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Baseline

Bilateral asymmetry in size of otolith of *Otolithes ruber* (Bloch & Schneider, 1801) collected from the marine waters of Iraq

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ABSTRACT

The otolith length and width of adult teleost *Otolithes ruber* (Bloch & Schneider, 1801) were used to calculate the fluctuating asymmetry in these two characters. The results displayed that the amount of asymmetry of the otolith width was the highest between the two asymmetry values attained for the otolith of *O. ruber*. Further, the lowest level of asymmetry in the two otolith characters is at the fish length ranging between 150 and 180 mm and the highest at the fish length ranging between 461 and 2490 mm. The conceivable reason for the asymmetry in this species has been deliberated relative to different pollutants and their presence in the area. A tendency of increase in the asymmetry levels with the fish length was observed for the otolith length and width.

Tigertooth croaker, *Otolithes ruber* (Bloch & Schneider, 1801) (Sciaenidae) is a demersal species dispersed in tropical, subtropical and temperate seas, comprising the Persian Gulf, Oman Sea, Indian and Pacific Oceans, China and the Malayan archipelago (Brash and Fennessy, 2005). *Otolithes ruber* inhabits in shallow coastal area down to a depth of 40 m (Fischer and Bianchi, 1984). This species is usually collected along in the marine waters of Iraq using different fishing gears such as pots, gillnets, hooks, lines and trawls. *Otolithes ruber* is a highly valuable commercial species in all the locations along its geographical distribution range (Sasaki, 1996).

Whereas biodiversity investigations and checking means are skilled to reveal fluctuations in both community structures and species levels, they frequently need a remarkable time frame and enormous input of pains. Hence, the analysis of bilateral asymmetry has a number of benefits over more customary environmental checking methods; it is reasonable, low-cost and needs no skilled labour to attain. The latter advantages are particularly suitable for environmental monitoring programs in Iraq where technical and personal scientific skills are limited (Mabrouk et al., 2014; Elie and Girard, 2014).

In general, the association between fish morphology and fluctuating asymmetry has been investigated for adult fishes, and a number of traits have been examined, including the number of gill rakers, pectoral fin rays, fish body proportions, eye spot area, or otolith size and shape (Al-Hassan et al., 1990; Somarakis et al., 1997; Øxnevad et al., 2002; Gonçalves et al., 2002; Jawad, 2003, 2004).

Fluctuating asymmetry studies were never attained for the otolith width or length of Tigertooth croaker from the Iraqi waters or from other localities in its distributional range. Therefore, the objective of the present study is to reveal the level of bilateral asymmetry in both length and width of the otolith of the Tigertooth croaker collected from the Iraqi marine waters and to subsequently employ those characters showing the highest levels of bilateral asymmetry in more unconventional investigations.

The Iraq marine coastal area contains the estuary of the Shatt Al-Arab River at the city of Fao, Khor Abdulla, Khor al-Zubair and Um Qasar regions (Fig. 1). The geological history, temporal and geographical positions at the top of the Persian Gulf, and the physiographical complexity have helped shape the character of Iraqi marine biodiversity (Jawad, 2016). At the time of the Mesopotamian Civilization (3, 000 years B.C.), the shore line was located further north near Basrah where the river opened into the Persian Gulf. Part of the old river channel is now the present inlet between Khor al-Zubair and Um Qasar. The Shatt al-Arab delta is a contribution of the Karun River and the two major Mesopotamian Rivers (Purser et al., 1982; Baltzer and Hurser, 1990). Together, they narrowed the depression south of Basrah and contributed to the recent south eastward development of the Shatt al-Arab delta. The western side of the Iraqi coastal area has become a navigational area, with a length of 40 km, a width of 600–800 m, and a depth of up to 22 m.

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It has a semi-diurnal tidal rhythm with amplitude ranging within 5 m. This region contains a group of important Iraqi ports. The climate and hydrology of the lower Mesopotamian plain, which includes the coastal area were fully designated by Purser et al. (1982) and Al-Azzawi (1986). Prior to the end of the 20th century, the discharge rate of the Tigris ranged from 3000 $m^3 \cdot sec^{-1}$ to less than 500 $m^3 \cdot sec^{-1}$, while that of the Euphrates ranged from 2000 $m^3 \cdot sec^{-1}$ to less than 250 $m^3 \cdot sec^{-1}$, thus accounting for the variations in T.D.S. (total dissolved salt) of the rivers' waters (0.4 to 0.75‰ or $g \cdot l^{-1}$) (Jawad, 2016).

The Persian Gulf has about 800 offshore oil and gas platforms and 25 major oil terminals (Al-Saad and Salman, 2012). This Gulf is also tremendously busy shipping line for oil transports, with accidental spilling being unavoidable. About 25,000 tanker movements sail in and out of the Strait of Hormuz annually and transport about 60% of all the oil carried by ships. In combination, these sources provide on a long-term a kind of input source of petroleum (Kirby and Law, 2008). In addition, about two million barrels of oil are spilled annually from the routine discharge of dirty ballast waters and tank washing, partly due to the lack of shore reception facilities. Some major spills, either unintentional or as consequence of military activities, have added occasional dramatic pulses of oil contamination to long-term background (Ehrhardt and DouAbul, 1989; Price et al., 1993).

The late 1978 has marked the appearance of early publication on the pollution in the Persian Gulf (Oostdam and Anderlini, 1978) who performed their studies on the incidences of oil spills on the shores of Kuwait. Later, Oostdam (1980) assessed volume off oil slick in the Gulf, while Anderlini and Al-Hamri (1979) studied the slick dispersal patterns and Burns et al. (1982) estimated the average quantities of tar in the beaches at the Strait of Hormuz. Burns et al. (1982). Badawy et al. (1985) gave the mean constrictions of hydrocarbons in oyster collected from Kuwait, Bahrain and Oman.

Iraq's environment has been subject to a number of converging pressures stemming from population growth, the impact of three wars, climate change, poor land use planning, and encroachment on fragile ecosystems (World Bank, 2017). Iraq faces serious environmental problems, ranging from poor water quality, soil salinity, air pollution, and pollution with all kinds of materials to the deterioration of key ecosystems, climate change impacts and threat of water shortages

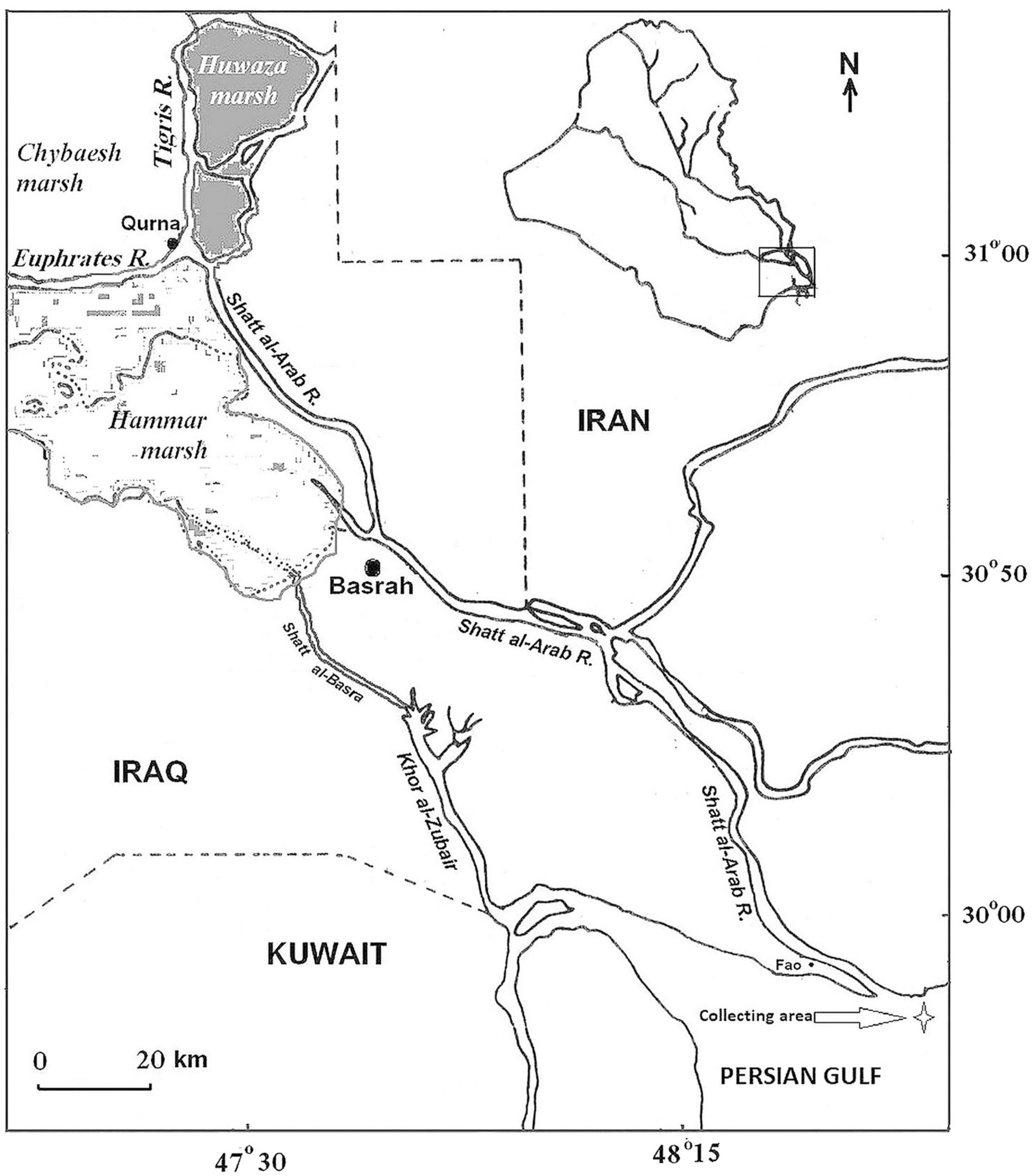

Fig. 1. Map showing the sampling area of *Otolithes ruber*.

(Price, 2018).

In Iraq, water pollution in general and the marine water pollution in particular started in early 1980s. For marine waters, such studies were concentrated on Iraqi Coasts of the Persian Gulf such Khor Zubair, Shatt Al-Arab estuary, Shatt AlBasrah and the marine water proper region. Most of the coastal areas are under development and water in these areas received pollutants from water discharge by boats and ships, marine transportation and ballast water discharges. While, wastewater, industrial and agricultural discharges and dredging are another sources of pollutant in this coastal area. These activities along the Iraqi coasts have caused this area to be exposed to different kinds of pollutants especially heavy metals. (Khwedim et al., 2009; Raaheem, 2009).

Fish specimens of *Otolithes ruber* (120) (Fig. 2) were collected using small trawler (21 m length × 3.5 m width) equipped with net of mesh size 2.5 cm operating at from the Khor Abdullah at the south extent of the marine waters of Iraq. Collection was made in the period February–September 2017 at depth of 10–25 m. Sagittae from both sides of the fish head were dissected out from the sacculus part of the fish inner ear. Fish samples range 150–466 mm TL. Otolith length and width were measured to nearest millimetre under dissecting microscope (Fig. 3). The characters selected for bilateral asymmetry analysis were formerly used in fish studies (Al-Rasady et al., 2010; Jawad et al., 2012; El-Regal et al., 2016). Asymmetry in the otolith length and width is aimed to be study in the fish species in question. In the present study fluctuating asymmetry was not correlated with sex because asymmetries develop in the early life stages, when larvae sex cannot be recognized. The asymmetries cannot be removed by further growth as they are insistent and thus become a problematic for an individual throughout its life.

The statistical analysis was based on the squared coefficient of asymmetry variation (CV^2_a) for the two otolith dimensions according to Valentine et al. (1973)

$$CV^2_a = (S_{r-1} \times 100/X_{r+1})^2$$

where S_{r-1} is the standard deviation of signed differences and X_{r+1} is the mean of the character, which is calculated by adding the absolute scores for both sides and dividing by the sample size. The vicinity of southern part of the Iraqi marine waters was chosen as it embodies one of the main fishing grounds for the species in question in Iraq and asymmetry study for *O. ruber* is significant to the effect of this phenomenon on the settlement of the larvae of this species in this important fishing ground. Bilateral asymmetry values and measurement errors are in best cases small and normally distributed around a mean of zero (Merilä and Björklund, 1995). Personal error in taking measurements can interrupt the results of bilateral asymmetry analysis, leaving it undistinguishable (Palmer, 1994). Consequently, in the present study, all the measurements were achieved by only one person to avoid any unwanted error (Lee and Lysak, 1990), and were repeated twice. Coefficients of asymmetry were compared between the different total length classes using ANOVA test.

Fig. 2. Specimen of *Otolithes ruber*, 355 mm TL collected from the marine waters of Iraq.

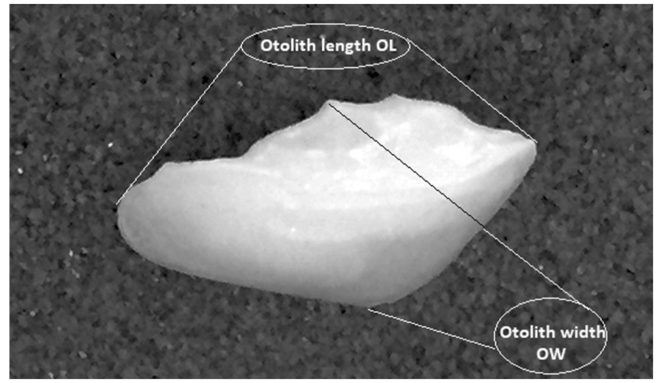

Fig. 3. Otolith of *Otolithes ruber*, 234 mm TL showing the length and width of the otolith.

The results of asymmetry analysis of the data of the otolith length and width of *O. ruber* collected from the marine waters of Iraq are shown in Table 1. The results exhibited that the amount of asymmetry of the otolith width was the highest among the two asymmetry values obtained for the otolith of *O. ruber*. For the two otolith characters investigated in the present work, the results showed that the level of asymmetry at its lowest and highest values in fish ranging in length between 150–180 mm and 451–480 mm respectively.

The percentage of the individuals display asymmetry in the otolith width character was the highest among the percentages obtained for the two otolith characters (Table 1). Individuals of *O. ruber* were grouped into length classes (Table 2). A tendency of escalation in the asymmetry values with the increase of the fish length was observed in the length and width of the otolith studied.

There is some disparity in the asymmetry values among the two morphological characters of the otolith of *O. ruber*. In the present time, it is difficult to assess the level of asymmetry of those traits and to decide if they are higher or lower than the typical due to the absence of data concerning natural asymmetry in this part of the world. Though, character like otolith width displayed higher asymmetry value than the otolith length character. The high asymmetry value of the otolith width might specify the susceptibility of this characteristic to the direct changes in the habitat. It is not likely at this stage to approve such outcome as the correlation between diverse environmental pollution and the morphology of the fish species in question is not accessible. But, based on preceding studies in this field, it is possible to conclude that there is a straightforward correlation between environmental strains owing to pollution and asymmetry in this species. These environmental factors are present in the marine waters of Iraq. Contrarily, the low asymmetry value showed by the otolith length trait might be elucidated on the basis that this character is less susceptible to environmental strains. Jawad (2003) proposed that the lower bilateral asymmetry level attained for otolith length may be explained on the basis that the

Table 1
Squared coefficient of asymmetry (CV^2_a) value and character means (X_{r+1}) of *Otolithes ruber* collected from the marine waters of Iraq.

Character	CV^2_a	N	Character mean ± SD	% of individuals with asymmetry
Otolith length	39.65	120	11.35 ± 3.2	79
Otolith width	87.53	120	9.91 ± 2.1	96

Table 2
Squared coefficient of asymmetry and character means by size class of *Otolithes ruber* collected from the marine waters of Iraq.

Character	CV^2_a	N	Character mean ± SD	% of individuals with asymmetry
Otolith length				
150–180	23.5	5	11.34 ± 1.2	100
181–210	27.9	13	11.23 ± 2.2	100
211–240	29.9	10	11.22 ± 2.4	69
241–270	33.5	21	10.93 ± 1.3	98
271–300	38.7	10	10.98 ± 1.6	99
301–330	41.6	50	11.41 ± 1.9	100
331–360	47.7	10	11.74 ± 1.3	100
361–390	49.9	8	11.56 ± 2.5	84
391–420	52.4	8	11.87 ± 2.3	79
421–450	56.8	9	10.98 ± 2.1	89
451–480	78.9	6	11.23 ± 2.2	100
Otolith width				
150–180	18.2	5	9.8	90
181–210	18.9	13	9.5	100
211–240	19.6	10	9.3	89
241–270	20.9	21	9.2	98
271–300	21.6	10	9.1	100
301–330	21.9	50	8.8	100
331–360	22.1	10	8.9	87
361–390	22.5	8	8.9	94
391–420	22.8	8	9.4	99
421–450	22.9	9	9.4	99
451–480	23.0	6	9.8	100

developmental period of these characters may not correspond with the occurrence of contrasting environmental events. Diversely, slight changes throughout development can depart from normal developmental paths (Palmer and Strobeck, 1992). These improprieties may be due to the feature and quantity of food, extreme temperatures, parasites, disease and behavioral burden enforced by interactions with the related species living in the same environment (Markov, 1995).

The source and reason of asymmetry in fishes can be influenced by several factors, one of which is genetic factors that might be accountable for the asymmetry in these two.

traits, but these cannot be deliberated at this stage due to the lack of genetic data on the marine ichthyofauna of Iraq. The other likely factor is the environmental pressure which clues to an augmented level of asymmetry, but might occur at low levels before producing wide spread death (Bengtsson and Hindberg, 1985).

Pollution of sea water and sediments by hydrocarbons, heavy metals, pesticides and organic matter are considered the chief source of environmental pressure. This state of pollution is familiar for the marine waters of Iraq, where diverse pollutants were stated to disturb its water for at least in the last twenty years (Al-Jaberi and Al-Dabbas, 2014).

Abaychi and Al-Saad (1988) reported on the presence of heavy metals in a number of fishes collected from the marine waters of Iraq. Such study showed those species were exposed to high levels of pollution with heavy metals and it was possible to trace the concentration of these metals. On the other hand, Zahraw et al. (2019) have shown that the sediments of another brackish water locality, Shatt al-Basrah canal, was polluted with heavy metals. AL-Khion et al. (2016) have indicated the presence of high level of polycyclic aromatic hydrocarbons in some fishes from the Iraqi marine waters. The high concentration of these pollutants in the tissues of different species belonging to several taxonomic group means that the whole fish fauna in the marine waters of Iraq is vulnerable to pollutants and not a particular taxa. Water in the marine area of Iraq also showed high concentration of pollutants. Abdulnabi (2016) suggested that several stations inside the marine waters of Iraq have shown high concentrations of heavy metals. The stations were widely distributed (near and off shore), which designate that pollution in these metals is widely distributed and habitats in both coastal and open sea were affected.

The environmental effects could be natural happenings, and numerous aspects are identified to yield nutritional shortages such as several pathogens and various population phenomena (Bengtsson and Hindberg, 1985), and it is conceivable that these issues may be in action in the marine waters of Iraq as they seem to be shared in the aquatic habitat. Some authors have shown an association between the coefficient of asymmetry and fish length (Al-Hassan et al., 1990; Al-Hassan and Shwafi, 1997; Jawad, 2001) where there was a tendency of increase in the asymmetry estimate with the increase in fish length. As substantiated in earlier studies (Al-Mamry et al., 2011a, 2011b; Mabrouk et al., 2014), ANOVA test analysis in the current study revealed that large size specimens of *O. ruber* had higher bilateral asymmetry values than smaller young specimens ($P < 0.001$). It was clear that the amounts of fluctuating bilateral asymmetry of the length and width of the otolith increased with fish size (Table 2). This affinity is perhaps the result of deficient development; trait means are always the lowest in smaller size classes (Valentine et al., 1973). Comparable results were attained by Valentine et al. (1973) in designated fish species collected from California, U.S.A. They suggested two likely theories that may accountable for such an approach; ontogenetic variations connected to an upsurge in bilateral asymmetry with size (age), and conceivable historical events which results in a secular increase in bilateral asymmetry. Differently, Thiam (2004) acclaimed that an increasing trend in bilateral asymmetry levels with fish size could be owing to the fact that the large size individuals had longer periods of interaction to contrasting environmental settings and therefore lose their stability in such environments.

Developmental disorders resulting from chemical and organic pollution can lead to harsh morphological deformities (Elie and Girard, 2014). In the marine waters of Iraq, fish abnormalities were reported which were connected to heavy metal and organic pollution (Jawad et al., 2014, 2017).

A management strategy is instantly necessary in order to restore a healthy environment in the marine waters of Iraq. Numerous aquatic organisms within this water body have previously been critically distressed (Saeed et al., 1999).

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Experimental ethics

The animal experimental ethics approval was obtained before conducting this research.

CRediT authorship contribution statement

LAJ: design the project, analyse the data, wrote the manuscript and follow up the submission.
AMQ: Collect fish specimens, analyse the data
NAAF: Collect fish specimens, analyse the data

Declaration of competing interest

The authors declare that they have no conflicts of interest.

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