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**First data on the freshwater fish fauna of Calabria
(Southern Italy)**

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Abstract

Studies on freshwater fish presence and distribution in southern Italy are scarce and sporadic, and in particular, ichthyological information regarding Calabria lotic systems is practically inexistent. Aim of this study is to provide information about the present status of freshwater fish fauna in some of the most important lotic systems of Calabria. Ichthyological samplings were performed in fifty-four stations along fifteen Calabrian rivers. Sixteen fish species belonging to eight families were found, and their presence and distribution were discussed on the basis of biogeographical and ecological considerations. Results indicate that freshwater fish fauna of the area has been dramatically altered by recent and contemporary introduction of allocthonous species, mainly originating from the Po plain catchments, representing a prime example of faunistic transformation of a Mediterranean area.

Keywords: Freshwater fish, Calabria, ichthyology, allocthonous species.

Introduction

The natural distribution of native fish fauna in Italy is the result of complex paleogeographic and paleoecologic processes. According to the salinity tolerance, Bianco (1995a) recognized four categories of freshwater fish in Italy: 1) Primary, taxa that originated and spread only in freshwaters (such as Cypriniformes); 2) Primary-like, freshwater species of marine origins (such as many Gobiidae); 3) Secondary taxa, that are euryhaline and can survive in marine environments (such as Cyprinodontidae); 4) Peripheral, recent marine derivatives and diadromous taxa (such as Salmonidae, Gasterosteidae and Acipenseridae). Dispersal capacity changes in these groups, and in particular primary freshwater fishes represent an important group for biogeographical studies: these fish tolerate only low salt concentrations and are unable to disperse through marine environments, so that their distribution is strictly related to the history of hydrographic systems. In fact, primary fish can't diffuse from a river network to another via sea, while secondary and peripheral fish can move in this way. On the basis of the distribution of indigenous taxa, Bianco (1990) individuated two distinct ichthyogeographic regions in the Italian peninsula, with many endemisms that possibly were isolated since the Messinian Age (about 5 million years). The Padano-Venetian district contains basins of middle and upper Adriatic sea to the north of the river Vomano, while the Tuscano-Latium district includes Serchio, Arno, Ombrone and Tevere basins. For paleogeographic reasons, southern Italian basins were isolated from the rest of the peninsula and are with few or no native primary freshwater fishes, and rivers and streams of this area were colonised mainly by saline-tolerant species, coming from the Mediterranean. Unfortunately, this picture dramatically changed because anthropic introductions has radically altered the original distributions of freshwater fish in almost all Italian basins (Gandolfi et al. 1991; Zerunian, 2002).

At present, studies on freshwater fish presence and distribution in southern Italy are scarce and sporadic, and in particular, ichthyological information about Calabria lotic systems are practically inexistent. In particular, there are a few isolated reports, regarding the presence of single species in particular Calabrian rivers (e.g.: Bianco, 1981; Bianco & Recchia 1983).

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3 The aim of this study is to provide information about the present status of freshwater fish
4 fauna in some of the most important lotic systems of Calabria, analysing historical and
5 ecological reasons of their presence and distribution.
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10 **Materials and Methods**

11 This study collates data from some ichthyological surveys in Calabria (Southern Italy).
12 Fifty-four sites belonging to fifteen lotic systems were analysed to investigate presence
13 and distribution of fish (Figure 1). The examined rivers (and stations) were: Abatemarco
14 (AB1-AB2), Coscile (CO1-CO5), Crati (C1-C5), Esaro (ES1-ES3), Lao (L1-L3), Lipuda (LI1-
15 LI2), Neto (NE1-NE5), Ampollino (AM1), Lese (LE1-LE2), Vitravo (VI1-VI3), Rosa (RS1-
16 RS2), Savuto (SV1-SV4), Tacina (TA1-TA7), San Antonio (SAN1-SAN2), Soleo (SO1-SO3),
17 and Trionto (TR1-TR4). More information on the chemical and biological characteristics of
18 major Calabrian rivers are reported in Lucadamo et al. (2008). The location of each
19 sampling station within a river reach was selected in the field based on representativity
20 and accessibility: a variety of habitat types (pools, riffles and runs) was sampled in each
21 occasion. During low flow conditions, each stations was electrofished by passing once
22 upstream, searching from one bank to the other, following the methods outlined by Bohlin
23 et al. (1989) for a total length of almost 200 m. Single-pass qualitative electrofishing was
24 conducted using a backpack electric fishing machine (SCUBLA ELT60, operated at 25-100
25 Hz and 300/550 V, depending on the water conductivity). Single pass electrofishing is
26 infact a suitable and usual method for assessing distribution of freshwater fish in small
27 and medium size lotic environments (Jowett & Richardson, 1996; CEN, 2003; Maceda-
28 Veiga et al. 2010). Once collected, fish were identified, counted, then returned to the river;
29 some species, mainly Salmonidae, were also measured (standard length and weight), and
30 sorted them in size classes. Taxonomic nomenclature used is consistent with the checklist
31 of the species of the Italian fauna (Stoch 2004). Main abiotic parameters (altitude,
32 streambed width, water depth, conductivity, pH, C.O.D., B.O.D.) were recorded and the
33 biological quality of the site was calculated using macroinvertebrate assemblage
34 composition and structure (I.B.E. index, Ghetti 1997).
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58 In order to identify the faunal similarity of stations, cluster analysis using the Bray-Curtis
59 similarity coefficient (Bray & Curtis 1957) was applied, and a similarity dendrogram was
60 produced using Biodiversity Pro software. Canonical Correspondence Analysis (CCA), a

widely used method for direct gradient analysis, was employed in order to analyse relationships between fish distribution and the measured environmental parameters, by using SYNTAX statistical program.

Results

In this study, 54 stations were sampled to assess fish presence. List and distribution of fish species are reported in Table 1.

Fish species

A total of sixteen fish species was found: eight belonging to the family Cyprinidae, two to Salmonidae, one to Anguillidae, one to Ictaluridae, one to Mugilidae, one to Blennidae, one to Cobitidae and one to Poecilidae. In the following paragraphs, information on each species is provided.

- *Anguilla anguilla* Linnaeus, 1758. Eel represents one of the few native species of the area (Rogliano 1963). These catadromous fish have been found in many lotic systems of the area, such as Crati, Lao, Abatemarco, Coscile, Neto, San Antonio, Soleo and Tacina, also if their present distribution is probably affected by dams and other artificial elements, that can restrict access to upstream river areas.

- *Rutilus rubilio* (Bonaparte, 1837). This species is probably native of central Italy. Costa (1850) found no fish attributable to this particular and characteristic cyprinid species in Calabria, so we agree with Bianco and Taraborelli (1984) that *R. rubilio* has been introduced in Calabrian inland waters. These same authors also reported that *R. rubilio* can hybridize with other cyprinids (e.g., a hybrid *R. rubilio* x *L. cephalus* was found in the Crati river near Terranova di Sibari).

- *Barbus plebejus* (Bonaparte, 1839) is endemic to the Padano-Venetian district (Bianco 1995b, 2003), but it was trans-introduced in many rivers in central and southern Italy. In our study area, this species was only found in the Crati basin (Crati, Esaro and Coscile rivers) as a result of a probably recent local and successful introduction.

- *Alburnus alburnus alborella* (De Filippi, 1844), native of the Padano-Venetian district, is now spread through all of Italy, including Calabria. Bianco and Taraborelli (1984) suggested that this species was introduced in Calabria, and particularly in area of the Sila mountains, not for direct fishing but as a prey species for introduced trout.

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3 - *Leuciscus cephalus* (Linnaeus, 1758). This species is one of the most important examples of
4 trans-introduced fish in Italy: characterised by a wide range of tolerance for different
5 environmental factors, *L. cephalus* is able to withstand certain levels of pollution. In our
6 study this species has been found in many lotic systems, from both Ionian and Tirrenian
7 catchments. Recently, a new subspecies of chub from the Savuto river has been described,
8 named *Leuciscus ruffoi* Bianco & Recchia, 1983, but its taxonomical position still remains
9 unclear. Our samplings in the Savuto river detected an high incidence of mycosis and
10 health problems in the local chub population, presumably due to chemical alterations of
11 the water.
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14 - *Scardinius erythrophthalmus* (Linnaeus, 1758) is a cyprinid known for Padano-Venetian and
15 Tusco-Latium district. Its presence in southern aquatic systems is due to recent
16 introductions. The rudd is a typical lentic cyprinid, and its presence in running waters is
17 very sporadic: rudds in the mountainous reach of the Savuto river surely come from a
18 nearby, upstream artificial lake.
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21 - *Carassius carassius* (Linnaeus, 1758). This allocthonous species is quite common in
22 northern Italy, but is rare in central and southern basins (Forneris et al. 1990). Our study
23 demonstrates that *C. carassius* is present in many lowland Calabrian running water
24 systems, such as the Crati, Tacina and Coscile.
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27 - *Cyprinus carpio* Linnaeus, 1758. This species was a prime example of invasive freshwater
28 taxon, because it was diffusely introduced in Italy since the Roman period from the
29 Danube basin (Balon 1995). In Calabria the species seems to be present in many high-
30 order, lowland habitats, such as the Neto, Tacina and Crati.
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33 - *Tinca tinca* (Linnaeus, 1758). This species was only found in the lower reach of the Tacina
34 river, and its presence is surely due to recent introductions for sport-fishing purposes.
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37 - *Cobitis taenia* Linnaeus, 1758. Bianco and Taraborelli (1984) signalled the presence of this
38 species in the Ampollino lake and in the Savuto river, suggesting that the introduction of
39 loach was made for the purpose of foraging introduced trout. Our study confirms the
40 presence of this species in the Savuto river, and for the first time reports its presence in
41 some other Calabrian lotic systems.
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44 - *Salmo (trutta) trutta* Linnaeus, 1758. In the Mediterranean area, brown trout is considered
45 a freshwater species of recent marine origin (Bianco 1995a). Fossil evidences indicate that
46 trout were present in southern Italy since the Pleistocene (Durante 1978). The typical
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3 Mediterranean trout, *Salmo (trutta) macrostigma* Duméril 1858, is a salmonid species
4 occurring in inland water habitats in northern Africa, southern Europe, western Asia and
5 Anatolia (Gandolfi et al. 1991). This species is supposed to be the characteristic trout of
6 southern Italy, including Calabria. In our samplings, a very puzzling situation was found:
7 some specimens from few populations (found for example in the upper Lese, San Antonio
8 and Lao) have phenotypic characters that may be referred to *macrostigma* type, such as the
9 permanence of parr marks in the adults. Unfortunately, great part of populations are
10 clearly derived by recent or contemporary introductions, with trout showing in great part
11 Atlantic phenotypic traits. Our findings confirms for Calabria the thesis reported in
12 Schöffmann et al. (2007) that, while in the past century many rivers of southern Italy were
13 stocked with hatchery-reared brown trout originating from the northern part of the
14 Mediterranean basin (Sommani 1969), in recent time the majority of introduced trout have
15 derived from hatchery stocks of Atlantic origin (Ketmaier & Bianco 2004).

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28 - *Onchorynchus mykiss* (Walbaum, 1792). Rainbow trout is probably the most widely
29 introduced fish species in the world (Fausch 2008). Our findings suggest that very few
30 populations are present in Calabria, with no traces of self-sustaining capacity, so that these
31 populations seems to be exclusively sustained by continuous releases.

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36 - *Ictalurus* sp. To our knowledge, this is the first citation of the presence of the American
37 catfish in Calabrian inland waters. This species seems to be very sporadic, and its presence
38 due to occasional introductions in the lower part of the Crati river.

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42 - *Gambusia holbrooki* Girare, 1859. This Poeciliid, native of Atlantic areas of the United
43 States, has been introduced in Calabria for the first time in 1928-31, in the context of a
44 complex anti-mosquito campaign (Paladino-Blandini 1933). This species seems to be
45 acclimated in some lowland, slow running water systems (such as the inferior parts of
46 Tacina, Neto and Lese rivers).

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51 - *Lipophrys fluviatilis* (Asso, 1801) This Blennidae is a peri-Mediterranean freshwater fish
52 with benthic habits, autochthonous for Calabria, that is considered as a Messinan survivor
53 derived by *Lipophrys pavo* (Zander 1973).

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57 - *Liza ramada* (Risso, 1826): this species, such as *Mugil cephalus* and other Mugilidae, is quite
58 widespread in Mediterranean costal waters, and often penetrate in freshwater systems. *L.*
59 *ramaza* was found in some lowland stations of Ionian catchments.
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Stations and lotic systems

On the whole, nine stations resulted fishless, eleven stations had only one species and only four presented a relatively rich fish community, with a total of seven species. Comments on community richness can be made only considering the huge number of allocthonous species: in fact, the number of species in a stream reach depends not only on environmental characteristics but also on the history of introductions that took place in the area. Bray-Curtis similarity analysis showed two distinct and major clusters (Figure 2). Headwaters of Abatemarco, Coscile, Crati, Lese, Rosa, San Antonio, Savuto, Soleo, Trionto and Vitravo contained stations characterised by the presence of *Salmo trutta*: trout were found as unique fish taxon, or in association with *A. anguilla*, or more rarely with *O. mykiss* or some accompanying cyprinids, mainly *L. cephalus* and *B. plebejus*. The other most important cluster is basically characterized by stations lacking Salmonidae, with various assemblages of Cyprinidae (for the most part including *L. cephalus*, *R. rubilio*, *C. carpio*) and other species. Within this group, two clusters can still be recognized: a first cluster (including mainly lowland stations of the Neto hydrographic network, plus the final segment of Tacina) is characterised by the presence of *A. anguilla*, *L. fluviatilis*, *G. holbrooki*, while the other (including stations from Crati network, plus few others from Neto and Tacina networks) is characterised by the presence of *B. plebejus*, *C. carassius*, and *L. ramada*. This difference in fish fauna composition can be related to different episodes of anthropic introduction and to some environmental differences among stations (mainly regarding streambed width, water column depth, conductivity). The final part of the Trionto river is isolated in the cluster analysis: this station corresponded to a peculiar environment, called 'fiumara'. Water presence in these environments is intermittent and seasonal, so that in these and similar environments, biological communities are constituted by well adapted species (Fenoglio et al. 2006). The presence of *R. rubilio* in this station is limited to few deep pools, and can be considered occasional and ephemeral.

The Canonical Correspondence Analysis (Figure 3) indicates that both native and alien species are located on environmental gradients determined largely by altitude and streambed characteristics: in particular, Salmonidae are only present in high, low order environments, while the presence of *S. erythrophthalmus* in two stations seems not to be correlated with any biological or environmental parameters, but seems the result of punctual releases.

Discussion and conclusions

This study is probably the first structured attempts to analyse the presence and distribution of freshwater fish in lotic systems of Calabria. Analysing data from fifteen rivers, from both Ionian and Tyrrhenian slope, a preliminary but quite comprehensive picture of the current situation was obtained. The present distribution of freshwater fish in Calabria is the result of recent events, mostly related to human interventions. The displacement of fish in new hydrographical basins has been a common practice for a long time: Romans were the first to breed and introduce Carps (*Cyprinus carpio*) from the Danube to the Mediterranean area for breeding purposes, and the tradition of the "piscinae" was expanded in monasteries throughout Europe in the Middle Age (Balon 1995). Another interesting example of fish introduction is Rainbow Trout (*Onchorynchus mykiss*): this species is probably the most widely introduced fish species in the world, released in almost all continents (except Anctarctica) for fishing purposes, with great impacts on local fauna (Cambray 2003). But, while introduction of a single species can represent a great but also localised and punctual threat to biodiversity, a totally different scenario is represented by the complete change of the fish fauna of an entire area, as occurred in Calabria. Few species (such as Eel and Trout) represented, according to Rogliano (1963) and Bianco (1987) the only freshwater fish present in great part of Calabria (for example in the running waters of the Sila mountainous system), where many streams were even devoid of fish fauna. In facts, Bianco (1987) reported that Cyprinid distribution in Southern Italy was limited to the rivers to the north of the line connecting Sinni to Alento. This original situation has dramatically changed because of massive introduction of allocthonous species. The official and unofficial introduction of "white fishes" caused a process of 'padanization' (*sensu* Cambray 2003) in most basins of Calabria: the transplantation of native species from north to southern Italy is a phenomenon that began more than forty years ago and completely altered the ichthyological fauna of the area. Human introductions altered not only biodiversity at community level, but also altered genetic pools at population level: in particular, allocthonous trout strains dramatically altered the genetic characteristics of native populations. In fact, as reported by Nonnis Marzano et al. (2003) during the last century, domesticated strains of *S. (trutta) trutta* (also known as morpha *fario*) have been transferred from northern Italy to most of southern

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3 freshwater basins without considering the presence of autochthonous populations of *S.*
4 (*trutta*) *macrostigma*. This practice has been then subsequently replaced by the introduction
5 of trout of Atlantic origin, as evidenced by our study.
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9 At present, freshwater fish distribution in Calabria reflects some main patterns, such as the
10 history of local introductions and naturalisations and ecological and life-history
11 characteristics of each species. Interestingly, while northern and central Italian basins
12 experienced a diffuse 'danubianization' and 'globalisation' of their ichthyological
13 communities, the Calabrian fish fauna has been altered by massive introduction of
14 Padano-Venetian species.
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20 21 22 23 24 **Acknowledgements**

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For Peer Review Only

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3 **Captions to figures**
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7 Fig. 1 : Main Calabrian lotic systems and sampling stations.
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11 Fig. 2: Bray-Curtis similarity dendrogram regarding 54 freshwater fish sampling stations.
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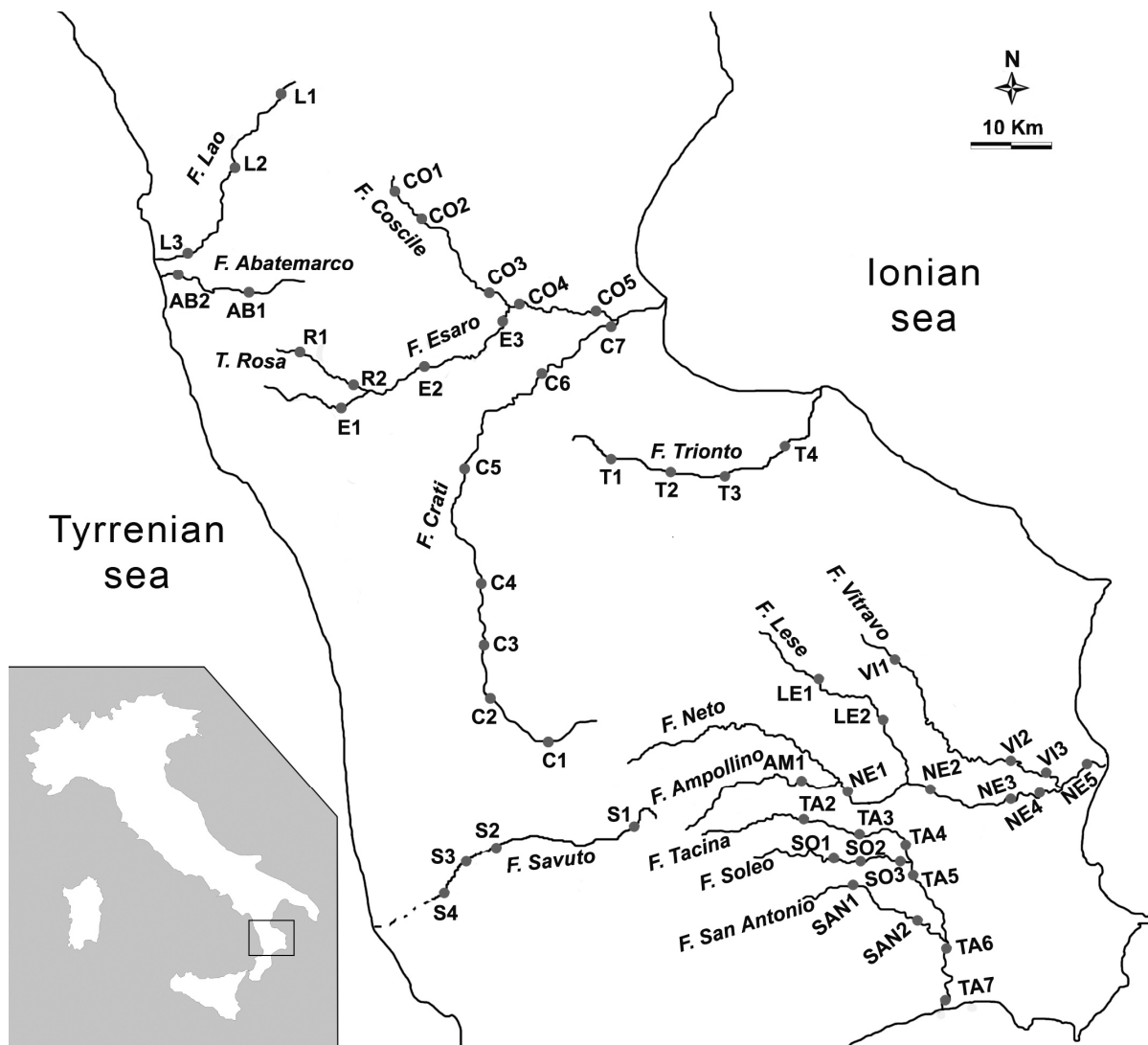
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15 Fig. 3: Canonical Correspondence Analysis ordination of fish and main environmental
16 characteristics in Calabrian lotic systems.
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20 Table I: List of freshwater fish species collected in the sampling stations.
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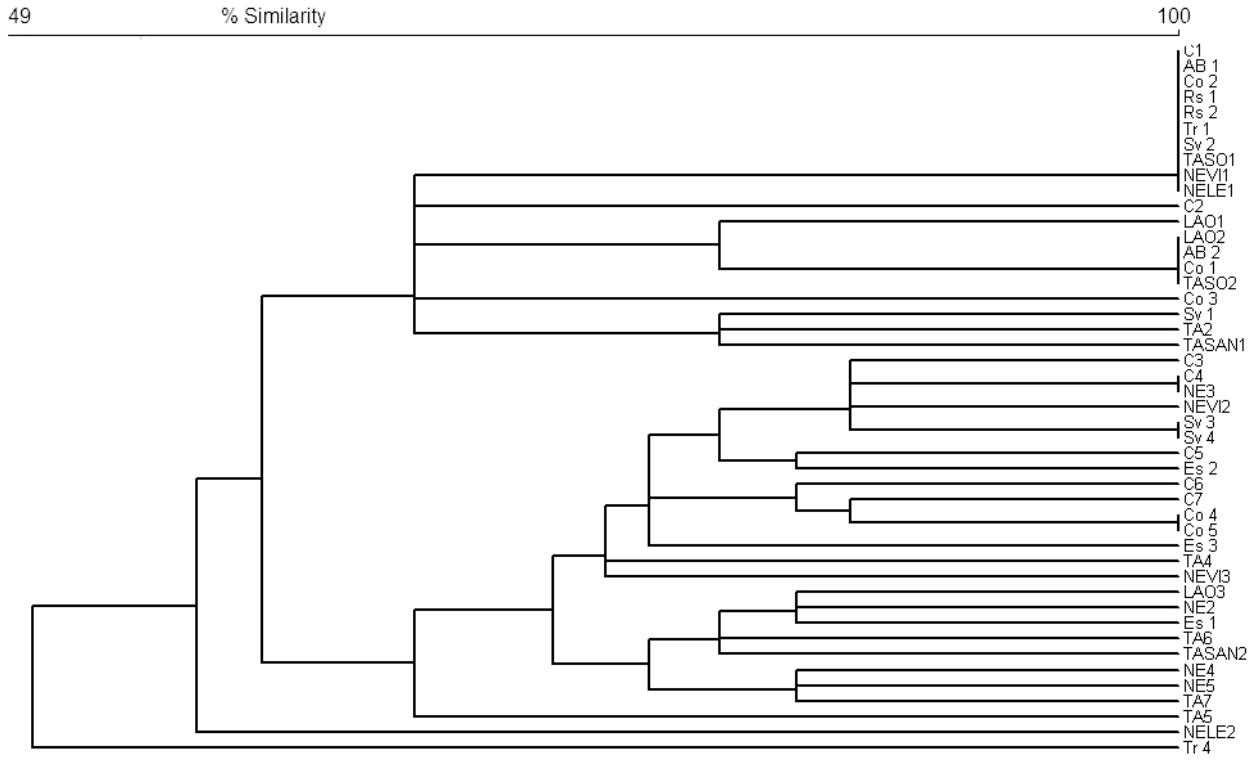
	<i>Salmo trutta</i>	<i>Leuciscus cephalus</i>	<i>Barbus plebejus</i>	<i>Carassius carassius</i>	<i>Anguilla anguilla</i>	<i>Ictalurus sp.</i>	<i>Liza ramada</i>	<i>Rutilus rubilio</i>	<i>Cyprinus carpio</i>	<i>Alburnus alburnus</i>	<i>Lipophrys fluviatilis</i> <i>Scardinius erythrophthalmus</i>	<i>Cobitis taenia</i>	<i>Gambusia holbrooki</i>	<i>Onchorynchus mykiss</i>	<i>Tinca tinca</i>
AB1	X														
AB2	X				X										
C1	X														
C2	X	X													
C3		X						X	X						
C4		X						X	X	X					
C5		X	X			X		X	X	X					
C6			X	X			X	X	X						
C7		X	X	X	X	X	X	X							
Co1	X				X										
Co2	X														
Co3	X	X	X		X										
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Co5		X	X	X	X		X	X	X						
Es1	X	X						X		X	X				
Es2		X	X	X				X	X	X					
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LAO2	X				X										
LAO3		X			X			X		X	X				
NE2	X	X			X			X	X	X	X			X	
NE3		X						X	X	X					
NE4		X					X	X	X	X	X				X
NE5		X			X		X	X	X	X	X				
LE1	X														
LE2									X			X	X		
VI1	X														
VI2		X						X	X			X			
VI3		X		X				X				X			
Rs1	X														
Rs2	X														
Sv1	X										X				
Sv2	X														
Sv3		X						X				X			
SV4		X						X				X			
TA2	X										X			X	
TA4		X		X				X				X			X
TA5								X		X		X			X
TA6					X			X	X	X	X				
TA7		X			X			X	X	X			X		
SAN1	X													X	
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TASO1	X														
TASO2	X				X										
T1	X														
T4								X							

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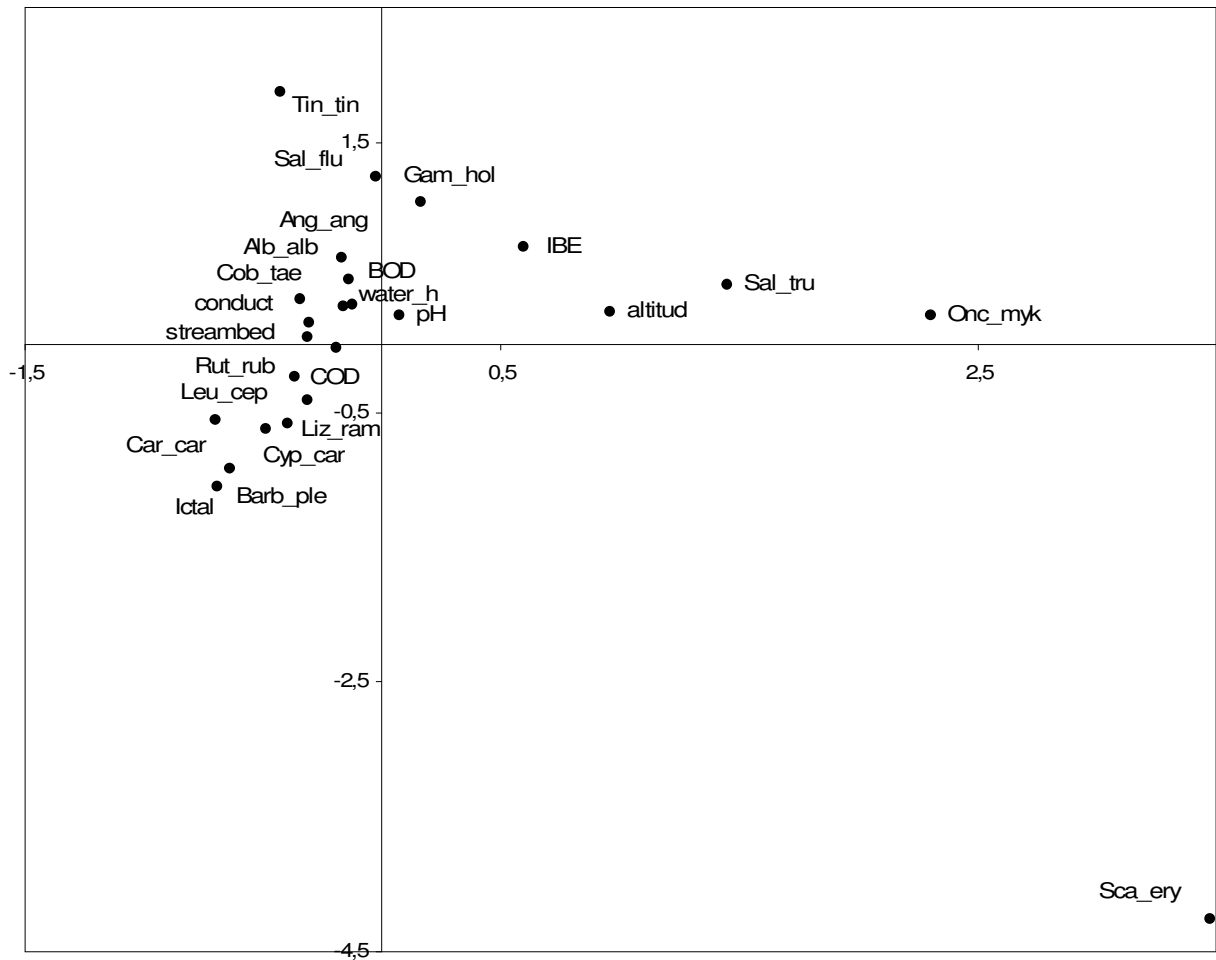
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Canonical Correspondence Analysis



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