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Two new species of the tooth-carp *Aphanius* (Teleostei: Cyprinodontidae) and the evolutionary history of the Iranian inland and inland-related *Aphanius* species

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Abstract

Two new species of *Aphanius* are described from the Kol drainage in southern Iran (*Aphanius darabensis* n. sp.) and the endorheic Kavir Basin in northern Iran (*A. kavirensis* n. sp.), and compared with eight closely related species. *Aphanius darabensis* n. sp. is sister to *A. shirini*, from which it is distinguished by molecular characters (cytochrome *b*) and the combination of three morphological characters: 9–18 flank bars in males (vs. 7–10), females with irregular vertical patches of brown color on the flank (vs. prominent dark brown blotches of round or irregular shape), and symmetrically-shaped triangular to trapezoid otoliths with a rostrum distinctly longer than the antirostrum (vs. quadrangular to trapezoid otoliths with short and equally sized rostrum and antirostrum). *Aphanius kavirensis* n. sp. is closely related to a group containing *A. sophiae*, *A. mesopotamicus* and *A. pluristriatus*, from which it is distinguished by cytochrome *b* characters and the combination of three morphological characters: females with irregularly arranged large blotches of dark brown color on the flank, short pectoral fin in both sexes (13.4–18.1% SL in males, 11.2–18.3% SL in females), and asymmetrically shaped triangular to trapezoid otoliths with a pronounced predorsal region. Our tree based on the cytochrome *b* data demonstrates that the Iranian inland and inland-related *Aphanius* species (IIRAS) form a monophyletic clade with three subclades (*A. vladykovi* -, *A. shirini* -, *A. sophiae* subclades). The *A. sophiae* subclade, which is the most diverse of the three subclades, can be further divided into three lineages (*A. isfahanensis* -, *A. farsicus* -, *A. sophiae* lineages). The temporal diversification of the IIRAS clade is discussed and two evolutionary groups of *Aphanius* are depicted. *Aphanius vladykovi*, together with *A. shirini*, *A. darabensis* n. sp. and *A. isfahanensis* characterize the “old” evolutionary group. Their divergences may have happened 10–5 m.y. ago (Late Miocene–Early Pliocene). *Aphanius farsicus*, *A. arakensis*, *A. sophiae*, *A. mesopotamicus*, and *A. pluristriatus*, together with *Aphanius kavirensis* n. sp., represent the “young” evolutionary group, which developed in the Late Pleistocene (100,000–11,700 y. ago) and Early to Middle Holocene (c. 11,700–4,000 y. ago).

Key words: Tooth-carp, *Aphanius*, mt-DNA, phylogeny, zoogeography, geology, conservation

Introduction

Cyprinodonts of the genus *Aphanius* inhabit a wide range of habitats in the Mediterranean Sea, Red Sea and Persian Gulf basins, from Morocco east to western India (Wildekamp 1993). There are 23 species recognized as valid in the genus, and two centers of high species diversity are known: Central Anatolia and Iran (Coad 1988, 2000; Hrbek & Meyer 2003; Hrbek *et al.* 2006; Esmaeili *et al.* 2012; Teimori *et al.* 2012a–b).

Six species of *Aphanius* were recognized in Iran as at 2006. These included the widely distributed *A. dispar* (Rüppell, 1829), four endemic species, i.e. *A. sophiae* (Heckel, 1849) from the endorheic Kor River basin, *A. farsicus* Teimori, Esmaeili & Reichenbacher, 2011 from the endorheic Lake Maharlou basin, *A. ginaonis* (Holly, 1929) from the Genow hot spring and *A. vladykovi* Coad, 1988 from the upper reaches of the Karoun drainage, as well as *A. mento* (Heckel, 1843). The latter was recorded from southern Iran, near the border to Iraq (Wildekamp 1993), but its occurrence in this region has not been confirmed in subsequent studies.

geological history. It is therefore likely that factors such as sensory-driven speciation (Teimori *et al.* 2012a) and the increased aridity in the course of the Holocene (Kehl 2009) played an additional role in population isolation and species divergence.

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