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Author Affiliation:

¹Postgraduate Student, Department of Animal Production, Faculty of Agriculture, Tishreen University, Lattakia, Syria

²Professor, Zoology Department, Faculty of Science, Tishreen University, Lattakia, Syria

³Assistant Professor, Department of Basic Sciences Laboratory, Faculty of Agriculture, Tishreen University, Lattakia, Syria

Contact List

Zen A Bsema	zen0bsemah0@gmail.com , Zeinelabidine.bassima@tishreen.edu.sy
Waad G Sabour	WaadSabour@gmail.com
Amina H Alnesser	aminaalnesser@gmail.com

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Recording of Hermaphroditism in the migratory fish *Sillago suezensis* (Sillaginidae) in Syrian Marine Waters (Lattakia)

Zen A Bsema¹, Waad G Sabour², Amina H Alnesser³

ABSTRACT

In our current research titled "Study of the Biology of Reproduction, Trophic Spectrum, and Fish Stocks of Migratory Fish Species *Sillago suezensis* (Forskal, 1775) (Sillaginidae) in the Marine Waters of Lattakia", we collected 338 individuals between June 23, 2022, and June 23, 2023, using local fishing methods, particularly gill nets, at depths ranging from 3 m to 50 m. While analyzing the gonads and stages of sexual maturity of these specimens, we identified hermaphroditism in some members of the fish species *Sillago suezensis*. Our findings, when compared to existing data indicating that this species is typically gonochoristic, reveal the presence of hermaphrodite individuals in the Syrian marine environment for the first time. Consequently, this research documents the first global observation of hermaphroditism in *S. suezensis*, classifying it as an early protandrous species.

Keywords: Hermaphroditism, Protandrous, *Sillago suezensis*, Syrian marine waters.

1. INTRODUCTION

The Mediterranean Sea is currently under significant population pressure, with its temperature rising by one degree and projected to increase by another degree soon. The sea has become warmer, more acidic, and more saline, which has impacted marine organisms and their migratory patterns, thus exacerbating the challenges related to biodiversity in the Mediterranean environment (Lakkis and Sabour, 2014). Additionally, the sea is exposed to multiple pollutants from various activities (domestic, industrial, and agricultural), contributing to environmental pollution—one of the most critical risks facing humanity and other living organisms (Mishra, 2019). These factors have had adverse effects on fish populations. The family Sillaginidae, consisting of coastal marine benthic fish, occupies a vast range from the Indian Ocean to the northern Red Sea (Gulf of Suez, Egypt) and extends westward along the African coast, eastward to Japan, and southward to Australia.

Due to Lessepsian migration, this family has spread into the eastern Mediterranean, including regions such as Egypt, Palestine, Lebanon, and Turkey

(Golani et al., 2014). This family includes 36 species across three genera (McKay, 1992; Kaga et al., 2010; Gao et al., 2011; Golani et al., 2014; Xiao et al., 2016; Panhwar et al., 2018; Xiao et al., 2021). Two species, *Sillago Sahima* and *Sillago suezensis*, have been recorded in Syrian commercial fishing (Saad, 2005; Ali, 2018). *Sillago suezensis*, a Lessepsian migratory species, has been reported in Lebanon, Egypt, Palestine, Turkey, Cyprus, and Greece (Katsanevakis et al., 2009; Golani et al., 2014; Akel and Rizkalla, 2015; Innal et al., 2015; Çelik et al., 2019; Kousteni et al., 2019). The first specimen observed in Syrian marine waters was documented in 2021.

The length-weight relationships and morphological measurements of *S. suezensis* have been studied in the Gulf of Antalya and various locations along the Turkish coast Innal, (2019), Innal et al., (2015), and its reproductive biology has been examined in the Egyptian Mediterranean waters off Port Said (Akel and Rizkalla, 2014). Additionally, its age, growth, and mortality rates have been estimated in the Gulf of Alexandretta, North Mediterranean (Ergüden and Doğdu, 2020). In most fish, reproduction follows the typical vertebrate pattern, with distinct sexes, and hermaphroditism is generally considered an anomaly (Chan and Yeung, 1983).

However, sex change represents an alternative reproductive strategy that enables individuals to maximize their lifetime reproductive success by functioning as one sex when small and the other when large (Buxton and Garratt, 1990). Historically, no evidence has suggested sex change within the Sillaginidae family. Furthermore, a reproductive analysis of *Sillago suezensis* in Egypt did not indicate any hermaphroditism (Akel and Rizkalla, 2015). To date, no local studies have focused on the reproduction of *Sillago suezensis*. Our research investigates the reproductive characteristics of *S. suezensis* in Syrian marine waters for the first time. We observed the phenomenon of hermaphroditism during our study to determine the reproductive period and gonad maturity development, both morphologically and histologically, in this migratory fish species in Syrian marine waters, which is also recorded for the first time globally.

2. MATERIALS AND METHODS

We collected samples of *Sillago suezensis* from the marine waters off the coast of Lattakia between June 23, 2022, and June 23, 2023, using gill nets. We obtained a total of 338 individuals. Morphometric measurements were taken, and the sex of each fish was determined along with the stage of sexual maturity, categorized into six different stages. The gonads were preserved in 10% formalin for subsequent histological examination to assess fertility and the reproductive period.

3. RESULTS AND DISCUSSIONS

The examination of the gonads of *Sillago suezensis* caught in Syrian marine waters between June 23, 2022, and June 23, 2023, revealed the presence of hermaphroditism in 19 individuals. The histological analysis identified three types of gonads: functional testes (Figure 1: A, B), functional ovaries (Figure 2: A, B), and hermaphroditic gonads containing both male and female tissues within the same gonad (Figure 3: A, B). These findings confirm that the studied fish species belong to the protandrous type.

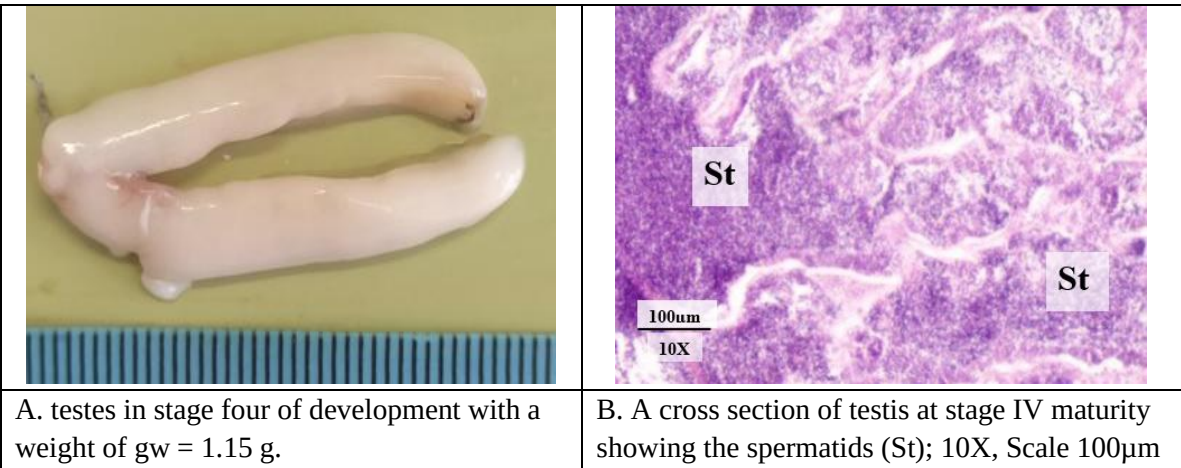


Figure 1 Normal testes at the IV stage of maturity in a *Sillago suezensis*

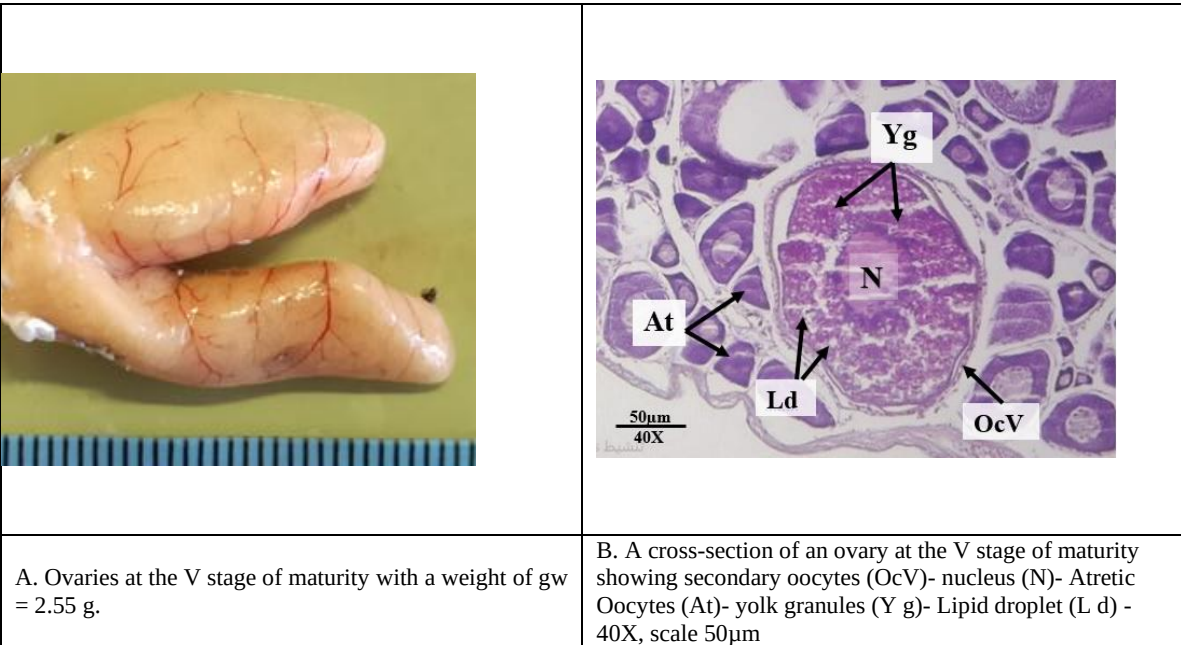


Figure 2 Normal ovaries at the V stage of maturity in a *Sillago suezensis*

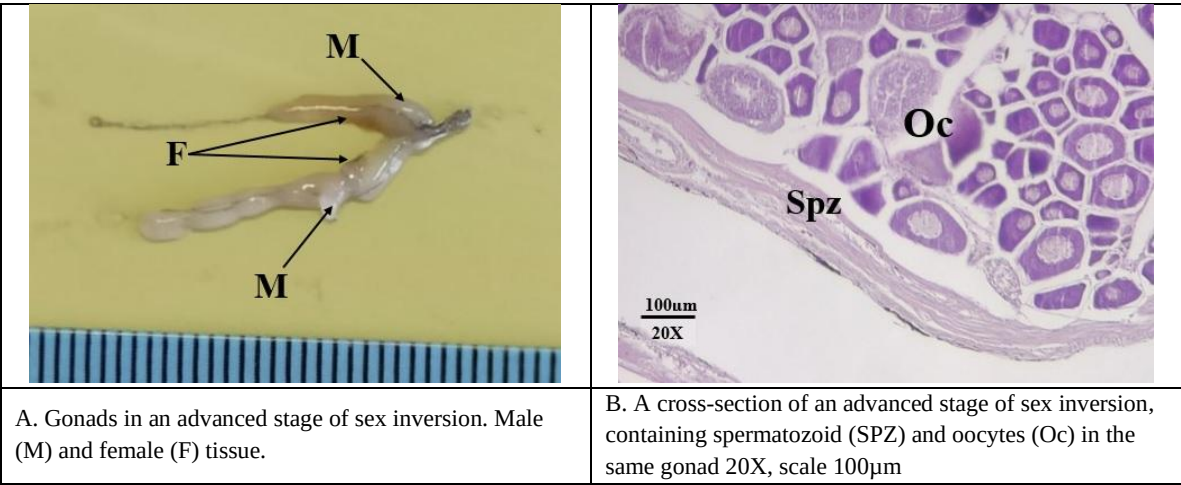


Figure 3 Hermaphrodite gonads (development of female tissue and regression of male tissue) in a *Sillago suezensis*

The histological structures of the functional testes and ovaries of *S. suezensis* conform to the hexagonal scale of gonad maturation. Throughout the year, several gonads exhibited hermaphroditism, with male cells in advanced stages found within the female gonads. This pattern of hermaphroditism aligns with the protandrous type (Figure 3). In most bony fish, sex reversal is influenced by environmental factors such as temperature and photoperiod but is primarily dependent on size (age) or gregarious behavior, closely related to the species mating system (Munday et al., 2006; Kobayashi et al., 2013). This process involves complex hormonal interactions (Moreira et al., 2019).

4. CONCLUSION

This study documents the first occurrence of hermaphroditism in the migratory fish species *Sillago suezensis* (Sillaginidae) in Syrian marine waters. This phenomenon has not been observed in this species in its original habitat or among other original and migratory species of the Sillaginidae family. Therefore, further histological studies on the gonads of male and female species within the

Sillaginidae family are recommended to monitor the presence of hermaphroditism. In-depth research should also investigate the relationship between histological developments within the gonads and variations in the lengths of the studied samples where hermaphroditism was observed.

Author Contributions

All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Zen Alabdin Adel Bsema, Waad George Sabour and Amina Hussien ALnesser.

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Ethical approval

In this article, as per the animal regulations followed in Zoology Department, Faculty of Science, Tishreen University, Lattakia, Syria, the authors documented the first occurrence of hermaphroditism in the migratory fish species *Sillago suezensis* (Sillaginidae) in Syrian marine waters. The Animal ethical guidelines are followed in the study for species observation, identification & experimentation.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

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