

First record of the dusky grouper *Epinephelus marginatus* (Actinopterygii: Epinephelidae) undergoing sexual transition in the South Western Atlantic, Brazil

Primer registro del mero *Epinephelus marginatus* (Actinopterygii: Epinephelidae) en transición sexual en el Atlántico Sudoccidental, Brasil

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ABSTRACT

The dusky grouper *Epinephelus marginatus* by fisheries is a marine species historically exploited showing slow growth, late maturation and protogynous hermaphroditism. Currently, it is considered as endangered by the IUCN. Therefore, it is essential to increase the knowledge about its biology and ecology to help conservation of this species. The present study reports the first record of a dusky grouper individual undergoing sexual transition, from female to male, in the Atlantic Ocean based on histological analyses of gonads. The specimen with total length: 770 mm; total weight: 8.1 kg and age: 21 years was captured in a rocky bottom along the coastline of the southernmost in state Brazil.

Key words: Endangered species, protogynous hermaphroditism, southern Brazil.

RESUMEN

El mero *Epinephelus marginatus* es una especie que ha sido históricamente explotada por los pescadores y que presenta crecimiento lento, madurez sexual tardía y hermafroditismo protogínico. Actualmente está clasificada por la IUCN como amenazada, razón por la cual es esencial aumentar el conocimiento sobre su

biología y ecología, para ayudar en su conservación. Se presenta el primer caso documentado de transición sexual gonadal de un mero, de hembra a macho, en el Océano Atlántico sudoccidental basado en análisis histológicos de las gónadas. El espécimen con largo total de 700 mm, peso total de 8.1 kg y edad de 21 años fue capturado en un fondo rocoso en la costa del extremo sur de Brasil.

Palabras clave: Especie amenazada, hermafroditismo protogínico, sur de Brasil.

The dusky grouper *Epinephelus marginatus* (Lowe, 1834) inhabits shelter-rich, hard substrates from the surface to 250 m (Heemstra & Randall, 1993) and reaches maximum densities above 50 m depth (Harmelin & Harmelin-Vivien, 1999). It is widespread distributed in the Mediterranean coast and in the Atlantic Ocean, occurring from the British Isles to South Africa and from the Bermuda Islands to Argentina (Heemstra & Randall, 1993). It is also found in the Indian Ocean along the southeastern-south coast of Africa (Fennessy, 2006). The dusky grouper is considered to be overexploited in its entire distribution range and is listed as endangered

by the IUCN red list of threatened species (Cornish & Harmelin-Vivien, 2004). The increasing fishing pressure associated with some of its biological characteristics (*e.g.*, territorial behavior, low growth rate, late maturation, and complex reproductive strategy) probably contributed to its overexploitation and precarious conservation status (Fennessy, 2006). It is essential to increase our knowledge of its reproductive biology in order to guide fishery management and conservation plans to protect this endangered species.

The hermaphroditism is a successful reproductive strategy found in 27 teleostean families, including Epinephelidae (Sadovy & Liu, 2008). The dusky grouper is a monandric protogynous hermaphrodite species, where all individuals are born as females with the potential to change their sex to males along their life span (Heemstra & Randall, 1993; Reñones *et al.*, 2010). Prior studies conducted on '70s, '80s and '90s with grouper populations in the Mediterranean Sea have shown that sexual transition occurred on individuals 9 to 16 years old, and total length (TL) ranging from 68 to 90 cm (Chauvet, 1988). More recent observations suggested that sexual transition can occur in much younger and smaller individuals: from 7 to 17 yrs and from 52.1 to 76.9 cm TL, respectively (Reñones *et al.*, 2010). Such reduction in the age and size of hermaphroditic individuals undergoing sexual transition could be due to the withdraw of males by fishery, since large individuals are the main target of fishermen and the first ones to be taken out of the fish stock (Gulland, 1993).

The knowledge of the sexual transition phase is crucial information in order to achieve a complete understanding of the

reproductive cycle of hermaphroditic species, especially those with commercial value needing fishery regulation. However, it is usually difficult to unravel individuals undergoing sexual transition due to the low number of individuals involved in this phase of the life cycle, which is probably significantly faster and more brief compared with the others phases like development and maturation to adulthood (Sadovy & Shapiro, 1987). For instance, Brulé *et al.* (2003a) found only 5 individuals at the sexual transition phase out of 1125 analyzed specimens of *Mycteroperca bonaci* (Poey, 1860), whereas Brulé *et al.* (2003b) obtained only two in this stage among the 319 studied individuals of *Mycteroperca microlepis* (Goode & Bean, 1879). A similar trend is observed in the few studies with populations of *E. marginatus* reporting the occurrence of individuals at sexual transition in the Mediterranean (*e.g.*, only 10 out of 399 individuals; Reñones *et al.*, 2010) and in the Indian Ocean (*e.g.*, only 1 out of 395 individuals Fennessy, 2006). No individual at sexual transition stage was reported in prior works on the reproductive biology of *E. marginatus* in the Western Atlantic Ocean (Andrade *et al.*, 2003; Seyboth *et al.*, 2011).

The current work provides the first record of an individual of *E. marginatus* at sexual transition in the South Western Atlantic Ocean. This individual was collected on 28 March 2008 by a commercial fishing boat at the Carpinteiro Bank (Fig. 1) ($32^{\circ}11'S$; $051^{\circ}48' W$). This subsurface bank is situated at the 16 nautical miles southeast of the mouth of Patos Lagoon estuary. The Carpinteiro Bank represents one of the few consolidate substrate sites found along the coastline of the Rio Grande do Sul state, Brazil, which is characterized by extensive sand bottoms (Abreu & Calliari, 2005).

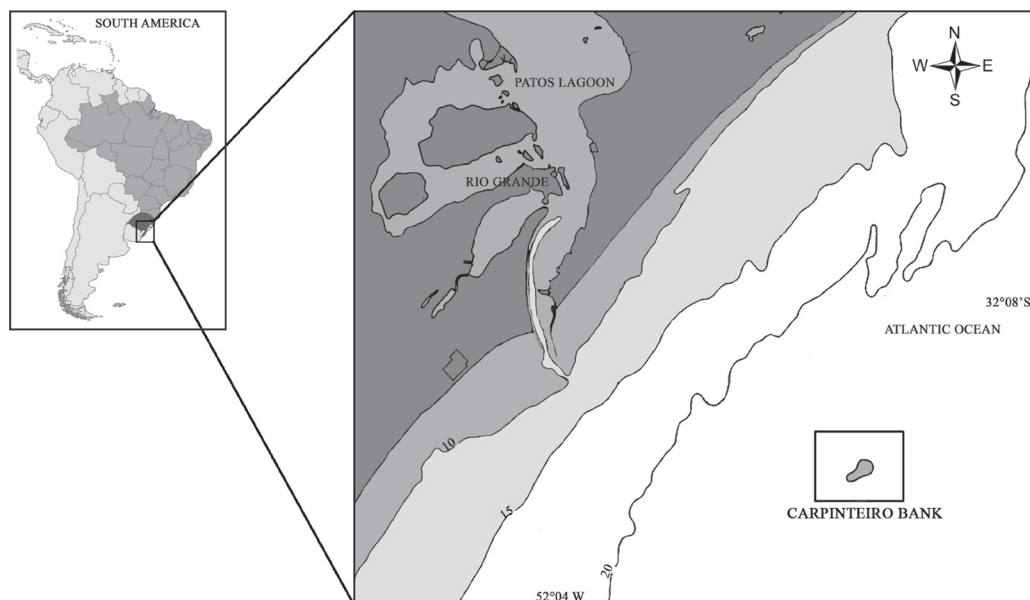


Figure 1. Patos Lagoon (10.360 km^2) and its estuarine zone in the southernmost state in Brazil, showing the location of the Carpinteiro Bank in the adjacent marine area. The lines along the coast denote 10, 15 and 20 m isobaths, respectively.

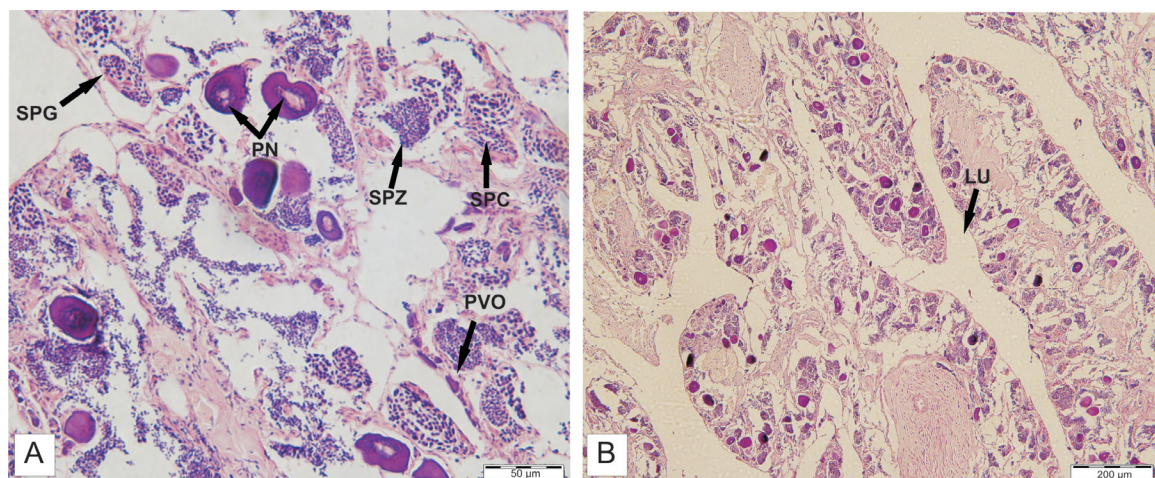


Figure 2A-B. Gonad section of a dusky grouper *Epinephelus marginatus* specimen in sexual transition collected in the Carpinteiro Bank. A) Section showing both female (*e.g.*, previtellogenic oocytes, PVO; peri-nucleolus oocytes, PN) and male features (*e.g.*, spermatogonia, SPG; spermatocytes, SPC; spermatozoa, SPZ). B) Occurrence of the vestigial lumen (VL) that was previously delimited by the ovigerous lamellae. The gonad section was stained with haematoxylin-eosin.

The specimen measured 770 mm (TL) and weighted 8.1 kg. Readings of growth rings of its right *sagittae* otolith (sectioned at approximately 0.5 mm thick sections), using a microscope at 15–30x magnification, revealed that the specimen was 21 years old. Its gonads were extracted, weighted (0.01 g) and preserved in 10% formalin for 7 days and later stored in 70% alcohol for later histological processing following Seyboth *et al.* (2011). The gonad weighted, the gonado-somatic index (*IG*), and the hepato-somatic index (*IH*) were 17.9 g, 0.22 and 1.66, respectively. The macroscopically observation of the appearance, consistence and size of the gonad suggested that the individual was a male.

Histological analyses were carried out in the apical, central and caudal portions of the gonads. However, there were no differences between portions of gonads. In contrast with the pattern suggested by the macroscopic analyses, the histological analyses revealed the gonad had female features, with absence of the empty follicles, presence of previtellogenic ovarian follicles disperse over a large amount of connective tissue. And we also found cysts containing proliferating male germinative cells in different development stages in this same conjunctive tissues, corresponding to a male gonad in maturation stage, containing spermatogonia (SPG), spermatocytes (SPC) and spermatozoa (SPZ) (Fig. 2A). It was also possible to observe the ovarian vestigial lumen (LU) (Fig. 2B), as previtellogenic oocytes (PVO), and peri-nucleolus oocytes (PN) (Fig. 2A) and low quantity of female tissue when compared with the portion of the gonad with male characteristics.

The histological analyses employed in the present study were based on descriptions and criteria of classical papers on the microscopic analyses of gonads of hermaphroditic species (Hastings, 1981; Sadovy & Shapiro, 1987). Such criteria are related with

the different forms of re-absorption of the ovarian tissue, with the proliferation of the testicular tissue and the occurrence of the vestigial lumen in male's gonads.

The sexual transition occurs gradually and can be divided in initial, intermediate and final phases (Webb & Kingsford, 1992). According to Hastings (1981), the absence of ovarian follicle undergoing vitellogenesis should be expected, since vitellogenic oocytes would be initially reabsorbed during the sexual transition process. Hence, based on the histological characteristics described on prior studies, we believed our analyzed specimen is between the intermediate and final stages of the sexual transition process.

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