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OTOLITH MASS ASYMMETRY OF *PAMPUS CANDIDUS* (OSTEICHTHYES, STROMATIDAE) FROM IRAQI MARINE WATERS

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Otolith Mass Asymmetry of P*ampus candidus* (Osteichthyes, Stromatidae) from Iraqi Marine Waters. Qasim, A. & Jawad, L. A. — The otolith mass asymmetry of the fish species *Pampus candidus* (Cuvier, 1833) was assessed. The findings indicated a significant level of asymmetry comparison with similar studies on other fish species. The level of asymmetry was shown to increase with the size of the fish, where the utmost estimate of the otolith weight irregularity was obtained. The detected otolith asymmetry may be linked to pollutants in the sampling area.
Key words: Ecology, Khor Abdullah, fish size, environment, pollution, Arabian Gulf.

Introduction

The otoliths, sometimes known as ear bones, were rigid anatomical structures situated within the intrinsic auditory system of vertebrates that assist as sound receptors and balance organs (Schulz-Mirbach & Ladich, 2016; Tuset et al., 2021). In most species the sagitta is large, but in some species like Cypriniformes the asteriscus is the largest, and in Siluriformes, Characiformes, and Gymnotiformes the lapillus is the largest (Berra & Aday, 2004). These structures have been the basis of fundamental studies until today (Yu et al., 2014; Yilmaz et al., 2015; Jawad et al., 2017; Bostanci & Yedier, 2018; Ozpicak et al., 2021; Pavlov, 2022; Qasim et al., 2022; Jawad et al., 2023). The external features of otoliths are very exclusive and fluctuate greatly throughout fish families, but they can also be rather species-specific (Maisey, 1987). Recently, several investigations were published to disclose that otolith mass asymmetry is a very significant study area due to its role in acoustic performance (Lychakov et al., 2006; Jawad et al., 2011; Jawad et al., 2017; Yedier et al., 2018; Bouriga et al., 2021; Jawad et al., 2021). Due to its quantifying practicalities, the otoliths form an outstanding biological model for investigating the physiological implication of otolith weight irregularity (Lychakov et al., 2006).

Otolith shape is hereditarily controlled (L'Abée-Lund, 1988 and Jawad et al., 2021). However, environmental factors can affect the fish's metabolism, which later disturbs the body's cell development and therefore the calcium deposition amount placed in otoliths (Cardinale et al. 2004, Galley et al., 2006; Stransky et al., 2008). Other influences, like the growth phases as characterized by the length of the fish (Hüssy 2008), age (Castonguay et al., 1991), and reaching adulthood (Mérigot et al., 2007), might likewise be bearing on the surface morphology of the otoliths.

Recently, most findings investigating the basis of otolith shape disparity have been dedicated to the influence of external influences, such as habitat variables, or species structures, such as genetic constitution or morphology (Mille et al., 2015). However, only a limited number of studies have explored the possible causes of individual disparity in otolith external morphology. For instance, the dissimilarity among the otolith morphology in both sides of the fish head (denoted to as otolith position end). The location of the otolith inside ear construction of the fish revealed that both partitions of the ear structure are precisely similar with ear internal structure which allow sensing certain movement and otoliths allocated for perceive sound and equilibrium (Panfili et al., 2002). Even though several among species modifications in the length of the fish and the morphology of these characters, otoliths are bilaterally even in round fishes (Popper & Lu, 2000).

Somarakis et al. (1997) suggested that results of changing otolith asymmetry could be a good a valuable marker of fish health. Clark (1992) disclosed that this is an exceptionally sensitive strain indicator. Somarakis et al. (1997) found no changes in size-related age among the otolith characteristics they examined. The investigation of otolith asymmetry is an affordable, straightforward assessment that requires no special treatment or field facilities and is unaffected by damage caused by net capture or shrinking.

Normally, the correlation among fish external features and changeable irregularity has been inspected for adult fishes, and several features have been studied, as well as number of gill rakers, pectoral fin rays, fish body proportions, eye spot area, and otolith size and shape (Al-Hassan et al., 1990; Al-Hassan & Hassan, 1994; Escos et al., 1995; Somarakis et al., 1997; Jawad, 2001; Øxnevad et al., 2002; Gonçalves et al., 2002; Jawad 2003, 2004).

Mass otolith irregularity has not ever been assessed in Silver Pomfret *P. argenteus* wherever within its distributional range. The main aim of this search is to determine the level of two-sided irregularity observed in the otolith mass of *P. candidus* specimens obtained from marine water in Iraq.

Material and Methods

Samples of *P. candidus* (120) (fig. 1) were captured from drift gillnets, in addition to collecting samples from the landing site off Khor Abdullah at the southern extent of Iraqi marine waters (fig. 2). The selection of the specimen's collecting region was based on its significance as a primary fishing habitat for the species in Iraq. The presence of otolith asymmetry in *P. candidus* has the potential to disrupt the larval settling within this significant fishing habitat. The samples were collected within the time frame of February to September 2019, at a depth ranging from 10 to 25 meters. Sagittae were removed from the sacculus of the fish's ear, located on both sides of the fish head. The fish specimens exhibited a range of standard lengths (SL) spanning from 78 to 293 mm. The dimensions of the otolith were measured with precision to the near millimeters using a binocular microscope (fig. 3). The squared coefficient of asymmetry variation (CV^2_a) served as the basis for statistical analysis of the mass of the otolith Following Valentine et al. (1973)

$$CV^2_a = (S_{r\text{-}l}\, X \cdot 100 / X_{r+l})^2$$

where $X_{r\text{-}l}$ is the mean of the otolith's mass, The calculation involved the summation of all absolute scores of the two sides, followed by division by the selected sample size. According to Merilä & Björklund (1995) the estimations of bilateral asymmetry and measurement errors had a minor magnitude and followed a normal distribution with a mean value of zero. The presence of individual imperfections throughout the measuring process can interfere with the outcomes Analysis of bilateral asymmetry, hence causing ambiguity (Palmer, 1994). Therefore, in the current investigation, all measures were conducted in duplication by a single individual to minimize any unintentional errors (Lee & Lysak, 1990). ANOVA was used to compare the coefficients of asymmetry among the various (S.L) classes.

Results

Table 1 presents the asymmetry variables of the otolith mass of *P. candidus* obtained from Khor Abdullah, located at the southern border of Iraqi marine waters. The current study's findings demonstrated that as fish size increased, so did the value of the otolith mass asymmetry of *P. candidus* (table 1).

The percentage of specimens displaying asymmetry in the otolith mass trait exhibited a positive correlation with the size of the fish. The statistical analysis revealed that the divergence coefficients among the various fish length groups in *P. candidus* did not reach statistical significance ($P > 0.5$).

Table 1. Squared coefficient of otolith asymmetry and character means in the whole sample and by size class of *Pampus candidus* collected from the marine waters of Iraq

Parameters	CV^2_a	N	Character mean ± SD	% of individuals with asymmetry
Whole fish sample	4.2562 ± 0.176	120	0.201	
Fish body size classes				
70–100	3.7812 ± 0.165	4	0.2009 ± 1.3	73
101–130	3.8932 ± 0.247	10	0.2010 ± 1.1	85
131–160	3.9635 ± 0.264	9	0.2013 ± 1.5	89
161–190	3.9864 ± 0.186	20	0.2031 ± 1.8	92
191–220	3.9900 ± 0.193	10	0.2011 ± 1.3	95
221–250	4.5745 ± 0.172	49	0.204 ± 1.7	97
251–280	4.5843 ± 0.168	10	0.2034 ± 1.4	98
281–310	4.6542 ±0.193	8	0.20335 ± 1.3	99

Discussion

This investigation was conducted in conjunction with the demonstration of two-sided irregularity in *P. candidus* otolith mass. The young individual's ability to live in their appropriate habitats may be hampered by the apparent asymmetry in the otolith mass (Gagliano et al., 2008). The present study examines the variation in otolith weight between the right and left otoliths in fish species that have available data. These species may exhibit variations in otolith weight due to sudden differences in their habitats. As a result, this essential difference in the otolith mass may be considered a bioindicator of pressure in Iraq's maritime waters. Comparable work by Qasim et al. (2022). performed on *P. candidus* collected from the same area where the specimens of the present study were collected showed that a high asymmetry level is also noted in the otolith width. This proposes that these features might be more affected by the ecological impacts, comprising pollution (Jawad, 2003).

Previous studies on otoliths have identified a wide range of benthic and pelagic species exhibiting varying degrees of otolith mass irregularity, typically fluctuating from 0.2 to 2 Lychakov et al. (2008), Jawad & Sadighzadeh (2013), and Jawad (2013). In the current investigation, a greater otolith bulk irregularity estimates for *P. candidus* explored was reached. This result backs those of Bouriga et al. (2021) on *Trachurus mediterraneus* attained from unlike localities in the Tunisian waters of the Mediterranean Sea. Bouriga et al. (2021) associated these great levels with the biological state of these species, their habitats, and environmental

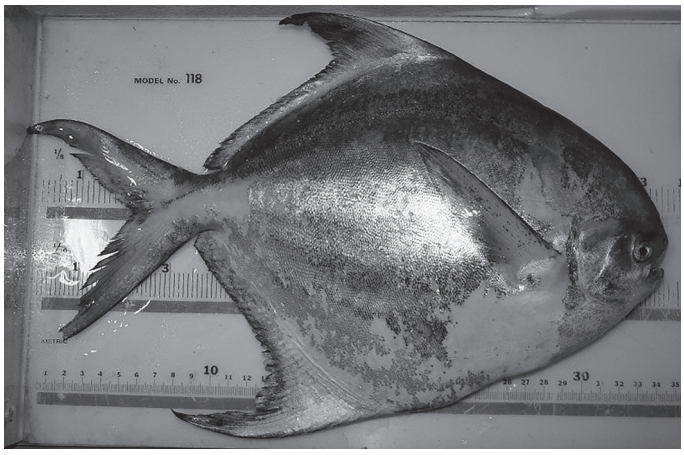

Fig. 1. Specimen of *Pampus candidus*, 326 mm TL collected from the marine waters of Iraq.

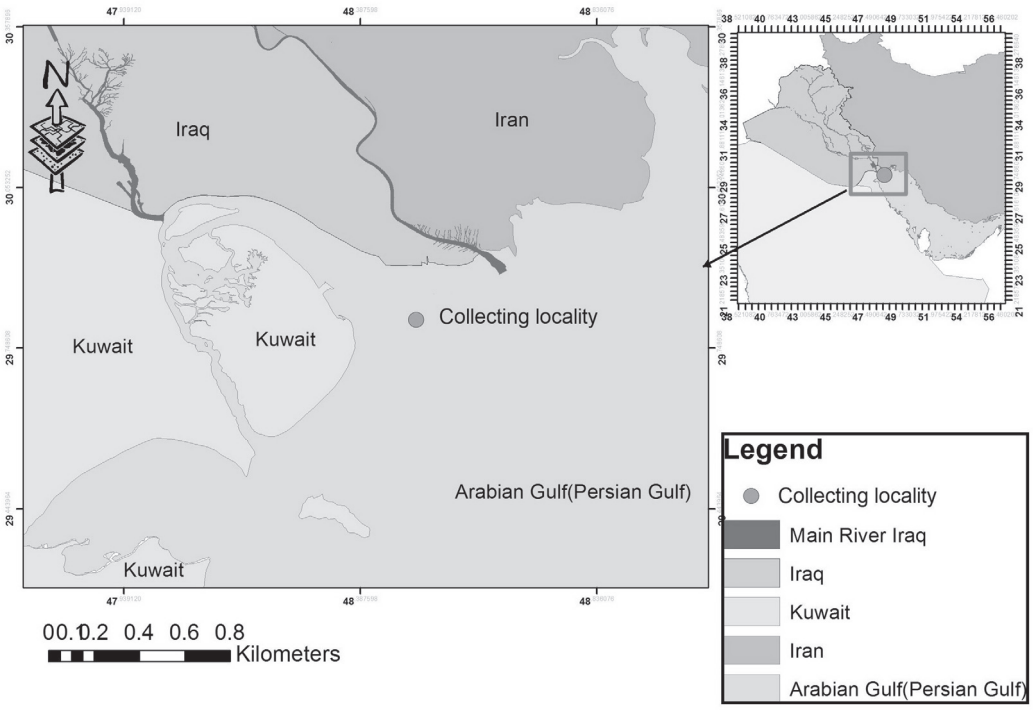

Fig. 2. The map illustrates the designated sampling region for *Pampus candidus*.

impacts, where habitat and human activities effects have a noteworthy pressure on the development of otoliths (Grønkjær, 2016).

Comparing the outcomes reached in the present study with those obtained by others on different species around the world showed that similar and diverse outcomes have been reached. For example, Jawad (2012) study revealed that the otolith mass of *Lutjanus bengalensis* exhibits a high level of asymmetry, as evidenced by the length and width data found. (Bloch, 1790) attained from the Muscat coast on the Sea of Oman, with a propensity to upsurge irregularity in the otolith dimensions as the fish grew. Moreover, this irregularity is attributed to the many impurities found in the environment. In addition, Jawad et al. (2012) studied *Sardinella sindensis* (Day, 1878) and *Sillago sihama* (Forsskål, 1775) collected from the Arabian Gulf near Bandar Abbas, and Jawad et al. (2020) studied *Sarotherodon melanotheron* (Rüppell, 1852), and *Coptodon guineensis* (Günther, 1862) from Lake Ahémé and Porto-Novo Lagoon, Bénin. Both studies reached comparable conclusions, with the exception that the otolith mass showed a propensity for an increase in the grade of irregularity with fish length. Yet, according to Al-Busaidi et al. (2017), the measurement of otolith length and otolith variables examined in *Lutjanus ehrenbergii* (Peters, 1869) Sea of Oman samples in Muscat City is considered a valuable indicator of fish length.

The asymmetry observed on the bilateral aspects of the otolith has been suggested by several researchers to potentially be attributed to hereditary causes (Panfili et al., 2005). However, this issue cannot be considered at this time because it requires genetic data on the examined *P. candidus*.

In general, the current findings contribute to the existing body of knowledge regarding the otolith characteristics that serve as effective means of differentiating and identifying the varying asymmetry observed in the right and left otoliths of *P. candidus*, which were

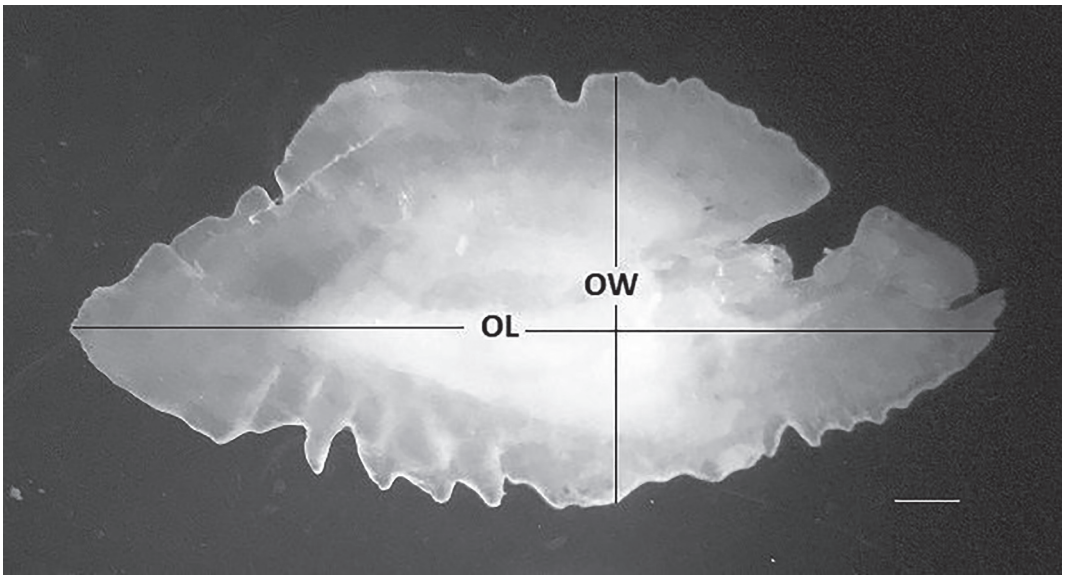

Fig. 3. Otolith of *Pampus candidus*, 326 mm TL showing the length and width of the otolith.

selected for this study. The otolith mass exhibits asymmetry, which can be accredited to ecological issues such as water temperature, salt, and pollution. Even so, this examination is considered a preliminary investigation that may involve assessing additional otolith characteristics like shape feature, circularity, ellipticity, and rectangularity, in addition to conducting hereditary analysis. These methods are crucial for gaining a comprehensive understanding of the factors contributing to the varying asymmetry observed in the otolith pairs of *P. candidus* currently studied in the marine waters of Iraq.

Conflict of interest

The authors state that there are no conflicts of interest.

Ethical statement

This work is based on specimens collected through a routine ichthyological survey by the first author, and the fish specimens obtained from the collection sites were dead. Therefore, no ethics is required in this case.

Author contribution

Both authors contributed to the study's conception and design. Material preparation and data collection were performed by AQ, and the statistical analyses were accomplished by LAJ. The first draft of the manuscript was written by LAJ, and both authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

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