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Rapid Communication

Range extension of the invasive freshwater fish species, gibel carp *Carassius gibelio* (Bloch, 1782) in western Turkey

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Abstract

Gibel carp *Carassius gibelio* (Bloch, 1782) has become an important non-native fish in all regions of Turkish inland waters with its wide distribution, high prevalence and impacts on native fish species through mainly reproductive and feeding interactions. This paper presents the first record of gibel carp caught on 15 December 2011 from Tersakan Stream in Muğla Province in SW Turkey. Size range of the species, possible introduction pathways and structure of the stream suggest that the species could well fit in its new environments and that further spread is likely.

Key words: Gibel carp; non-native species; invasion; Tersakan stream, Muğla Province

Introduction

Gibel carp, *Carassius gibelio* (Bloch, 1782) is a cyprinid species, which was originally distributed throughout Eastern Asia, even though it is considered a native species from central Eastern Europe to Siberia (Perdikaris et al. 2012). Initial introduction of this species from Asia to Europe occurred in the 17th century with an aim to enhance fish community composition (Copp et al. 2005). Since its introduction, it has proved highly invasive in many countries evidenced by its rapid increase in abundance, distribution and impact on endemic fish populations (Vetemaa et al. 2005; Tarkan et al. 2012 a, b). The most important biological trait responsible for the invasiveness of gibel carp is a unique reproduction strategy with gynogenetic or gonochorostic individuals, high resistance to adverse environmental conditions and phenotypic plasticity (e.g. Tarkan et al. 2012b).

Gibel carp was initially reported in Greece in the 1950s, it was first recognized in the European part (Thrace) of Turkey in the 1980s, entering Turkish waters through River Meriç

from Greece (Aydın et al. 2011). Earlier recognition of this species might have been prevented by misidentification because of its high physical similarity to the other two *Carassius* species introduced to Turkey: goldfish *Carassius auratus* (Linnaeus, 1758) and crucian carp *Carassius carassius* (Linnaeus, 1758). After its introduction, it was transported to numerous inland water bodies (lotic and lentic ecosystems) throughout Turkey, including the European region and the whole of the Anatolian (Asia Minor) peninsula, both intentionally by fisherman and accidentally by stocking, which is common in Turkish waters with an aim to increase fish production and sport fishing (Aydın et al. 2011; Önsöy et al. 2011; Tarkan et al. 2012b).

Recent studies on gibel carp clearly indicate that it is responsible for the decline of native cyprinid species in Europe and Turkey through reproductive interference (Tarkan et al. 2012a), habitat degradation (Navodaru et al. 2002) and hybridization (Hänfling et al. 2005). In Turkey, economically important native species such as vimba *Vimba vimba* (Linnaeus, 1758), common carp *Cyprinus carpio* Linnaeus, 1758, rudd,

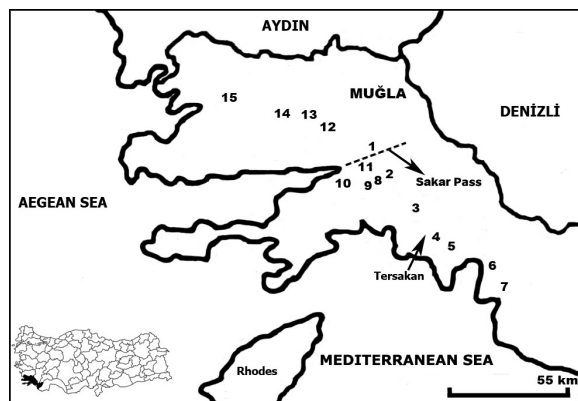


Figure 1. Map of Muğla Province separated by Sakar Pass. Numbers are denoting water bodies in the province (see details in Appendix 1).

Scardinius erythrophthalmus (Linnaeus, 1758) and endemic species such as shemaya *Alburnus istanbulensis* Battalgil, 1941 are shown to have suffered from gibel carp introductions mainly by reproductive competition (Tarkan et al. 2012a). This applies to many other inland water bodies in the country, given the species was reported as being established in at least in 46 water bodies by 2007, from all regions (geographically divided into six regions) of Turkey (Özcan 2007). Furthermore, a recent paper has identified 14 new locations for gibel carp, indicating a remarkably fast spread of invasion in the Marmara Region (NW Turkey) within the last three decades (Aydın et al. 2011).

Aside from Eastern mosquitofish *Gambusia holbrooki* Girard, 1859, gibel carp is the most commonly introduced non-native fish species in Turkey, while some regions remain least impacted in terms of low number of introductions of gibel carp. One such place is the Muğla Province (13.4 km² area) in the Aegean Region of Turkey, which has many inland water bodies (Figure 1). Most of these aquatic ecosystems are lotic systems represented by two big natural lakes and eight man-made reservoirs. The province can be divided into two large basins, separated by ‘Sakar’ mountain. There is a 9 km mountain pass connecting these basins, known as Sakar Pass, which provides a strong separation at about 600 m elevation (Figure 1). Ongoing studies have pointed out that gibel carp is not frequently encountered there and has a highly restricted distribution only in two reservoirs and one stream in the northwest of the

Sakar Pass (Figure 1) (Önsoy et al. 2011; Tarkan et al. 2012b). In particular, the most important and vulnerable part of the region (southeast of the Sakar Pass) in terms of high endemic species richness, has not been associated with the presence of any non-native fish species except for *G. holbrooki* and *Tilapia zilli* (Gervais, 1848) (Yılmaz et al. 2006), the latter of which survives in only one natural lake (Lake Köyceğiz), as its survival is not possible below certain water temperatures. In this paper, we report for the first time, the occurrence of gibel carp from this part of the province, considered a very important factor both in terms of the species’ further spread to previously un-occupied ecosystems and for consideration of conservation measures for endemic species.

Material and methods

The sampling site (Tersakan Stream) is a temperate stream (36°45'51"N, 28°49'20"E), which is impacted by unpredictable environmental conditions associated with a Mediterranean climate. Its length is 30 km and this stream has temporal and spatial water flow variations throughout the water course (48–780 m³/s) (Barlas et al. 2001). The lower section of the stream was channelized by local authorities to prevent seasonal floods. The stream flows into Mediterranean Sea. Vegetation is usually abundant throughout the stream banks and depth varies between 0.5–2 m. The sampling site was characterized by muddy substrate, limited vegetation and slow flow velocity. It had recently been affected by heavy floods, which occur seasonally because of high annual precipitation (Önsoy et al. 2011). There are eight known species inhabiting the stream (Barlas et al. 2001) while Aegean chub *Squalius fellowesii* (Günther, 1868), *Barbus pergamonensis* Karaman, 1971, *Capoeta bergamae* Karaman, 1969 are the most abundant fish species (unpublished data).

We visited various water bodies in Muğla Province between 9 April 2009 and 15 December 2011 (Appendix 1). Fish were captured by backpack electrofishing with a battery-powered unit (550 V, 5 – 100 Hz). After collection, fishes were killed using an overdose of 2-phenoxy-ethanol and transported on ice to the laboratory. The fish were measured for standard length to the nearest 1 mm and for body weight to the nearest 0.1 g. Sex was determined by visual examination of the gonads. Age was determined



Figure 2. *Carassius gibelio* specimens caught in Tersakan Stream, Muğla, Turkey on 15 December 2011. Photograph by Sevan Ağdamar.

from scales removed from between the left lateral line and dorsal fin. Ageing was validated independently by a second operator interpreting true annuli (Bagenal and Tesch 1978).

Results and discussion

Gibel carp was previously found in three different locations northwest of the Sakar Gate namely Ula and Kazan reservoirs, and Sarıçay Stream in different sampling dates between 9 April 2009 and 29 July 2009 (Appendix 1). Tersakan Stream was the only location where gibel carp found in southwest of the Sakar Pass in the present study. Three adult gibel carp were collected on 15 December 2011 from the Tersakan Stream (Figure 1). Standard lengths, weights and ages are 175 mm, 176.3 g, 6+; 119 mm, 55.5 g., 4+ and 101 mm, 35.6 g, 3+, respectively (Figure 2). This is the first record of gibel carp from southeast of the Sakar Pass, covering more than half of the Muğla Province. Gibel carp had not previously recorded from this part of the Muğla Province (Barlas et al. 2001; Yılmaz et al. 2006).

There would be several scenarios to explain how this species was introduced into the Tersakan Stream, and the most plausible would be human aided translocation. Because the accidental introduction and release of gibel carp within the stocking campaigns of native cyprinids for aquaculture purposes seem to provide the most important pathway of gibel carp spread into its expanded range (Önsoy et al. 2011; Tarkan et al. 2012b), its presence in

Tersakan Stream can be explained in this way. The introduction possibly came from a near natural lagoon lake (Lake Kocagöl), as our communication with local inhabitants confirmed that common carp translocations were previously carried out several times, with the last introduction occurring in 2009 with 50,000 YOY common carp. This might explain occurrence of gibel carp in this area, since our sampling location in which gibel carp was found on Tersakan Stream is very close to the connection point of Lake Kocagöl to the stream. The only scientific study conducted in this lake between 1996 and 1997, noted only three brackish water fish species: European eel *Anguilla anguilla* (Linnaeus, 1758), Flathead grey mullet *Mugil cephalus* Linnaeus, 1758 and Golden grey mullet *Liza aurata* (Risso, 1810) (Özdemir et al. 1998).

Notwithstanding the fact that gibel carp has been shown as relatively unsuccessful in colonizing lotic waters (e.g. Clavero and Hermoso 2011; Tarkan et al. 2012b), aquatic pollution and environmental degradation favors this species' invasion success (Tarkan et al. 2012a), which is likely to increase in this area because of human pressure. As common features of invading gibel carp populations, female dominant populations with gynogenetic reproduction and faster individual growth are normal (Tarkan et al. 2012b); this was true for the population we consider in the present study (in spite of a very small sample size, i.e. only three specimens) as all captured specimens were females with developed gonads and had relatively higher growth in relation to other gibel carp populations in their introduced range in Turkey (e.g. Tarkan et al. 2012b). Preventing gibel carp populations to become established in this region is important since native and endemic fish species of Muğla Province is already under high pressure and suffers from habitat destruction and degradation, such as water extraction, eutrophication, marshland drainage, flow alteration and pollution (e.g. Yılmaz et al. 2006).

This is the first finding of this species in an area unoccupied by non-native species, which is quite vulnerable and very rich in terms of endemic species. Considering invasive character and previous reports on significant problems gibel carp created, management plans should be immediately initiated to minimize its negative impacts on other fish species and ecosystem functioning. This also can be considered as a cautionary signal of new invasion probabilities. The most effective conservation measure is to

prevent introduction of any pest species, such as gibel carp. However, taking preventative action at the beginning of the invasion would also be important to stop further spread of the species (Copp et al. 2005). In this part of the Muğla Province, the many interconnected streams present provide favorable habitat for gibel carp. This may consequently impact on the native fauna. Most importantly, multiple introductions of gibel carp should be prevented, as invasion success of any non-native species is highly dependent on propagule pressure (Simberloff 2009).

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Supplementary material

The following supplementary material is available for this article:

Appendix 1. Records of *Carassius gibelio* in freshwater ecosystems of Muğla Province, southwestern Turkey.

Appendix 1. Records of *Carassius gibelio* in freshwater ecosystems of Muğla Province, southwestern Turkey.

Site code (Map ref)	Location name	Geographic coordinates		Survey/Record date	Number of collected fish	Reference
		Latitude, N	Longitude, E			
1	Ula Reservoir	37°07'38"	28°23'20"	09 April 2009	197	Tarkan et al. 2012b
2	Namnam Stream	37°00'41"	28°31'02"	13 May 2011	Not found	Present study
3	Yuvarlakçay Stream	36°54'24"	28°44'32"	13 May 2011	Not found	Present study
4	Tersakan Stream	36°45'51"	28°49'20"	15 December 2011	3	Present study
5	Dalaman Stream	36°50'24"	28°47'45"	08 December 2010	Not found	Present study
6	Kargı Stream	36°42'24"	29°02'52"	12 November 2010	Not found	Present study
7	Eşen Stream	37°44'52"	29°23'16"	12 November 2010	Not found	Present study
8	Balıkli Stream	37°00'26"	28°32'55"	13 May 2011	Not found	Present study
9	Sarıöz Stream	37°00'27"	28°30'43"	13 May 2011	Not found	Present study
10	Gelibolu Stream	36°56'59"	28°17'25"	02 June 2011	Not found	Present study
11	Tahliye Stream	37°00'48"	28°30'34"	01 June 2011	Not found	Present study
12	Bayır Reservoir	37°16'51"	28°14'04"	12 May 2010	Not found	Present study
13	Kazan Reservoir	37°17'39"	28°12'41"	23 July 2009	30	Tarkan et al. 2012b
14	Kamış Stream	37°19'53"	28°06'48"	08 July 2011	Not found	Present study
15	Sarıçay Stream	37°20'38"	27°43'45"	29 July 2009	11	Top 2011