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Fish Community in Karla Reservoir (Central Greece) after the Filling Stage

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Abstract: Karla Lake was drained in 1962 and restored as a reservoir in 2009. This re-established water body is considered a vital aquatic ecosystem as it is recognised as a Special Area of Conservation under the EC Habitat Directive (92/43/EEC). As recommended by the European Water Framework Directive, in 2013 and 2016 the fish community was characterised. A total of 8,974 specimens weighting 130.6 kg and belonging to 11 species and six families (Centrarchidae, Clupeidae, Cobitidae, Cyprinidae, Gobiidae and Poeciliidae) were caught. Four species (*Alburnus thessalicus*, *Vimba melanops*, *Squalius vardarensis* and *Knipowitschia thessala*) are considered as endemic to Greece and the Balkan Peninsula and three (*Lepomis gibbosus*, *Carassius gibelio*, *Gambusia holbrooki*) are alien. The reservoir fish community was dominated by species of the family Cyprinidae, both in terms of number and weight, supporting the eutrophic character of the water body. NPUE and BPUE values did not differ significantly between the two sampling campaigns (Wilcoxon's test, P>0.05). The current results could be used as a database for future comparisons and for management and conservation of fish assemblages. One sampling every three years (as required by the European Water Framework Directive) is assumed as insufficient in such rapidly developing ecosystems.

Key words: fish monitoring, fish community, fish assessment, lake restoration

Introduction

Recently, restoration of lakes presents a significant part of aquatic ecosystems' management. Restoration activities have been taken all over the world, including Europe. In most cases, the actions taken concern the balance of material and/or certain ecosystem components e.g. macrophytes (Hilta et al. 2006). In Greece restoration measures have been undertaken in Lake Pamvotis (Mylopoulos et al. 2007) but the restoration of a drained lake as Karla represents a pilot challenge for the country.

Karla Lake was drained in 1962 and rebuilt as a reservoir in 2009. This newly re-established water body is considered a vital aquatic ecosystem as it is recognised as a Special Area of Conservation (SAC) under the EC Habitats and Species Directive (92/43/EEC). Restoration activities as construction of dykes and floodgates were undertaken in 2000, following the Ramsar guidelines (Zalidis et al. 2004).

The reservoir inflows derive primarily by the diversion of the Pinios River floods, the surface runoff of the watershed and the direct precipitation on the reservoir surface. The annual water abstraction from the Pinios River to the reservoir is 80 km^3 for the period mid-October to mid-April each year (Ministry of Environment, Planning and Public Works 2000).

At present, the reservoir suffers from a large-scale water deviation. Since September 2009 (start of refilling) it has not still achieved the lowest ecological limit that would support the functions of the wetland, as set by the environmental terms of the project (at +46.4 m) (Sidiropoulos et al. 2015). Moreover,

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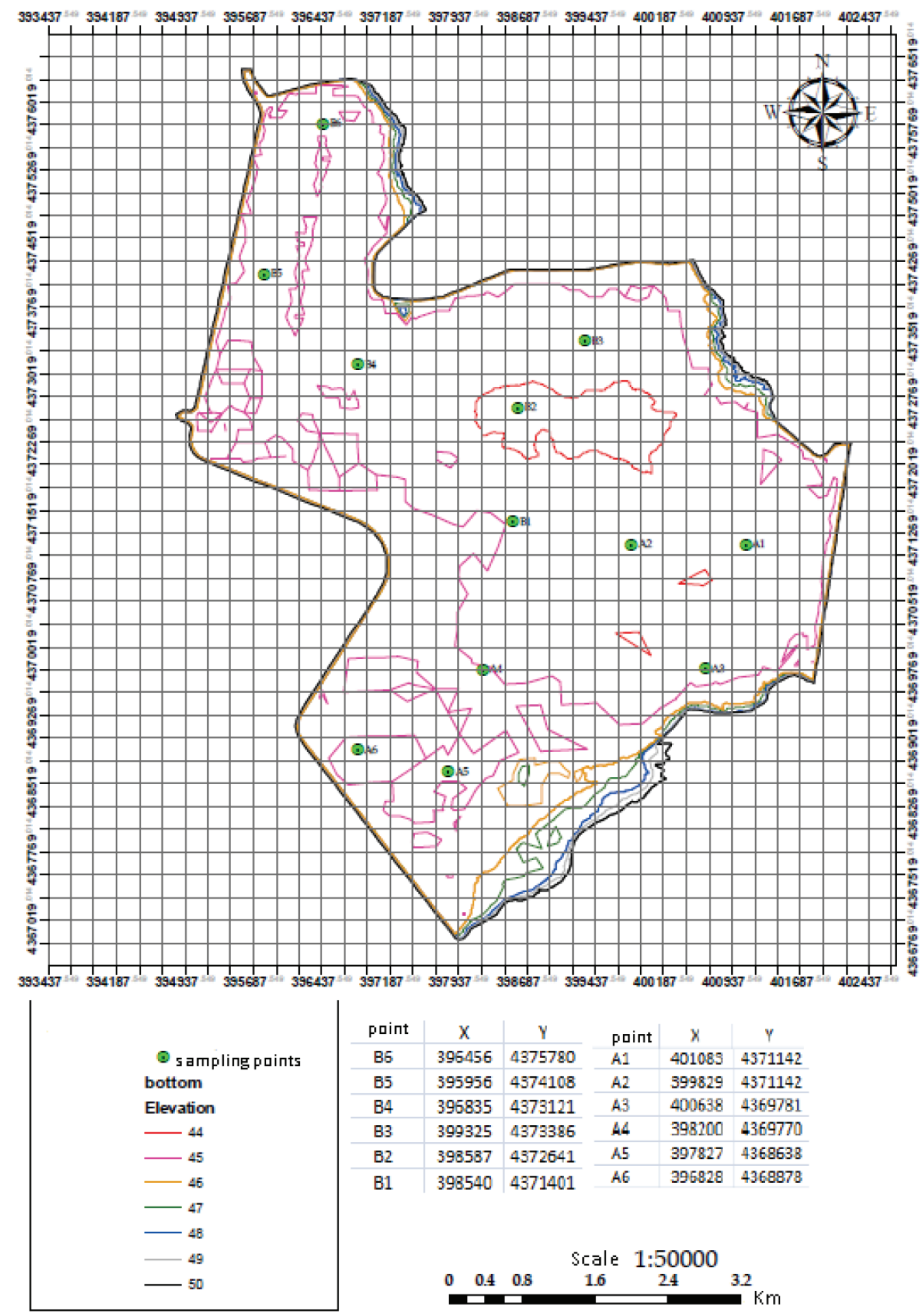
cyanobacterial water blooms during the warm period have been reported (Oikonomou et al. 2012, Nikouli et al. 2013). The reservoir has been designated as a nature wildlife shelter and as part of the NATURA 2000 network (code GR 1420004 “Karla - Maurovouni - KefalovrisoVelestino - Neohori”).

In the past, before its drying in 1962, the Karla Lake was among the most important lakes in Greece as far as fisheries were concerned. It was a place of cultural traditions and development of an impressively unique lifestyle of the people who – for centuries – have been living off fishing (Rouskas 2001). The only scientific data for the fish fauna of the former lake derive from a single survey. According to Ananiadis (1956), fish fauna of the Karla Lake was characterised by the family of Cyprinidae. The most abundant species were *Cyprinus carpio* Linnaeus, 1758 along with *Rutilus rutilus* (Linnaeus, 1758) and *Scardinius erythrophthalmus* (Linnaeus, 1758). The population of *Alburnus thessalicus* Stephanidis, 1950 was declining in terms of abundance, while *Anquilla anquilla* (Linnaeus, 1758) was rare (Ananiadis 1956). The former Karla Lake has remained drained for 47 years until the recent construction of the reservoir. Any



point	X	Y
B6	396456	4375780
B5	395956	4374108
B4	396835	4373121
B3	399325	4373386
B2	398587	4372641
B1	398540	4371401

point	X	Y
A1	401083	4371142
A2	399829	4371142
A3	400638	4369781
A4	398200	4369770
A5	397827	4368638
A6	396828	4368878

Fig. 1. The studied area of the Karla Reservoir with the sampling stations.

scientific information for the fish community of the drainage (channels and 12 small reservoirs) except a technical report (Economidis et al. 2004) is lacking.

At present, in the artificial ecosystem the fishing is prohibited by Greek law.

The objective of the study was to clarify the fluctuations in the structure and abundance of the newly-formed fish community after the restoration of a drained lake (Karla).

Materials and Methods

Study area

Karla Reservoir (39°29´02´´N, 22°51´41´´E) is located in the south-east part of Thessaly Region, Central Greece. It is constructed as part of the project 'Recreation of Lake Karla' funded initially by the 3rd CSF 2000-2006 and subsequently by the NSRF 2007-2013. According to WFD, the Karla Reservoir, in terms of typology is considered a heavily modified water body (Management Plan of River Basin Thessaly (GR 08)). It represents an eutrophic (Chamoglou et al. 2014) reservoir at an altitude of 44 m a.s.l, drainage area of 1,171 km^2, surface area of 38 km^2 and a maximum depth 4.5 m.

Sampling

Fish sampling was carried out in April 2013 and 2016 with type Nordic benthic gillnets (according to CEN, 2005, Water Quality – Sampling of Fish with Multimesh Gillnets) by performing stratified random sampling (Appelberg 2000). The fishing effort was set according to the area (38 km^2) and the maximum sampling depth (≈ 4.5 m) of the reservoir corresponding to 12 sampling points (Fig. 1). Nets were set before dusk and hauled after dawn, in order to ensure a standard soak time of 12 hours for two days (6 nets on the first day and 6 the other). Nets were

Table 1 Catch per unit effort in terms of (a) number (NPUE, ind./m^2) and (b) weight (BPUE, g/m^2) of fish species from Karla Reservoir in 2013 and 2016. N – native species, A – alien; EN – Endemic; ENNO – Endemic to Northern Greece, including Thessaly; ENBA – Endemic to the Balkans, MED – Mediterranean; NA – non-applicable; + presence; - absence.

Year	Ananiadis (1956)	2013		2016		Mean difference in TL (cm)	Mean difference in W (gr)	Origin (Barbieri et al. 2015)	Endemicity (Economou et al. 2007)
		NPUE	BPUE	NPUE	BPUE				
Family/Species								(1)	(2)
Anguillidae									
Anguilla anguilla	+	-	-	-	-	-	-	N	
Centrarchidae									
Lepomis gibbosus	-	1.07	27.12	0.517	5.416	-2.818	-14.08	A	
Clupeidae									
Alosa fallax	-	0.007	3.772	-	-	NA	NA	N	MED
Cobitidae									
Cobitis sp.	-	0.083	0.658	0.006	0.023	0.185	-3.707	N	EN
Cyprinidae									
Alburnus thessalicus	+	3.744	49.876	10.291	81.974	-1.557	-5.681	N	ENBA
Carassius gibelio	-	0.074	6.056	0.026	5.338	5.341	124.151	A	
Cyprinus carpio	+	0.17	8.602	0.165	24.568	4.917	98.574	N	
Rutilus rutilus	+	0.296	26.596	0.044	1.001	-6.12	-63.749	N	
Scardinius erythrophthalmus	+	-	-	-	-	-	-	N	
Squalius vardarensis	-	-	-	0.013	0.161	NA	NA	N	ENBA
Vimba melanops	-	-	-	0.024	0.722	NA	NA	N	ENBA
Gobiidae									
Gobio feraeensis	+	-	-	-	-	-	-	N	ENNO
Knipowitschia thessala	-	0.002	0.005	0.065	0.051	3.857	0.789	N	ENNO
Poeciliidae									
Gambusia holbrooki	-	0.02	0.044	-	-	NA	NA	A	

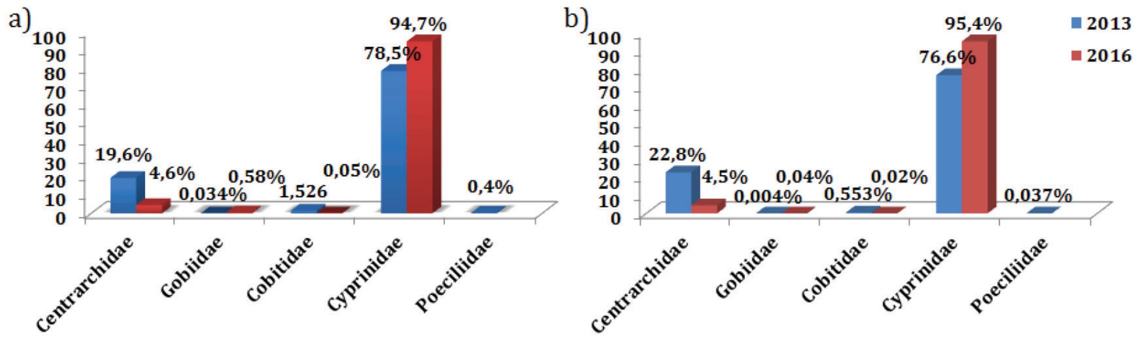


Fig. 2. Percentage (%) participation of *fish species* by *family* in terms of a) abundance and b) weight caught at the Karla Reservoir in 2013 (blue colour) and 2016 (red colour). Clupeidae is not included, since only four specimens were captured in 2013.

set in the same location in both surveys following the same methodology. A handheld GPS was used to mark the precise location of each net.

Fish samples were identified to the species level according to Kottelat & Freyhof (2007), with the exception of species of Cobitidae that were identified at the generic level (*Cobitis* sp.). Some of the caught specimens expressed specific external characteristics, such as *C. stephanidisi* Economidis, 1992, others, such as *C. vardarensis* Karaman, 1928 showed intermediate characteristics. Due to the fact that hybridisation in the genus *Cobitis* is common (Choleva et al., 2008), it is safer to identify these samples to genus level, until molecular-genetic analyses enlighten this issue.

Statistical analysis

Catches were analysed separately for each survey and the total number and weight of specimens per species were recorded. For each species, CPUE was calculated as the number of individuals per m^2 net (NPUE) and the weight of fish per m^2 net (BPUE; Appelberg 2000). The values of CPUE per survey were compared by Wilcoxon's test. Mean difference in TL (cm) between the two samplings (mean TL during second - mean TL during first sampling) were also calculated.

Results

These are the first data on the fish fauna of the Karla Reservoir. Based on the results of both campaigns, a total of 8974 specimens weighting 130.6 kg of 11 fish species (Table 1) and six families (Centrarchidae, Clupeidae, Cobitidae, Cyprinidae, Gobiidae, Poeciliidae) were identified. Eight are native, whereas *Lepomis gibbosus* (Linnaeus, 1758), *Carassius gibelio* (Bloch, 1782) and *Gambusia holbrooki* Girard, 1859 are alien (Barbieri et al. 2015). Among the native species, five species are considered as endemic to Greece and the Balkan Peninsula (Economou et al. 2007). *Alosa fallax* (Lacepède, 1803) is listed in annexes II and V of the EU Habitats and Species Directive. Both sampling campaigns revealed a fish community dominated by cyprinids (6 out of 11 species).

Comparing the samples collected in 2016 with those taken in 2013, the fish fauna of the Karla Reservoir was similar in terms of species composition. However, we recorded between-year differences in abundance for some fish families. Cyprinidae increased by 16.2% in terms of abundance (Fig. 2). The second most abundant family Centrarchidae, represented by *L. gibbosus*, showed a decrease of 15% from 2013 to 2016. The decline in abundance of *L. gibbosus* and *G. holdbrooki*, should be probably considered as positive for native fish (Mills et al. 2004, Copp et al. 2005).

Comparison of the overall sampling results did not show significant differences (Wilcoxon test values for NPUE and BPUE were 33 and 28, respectively, at $P>0.05$). Moreover, samplings were performed when water level was similar. However, the examination of the values of NPUE and BPUE that accounted for each species revealed some differences between the surveys. A considerable increase in terms of NPUE was observed for *K. thessala* from 0.002 individuals/m^2 in 2013 to 0.065 ind./m^2 in 2016, followed by *A. thessalicus* from 3.744 ind./m^2 in 2013 to 10.291 ind./m^2 in 2016. On the contrary, a decline in terms of NPUE was displayed by *Cobitis* sp. (from 0.083 ind./m^2 in 2013 to 0.006 ind./m^2 in 2016), *R. rutilus* (from 0.296 ind./m^2 in 2013 to 0.044 ind./m^2 in 2016), *C. gibelio* (from 0.074 ind./m^2 in 2013 to 0.026 ind./m^2 in 2016) and *L. gibbosus* (from 1.07 ind./m^2 in 2013 to 0.517 ind./m^2 in 2016; Table 1). The species that increased their biomass were *K. thessala* (from 0.005 g/m^2 in 2013 to 0.051 g/m^2 in 2016), *C. carpio* (from 8.602 g/m^2 in 2013 to 24.568 g/m^2 in 2016) and *A. thessalicus* (from 49.876 in 2013 g/m^2 to 81.974 g/m^2 in 2016).

Discussion

Generally, fish species of the family Cyprinidae are well adapted to eutrophic conditions (Persson 1991, Mehner et al. 2005) similar to those in the Karla Reservoir (Chamoglou et al. 2013). The other five families that we recorded were represented by a single species. Two cyprinid species, the eurytopic *Vimba melanops* (Heckel, 1837) and *Squalius vardarensis* were recorded only in 2016 and they probably have entered from the Pinios River, where they are abundant (Barbieri et al. 2015). *Alosa fallax* was recorded for the first time in the reservoir but only in 2013. It has likely entered the reservoir from the Pinios River, most probably during the spawning period. The alien *Lepomis gibbosus* was registered for the first time in the adjacent Pinios River in 2011 (Koutsikos et al. 2012), indicating its further spreading.

Anguilla anguilla, *Gobio feraeensis* and *Scardinius erythrophthalmus*, previously reported by Ananiadis (1956) for the former Lake Karla, were not detected during our study.

The fact that *G. holbrooki* was present only in 2013 survey needs further investigation, in order to clarify the reasons for the decline of this eurybiont and invasive species.

Karla Reservoir will likely face numerous challenges and changes, regarding the structure of the local fish fauna, since it is still in its initial stage of filling with water from the Pinios River. These challenges are related with the multipurpose use of the reservoir as it has to satisfy both environmental (ecological restoration) and social needs (irrigation, flood protection, water supply of the nearby Volos City and ecotourism activities) in the near future. Furthermore, several variables, such as physical, chemical and biological properties of the water, surface area, age, hydraulic retention time of the reservoir, the composition of the fish fauna in the river and watershed area may influence the composition of the fish community in the reservoir (Agostinho et al. 1999, 2016).

Our results provide initial information on the fish community structure of the Karla Reservoir after its refilling and could be used as a basis for future management, as well as conservation of local fish assemblages. The followed sampling strategy recommended by the WFD 2000/60/EC represents a useful tool for interpreting differences in fish communities based on catch per unit effort (Emmrich et al. 2011, Brucet et al. 2013), however, is insufficient in such ecosystems. A sampling every three years is not enough to reflect quick changes, characterising an ecosystem under restoration, as is the case of the Karla Reservoir. Combining sampling methods is also recommended, in order to explore in detail fish biodiversity and abundance (Hubert 1996). In the case of the Karla Reservoir, beach seine/long lines/electrofishing could be used altogether with gill nets.

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