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First Report of Pughead Deformity in *Nemipterus japonicus* (Bloch, 1791) from the Red Sea, Egypt

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ABSTRACT

Pughead deformity, characterized by craniofacial abnormalities resulting in a shortened and blunt snout, is a significant developmental anomaly observed in wild and cultured fish populations. This condition arises from multifactorial influences, including genetic predispositions, environmental stressors, nutritional deficiencies, and anthropogenic factors. The deformity is marked by abnormal bone structure, often manifesting as a steep, protruding forehead. While pughead deformity has been documented in numerous fish species, *Nemipterus japonicus* remains notably absent from scientific reports. However, pugheaded specimens have been identified in the Red Sea, specifically in the Suez Canal and Hurghada regions. Elevated deformity rates in this area have prompted investigations into potential causative factors, including hypoxia, contamination, and genetic defects, emphasizing the need for targeted research and management interventions.

INTRODUCTION

Nemipterus japonicus (Bloch, 1791), commonly known as the Japanese threadfin bream, belongs to the family Nemipteridae and is widely distributed in the Indo-Pacific region, inhabiting coastal waters from the Red Sea to the Persian Gulf, extending east to the Philippines and Japan, and south to Indonesia and Timor-Leste. This demersal and non-migratory species is often found on mud or sand bottoms in schools **(Ning *et al.*, 2015)**. This species is a demersal fish, typically found at depths ranging from 5 to 80 meters on sandy and muddy substrates **(Russell, 2001)**.

Pughead deformity is a distinct craniofacial and skeletal anomaly in fish, characterized by a shortened, flattened snout and a blunt, distorted cranial structure. This condition often involves mandibular malformations, leading to misaligned jaws that impair feeding efficiency. Additionally, pughead deformity is commonly associated with skeletal abnormalities, including spinal deformities such as scoliosis or kyphosis, which further compromise the fish's overall physiology and functional capacity **(Koumoundouros, 2010)**. The etiology of pughead deformity is multifactorial, encompassing genetic, environmental, and mechanical influences. Genetic factors, such as mutations in craniofacial genes, are particularly prevalent in inbred populations where reduced genetic variability increases the likelihood of deformities **(Witten & Huysseune, 2009)**. Selective breeding practices in aquaculture that promote growth and productivity can also inadvertently contribute to higher deformity rates by prioritizing certain traits over genetic health **(Koumoundouros, 2010)**. Environmental factors such as poor water quality, high ammonia, nitrate, or carbon dioxide levels, particularly in high-density aquaculture systems, can interfere with normal developmental processes during embryogenesis **(Boglione *et al.*, 2013)**. Temperature fluctuations and suboptimal conditions during early development have been linked to malformations in several species **(Fraser *et al.*, 2014)**, while deficiencies in essential nutrients like vitamins C, D, and E, along with minerals such as calcium and phosphorus, contribute to skeletal anomalies, including pughead deformity **(Gavaia *et al.*, 2009)**. Mechanical factors, including injuries from improper handling or excessive pressure during larval growth, also disrupt craniofacial development **(Berillis, 2015)**.

The biological consequences of pughead deformity are profound, affecting survival and reproductive success. Misaligned jaws reduce fish's ability to capture and process prey, leading to feeding inefficiencies that threaten survival, especially in wild populations **(Witten & Huysseune, 2009)**. Furthermore, cranial malformations interfere with hydrodynamics, increasing drag and reducing swimming performance, which heightens susceptibility to predation **(Koumoundouros, 2010)**. In terms of reproduction, deformities can hinder courtship behaviors or reduce mating success, affecting population dynamics in natural habitats **(Berillis, 2015)**. In addition, deformities like pugheadness can impair buccal-opercular pumping, further stressing malformed individuals, who may need to swim more frequently to breathe adequately **(Lijalad & Powell, 2009)**.

Physical deformities, including pugheadness, are common across both actinopterygian and elasmobranch species, reflecting the various environmental and genetic factors influencing fish development **(Moore, 2015; da Silva & Casas, 2020)**. Pughead deformity, often accompanied by a pronounced shortness of the upper jaw, swollen forehead, and misaligned lower jaw, is considered a severe osteological disorder **(Grinstead, 1971; Hickey, 1972)**. Specimens often exhibit protruding eyes, sloping foreheads, and mouths that fail to close completely **(Shariff *et al.*, 1986)**. While pughead deformity has been documented in various species **(Nakamura, 1977; Shariff *et al*., 1986; Jawad & Hosie, 2007; Macieira & Joyeux, 2007; Jawad *et al.*, 2014; Jawad *et al.*, 2015; Schmitt & Orth, 2015; Catelani *et al.*, 2017; Jawad & Ibrahim, 2018; Grimaldi & Bertoncini, 2021; Ugbomeh *et al.*, 2022)**, most reported cases are based on isolated specimens. Notably, there are no reports of pughead deformity in *N. japonicus* in the current literature. This study presented the first documented case of pugheadedness in *N. japonicus*, examining potential causes and the spatial distribution of this deformity and comparing deformity rates among fish from the same locations.

MATERIALS AND METHODS

Fish were collected from a commercial fish market in the Suez Canal and Hurghada, located along Egypt's Red Sea (Fig. 1), using a random sampling method. Among the collected specimens, two individuals exhibited distinct cranial deformities characteristic of pughead deformity (Fig. 2). These pugheaded specimens were separated from the other samples for further analysis. Each *N. japonicus* exhibiting pughead deformity was measured for total length (cm) and body weight (g). To assess the deformed bone structure, particularly in the cranial region, the specimens were transported to a radiographic laboratory where X-ray imaging was performed to capture detailed images of the head zone.

Fig. 1. Map of Egyptian Red Sea showing the two collecting zones (Suez Canal and Hurghada)

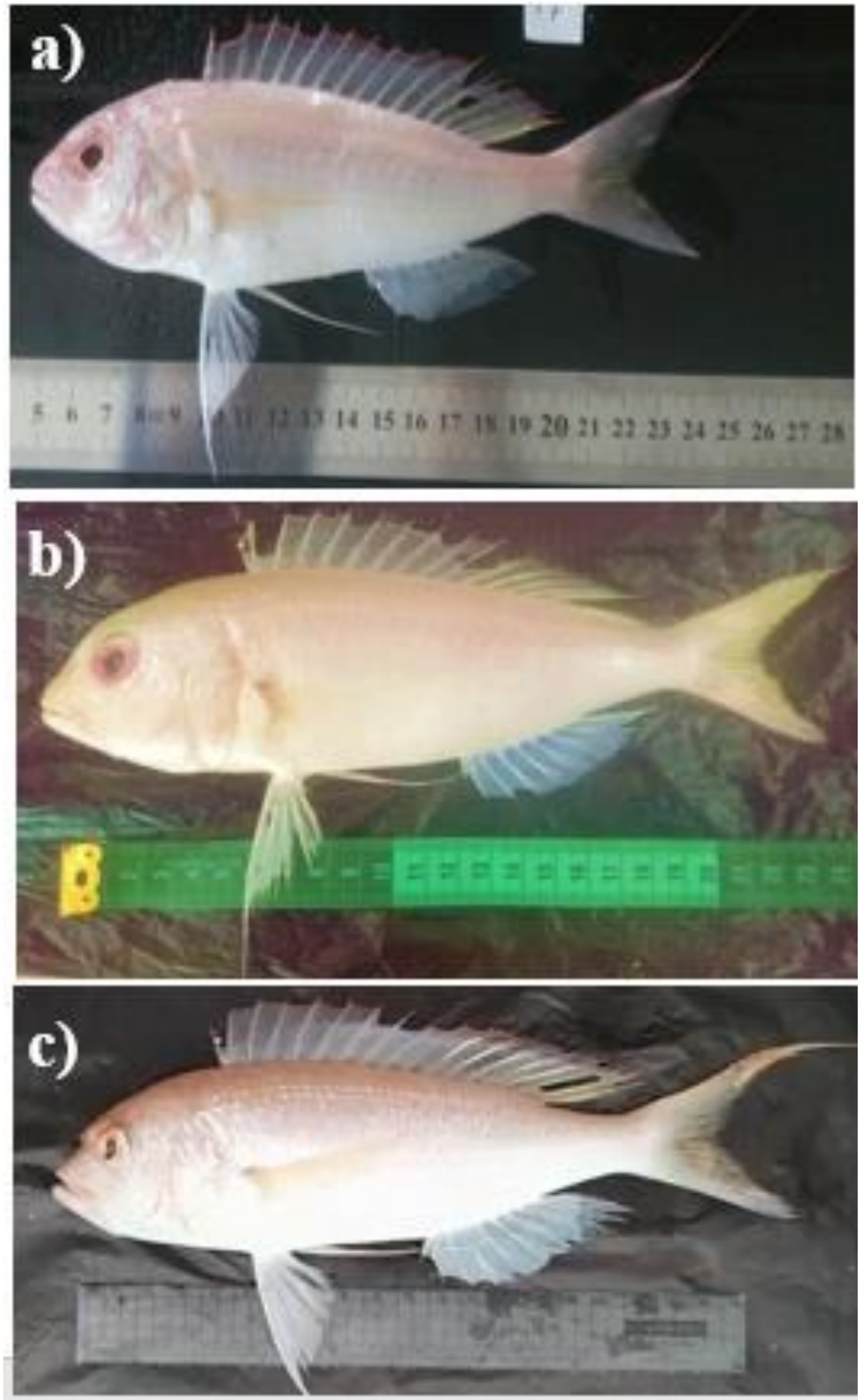

Fig. 2. Photos of *N. japonicus* **a)** Normal fish, **b)** from Suez Canal and **c)** from Hurghada, Red Sea, Egypt

RESULTS

Two pugheaded specimens of *N. japonicus* were captured in December 2022 from Suez Canal and Hurghada, with total lengths of 24.5 and 23.5cm and weights of 195 and 187g, respectively. These specimens exhibited characteristic craniofacial abnormalities, with a notably small neurocranium and otherwise normal upper and lower jaws, as observed in the external morphology (Fig. 3). The mouth remained closed, and the deformity appeared to have minimal impact on its function, with no evident disruption in the mouth's operational mechanics. The most prominent feature was a steeply inclined forehead, resulting from the shortening of the snout, which caused the nostrils to be positioned unusually close to the eyes.

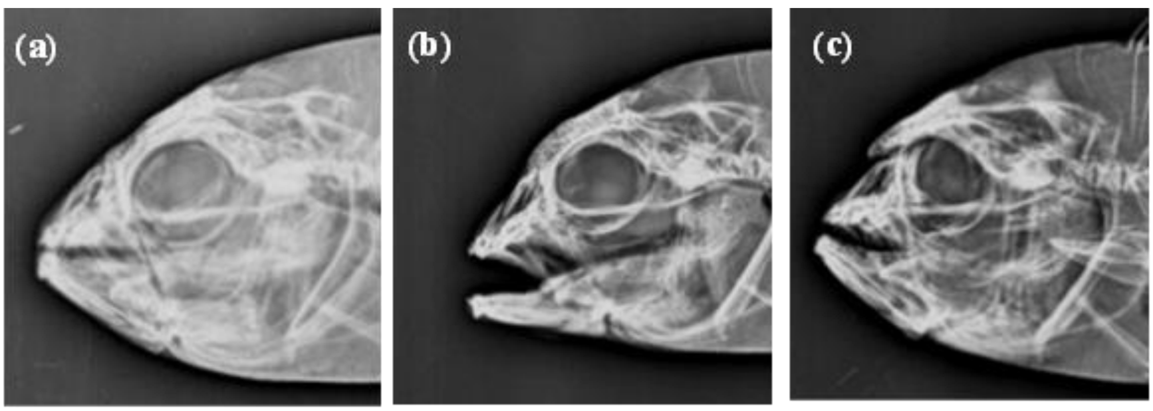

Fig. 3. X-ray images of *N. japonicus* **(a)** normal fish, **(b)** fish from the Suez Canal, and **(c)** fish from Hurghada, Red Sea, Egypt

Internally, several cranial bones displayed significant structural alterations. The nasals, frontals, vomer, and palatines were all displaced or curved, with the vomer and parasphenoid fully fused, further contributing to the cranial deformity. The maxilla and premaxilla exhibited minor deformities, while the bones anterior to the orbit were distinctly altered. These bones were bent perpendicularly downward toward the oral cavity, contributing to the pronounced and sharp contour of the forehead. Notably, no other morphological abnormalities were observed in the specimens, suggesting that the craniofacial deformities were isolated to the head region. These anatomical alterations are consistent with the typical features of pughead deformity in fish.

DISCUSSION

Pughead deformity in fish, as described by **Hickey *et al*. (1977)**, is often classified into four stages: normal, primary, secondary, and tertiary. The specimens in this study exhibit characteristics that suggest a primary or secondary stage of deformity, based on the morphological alterations observed, including a steep forehead, shortened snout, and displaced cranial bones.

Noble *et al.* (2012), reported that mouth deformities, such as those associated with pughead deformity, often lead to reduced feeding capacity, which can significantly hinder growth. Consistent with this, the pugheaded specimens in our study exhibited lower relative body weights compared to normal fish, further suggesting that the feeding inefficiencies associated with the deformity might compromise their overall health and growth.

Introducing of exotic species into new environments has been shown to result in significant deformities, as **Whitney (1961)** noted. In this context, it is possible that the high population densities in the Red Sea region, particularly around the Suez Canal and Hurghada, have created environmental conditions conducive to similar deformities. Overcrowding, particularly during early developmental stages, could have exacerbated the deformities observed in the present specimens.

Furthermore, exposure to pollutants such as cadmium, zinc, lead, mercury, and other toxins has been implicated in causing skeletal deformities in various fish species **(Davies & Everhart, 1973; Bengtsson, 1974, 1975; Nakamura, 1974; Valentine, 1975; Bengtsson, 1991; Johnson *et al.*, 2007; Hou *et al.*, 2011; Sfakianakis *et al.*, 2015; Garai *et al.*, 2021)**. Of particular concern are polychlorinated biphenyls (PCBs), which have been linked to skeletal abnormalities by interfering with calcium metabolism and obstructing enzymes essential for bone development **(Valentine, 1975)**. The Red Sea region, particularly the Suez Canal area, is subject to high levels of industrial activity and runoff, which could introduce pollutants into the aquatic environment, potentially contributing to the observed deformities in *N. japonicus*.

Oxygen depletion, often resulting from overpopulation during early development, has also been proposed as a factor contributing to skeletal abnormalities **(Hilomen-Garcia, 1997; Shariff *et al.*, 1986)**. In aquaculture settings, hypoxia during embryogenesis can disrupt normal developmental processes, leading to deformities. Similarly, in natural environments, hypoxic conditions can be exacerbated by nutrient overloading, particularly from algal blooms that consume dissolved oxygen when decomposing **(Boesch *et al.* 2001)**. While hypoxia and nutrient loading are not always directly correlated, the hydrographic conditions of the Red Sea, with its periodic eutrophication and reduced water mixing in spawning areas, may create localized hypoxic zones, potentially impacting the development of N. japonicus.

Although several factors—such as overcrowding, pollution, and hypoxia—have been suggested as potential contributors to the deformities observed, the exact causes remain unclear. Further research is needed to elucidate the interplay between these environmental stressors and their potential role in the development of pughead deformity in this species.

RECOMMENDATIONS

The study of pughead deformities in *N. japonicus* suggests several areas for future attention. To better understand the causes of these deformities, further research should focus on the environmental stressors potentially contributing to their development, such as overcrowding, pollution, and hypoxia. Monitoring the water quality in the Red Sea, especially near industrial areas like the Suez Canal, will help identify harmful pollutants, such as heavy metals and PCBs, that may be linked to skeletal deformities. Additionally, managing fish population densities and reducing overcrowding in spawning areas could help alleviate the effects of hypoxia and developmental stress. Long-term ecological studies on fish health and deformities in relation to environmental conditions will provide valuable insights for conservation efforts. Furthermore, raising awareness among stakeholders and enacting stricter pollution regulations will help mitigate the impact of environmental degradation on marine life. By addressing these factors, it will be possible to protect the health of fish populations and to reduce deformities in the region.

CONCLUSION

The study of two *N. japonicus* specimens with pughead deformities has revealed significant craniofacial abnormalities, including a shortened snout, displaced cranial bones, and a steeply inclined forehead. These deformities, classified as primary or secondary stages of pughead deformity, did not appear to significantly impact the functional mechanics of the mouth, although the specimens exhibited lower body weight relative to normal fish, indicating potential feeding inefficiencies. The deformities observed in these specimens could be attributed to several environmental stressors, including overcrowding, pollution, and hypoxia, which may be exacerbated by the high population densities and industrial activities in the Red Sea region.

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