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Scale Characteristics of Two Fish Species, *Acanthopagrus bifasciatus* (Forsskål, 1775) and *Rhabdosargus sarba* (Forsskål, 1775) from the Red Sea at Jeddah, Saudi Arabia

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Abstract: The present work aimed to screening and documenting the diversity of scale characteristics of two species belonging to two different genera of the family Sparidae: *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* from the Red Sea. The valid useful scale characters for systematic purposes were determined in the term of morphometry and Scanning Electron Microscopic techniques. A wide spectrum of size-free intraspecific variations between different body regions was recorded in each species in terms of morphometric indices. The scale characters included the overall form of the scales and their morphometrics, radii counts, shape of interradial tongues, the first circuli, form of interradial circuli and their denticles, the outer lateral and inner lateral circuli and the form of their denticles, granulation of the caudal field and the shape of ctenii. Moreover, the form of the lateral line canal, the relative position of their anterior and posterior openings and the cantilevered anterior extension of the canal were valid in differentiation between species.

Key words: Sparidae, *Acanthopagrus*, *Rhabdosargus*, scales, scanning electron microscopy

INTRODUCTION

The family Sparidae (order perciformes) represents one of the most important fish families in the Red Sea. Its members are carnivorous, marine, brackish, reef-associated and inhabit shallow coastal waters mainly aroreefs at depth ranged from 2-20 m (Riede, 2004; Sommer *et al*., 1996). From taxonomical points of view, the Red Sea at Saudi Arabia seems to be one of the least studied areas dealing with Sparidae.

Scale characteristics have been considered relevant for fish identification, taxonomy and phylogeny especially with great developments of Scanning Electron Microscopy that had facilitated the application of scale microstructures to systematic (Mekkawy *et al*., 2011; Harabawy *et al*., 2012).

The morphological features and ultrastructure of teleost scales were studied by many authors In an attempt to discover new characteristics for scales that may be useful in fish taxonomy (Mekkawy, 1980; Khalil *et al*., 1982; Lippitsch, 1993; Mekkawy *et al*., 1999, 2003, 2006, 2011; Jawad, 2005; Jawad and Al-Jufaili, 2007; Mahmoud *et al*., 2005; Harabawy *et al*., 2007, 2012; Reza *et al*., 2009; Matondo *et al*., 2010; Esmaeili and Gholami, 2011; Dapar *et al*., 2012; Ganzon *et al*., 2012). Some of these authors also used the scale morphometric characteristics in addition to the morphological ones in identification of different species (Mekkawy *et al*., 1999, 2003, 2006, 2011; Mahmoud *et al*., 2005 and Harabawy *et al*., 2007, 2012). Most of these studies aimed to provide a wide range of valuable scale characters that can reflect a clear taxonomic status and a well-founded phylogenic tree of different groups of fishes in addition to the functional and systematic approaches.

The present work aimed to screening and documenting the diversity of scale characteristics of two species belonging to two different genera of family Sparidae: Acanthopagrus bifasciatus and Rhabdosargus sarba from the Red Sea at Jeddah in an attempt to determine the valid scale characters for fish identification and to give an interpretation for the surface scale ornamentation in terms of functional approaches.

MATERIALS AND METHODS

Specimen collection: In the present study, 678 scales from ten specimens of two genera of family Sparidae: *Acanthopagrus bifasciatus* (110 -235 mm Standard Length (SL)) and *Rhabdosargus sarba* (200-290 mm SL) were examined to elucidate their scale structure characteristics.

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These specimens were collected from the Red Sea at Jeddah, Saudi Arabia through the period from May to June 2012.

Scale preparation and measurements: The scales were gently removed from the left side of the body from seven positions on the body: (1) Region A, directly below the anterior part of the dorsal fin (BDFS), (2) Region B, postoperculum (POS), (3) Region C, below the lateral line, between the pectoral and pelvic fins (BLLS), (4) Region D, caudal peduncle directly above the lateral line (CPS). In addition, Anterior Lateral Line Scales (ALLS), Middle Lateral Line Scales (MLLS) and Posterior Lateral Line Scales (PLLS) from caudal peduncle region. The scales of the first four regions (regions A, B, C and D) were used for morphometric measurements and radii counts. While scales forming the lateral line were examined to show the lateral line pattern, shape and characters of the lateral line canal.

Scales examined were cleaned carefully to remove the adhering tissues debris without damage in the scale surface. Then they were immersed in a solution of 10% ammonia for 24-36 h to soften adhering tissues and to clean them. Cleaned scales were dried on a filter paper and kept between two glass slides.

Figure 1 shows the structure of a sectioned scale, types of radii and the morphometric measurements considered. The primary, secondary and tertiary radii were counted to reveal intraspecific and interspecific variations. The morphometric measurements were treated in terms of indices (L1/L, L2/L, L1/L2 and W/L) where L, L1, L2 and W are scale length, rostral field length, caudal field length and scale width, respectively.

Microscopic study: Scanning Electron Microscopy (SEM) was used to study the morphology and microstructures of the scales in the rostral, lateral and caudal regions. The cleaned and dried scales that are used for Scanning Electron Microscope (SEM) examination were mounted and fixed by sticker tape on a specimen holder and coated with a 30 nm layer of gold. The electron micrographs were produced on GAOL, GSM5400LV, SEM in back scattering mode and on a Stereo Scan Cambridge Mark 2A (15 kv) in Assiut University Electron Microscope Center, Assiut, Egypt.

Also, the light microscope was used to examine the morphology of the rostral field, lateral regions, the shape of overall granulation area in the caudal field, the shape of rostro-caudal separation line, the posterior rim and the shape of granulation area in the caudal field.

Statistical analysis: Basic statistics of scale characteristics were estimated. To clarify intraspecific variations of both species *A. bifasciatus* and *R. sarba*, ANOVA (Design: Species+Region+Species *Region, R^2 = 0.96-0.99) was applied on the morphometric indices of scales using SPSS package, release 9.0.0 (SPSS, 1998) with the assumption of homogeneity of variance.

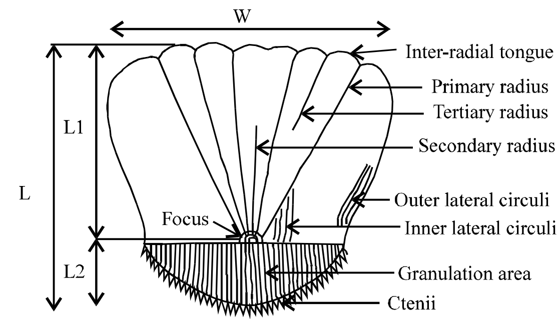

Fig. 1: A diagrammatic structure of a representive scale showing the different regions, terms and morphometric measurements used in studying scales of *A. bifasciatus* (ctenoid scales) and *R. sarba* (cycloid scales without ctenii); L: Scale length; L1: Rostral field length; L2: Caudal field length; W: Scale width

RESULTS

General morphology of the scales: The scales of *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* are mainly of the sectioned type (i.e., with well-developed radii) on all parts of the body; these scales are also ctenoid in the first species and cycloid in the second one. No simple scales (i.e., without or with only weakly developed radii) were recorded. The scales of the two species studied show a distinctive surface ornamentation which in its simplest case consists of circuli and grooves, forming nearly circular rings aroa center called focus. The variable scale shape has its effect on the shape and arrangement of the circuli. The regenerated scales without any ornamentation at least at the central part of the scale were recorded. The scales that are recorded in postoperculum region (POS) below the lateral line were the largest ones in comparison with those of the other regions studied. In the rostral part of the scale, the circuli are partitioned by deep and narrow grooves (radii) that run radially between the focus and anterior rim. The radii on the scales of the two species studied can be categorized into three types depending on their origin and end on the scale including: Primary, secondary and tertiary (Fig. 1). In comparison to the primary and tertiary radii, the relative number of secondary radii is few in number.

Table 1: Basic statistics, Mean±SD (Range) of the morphometric indices of scales from four body regions of *Acanthopagrus bifasciatus* from the Red Sea, Jeddah, Saudi Arabia, the Postopercular Scales (POS), Below Dorsal-Fin Scales (BDFS), Below Lateral Line Scales (BLLS) and Caudal Peduncle Scales (CPS)

Index	Region A (N = 31) Mean±SD (range)	Region B (N = 30) Mean±SD (range)	Region C (N = 29) Mean±SD (range)	Region D (N = 26) Mean±SD (range)
L1/L*	72.29±2.58 (66.67-77.41)	74.24±3.07 (65.14-78.12)	72.78±3.043.04 (66.67-77.75)	74.89±3.29 (69.89-81.2)
L2/L*	27.74±2.58 (22.59-33.33)	25.77±3.1b (21.88-35.05)	27.2±3.04 (22.25-33.39)	25.09±3.28 (18.7-29.89)
L1/L2**	263.54±33.62 (200-342.58)	292.96±41.98 (185.86-356.94)	271.83±39.66 (200-349.45)	305.32±55.17 (233.82-434.21)
W/L**	117.07±9.61 (95.28-135.85)	123.53±11.59 (97.39-137.42)	106.57±6.94 (93.73-118.58)	104.87±5.75 (92.96-116.05)

*Differences are significant at 0.05 level, **The differences are highly significant at 0.01 level

Table 2: Basic statistics, Mean±SD (Range) of the morphometric indices of scales from four body regions of *Rhabdosargus sarba* from the Red Sea, Jeddah, Saudi Arabia, the postopercular scales (POS), below dorsal-fin scales (BDFS), below lateral line scales (BLLS) and caudal peduncle scales (CPS)

Index	Region A (N = 42) Mean±SD (range)	Region B (N = 32) Mean±SD (range)	Region C (N = 37) Mean±SD (range)	Region D (N = 34) Mean±SD (range)
L1/L**	71.05±2.34 (64.41-74.96)	71.37±3.62 (64.5-77.43)	71.23±2.8 (66.95-77.7)	74.42±2.32 (69.17-78.69)
L2/L**	28.95±2.35 (25.04-35.59)	28.62±3.61 (22.57-35.5)	28.75±2.79 (22.3-33.05)	25.55±2.3 (21.31-30.83)
L1/L2**	247.58±27.3 (180.97-299.4)	254.59±42.85 (181.68-343)	251.17±36.34 (202.6-348.5)	294.3±35.02 (224.32-369.17)
W/L**	135.61±12.84 (114.41-161.64)	138.83±10.65 (117.98-163.25)	114.78±8.55 (101.15-132.25)	115.83±8.02 (95.52-129.71)

**Differences are highly significant at 0.01 level

Table 3: Percentages of occurrence and basic statistics of the primary radii counts of the postopercular scales (POS), below dorsal-fin scales (BDFS), below lateral line scales (BLLS) and caudal peduncle scales (CPS) of *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* from the Red Sea at Jeddah, Saudi Arabia

			Primary radii counts											
Species	Scales	N	6	7	8	9	10	11	12	13	14	15	16	Mean±SD
Acanthopagrus	BDFS	66	0	0	1.52	10.61	10.61	28.79	37.88	9.09	1.52	0	0	11.24±1.23
bifasciatus	POS	48	0	0	0	0	2.08	29.17	27.08	18.75	12.5	6.25	4.17	12.46±1.46
	BLLS	53	0	3.77	26.42	37.74	22.64	9.43	0	0	0	0	0	9.08±1.02
	CPS	44	0	0	2.27	6.82	50	34.09	2.27	4.55	0	0	0	10.41±0.92
Rhabdosargus	BDFS	71	0	12.68	23.94	18.31	33.8	9.86	1.41	0	0	0	0	9.08±1.27
sarba	POS	48	0	6.25	22.92	29.17	31.25	8.33	2.08	0	0	0	0	9.19±1.14
	BLLS	49	8.16	24.49	46.94	18.37	0	2.04	0	0	0	0	0	7.84±0.96
	CPS	38	0	0	2.63	18.42	31.58	26.32	21.05	0	0	0	0	10.45±1.11

Morphometrics and counts of radii: Table 1 and 2 show the basic statistics of the scale morphometric indices (relative to scale length, L) from four different body regions. These tables reveal intraspicific variations in these scale morphometric characteristics of the four body regions considered in each species. In *A. bifasciatus*, the indices L1/L and L1/L2 show significant difference between scales of the four body regions ($p<0.05$) whereas, L2/L and W/L revealed highly significant variations ($p<0.01$) (Table 1). In *R. sarba*, all indices revealed highly significant variations ($p<0.01$) between scales of the four body regions (Table 2).

The percentages of occurrence and basic statistics of the primary, secondary and tertiary radii counts are given in Table 3-5. Table 3 shows variations in the primary radii counts between *A. bifasciatus* and *R. sarba*. These counts are ranged between 7-16 and 6-12 in *A. bifasciatus* and *R. sarba*, respectively. The secondary radii counts varied between 0-1 and 0-3 in *A. bifasciatus* and *R. sarba*, respectively. The tertiary radii ranged between 0-5 and 0-9 in *A. bifasciatus* and *R. sarba*, respectively. Such counts were size free in species considered ($p>0.05$). The patterns of distribution of such size-free counts revealed significant scale interspecific variations using G-statistics test ($p<0.01$).

Scanning electron microscope studies

Rostral field: In the inter-radial space, the rostral rim of the scales of all scales of both *A. bifasciatus* and *R. sarba* form tongue-like projections that are free of circuli near the rim (Fig. 2a); on the same scale, these projections may be convex, straight or convex and straight. The 1st inter-radial circulus is straight or slightly convex. The radial grooves in the rostral field of the scales of two species studied have two different forms. In the first form, the groove appeared as a deep irregular groove (*A. bifasciatus*) (Fig. 2b) whereas in the second form, the groove is relatively shallow without split (*R. sarba*) (Fig. 2c).

Inter-radial circuli, grooves and denticles: The intercircular grooves in the rostral field were narrow in scales of *A. bifasciatus* (Fig. 3a) and flat and wide relative to the circulus thickness in most of the scales of *R. sarba* (Fig. 3b). The interradial circuli bear small denticles or tooth-like structures that can be seen only under high

Table 4: Percentages of occurrence and basic statistics of the secondary radii counts of the postopercular scales (POS), below dorsal-fin scales (BDFS), below lateral line scales (BLLS) and caudal peduncle scales (CPS) of *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* from the Red Sea at Jeddah, Saudi Arabia

			Secondary radii counts				
Species	Scales	N	0	1	2	3	Mean±SD
Acanthopagrus	BDFS	66	100	0	0	0	0±0
bifasciatus	POS	48	91.67	8.33	0	0	0.08±0.28
	BLLS	53	92.45	7.55	0	0	0.08±0.27
	CPS	44	95.45	4.55	0	0	0.05±0.21
Rhabdosargus	BDFS	71	98.59	1.41	0	0	0.01±0.12
sarba	POS	48	89.58	8.33	0	2.08	0.15±0.5
	BLLS	49	97.96	2.04	0	0	0.02±0.14
	CPS	38	86.84	13.16	0	0	0.13±0.34

Table 5: Percentages of occurrence and basic statistics of the tertiary radii counts of the postopercular scales (POS), Below Dorsal-Fin Scales (BDFS), Below Lateral Line Scales (BLLS) and Caudal Peduncle Scales (CPS) of *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* from the Red Sea at Jeddah, Saudi Arabia

			Tertiary radii counts										
Species	Scales	N	0	1	2	3	4	5	6	7	8	9	Mean±SD
Acanthopagrus	BDFS	66	12.12	19.7	40.91	12.12	12.12	3.03	0	0	0	0	2.02±1.37
bifasciatus	POS	48	25	31.25	31.25	8.33	4.17	0	0	0	0	0	1.35±1.08
	BLLS	53	24.53	28.3	32.08	7.55	3.77	3.77	0	0	0	0	1.49±1.27
	CPS	44	13.64	29.55	27.27	25	4.55	0	0	0	0	0	1.77±1.12
Rhabdosargus	BDFS	71	9.86	11.27	23.94	21.13	14.08	7.04	5.63	5.63	0	1.41	3.00±1.99
sarba	POS	48	2.08	14.58	22.92	29.17	18.75	8.33	4.17	0	0	0	2.90±1.39
	BLLS	49	6.12	30.61	32.65	20.41	6.12	2.04	2.04	0	0	0	2.04±1.24
	CPS	38	2.63	34.21	36.84	10.53	0	10.53	5.26	0	0	0	2.24±1.53

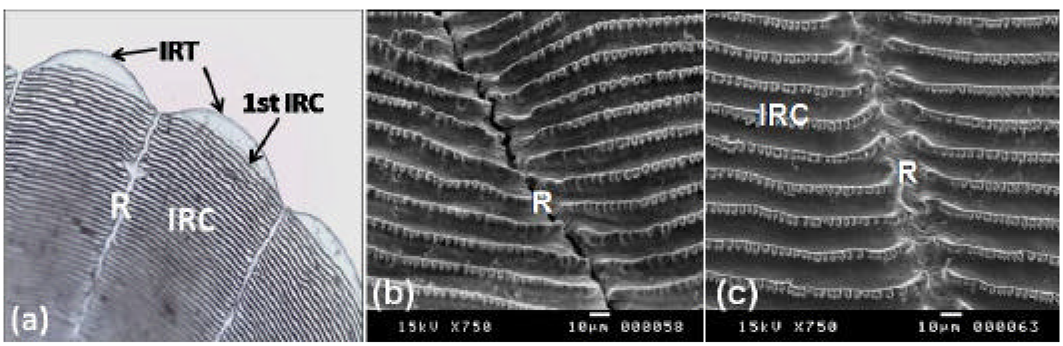

Fig. 2(a-c): Light (a) and scanning electron micrographs (b and c) show (a) The Inter-radial Tongues (IRT), 1st inter-radial circulus (1st IRC), Inter-Radial Circuli (IRC) and Radii (R) in the rostral field of the scales recorded in *Acanthopagrus bifasciatus* and *Rhabdosargus sarba* considered (X = 100); (b) Deep radial grooves (R) with irregular split recorded in *A. bifasciatus* and (c) Shallow radial grooves (R) without split recorded in *R. sarba*

magnification (lepidonts). Two different characteristic types of denticles or lepidonts were identified on the inter-radial circuli (Fig. 3a and b). Type 1: The circuli bear strong denticles with thick free ends oriented backwardly; some denticles are based on vesicle-like base (*A. bifasciatus*) (Fig. 3a). Type 2: The circuli bear strong denticles with pointed ends (claw-like ends) oriented backwardly (*R. sarba*) (Fig. 3b).

Outer lateral circuli: The most outer lateral circuli in scales of *A. bifasciatus* are low and bear very weak denticles (Fig. 3c). The grooves between these circuli are wide and flat. But, in scales of *R. sarba*, the denticles of the outer lateral circuli are numerous and have tubercular shape (Fig. 3d).

Inner lateral circuli and denticles: The inner lateral circuli of *A. bifasciatus* are thick and separated by V-like

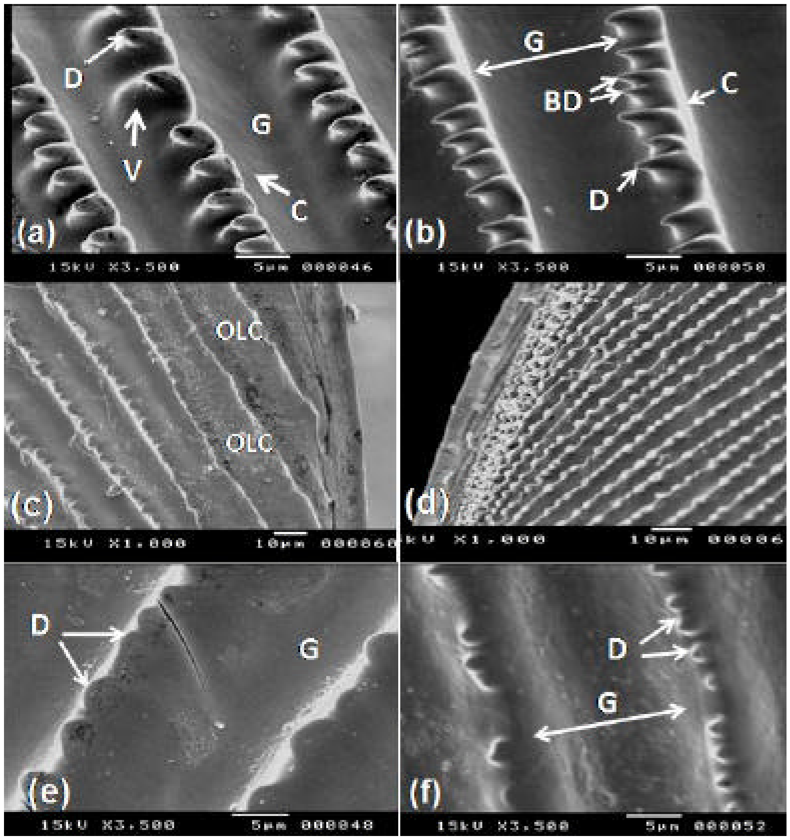

Fig. 3(a-d): Scanning electron micrographs show (a and b): The inter-radial circuli recorded in scales of *A. bifasciatus* and *R. sarba*, respectively; (c and d): The most Outer Lateral Circuli (OLC) recorded in scales of *A. bifasciatus* and *R. sarba*, respectively and (e and f): The inner lateral circuli recorded in scales of *A. bifasciatus* and *R. sarba*, respectively. Denticles (D), vesicle-like bases (V), groove (G), inter-radial circuli (C), bicuspid denticles (BD)

grooves (Fig. 3e). These circuli bear thick and wide denticles with rounded tops. In scales of *R. sarba*, the denticles of the inner lateral circuli are small tooth-like structures with unequal interval distances between them on the same circulus (Fig. 3f). Some of these denticles have molar-like shape. The free ends bend slightly towards the focus.

Focus region: The focus of the scales of *A. bifasciatus* and *R. sarba* has no circuli. This focus is characterized by unique pattern of horny plates-like structures surrounded by rows of tubercular ridges in scales of *A. bifasciatus* (Fig. 4a, b). The focal region of *R. sarba* appears as pits of different shapes and sizes and surrounded by elongated ridges (Fig. 4c, d).

Caudal field

The separation line, the posterior rim and the shape of granulation area: Based on separation line (Fig. 5b), the area of the caudal field is sharply separated from the anterior rostral field and is easily recognizable. This separation line was relatively straight and the posterior rim was rounded in all scales of both species studied. The granulation area in caudal field has no circuli and alternatively, contains segments and ctenii extended posteriorly in the ctenoid scales of *A. bifasciatus* (Fig. 5a). On the other hand, the caudal field of the cycloid scales of *R. sarba* appears as a smooth area without any segmentation or ctenii at the posterior margin (Fig. 5b).

Lateral line canal: Figure 6 shows the characteristics of the lateral line canal of *A. bifasciatus* and *R. sarba*. In *A. bifasciatus*, the lateral line canal is divided into a rostral wide tube extend anteriorly to some extent and do not reach the anterior margin; two caudal short narrow tubes embedded in scale matrix (Fig. 6a). The lateral line canal of *R. sarba* has a wide anterior tube similar to that of

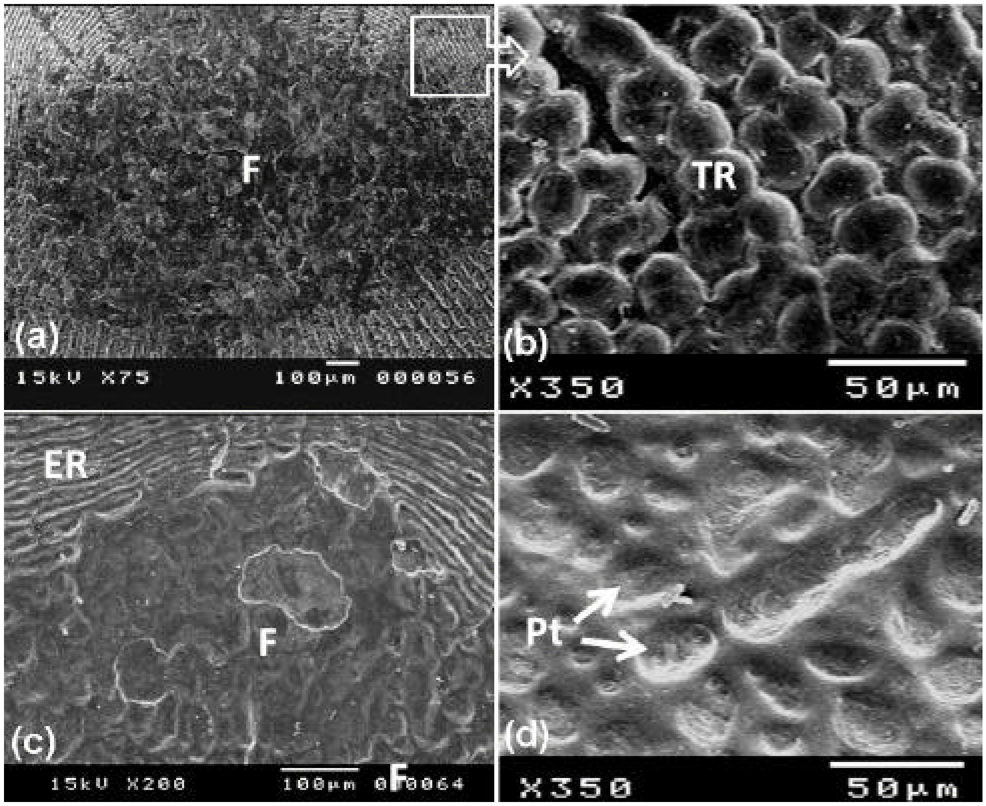

Fig. 4(a-d): Scanning electron micrographs show the focus region (F) with horny plates-like structures surrounded by rows of tubercular ridges (TR) recorded in scales of Acanthopagrus bifasciatus (a and b, enlarged part) and the focus region of Rhabdosargus sarba that appears as pits of different shapes and sizes and surrounded by elongated ridges (ER) (c and d, enlarged part)

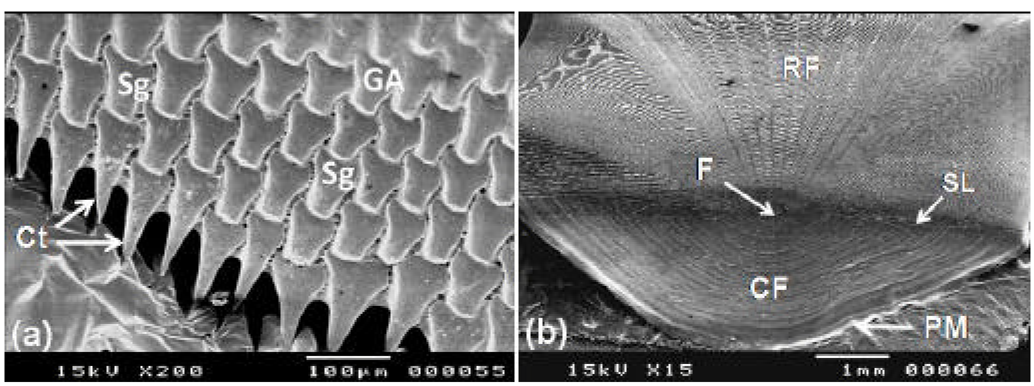

Fig. 5(a-b): Scanning electron micrographs show (a): The forms of ctenii (Ct) and segments (Sg) in the Granulation Area (GA) of the ctenoid scales of *A. bifasciatus* and (b): The cycloid scale of *R. sarba* with Caudal Field (CF) that appears as a smooth area without any segmentation or ctenii at the Posterior Margin (PM). Note, the Focus (F), the Separation Line (SL) and the Rostral Field (RF).

A. bifasciatus, but in its caudal field there are several pores that are arranged in two unique rows extended from the center of the scale toward the posterior margin having V-like shape (Fig. 6b). In general, the anterior lateral line canal gradually decreases in size at the middle part of the lateral line to be the smallest in the posterior part in caudal peduncle (Fig. 6b-d). Also, the number of pores decreases backwardly. The rostral wide tube (canal)

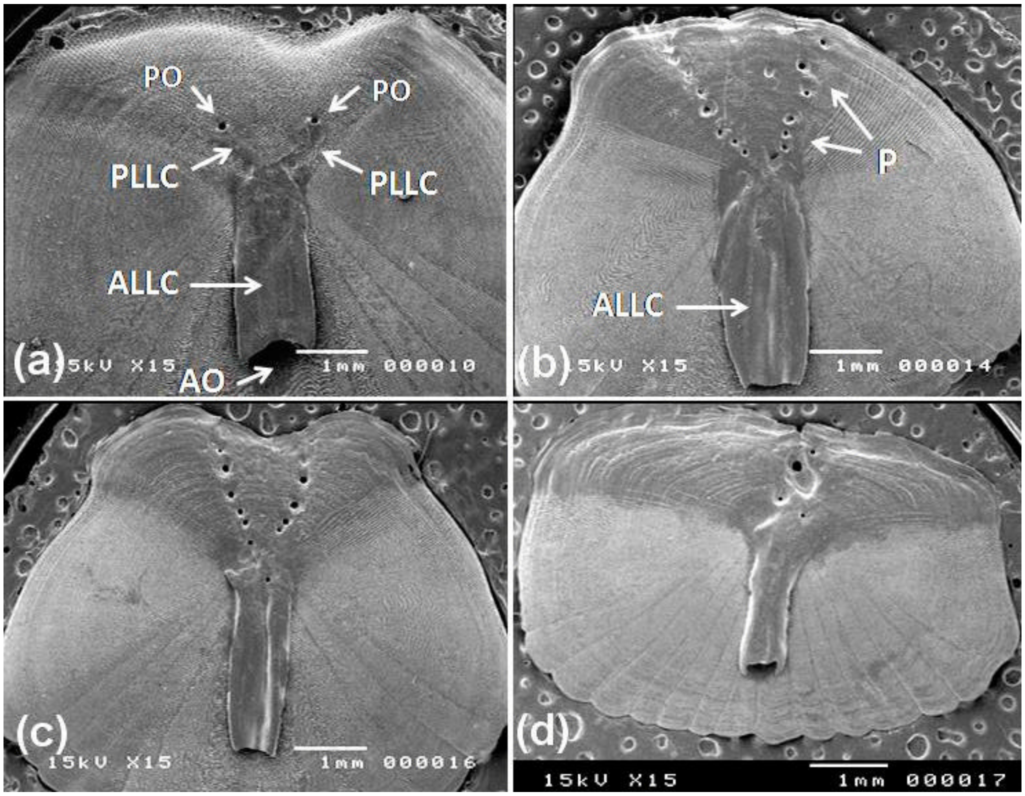

Fig. 6(a-d): Scanning electron micrographs show the characteristics of the lateral line canal of the both species considered. (a): Recorded in *A. bifasciatus*, a wide Anterior Lateral Line Canal (ALLC) with Anterior Opening (AO) and two small Posterior Lateral Line Canals (PLLC) embedded in scale matrix, with one Posterior Opening (PO) for each and (b, c and d): Recorded in anterior, middle (c) and posterior part of the lateral line scales of *R. sarba*, respectively, note that (in b and c) several pores (P) arranged in two rows having V-like shape

of the scales of both species studied is parallel to the anteroposterior axis of the scale (straight) and the anterior opening is hidden by a cap-like projection cantilevered over it. The anteriorly projecting cap-like extensions are adorned by two forward-projecting spines from the antero-dorsal and antero-ventral corners of the cover.

DISCUSSION

Many authors have been studied the stability of surface structure and surface ornamentation of the rostral and caudal field of scales (Mekkawy, 1980; Khalil *et al*., 1982; Lippitsch, 1993; Mekkawy *et al*., 2003, 2006, 2011; Jawad, 2005; Mahmoud *et al*., 2005; Harabawy *et al*., 2007, 2012; Reza *et al*., 2009; Matondo *et al*., 2010; Esmaeili and Gholami, 2011; Dapar *et al*., 2012; Ganzon *et al*., 2012). These studies investigated the potential of scale and squamation characters of some teleosts species revealing a wide spectrum of unexplained useful characters. In the present work, it was noted that, in spite of the fact that *A. bifasciatus* and *R. sarba* are reef-associated and inhabit shallow coastal waters mainly aroreefs and were subjected to various environmental factors, their size-free scale characters and ornamentation were stable. Hence, one can conclude that the impacts of such factors were omitted and the size-free fixed scale characters are expressions of their divergent evolution. Moreover, these structures were not controlled by the environmental factors. It is concluded that the intraspecific and intergeneric variations were considered to be genetically controlled. The genetically fixed scale characters would not appear to be subjected to strong selectional pressures in spite of their functional significance as referred by Burdak (1979) and Sire (1986). These findings were emphasized by results of Lippitsch (1991), Mekkawy *et al*. (1999, 2003) and Harabawy (2002). The results of the present work reflected the stability of the surface structures of rostral and caudal field of scales of *A. bifasciatus* and *R. sarba*. This stability may provide useful criteria for systematic purposes in other teleosts (Lippitsch, 1993; Mekkawy *et al*., 1999, 2003; Mahmoud *et al*., 2005; Harabawy *et al*., 2007, 2012; Reza *et al*., 2009; Matondo *et al*., 2010; Esmaeili and Gholami, 2011; Dapar *et al*., 2012; Ganzon *et al*., 2012).

In the present study, intraspecific variations were reflected on the bases of quantitative scale characters in terms of the size-free morphometric indices of the scales from different body regions. Mekkawy *et al.* (1999, 2006, 2011), Mahmoud *et al.* (2005), Mekkawy and Abdel-Rahman (2005) and Harabawy *et al.* (2007, 2012) used similar morphometric characteristics of scales for identification of some teleosts.

The presence of primary, secondary, and tertiary radii is considered as a growth phenomenon. It is weakly influenced by genetic factors (Lippitsch, 1990). The better nutritive conditions of the fish may be correlated with the higher number of radii (Tandon and Johal, 1996). Radii represent the line of scale flexibility (Esmaeili and Gholami, 2011). There is no significant correlation between number of radii and fish size and consequently were size free for the both species considered in the present work. The patterns of distribution of such size-free counts in scales of *A. bifasciatus* and *R. sarba* revealed significant intraspecific and intergeneric variations. Although, the number of radii may be correlated to fish size in some teleosts such as *Mullus surmuletus* and *M. barbatus*, the number of radii may remains constant on a given scale during ontogeny as recorded in greater lizard fish (Jawad and Al-Jufaili, 2007).

Ganzon *et al.,* 2012 stated that the environment is recognized as a powerful force in modeling the morphology of an organism during ontogeny. The epidermal cover of the two species studied, *A. bifasciatus* and *R. sarba*, like other swimming fishes undergo friction forces due to water flow in coral reefs habitats. So, one can speculate that the interradial circuli with their denticles and those of lateral fields may play an important role to offer a resistance to these frictional forces by mechanical anchoring. This statement could be generalized for reef fishes.

The present study revealed that the shape of the first interradial circuli was convex, straight, or concave. Such variations in shape are characteristic for different species (Lippitsch, 1993; Mahmoud *et al*., 2005; Mekkawy *et al*., 2006, 2011 and Harabawy *et al*., 2012); but in some cases may be modified by external factors (Lippitsch, 1990).

The results of the present work revealed that all denticles on the interradial circuli were oriented posteriorly towards the scalar focus, while those foon the inner lateral circuli are slightly oriented towards the scale center. This means that the denticles have multi directions and hence, may be involved in the mechanical anchoring of the scale into the covering dermis to prevent the movement or detachment of the scale (Lippitsch, 1992; Mahmoud *et al*., 2005; Mekkawy *et al*., 2006, 2011; Harabawy *et al*., 2012). Jawad (2005) stated that the small-sized processes located on the circuli cannot anchor the scale in the dermis as securely as can the well-developed denticles but may be anchored in the surrounding tissue by the bundles of collagen fibers connecting the upper part of the scale to the overlying dermis (Zylberberg and Meunier, 1981). These denticles are not homologous to breeding tubercles and contact organs (Esmaeili and Niknejad, 2007).

The pattern of granulation of the caudal field including shape and size of segments and ctenii if present and overall caudal field of the scales of *A. bifasciatus* and *R. sarba* were constant with fish size. A large degree of morphological variations between the two genera of the same family (Sparidae) were evident. A complete change in morphology for several species outside the family was evident (Mahmoud *et al*., 2005; Mekkawy *et al*., 2006; Harabawy *et al*., 2007, 2012). Such findings emphasized on the importance of the caudal field of scales as a taxonomic character not only at the level of species or genera but also at family level (DeLamater and Courtenay, 1974; Mekkawy *et al*., 1999, 2003, 2006; Mahmoud *et al*., 2005; Harabawy *et al*., 2007, 2012).

The anterior opening of the lateral line canal of *A. bifasciatus* and *R. sarba* studied is hidden by an evelike extension cantilevered over it. The anterior opening is wider than the posterior one. The cantilevered anterior extension of the canal may help in detection of water motion speed and direction (Delamater and Courtenay, 1973). A wide range of various structural patterns of lateral line canal was recorded in different teleost species by many authors (e.g., Mekkawy *et al*., 1999, 2003; Mahmoud *et al*., 2005 and Harabawy *et al*., 2007, 2012). Its form was ranged from a simple perforation to a long canal with or without simple to highly complex cantilevered extensions acting as covers for the anterior opening. Also, it may be a complex branched canal (Harabawy *et al*., 2007). On the other hand, no definite structural lateral line canal was recorded in *Epinephelus* and *Cephalopholis* species and *variola louti*, since such canals are formed as result of special arrangement of body scales to appear as a false lateral line canal (Mekkawy *et al*., 1999, 2006).

Among the scale characteristics that were used in the present study to differentiate between the two species studied, *A. bifasciatus* and *R. sarba*, are the unique form of the lateral line canal. Variations in the shape and position of the anterior and posterior openings of the lateral line canal reflect its importance to differentiate between some fish species belonging to the same genus or different genera. Also, it may be important in identification of groups (orders, families, genera and species) especially when combined with other equally impressive characters of scale structure (DeLamater and Courtenay, 1974; Harabawy *et al.*, 2007, 2012).

In conclusion, the qualitative and quantitative (morphometrics and radii counts) characters of the scales exhibit a lot of species-specific characters for *A. bifasciatus* and *R. sarba*. These characteristics may be genetically fixed and more stable. In contrast, Mahmoud *et al.* (2005) and Harabawy *et al.* (2007) have fothat the qualitative characters are more valid than the morphometric ones in species identification. These authors stated that the qualitative scale characters are genetically fixed and more stable than the quantitative ones.

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