

## CURRENT RESEARCH

### DOES ENVIRONMENTAL TEMPERATURE VARIATION AFFECT BODY SIZE OF TWO LOTIC TANYTARSINI (DIPTERA: CHIRONOMIDAE) FROM THE NEOTROPICS?

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#### Introduction

In general, variation in the environmental temperature encountered by early life stages of ectotherms during their development results in differential final adult body size, with larger adults found in habitats with lower average temperatures (temperature–size rule; e.g. Atkinson 1994; Chown and Gaston 1999). This phenomenon has been observed in different groups of organisms, including fishes, amphibians, arthropods, mollusks, protists, and bacteria (reviewed by Atkinson 1994).

Aquatic insects that live in the temperate zone may experience different developmental temperatures, with cold seasons alternating with warmer seasons (Wolda 1988). The window of opportunity to grow and reproduce may occur for a few months of the year and their body size usually decreases from spring to summer (Sweeney and Vannote 1981). Among Chironomidae (Diptera), increase in body size is in general restricted to larvae, particularly second to fourth instars, and temperature constitutes a major controlling factor (Tokeshi 1995). For example, Menzie (1981) demonstrated in an experimental study that the growth rate of *Cricotopus sylvestris* Fabricius larvae is increased at higher temperatures. Other factors such as food availability (Vodopich and Cowell 1984) and intraspecific competition (McLachlan 1983) are also known to affect chironomid larval growth. Kobayashi (1998) studied the emergence of *Procladius choreus* Meigen in central Japan and determined that body size and male genital structure lengths were negatively correlated to environmental temperature. In the Neotropics, Strixino and Trivinho-Strixino (1985) also found

a negative relationship between temperature and body mass for a tropical chironomid species (*Chironomus sancticaroli*), but under laboratory controlled conditions.

In tropical areas, many aquatic insects tend to emerge continuously throughout the year (Resh and Rosenberg 1984). Although changes in temperature through the entire year are slight when compared to temperate ones, some regions, such as southeast Brazil, may experience a variability of 25.0°C in air temperature within a year (EMBRAPA). This range is comparable to temperate areas during the period of growth and reproduction (i.e. from spring to fall). In this paper we assessed if there is a relationship between body size and environmental temperature within populations of two Tanytarsini (Chironomidae: Chironominae) species from southeastern Brazil. The two undescribed species used in this study belong to the speciose Neotropical genus *Caladomyia* Sæwedal (Reiff 2000) hereafter named *Caladomyia* sp. 1 and *C.* sp. 2. These two new species will be completely described (with larvae, pupae and males) in a forthcoming paper.

#### Materials and methods

Since chironomid adults are short-lived and most do not feed, we collected floating exuviae of emerged adults, assuming that the size of the pupae reflects all energetic gains of larval development. According to Coffman and de La Rosa (1998), the advantages offered by the collection of pupal exuviae are well documented and include: all species emerge at the water surface, the exuviae remain floating for at least a

day, large numbers of specimens can be rapidly collected, and species from all microhabitats are included.

We worked within Fazzari Stream, a first order forested stream located in the State of São Paulo in southeastern Brazil (21°59'S - 47°54'W, ~910 m a.s.l.). Regional climate is humid subtropical, with a wet summer and dry winter. The dry season extends from June to August and the wet season, from September to May. Annual rainfall and mean temperature are around 1,595 mm and 21.7°C, respectively. We made surface samples in three stream segments with similar riffle/pool areas from April 2004 to March 2005. At each segment (10-20m) we took surface samples (20min. effort) using a hand net (200µm mesh size) to collect natural accumulation of floating pupal exuviae from behind stream flow blocks (e.g. logs). We also used drift nets (200µm mesh size) to intercept exuviae that were possibly induced to drift through the main current by any disturbance caused during hand netting. Water temperatures were measured concurrently with sampling.

The material was sorted in the laboratory and chironomid exuviae counted and mounted on slides in Hoyer's solution. We measured the abdominal length of male pupae by measuring the distance from the anterior margin of tergite I to the tip of the anal lobe. We used data from the sampling dates in which at least two well preserved male pupae of each species were present. Since we do not have data on minimum and maximum water temperature, we used minimum and maximum air temperatures from the EMBRAPA SUDESTE Meteorological Station, located approximately 5 km from Fazzari Stream. Temperature-body size relationship was analyzed using Ordinary Least Squares (OLS) linear regressions. Statistical tests adopted a critical probability value of 0.05.

## Results

From the 17 sampling dates between May/2004 and March/2005 we measured 40 specimens of *C. sp. 1* and 42 of *C. sp. 2* that met our criteria. Both the smallest (2.09 mm) and the largest (2.45 mm) specimens of *C. sp. 1* were collected in August 2004, whereas the smallest specimen of *C. sp. 2* (2.37 mm) was collected in March 2005 and the largest (3.22 mm) in June 2004. Maximum and minimum air temperature varied from 16.0 (July 2004) to 32.0°C (August 2004) and from 7.0 (August 2004) to 20.0°C (February 2005)

respectively. Water temperature varied from 14.4 °C in October 2004 to 21.6°C in March 2005.

In both species body size was not related to any of the environmental temperatures: water temperature (*C. sp. 1*:  $N = 40$ ,  $P = 0.403$ , Fig. 1a; *C. sp. 2*:  $N = 42$ ,  $P = 0.256$ , Fig. 1b), maximum air temperature (*C. sp. 1*:  $P = 0.626$ , Fig. 1c; *C. sp. 2*:  $P = 0.124$ , Fig. 1d), and minimum air temperature (*C. sp. 1*:  $P = 0.224$ , Fig. 1e; *C. sp. 2*:  $P = 0.103$ , Fig. 1f).

## Discussion

The correlation between temperature and body size found by Kobayashi (1998) for chironomids, and by others for many ectotherms was not found in our one-year study. In both *Caladomyia sp. 1* and *C. sp.2*, body size was not related to environmental temperature variation.

Most cases in which a negative relationship between temperature and body size was identified occurred in laboratory studies, where temperatures were controlled (see Atkinson 1994). However, environmental temperature is not constant in most aquatic habitats and exhibits a daily cycle sometimes with broad amplitude (Pétavy et al. 2001). Moreover, since other factors such as food availability and biological interactions are known to influence body size relationships, studies on natural patterns of body size relationships could add complementary information for extrapolations from responses in the laboratory (Belk and Houston 2001). This is especially true for tropical regions where there is a continuous input of falling detritus, like leaves, woody debris and fruits in streams (Henry et al. 1994).

Kobayashi (1998) used mean monthly air temperatures as the explanatory variable in his regression models. These temperatures had an amplitude variation of 20°C (range: 12.0 - 32.0°C) during the periods when adults emerged, which occurred from April to December (8 months). Both species used in our study emerged continually throughout the year. We used three measures of environmental temperature, maximum and minimum air temperature, and water temperature, as predictor variables with an amplitude variation of 16, 13 and 7.2°C respectively. Hence, the natural temperature variation which *C. sp. 1* and *C. sp.2* experienced is comparable to the variation, during the periods when adults emerged, of Kobayashi's study. However, larvae that stay over the winter in temperate regions experience much lower temperatures than the lowest

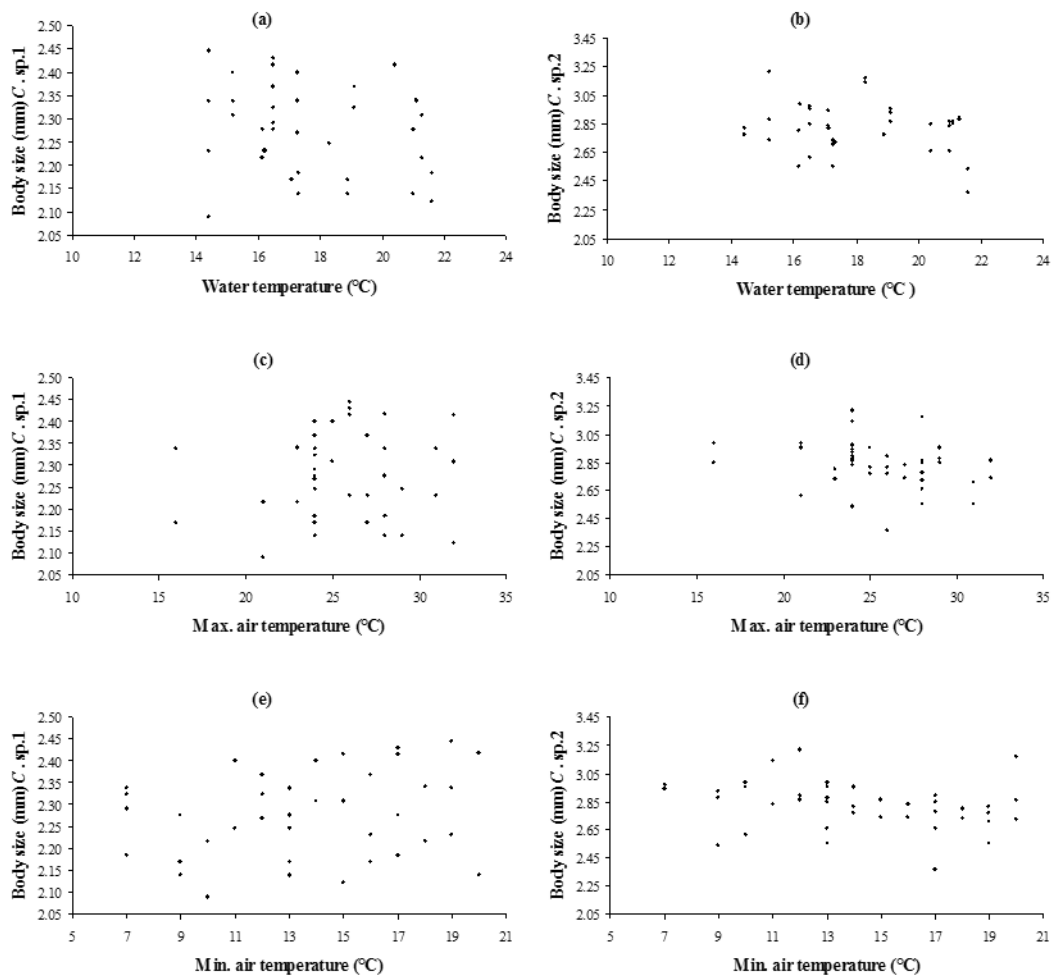


Figure 1. Relationships between environmental temperatures and body size. (a) water temperature and *C. sp. 1*, (b) water temperature and *C. sp. 2*, (c) maximum air temperature and *C. sp. 1*, (d) maximum air temperature and *C. sp. 2*, (e) minimum air temperature and *C. sp. 1*, (f) minimum air temperature and *C. sp. 2*.

temperature of our study region (7.2°C). Differently from these temperate regions where larval development is interrupted during the winter season, our study area assures development of the larvae to continue even in the coldest season. So, probably the lowest temperature which the larvae of these tanytarsine taxa experienced during the period of our study was not so cold to control their development affecting their body size.

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#### References

- Atkinson, D. 1994. Temperature and organism size: a biological law for ectotherms? - *Adv. Ecol. Res.* 25: 1-58.
- Belk, M. C. and Houston, D. D. 2001. Bergmann's rule in ectotherms: A test using freshwater fishes. - *Am. Nat.* 160: 803-808.
- Chown, S. L. and Gaston, K. J. 1999. Exploring links between physiology and ecology at macro-scales: the role of respiratory metabolism in insects. - *Biol. Rev.* 74: 87-120.

- Coffman, W. P. and De La Rosa, C. L. 1998. Taxonomic composition and temporal organization of tropical and temperate species assemblages of lotic Chironomidae. - *J. Kans. Entomol. Soc.* 71:388-406.
- Embrapa dados meteorológicos [Internet]. Embrapa Pecuaría Sudeste. Available from: <http://www.cppse.embrapa.br/080servicos/dados-meteorologicos/>
- Henry, R., Uieda, V. S., Afonso, A. A. O. and Kikuchi, R. M. 1994. Input of allochthonous matter and structure of fauna in a Brazilian headstream. - *Verh. Internat. Verein. Limnol.* 25: 1866-1870
- Kobayashi, T. 1998. Seasonal changes in body size and male genital structures of *Procladius choreus* (Diptera: Chironomidae: Tanytopodinae). - *Aquat. Insects* 20: 165-172.
- McLachlan, A. 1983. Life history tactics of rain-pool dwellers. - *J. Anim. Ecol.* 52: 545-561.
- Menzie, C. A. 1981. Production ecology of *Cricotopus sylvestris* (Fabricius) (Diptera: Chironomidae) in a shallow estuarine cove. - *Limnol. Oceanogr.* 26: 467-481.
- Pétavy, G., Moreteau, B., Gibert, P., Morin, J. and David, J. R. 2001. Phenotypic plasticity of body size in *Drosophila*: effects of a daily periodicity of growth temperature in two sibling species. - *Physiol. Entomol.* 26: 351-361.
- Reiff, N. 2000. Review of the mainly Neotropical genus *Caladomyia* Sæwedal, 1981, with descriptions of seven new species. - *Spixiana* 23: 175-198.
- Resh, V. H. and Rosenberg, D. M. 1984. The ecology of aquatic insects. Praeger, New York, U.S.A.
- Strixino, G. and Trivinho-Strixino S. 1985. A temperatura e o desenvolvimento larval de *Chironomus sancticaroli* (Diptera: Chironomidae). - *Rev. Bras. Entomol.* 3: 177-180.
- Sweeney, B. W. and Vannote, R. L. 1981. *Ephemerella* mayflies of White Clay Creek: bioenergetics and ecological relationships among six coexisting species. - *Ecology* 62: 1353-1369.
- Tokeshi, M. 1995. Life Cycles and Population Dynamics. In: Armitage, P. D., Cranston, P. S., Pinder, L. C. V. (eds). *The Chironomidae: Biology and ecology of nonbiting midges.* Chapman and Hall. p 225-268.
- Vodopich, D. S. and Cowell, B. C. 1984. Interaction of factors governing the distribution of a predatory aquatic insect. - *Ecology* 65: 39-52.
- Wolda, H. 1988. Insect seasonality: Why? - *Annu. Rev. Ecol. Syst.* 19: 1-18.
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