# Expansion of invasive mosquitofish, Gambusia holbrooki into the desert

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**Abstract**

The aim of this study was to report a new locality for invasive mosquitofish Gambusia holbrooki in Iranian inland waters. In this study, the presence of G. holbrooki is reported in Kouski Spring located in the desert area of Yazd Province in the central plateau of Iran. Due to the special characteristics of invasive mosquitofish including small size, ability to spread rapidly, adaptability to different environments, extensive competition with other species, and success in rapid colonization, the distribution pattern of this species in inland waters is spreading rapidly. Since the introduction of exotic fish species into new ecosystems can have many ecological consequences, therefore, an integrated ecosystem management approach in the inland waters of Iran is crucial.

**Keywords:** Distribution, Invasive, Fecundity, Integrated ecosystem management.

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## Introduction

Introducing exotic species outside their distribution range is one of the serious concerns worldwide that become even more important when the species become invasive (Pinder and Gozlan, 2003). According to the latest reports (Esmaeili et al., 2018), a total of 297 fish species in 109 genera and 30 families are found in different inland water basins of Iran, of which 95 species (32%) are endemic fish, and 29 species (9.76%) are exotic. Eastern mosquitofish Gambusia holbrooki (Cyprinodontiformes: Poeciliidae) is native to tropical and subtropical regions of the United States. This species has been introduced to many parts of the world to fight Anopheles mosquitoes (Nowak et al., 2008; Keivany, 2008) and is found in many freshwater waterbodies of Iran since it can tolerate high temperatures, water hardness, chlorides, salinities, and water pollution (Esmaeili et al., 2018; Froese & Pauly, 2021).

Given the importance of protecting native and endemic fish species in Iran, preventing the introduction of exotic and especially invasive species is of great importance in conservation programs. Hence, the present study aimed to report new information on the distribution of G. holbrooki in a spring located in the desert region of Yazd Province.

## Material and methods

The present study was conducted during a sampling operation of aquatic ecosystems in Yazd Province in November 2021. The sampling area is located in Kouski Spring, wildlife sanctuary, Bahabad County (32°10'10"N, 55°46'46"E) (Figure 1). Bahabad region with an area of about 65,000 hectares includes pristine and untouched lands in the north of Bahabad County and southwest of Ardakan, which are important due to the special topographic condition and no fundamental change in habitats and natural landscapes. This area has been introduced as a no-hunting zone in 2011 under the management and control of the Department of Environmental Protection of Yazd Province (Environmental Protection Organization of Yazd Province, 2021).

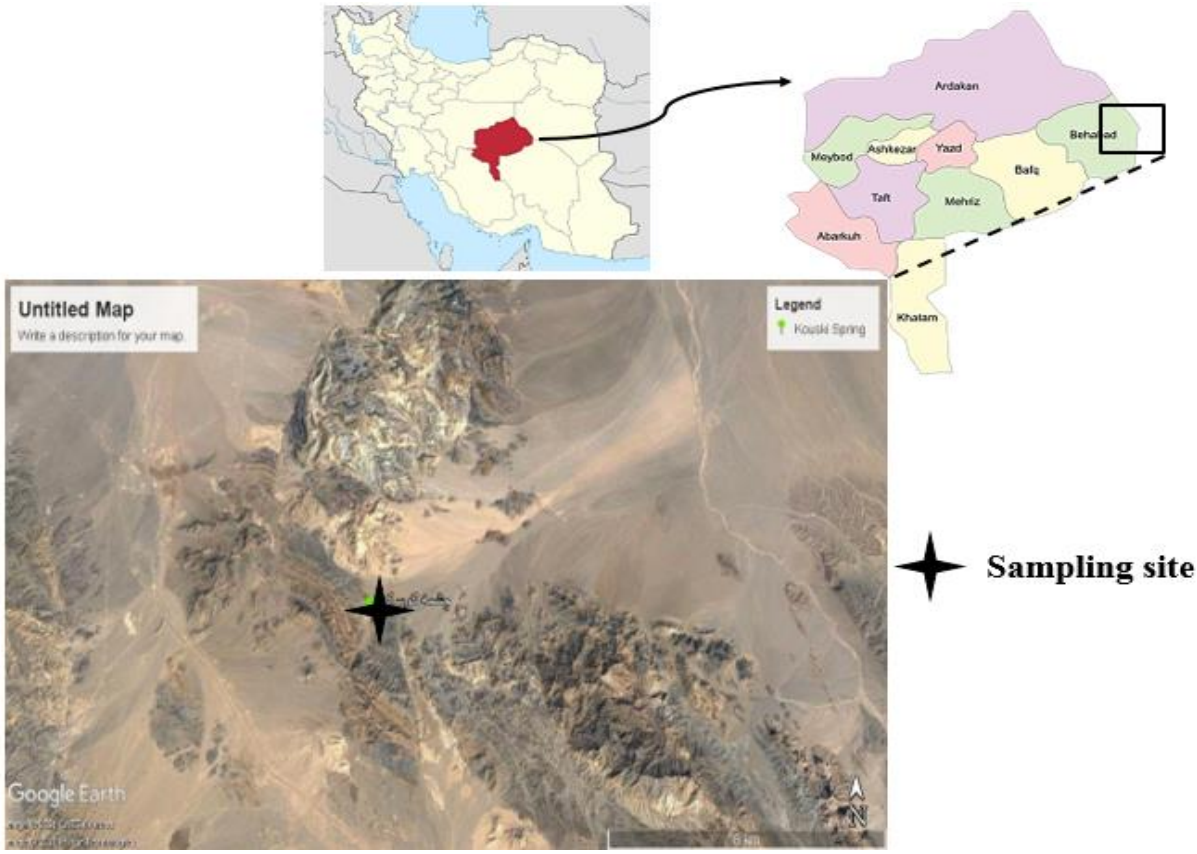


**Figure 1: The geographical location of the study area in Yazd province, Central Plateau of Iran.**

The sampling operation from Kouski Spring was performed by fishing nets. After sampling, the fish were preserved in 4% buffered formaldehyde after anesthetizing with 1% clove solution and transferred to the laboratory for further study. Esmaeili et al. (2018) and Coad (2021) were used to confirm fish identifications.

**Results and Discussion**

This study reports the presence of eastern mosquitofish (Figure 2) in Kouski Spring located in the desert region of Yazd Province. The presence of G. holbrooki in Kouski Spring (Figure 3) has probably been done by humans unintentionally. The introduction of G. holbrooki to many parts of the world has occurred for biological control of the mosquito population, however, this species eventually became an invader by entering new habitats.


**Figure 2: Eastern mosquitofish collected from Kouski Spring, Yazd Province.**

**Figure 3: Habitat of eastern mosquitofish in Kouski Spring, wildlife sanctuary, Bahabad County, Yazd Province.**

Yazd Province is one of the driest regions of Iran, which covers about 12.5 million hectares of natural resources in the central desert of Iran. Air temperature in this province has an annual average that varies from 10°C in the southern part to about 23°C in the desert area.

Also in this province, the temperature difference between the heights and desert areas is very high (Environmental Protection Organization of Yazd Province, 2021). In such climatic conditions, the effect of air temperature on water bodies is significant, so large fluctuations in water temperature are observed in aquatic ecosystems as well. However, some invasive species such as mosquitofish have a high ability to adapt to these complex conditions.

The Eastern mosquitofish can inhabit water bodies with temperatures of about 0 to 45 °C, the salinity of 0 to 41 ppt, the acidity of 4.5 to 9.0, oxygen concentration of 1 to 11 mg/L and turbidity 3 to 275 Jackson (Coad, 2017; CABI, 2021). This species is mostly found in the margins and areas with dense vegetation and prefers slow water compared to running water. In addition, other habitat preferences of this species include shallow water with dark substrates. The Eastern mosquitofish is highly adaptable and can be found in a wide range of aquatic habitats, including freshwater and brackish waters, cold to tropical climates, inland, coastal and estuarine waters, as well as stagnant and flowing water bodies. The main mechanism of mosquitofish, which directly affects native fish, involves special competition for access to resources such as food and space through aggression and predating eggs, larvae, and juveniles (Radkhah et al. 2018; Zwerschke et al., 2018; CABI, 2021). Since this species is a live breeder, therefore they do not need spawning grounds with water quality conditions. The Eastern mosquitofish is very successful in terms of reproduction so, in most studies, the fecundity of this species has been reported to be very high (Patimar et al. 2011).

Desert springs have high functional and biological diversity. Non-native fish species are associated with such desert water bodies that can treat other native animals e.g. insects and reptiles that depend on these water resources. Biological invasion is often associated with the depletion of native species can alter biodiversity patterns and lead to biological homogenization (Tran et al., 2015).

On the other hand, the potential of the species to form high-density populations can lead to the sharing of common food sources with native species and ultimately lead to overlap in ecological nests (Gavriloaie et al., 2014) in such a fragile desert ecosystem. Due to the threats posed by the introduction of exotic species, it is necessary to adopt management and conservation strategies to prevent the negative effects of these species on aquatic ecosystems.

## Conclusion

In the present study, a new locality of the presence of G. holbrooki in the deserts of Iran (Kouski Spring, Yazd Province, Lut Desert) was recorded. This species is known as an exotic and invasive species in Iran, therefore, the expansion of its distribution in inland waters of Iran is considered an ecological concern. The findings showed that the presence of G. holbrooki in a protected area in Bahabad County of Yazd province is probably due to human interventions and unintentional displacement of the species. This is somewhat unpredictable in a protected area and is probably due to mismanagement of the area. However, it is necessary to take precautionary measures by the country's environmental and fisheries policymakers to prevent the growing spread of G. holbrooki in Iranian inland waters.

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