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# Fin morphology variation in *Aphanius farsicus* in two local populations

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ABSTRACT

The teleost genus *Aphanius* is currently composed of at least 32 species. Here, we present observational data from breeding experiments in which we studied two local populations of the Farsi tooth-carp *A. farsicus* in captivity. Combinations of parental fish from both populations were allowed to spawn in separate aquaria. The resulting offspring showed unpredictable variations in their dorsal and anal fin shapes, including backward extended fins, dual or singular fins, as well as normal fin forms. This variation in *A. farsicus* fins likely affects the swimming performance of these fish. We judge that the observed fin shape variation in *A. farsicus* could become an inviting trait for the ornamental fish industry, because of the potential of producing fish with elaborate and attractive fins through selective breeding procedures.

## 1. Introduction

The teleost genus *Aphanius* is currently composed of at least 32 species (Esmaeili et al., 2016) and is widely distributed in coastal and interior bodies of water in the Mediterranean, the Red Sea and the Persian Gulf (VanVierssen et al, 1984; Wildekamp, 1993; Blanco et al., 2006; Esmaeili et al., 2016). In the past, it was thought that the greatest species diversity of the genus *Aphanius* exists in central Anatolia (Wildekamp et al., 1999), although it is known that Iran shows high species diversity as well (Coad, 2000; Hrbek et al., 2006; Esmaeili et al., 2016; Masoudi et al., 2016). So far, fifteen species of *Aphanius* have been recognized in Iran, including one fossil species. Most of the native *Aphanius* species are found in the Zagros endorheic basins (Esmaeili et al., 2016).

The Farsi tooth-carp (*Aphanius farsicus* Teimori, Esmaeili and Reichenbaher 2011) (Cyprinodontidae) is an endemic species found in the Lake Maharlu basin. This hypersaline lake, located in the Shiraz valley basin in the Fars province, Southern Iran, at an altitude of about 1460 m, is otherwise fishless except for the surrounding streams and springs (Yaripour, 2014). So far *A. farsicus* has been found only in a few localities, including certain springs around Lake Maharlu (Coad, 2000; Keivany and Esmaeili, 2013). Habitats of the species are assumed to be threatened by drought, water pollution, habitat destruction and the recent introduction of exotic species. One of the most known habitats in Fars Province is unfortunately drying out due to the current severe drought conditions, intensive draining for agriculture and water usage for fish farms in the area.

*Aphanius farsicus* feeds on insects and hence may exert a controlling force on insect populations in its ecosystem, which suggests its potential use as a biological control against mosquitoes such as *Anopheles* that act as vectors for malaria (Esmaeili and Shiva, 2006). The Farsi tooth-carp are in general colorful small fish with a life span of 0–3 years that have relatively high tolerance for handling stress and show easy adaptation to aquarium conditions. These characteristics make the species potentially suitable for entering the aquarium trade. Because of its current endangered status, it is essential to find ways to preserve this endemic threatened species from extinction. Experiments for reproduction and rearing in captivity were initiated in 2014, and have already resulted in reproduction and subsequent release of individuals in a protected habitat (Yaripour et al., 2015). During these first experiments under artificial breeding conditions we observed an interesting plasticity in the fin shapes. This notable fin shape variation may increase the attractiveness and value of the species for aquarium marketsand can be seen especially as elaborated variation in the dorsal and caudal fins. Normally wild adult *A. farsicus* individuals typically show a fairly stable pattern in dorsal and caudal fins (Fig. 1), but the first and second generations reared in captivity showed different patterns (Fig. 1). In this article, we present our observations and discuss possible interpretations.

## 2. Materials and methods

The study was preceded by a pilot project. Between 25 May and 20 June 2014, we sampled in total 30 individuals, including males and females, from two isolated wild populations. These two populations were caught from a small spring (area ca. 10 m × 50 m) with slow

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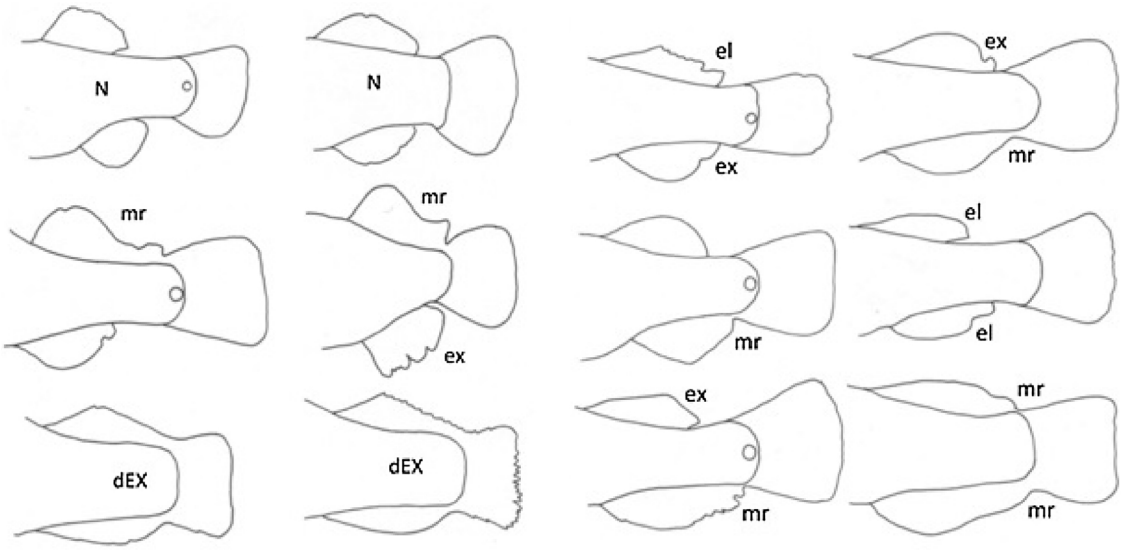


**Fig. 1.** Normal and variant examples of dorsal and anal fins of *A. farsicus*. N: normal fin form seen in the wild fish; ex: extended fin form; el: elongated fin form; mr: merged fin form; dEx: dually extended fin form.

running water, 5 km east of Lake Maharlu (estimated population size > 200 adult fish), and a small pond (area ca. 50 m × 100 m) 20 km west of Lake Maharlu (estimated population size > 1000 adult fish). The spring (location of the eastern population) rarely exceeds 50 cm in depth and has poor aquatic vegetation in the margins. The spring bed is covered with silt and sandand scattered small gravel. There is a local fish farm at a close distance (ca. 50 m) practicing polyculture of various carp species, especially common carp (*Cyprinus carpio* L.). The pond (location of the western population) is human-made and around 100 years old. No rivers flow into it, but the water is supplied by groundwater and/or via connections to artificial underground waterways (Qanats), which were constructed in old times for the management of water in the city. The pond is usually only partially filled, and during our sampling the water surface was about 10 m below the ground surface. A dense community of various aquatic macrophytes, including tall reeds, covers the littoral zone of the pond. The pond also hosts eastern mosquitofish (*Gambusia holbrooki* Girard, 1859), several species of water birds, snakes and turtles.

The fish were kept separately for one month at a water temperature of 26 °C, pH 7.8 and dissolved oxygen of 6 mg/l to adapt to the experimental conditions. Then combinations of three males and one female from both populations were put together in an experimental aquarium (50 × 30 × 40 cm) for courtship and reproduction. Plastic skeins were provided as a spawning substrate. After eight months, almost 250 larvae had been produced, of which 25 matured after five months with average weight of 0.36 (SD = 0.18) g and standard length of 2.11 (SD = 0.36) cm. The other fish died before reaching full maturity. The mature offspring subsequently produced the second generation in separate aquaria. All the fish were fed with 0.5 mm commercial dry pellet food (BioMar), which was ground to a fine powder to feed the larvae.

In this pilot project we noticed that approximately 80% of the individuals of the first generation showed morphological variation different from what is usually seen among wild fish. This variation was observed mostly in dorsal and anal fins. Some fish had both dorsal and anal fins elongated and extended to be merged with caudal fin (dual extension), while other fish showed normal dorsal fins but elongated anal fins merged with the caudal fin (partial extension) (Figs. 1 and 2). Because the parents in the first experiments originated from two different populations, we faced the question of whether this morphological variation was a result of intra-specific hybridization, or just due to our experimental conditions (including diet).

To study this topic in more detail, we conducted three additional within-population and between-populations mating experiments. The mating experiments were conducted in environmental conditions similar to our pilot work (see above). In the first two experimentsten randomly sampled wild parent individuals, i.e. five females and five males, were randomly mated within their population of origin (Experiment 1: the eastern spring population; Experiment 2: the western pond population) over two generations. When the number of offspring produced in the first generation exceeded ten, the number participating in the second cross was lowered to ten, with random selection of individuals.

In Experiment 3, we crossed, with similar methods, these two populations using ten randomly sampled parent individuals, five females and five males. All three mating experiments were successful, as we were able to produce viable offspring for two generations. As we observed that the first generation fish in the within-population experiments showed morphological variation in their fin shape, we decided to estimate the species' potential for selective breeding, by excluding individuals with typical fin characteristics as parents producing the second generation, so that all individuals in the last generation of the last experiment were offspring of fish with the extended fin type.

The eggs were typically observed among the plastic skeins, which were used as spawning substrate, after male and female fish had been kept together for ten days. On average, there were 10–25 eggs per female. The fertilized eggs were moved to hatching tanks, where they normally hatched after a maximum of 14 days. Most of the eggs were fertilized and hatched successfully, but also some unhatched eggs were observed (ca. 10%). External body features like fins could be observed within 4 months when the fish were fully grown.

## 3. Results

Maturity was typically reached after four months but many fish died before reaching maturity. In Experiment 1 (the western pond population), we were able to produce fourteen fully grown fish in the first generation. Twelve individuals of the first generation showed normal forms of dorsal and anal fins, while two individuals had partially extended fins (only anal fins were extended and joined to caudal fin) (Table 1). In the second generation, all six fully grown individuals showed dual extended fins.

In Experiment 2 (the eastern spring population), we were able to produce six fully grown fish in the first generation which were all of the