified in sub-groups according to the feeding mechanism: shredders, collectors, filters and gatherers (Cummins and Klug 1979). Shredders actively feed on large particles of organic matter such as entire leaves, incorporating organic matter into secondary production and accelerating the

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decomposition (Webster and Benfield 1986, Gessner et al. 1999, Graça 2001). They are particularly abundant in low order streams and provide a trophic link between the head waters and lower stream sections by the transformation of large particles into fine particulate organic matter which can be used as food by collector-gathers and filter-feeders further downstream (Vannote et al. 1980, Heard and Richardson 1995).

Forests in the Centre of Portugal have been recently subjected to major changes with the replacement of pine and deciduous species by *Eucalyptus globlus* Labill.. This affects the dynamic of organic matter and consequently has the potential to influence the structure of aquatic communities (Abelho and Graça 1996, 1998, Pozo et al. 1997).

Feeding activities of shredders may be affected by the nutritional value of leaves (Irons III et al. 1988) and microbial colonisation (conditioning) (Golladay et al. 1983; Rounick and Winterbourn 1983, Bärlocher 1985, Graça et al. 1993, Graça 1993). Given the importance of leaf stream invertebrates changes in the riparian vegetation have the potential to affect performances of shredders and the dynamic of organic matter (Canhoto and Graça 1995).

In Mondego basin catchment area, studies on the ecology of shredders have been carried out at Ribeira de S. João, Serra da Lousã (4th order stream, catchment area 18 km^2, mean bank full width in the lower section 6.8 m, mean depth 0.35m; mean flow 8.9×10^{-2} m^{3}s^{-1}, pH 7.3, temperature 12.4 °C, O_2 96% saturated; Canhoto and Graça 1995).

Two common shredder species have been selected for experimental work at the Dep. of Zoology, University of Coimbra: the cadisfly *Sericostoma vittatum* (Thrichoptera: Sericostomatidae) and the cranefly *Tipula lateralis* (Diptera: Tipulidae). In this chapter we describe experiments aimed to get information on their growth, feeding rates and food preferences. This chapter summarises information published by Canhoto and Graça 1995, Feio and Graça 2000 and Graça et al. 2001.

Material and Methods

Experimental conditions

Experimental animals were captured in the location of "Piscinas", Lousã. In the laboratory the animals were kept in plastic boxes containing filtered aerated stream water (GF/C Whatman) or APW (Ca: 80 mg l^{-1}, Cl: 145 mg l^{-1}, Mg: 12 mg l^{-1}, Na: 18 mg l^{-1}, K: 3 mg l^{-1}, pH 7.9) and ignited stream sand (<1mm; 500°C for 1h). A photoperiod was set to 12:12 hours and temperature to 15 °C. Senescent leaves from tree species were collected in autumn and air dried. For conditioning leaves were placed inside bags (10x14 cm; 0.5 mesh size) and submerged in the river for 3 weeks. When unconditioned leaves were offered as food they were previously leached under tap running water for 24 hours.

Consumption and selectivity

To quantify food consumption, disks were cut from leaves with a cork borer (9 mm ø for *Sericostoma vittatum* and 14 mm ø for *Tipula lateralis*). Consumption was measured as the difference between the initial and final mass of disks. In experiments with *Tippula lateralis* initial mass was obtained by weighting the leaf disks previously dried at 50 °C for 48h; the disks were then re-hydrated and offered to the shredders. In the case of experiments with *Sericostoma vittatum* pairs of disks were obtained from contiguous areas of the leaves. The disks were assumed to have identical mass. One disc was exposed to the invertebrate whereas the other disk was hanged inside the same cup but protected from the invertebrate by a bag (0.5 mesh size). Invertebrates were allowed to fed until ≈ 2/3 of the offered food was consumed. Consumption was expressed as the difference between the unexposed and exposed discs, divided by the elapsed time in days and the initial mass of the experimental animals. When more than one leaf type was exposed to the invertebrates they were marked with a coloured pin. For more details of the experimental designs see Canhoto and Graça 1995, Feio and Graça 2000.

This design was used to determine: (a) Feeding rates of *Sericostoma vittatum* (0.81-0.19 mg initial dry mass; n=20) and *Tipula lateralis* (9.27-10.81 mg initial dry mass; n=30). (b) Selection among conditioned and unconditioned *Castanea sativa* Mill. leaves by *Sericostoma vittatum*. c) Selection among leaves of 4 tree species differing in their quality: *Alnus glutinosa* L., *Castanea sativa*, *Quercus faginea* Lam. and *Eucalyptus globulus*.

Influence of food quality on growth

Eighty individuals of *Tipula lateralis* (0.65 – 0.93 mg dry mass) were individually allocated to rearing cups (with 200 ml of water) containing leaves of alder, oak, chestnut or eucalyptus. The leaves were previously conditioned for 2 weeks. The experiment lasted for 126 days. Food, water and sand was changed weekly when animals were weighted. Dry mass (Dma) of larvae was estimated from their wet mass (Wma) by the expression ($r^2=0.985$):

$$\log_e \mathrm{Dma} = [(\log_e \mathrm{Wma} - 0.0596) / 1.0837]$$ (Canhoto and Graça 1995)

Patterns of activity and metabolism

Larvae of the species *Sericostoma personattum* are known for their higher nocturnal than diurnal activity (Wagner 1990). *Sericostoma vittatum* is an Iberian endemic species and no equivalent data was available.

A total of 23 *Sericostoma vittatum* individuals were allocated into 3 plastic containers (27 × 15 × 10 cm; containing 1.5 L of water) in the laboratory. The number of active animals in each container was registered during darkness and during light periods with intervals of 10 minutes (n=7 for each night and day periods).

Assuming that respiratory rates are indicators of activity, ten *Sericostoma vittatum* larvae were selected to measure oxygen consumption during dark (n=5) and light periods (n=5). The animals were individually placed in 8 ml chambers (glass syringes) to which oxygen saturated water was pumped (through-flow: 5-8 ml/h). The difference in oxygen between incoming (O_2i) and outcoming (O_2o) water from the syringes was attributed to the invertebrate respiration (see Graça 1990). The dry mass (Dma) of each experimental animal was determined and a mean respiratory rate (RR) was calculated for each animal for light and dark using the expression:

$RR = [(O_2i) - (O_2i) \times F] / Dma$ (Feio and Graça 2000)

Results

Consumption rates of conditioned leaves of *Castanea sativa* by *Sericostoma vittatum* were 0.47 ± 0.42 mg mg animal^{-1} day^{-1}, while the consumption registered for *Tipulla lateralis* was 0.02 ± 0.006 mg mg animal^{-1} day^{-1}. When given the choice, larvae of *Sericostoma vittatum* feed preferentially upon conditioned leaf disks, almost ignoring unconditioned disks ($t = 2.464$, d.f = 30; $p<0.05$) (Fig.1).

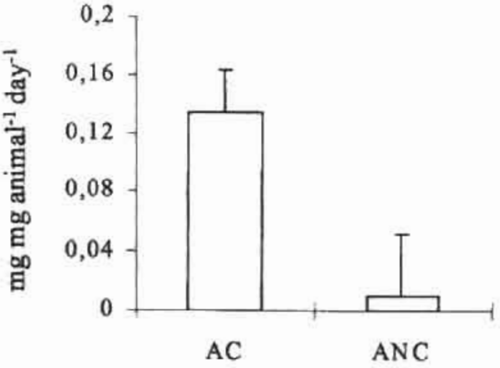

Figure 1. Consumption of *Alnus glutinosa* leaves by *Sericostoma vittatum* when exposed to conditioned (AC) and unconditioned (ANC) leaves (mean+s.e.).

In the multiple selection tests, *Tipula lateralis*, larvae prefered leaves of *Alnus glutinosa*. Consumption on leaves of *Castanea sativa*, *Quercus robur* and *Eucalyptus globulus* was significantly lower ($F= 70.06$, $p<0.001$; Tuckey test: $p<0.05$; Fig.2).

Differences in consumption rates were consistent with growth when only one leaf type was available. Growth followed a logistic curve when larvae were fed with alder ($y = -12.99+15.85 \log x$; $r^2=0.93$) and presented the fastest mean specific growth rate (7.23% day; Fig. 3). Individuals fed with chestnut grew at a slower rate ($y = -9.83+8.71$; r2=0.78; specific growth rate = 3.01% day^{-1}; Fig.3). Differences in growth were significant ($t=9.02$; $p<0.001$). No growth occurred in larvae fed with oak or eucalyptus and all specimens died after 63 and 91 days, respectively. For individuals fed with alder,

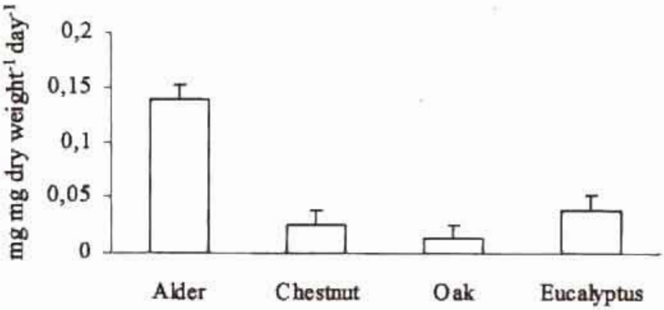

Figure 2. Food preferences of *Tipula lateralis* when leaves of *Alnus glutinosa*, *Castanea sativa*, *Quercus faginea* and *Eucalyptus globulus* were offered (mean+95%CL).

the survival was 90% and for chestnut 80% (logrank statistic > 10.83; p>0.05). There was therefore a tendency for *Tipula lateralis* to select leaves promoting high growth.

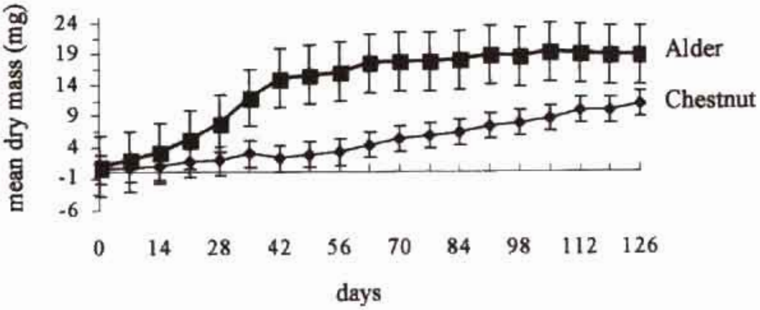

Figure 3. Growth of *Tipula lateralis* larvae fed with *Alnus glutinosa* or with *Castanea sativa* leaves during 126 days (mean±95%CL).

Active *Sericostoma vittatum* larvae were significantly more frequent during the light than during the dark periods (t=8.18; df=12; p<0.001; Fig.4). Consistently respiratory rates increased from 0.46-2.91 µg O_2 h^{-1} mg animal^{-1} during the day to 0.95-4.49 µg O_2 h^{-1} mg animal^{-1} during the night (paired t-test: t=5.56; df=6; p<0.001; Fig.5).

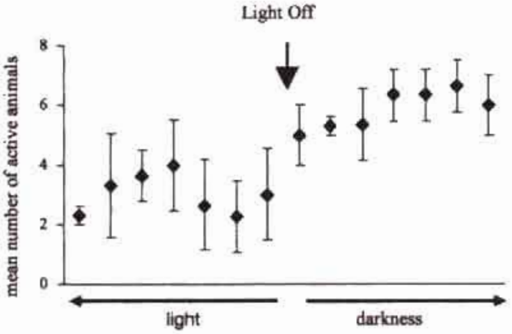

Figure 4. Number of active animals during day and night measured at 10 minutes intervals (mean±s.e.).

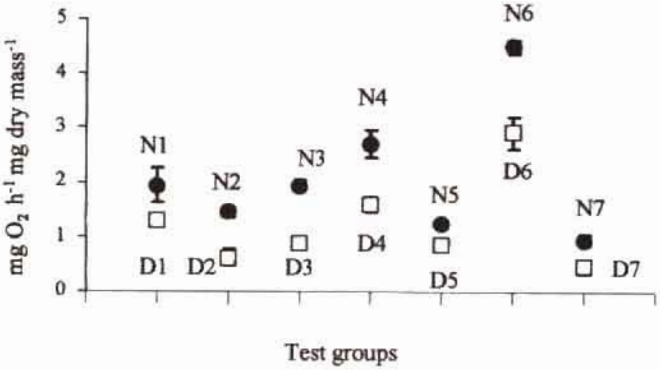

Figure 5. Nocturnal (N1-N7) and diurnal respiratory rates (D1-D7) for each specimens of *Sericostoma vittatum* (mean±s.e.).

Discussion

The experiments here reported using stream species from Mondego river Basin reinforce some known facts about the detritivores in general, reported for other geographic areas: (1) Some stream invertebrates feed on decomposing allochtonous organic matter. (2) Stream invertebrates of the same species and similar sizes can feed at different rates. (3) They prefer conditioned to unconditioned leaves. (4) They discriminate among leaf types. (5) Selected leaves are the ones promoting high growth and survivorship. (6) Some detritivores are more active during the night.

Larvae of *Sericostoma vittatum* are strong food processors when compared with the larger *Tipulla lateralis*, a diptera larvae that reaches greater sizes. Considering the high densities of the trichoptera (annual mean of 25 individuals m^{-2} for Ribeira de S. João) and the presented values for leaf consumption, we consider this species as having a key role on the fragmentation of allochtonous organic matter in Ribeira de S. João.

The importance of alder leaves as a food resource for shredders is also here reinforced (see also Kaushik and Hynes 1971, Iversen 1974, Irons et al. 1988). This riparian species produce leaves that are rapidly colonised and consumed by aquatic shredder detritivores. This is probably due the higher intrinsic content of nitrogen of the alder leaves along with the low levels of refractory compounds, absence of leaf protecting structures and reduced hardness (Nykvist 1962, Mellilo 1982, Cortes et al. 1994, Pereira 1998). Other authors have reported that alder leaves become rapidly conditioned and are probably more palate and easy to digest by larvae (Martin et al. 1980, Bärlocher 1985). This information underlines the link between stream systems and terrestrial systems and has important implications for the management of riparian zone.

Microbial colonisation enriches the nutrient content of leaves and may result in a decreased hardness (Suberkropp 1992, Graça et al. 1993). Once more this was verified in our tests with the obvious preference of *Sericostoma vittatum* individuals for conditioned leaves when faced with the possibility to eat unconditioned material. The implication is that the river health has to take in consideration factors affecting decomposing microbes, a subject normally underestimated in the rivers management.

Nocturnal behaviour of detritivores is understand as a predator avoidance mechanism (Elliot 1969, Wagner 1990) and it was also suggested that could also be a way of avoiding the competition for food since when the temperatures become higher (day) search for food also increases (Wagner 1990). These are probable explanations for the clear nocturnal behaviour of *Sericostoma vittatum*. The low mobility of these animals may force them to do their food search and the observed relative long distance displacements during the night, period when most of the predators (other insects, fishes or ducks) rest or can not easily detect them.

Leaves are a primordial food source for stream invertebrates. Therefore the knowledge of the stream ecology is strongly dependent on the knowledge of the interactions of the trilogy: leaves, microbes and invertebrates. This is still a wide and complex study field.

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