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Full Length Research Paper

Effects of forest habitat to brown trout: A case study from Northeastern Turkey

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Brown trout (*Salmo trutta macrostigma*) is regarded as a most sensitive species to ecosystem changes. Habitat quality especially in the forest areas can be thought as the most crucial element for survival of brown trout population. This case study compared brown trout population size in response to forest habitats. The study was carried out by field survey, direct observation for brown trout population and survey with local people and other interested groups. Brown trout population was higher in the streams covered much more forest habitats, but streams, presenting low forest habitats, had much less brown trout population size. The study showed that, Brown trout population size was positively correlated with the forest cover size and types. It was also inferred that, brown trout can be used as an indicator species due to sensitivity for habitat changes in the ecosystems.

Key words: Brown trout, *Salmo trutta macrostigma*, Turkey.

INTRODUCTION

Anthropogenic changes in temperature and stream flow, associated with watershed land use and climate change, are critical influences on the distribution and abundance of riverine fishes (Peterson and Kwak, 1999). Brown trout has been a crucial part of the natural biodiversity of the freshwater ecosystems of temperate and sub-arctic regions (Youngson et al., 2003). Brown trout is one of the most widely distributed freshwater fish species in the world and top predators in most systems (Strakosh et al., 2003). Brown trout is distributed in North Africa, South Europe, West Asia and Anatolia. This subspecies occurs in the upper parts of streams and rivers and was reported from many running waters in Turkey (Alp et al., 2005). It is also an economically and ecologically very important fish species (Geldiay and Balik, 1988).

Many fish species are in decline and some have become endangered due to a combination of over exploitation, pesticides and aquatic pollution, spread of disease, uncontrolled introduction of exotic fishes and habitat modification due to industrialization, river-valley projects, excessive water abstraction and siltation due to clearing (Mijkherjee et al., 2002). In Turkey, native brown trout population decline or go into extinction due to a number of reasons such as illegal and heavy fishing pressure, reduced spawning success caused by pollution of streams, degradation of spawning habitats, river damming (Alp et al., 2005). For this subspecies, there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status (Tarkan et al., 2008). This subspecies is listed as DD = Data Deficient in IUCN Red List of Threatened Species (Smith and Darwall, 2006).

Fish species may be the most sensitive species for ecosystem changes. Brown trout has been used as a keystone species in some biodiversity conservation actions. But this species is due to the especially ecological sensitivity to ecosystems changes which can also be used as an indicator species in biodiversity conservation. This study was dealing with effects of forest to brown trout population size and the usability of the species as an indicator. The present study also aims to discuss conservation measures and threats for brown trout in Northeastern Turkey.

METHODS

Study area

The brown trout population density was monitored in mainly the streams of Coruh River, located in Northeastern Turkey (Figure 1).

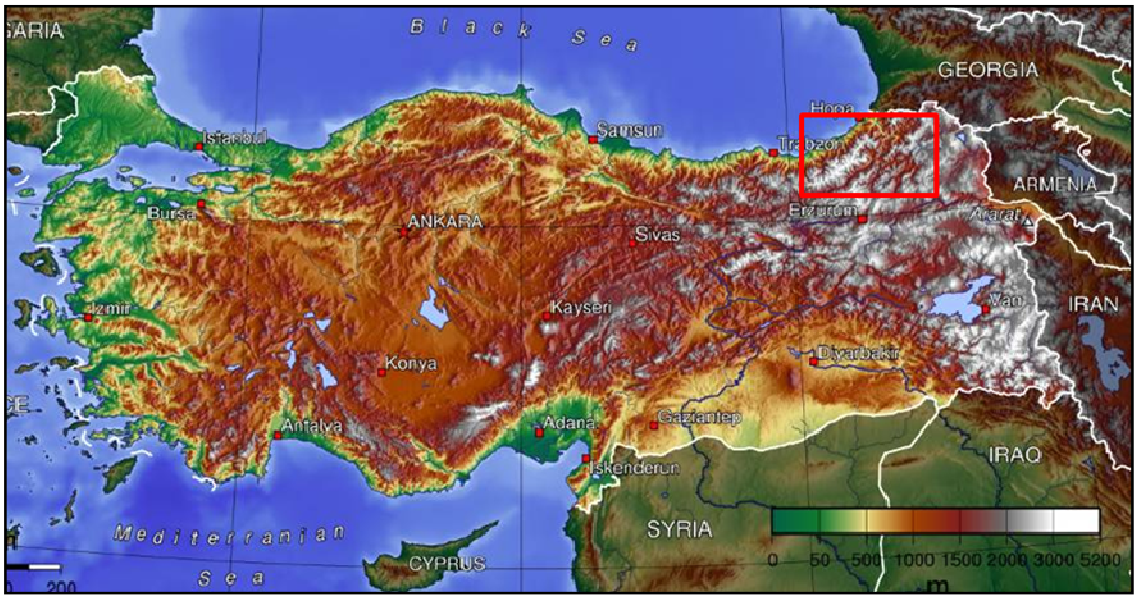

Figure 1. Map of the study area (indicated by rectangular).

Table 1. The rundown of stream properties and brown trout density.

Stream type	Forest cover	Forest edges	Depth of streams	Brown trout density
Group 1	High	High	Up to 1,5-2 m	High
Group 2	Medium	Medium	Up to 1 m	Medium
Group 3	Low	Low	Up to 1 m	Low

The table showed that, brown trout density was strictly related to forest cover and forest edges. The watersheds covered mainly forest habitats, but groups 2 and 3 had much more alpine and meadow areas. Disturbance factors were nearly similar for all streams.

The watersheds were primarily forest and alpine habitats. Forest composition and structure show considerable variation from east to west and from north to south. The forest habitat is predominantly consisting of Oriental spruce (*Picea orientalis*), Oriental beech (*Fagus orientalis*), Caucasian fir (*Abies nordmanniana* subsp. nordmanniana), Scotch pine (*Pinus sylvestris*) and Oak species (*Quercus* spp.) and other species. Disturbance effects were nearly similar for each stream. The streams were also utilized as an additional recreation, angling and fish catching.

Study design

Data were collected during the different season between 2007 and 2010 years. Brown trout was particularly monitored and catched by gill or fishing net in streams of Coruh basin. Sampling occurred mainly on sunny days and between nearly 10:00 and 17:00 h. The river streams were also observed such as ponds deeps and amount, environmental conditions and forest edges also noted. Total depth of each stream was estimated when the fish catching with net and direct observation.

Forest habitat types and distribution was determined from topographical maps and field observations. Surveys were carried out with local people and interested groups to supply more information about brown trout density. The brown trout population size was examined in response to forest cover in three stream types. Group 1 had high forest cover and edges, group 2 medium forest cover and edges and group 3 had low forest cover and edges, in view of all streams and forest in the regions. After that, brown trout density was discussed in response to three group streams properties.

RESULTS

Effects of forest on brown trout

The study has showed that, forest habitats distribution for the watersheds had crucial effects for brown trout (Table 1). Firstly, group 1 having high forest cover and edges had high brown trout density. Secondly, group 2 presenting medium forest cover and edges had medium brown trout density. Finally, group 3 having low forest cover and edges had low brown trout density. It was implied that depth of streams were nearly similar and some effects to brown trout density but no crucial effects.

Usability of brown trout as an indicator species

Brown trout can be used as an indicator species due to its special sensitivity to stress and disturbance. Brown trout population size was also mainly limited by dispersal

Table 2. Selecting criteria for indicator species.

Criteria	Brown trout	References
Limited by dispersal ability	Yes	Beazley and Cardinal, 2004
Limited by resource availability	Yes	Beazley and Cardinal, 2004
Limited by ecological processes	Yes	Lambeck, 1997; Beazley and Cardinal, 2004
Sensitive to stresses	Yes	Landres et al., 1988; Beazley and Cardinal, 2004; Hannon and McCallum, 2004; Machange et al., 2005; Fulton et al., 2005
Sensitive to disturbance	Yes	Beazley and Cardinal, 2004
Endangered species		Lawler et al., 2003
Rare species		Lawler et al., 2003; Tognelli, 2005

ability, ecological processes and resource availability. It can be inferred that, brown trout was correspond to indicator species criteria summarized from literature in the region (Table 2). Due to the fact that, brown trout can be easily affected by the ecosystem changes, this species can serve as a good indicator species in biodiversity conservation actions in the region.

DISCUSSION

Effects of forest on brown trout

Forest cover and edges had crucial effects on brown trout density. Shade is important in small brown trout streams. Riparian trees and bushes help keep water temperatures down, during the hot summer months, provide habitat for potential terrestrial insect prey, and provide materials for much of the primary production in a stream ecosystem (Raleigh et al., 1986). Streams having high forest edges and shade had high brown trout density. Despite, shading becomes less important as stream size increases (Raleigh et al., 1986), these streams were small and shading and forest habitats are essentials to brown trout population in the region. On the other hand, too much shade can restrict primary productivity in small, cold trout streams (Brocksen et al., 1968; Murphy and Hall, 1981) but our streams were small brown trout streams and for these 50 to 75% midday shade was assumed to be optimal (Raleigh et al., 1986). This rate can be supplied mainly by group 1 and these streams had good conditions for shade and forest edges.

It might be suggested that generally, growth and condition for brown trout in streams of Coruh basin is in better condition, in comparison with those in other population in the world but variability in growth and nutrition for brown trout among the stream might be attributed to physical environmental variables (Ozvarol et al., 2010). It can be easily implied that forest cover size and types may be the most crucial environmental variables regulating the brown trout density in the region. Streams having the same ponds up to 1.5 to 2 m depths, more suitability than streams having up to 1 m depth (Strakosh et al., 2003). It was implied that, depth of our streams were nearly similar and some effects to brown trout density but no crucial effects.

Usability of brown trout as an indicator species

Wildlife species or groups, such as small mammal species, have the potential to tell us about the functional effects of forest change. Although, many small mammal species have the potential to function as ecological indicators (Pearce and Venier, 2005), brown trout served as a good indicator species in the region. Brown bear (*Ursus arctos*), Wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*), Roe deer (*Capreolus capreolus*), Otter (Lutra lutra), Golden eagle (*Aquila chrysaetos*), Griffon vulture (*Gyps fulvus*), Cinereous vulture (*Aegypius monachus*), and Bearded vulture (*Gypaetus barbatus*) were used as other focal species in Yalnizçam Forest in the region (Ucarli, 2006). The majority of studies have dealt with taxonomy and zoogeographic distributions of brown trout in Turkish inland waters (Alp et al., 2003). This study can do good contribution to brown trout knowledge and conservation minded.

Threats to brown trout

Previous studies showed that, brown trout prefers cold, well-oxygenated upland waters and favors large streams in the mountainous areas with adequate cover in the form of submerged rocks, undercut banks and overhanging vegetation. With these features, this fish shows quite fragile life history characteristics and consequently, its several populations diminishing or have become extinct in Turkish inland waters (Alp et al., 2003).

Observations and surveys were suggested that, population of brown trout was more abundant in the past and is now in risk of extinction in some streams in the regions. Brown trout in Turkish inland waters has been under threat because of human disturbance as habitat

destruction, illegal and overfishing and other environmental changes, including hydroelectric plants and pollution (Alp et al., 2003; Tarkan et al., 2008). Brown trout has similar threats in the region. All streams and rivers in Turkey, this fish was officially protected and its catching was banned by the Turkish government. But many streams of the region suffered illegal and heavy fishing pressure on brown trout because of its high economic importance and local use. Conservation of forest habitats, preventing pollution and solving the dam effects on brown trout are essential for conserving self-sustaining populations in the future.

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