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Short Communication

Alien fish species in reservoir systems in Turkey: a review

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Abstract

Turkey's natural river systems have been anthropogenically altered in the past century. Native fish communities of river systems have come under increasing pressure from water engineering projects, pollution, overfishing and the movements of alien fish species. Introduction of alien fishes is one of the main threats to the survival and genetic integrity of native fishes around the world. In Turkey, alien freshwater fish are continuing to increase in number of species, abundance, and distribution. The present paper reviews fish stocking studies in Turkey's reservoirs.

Key words: alien fish; native translocated fish; distribution; Turkey

Introduction

The introduction of alien fishes is a major cause of biodiversity decline in freshwater ecosystems (Rowe et al. 2008). Certain freshwater fish species used for recreational angling have been transported around the globe to rivers, dams and lakes, frequently without environmental impact assessments or monitoring (Cambray 2003). The abundance of introduced fish has apparently increased in recent years and the diversity of freshwater species has changed in Turkey (Cetinkaya 2006; Innal and Erk'akan 2006; Unlü et al. 2011).

Aquatic species have been introduced for several reasons, namely to establish fisheries (commercial and sport) and for aquaculture, as forage for other important species, control of unwanted organisms (aquatic vegetation, mosquitos, snails, blooms of phytoplankton, other fish) and accidental (Welcomme 1988; Coad 1996; Cowx 1999).

The impacts associated with the introduction of alien fishes are many, including; competition, habitat alteration, parasitism, predation, hybridisation, alteration of habitat quality and/or ecosystem function, host of pests or parasites (Westman and Tuunainen 1984; Copp et al. 2005; Roll et al. 2007; Britton et al. 2010; Pino Del Carpio et al. 2010).

The Turkish Rivers contain a distinctive fish fauna characterized by endemic species and species of biogeographic significance (Geldiay and Balik 1999). Turkey's natural river systems have been anthropogenically altered in the past century and some alien fish species are now considered a threat factor for endemic species. The purpose of the present study is to investigate the alien fish species of reservoir systems in Turkey.

Materials and methods

This report examines reviews of published literature, reports and working papers about distribution and biology of alien fish species in the natural and altered aquatic systems of Turkey. For each species, introduced systems (including reservoir, river, lake and closed systems) and reason for introduction

(aquaculture, research, improvement of wild stocks, recreational or commercial fishing, biocontrol, biotheraphy and accidental) are assessed.

Results and discussion

The number of reservoir systems in Turkey has apparently increased in recent years. Fish introduction is widely applied in these reservoirs. This practice is primarily financed by the State and other agencies, e.g., hydroelectric power companies, universities, fishermen or fisheries organizations. The main reason for the introduction of fish species is for the purpose of food production. Other reasons include fisheries improvement, aquaculture, ornamental fish production and plant and animal control. Some introductions have been recorded as accidental. Alien and native translocated fish species of Turkey are given in Appendix 1. Introduced fish species of some reservoir systems are given in Appendix 2.

Alien and native translocated fish species of Turkey are reported as 54 (listed in Appendix 1) in this paper. Fish species are distributed amongst 22 families, with Cyprinidae representing the greatest number of species, followed by Salmonidae and Cichlidae.

Translocations of native fish species have been one of the major reasons for the enhancement of inland water bodies in Turkey. Translocated native freshwater fish are reported as 24. Common carp (*Cyprinus carpio* Linnaeus, 1758) and European tench [*Tinca tinca* (Linnaeus, 1758)] are currently the most widely distributed translocated fish in Turkey's reservoirs.

Overall alien fish species in Turkey are reported as 30. with 15 species specifically introduced into reservoirs namely, *Lepomis gibbosus* (Linnaeus, 1758), *Oncorhynchus mykiss* (Walbaum, 1792), *Oreochromis aureus* (Steindachner, 1864), *Oreochromis mossambicus* (Peters, 1852), *Oreochromis niloticus niloticus* (Linnaeus, 1758), *Sarotherodon galilaeus galilaeus* (Linnaeus, 1758), *Tilapia rendalli* (Boulenger, 1897), *Tilapia zillii* (Gervais, 1848), *Carassius auratus* (Linnaeus, 1758), *Carassius gibelio* (Bloch, 1782), *Ctenopharyngodon idella* (Valenciennes, 1844), *Pseudorasbora parva* (Temminck and Schlegel, 1846), Hybrid of *Morone chrysops* x *Morone saxatilis*, *Gambusia affinis* (Baird and Girard, 1853) and *Gambusia holbrooki* Girard, 1859.

12 species have established self reproducing populations. Five species, gibel carp (*C. gibelio*), topmouth gudgeon (*P. parva*), rainbow trout (*O. mykiss*) and mosquito fishes (*G. affinis* and *G. hoolbroki*), are currently the most widely distributed alien fishes in Turkey's reservoirs.

The introduction of alien fishes into inland waters of Turkey has a long history beginning with the stocking of exotic Poeciliidae (*G. affinis, G. holbrooki*) to control mosquito larvae (Innal & Erk'akan 2006). Introduction and translocations of exotic and indigenous species have been carried out mostly in the last 60 years in Turkey. At the end of 1960s DSI (State Water Works) began to stock common carp, *C. carpio*, zander *Sander lucioperca* (Linnaeus, 1758), wels catfish *Silurus glanis* Linnaeus, 1758 and bleak, *Alburnus* spp. in reservoirs (Anonymous 1988; Geldiay and Balik 1999). Currently, rainbow trout *O. mykiss*, wels catfish *S. glanis*, zander *S. lucioperca,* common carp *C. carpio*, grass carp *C. idella*, silver carp *Hypophthalmichthys molitrix* (Valenciennes, 1844), European perch *Perca fluviatilis* Linnaeus, 1758 and barb *Barbus grypus* Heckel, 1843 are the species produced in hatcheries for stocking inland waters. Common carp, mirror carp (*C. carpio* Linnaeus, 1758) and rainbow trout are the most common species used for stocking reservoirs. Common carp and mirror carp account for the major production in reservoir freshwater fisheries.

Many introductions into reservoirs are associated with aquaculture. Some species have succesfully maintains populations from escapes and releases. Cichlids *Oreochromis* spp. and *Tilapia* spp., and hybrid striped-bass *Morone chrysops* x *Morone saxatilis* were introduced to open waters as aquaculture experiments (Dikel and Celik 1998; Gökce at al. 2003; Celik and Gökce 2003; Güner et al. 2007).

The ornamental fish trade is also a source of accidental introductions of non-native fish species into open water systems. A few introductions of exotic fish into open freshwater systems of Turkey have involved the accidental or deliberate release of aquarium species, mainly piranha Characidae [*Pygocentrus nattereri* Kner, 1858] and catfish Loricariidae [*Pterygoplichthys disjunctivus* (Weber 1991)]. These species were reported from natural lakes and streams of Turkey (Yalçın Ozdilek 2007; Innal 2008).

Three species of Carassius carp were introduced to numerous inland waters throughout Turkey. These species were physically similar to the native carp and through early mis-

identification their expansion was originally unnoticed. Currently they compete with native carp for food and space in several systems (Mumcular Dam Lake, Nazik Lake) (Yılmaz 2004; Cetinkaya et al. 1999). Economic losses of *C. carpio* stocking practices have been continuing for many years. There are no monitoring or evaluation programs in place regarding fish stock assessments.

Fish species have been introduced into aquatic systems to control unwanted organisms e.g. aquatic vegetation, phytoplankton blooms and mosquitos. *Gambusia* spp. used in the biological control of mosquito species, has been introduced into Turkey's reservoirs; stocking research was carried out by local fisherman, pest control corporations and the Ministry of Health and Malaria Control Department. Grass carp, *C. idella*, has been introduced into reservoirs to control aquatic vegetation.

In many systems, natural river fauna is unable to adapt to new reservoir habitat and fail to colonize the new waterbody. Many native river fish species of Turkey have been seriously damaged by the river damming and construction operations (Sarı and Bilecenoğlu 2002; Smith and Darwall 2006; Ozcan 2008a; Turan and Ozcan 2009; Kara et al. 2010). Habitat modification combined with stocking practices, cause displacement of unique local assemblages, with widespread species that are better able to tolerate human activities, leading to homogenization (Havel et al. 2005).

Introduced and transplanted species contribute significantly to the overall fish production of reservoirs in Turkey. Distribution, abundance and reproduction of many native river species have been affected by invasive species. Water released from the reservoirs can facilitate the spread of alien species to downstream reaches. Escapees of some fish species have resulted in the establishment of self-maintaining populations in river systems. Gibel carp (*C. gibelio*) and topmouth gudgeon (*P. parva*) are now considered a threat for endemic species in river systems. These exotic species can significantly affect the community structure of aquatic systems.

Alien freshwater fish and translocated native freshwater fish continue to increase steadily in number. 21 out of 32 reservoirs studied have been invaded by at least one alien fish species. The impact of most introductions of fishes is still unknown. Recent interest in exotic fish species for aquaculture, biological control and fish stocking programmes raise the possibility of future introductions. An increasing number of alien fish introductions in the river basin of Turkey will inevitably alter natural fish species diversity.

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Supplementary material

The following supplementary material is available for this article.

Appendix 1. List of alien and native translocated fish species of Turkey.
Appendix 2. Introduced fish species of some reservoir systems.

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