Geotargeting spatial and temporal data of Italian freshwater high-altitude macroinvertebrates

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ABSTRACT

A data set including information on macroinvertebrates identified to genus/species group/species level was created within the monitoring activities of several European and national projects. The data set includes 2111 macroinvertebrate records on temporal fragmentary data from lakes Paione (upper, middle, and lower lakes Paione), and 530 records on spatial data relative to eight other high-altitude lakes from the Ossola Valley (North-western Italy, Piedmont, Central Alps). The study area is included within the Lake Maggiore watershed. All records are georeferenced because, since the beginning of the studies, temporal data were taken in the same sampling sites over years. The temporal data span the period 1989-2020, the spatial data refer to the 2019-2020 sampling activity. The dataset is available for download in .csv format at the Global Biodiversity Information Facility (GBIF) data infrastructure.

INTRODUCTION

Since 1992, after the United Nations Conference on Environment and Development (better known as the 'Earth Summit') held in Rio de Janeiro (Brazil), terms such as biodiversity, biodiversity monitoring and biodiversity conservation become increasingly widespread and commonly used in research papers and programs, and even in newspapers and in daily life. In particular, biodiversity data are of foremost importance within the International Cooperative Programme (ICP Waters) for the assessment and monitoring of the effects of air pollution on rivers and lakes and more generally in monitoring programs aiming to provide data to assess the biological response to atmospheric pollution under the National Emission Ceilings Directive (NECD, 2016/2284/EU), as well as within the Water Framework Directive (WFD, 2000/60/EC) to evaluate the improvement of the environmental quality status of freshwaters following the main goals defined by the European Community regarding water protection.

Moreover, strong impulses by the Commission to increase the availability of environmental data and promote data sharing have been given: among them, the INSPIRE Directive (INfrastructure of SPatial InfoRmation in Europe - 2007/2/EC), a Community law that obliges Member States to adopt measures for the creation of services that allow the sharing of spatial data among all public authorities, with the aim of ensuring that future environmental policies can count on a greater amount of high-level information and therefore be more effective, the Environmental Information Directive (2003/4/EC) on Public Access to Information on Environmental Matters, requiring public authorities to release their own data when required and to facilitate their reuse (Public Sector Information Directive - 2003/98/EC). European legislation, therefore, agrees that all territorial data (i.e., those relating to a specific location or geographical area) held by or on behalf of a public authority are archived, made available and stored at a more suitable level.

We focused in particular on high-altitude freshwater ecosystems, which have been identified as sensitive and reliable monitoring sites to assess the response of freshwater biota to air pollution (Battarbee *et al.*, 2009), and global change (Woodward *et al.*, 2010; Rogora *et al.*, 2018). Thus, our aim was to share the data on lakes Paione (Boggero, 2018; Boggero *et al.*, 2021), and on other Italian mountain

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Key words: aquatic habitat; zoobenthos; occurrence; mountain area; geographic distribution; long-term data.

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lakes and their respective river networks in Northern Piedmont (N-W Italy, Fornaroli and Boggero, 2022) within the several freshwater monitoring programs envisaged by the above Directives and Plans and to facilitate communication and comparisons at the national and the international level. Some of these high-altitude lakes have been monitored since the '80s in the context of EU research projects on the effects of transboundary air pollution and climate change on mountain lakes (*e.g.*, AL:PE1, AL:PE2, MOLAR, EMERGE) and are sensitive to acidification, particularly those lying in watersheds composed of acid rocks. The lakes Paione are sites of the Italian and European LTER networks (sites LTER_EU_IT_088 and LTER_EU_T_089). The lakes are not only affected by atmospheric deposition pollution, but they also undergo indirect anthropogenic pressure such as climate change (Rogora *et al.*, 2013; Boggero *et al*., 2019). A few of them are also included within the Italian network of sites for the monitoring of the effects of emission reduction on ecosystems under the National Emission Ceilings Directive (NECD) (De Marco *et al.*, 2019).

Our aim was also in line with i) two main sustainability objectives for the 2030 Agenda of the United Nations such as "Protect and restore water-related ecosystems including mountains, forests, swamps, rivers, aquifers and lakes" (objective 6.6) and "Take effective and immediate actions to reduce the degradation of natural environments, halt and reversing biodiversity loss, and protect the endangered species" (objective 15.5); ii) with the European and Italian biodiversity strategies for 2030; iii) with the National Recovery and Resilience Plan (PNRR); as well as iv) with local strategies that aim to preserve nature and reverse the degradation process of ecosystems, to restore the natural capital ensuring in the meantime its resilience to future challenges posed by climate change. The information collected allows supporting the Italian Ministry of Ecological Transition (MiTE) in directing future national legislation actions. The collected samples, fixed in alcohol, are still available at the CNR-IRSA plankton museum for further integrative analyses such as DNA barcodes for the creation of reference datasets for these environments.

Data set development

The data set was developed at CNR-IRSA during the period 2019-2020 and organised in a systematic and coherent way. It explores the macroinvertebrates belonging to lakes and their river network in the Ossola Valley high altitudes (higher than 1500 m asl. or above the tree line) (north-western Italy, Piedmont, Central Alps) (Tab. 1). The reduced watersheds of these lakes consist mainly of harsh habitats with open bare rocks, scarce alpine meadows and absent or very thin soil layers, implying they do not suffer from high nutrient contribution from the watershed. The watershed lithology is simplified and dominated by acidic rocks, although small lenses of carbonate rocks are present, thus they show different acid-sensitive levels, and different macroinvertebrate assemblages.

During the dataset development, the taxonomy was updated and uniformed to allow comparisons with data collected in other geographical areas. The final checklist presents a total of 136 samples and 2641 records. The records classification followed Fauna Europaea organisation (de Jong *et al.*, 2014). A detailed description of the information included in the dataset is shown in Tab. 2.

Object name: Italian_freshwaters_mountain_macroinvertebrates

Data set citation: Italian_freshwaters_mountain_macroinvertebrates

Character encoding: UTF-8

Format name: csv

Format version: 1.0

Distribution (permanent link): https://www.gbif.org/

Tab. 1. Main geographic features of the study lakes with their river network (modified by Fornaroli and Boggero, 2022).

Valley	Lake name	Lake code	Altitude	Latitude N	Longitude E	Inlet	Outlet
			m asl	WGS 84 decimal degrees			
Agarina	Gelato	GEL	2418	46.24843	8.44028	no	no
Agarina	Matogno	MAT	2087	46.24947	8.40237	x	x
Anzasca	Grande	GRA	2214	46.00184	8.07801	no	x
Bognanco	Paione inferiore	LPI	2006	46.16924	8.19024	x	x
Bognanco	Paione di mezzo	LPM	2145	46.17252	8.19076	x	x
Bognanco	Paione superiore	LPS	2251	46.17591	8.18991	no	x
Bognanco	Variola medio	LVM	2137	46.17707	8.21402	x	x
Bognanco	Variola superiore	LVS	2198	46.17980	8.21010	no	x
Strona	Capezzone	CAP	2100	45.93810	8.20895	no	x
Vigezzo	Muino inferiore	LMI	1886	46.18085	8.49251	no	x
Vigezzo	Muino superiore	LMS	1889	46.18284	8.48853	no	x

dataset/4e1e783d-421c-404e-aa95-803235c8fe16
Date of creation: 17 October 2022
Date of last revision: 17 October 2022
Date of publication: 17 October 2022
Update policy: GBIF policy rules.
Language: English
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Tab. 2. Information retrieved on the data set on VCO high-altitude lakes/river network with variables, their definitions, Darwin Core Thesaurus identifier, units, storage type (modified by Boggero *et al.*, 2021).

Variables	Description	Univocal references	Units	Storage type
ID_Code	Unique identifier for the record within the dataset	catalogNumber		Integer
Kingdom	Full scientific name of the kingdom in which the taxon is currently classified (2020)	kingdom		String
Phylum	Full scientific name of the phylum in which the taxon is currently classified (2020)	phylum		String
Subphylum	Full scientific name of the subphylum in which the taxon is currently classified (2020)	subphylum		String
Class	Full scientific name of the class in which the taxon is currently classified (2020)	class		String
Order	Full scientific name of the order in which the taxon is currently classified (2020)	order		String
Family	Full scientific name of the family in which the taxon is currently classified (2020)	family		String
Subfamily	Full scientific name of the subfamily in which the taxon is currently classified (2020)	subfamily		String
Tribe	Full scientific name of the tribe in which the taxon is currently classified (2020)	tribe		String
Genus	Full scientific name of the genus in which the taxon is currently classified (2020)	genus		String
Subgenus	Full scientific name of the subgenus in which the taxon is currently classified (2020)	subgenus		String
Species	Full scientific name of the species in which the taxon is currently classified (2020)	species		String
Taxon	Full scientific name at the lowest taxonomic resolution available in which the taxon is currently classified (2020)	taxon		String
GBIF_Code	Unique identifier for the record within GBIF database	taxonID		Integer
Quantity_Type	Data format in which the frequency of occurrence is provided	organismQuantityType		String
Frequency	Number of individuals in each sample	organismQuantity	No. ind/sample	Numeric
Sample_Code	Unique identifier for the sample within the dataset	eventID		String
Lake_Code	Unique identifier for the lake within the dataset	locationID		String
Sampling_Date	Date-time when the event was recorded expressed as yyyy/mm/dd	eventDate		String
Substrate	Substratum type of sampling site			String
Zone	Lake layer sampled			String
Lake	Lake name	waterBody		String
Datum	Spatial Reference System (SRS) to locate geographic water bodies or their habitats	geodeticDatum		String
Longitude	Geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of a location	decimalLongitude	Decimal degrees	Numeric
Latitude	Geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of a location	decimalLatitude	Decimal degrees	Numeric
Altitude	Explicit elevation above sea level of the sampled lake or river	verbatimElevation	Meters	Numeric

Metadata language: English
Metadata managers: Angela Boggero (angela.boggero@cnr.it) or Riccardo Fornaroli (riccardofornaroli@gmail. com)

Summary statistics

The data set developed during the period 2019-2020 explores the macroinvertebrates belonging to 11 lakes and their river network in the Ossola Valley high-altitudes (1886-2418 m asl). The dataset stores a large number of information related to Linnean classification, different spatial scales, from the substrate type sampled in each lake, to the lake, or the lake-reach, or the tributary/outflowing stream sampled. The checklist presents a total of 104 samples and 2111 records dedicated to lakes Paione (upper, middle and lower lakes Paione) and 32 samples and 530 records to other eight mountain lakes (Tab. 1, Figs. 1 and 2).

Management details

Project title: Geotargeting spatial and temporal data of Italian freshwater high-altitude macroinvertebrates
Database managers: Angela Boggero, Riccardo Fornaroli
Temporal coverage: Data covered the 1989-2020 period for lakes Paione (although fragmentary), and the period 2019-2020 for the remaining 7 mountain lakes (Figs. 1 and 2).
Record basis: preserved specimens (80% ethanol)
IT specialists: Angela Boggero, Riccardo Fornaroli
Funding grants: Data were gathered within the framework of EU research projects (*e.g.*, AL:PE1, AL:PE2, MOLAR, EMERGE). Some of the sites are also included within the network of sites for the monitoring under the National Emission Ceilings Directive (NECD) and the data collected in 2019-2020 were funded by a 2-year cooperation agreement between the Italian Ministry for Ecological Transition (MiTE) and Carabinieri - CUFA (Command of Forestry, environmental and Agrifood Units; formerly National Forest Service) for the development of the Italian monitoring network under the NECD (NEC Italy).

Geographic coverage

Study area: All the study lakes are in the Ossola Valley (Fig. 3), a main valley consisting of 7 secondary Alpine valleys fan-like distributed in the northern edge of Piedmont Region at the border with Switzerland and with Lake Maggiore area to the south, surrounded by the Pennine Alps on the western side and by the Lepontine Alps on the northern and eastern sides. The lakes occupy only 4 out of 7 secondary valleys (Tab. 1). Data were georeferenced directly on site according to WGS 84 datum.
Bounding box: min longitude: 8.077569 – min latitude 45.93852 – max longitude: 8.492839 – max latitude: 46.24935
Geographical subdivisions: Piedmont north-western Italian region
Sampling design: Macroinvertebrates sampling was performed following the standard sampling methodologies developed within NIVA and, more recently, ICP WATERS Manuals and Programmes (NIVA 1987; ICP Waters Programme Centre 1996, 2010). Semi-quantitative macroinvertebrate samples were taken, during the ice-free season, mainly in Autumn before insect diapause, through a 2-5 min handle-netting the substrate (250 µm mesh size). At the same time, 1 L water bottle for water chemistry analyses was taken at lake-mouth where littoral water temperatures have also been recorded through a thermometer. Different habitats were considered (gravel, pebbles, boulders, rock faces) over a 0.5-1.0 m littoral- or river-reaches sampling. Sorting and identification were performed at genus/species group/species level using Italian macroinvertebrate identification guides based each on single taxa

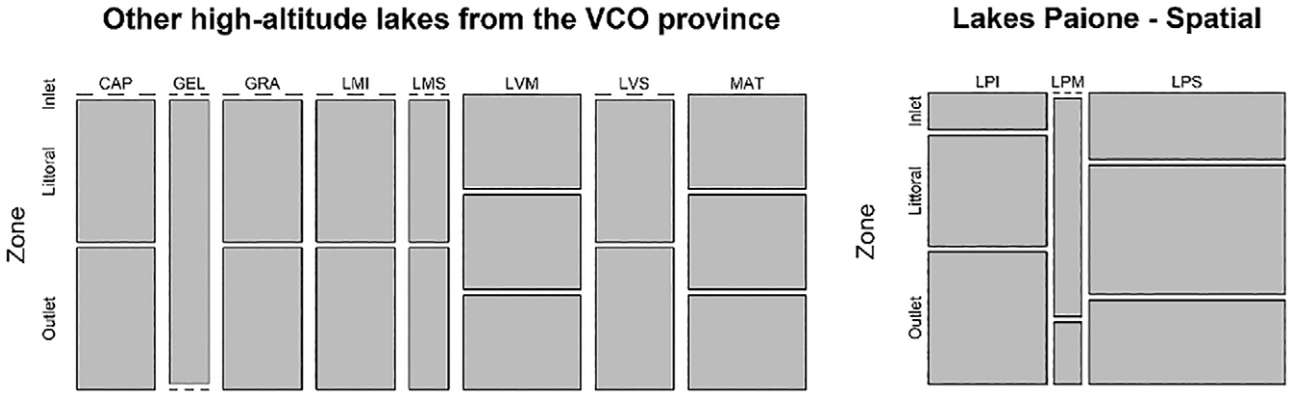

Fig. 1. Frequencies of samples for each habitat for both lakes Paione and other high-altitude lakes from the Ossola Valley (spatial distribution). See Tab. 1 for lake code.

group (AA.VV. 1977-1985), or on European identification guides on oligochaetes (Timm, 2009; Schmelz and Collado, 2010), or on chironomids (Andersen *et al.*, 2013).
Habitat type: Habitats were defined according to the second-level EUNIS classification system (http://eunis.eea.europa.eu/ - Davies *et al.*, 2004), a pan-European system for habitat identification, including standing waters (C1.1: Permanent oligotrophic lakes, ponds and pools; 9 sites), and

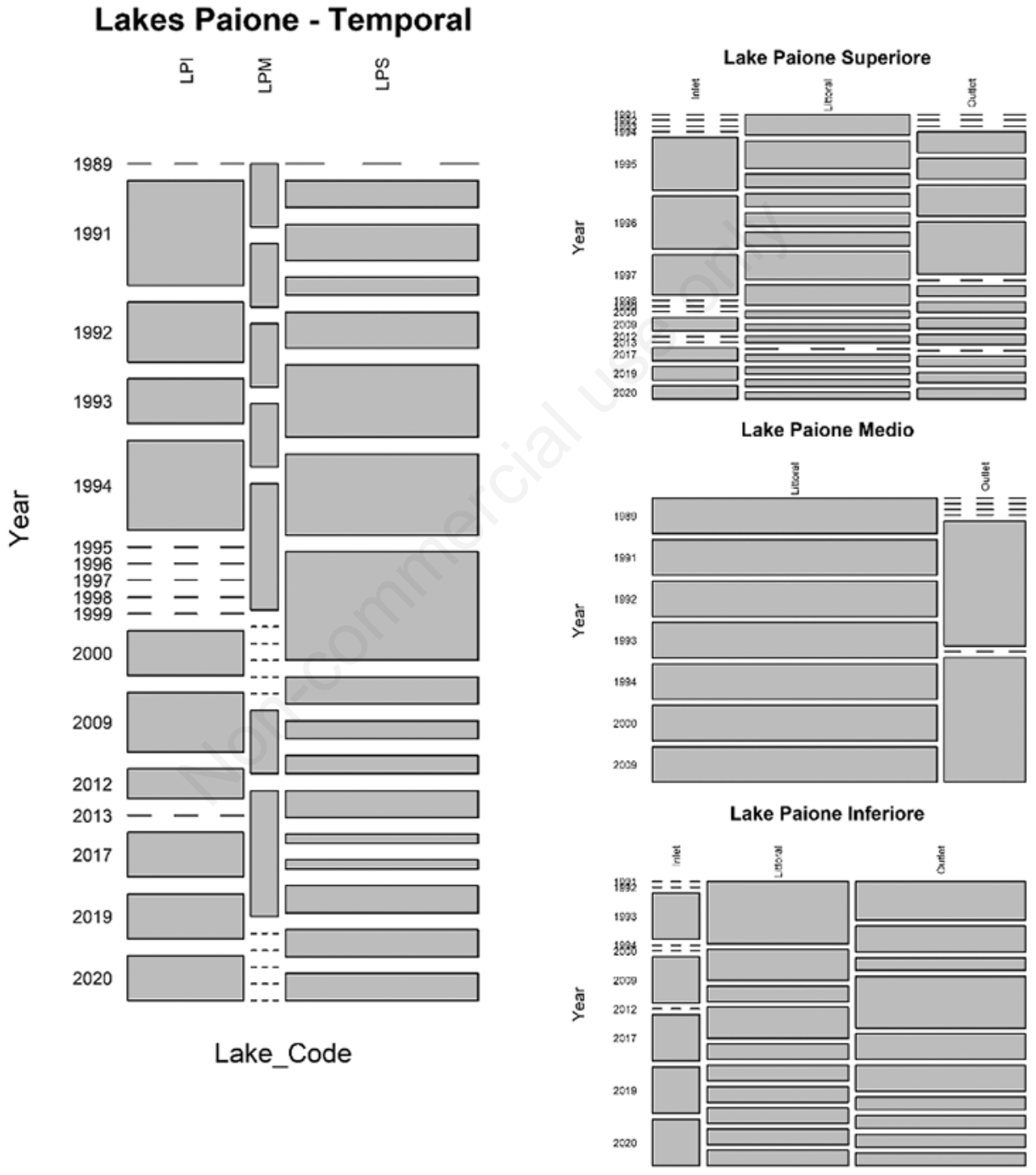

Fig. 2. Frequencies of samples for each sampling year in lakes Paione (left panel) and for each habitat and sampling year, divided by lake (right panel) (temporal distribution). See Tab. 1 for lake code.

running waters (C2.5: Surface temporary running waters; 11 sites).
Biogeographic region: Alpine (EEA, 2017).
Country: Italy.
Quality control for geographic data: Quality control was performed using a Spell Checker to correct the spelling of names, and Google maps identification of lakes, altitude, latitude and longitude coordinates standardized to WGS84 DD. The absence of anomalous ASCII characters in the dataset was also additionally checked.

Taxonomic coverage

General description: The data set represents the aquatic organisms constituting the numerous taxonomic groups within macroinvertebrates as a whole. The list of taxa contains information updated until December 2020. To be considered valid, and therefore to be included in the checklist, a species name must meet the criteria of publication in Articles 8 and 9 of International Code of Zoological Nomenclature (ICZN) (1999, 2011). The checklist presents taxa arranged according to the Fauna Europaea classification where subgenera, species groups/series/types and species are listed alphabetically within each genus (de Jong *et al.* 2014, Tab. 3).
Taxonomic ranks: macroinvertebrates both immature and adult stages include different types of macroinvertebrates easily visible without optics, such as insects, crustaceans, molluscs, annelids, flatworms, and clitellata. They are found in contact with sediments on the bottom of lotic and lentic ecosystems.
Taxonomic methods: revision of names, synonyms, delimitation of genera and higher taxa, was accomplished manually using Fauna Europaea (https://fauna-eu.org/) as a reference collection (de Jong *et al*., 2014).
Taxon specialist(s): Angela Boggero, Elzbieta Dumnicka, Daniele Paganelli, Silvia Zaupa are responsible for taxa identification, taxonomic revision/update of the whole set of species included in the data set, and Angela Boggero and Riccardo Fornaroli for the dataset management from the central-western Alps (Piedmont).
Quality control for taxonomic data: Record validation and cleaning were based on data check for spelling errors, data standardization (check of nomenclatural changes or synonyms), and data cleaning and validation for taxonomic reliability and taxonomic consistency using Fauna Europaea.

Tab. 3. Information about the dataset: number of records divided by Class.

Class	No. of records
Insecta	1964
Clitellata	465
Arachnida	135
Turbellaria	57
Bivalvia	15
Malacostraca	5

Fig. 3. Distribution of the study lakes within the Ossola Valley, N-W Italy. Light blue, lakes.

DATA AND CODE AVAILABILITY

All georeferenced data are available at GBIF: DOI 10.15468/mzhrqh

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Conflict of interest

The authors declare no conflict of interest.

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