



Scale surface microstructure and scale size in the tooth-carp genus *Aphanius* (Teleostei, Cyprinodontidae) from endorheic basins in Southwest Iran

ZEINAB GHOLAMI^{1,5}, AZAD TEIMORI^{1,4}, HAMID REZA ESMAEILI², TANJA SCHULZ-MIRBACH³
& BETTINA REICHENBACHER¹

¹Department of Earth- and Environmental Sciences, Palaeontology & Geobiology & GeoBio-Center, LMU, Ludwig-Maximilians-University, Richard-Wagner-Strasse 10, D-80333 Munich, Germany

²Department of Biology, College of Sciences, Shiraz University, Shiraz 71454, Iran

³Department of Behavioral Biology, University of Vienna, Althanstrasse 14, A-1090, Vienna, Austria

⁴Department of Biology, Faculty of Sciences, Shahid-Bahonar University of Kerman 22 Bahman Blvd. Kerman, 76169-14111 Iran

⁵Corresponding author. E-mail address: z.gholami@lrz.uni-muenchen.de

Abstract

A substantial number of species within the tooth-carp *Aphanius* Nardo, 1827 (Cyprinodontidae, Teleostei) has been recorded from the endorheic drainage systems of Iran, and several isolated populations in these systems may deserve species status. Descriptions of these species and populations have been based mainly on morphological and molecular data; however, the characters related to the fish scales have not up to now been intensively studied and employed for the identification of the species belonging to this genus. The objective of this study is to test as to whether (i) scale surface morphology, (ii) scale surface microstructure, and (iii) scale size can be used to discriminate species and/or populations and, (iv) to discuss the possible causes of the observed differences. To achieve these objectives, scales of three species of the genus *Aphanius* from endorheic basins in SW Iran, viz. *A. sophiae* (nine populations from the Kor River Basin), *A. farsicus* (four populations from the Maharlou Lake Basin) and *A. pluristriatus* (a single population from the Mond River Basin) have been studied using SEM images, scale measurements, and uni- and multivariate statistics. It is opined that scale surface morphology and microstructure cannot help in distinguishing the species, but can be employed to discriminate certain populations of *A. sophiae* (those from Safashahr, Kharameh, Tashk, Gol). In addition, scale size and J-indices, respectively, represent a valuable tool for species separation, which corroborates earlier studies for the use of these indices in taxonomy. Major driving forces of the differentiation within *A. sophiae* probably include habitat fragmentation resulting from the geological history and local adaptations. Thus the differentiation results from a balance between both genetic and environmental effects.

Key words: fish, Cyprinodontidae, scale surface morphology, J-indices, *Aphanius*, SEM

Introduction

The only native representative of the cyprinodontids in the Mediterranean and Persian Gulf areas as far as Iran and Pakistan is the genus *Aphanius* Nardo, 1827 (Wildekamp 1993). The highest species diversity of this genus occurs in the endorheic basins of central Anatolia and the Iranian plateau (Coad 2000 a–b; Hrbek *et al.* 2002, 2006; Esmaeili *et al.* 2010). Eight endemic species have been described from Iran to date, distinguished by genetic differentiation and specific otolith features; however, they differ only weakly (or only in multivariate space) with regard to meristic and morphometric characters (Coad 1988, 1996, 2000 a–b, 2009; Hrbek *et al.* 2006; Esmaeili *et al.* 2012; Teimori *et al.* 2012a).

Scale-surface morphology and microstructures have previously been used for the identification of certain species of the Cichlidae (Lippitsch 1990, 1992, 1993, 1995) and Cyprinidae (Jawad 2005a), and also for several species of the genus *Aphanius* from the Mediterranean area and Arabian Peninsula (Ferrito *et al.* 2003, 2009). In addition, scale surface morphology and microstructures are considered to be an authentic tool for the recognition of intraspecific differences between individuals collected at different sites of the same river, for the detection of