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Research article

Changes in the fish community of the Ömerli Reservoir (Turkey) following the introduction of non-native gibel carp *Carassius gibelio* (Bloch, 1782) and other human impacts

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Abstract

Changes in the relative density (catch per unit effort; CPUE) of introduced gibel carp *Carassius gibelio* (Bloch, 1782) and native fish species were monitored over four years in the Ömerli Reservoir, a temperate drinking-water reservoir in northwestern Turkey. Following the species' introduction, the CPUE of gibel carp increased significantly with the decrease in CPUE of large-bodied native fish species.

Key words: invasive species, CPUE, relative density, eutrophication

Introduction

The introduction of non-indigenous fish species for aquacultural and ornamental purposes has a long history (Welcomme 1988), and several of these species have established self-sustaining populations in natural or semi-natural habitats, with expanding geographic distributions in many cases. Non-native species introductions have been linked to habitat alteration and the reduction or extinction of native fish species (Minckley and Deacon 1991, Moyle and Leidy 1992). One of these species is the gibel carp *Carassius gibelio* (Bloch, 1782), which was first introduced to Europe from Asia in the 17th century (Lever 1996), and subsequently has been identified as responsible for impacts on native species (Balik et al. 2004, Vetemaa et al. 2005). The presence of gibel carp in the European part of Turkey was not recognized until the 1980s (Baran and Ongan 1988), perhaps because of its strong physical resemblance of the other two *Carassius* species introduced to Turkey: crucian carp *Carassius carassius* (L., 1758), and goldfish *Carassius auratus* (L., 1758). As species identification of *Carassius* species have improved, the distribution of gibel carp in Turkey is now thought to include both the Thrace (European) region (Özuluğ et al. 2004) and the entire Anatolian (Asia Minor) peninsula (Şaşı and Balık 2003, Balık et al. 2003, İlhan et al. 2005). Approximately 500-600 specimens of gibel carp were intentionally introduced from Kayalı Dam Lake (Kırklareli-Thrace) into Ömerli Reservoir by a fisherman in 1998 (N. Gokalp, personal communication). The aim of the present study was to assess the relative density of introduced gibel carp and native fish species in this reservoir following the introduction of the gibel carp.

Materials and Methods

The Ömerli Reservoir was built in 1972 and currently is the biggest such reservoir in the northern part of the Marmara region of Turkey (area = 23.5 km^2; maximum depth = 62 m; volume = 2.2 x 10^6 m^3; Latitude 41°02′N, Longitude 29°22′E). The reservoir provides nearby Istanbul with ≈ 48% (mean = 872000 m^3 per day) of its drinking water, but the reservoir has been suffering from increased eutrophication over the last few decades due to input of domestic and industrial waste water, which enter mainly via small streams (Albay et al. 2003a). The reservoir is now mesotrophic and in the late 1990s it began to suffer toxic cyanobacterial (blue-green algae) blooms during late summer and mid autumn. In subsequent years, several thousand of fish (mainly *Cyprinus carpio* L., 1758) died from the cyanotoxin (microcystin) levels, and in recent years the Istanbul Water Authority has applied copper sulphate (algicide) at specific sites in the reservoir (Albay et al. 2003b). Prior to the introduction of gibel carp, the most common native fish species were Baltic vimba *Vimba vimba* (L. 1758), Shemaya *Chalcalburnus chalcoides* (Güldenstädt, 1772), common carp *Cyprinus carpio* L. 1758, sand smelt *Atherina boyeri* Risso, 1810, bitterling *Rhodeus amarus* (Bloch, 1758), chub *Leuciscus cephalus* (L. 1758), and Danube chub *Petroleuciscus borysthenicus* (Kessler, 1859).

Fish samples were collected monthly over four consecutive years (2002-2005) using multi-mesh gill nets (length = 50 m, height = 2.5 m, mesh sizes: 10, 15, 22, 26, 32, 36, 40, 45, 50, 60 and 70 mm from knot to knot). The nets were set from dusk until dawn at the surface in areas where water depth was <10 m. Owing to logistical constraints, sampling was undertaken in the southern part of the reservoir only (41°05′05″N and 29°25′19″E), but the entire reservoir is of similar physical and chemical character (Gürevin 2004). Captured specimens were preserved in 5% formaldehyde and subsequently identified to species and measured for total length (TL) to the nearest 0.1 cm and for total weight (W) to nearest 0.01 g. Nominal catches were standardized to catch per unit effort (CPUE) for all fish species using the formula: CPUE = (CN*(AS/AN))/t, where CN = nominal catch; AS = area of standard net (100 m^2); AN = area of net used (m^2); t = time of exposure (h).

Results and Discussion

Seven native and one non-native species were captured during the study: 993 gibel carp (TL = 3.0-35.7 cm; mean = 20.07 ± 0.22), 488 Baltic vimba (TL = 8.1-29.4 cm; mean = 19.02 ± 0.20), 280 shemaya (TL = 8.8-28.4 cm; mean = 20.27 ± 0.25), 62 common carp (TL = 12.8-84.0 cm; mean = 26.26 ± 1.24), 89 Dnieper chub (TL = 6.8-16.5 cm; mean = 9.88 ± 0.24), 58 chub (TL = 8.9-30.5cm; mean = 17.59±0.66), 5680 bitterling (TL = 5.6-9.0 cm; mean = 6.68 ± 0.04), 1379 sand-smelt (TL = 7.7-12.9 cm; mean = 10.34 ± 0.04). Local fishermen claim to have introduced some other non-native species (common bream *Abramis brama* (L., 1758) and tench *Tinca tinca* (L., 1758)) to the reservoir, but none of these species were observed during the four-year study.

A major biological trait responsible for the invasiveness of gibel carp is reproduction. Invading gibel carp populations are often composed of almost exclusively triploid gynogenetic females (e.g. Peňáz et al. 1979, Peňáz and Dulmaa 1987, Kalous et al. 2004). It remains unknown whether gibel carp in Ömerli Reservoir is reproducing gynogenetically, but it is likely to be the case, given that 89% of the gibel carp captured (Figure 1) were females.

Similar to reports on native fish community change after gibel carp introduction elsewhere in Turkey (Şaşı and Balık 2003, Balık et al. 2003, 2004), gibel carp abundance (i.e. mean CPUE) increased in Ömerli Reservoir over the four-year study, and this correlated significantly with decreases in the CPUE of large-bodied native species (Figure 1): Baltic vimba (rs= -0.90, P <0.05), shemaya (rs = -0.99, P <0.001), common carp (rs = -0.90, P <0.05), Dnieper chub (rs = -0.91, P <0.05), and chub (rs = -0.99, P <0.05).

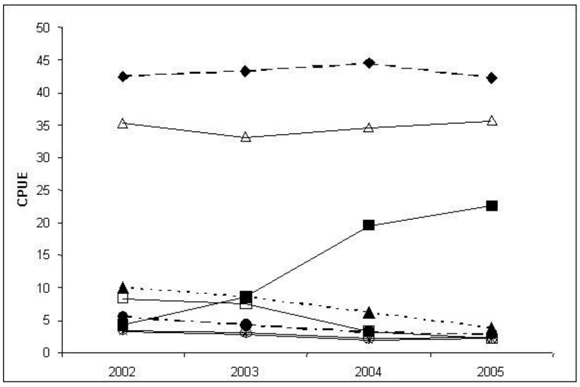

Figure 1. Variation in Catch per Unit Effort (CPUE) of fish species inhabiting in Ömerli Reservoir between 2002 and 2005. Gibel carp (■), Baltic vimba (▲), shemeya (☐), common carp (✱), Danube chub (○), chub(✷), sand smelt (△), bitterling (◆)

No correlation (Ps >0.18) was found with small-bodied, native species (i.e. bitterling, sand-smelt).

Gibel carp has recently attracted increased scientific interest due to their impacts on native species, e.g. through hybridization with crucian carp *C. carassius* (Hänfling et al. 2005) and demonstrated or suspected alterations to aquatic ecosystem food webs and function (e.g. Navodaru et al. 2002, Vetemaa et al. 2005). In some parts of Europe, declines in native crucian carp have been linked to habitat degradation that was attributed to the introduction of non-native *Carassisus* species (Navodaru et al. 2002). The correlation between increases in gibel carp CPUE and the declines of native large-bodied fishes in Ömerli Reservoir are suggestive of a potential impact by gibel carp. However, other factors such as the eutrophication during recent decades could be responsible, at least in part, for the observed declines in native fish abundance. The daily fluctuations in water level, however, are not likely to have caused these declines, as the fish assemblage in the reservoir has been subjected to this fluctuation since the reservoir's creation in the 1970s. However, the algicide (copper sulphate) treatments applied to the reservoir to control the cyanobacterial blooms can have adverse effects on water quality, leading to fish mortalities. The reservoir has also been subjected to extensive habitat destruction or degradation since the late 1990s (i.e. marshland draining, eutrophication, water extraction and pollution and flow alteration), which coincides with the introduction and expansion of gibel carp (Albay et al. 2003b, Özuluğ et al. 2005). Therefore, the decline in native species is likely to be the result of a combination of factors, and this suggests that the invasion by gibel carp is being facilitated, at least in part, by human impacts on the reservoir. Further studies are urgently needed to understand the real impact of introduced gibel carp on native species and ecosystems.

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