

Original Article

The first record of Koi fish, *Cyprinus rubrofuscus*, from a natural waterbody in the Hormuz basin, southern Iran

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Abstract: The number of exotic freshwater ornamental fish species released from the aquarium trade in Iran has been increasing in recent years. The Koi fish has already been reported from Iran, where it occurred in the southern Caspian Sea and Namak Lake basins. This is the first documented record of *Cyprinus rubrofuscus* from the Hormuz basin in southern Iran, which shows the range extension of this species in Iran. It seems there is no natural predator in most of the Iranian aquatic ecosystems for large Koi specimens. Therefore, the establishment of established populations in the natural lentic habitats is probable. Hence, eradication programs need to be accompanied by a public awareness campaign to ensure that the aquarium trade and hobbyists do not release these pet fishes into natural habitats.

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Introduction

The introduction of non-native fish species has increased considerably in recent decades in Iran (Mousavi-Sabet, 2018, 2019; Çiçek et al., 2022; Mousavi-Sabet et al., 2023). Based on the latest checklist, the exotic fishes in Iran reached 29 confirmed species (about 9.9% of its ichthyofauna), belonging to eleven families (Eagderi et al., 2022), and recently Mousavi-Sabet et al. (2023) have added two more species to this list. Ten of reported exotic fishes of Iran are ornamental fish species, reported within the last few years, including goldfish, *Carassius auratus* (Linnaeus, 1758), piranha, *Piaractus brachypomus* (Cuvier, 1818) (Esmaeili et al., 2017), convict cichlid, *Amatitlania nigrofasciata* (Günther, 1867) (Mousavi-Sabet and Eagderi, 2016; Esmaeili et al., 2017), sailfin molly *Poecilia latipinna* (Lesueur, 1821) (Esmaeili et al., 2017; Mousavi-Sabet, 2018), guppy, *P. reticulata* (Peters, 1859) (Mousavi-Sabet and Eagderi, 2014), swordtail, *Xiphophorus hellerii* (Heckel, 1848) (Esmaeili et al., 2017), Koi (Mousavi-Sabet, 2019), *Chitala ornata* (Gray, 1831) and *Pterygoplichthys joselimaianus*

(Weber, 1991) (Mousavi-Sabet et al., 2023). Therefore, aquarium trade is one of the important pathways for the introduction of non-indigenous species in the country. In addition to the ornamental fish trade, aquaculture, sport fishing, control of malaria, research and accidents have been the main reasons for these introductions (Radkhah et al., 2016; Mousavi-Sabet, 2019).

The Koi fish has gone through a lot of taxonomic variations due to extensive cultivation and breeding history (Gross et al., 2002; Zhou et al., 2003a). Its origins are uncertain leaving its taxonomic status unclear (Dong et al., 2015), but Koi probably originated in East Asia, and after thousands of years of selective breeding for striking coloration patterns, have become a widely popular ornamental species (Daniel et al., 2000; Balon, 2004). Gross et al. (2002) found koi to be a distinct monophyletic group resulting from domestication, but more closely related to East Invasive Carp groups, and recognized as the subspecies *Cyprinus carpio haematopterus*. This was also the conclusion and taxonomic assignment in similar studies from the same period that used

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Figure 1. Sabz-poushan Spring, Hormuz basin, Iran; catching site of *Cyprinus rubrofuscus*.



Figure 2. Koi, *Cyprinus rubrofuscus*; Iran, Hormuz basin, Sabz-poushan Spring

allozyme data (Kohlmann and Kersten, 1999). Investigation from a decade later has also recognized koi as carp subspecies *Cyprinus carpio haematopterus* (Kim et al., 2017). Later Matsui et al. (2008) recognized koi as a carp subspecies *Cyprinus carpio koi*. Although Zhou et al. (2003b) used the subspecies name *rubrofuscus* to describe other carp strains. Eschmeyer's Catalog of Fishes based on an Integrated Taxonomic Information System (ITIS) recognizes *Cyprinus rubrofuscus* as a distinct species (Fricke et al., 2019), putting a lot of the other subspecies assigned to the koi as synonyms (Dong et al., 2015).

Koi is a domesticated ornamental carp taxa that vary widely in coloration with combinations of bright gold, orange, silver, white, and black colors patterns (Kottelat and Freyhof, 2007). They reach sexual maturity around age 4 and breed yearly thereafter

(Smithsonian National Zoo and Conservation Biology Institute, 2019). This exotic fish was recorded for the first time in the natural water bodies of the Hormuz basin, Iran which is reported in the current study.

Materials and Methods

Cyprinus rubrofuscus specimens were collected by hand-net from the Sabz-poushan Spring (28.258012°, 55.751949°; Fig. 1), during a fieldwork in the Hormuz basin, southern Iran, on 8 February 2022. The collected specimens were preserved in 10% formalin after anesthetizing with 1% clove solution and transferred to the laboratory for further examinations.

Results

A total of three specimens of *C. rubrofuscus* (Fig. 2) were collected by hand-net from the Sabz-poushan



Figure 3. A specimen of Koi (~50 cm TL), *Cyprinus rubrofuscus*; Iran, Hormuz basin, Sabz-poushan Spring.

Spring. The collected specimens ranged from 9-15 cm TL, whereas there were still some small to large (up to 60 cm TL) specimens in the spring (Fig. 3). The Koi can be distinguished by having 29-33 + 2-3 lateral line scales, 18-22.5 branched dorsal rays, a silvery body with red pelvic, anal, and lower caudal lobes (Kottelat and Freyhof, 2007).

Discussions

The reported species was not previously recorded from the Hormuz basin, and this is a new record for southern Iran and the third report for the country, which was reported firstly as *Cyprinus carpio* from the Namak Lake basin and then from the southern Caspian Sea basin as *C. rubrofuscus* (Mousavi-Sabet et al., 2023). *Cyprinus rubrofuscus* was introduced into Iran as an aquarium fish, but it is now established in natural habitats e.g., in the Sabz-poushan Spring and Sarcheshme Springs in southern and central Iran, respectively. This species is native to East Asia inhabiting the grassy or muddy edges of rivers (Wu, 1977). The species is characterized by cold-resistance, alkali-resistance, and hypoxic tolerance (Ma et al., 2018). Koi are widely available in most countries and remain popular additions to water gardens and home aquaria worldwide (Fife-Cook and Franks, 2021). As the introduction of exotic fishes may affect populations of native fishes through predation, competition, habitat changes, genetic changes, and introduction of parasites and diseases, special care

should be taken to prevent such introductions (Mousavi-Sabet et al., 2021).

The first evidence of *C. rubrofuscus* introduction in natural water bodies of Iran comes from Mousavi-Sabet (2019), who collected the fish from Sarcheshme Spring, Sarcheshme Park, in Mahalat City, Markazi Province, where it was introduced by the Mahalat municipality for tourism purposes. Also, from the Anzali lagoon in the southern Caspian Sea basin (Mousavi-Sabet et al., 2023).

The study emphasized the importance of recording exotic fish species occurrences in new areas as well as subsequent records in the same area, to better detail the exotic fish action and to identify new areas of spread and establishment. Considering the probable impacts of exotic species on the biodiversity of the Hormuz basin, the application of distribution studies may support the processes of management and risk prevention. Eradication programs can be successful in the case of *C. rubrofuscus* in the Hormuz basin, based on the restricted distribution. However, such programs have to be accompanied by a public awareness campaign to ensure that the aquarium trade and hobbyists do not release these pet fishes into natural habitats. Monitoring of this fish is recommended.

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