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Scale deformities in three species of the genus *Garra* (Actinopterygii: Cyprinidae)

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ABSTRACT

Different types of scale deformities have been reported from fishes worldwide, however there is no available study on the abnormal scales in the genus *Garra* except for *G. variabilis*. In the present study, scale deformities of three species of *Garra* including *G. rufa*, *G. persica* and *Garra* sp. from 6 sites of the Iranian drainages were examined and described. Different deformations were observed in focus, anterior, posterior and lateral sides of scales in the studied species, showing both slight and severe abnormalities. The occurrence of twin scales was one of the most interesting cases among various types of scale deformities observed on *G. persica* and *Garra* sp. Genetic disorders, diseases (including infection and lesions), developmental anomalies, incomplete regeneration after wounding, physical, and chemical environmental variables including pollutions might be considered as potential factors for scale abnormalities remained to be investigated.

Keywords: *Garra*, Scale morphology, Taxonomy, Abnormal scale, Iranian drainage basins.

INTRODUCTION

Among the morphological abnormalities reported in fishes (e.g. Poppe *et al.* 1997; Corrales *et al*. 2000; Jawad 2005; Jawad & Ibrahim 2017), abnormalities in scale shape and structure have been described from a limited number of species worldwide (Jawad *et al*. 2018). Since the time of Agassiz (1833) as the first person to use fish scales for taxonomy and divided fishes into four groups according to the structure of their scales: Placoidei, Ganoidei, Ctenoidei, and Cycloidei, scale morphology has been used in fish systematics and comparative morphology, followed by describing scale deformities in several fish species (see Jawad *et al*. 2017). Although the anatomy and developmental patterns of fish scales and the relationship of scale morphology to genetic and environmental factors have been described in some pervious research (Yamada 1961; Sire 1986; Bereiter-Hahn & Zylberberg 1993), more studies on abnormal scales could help us to deeper understanding the relationships between water pollution and scale abnormalities as a bio-indicator (Khanna *et al*. 2007; Jawad *et al*. 2018). The genus *Garra* Hamilton 1822, by about 140 valid species, distributed from East Asia to Africa (Sayyadzadeh *et al*. 2015; Esmaeili *et al*. 2016; Mousavi-Sabet & Eagderi 2016; Froese & Pauly 2017). Of those, 13 species (1 unconfirmed) are currently reported from Iran (Esmaeili *et al*. 2016; Esmaeili *et al*. 2018). Among various research studies on this genus in Iran (e.g. Esmaeili *et al.* 2012; Keivany *et al.* 2015; Sayyadzadeh *et al*. 2015; Keivany *et al.* 2016; Segherloo *et al.* 2017), only limited studies addressed morphological characterization of the scales in the genus *Garra*, and none of them studied the abnormalities of scales except for *G. variabilis* (Jawad *et al*. 2017). The current study is a first attempt to shed light on the types of abnormal scales for the three species of *Garra* in Iran including (a) *G. rufa* which is distributed in the Tigris River, Maharlou and Persis drainage basins, (b) *G. persica* which is known from the Rudan and Kol River drainages and also Shour, Bampour and Karvandar rivers

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and (c) *Garra* sp. which is restricted to the upper reaches of the Kol River (Sayyadzadeh *et al*. 2015; Esmaeili *et al*. 2016).

MATERIALS AND METHODS

Ninety specimens of *G. rufa*, 45 *G. persica* and 30 *Garra* sp. from Southern Iran deposited in the Zoological Museum-Collection of the Biology Department of Shiraz University (ZM-CBSU), were examined (Table 1). Lepidological observations using light microscopy were performed and scale deformations were diagnosed by visual inspection. Normal and abnormal scales were removed using forceps from the fish individuals, cleaned mechanically using fine brush and distilled water, kept between two microslides and drawn using camera Lucida attached to the Stereo-microscope (model ZEISS, Stemi SV6). For normal scales, we removed three scales from the left side of each fish below the dorsal fin and three from lateral line scales. In the case of abnormal scales, we screened the left and right sides of each fish under a stereo microscope visually and all abnormal scales were removed. Normal and abnormal scales were compared with those from the same fish specimen.

Table 1. Species, number of studied specimens, collection site and number of examined scales.

Species	Number of specimens	Locality	Drainage basin	Number of abnormal scales examined
G. rufa	30	Kazeroun, Shahpour River	Persis	2
G. rufa	30	Nourabad, Fahlian River	Tigris	1
G. rufa	30	Firouzabad, Rodbal River	Persis	1
G. persica	30	Gahkom	Kol	1
G. persica	15	Goud gaz	Kol	1
Garra sp.	30	Estahban, Eij River	Kol	3

RESULTS

The scale morphology in three members of the genus *Garra* from different basins in southern Iran shows the architecture of a general cycloid scale including focus, circuli and radii (Fig. 1). The focus of scales in the examined *Garra* species lies on the anterior part and divides scale into the anterior, posterior and lateral fields [Figs. 2(a, b) 3(a, b) 4(a, b)]. Among the three species, different deformations were observed on the focus, anterior, posterior and lateral sides of the scales. The main deformation occurred on the scales of these species can be summarized into three categories based on the shape of abnormal scale: i) fused pairs, with two well-developed foci or one canal, ii) developmental irregularity and iii) pause of growth in a part of scale.

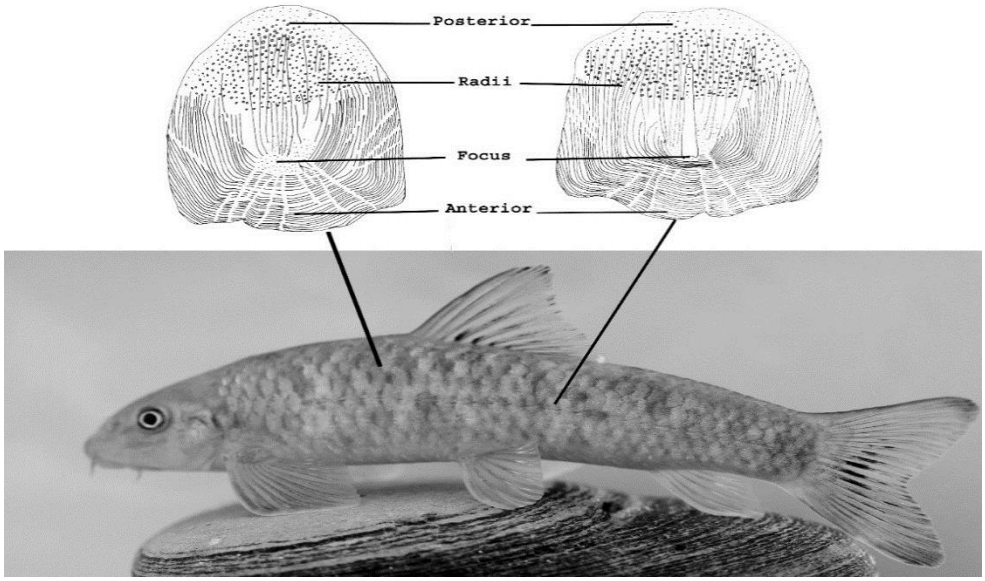

Fig. 1. *Garra* specimen showing normal cycloid scales on the left side (from below dorsal fin and lateral line).

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Garra rufa

Two types of abnormal scales were diagnosed in *G. rufa* from Shahpour River (Persis basin).

I) Anterior abnormality: The scale was anteriorly extended with two overlapping lobes and with a wide focus on the middle part of scale in comparison with a normal scale (Fig. 2c).

II) Lateral side deformity: One of the sides of the scale was severely reduced and the radii were created irregularly (Fig. 2d). Therefore right down corner was completely missing.

Asymmetry scale was also observed in *G. rufa* from Roudbal River (Persis basin), which has developed unilaterally and the focus was displaced to the right side of scale instead of being situated in the middle (Fig. 2e). The deformed scale of *G. rufa* from Fahlian River (Tigris basin) was anteriorly extended with one lobe located at the right side and with extensive focus at the middle. In this scale, lateral line canal was tripartite terminally (Fig. 2f).

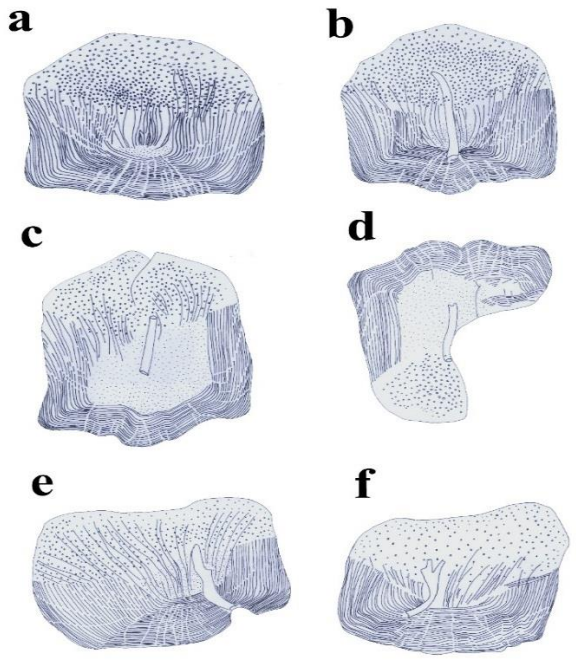

Fig. 2. Normal (a,b) and abnormal scales (c,d,e,f) of *Garra rufa.*

Garra persica

Among *G. persica* individuals from God-Gaz River (Kol basin), anterior and posterior abnormalities with irregular development at both fields of the same scale were observed (one abnormal scale). Circuli on the caudal deformed area were distorted. In this scale, groves were made on the margins of scale (two anterior and three posterior groves) (Fig. 3c).

Two fused scales also were observed in *G. persica* from Gahkom (Kol basin). This fusion made a scale with two incomplete foci and an anterior abnormality with two slightly overlapping lobes. Circuli on the caudal area were distorted (Fig. 3d).

***Garra* sp.**

Three types of abnormal scales were diagnosed in *Garra* sp. from Eij River (Kol basin). The first was two scales fused in focus part, one of them was a complete lateral line scale, while the another was an incomplete typical one. Elongated canal was observed at its middle part (Fig. 4c). The second one was also diagnosed as two fused scales: a typical and a lateral line ones creating a wide scale with two foci and a lateral canal at the right side (Fig. 4d). Finally, two anteriorly extended lobes with a deep groove at the anterior middle of the scale was observed in the fish collected from Eij River (Fig. 4e).

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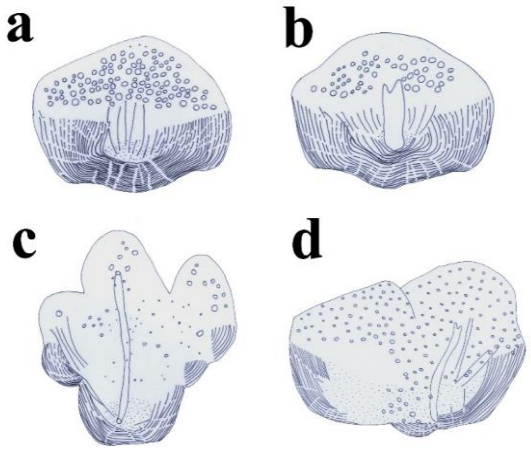

Fig. 3. Normal (a,b) and abnormal scales (c,d) of *Garra persica*.

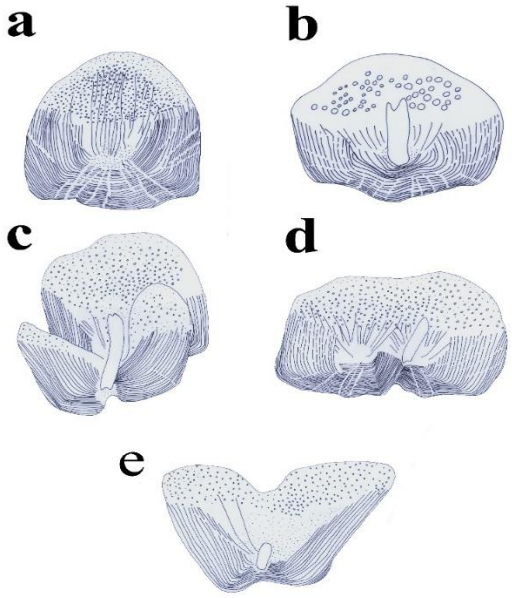

Fig. 4. Normal (a,b) and abnormal scales (c,d,e) of *Garra* sp.

DISCUSSION

The genus *Garra* has general cycloid scales as found in some other cyprinids (Johal *et al*. 1999; Esmaeili 2001; Esmaeili *et al*. 2007; Esmaeili *et al*. 2012; Teimori 2016; Yedier *et al*. 2016). In the present study, some cases of abnormal scales in three species of *Garra* from Southern Iran were examined and described. Nine abnormal scales were observed, almost showing severe abnormalities. Anterior abnormalities reported for all three examined *Garra* species in this study, were also observed in *Carassius auratus*, *Cyprinus carpio*, *Coelorinchus bollonsi*, *C. fasciatus*, *C. oliverianus*, *C. parvifasciatus*, *C. subserrulatus*, *Macrourus whitsoni* and *Trachyrincus longirostris* (Jawad *et al*. 2017). Esmaeili *et al.* (2012) indicated that focus of the scale in *G. rossica* is distinct and located at the anterior field. The present study also shows that the focus of the scale in *G. rufa*, *G. persica* and *Garra* sp. are also located at the anterior field. The focus is the first part of the scale to be formed during ontogenesis (Helfman *et al*. 2009) and the case of abnormal scales with multiple foci is rare (Mookerjee 1948; Jawad 2005). However, this study present an incomplete focus in *G. rufa*, a deformed focus in *G. persica* and two scales with multiple foci in *Garra* sp. Multiple foci also were reported for *Cremnochorites capensis*, *Forsterygion lapillum*, *Karalepis stewarti*, *Matanui bathytaton* and *Ruanoho decemdigitatus* (Jawad *et al*. 2017).

In this study, scale with lateral deformities is reported for *G. rufa* with completely missing right down corner. The lateral side deformities with severely-reduced side were also reported in *G. variabilis* collected from Tigris River,

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Turkey by Jawad *et al*. (2017). The main factors which considered to be reason for most of abnormality in fishes include: genetic disorders, diseases (include infection and lesions), physical, and chemical environmental variables (e.g. Corrales *et al*. 2000; Heintz *et al*. 2000; Pichavant *et al*. 2000; Smith & Fuiman, 2004; Yu *et al*. 2006; Vignon *et al*. 2008; Bendoy *et al*. 2011). The deformity and abnormality issues are complex because of dealing with different reasons (Blaustein & Johnson 2003) including both genetic and epigenetic factors, as well as environmental variables (which can produce epigenetic effects) and also some other unknown factors. However, most fish populations apparently exhibit a natural number of abnormalities. The occurrence of twin scales found in *G. persica* and *Garra* sp. in the present study, was also reported in *Esox lucius* by Jawad *et al.* (2018) that may be due to developmental anomalies. Incomplete regeneration after wounding were also proposed for some scale deformities (Sire 1986).

Freshwaters are identified to be the most threatened out of all the ecosystems in the world. The pollution of aquatic system makes a noticeable change in physicochemical characteristics (Khanna *et al*. 2007). Therefore, an important indicator of habitat degradation in aquatic environments is a change in the prevalence of diseases or deformities in exposed populations (Sindermann 1996). Fish have been used for many years to determine the pollution status of water and are thus regarded as excellent biological marker in aquatic ecosystems (Romeo 1987; Currey *et al*. 1992). The observed deformation in the members of the genus *Garra* might be due to environmental pollution which has been observed during many fieldwork by the authors in recent years or any above-mentioned reasons. However, in this study it is impossible to conclude the cause of the abnormalities and this issue remains to be investigated.

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CONFLICTS OF INTERESTS

The authors declare that they have no conflict of interest.

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ناهنجاری‌های فلس در سه گونه ماهی از جنس *Garra* (ماهیان باله شعاعی: کپورماهیان)

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چکیده

تاکنون انواع مختلفی از ناهنجاری‌های فلس در ماهیان سراسر جهان گزارش شده است. با وجود این، گزارشی از ناهنجاری فلس در گونه‌های جنس *Garra* به جز در گونه *G. variabilis* وجود ندارد. در این مطالعه، ناهنجاری فلس در سه گونه ماهی از جنس *Garra* شامل *G. rufa*، *G. persica* و *G.* sp. از شش محل در حوضه‌های مختلف آبریز ایران بررسی و توصیف شده است. در فلس‌های بررسی شده، ناهنجاری‌های مختلف در نواحی مرکز، جلویی، عقبی و جانبی فلس دیده شد که نشان دهنده ناهنجاری‌های خفیف تا شدید است. وجود فلس‌های به هم چسبیده (دوقلو) یکی از جالب‌ترین موارد در بین انواع مختلف ناهنجاری‌های مشاهده شده در گونه‌های *G. persica* و *G.* sp. است. مشکلات ژنتیکی، بیماری، ناهنجاری‌های تکوینی، ترمیم ناقص بعد از جراحت، متغیرهای فیزیکی و شیمیایی محیطی مثل آلودگی می‌تواند به عنوان عوامل بالقوه ایجادکننده ناهنجاری‌های فلس مطرح باشند که لازم است بیشتر بررسی شوند.

*مولف مسئول

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