

## Spread of biological invasions: The experience of Tilapia species in the Shadegan Wetland, southwest of Iran

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### Abstract

The status of non-native tilapia species was evaluated by sampling campaigns in fishing grounds in the central part of the Shadegan Wetland, southwest Iran in 2014–15 (with follow-up in 2019). Considering a high percentage of relative species abundance, the tilapia species (*Coptodon zillii* and *Oreochromis aureus*) are well established in the wetland. As the management plans of such species are difficult and expensive, prevention of the introduction of these species to other water bodies is highly recommended.

**Keywords:** Blue tilapia, Exotic/non-native species, Fishery, Redbelly tilapia

### Introduction

The arrival of tilapia fish in Iran has already been warned (Coad & Abdoli, 1993; Abdoli, 2000). In 2012, redbelly tilapia *Coptodon zillii* (Gervais, 1848) was spotted in the Shadegan Wetland and the other water bodies of the area (Khaefi et al., 2014; Roozbhfar et al., 2014) and blue tilapia *Oreochromis aureus* (Steindachner, 1864) observed from the Arvand and Karun River drainages in 2015 (Valikhani et al., 2016). The tilapia species introduction to the southwest of Iran has likely

occurred accidentally via water connections with Iraq (Valikhani et al., 2018), as the species *C. zillii* and *O. aureus* were previously found in this country in 2009 (Mutlak & Al-Faisal, 2009), and Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) in 2013 (Al-Faisal & Mutlak, 2014). Some species in the tribe of Tilapiini in the Cichlidae family are well-established as invasive alien species for many reasons. For example, *C. zillii* has a high level of tolerance for wide fluctuations in environmental parameters such as salinity (ISSG, 2008), early maturation, a long breeding season (Ishikawa & Tachihara, 2008), multiple spawning strategies (Rana, 1988), parental care (Canonico et al., 2005), and omnivorous diet (Dadebo et al., 2014).

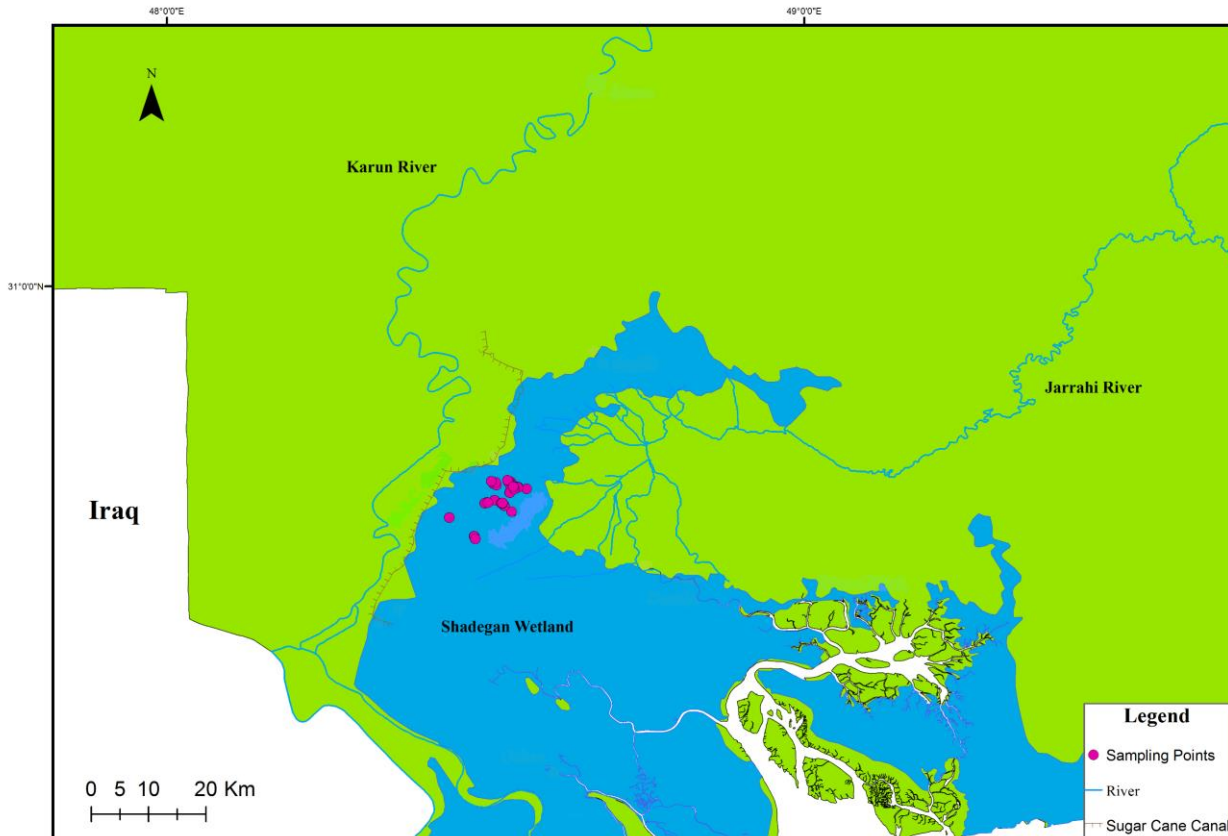
The introduction of non-native species, such as tilapia species, causes risks to native biota and ranks second after habitat modification as a threat to freshwater fish biodiversity through competition for resources, predation, habitat and water quality alterations, hybridization, and the importation of parasites and diseases (Arthur et al., 2010). The Shadegan Wetland has been considered a unique habitat for diverse flora and fauna, having ecological and conservational importance, nationally and globally (Rahimi et al., 2020). Some valuable commercial fish of the wetland include the native freshwater species 'benni fish' *Mesopotamichthys sharpeyi* (Günther, 1874), shabout *Arabibarbus grypus* (Heckel, 1843), yellow barbell *Carasobarbus luteus* (Heckel, 1843), Tigris asp *Leuciscus vorax* (Heckel, 1843), barbell *Luciobarbus barbulus* (Heckel, 1847), and abu mullet *Planiliza abu* (Heckel, 1843) and the non-native cyprinids such as common carp *Cyprinus carpio* Linnaeus, 1758 (Keivany et al., 2016).

The purpose of the study was to determine the status of non-native tilapia species, in the Shadegan Wetland through sampling campaigns aimed at evaluating the composition and abundance of the local fish community in the fishing areas. It should be noted that this study did not have the purpose of studying ichthyofauna of the study area, but rather investigated the status of fish with fishing value in one of the fishing areas of this wetland.

## **Material and methods**

### **Study area**

The Shadegan Wetland, the largest Ramsar site in Iran (designated since 1975), is a vast body of water comprising freshwater and brackish in the northern and middle parts, respectively, and saline water in the southern part (Fig. 1); it lies downstream of the Jarrahi River basin and finally pours into the Persian Gulf (SIMP, 2011). At the time of sampling, most parts of the southern and central parts of the wetland were dry, and getting access to the northern part was difficult due to inappropriate conditions of road access all over the year. For this reason, the central part of the wetland was sampled four times seasonally (in 2014-15).



**Figure 1.** Location of the sampling points in the central part of the Shadegan Wetland, Khuzestan Province, southwest of Iran.

### Fish sampling

Collecting of samples was conducted on fishing grounds in 2014–15 in autumn (November), winter (March), spring (April), and summer (September), with samples taken on consecutive days in each season. Sampling took place again in March 2019, intending to understand the status of the non-native fishes in the study area following the 2014–15 sampling campaign. The sampling was done in different directions near the Sarrakhih village, which is one of the most important fishing grounds in the Shadegan Wetland, based on access through local fishing boats, and sampling points were randomly selected in areas where fishing was possible. On each sampling day, different numbers of gillnet fleets were deployed at random points within the sampling area, noting that net placement varied from one season to the next. Gill nets with mesh sizes ranging from 23 to 42 mm, to catch the commercial fish species of the wetland according to the aim of the study, and in different numbers, heights, and lengths were set in the afternoon and retrieved the next morning. Fishing effort was standardized to 100 m<sup>2</sup> net per 12 hrs to allow comparison of catchment rate amongst different gillnet sizes (Table 1). Figure 1 and Figure 2 have been prepared in ArcGIS 10.2 and Excel 2021, respectively.

**Table 1.** Features of the gill nets used in the Shadegan Wetland, southwest Iran.

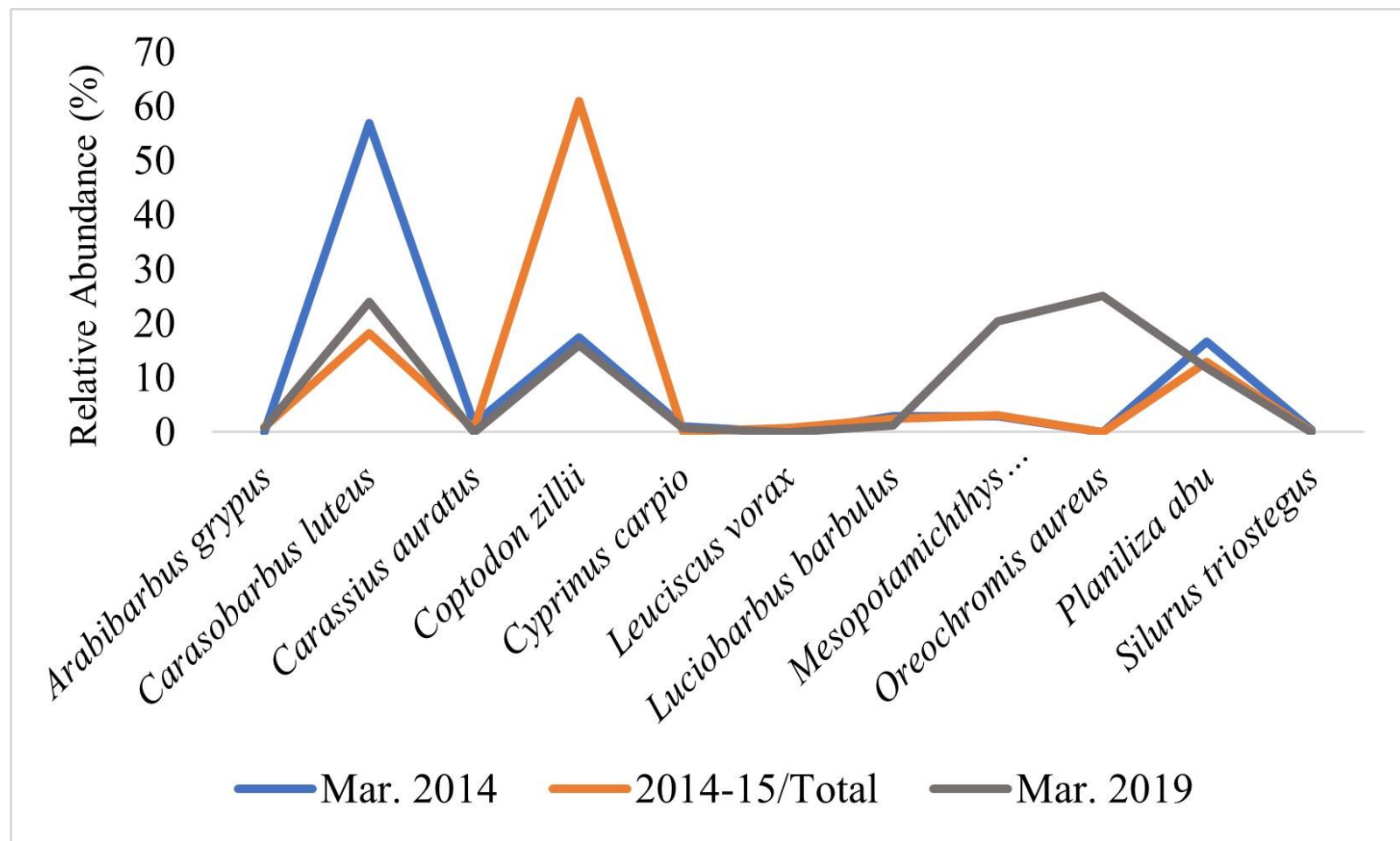
Month	Sampling Points	Net No.	Net Size Range (m) Height	Length	Net Area (m <sup>2</sup> )	Fishing Effort (100 m <sup>2</sup> net per 12h)
Nov. 2014	5	131	1-2	5-25	2584	25.84
Mar. 2015	5	74	1-2	11-25	2663	26.63
Apr. 2015	5	49	1-2	11-25	1328	13.28
Sep. 2015	3	26	1-2	11-25	850	8.50
Mar. 2019	4	81	1.5-2	5-25	2606	26.06

## Results and discussion

Based on the sampling campaigns, 11 fish species were detected in total to inhabit the fishing grounds in the central part of the Shadegan Wetland. Among which, four were non-native including *C. zillii*, *O. aureus*, goldfish *Carassius auratus* (Linnaeus, 1758), and *Cyprinus carpio* and seven native species, including *A. grypus*, *Carasobarbus luteus*, *M. sharpeyi*, *Leuciscus vorax*, *Luciobarbus barbulus*, *P. abu*, and Tigris catfish *Silurus triostegus* Heckel, 1843 (Table 2, Fig. 2). Based on fish community composition and abundance, *C. zillii* was by far the most abundant species followed by *Carasobarbus luteus* and *P. abu*. Notably, *O. aureus* was sampled in March 2019 but not in 2014–15.

**Table 2.** Absolute (*n*) and relative (%) abundance of the native and non-native fish species sampled in the Shadegan Wetland, southwest Iran in 2014–15 and 2019. For each species, the common name and authority is provided in the text (The species names in bold type indicate the non-native species).

Species name	Status	2014–15										March 2019	
		November		March		April		September		Total		<i>n</i>	%
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%		
<i>Arabibarbus grypus</i>	Native	10	1.58	–	–	–	–	3	0.84	13	0.84	2	0.78
<i>Carasobarbus luteus</i>	Native	4	0.63	153	56.88	67	23.83	56	15.77	280	18.22	61	23.92
<b><i>Carassius auratus</i></b>	Non-native	3	0.47	4	1.49	1	0.35	–	–	8	0.52	–	–
<b><i>Coptodon zillii</i></b>	Non-native	486	76.90	47	17.47	166	59.07	239	67.32	938	61.03	41	16.08
<b><i>Cyprinus carpio</i></b>	Non-native	–	–	3	1.11	–	–	–	–	3	0.19	2	0.78
<i>Leuciscus vorax</i>	Native	5	0.79	–	–	–	–	6	1.69	11	0.71	–	–
<i>Luciobarbus barbulus</i>	Native	2	0.32	8	2.97	22	7.83	6	1.69	38	2.47	3	1.18
<i>Mesopotamichthys sharpeyi</i>	Native	9	1.42	8	2.97	25	8.90	5	1.41	47	3.06	52	20.39
<b><i>Oreochromis aureus</i></b>	Non-native	–	–	–	–	–	–	–	–	–	–	64	25.10
<i>Planiliza abu</i>	Native	113	17.88	45	16.73	–	–	40	11.27	198	12.88	30	11.76
<i>Silurus triostegus</i>	Native	–	–	1	0.37	–	–	–	–	1	0.06	–	–



**Figure 2.** Comparison of relative abundance of the caught fish species in the Shadegan Wetland.

According to the results of this study, *C. zillii* has invaded the majority of parts of the Shadegan Wetland in about three years, i.e., since the first report of the species in 2012 (Khaefi et al., 2014) to 2014. Similarly, *O. aureus* has also been recorded as one of the dominant species among all surveyed fishes in a period of about three years, from 2015 (Tabasian et al., 2020) to 2018 (Kiyani Ersi et al., 2022). These two species have since been highly prolific in the wetland, have dispersed throughout most of the adjacent water bodies in the region (Al-Faisal et al., 2014; Esmaeili, 2021; Abdoli et al., 2022), and are also present in relatively high abundance in the downstream part of the River Karun basin (Shahraki et al., 2022). *C. zillii* and *O. aureus* could have significant ecological and economic impacts in the Shadegan Wetland (Tabasian et al., 2021). Recently another species of tilapia fishes, *O. niloticus*, has been caught from the wetland (Kiyanersi et al., 2022).

The Shadegan Wetland provides a variety of ecosystem and economic services for fisheries, agriculture, tourism, and industry (SIMP, 2011), and it is very important and internationally well-known for its fish diversity including some endemic species (Hashemi et al., 2015). Therefore, the introduction of such tilapia species can likely increase the negative effects on the native fauna and the whole ecosystem, especially through synergistic effects (Gu et al., 2016). Tilapia species are listed among invasive fish species by international conservation organizations (GISD, 2023) and have been demonstrated to have an adverse impact on native species and ecosystems (Peterson et al., 2005).

Literature reviews indicate that the tilapia species has already been successfully established in the Mesopotamia region, including Turkish, Syrian, Iraqi, and Iranian freshwater ecosystems (e.g., Kuru et al., 2014; Al-Zaidy, 2013; Esmaeili, 2021). Predictions have indicated that not only could these tilapia species thrive in their current state but also they could potentially invade other areas of Iran and survive even in the northern part of the country because of their wide tolerance range to environmental variables (Peymani, 2023). Teimori et al. (2017) recorded *C. zillii* in 600 to 800 km away from Khuzestan Province in a different basin. While the source of this introduction is not known, the most likely pathway is the accidental introduction from its previous habitats with commercial fish species (Teimori et al., 2017).

## **Conclusion**

The invasion of invasive non-native species is problematic to manage; thus, the best way to manage these species (such as tilapia) is prevention (Maynard & Nowell, 2009). Hence, the decision-makers and the managers should be aware of different ways to introduce the species to other water bodies of the country and control their population in the polluted areas.

Appropriate management plans should be taken to prevent the introduction of the species into non-polluted areas, such as monitoring the transfer of juveniles of cultured fish and stopping deliberate stocking of the juveniles into natural water bodies, as one of the most important vectors for the spread of the non-native species.

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