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On Some Cases of Fish Anomalies in Fishes from the Port of Jubail, Saudi Arabia, Arabian Gulf

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Abstract Cases of deformities in the operculum, dorsal fin and cases of albinism, color disorder and hyperostosis were observed and examined in fish samples collected from the Jubail City, Saudi Arabia. An attempt was made in this study to find a possible relationship between these anomalies and several types of pollutants presents in the environment. The assessment of abnormalities was carried out by their diagnosis morphologically. All cases were not fatal as they occurred in adult individuals. The possible causes for such deformities as well as the suitability of this kind of study for environmental monitoring are discussed. Further studies are needed to relate specific pollutants with the observed types of deformities.

Keywords Deformities; Operculum; Fins; Albinism; Color disorder; Hyperostosis

Introduction

Since the 16th century, the anomalous fish specimens were attracted the attention of scholars (Berra and Au, 1981), since then enormous amount of literature has been added to the world data bases on the subject of fish abnormalities in fish species in both aquaculture and wild (Boglione et al., 2006; Jawad and Hosie, 2007; Jawad and Öktoner, 2007; Koumoundouros, 2008; Jawad and Al Mamry, 2012; Rutkayová et al., 2016; Jawad et al., 2016).

The first mentioned about pughead deformity was in 1929, when Gudger (1928) suggested that the French naturalist Pierre Belon in 1554 was the first to publish the first figure of a pughead deformity in female salmonid female fish. On the other hand, Buckland (1877) is believed to have published the earliest account on this case of abnormality in salmonids. Large number of publications have appeared to report on this condition in different species of fish (Hickey et al., 1977; Shariff et al., 1986; Al-Hassan, 1988; Jawad and Hosie, 2007; Macieira and Joyeux, 2007; Jawad et al., 2014; Jawad et al., 2015). Pughead deformity is an abnormal osteological condition that results in the aberration of the maxilla, premaxilla, or infraorbital bones, with variable degrees of severity (Hickey, 1972). The affected specimens often show bulging eyeballs, acutely steep foreheads, and incomplete closure of the mouth (Shariff et al., 1986). The pughead abnormality is generally rare in wild populations, and the majority of documented instances have been based on single specimens (Dahlberg, 1970; Berra and Au, 1981).

Operculum deformities are part of the cranial anomalies affected several bones in the front part of the fish skull. Such abnormality is common in aquaculture stock and may reach to 80% of the reared individuals (Koumoundouros, 2010). On contrary it is rare in the wild (Divanach et al., 1996). Anatomically, operculum anomalies are related to inside or outside folding, shortening or abnormal positioning of the opercular and subopercular bones, both bilaterally or monolaterally (Verhaegen et al., 2007; Fernandez et al., 2008). This abnormality develops during the pre-flexion and flexion stage (Koumoundouros, 2010). Opercular plate reduction or folding leaves the branchial arches more exposed to injuries or parasites, so affecting the health status of affected fish (Boglione et al., 2013).

Fin anomalies in general are extremely well documented in both wild and reared fish (Divanach et al., 1996), but those of the dorsal fin are not adequately reported (Hussain, 1979). Dorsal fin anomalies usually involved in the saddleback syndrome (Sfakianakis et al., 2003; Al-Mamry et al., 2010; Jawad and AL-Mamry, 2012).

Productive growth in the bone tissue known as hyperostosis, which characterized by an increase of the periosteal ossification combined with resorption of the bony tissue (Meunier et al., 2010). This type of anomaly is known for the first time as “os vormianum” by Worm in 1655 (Schlüter et al., 1992) and later on it was described by Grabda (1982) as “like cystic growths”. In fishes, hyperostosis occurs in specific bones such as skulls, clavicular, and hemal and neural spines (Smith-Vaniz et al., 1995). It has been reported from a wide range of fish species belonging to about 22 (Smith-Vaniz et al., 1995; Smith-Vaniz and Carpenter, 2007; Rapisarda et al., 2008; Meunier et al., 2010; Giarratana et al., 2012). One of the usage of hyperostosis is in the identification between closely related species (Yasuda and Mizuguchi, 1969).

Due to hereditary causes that resulted in an enzyme disorder that control the metabolism of melanin, lack of pigmentation happened in the cells and this case is known as albinism (Kinnear et al., 1985). The incidence of albinism can be: complete or total albinism, which is due to a lack of skin pigmentation; incomplete, where absence of melanin pigments from parts of the fish body; imperfect, which is recognized by reduced or diluted pigmentation from skin and partial albinism known when pigmentation that is reduced or absent from localized portions of skin (Berdeen and Otis, 2011). These forms of albinism were reported from several species of teleost fishes (e.g., Shinohara and Amaoka, 1993; Delgado et al., 2009; Mansur, 2011; Pillai and Somvanshi, 2011), as well as among chondrichthyans (Reum et al., 2008; Veena et al., 2011; Bigman et al., 2015).

Disturbance of melanophore order will lead to skin pigment anomalies both in wild or farming conditions. Such changes cause either partial or hyperpigmentations. The former is characterised by the presence of few dark spots in different parts of the fish body, while the latter is distinguished by the occurrence of focal or generalised spots, patches or bands of dark coloration (Groff, 2001).

The 5 types of aberrations were reported in some parts of the northwest Indian Ocean are such as Sea of Oman and Arabian Gulf (Jawad and Hosie, 2007; Almatar and Chen, 2010; Al-Mamry et al., 2010; Jawad, 2013; Jawad et al., 2013). No previous such abnormalities reports on any fish species on record from the Arabian Gulf coasts of Saudi Arabia. Therefore, the aim of the present study are: (1) to report for the first time several skeletal deformities observed in fishes from Saudi Arabia; (2) to describe these anomalies and compare them with those of the normal individuals.

1 Materials and Methods

One specimen of the families Labridae, *Bodianus macrognathus* showed pughead anomaly; Lethrinidae, *Lethrinus nebulosus*; Soleidae, *Euryglossa orientalis*; Scatophagidae, *Scatophagus argus*; and Haemulidae, *Diagramma pictum* have showed pughead, operculum, dorsal fin, albinism and color disorder anomalies respectively. Two specimens of the families, Sparidae, *Argyrops spinifer* and Carangidae, *Alepes vari* have showed hyperostosis abnormality. Fishes were captured on 11th March 2016 in the waters of Jubail City, Saudi Arabia. The specimens were collected by local fishermen using drifting gill net. Body and fins were examined carefully for external parasites, malformations, amputations and any other morphological anomalies. Specimen of *A. vari* was dissected to show the shape of the hyperostotic bones. The specimens were deposited in the fish collection of the Fish Welfare Branch, Jubail, Saudi Arabia. Once in the laboratory, measurements were recorded to the nearest millimetre.

2 Results

Pughead deformity

Family: Labridae

Bodianus macrognathus, 450 mm TL, 443 mm SL (Figure 1; Figure 2).

The pug-headed specimen had, 83 mm preorbital length. This specimen is compared to normal fish having 475 mm total length, 464 mm standard length, 93 mm preorbital length. The abnormal specimens were shown to have, short neurocranium, presence of thick turned up premaxilla equipped with thick and sharp 4 teeth and a normal lower jaw. The mouth was partially open when we obtained the fish, which means that the deformity has not affected the mechanism of opening and shutting the mouth. The shortening of the snout had brought the steep forehead and the posterior nostril close to the eye and deformed the anterior nostril (Figures 1; Figure 2). It looks that all the bones anterior to the orbit were deformed and curved downward perpendicularly toward the mouth cavity. For these reasons, the forehead is upraised and steep. No other morphological deformities were observed.



Figure 1 *Bodianus macrognathus*, 450 mm TL, 443 mm SL, side view



Figure 2 *Bodianus macrognathus*, 450 mm TL, 443 mm SL, front view

Operculum deformity

Family: Lethrinidae

Lethrinus nebulosus, 2 specimens, 354, 356 mm TL, 344, 345 mm SL (Figure 3A; Figure 3B).

The specimen shown in Figure 3A has lost the lower part of the operculum and the whole suboperculum bones. The interoperculum bone appeared to be thinner than that in the normal specimen. Branchiostegal rays were normal. The specimen shown in Figure 3B, appeared mild deformity of the operculum, where the posterior dorsal and posterior ventral margins of the operculum were deformed and appeared not covering the gill's chamber. No other anomalies were noticed.



Figure 3 *Lethrinus nebulosus*, A: abnormal specimen, 354 mm TL, 344 mm SL; B: normal specimen, 356 mm TL, 345 mm SL

Dorsal fin deformity

Family: Soleidae

Euryglossa orientalis, 245 mm TL (Figure 4)

The dorsal fin of this specimen showed a deformed middle soft rays. The rays appeared clumped together, displaced and shorter than the normal rays in the anterior and posterior parts of the fin. The deformed area showed to be curved and extended ventrally toward the base of the fin, but did not affect the dorsal side of the body. All other fins were normal and no other abnormalities were shown.



Figure 4 *Euryglossa orientalis*, 245 mm TL

Hyperostosis deformity

Family: Sparidae, *Argyrops spinifer*, 467 mm TL, 455 mm SL (Figure 5)

This specimen showed hyperostotic deformity, where the whole supraoccipital crest showed to be swollen having a size of 200 × 50 mm. The hyperostotic area looks like a dome with a distance of 270 mm from the posterior edge of the orbit. The sides of the hyperostotic area are all covered with scales, which appeared to be dispersed and larger in size than those scales found below the affected area. A narrow strip of skin with disturbing and missing scales running from the base of the hyperostotic dome and down to just dorsal to the upper edge of the orbit was observed.



Figure 5 *Argyrops spinifer*, 467 mm TL, 455 mm SL

Family: Carangidae

Alepes vari, 470, 465 mm TL, 462, 456 mm SL (Figures 6; Figure 7)

The specimen shown in Figure 7 has 3 hyperostosis in the neural spine of the 6th - 8th caudal vertebrae. The hyperostotic bones have oval shape with 20 × 15 mm dimensions. No other hyperostotic bones were noticed and no other morphological anomalies have seen too. The specimen in Figure 8 has hyperostosis in the neural and hemal spines of the 6th - 10th caudal vertebrae with size ranging 20 × 12 mm to 30 × 20 mm. Those hyperostotic bones on the 7th - 9th caudal vertebrae were the largest of the hyperostotic bones examined. No other bones showed such anomalies and further deformities in the fish body were revealed.



Figure 6 *Alepes vari*, 470 mm TL, 462 mm SL



Figure 7 *Alepes vari*, 465 mm TL, 456 mm SL

Color deformities

Albinism

Family: Scatophagidae

Scatophagus argus, 243 mm TL, 234 mm SL (Figure 8)

The specimen in this category showed incomplete albinism in term of the disappearance of the melanophores was incomplete and still the natural color of the fish showing underneath a sheen of white coloration. The dark spots that normally distributed on the body of the fish and the part of the yellow coloration are evident on the body of the fish. No other anomalies were accompanied this case of partial albinism.



Figure 8 *Scatophagus argus*, 243 mm TL, 234 mm SL

Partial melanic pigmentation

Family: Haemulidae

Diagramma pictum, normal specimen, 385 mm TL, 374 mm SL; abnormal specimen 383 mm TL, 371 mm SL (Figure 9A; Figure 9B)



Figure 9 *Diagramma pictum*; A: normal specimen, 385 mm TL, 374 mm SL; B: abnormal specimen 383 mm TL, 371 mm SL

The specimen of *D. pictum* showed partial melanic pigmentation. There are 4 and 6 dark large and small patches respectively on the body of the fish. The large patches were located under the spinous part of the dorsal fin, while

the small patches dispersed anteriorly from just under the spinous part of the dorsal fin and extended posteriorly to underneath the soft part of the dorsal fin, and dorsally from base of the dorsal fin and just below the lateral line, where one patch is present. The areas around the orbit and the ventral surface of the lower jaw showed to have dark patches. No other anomalies were observed in the body of the fish.

3 Discussion

Six different types of fish abnormalities were investigated in the present, where it is the time to be reported for the examined species from the Arabian Gulf in general and the Saudi Arabian waters in particular. It designed to diagnose skeletal deformities in the specimens of studied species and found a probable connection between these deformities and several types of environmental disturbs such as pollutants.

There is a considerable amount of literature on wild fish anomalies in the present time (Divananch et al., 1996; Jawad et al., 2013; Jawad and Liu, 2015) that describes the causes of different deformities. They include both genetic (Ishikawa, 1990) and epigenetic factors as a possible source of such aberrations (Fjellidal et al., 2009), as well as environmental factors such as temperature, light, salinity, pH, low oxygen concentrations, inadequate hydrodynamic conditions and parasites (Chatain, 1994; Gavaia et al., 2009).

The severe case of pughead deformity observed in *B. macrognathus* can be classified as the tertiary stages on the system Hickey et al. (1977). The present case is similar to those reported from several fish species by different authors around the world (AL-Hassan, 1988; Jawad and Hosie, 2007; Macieira and Joyeux, 2007; Francini-Filho and Amado-Filho, 2013; Jawad et al., 2014; Schmitt and Orth, 2015; Jawad et al., 2015; Sawayama and Takagi, 2016).

The displacement of the posterior part of the skull in this specimen might have a direct effect on the brain. Since the preorbital area was reduced very much and the nasal openings were displaced and deformed, the nasal organs and probably the olfactory nerve might lost. Dissection of the skull to study the brain is required to reveal the damages that might occurred to the brain due to the pughead deformity. Similar anomaly was reported in the historical case observed by Yung (1901) on small specimen of salmon species obtained from France.

The effect of pughead can be seen in the inability of the fish to breathe and feed, which in turn became unable to compete for obtaining food have a debilitating effect on the fish's ability to breathe and feed (Bortone, 1972). This hypothesis cannot apply in this case as the specimen has no obvious signs of poor health, so feeding was obviously unrestricted. With the present state of the mouth and the presence of the strong sharp teeth, the fish may have sort of plasticity and change in its feeding menu to fit the deformity in its mouth as other fish species do (Maitipe and De Silva, 1985; de Moor and Bruton, 1988). Escaping from the predators was also not likely deterred by the observed abnormality, because the body of the deformed fishes were robust inferring the ability to have a quick move when potential predators appear.

The causes of the observed pughead anomaly in the specimen examined are unknown, but they probably arise during early development (Cobcroft et al., 2001). The survival rate of abnormal fish, especially during the early ontological stages in the wild, is unknown (Bueno et al., 2015). To determine the overall incidence and effect of these abnormalities, survival throughout development, larva through adult, must be considered. Genetic and epigenetic factors such as mutations or recombination of genes and exposure to contaminants such as cadmium, zinc, lead, mercury could cause pughead deformity (Dahlberg, 1970; Sloof, 1982).

Koumoundouros et al. (1997a) found that gill-cover deformity was mainly caused by an inside folding of the operculum and/or suboperculum, rarely by bone atrophy, and was frequently correlated with malformations of the branchiostegal rays. The branchiostegal rays in the present case of *L. nebulosus* were normal. Therefore, the suggestion of Koumoundouros et al. (1997b) cannot apply here. Operculum deformity has been shown to increase the sensitivity to oxygen stress and a predisposition to myxobacterial infections (Paperna et al., 1980), whereas during the larval stage their incidence has been shown to correlate negatively with the growth rate of the fish (Koumoundouros et al., 1997b).

For fishes, dorsal fin is important in locomotion and stability (Drucker and Lauder, 2005; Standen and Lauder, 2005); therefore it must be structured so as to face the hydrodynamic stresses with the least possible disbursement of energy (Boglione et al., 1993). Any anomaly in the dorsal fin will weaken its flexibility, so obstructing the swimming function of the fish. Combination of genome, environment and developmental noise can produce dorsal fin deformities (Scheiner, 1993). In the present case of dorsal fin aberration in *Euryglossa orientalis*, it is impossible to support the biotic and abiotic hypotheses in causing such anomalies without additional data.

Hyperostosis is present in several groups of vertebrates, including fishes (Capasso, 2005), where it has been used by archeologists and fish systematists as a diagnostic criterion and as a taxonomical tool, respectively.

Several authors have considered hyperostosis as a non-pathological formation (Olsen, 1971; Desse et al., 1981; Gauldie and Czochanska, 1990; Smith-Vaniz et al., 1995), but there is an acceptable reason to not consider hyperostosis as a pathological condition is that it is a species-specific characteristic. Furthermore, the foreseeable ontogenetic manifestation of these structures in fish species contradicts the hypothesis that it is a disease.

The size, shape, and position of the hyperostotic bones revealed in the two fish species reported on herein are comparable with those given by Smith-Vaniz et al. (1995). The results of this study support this suggestion. The shapes of the hyperostotic bones revealed in the present study are not distinctive from one another. Since only a single specimen was obtained for each of the two Saudi species, it is not possible to test the hypothesis of Capasso (2005) in correlating fish size (total length and weight) and number of hyperostotic bones found in each specimen to increase body weight to facilitate bottom browsing.

When genetic disorder happened, albinism may generated in conjunction with environmental factors such as the exposure to high concentrations of trace metals (Oliveira and Foresti, 1996) as these metals have the ability to create a genetic random alteration (Wakida-Kusunoki and Amador-del-Ángel, 2013). The recessive autosomal gene will find an opportunity to produce an albino individuals lacking of melanin pigmentations.

The possibility of the trace metals as the cause for albinism in our specimen looks possible as the Arabian Gulf waters of Saudi Arabia has been shown to have high levels of trace metals due to the oil spillage from the large number of the giant oil tankers that navigate this water way (Al-Saleh and Shinwari, 2002; Al-Homaidan, 2007).

Albinism may have less influence in feeding, growth and another aspects of life, such reproduction (Joseph, 1961). Due to the considerable size of the albino specimen obtained in the present, our result agrees with Joseph (1961) and Sandoval-Castillo (2006) permits us to postulate that, despite being an albino phenotype that makes an individual more visible to predators, it can employ little impact on aspects of growth and performance of these specimens.

This is the first report of albinism in the species *S. argus* from the Arabian Gulf area in general and the Saudi Arabian waters in particular. This species of moderate commercial value and it is common in the fisheries catches, with a high number of individuals being captured for decades from the Arabian Gulf area with no previous record of albinism. This, then, is a rare event still unnoticed in most wild fish species, at least regarding adult individuals. The partial amelanic patches were appeared on the body side a location where shown to be most affected by several fish species. Such consistency in the location of the patches might be due to the manoeuvring of the genes of the melanocortin system or of their products will have significant effects on a set of characters species. Slominski et al. (2000) found that the level of activity of the different melanocortins is correlated across tissues. Other studies indicated that with the aid of neuroendocrine communication, the activity of the melanocortin system can be locally regulated and coordinated (Slominski and Wortsman, 2000; Slominski, 2005; Zbytek et al., 2006) and such manipulation could vary between tissue of the fish body (Hoglund et al., 2000).

For Saudi Arabia as for other Arabian Gulf states, the fisheries industry is very important from both social and economic perspectives. Management and monitoring of many commercial fish species are still in need by the relevant fisheries agencies. In order to understand the exact cause and impacts of the fish aberration examined in

the present study further researches are needed to study the variability of the anomalies discussed in the present study in both juvenile and adult commercial fish species in different locations and years, taking into consideration the mortalities that related to these anomalies. Through the experiments, it is important to identify the specific mechanism(s) responsible for this deformity, whether the causes are genetic or epigenetic.

Authors' contributions

Both authors have contributed equally toward the publication of this paper.

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