

## Investigation of asymmetry in the Sagitta of the bartail flathead *Platycephalus indicus* (Linnaeus, 1758) in the marine waters of Iraq

by

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### Abstract

In this study, 76 specimens of *Platycephalus indicus* collected from the coasts of Iraq were examined, assessing the asymmetric square coefficient of variation ( $CV^2_s$ ) among three features: the length, width, and weight of the otolith from both sides of the fish head. In the statistical analysis, the squared coefficient of fluctuating asymmetry (FA) deviation ( $CV^2_s$ ) for the three sagitta features based on Valentine et al. (1973) formula was used to assess the values of FA in the three otolith features examined. The feasible source of the FA in the sagitta features considered has been resolved relative to the discrepancy in growing driven by environmental influence accompanying with the incongruence in water temperature, salinity, depth and impurities occurring in the coasts of Iraq. The application of bilateral irregularities in otolith parameters of *P. indicus* was discussed. Future studies will incorporate the collection of otoliths FA data from additional species in the marine waters of Iraq eventually improving the consistency and exactness of niches stress estimations in this marine waters.

**Key words:** Actinopterygii, Platycephalidae, ecological factors, otolith, bartail flathead, contaminations, Arabian Gulf

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## 1. Introduction

Otoliths are calcium carbonate structures located in the auditory system of teleosts and play a crucial role in hearing and balance. The analysis of fish otolith external features is considered a focus of interest in fishery studies. These sagitta not only assist in fish recognition but additionally grant perceptions into their life record and the ecological impacts they encountered throughout their lifetime (Kennedy et al., 2002; Pannella, 1971). Fluctuating asymmetry (FA) in otoliths can disclose in what way a species acclimatizes to ecological burden and haphazard changes between bilateral appearances and absolute symmetry consequential from developing ecological variations (Clarke, 1992; Somarakis et al., 1997). This asymmetry serves as a sensitive indicator for assessing the effects of environmental stress and pollution on fish populations (Abdulsamad et al., 2020; Jawad, 2013). Whilst matched to other procedures for ecological search and recognition, sagitta asymmetry exploration poses benefits such as being cost-effective, needing a slight scientific workforce, and depicting precisely positive outcomes (Jawad et al., 2021; Mabrouk et al., 2014).

The bartail flathead, *Platycephalus indicus* (Linnaeus, 1758), is a marine fish, which occasionally occurs in brackish waters (Riede, 2004). This fish is established right through the Indo-West Pacific zone. It has also been introduced into the eastern Mediterranean Sea (Froes & Pauly, 2024). It grows up to 1000 mm in total length (Kottelat et al., 1993) and attaining regular length of around 600 mm (Knapp, 1984) and an utmost given body mass of 3.5 kg (IGFA, 2001).

Bartail flatheads dwell in sandy and muddy bottoms in coastal waters (Fischer et al., 1990; Kuitert & Onozuka, 2001). They are usually captured in the top area, and from a depth of up to 30 m (Knapp, 1999). This species is commercially substantial in its indigenous provinces (Knapp, 1986) and is sold fresh in marketplaces (Sousa & Dias, 1981).

Variations in water temperature were reported in the marine waters of Iraq by Abbas et al. (2020). The study of Abbas et al. (2020) showed that water temperature values have shown a significant variation annually. On the other hand, water salinity was studied by Lateef et al. (2020). Their study revealed a noticeable variation in the values of the water salinity in the marine waters of Iraq. Al Abdulazi et al. (2021) mentioned that the Iraqi marine waters are polluted by several pollution elements.

In this research, we accomplished an examination focusing on the sagitta external features of *P. indicus*

sampled from the northwest Arabian Gulf. The aim of this investigation is to discover the efficacy of otolith FA in its relationship with environmental pressures in the water body investigated. This was accomplished throughout the subsequent methods: (1) Evaluation of sagitta asymmetry amongst individuals of *P. indicus* collected from the investigated site; and (2) Comparison of otolith asymmetry among specimens of *P. indicus* contained by diverse fish size categories. The conclusions of this investigation not only promote to inspiring the record relating sagitta asymmetry in marine fish but also launch an effective basis for verifying the model numerical principles of sagitta asymmetry. Likewise, the analysis suggests necessary perceptions for forthcoming outdoor measures accompanied in the other marine areas of Iraq and the adjacent countries in the Arabian Gulf area, supporting the progress of related strategies and survey plans.

## 2. Materials and methods

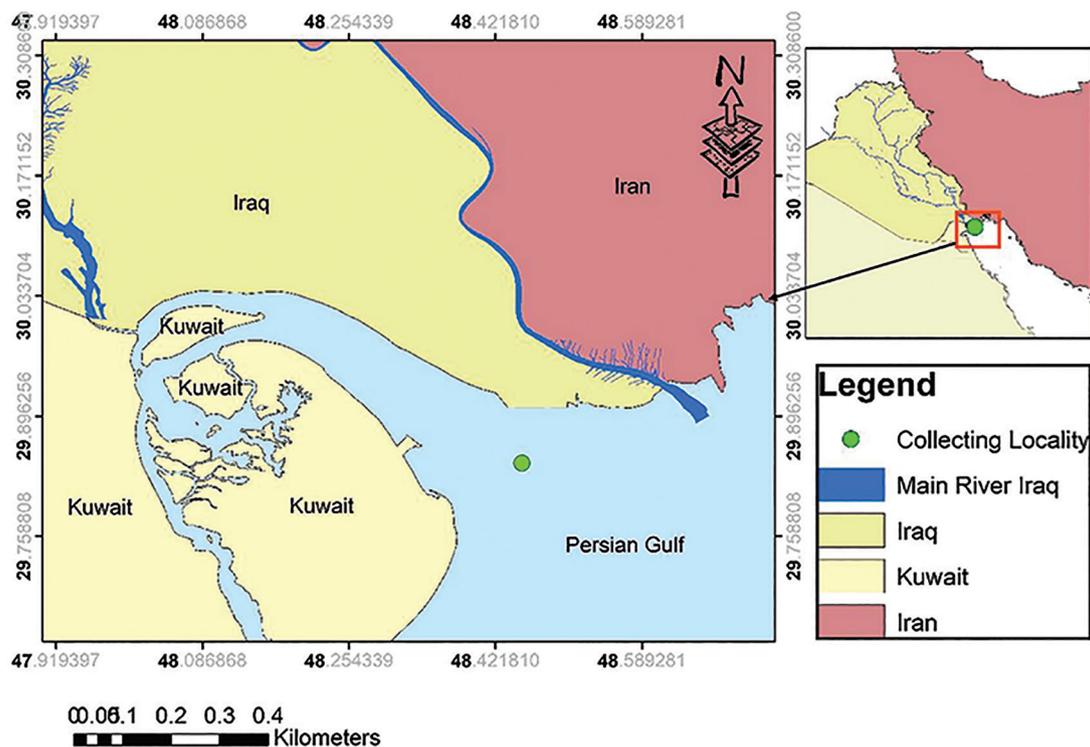
### 2.1. Study area

The maritime shoreline zone of Iraq contains the river mouth of the Shatt Al-Arab River, placed adjoining the city of Fao, alongside with the Khor Abdulla, Khor al-Zubair, and Um Qasar areas (Figure 1). Such sites are essential to Iraq's nautical system and economy. The locality's geological background, beside with its chronological and geographic placing at the northerly point of the Arabian Gulf, provides to the distinctive physiographical involvedness that symbolizes Iraqi marine biodiversity (Jawad, 2018).

In general, throughout the epoch of the Mesopotamian Civilization around 3000 B.C., the coastline continued expand substantially north, adjoining Basrah and finally reaching the Arabian Gulf. Throughout the times, sedimentation and river dynamic contrast have reworked the shoreline, with relics of prehistoric river channels now establishing the firth linking Khor al-Zubair and Um Qasar. The delta of the Shatt Al-Arab is modelled by the impacts of the Karun River and the two fundamental Mesopotamian rivers, the Euphrates and Tigris. These water courses have been helpful in reducing the fall south of Basrah and enabling the south-eastward extension of the Shatt Al-Arab delta.

The western region of Iraq's seaside range has altered into a fundamental navigational passage, stretching around 40 km in length, with a width of 600–800 m and depths reaching up to 22 m. This zone serves as a fundamental shipping path, connecting Iraq to international naval trade and contributing



**Figure 1**

Map showing the location of the collection of specimens of *Platycephalus indicus* from the marine waters of Iraq.

considerably to the nation's savings. The Arabian Gulf waters are prominent for their rich marine life, incorporating diverse fish species, molluscs, and crustaceans, which are significant for regional fisheries. Furthermore, the estuarine setting supports a diverse biota, including mangroves and seagrasses, which are essential for maintaining conservation stability and providing habitats for numerous marine species.

Nevertheless, this marine section encounters various confronts, such as pollution, habitat deprivation, and the impacts of climate alteration, which threaten the sensitive equilibrium of these niches. Supervising and maintenance powers for marine biodiversity in Iraqi waters are essential for guaranteeing the permanency of both the marine habitat and the occupations that depend on it. The neighbourhood of southerly region of the Arabian Gulf waters of Iraqi selected as it represents one of the cores catch fish landing sites for the species explored in Iraq and sagitta FA research for *P. indicus* is important to the impact of this event on the inhabiting of the larval phase of the species in this imperative fishing area.

## 2.2. Sample collection

Fish samples of *P. indicus* ( $n = 76$ ) (Figure 2) were attained with a trivial trawler (21 m in length and

3.5 m in width) endowed with a net of 2.5 cm mesh size. The gathering occurs in Khor Abdullah, situated at the southerly limit of Iraq's coastal area, from January to June 2023, at depths varying from 7.5 m to 12 m. Sagitta were precisely removed from the left and right sides of the fish head, explicitly from the sacculus of the inner ear, using normal surgical tools. Otoliths were washed in 70% to remove any adherent tissues. The total length of the fish individuals differed from 249 mm to 550 mm. Otolith length and width were determined to the closest millimetre using a compound microscope (Figure 3). Otolith weight was recorded using a Sartorius TE 313S analytical balance to an accuracy of 0.0001 g. The characteristics chosen for examining bilateral asymmetry have been formerly employed in studies of fish (Al-Rasady et al., 2010; El-Regal et al., 2016; Jawad et al., 2012). Sexes were not separated.

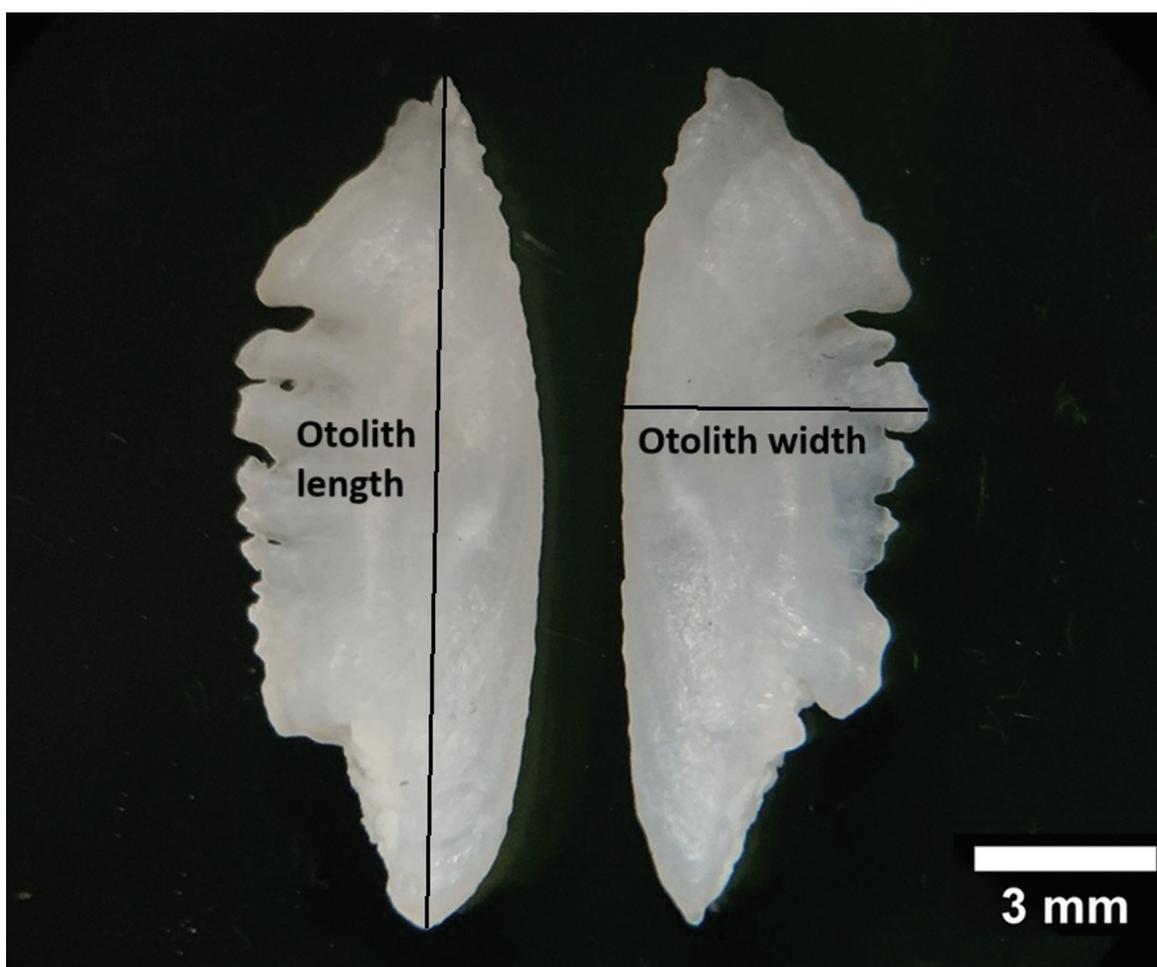
## 2.3. Statistical analysis

The statistical assessment was constructed on the squared coefficient of FA deviation ( $CV_a^2$ ) for the three sagitta features based on Valentine et al. (1973) formula:

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

**Figure 2**

*Platycephalus indicus*, 420 mm TL collected from the marine waters of Iraq.

**Figure 3**

Otolith of *Platycephalus indicus*, 420 mm TL, showing the length and width of the otolith.



In this perspective,  $S_{r-1}$  denotes the standard deviation of signed differences, and  $X_{r+1}$  signifies the mean of the trait, determined by summing the absolute scores from both sides and dividing by the number of the fish specimens. The rationale behind using the coefficient of variation squared ( $CV^2_a$ ) for FA is a direct response to the fundamental properties and challenges of FA data. Here's a breakdown of the rationale, moving from the problem to the solution. FA estimations and magnitude miscalculations are in general little and attend to be normally distributed around a mean of zero (Merilä & Bjöklund, 1995). Errors in recording otolith features may modify the conclusions of bilateral asymmetry investigation, requiring them problematic to explain (Palmer, 1994). To alleviate this concern, all lengths in the existing investigation were accompanied by a single individual to cut down the likely inaccuracies (Lee & Lysak, 1990), and each measurement was copied double. Coefficients of FA were related across different total length classes using a two-way ANOVA test.

### 3. Results

These findings aim to assess the FA in the sagitta length, width, and weight of the species explored. Notably, the FA was not found to be interrelated with sex, as these irregularities characteristically happen through early life phases when larval sex cannot be verified.

The asymmetry levels for the OL, OW, and OWe of *P. indicus* attained from the northwest corner of the Arabian Gulf are shown in Table 1. The OW asymmetry estimate was greater than that of the OL and OWe for the species researched (Table 1). The outcomes of this investigation suggest an upsurge in the FA levels of the three otolith features (length, width, and weight) of *P. indicus* as the size of the fish increases (Table 2). Amongst the otolith traits surveyed, the proportion of specimens showing asymmetry in the OW attribute was the greatest (Table 2). As well, the proportion of

**Table 1**

Squared coefficient of asymmetry ( $CV^2_a$ ) value and character means ( $X_{r+1}$ ) of *Platycephalus indicus* collected from the marine waters of Iraq

Character	$CV^2_a$	N	Character mean $\pm$ SD	% of individuals with asymmetry
Otolith length	49.85	76	10.62 $\pm$ 3.21	67
Otolith width	96.42	76	3.24 $\pm$ 5.11	88
Otolith weight	64.25	76	0.0829 $\pm$ 7.35	75

**Table 2**

Squared coefficient of asymmetry ( $CV^2_a$ ) value and character means ( $X_{r+1}$ ) by size class of *Platycephalus indicus* collected from the marine waters of Iraq

Character	$CV^2_a$	N	Character mean $\pm$ SD	% of individuals with asymmetry
Otolith length				
200–250	43.88	4	9.99 $\pm$ 4.21	73
251–300	44.31	6	10.87 $\pm$ 3.11	77
301–350	44.87	12	10.75 $\pm$ 4.53	81
351–400	45.22	10	10.66 $\pm$ 5.13	88
401–450	45.31	9	10.87 $\pm$ 6.23	93
451–500	47.82	12	10.89 $\pm$ 5.15	95
501–550	49.78	47	10.97 $\pm$ 6.19	96
Otolith width				
200–250	93.22	4	3.19 $\pm$ 5.81	79
251–300	93.55	6	3.17 $\pm$ 4.11	81
301–350	94.51	12	3.16 $\pm$ 3.75	87
351–400	94.76	10	4.01 $\pm$ 2.11	89
401–450	95.42	9	3.17 $\pm$ 4.15	92
451–500	96.11	12	3.27 $\pm$ 3.51	97
501–550	96.32	47	4.09 $\pm$ 2.17	99
Otolith weight				
200–250	61.32	4	0.0827 $\pm$ 6.33	45
251–300	61.54	6	0.0830 $\pm$ 5.44	49
301–350	62.55	12	0.0827 $\pm$ 4.75	52
351–400	62.78	10	0.0831 $\pm$ 3.52	65
401–450	63.42	9	0.0834 $\pm$ 4.72	76
451–500	63.51	12	0.0825 $\pm$ 6.23	87
501–550	64.31	47	0.0824 $\pm$ 5.41	90

individuals displaying FA augmented with fish length (Table 2). The divergence coefficients among diverse fish length groupings for the examined *P. indicus* samplings were discovered to be significant ( $P < 0.05$ ).

### 4. Discussion

In this analysis, we conducted an examination of the external features markers of the bilateral sagittal otolith's asymmetry of *P. indicus*, finding changes in the coefficient of deviation  $CV^2_a$  throughout the three features of the otolith external features and the ratio of asymmetric fish specimens.

The detected asymmetry in the sagitta features of *P. indicus* may impair the ability of young individuals to stay in and be located within their appropriate

surroundings (Gagliano et al., 2008). Markedly, we detected that sagitta width demonstrated a greater asymmetry related to length, implying a larger sensitivity to territory variations, which aligns with conclusions by Jawad et al. (2021). Therefore, this significant variation in the OW can serve as a reliable bioindicator of environmental stress in Iraqi marine habitats. The high asymmetry in the OW might be due to the variation in the calcium deposition sensitivity, as each species has its own sensitivity towards this factor (Gagliano et al., 2008). On the contrary, the sagitta length and weight usually exhibited a smaller impact on ecological strain, generating slightly asymmetry rates, in harmony with conclusions by El-Mahdy et al. (2019) and Koeberle et al. (2020). In general, modifications in fish sagitta external features are induced by inherited and ecological influences, operating as the initial core for our assessment of sagitta asymmetry.

Discovering the differences in  $CV^2_a$  throughout various fish size classes of *P. indicus* proposes perception into the inherited issues manipulating sagitta asymmetry within many growing phases. In our investigation, as body length augmented, the deviation tendencies in asymmetry coefficient across the three otolith traits of *P. indicus* demonstrated an increasing trend. Preceding investigations implied that ecological stress underwent by fish manages to weaken as their life history continues (Fey et al., 2020; Zenteno et al., 2014). This is first and foremost owing to the uncertainty of many physiological markers throughout initial growth phases, which can end up to growing and change ailments affected by significant ecological influence, subsequently give rise of sagitta external features variations (Abdulsamad et al., 2020; Jawad et al., 2021). Gao et al. (2024) exhibited that the asymmetry of the sagitta three characteristics in *C. joyneri*, a dweller fish, steadily diminished as body length upsurge, implying a decline in ecological tension. Later, in this investigation, we utilised the body length classes criteria to explore variations in sagitta asymmetry throughout various life history phases of *P. indicus*. The  $CV^2_a$  of all three otolith features investigated all summited in the 501–550 mm class, with a statistical significance. The fish length group 501–550 mm characterizes the prevailing fish size class, totalling 61.4% of the total individuals. Accordingly, our analysis mostly centres on *P. indicus* within the 501–550 mm fish size class. This emphasis derives from the greater group of *P. indicus* contained by this fish size class, as specified in Wu et al. (2015), where 90–200 mm signifies the prevalent fish size class, representing 61.8% of the total individuals. As well, these conclusions are probably affected by

differences in eating behaviours and marine settings throughout the life phases of *P. indicus*. Investigations demonstrate that eating behaviour of *P. indicus* develop throughout various development phases, with a broader dietetic selection as fish size upsurges, theoretically indicating to intensified introduction to ecological strains and giving in extreme  $CV^2_a$  (Ahmadreza Hashemi et al., 2012; Ahmed et al., 2021). Though, it is fundamental to hint that as fish length grows, sagitta asymmetry in another fish species reveal definite tendencies (Jawad et al., 2021; Jawad & Sadighzadeh, 2013; Mabrouk et al., 2014). These developments consequence from manifold influences and require debate in combination with habitat impacts, acting as the core for developing our exploration to investigate differences in otolith asymmetry of *P. indicus* in following phases.

Numerous investigators have implied that genetic reasons might have an influence on the asymmetry examined in the two borders of the sagitta (Panfili et al., 2005). However, this topic is difficult to fully address here due to the deprivation of hereditary information for the four mullet species studied.

In assumption, this significant investigation stands for the first search for fish sagitta asymmetry in the coasts of Iraq, exclusively researching the alterations in the sagitta asymmetry of *P. indicus*. This research acts as a vital indication for determining ecological stress markers. Our outcomes unveil that *P. indicus* constantly establishes asymmetry episodes throughout its growth phases. This phenomenon may relate to the species' varying dietary preferences across habitats. Differences in asymmetry spreading between different sagitta features of *P. indicus* underline reactions to apparent ecological tensions.

#### 4.1. Implementation of bilateral asymmetry in otolith dimensions of *Platycephalus indicus*

The analysis explored bilateral asymmetry in the otoliths of *Platycephalus indicus* by assessing changes in length, width, and weight between the left and right sagitta. FA, determined via the  $(CV^2_a)$ , disclosed that otolith width demonstrated the maximum degree of unevenness, while length appeared to be the smallest. This implies that environmental influence causes excessively have an excessive effect on selected otolith proportions. Remarkably, the 501–550 mm fish size group exhibited expressively larger  $CV^2_a$  estimates throughout all otolith attributes associated with other size ranks, implying that growing variability might crown at this progress period. The conclusions suggest that otolith asymmetry acts as a delicate biomarker of swinging habitat settings through fish growth.



The detected unevenness in *P. indicus* otoliths probably begins from environmental anxieties such as changes in water temperature, salinity, depth, and pollution by Iraq's coastal waters. These issues can interrupt balanced growing, directing to contradictory maturity between bilateral otoliths. The finding features the value of otolith FA as a marker of niche features, with width being specifically approachable to natural variabilities. By relating unevenness to niche issues, this inquiry gives insights into how anthropogenetic and niche forces affect marine organisms, emphasizing the necessity for additional reports on otolith morphology as a device for checking niche health.

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## Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability statement

The data supporting these study findings are available from the corresponding author upon reasonable request.

## Ethics statement

This work is based on commercial fish species, and the specimens were collected from a commercial catch. Therefore, ethical aspects are not applicable.

## CRedit authorship contribution statement

LAJ designed the project, analysed the data, wrote the manuscript, and followed up on the submission.

AMQ collected fish specimens and collected and analysed the data.

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