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The chironomids (Diptera: Chironomidae) from 108 Italian Alpine springs

Laura Marziali, Valeria Lencioni and Bruno Rossaro

Introduction

Chironomids are one of the most abundant and species-rich groups in crenal habitats. Up to 200 species are reported from cold European springs and 73 from Italian Alpine springs, representing about 20 % of the species recorded in Europe and in Italy, respectively (LINDEGAARD 1995, CREMA et al. 1996, FERRARESE 2006, LENCIONI 2007). Nevertheless, most crenal systems remain unexplored, and no biotic indexes have been developed to determine their ecological status (CANTONATI et al. 2006). We aimed to analyze chironomid taxa distribution in natural or slightly impacted cold springs from an ecological and geographical point of view.

Key words: biodiversity, crenophilous taxa, Italian Alps, microhabitat

Study area and methods

We surveyed each of 108 cold springs (Gauss-Boaga: 5070190–5152540N; 1619748–1725432E; 170–2790 m a.s.l., Trentino, northeast Italy) once in 2005 within the CRENODAT project (see Acknowledgements). The springs are located in calcareous and siliceous basins; most are rheocrene, but a few are limnocrene and elocrene. Most were pristine or slightly impacted habitats, with only 5 severely affected by captation and morphological modification. Chironomid larvae and pupae were collected from 3 habitats: (1) submerged stones using a kick net (200 µm mesh size); (2) bottom sediments (i.e., gravel and sand) using a syringe; and (3) submerged mosses by washing moss clumps in water. Water temperature, conductivity, dissolved oxygen, pH, nutrients, anions, and cations were recorded. Chironomids were slide-mounted and identified to genus, species group, or species level according to ROSSARO (1982), WIEDERHOLM (1983, 1986), and JANECECK (1998).

Data were stored in a Microsoft Access® database. A Canonical Correlation Analysis was carried out using MatLab R2006b® to detect relations between taxa and environmental variables. Only taxa present in at least 10 sites were considered (37 taxa). We included 28 environmental variables, 7 of which were dummy variables (substrate size, submerged mosses, leaves, branches, water regime, current, light). Biological data were log (x + 1) transformed, and environmental data were standardized prior to the analysis. A χ^2 test was carried out to test the significance of the canonical axes.

Results

We caught 37 854 chironomid specimens and identified 104 taxa (listed in Lencioni et al. subm.), from 1 to 34 per spring. Only in one spring (Pejo) were chironomids absent. Orthocladiinae predominated (84 % of individuals), followed by Diamesinae (8 %), Tanytarsini (6 %), Tanypodinae (2 %), Prodiamesinae (0.1 %) and Chironomini (0.02 %).

The most species-rich sites (32–34 taxa) were the rheo-elocrene Nambino, Malga Lavazzi and San Giuliano. The sites less rich in taxa were highly mineralized, such as the ferruginous Ferruginosa Miola and Stol de Fer, where only *Bryophaenocladius* sp. (a semiterrestrial species), *Chaetocladius vitellinus* gr. and *Corynoneura* sp. were found, and Molino Frizzi Cimone (rich in Zn^{2+}), where only *Heleniella serratosioi* was captured.

The most frequent and abundant species were *Tvetenia calvescens/bavarica*, *Paratrichocladius skirwithensis*, *Corynoneura* sp., *Micropsectra* spp. and *Metriocnemus hygropetricus* gr. Species *Metriocnemus fuscipes* gr., *Zavrelimyia punctatissima* and *Pseudodiamesa branickii* were frequent, but with low abundance, while *Pseudokiefferiella parva* and *Cricotopus* spp. were present only on rare occasions but with high densities. The rarest taxa were Chironomini (*Polypedilum nubeculosum*, *Phaenopsectra flavipes*, *Saetheria* cf.). We recorded 22 taxa for the first time in the Italian springs, many of which have already been found in Berchstesgaden National Park (Oberbeyern, Germany; STUR & WIEDENBRUG 2006). In contrast, some species previously found in northeast Italian springs (Alto Adige Region) were not found (e.g., the crenobiontic species *Paraboreochlus minutissimus*; FERRARESE 2006).

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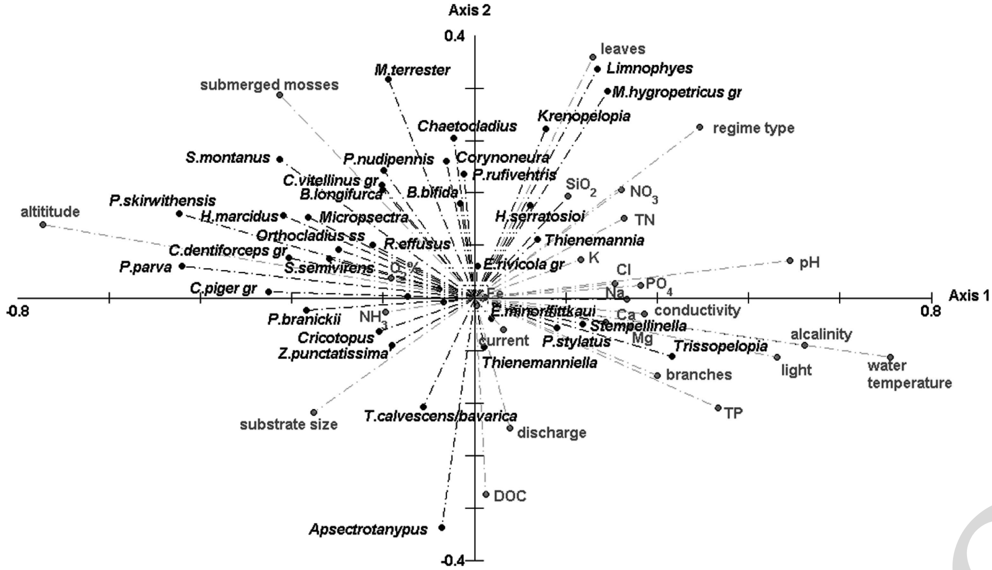

Fig. 1. Canonical Correlation Analysis: biplot of biological and environmental variables according to the first two axes.

The first canonical axis represented 9 % of total variance (χ^2 test, $p < 0.001$) and was positively correlated with water temperature and negatively with altitude (Fig. 1). Taxa associated with high altitude were *P. parva*, *P. skirwithensis*, *Stilocladius montanus*, *Chaetocladius piger* gr., *Chaetocladius dentiforceps* gr. and *Heterotrissocladius marcidus*. The second canonical axis explained 8 % of total variance (χ^2 test, $p < 0.001$) and was positively associated with submerged mosses and leaves (low water current, i.e., limnocrene springs) and negatively with substrate size, discharge and DOC (high water current, i.e., rheocrene springs). This axis also represented the ecological preference of taxa: bryophilous species were positively correlated (e.g., *Metriocnemus terrester*, *H. marcidus*, *Parorthocladius nudipennis*, *Chaetocladius vitellinus* gr., *Micropsectra* spp., *Brillia longifurca*, *Brillia bifida*), and lotic species were negatively correlated (e.g., *Eukiefferiella minor/fittkaui*, *Apsecrotanypus* sp., *T. calvescens/bavarica*, *Parametriocnemus stylatus*, *Trissopelopia* sp.). The third axis (7.5 % of total variance, χ^2 test, $p < 0.001$) was positively correlated with SiO_2, phosphates and nitrates and negatively with pH and alkalinity (Fig. 2). Chironominae and Tanypodinae were associated with calcareous basins, Orthocladiinae and Tanypodinae were ubiquitous.

Orthocladiinae predominated in all substrate types (75–90 % of specimens); Diamesinae were associated with stones (13 %); Tanytarsini were abundant in sediments (12.5 %); and Prodiamesinae (0.7 %); Chironomini (0.1 %) were found only in this habitat type; and Tanypodinae were present in all microhabitat types in low numbers (1.5–5.5 %).

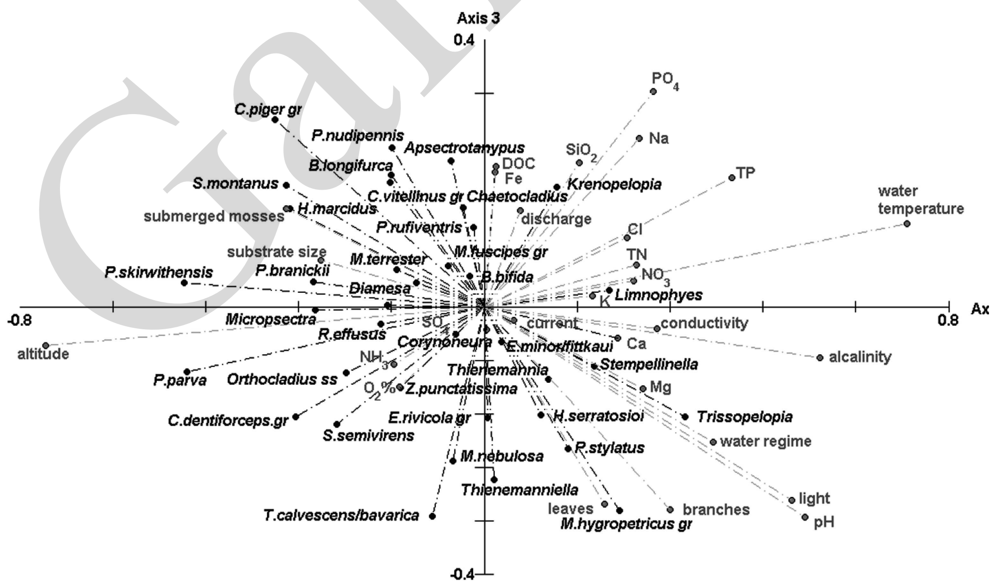

Fig. 2. Canonical Correlation Analysis: biplot of biological and environmental variables according to the first and third axis.

Discussion

The percentage distribution of taxa within chironomid subfamilies was in accordance with previous studies (Lindegaard 1995): Orthocladiinae, Diamesinae, and Tanytarsini predominated, being composed mainly of cold stenothermic taxa.

Taxa richness was maximum at intermediate altitude (1350–1950 m a.s.l.), probably because at low altitudes higher water temperature and anthropogenic impacts may cause a reduction in diversity, while above the tree and snow lines the harsh climatic and poor trophic conditions may hinder colonization. As expected, the rheoelocrene springs were the most species rich, being a mosaic of different niches (Lindegaard 1995, Cantonati et al. 2006, Sambugar et al. 2006). Orthocladiinae are grazing organisms and therefore were especially common in mosses. Diamesinae were associated with stones, as expected because of their rheophilous habits. The predators Tanypodinae were present in all microhabitat types, while the collectors Tanytarsini, Prodiamesinae, and Chironomini were abundant in sediments.

Springs were shown to be inhabited by crenophilous taxa, but also by lentic, lotic, and bryophilous taxa, while no crenobiontic or endemic taxa were detected, as expected on the basis of previous surveys (Lindegaard 1995).

Species were distributed according to altitude, microhabitat type, basin lithology, and trophic state; however, only 25 % of the total variance was explained by the 3 principal canonical axes, so other environmental factors may be important. A gradient of spring types (from rheocrene to limnocrene) was emphasized, and taxa assemblages changed gradually from one type to another. In this sense each spring can be considered a unique habitat.

The response of chironomid species to natural factors was explored to understand biotic and abiotic processes influencing species distribution in natural or slightly impacted spring ecosystems. This knowledge is needed to assess and monitor the ecological status of springs increasingly threatened by global warming, eutrophication, and acidification, along with direct impacts such as water abstraction (Cantonati et al. 2006).

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Authors' addresses: L. Marziali, V. Lencioni, Section of Invertebrate Zoology and Hydrobiology, Museo Tridentino di Scienze Naturali, Via Calepina 14, 38 100 Trento, Italy. E-mail: laura.marziali@unimi.it
B. Rossaro, Department of Biology, Section of Ecology, University of Milan, Via Celoria 26, 20 133 Milan, Italy.