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A ten-year geographic data set on the occurrence and abundance of macroinvertebrates in the River Po basin (Italy)

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SUMMARY

Rivers serve many societal functions and are one of the most intensively human influenced ecosystems worldwide, and, due to their importance, are included under the monitoring programs of the Water Framework Directive across Europe. Macroinvertebrates play an important role when monitoring running waters for the assessment of their environmental quality due to their reliability as bioindicators and utility in long-term studies. Macroinvertebrates do not constitute a systematic unit but they are formed by a set of different taxa, grouped according to taxonomic ranks, size and habitat preferences. They represent the base of the aquatic food chain, serving as a food source for amphibians, birds, reptiles, fish and humans, and contributing in the organic matter processing. Despite the large amount of data collected on Italian river macroinvertebrates and the increased interest in the study of this group, only few data are available for research scientist and managers. In this paper, we collected and homogenized knowledge on the presence, distribution and abundances of macroinvertebrates taxa inhabiting the River Po catchment (Northern Italy) in the last decade. The data set includes 130,727 records collected between 2007 and 2018 including 143 taxa of macroinvertebrates, mostly identified at family rank level. Moreover, the data set provides information on the geographic distribution of these families and their abundance by sub-catchment, altitude, meso- and micro-habitat.

INTRODUCTION

Rivers serve many societal functions and are one of the most intensively human influenced ecosystems worldwide, especially in the last decades (Wohl et al., 2015). The benefits of water provision to economic productivity, agriculture and drinking water are often accompanied by impairment to ecosystems and biodiversity (Vörösmarty et al., 2010), with potentially serious costs for the society. The key components of watershed management focus on identifying and pinpointing factors that impair system integrity followed by the development and implementation of remedial measures.

Anthropogenic activities threat riverine ecosystems through habitat loss and degradation (Allan & Flecker, 1993) such as modification of running water environments, deforestation of pristine wildernesses, pollution and introduction of exotic species (Nilsson & Berggren, 2000; Lewin et al., 2014; Mathers et al., 2020). Environmental scientists have thus focused their research topic on river condition assessment, system management and restoration measures (Vugteveen et al., 2006).

Running water environments, due to their importance, are included under the monitoring programs of the Water Framework Directive (WFD EC, 2000). Moreover, macroinvertebrates play an important role when monitoring running waters for the assessment of their environmental quality due to their reliability and utility in long-term studies (Gore et al., 2001; Hansen & Hayes, 2012). Benthic invertebrate fauna is one of the relevant Biological Quality Elements (EC, 2000) commonly referred to as macroinvertebrates. Macroinvertebrates do not constitute a systematic unit, but they are formed by a set of different taxa, grouped according to taxonomic ranks, size and habitat preferences. They live on, under, and around rocks and sediment on the bottoms of lakes, and rivers. As a result of their habitat choice, they are regarded as "benthos" which refers to organisms which live on or near the bottom or burrow in. They include immature and adult stages of aquatic insects, crustaceans, mollusks, annelids, flatworms, water mites and cnidarians (Tachet et al., 2010). They form the base of the aquatic food chain, serving as a food source for amphibians, birds, reptiles, fish and humans, and breaking down both living and decaying plants, contributing to the transformation of plant material into energy subsequently consumed by other water animals. They are considered good indicators of ecological status (Hering et al., 2006), and thus they are broadly used as warning sentinels of environmental changes, mainly related to hydrological regimes, flow permanence and pollution loads.

Despite the large amount of data collected on Italian river macroinvertebrates since the implementation of WFD only few data are available for research scientists and managers (e.g. Calabrese et al., 2020; Erba et al., 2020). We collected and homogenized knowledge on the presence, distribution and abundances of macroinvertebrates taxa inhabiting the River Po catchment (Northern Italy) in the last decade i) to provide the first checklist of macroinvertebrates occurring in this basin, including data on their geographic distribution (from east to west, and from the high altitudes to lowland), and ii) to create a comprehensive spatial and temporal data set (biological information coupled with mesohabitat classification and both mineral and biological substrates) on the macroinvertebrate communities of the rivers waters of the Po Valley which are a source of ecosystem services for humans (drinking water and hydro-power supply, tourism). This information will be useful for researchers and water managers to promote future targeted conservation and restoration strategies on river ecosystems.

RESULTS

The data set includes 143 taxa of macroinvertebrates, mostly identified at family rank level. Taxa are distributed among nine phyla (Annelida, Arthropoda, Cnidaria, Mollusca, Nematoda, Nematomorpha, Nemertea, Platyhelminthes and Porifera) (Table 1), twelve classes (Adenophorea, Arachnida, Bivalvia, Branchiopoda, Clitellata, Demospongiae, Gastropoda, Hydrozoa, Insecta, Malacostraca, Maxillopoda, Turbellaria), 33 orders and 141 families, occurring within the River Po catchment (71,000 km^2, Figure 1) across seven Italian Administrative Regions.

Table 1. Phylum-based distribution of taxa.

Phylum	Records
Annelida	14,721
Arthropoda	106,939
Cnidaria	5
Mollusca	4,228
Nematoda	879
Nematomorpha	439
Nemertea	135
Platyhelminthes	3,379
Porifera	2

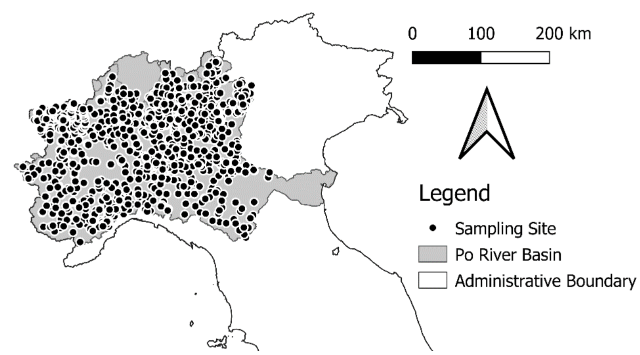

Figure 1. Location of the sampling sites considered in the present work distributed in Northern Italy.

There are no data on macroinvertebrates of those rivers that fall geographically in the Italian area, but politically belong to foreign Countries (Swiss, France). Data were collected by the Environmental Agencies using the Italian national standardised method (ISPRA, 2014) for the implementation of WFD activities between 2007 and 2018. Identification of organisms were performed at different taxonomic levels by operators of the

Environmental Agencies, thus, first we check for spelling errors and standardized the nomenclature, then we homogenised the taxonomic level to the least common denominator (mostly family level) using the "biomonitoR" package (Laini et al., 2018) within R software (R Core Team, 2019).

Summary statistics

The data set consists of 41 columns (Table 2) per 130,727 records. The first column reports the ID Code of each record. The successive six columns are a rank-based taxonomical classification including the categories of Kingdom, Phylum, Class, Subclass, Order, Family, when known and available. Then, one column reports the taxon name and one column the unique identifier for the occurrence of Global Biodiversity Information Facility database (GBIF, 2020). The following eight columns refer to: Frequency (expressed as absolute abundance and referred to the sampled area), Sampled Area, Sample code, Site code, Sampling date (as dd/mm/yyyy) and Sampled mesohabitat (Riffle, Pool or Generic). The next seventeen columns report the sampled microhabitat expressed as percentage, classified in nine mineral substrate classes and eight biological substrates as included in the national standardised method (ISPRA, 2014). The remaining seven columns refer to: Human impacts in the site (present or absent), Administrative Region, River Name, geodetic Datum, Longitude East and Latitude North and Altitude (as m a.s.l.).

Data set

Object name: Dataset_Biodiversity_River_Po_Macroinvertebrates_2020

Data set citation: Macroinvertebrates Po 2020

Character encoding: UTF-8

Format name: csv, comma-separated values

Format version: 1.0

Distribution (permanent link): 10.5281/zenodo.3991564

Date of creation: 10th April 2020

Date of last revision: 19th August 2020

Date of publication: 20th August 2020

Language: English

License of use: if used by researchers, administrators, managers, teachers, amateurs, general public, and others, the access is free and the use is based upon request. Details are defined in the intellectual property information. The data set authors would appreciate users, when using the data set, to consider the authors for co-authorship.

Metadata language: English

Metadata manager: Riccardo Fornaroli

Management details

Project title: Macroinvertebrates from River Po catchment

Database manager: Riccardo Fornaroli

Temporal coverage: the present data set refers to a decade (2007-2018) of monitoring activities carried on by the Environmental Agencies on the River Po and its tributaries.

Record basis: Mainly preserved specimens.

Sampling methods: The data set was created by collating different data sets included in storage databases and managed by several Environmental Agencies operating in Northern Italy.

Funding grants: no funding grants were received

Geographic coverage

Study area: the rivers considered are part of the River Po network. They cover the Northern part of Italy crossing different Administrative Regions (Aosta Valley, Piedmont, Lombardy, Liguria, Veneto, Trentino, and Emilia-Romagna) including mostly the Subalpine area and the Po Plain.

Bounding box: min Longitude: 6.71363 - max Longitude: 11.29543, min Latitude: 44.11007 - max Latitude: 46.49150, min Altitude: 10 - max Altitude: 2,280.

Sampling design: The data set was created including all the available records (biotic on macroinvertebrates and abiotic) on the River Po and its tributaries.

Habitat type: The considered rivers cover natural, artificial (channel), or partially modified by anthropic infrastructures rivers flowing through the Po Plain.

Biogeographic region: Alpine, Continental and Mediterranean (EEA, 2017)

Country: Italy

<u>Taxonomic coverage</u>

General description: The data set includes records of river macroinvertebrates. The checklist presents taxa (mainly, at family level) arranged and updated to December 2018 according to the Fauna Europaea classification (de Jong et al., 2014).

Taxonomic ranks: macroinvertebrates are a heterogeneous group of aquatic organisms visible to the naked eye without employing optical instruments, living in contact with sediments on the bottom of lotic and lentic ecosystems. Macroinvertebrates include immature and adult stages of many different types of invertebrates, such as aquatic insects, crustaceans, molluscs, annelids, flatworms, and cnidarians.

Taxonomic identification: Collected organisms were identified and counted in the field on live specimens (or in the laboratory within the working day). Some specimens were stored in denatured ethanol to confirm identification carried out in the field.

Taxonomic methods: These methods include the revision of names, and the delimitation of taxa following Fauna Europaea (https://fauna-eu.org/) as a reference.

Taxon specialist: The first author is responsible for the data management. The authors (RF, AL) are not responsible for the identifications carried out by operators of the Environmental Agencies.

<u>Quality controls</u>

Quality control for geographic data: Quality control was performed using:

i) Google satellite identification of rivers and sampling sites;
ii) Geographic coordinates format, coordinates within country/provincial boundaries;
iii) absence of ASCII anomalous characters in the data set were additionally controlled.

Quality control for taxonomic data: Record validation and cleaning using Fauna Europaea were based on several steps and divided into:

i) data check for spelling errors;
ii) data standardization (check of nomenclatural changes or synonyms);
iii) data cleaning and validation for taxonomic reliability and taxonomic consistency.

Quality control for microhabitat data: Quality control was based on two steps:

i) data check for spelling errors using ISPRA (2014) as reference;
ii) the number of sampled microhabitat must be equal to the number of replicates (10)

Table 2. Full information linked to the data set with variables, description, univocal references provided by Darwin Core Thesaurus, units and type of storage.

Variables	Description	Univocal reference	Units	Storage type
ID_Code	Unique identifier for the record within the data set	catalogNumber		String
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
Class	Full scientific name of the class in which the taxon is currently classified (2020)	class		String
Subclass	Full scientific name of the subclass in which the taxon is currently classified (2020)			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
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 taxon in the GBIF database	taxonID		Integer
Quantity_Type	The type of quantification system used for the quantity of organisms.	organismQuantityType		String
Frequency	The number of individuals in the sample	organismQuantity	Number of individuals per area squared	Numeric
Sampled_Unit	The unit of measurement of the area of a sample in a sampling event.	sampleSizeUnit		String
Sampled_Area	A numeric value for a measurement of the area of a sample in a sampling event.	sampleSizeValue	Meters squared	Numeric
Sample_Code	Unique identifier for the sample in the present database	eventID		String
Site_Code	Unique identifier for the site in the present database	locationID		String
Sampling_Date	Date of the sampling in the format dd/mm/yyyy. Two-digit day of the month, two-digit month of the year and four-digit year.	eventDate		String
Mesohabitat	Sampled mesohabitat. Possible levels are RIFFLE, POOL and GENERIC			String
ARG	Percentage of the sites covered by mineral substrate with dimension < 6 µm		Percentage	Numeric
SAB	Percentage of the sites covered by mineral substrate with dimension > 6 µm and < 2 mm		Percentage	Numeric

Variables	Description	Univocal reference	Units	Storage type
GHI	Percentage of the sites covered by mineral substrate with dimension > 2 mm and < 2 cm		Percentage	Numeric
MIC	Percentage of the sites covered by mineral substrate with dimension > 2 cm and < 6 cm		Percentage	Numeric
MES	Percentage of the sites covered by mineral substrate with dimension > 6 cm and < 20 cm		Percentage	Numeric
MAC	Percentage of the sites covered by mineral substrate with dimension > 20 cm and < 40 cm		Percentage	Numeric
MGL	Percentage of the sites covered by mineral substrate with dimension > 40 cm		Percentage	Numeric
ART	Percentage of the sites covered by artificial substrate (e.g. concrete)		Percentage	Numeric
IGR	Percentage of the sites covered by igropretic substrate		Percentage	Numeric
TP	Percentage of the sites covered by living parts of terrestrial plants		Percentage	Numeric
XY	Percentage of the sites covered by xylal (wood)		Percentage	Numeric
EM	Percentage of the sites covered by emergent macrophytes		Percentage	Numeric
SO	Percentage of the sites covered by submerged macrophytes		Percentage	Numeric
AL	Percentage of the sites covered by algae		Percentage	Numeric
CP	Percentage of the sites covered by coarse particulate organic matter		Percentage	Numeric
FP	Percentage of the sites covered by fine particulate organic matter		Percentage	Numeric
BA	Percentage of the sites covered by bacteria fungi and sapropel		Percentage	Numeric
Human_Impacts	Presence of human impacts			Boolean
Administrative_Region	First-level administrative division to which the sampled river belongs	stateProvince		String
River	Name of the sampled river	waterBody		String
Datum	Spatial Reference System (SRS) upon which the geographic coordinates given in Latitude and Longitude are based	geodeticDatum		String
Longitude	Geographic longitude (in decimal degrees, using the spatial reference system given in geodetic Datum) of the sampling site	decimalLongitude	Decimal degrees	Numeric
Latitude	Geographic latitude (in decimal degrees, using the spatial reference system given in geodetic Datum) of the sampling site	decimalLatitude	Decimal degrees	Numeric
Altitude	Explicit elevation above sea level of the sampled site	verbatimElevation	Meters	Numeric

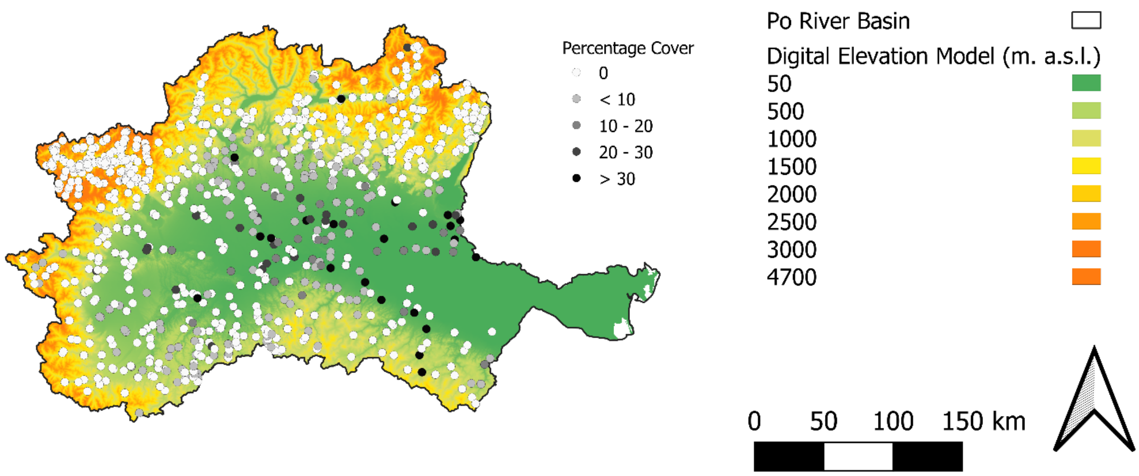

Figure 2. Mean percentage of each site covered by biological substrates, averaged among seasons and years.

DISCUSSION

The present dataset comprises detailed information about 866 sampling sites distributed in the River Po catchment sampled seasonally for ten years. Available information allows to develop biogeographical studies on single taxon or community as well as the definition of the suitability of environmental characteristics such as the availability of mineral and biological substrates. As an example, Figure 2 reports the availability of biological substrates (e.g. particulate organic matter and macrophytes) in the sampling sites, highlighting their importance in the Po Plain.

Figures 3 and 4 represent respectively the mean number of families and the mean number of individuals per square meter (density) of the most widespread orders of macroinvertebrates in running waters, averaged among sampling seasons and years. In general, the number of taxa is higher at relatively higher altitude and at lower latitude (Figure 3a), while higher densities were recorded in the Po Plain, showing an opposite pattern (Figure 4a).

Higher richness at higher altitude can be observed for many of the considered order such as Plecoptera and Ephemeroptera for which this association is well known (Kamler, 1967; Lessmann et al., 2016) but also for Trichoptera and Diptera (Figure 3 panels c, d, e and h). Plecoptera density shows its maximum at higher altitude (Figure 4c) as reported since the earlier studies on this order (e.g. Hynes, 1976) highlighting their vulnerability to climate change (de Figueroa et al., 2010) and oxygen deficiency. Trichoptera, Ephemeroptera and Diptera densities instead do not show a clear geographical pattern, this probably reflect the bigger niche width of the taxa belonging to those orders both in terms of oxygen needs (Jacobsen, 2000) and resistance to various source of pollution (Armitage et al., 1983; Kuemmerlen et al., 2015).

Odonata order is generally more represented in the Po Plain where bushes, shrubs or small plant cover are present, they are more diverse (Figure 3g) and abundant (Figure 4g) at lower altitude with the notable exception of the Apennines mountains (Ligurian Apennines, lower-left of each panel) where they are very well represented. It is well known that altitude could be one of the most important environmental variables explaining the variation in dragonfly species composition (e.g. Samways, 1989; Harabiš & Dolný, 2010) and this is reflected also in the present dataset.

Coleoptera richness (Figure 3f) and density (Figure 4f) show their maximum at intermediate altitudes (500-1,500 m a.s.l.), moreover, two geographical hotspots can be identified, one in the Apennines and one in the province of Trento.

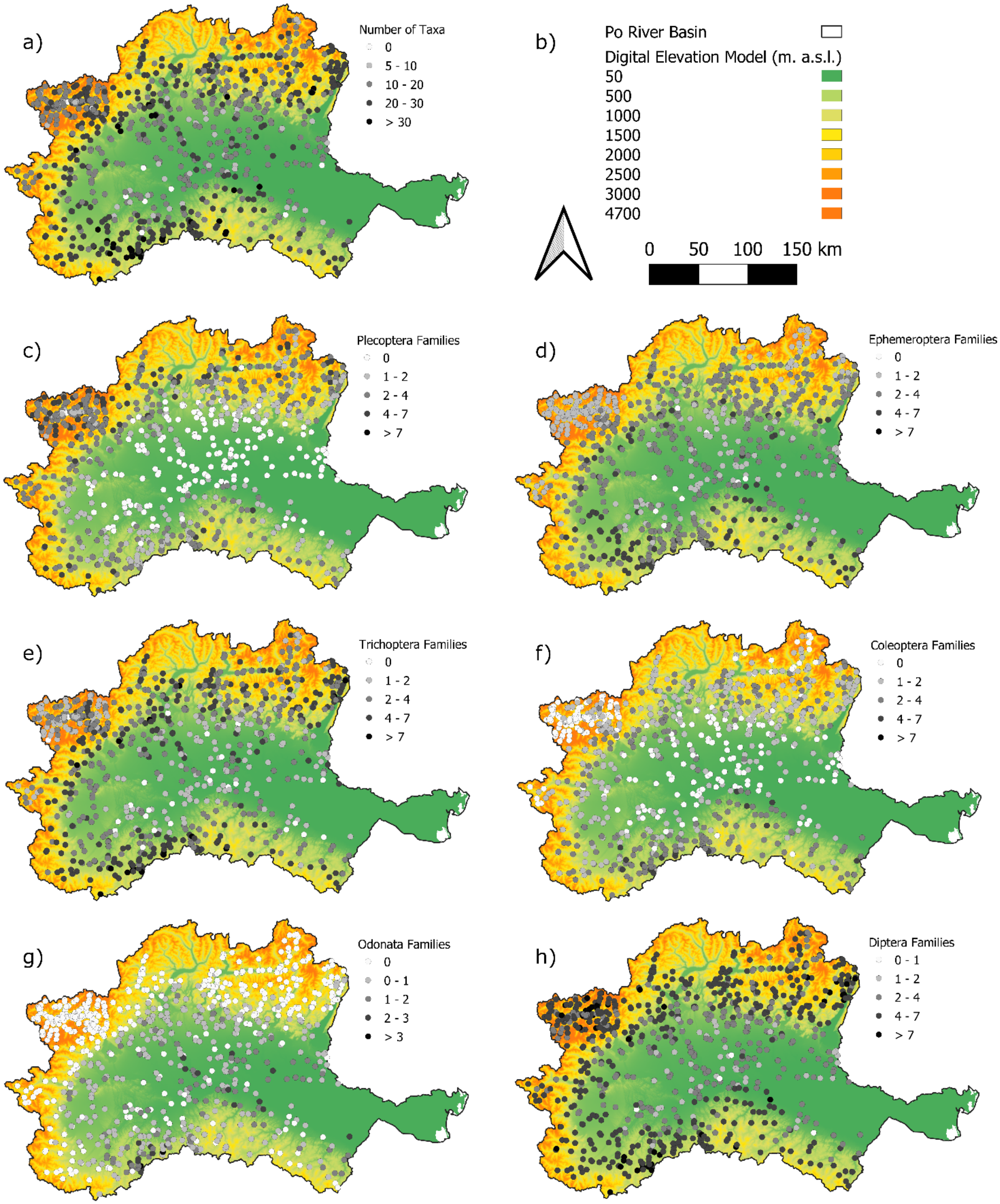

Figure 3. Mean number of taxa, and of families of different orders of macroinvertebrates in the sampling sites considered in the present work, averaged among seasons and years.

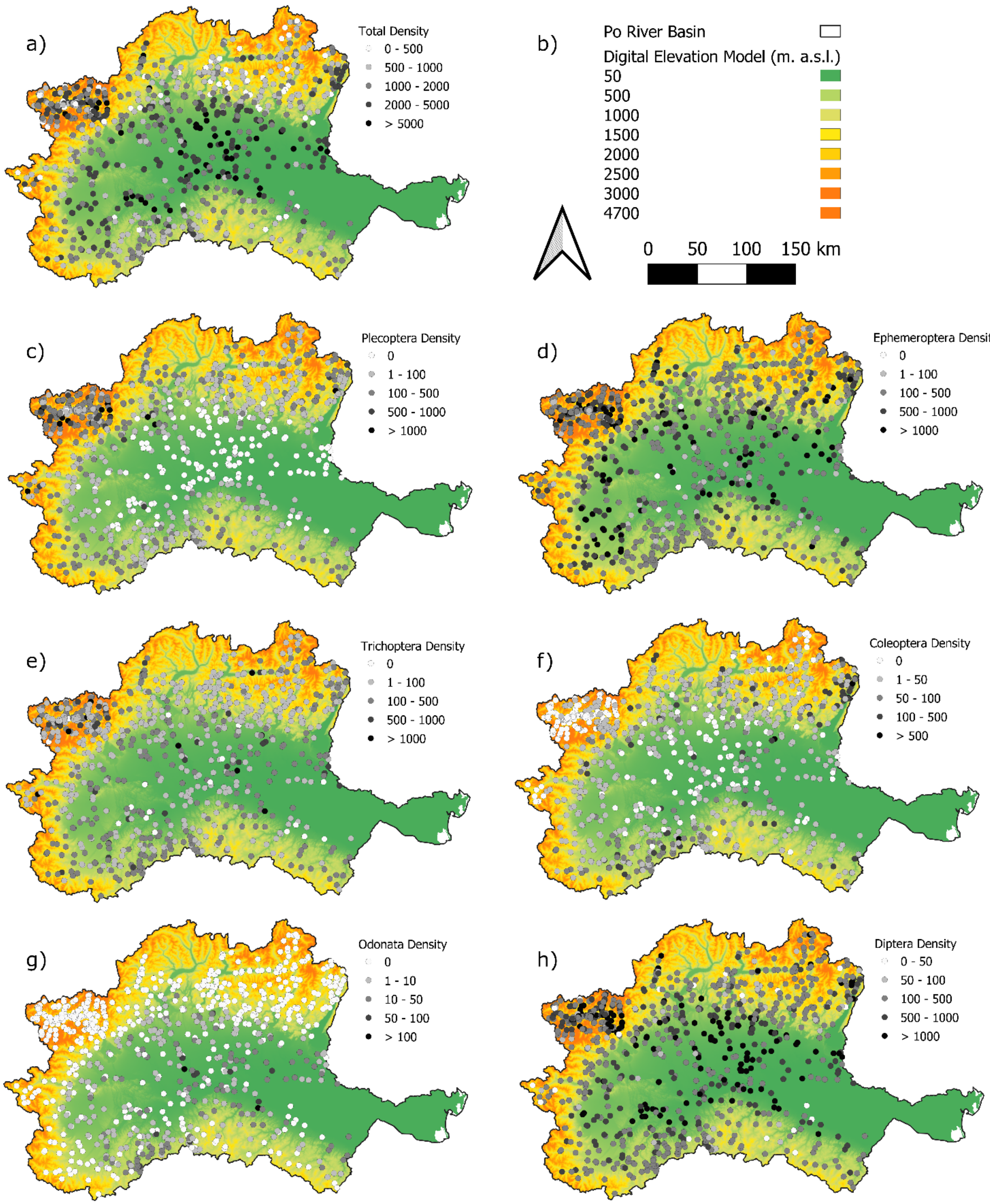

Figure 4. Mean number of individuals per square meter (here called density) of different orders of macroinvertebrates in the sampling sites considered in the present work, averaged among seasons and years.

CONCLUSIONS

Despite the large amount of data collected on Italian river macroinvertebrates since the implementation of WFD (EC, 2000) and the increased interest in the study of this group, only few data are available for research scientists and managers. The data set presented herein aims to give an updated account of taxonomically accepted family names recorded in the tributaries of the River Po catchment by different Environmental Agencies during the last decade. Moreover, the data set provides information on the geographic distribution of these families and their abundance by sub-catchment, altitude and Administrative Region. The dataset can be the basis for different studies, focused both on selected groups and on the whole macroinvertebrate community, improving the knowledge on factors that define their distribution in the River Po catchment.

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AUTHORS CONTRIBUTION

Riccardo Fornaroli: co-structured the data set, conceptualization, formal analysis and writing of manuscript.

Alex Laini: co-structured the data set and writing of manuscript.

Angela Boggero: contacts with data providers.

Alessandra Agostini, Elena Arnaud, Alberto Berselli, Eugenia Bettoni, Cristina Borlandelli, Giuseppe Cadrobbi, Manuela Cason, Luciano Castelli, Silvia Cerea, Laura Contardi, Sara Costa, Silvia Costaraoss, Valentina Dallafior, Alessandro Dal Mas, Francesco Elvio, Marco Fioravanti, Davide Fortino, Silvia Franceschini, Laura Fravezzi, Alessia Fuganti, Matteo Galbiati, Filippo Galimberti, Pietro Genoni, Daniela Gerbaz, Alessia Lea, Daniela Lucchini, Anna Maria Manzieri, Manuela Marchesi, Catia Monauni, Paola Montanari, Federica Morchio, Silvia Piovano, Natale Pizzochero, Mara Raviola, Filippo Richieri, Valeria Roatta, Daniela Rocca, Attilio Sarzilla, Ornella Siciliano, Paola Testa, Davide Tonna, Maria Enza Tumminelli, Franca Turco, Luciana Vicquery: field-work activities, identification of macroinvertebrates, data providers.

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