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A biotic index using benthic macroinvertebrates for Italian lakes

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Abstract

The relationship between benthic macroinvertebrates and environmental variables from 42 Italian lakes were analysed with the aim of developing a biotic index.

In the investigated lakes, 570 species were found of which 373 belonged to the family of Chironomidae and 85 to the class of oligochaeta. Rare species, those present in less than 10 samples, were excluded from the analysis, leaving 57 species for data analysis.

Multivariate analysis: canonical correlation analysis (CANON) and multivariate analysis of variance and covariance (MANCOVA) were carried out on a large database of 1060 sampling points, for which both environmental data (16 chemical and morphometric variables) and 57 species counts from soft bottom samples were available. In addition, a second dataset of 94 sites from small lakes sampled in 2005 in Northern Italy (Lombardy), was analysed for comparison.

The data analysis (CANON) from the large database gave the following results:

(1) the first canonical variate was related to conductivity, pH and alkalinity and accounted for 17% of the total variation;
(2) the second canonical variate was related to total phosphorus, N-NH_4 and dissolved oxygen, and accounted for 15% of the total variation;
(3) lake maximum depth, volume and water temperature were related to the third canonical variate, which accounted for 14% of the source of variation.

The analysis of the database from small lakes revealed that in the plane of the first two canonical variates dissolved oxygen was inversely correlated with the depth of sampling and that the second canonical variate showed an inverse relationship between transparency and nutrients.

MANCOVA found evidence for differences between lake types and sampling years, confirmed the CANON results and allowed the quantification of the contribution of different target variables on species composition.

A trophic status index was calculated ranking percentage oxygen saturation (O_2 %sat), transparency (transp) and total phosphorus (TP). The means of O_2 %sat, transp and TP weighted by the species abundances were calculated to have optimum

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values for each species; a benthic quality index was then obtained by multiplying the weighted means of O_2 %sat, transp and TP by species abundances and dividing the product by the total number of specimens present at each station. A significant correlation was observed between trophic status and the benthic quality index. A good agreement was also observed between the indexes calculated using the large database and the second dataset on small lakes.

Keywords: Bioindicators; Lakes; Chironomids; Oligochaetes; Multivariate analysis; Trophic status

1. Introduction

Benthic macroinvertebrate communities are valuable in the biological assessment and biomonitoring of lakes. Oligochaetes and chironomids are considered the most useful indicators of oxygen condition (Brundin, 1949) and trophic status (Sæther, 1979) but their usefulness as indicators of toxic substances is still uncertain (De Haas, 2004). Different species prevail depending on trophic status, which affects food quality and quantity, and oxygen status. Food is the main factor changing community composition when environmental conditions are not too severe, but when organic pollution is more intense, it is oxygen concentration rather than food that limits the species survival and determines the community composition.

Biological communities are certain to be highly influenced by site-specific conditions, therefore, even though some generalisations are possible, each lake has its own history that must be understood before benthic macroinvertebrates can be used for biological assessment. For the purposes of the Water Framework Directive (WFD) (Directive 2000/60/CE) an index of general validity is needed to assess high, good, moderate, poor or bad ecological quality.

The aim of the present paper is to test the feasibility of a protocol for developing and applying a benthic quality index for macroinvertebrates of Italian lakes, the protocol can be extended to lakes in other countries, but experimental data are needed.

1.1. The use of macroinvertebrates as lake quality indicators and their significance in lake classification

Freshwater biomonitoring using species assemblages of benthic macroinvertebrates dates back to the beginning of the 20th century (Cairns and Pratt, 1993); Naumann (1932), Lenz (1925), Lundbeck (1936), Thienemann (1954) and Brundin (1956) observed a distribution of different chironomid species according to trophic condition, oxygen saturation and depth in lakes. Brundin (1974) revised the state of knowledge about the indicator value of chironomids, discussing bio-geographical problems. Benthic macroinvertebrates have been extensively used in lake classification (Wiederholm, 1981; Kansanen et al., 1990; Aagaard, 1986) and are acknowledged indicators of lake quality (Johnson et al., 1993).

Several indices and classification systems have been developed using chironomid and oligochaete assemblages. The trophic indices, most of which were developed for lakes in Northern Europe, rely on relative abundances of chironomid species, the ratio of tolerant to intolerant tubificid oligochaetes, or the ratio of oligochaetes to chironomids (Wiederholm, 1980). Wiederholm (1980) developed a benthic quality index (BQI) using chironomids alone, proposing six different scores. A benthic quality index (BQI modified after Wiederholm, 1980) can be calculated as:

$$\mathrm{BQI}_i = \sum_{j=0}^{5} \frac{h_j y_{ij}}{\sum_{j=0}^{5} y_{ij}} \quad (1)$$

where y_{ij} is the number of individuals of each indicator group j at site i, $\sum_{j=0}^{5} y_{ij}$ the total number of individuals of all indicator groups j at site i and h_j is the score level which ranges from 0 to 5 according to the indicator value given to different species. The BQI could be considered a candidate metric for Italian lakes but unfortunately the presence or more generally the importance of the species used as indicators in Northern and Central Europe is not confirmed for Italy; for example, although the genus *Sergentia* is reported as present in Italy in Limnofauna Europea (http://www.faunaeur.org/distribution.php); this is probably incorrect due to misidentification with