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CHARACTERIZATION OF THE LONGNOSE STINGRAY Hypanus guttatus (CHONDRICHTHYES: MYLIOBATIFORMES) FISHERY IN A COASTAL AREA OF NORTHEAST BRAZIL

Caracterização da pesca da raia manteiga *Hypanus guttatus* (Chondrichthyes: Myliobatifomes) em uma área costeira do Nordeste do Brasil

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ABSTRACT

The longnose stingray *Hypanus guttatus* is frequently captured by artisanal fishing in the northeastern region of Brazil. This study aims to describe artisanal fishing activities targeting *H. guttatus* along the coast of Pernambuco state. Fishing landings were monitored from August 2013 to October 2015. A total of 167 individuals (94 females and 73 males) were captured using various methods, including "raieira" nets, shrimp trawl, handline, "mangote," estuarine shrimp trawling nets, and gill nets. The "raieira" net accounted for 78.7% of the recorded stingrays. This gear captures individuals across all life stages. Shrimp trawls and "mangote" are responsible for capturing immature and developing individuals. Coastal and estuarine areas serve as crucial habitats for maintaining local populations of *H. guttatus*. The species' low fecundity, combined with intense fishing efforts during the dry season, when key reproductive events occur, may negatively impact the *H. guttatus* population in this region. Conservation and management measures should be implemented to minimize the effects of human activities on the essential habitats of this batoid.

Keywords: artisanal fisheries; fishing gear; Southwestern Atlantic; Dasyatidae.

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RESUMO

A raia manteiga Hypanus guttatus é comum nos desembarques da pesca artesanal no Nordeste do Brasil. O objetivo desse trabalho foi descrever as atividades de pesca artesanal que capturam H. guttatus *na zona costeira do estado de Pernambuco. O desembarque foi monitorado de agosto de 2013 a outubro de 2015 na área litorânea do estado. Um total de 167 indivíduos (94 fêmeas e 73 machos) foram amostrados, oriundos de capturas por redes do tipo raieira, arrasto de camarão, linha de mão, mangote e rede de emalhar. A raieira foi responsável pela captura de 78,7% do total de raias amostradas. Essa rede captura indivíduos de todas as fases do ciclo de vida da espécie. O arrasto de camarão e o mangote foram responsáveis pela captura de indivíduos imaturos e em desenvolvimento. As áreas costeiras e estuarinas são habitats essenciais para a manutenção das populações locais de* H. guttatus*. A baixa fecundidade da espécie associada à intensidade do esforço pesqueiro no período seco, quando ocorrem os principais eventos do ciclo reprodutivo, podem afetar a população de* H. guttatus *em Pernambuco. Medidas de conservação e manejo devem ser implementadas para se tentar minimizar o impacto das ações antrópicas nos habitats essenciais desse batóide.*

Palavras-chave: *pesca artesanal, aparelhos de pesca, Atlântico Sudoeste, Dasyatidae.*

INTRODUCTION

The state of Pernambuco is located in the northeastern region of Brazil, with a coastline extending 187 km and encompassing 14 estuarine areas and mangroves that support approximately 34 fishing communities engaged in small-scale artisanal fishing (Braga, 2000; Lessa et al., 2006; Lessa et al., 2009). Fishing activities predominantly occur in mangroves and estuarine zones, which together account for over 60% of the total fish catch along the Pernambuco coast. However, fishing pressure and environmental degradation of coastal areas threaten these ecosystems, particularly through the removal of top predators from the habitat food web, such as Elasmobranchs (Turner et al., 1999; Estes et al., 2011; Elfes et al., 2014; Mérigot et al., 2016).

The artisanal fishery sector in Pernambuco is characterized by a low fishing income and a high number of fishers (Lessa et al., 2011). The fishing fleet is small and conducts short fishing trips (IBAMA, 2007; Lessa et al., 2009). In 2011, the state's fishery production totaled 10,880 t, accounting for approximately 9% of the national marine fisheries production (MPA, 2011). Elasmobranchs are often subject to high fishing pressure and their life history characteristics make them particularly susceptible to overfishing. In Brazil, the landings of batoids species (rays) provide a clear example of this trend. Between 2001 and 2007, a significant increase in catches was recorded, rising from 6 tons in 2001 to 50.5 tons in 2007 (IBAMA, 2004; IBAMA, 2007). Despite the absence of official records of landings in Pernambuco state, species of the genus *Hypanus* are among the 48 species that contributed the most to artisanal landings in the states of Alagoas and Pernambuco (Lessa et al., 2009).

Among batoids species captured by the artisanal fleet in Brazil, the stingray *Hypanus guttatus* (Bloch and Schneider 1801) is the most commonly caught species along the northern and northeastern coasts (Menni and Lessa, 1998; Yokota and Lessa, 2006; Rosa and Furtado, 2016; Gianeti et al, 2019). This species is typically demersal and occurs from the Western central to the South-west Atlantic Ocean, as well as in the Caribbean Islands (Carlson et al., 2020). From Costa Rica to Venezuela, it is captured as bycatch by the artisanal fisheries fleet (Thorson, 1983; Cordovés et al., 2009; Grijalba-Bendeck et al., 2012), although in some regions, this species is targeted (Tagliafico et al., 2013).

Populations of sharks and rays are declining in various parts of the world (Simpfendorfer et al., 2011). The main causes include both direct and indirect fishing, as well as the loss and degradation of coastal habitat used by these species during certain stages of their life cycle (Field et al., 2009). For example, most Dasyatidae species in Pernambuco inhabit coastal areas that are highly degraded due to domestic and industrial pollution, real estate development, and shrimp farming (Lessa et al., 2011).

Information on the exploitation status of these species is essential for supporting conservation management measures. *Hypanus guttatus* is classified as Near Threatened in the IUCN Red List of Threatened Species (Carlson et al., 2020). The aim of this study was to characterize the compositions of catches, populational structure and spatial distribution of *Hypanus guttatus* targeted by fisheries operating along the Pernambuco coast and to provide information that will aid in the development of management plans for species directly or indirectly impacted by this activity.

MATERIAL AND METHODS

Study area and data collection

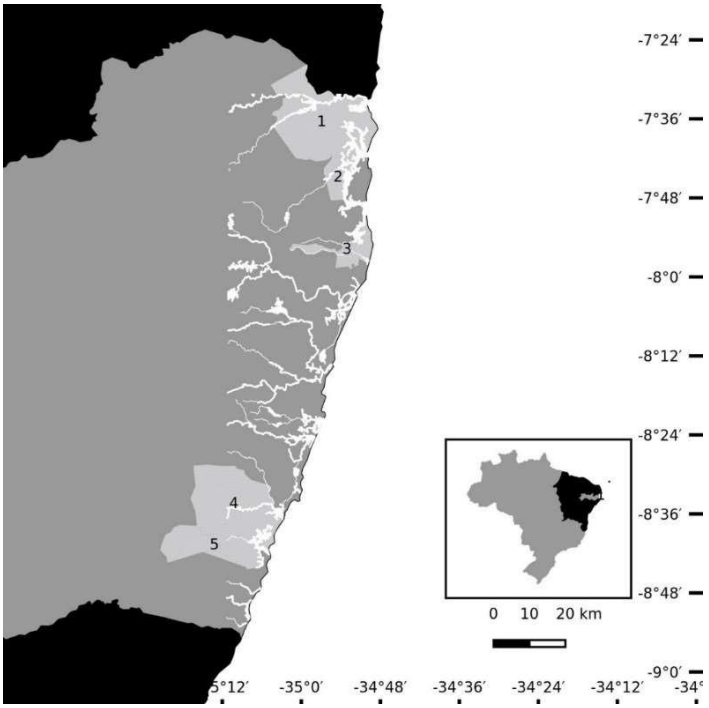
The state of Pernambuco (07°15'45'' - 09°28'18''S and 034°48'35'' - 041°19'54''W) (Figure 1.) has a coastline characterized by a narrow shelf and depths below 40 meters (Lessa et al., 2006). The environmental features of the region contribute to the high biological productivity of these coastal areas, providing valuable ecological resources that support biodiversity (Rönnback, 1999). Despite the high species diversity in the estuarine and coastal areas, the population abundance is low, which is a common characteristic of tropical regions (Lessa et al., 2006).

Overall, the climate is characterized by high temperatures (ranging from 20° to 32° C) and relative air humidity (70% to 90%) throughout the year (Silva, 2004; Regis et al., 2008). Rainfall in the region defines two seasons: the dry period, with monthly rainfall below 100 mm^3 (from September to February), and the rainy season, with monthly rainfall exceeding 100 mm^3 (from March to August) (Cavalcanti and Kempf, 1967).

Samples were collected monthly from different locations through monitoring fishing along the coastal zone of the state of Pernambuco. These locations ranged from the north to the south of the state, including the municipalities of Goiana, Itapissuma, Paulista, Sirinhaém, and Rio Formoso artisanal fisheries (Figure 1.). From August 2013 to October 2015, fishing methods such as fishweirs, "raieira" (a gillnet specific to batoids), shrimp trawl, "mangote" (an estuary shrimp trawl), gillnets, and handline were observed for *H. guttatus*. In the northern part of the study area, the location of fishing grounds was determined through two field trips. The fishing region encompasses the municipalities of Igarassu, Itapissuma, Itamaracá, and Goiana (Figure 1). During the fishing trips in March and April of 2015, abiotic parameters such as temperature, salinity, pH, and dissolved oxygen were recorded using an OAKTON PCD650 multiparameter meter. In addition, monthly precipitation data for the study period were obtained from the National Water and Climate Agency (Agência Nacional de A' guas e Clima -APAC).

The sex of each specimen was identified, and the disc width (DW) in centimeters (cm) and total weight (TW) in grams (g) were recorded. The life cycle phase of each individual was determined according to Melo (2016) and classified as neonate, young of the year, immature (subadult), or mature. For clarity, the neonate, young of the year, young, and immature (subadult) stages were grouped as ‘immature’, while the adult stage was classified as ‘mature’.

Figure 1. The State of Pernambuco, in northeastern Brazil, location and sampling area for major captures for *Hypanus guttatus*. The sampled regions include the municipalities of Goiana, Itapissuma, Paulista, Sirinhaém and Rio Formoso.



Fishing gears

Fishweirs

Fishweirs are common stationary traps in the northern part of the state of Pernambuco, particularly in Itamaracá and Goiana. These traps are typically constructed using wooden sticks and wrapped with a small mesh (30 mm). The design of the trap retains fish inside, preventing them from escaping once they enter the gear. Fishweirs are collected daily by fishers during the low tide (Lessa et al., 2009).

Shrimp Trawl

The shrimp fishery in Pernambuco uses double-rig twin otter trawls, locally named "tangones". Each net is 10 m long, with a mouth opening of approximately 6 m. The mesh size is 15 mm in the codend and 20 mm in the body of the net (Santander-Neto et al., 2016). Fishing operations are carried out at a relatively low towing speed, averaging two knots for about 4 hours (Santander-Neto et al., 2016). The seabed consists of mud, quartz sand, and calcareous algae (see Kempf, 1970). The target species include white shrimp (*Litopenaeus schmitti*, Burkenroad, 1936), Atlantic seabob (*Xiphopenaeus kroyeri*, Heller, 1862), and pink shrimp (*Farfantepenaeus subtilis*, Pérez-Farfante, 1967 and *F. brasiliensis*, Latreille, 1917) (Santander-Neto et al., 2016). The present study used landings at the municipality Sirinhaém, on the southern coast of Pernambuco.

Estuary shrimp trawl "mangote."

It is used in Itapissuma and Rio Formoso. This gear has stretched meshes of less than 18 mm and is hauled by hand while walking along the estuarine margin. Therefore, no vessel is required for this fishing operation (Lira et al., 2010). The fishing occurs within the estuary, and the typical target species are mullet (*Mugil curema*, Valenciennes, 1836) and sardine (*Opisthonema oglinum*, Lesueur, 1818) (Lessa et al., 2009).

Handline

The handline gear is made of nylon monofilament line with a diameter ranging from 0.3 and 2 mm, equipped with one or more hooks of size 05 to 07 (Lessa et al., 2009).

Gillnet

Gillnets are popularly known as "small net". This gear capture 14 different species of small pelagic fishes, is the most common and target species is *Ophistonema oglinum* (Lima and Andrade, 2018). The mesh size is 30 mm between opposite knots, and the gear is made of nylon monofilament line, with floats on the upper hoist and lead on the lower hoist. The net has variable dimensions, with a height ranging from 2.2 to 2.5 m and a length of 150 to 200 m (see Lima et al., 2021). The catches occur in the morning, during varying tidal cycles, with fish captured during each fishing trip (Lima et al., 2018).

Raieira" – Gillnets-for-batoids

The gillnet-for-batoids is a type of set gillnet made of Polyamide (PA) multifilament yarn, with a 200 mm mesh size (measured between opposite knots), an average height of 10 to 20 meshes and a meshing coefficient between 43 and 50% (Lira et al., 2010). It is a long and rectangular net that is opened vertically in the water by a headrope, usually equipped with styrofoam floats and a footrope with sinkers. The net is kept stable by weights (bricks) at both ends and is marked on the surface with buoys (made of styrofoam or PET). The capture method for this gillnet is entangling. In the study area, the gillnet was recorded in two locations: Itapissuma and Itamaracá, mainly in the estuary zone. In the past, fisheries used to occur in coastal areas and caught elasmobranchs (mainly stingrays and small coastal sharks) and marine turtles (incidentally caught). However, since 1989, the directive IN Nº1.522 (IBAMA, 1989) and State Law nº 9.931 of December 11 of 1986 (PERNAMBUCO, 1986) have prohibited the capture, killing, trade, and transport of marine turtles. As a result, the “raieira” gillnet ceased to be used in coastal areas, and fishing has since been restricted to the estuarine environment.

The Gillnet for batoids ("Raieira") was analyzed separately from the others due to its impact on stingray populations along the coast of Pernambuco State.

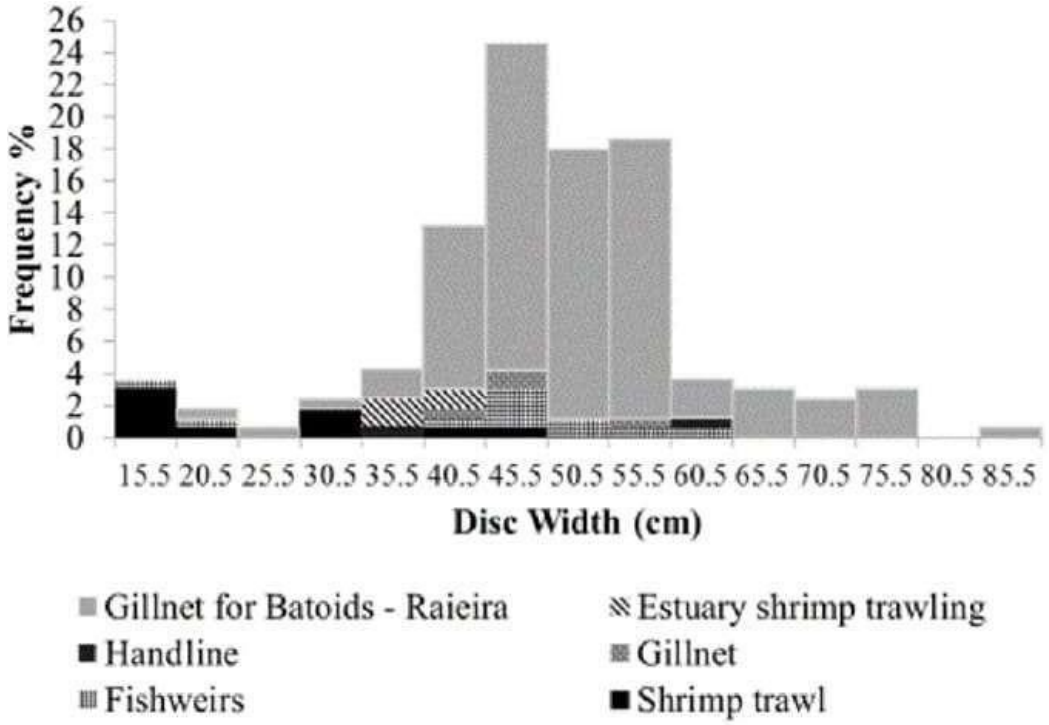
Data analysis

Data normality was assessed using the Kolmogorov-Smirnov test (K-S), and disk width (DW) was grouped by sex. The relationships between DW and total weight (TW) were established and tested by sex using ANCOVA. The lower limit of maturity size (DW50) in this study was considered as 40.8 cm DW cm (±1.2) for males and 49.3 cm DW (±1.3) for females (Melo, 2016). Additionally, the sex ratio and the ratio of immature and mature specimens were tested for between consecutive months using the $\chi 2$ test to verify the significance of deviation. All analyses were carried out using the significance level of p=0,05 (Zar, 2010). Based on the data obtained from the sample, a distribution map of immature and mature individuals by fishing ground was developed using the Q-GIS software 3.16 LAS PALMAS.

RESULTS

The fishing gears used to catch *H. guttatus* in northern Pernambuco were gillnets for batoids, fishweirs, gillnet, and handline, while shrimp trawl and estuarine shrimp trawl were used in the southern part of the state. A total of 167 individuals were sampled, ranging from 13.9 to 87.5 cm. The gillnet for batoids represented 79.6% of the total sample (n = 133), followed by shrimp trawling (6.59%, n = 11), fishweir (6.59%; n = 11), estuarine shrimp trawls (3.6%, n = 6), gillnets (2.4%, n = 4) and handline (1.32%; n = 2) (Figure 2).

Figure 2: Disc width distribution of *Hypanus guttatus* caught by the artisanal fleet: gillnet-for-batoids, handline, fishweirs, estuarine shrimp trawling, gillnets and shrimp trawling in the State of Pernambuco, Brazil.



Gillnet fishing for batoids ("raieira")

The Gillnet for batoids is a type of bottom gillnet (Figure 3A), made with No. 18 silk yarn panels. The net has a stretched mesh size of 160-250 mm between opposed knots (Figure 3B). The top of the net features a floatline with 32 floats along a polyamide multifilament No.04 rope. The distance between the floats is 240 cm. The leadline is made of polyamide multifilament No.03 rope and is equipped with 15 or 16 lead weights with 15 to 20 mesh height (Figure 3C). Some fishers opt to use silk yarn and polyamide monofilament when constructing the net.

Most of the "raieira" fishing grounds are found in the Santa Cruz Channel, but fishing with gillnets for batoid also occurs in the municipalities of Igarassu, Itapissuma, Itamaracá, and Goiana (Figure 5). The temperature ranged from 32°C to 33.70°C; salinity ranged from 20.14 to 35.27, and dissolved oxygen concentration ranged from 4.88 and 5.78 mg/L. The pH values ranged from a minimum of 8.61 to a maximum of 9.11.

The fishing operation in the estuary began at dusk, with the net deployed at high tide and retrieved at low tide. The depth of the fishing site ranged from 5 to 18 meters in muddy bottoms. Fishing operations lasted approximately 9 hours, resulting in batoids being entangled rather than enmeshed (Figure 4), as shown in video S1 (available in the online version). Fishing activity occurred year-round, except September, due to the windy season. Fishing intensity was higher during the dry months (October to December). Throughout the year, gillnets capture all stages of the stingray's development, with few immature males in the sample. In addition to *H. guttatus*, *Aetobatus narinari* (Euphasen, 1970), this gear also captures *Narcine bancroftii* (Griffith & Smith, 1834), which is only frequent during a specific period of the year, according to fishermen's reports. Among all species caught, *N. bancroftii* is the only species without commercial value, leading to it being released alive upon captured.

Figure 3: A gillnet-for-batoids is a rectangular net anchored on two sides at the bottom of the estuary, used to target batoids in the northern area of the State of Pernambuco, Brazil. A) Arrangement of the gillnet-for-batoid in the water. B) The gillnet mesh characteristics, with lateral meshed measuring 16-20 cm between opposite knots, and a stretched mesh size ranging from 32-40 cm. C) Distribution of floats along the head rope, with floats spaced 240 cm apart, and a footrope with sinkers.

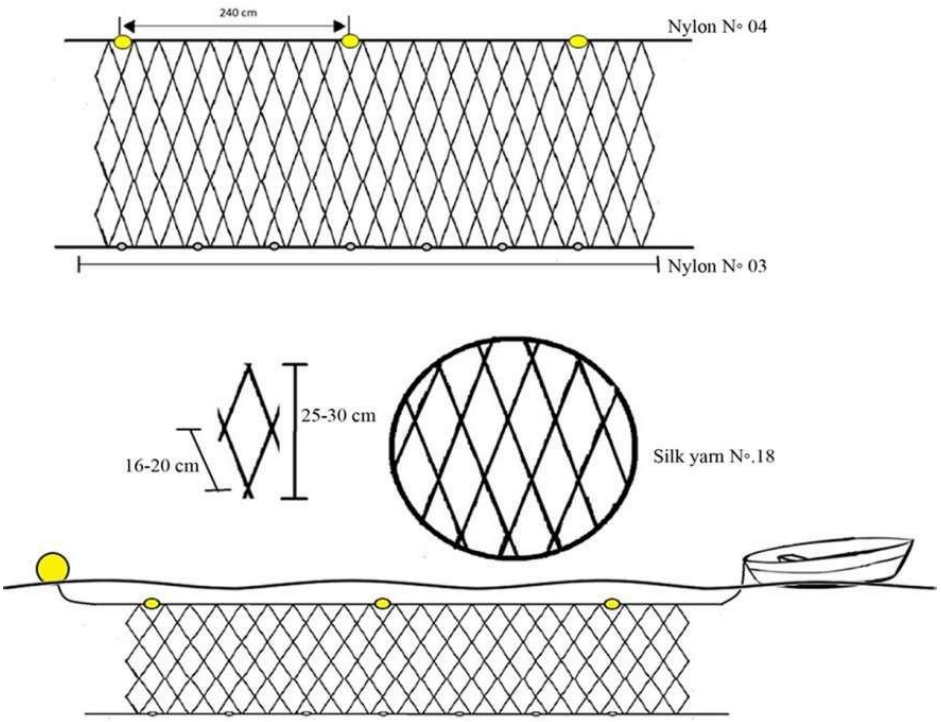
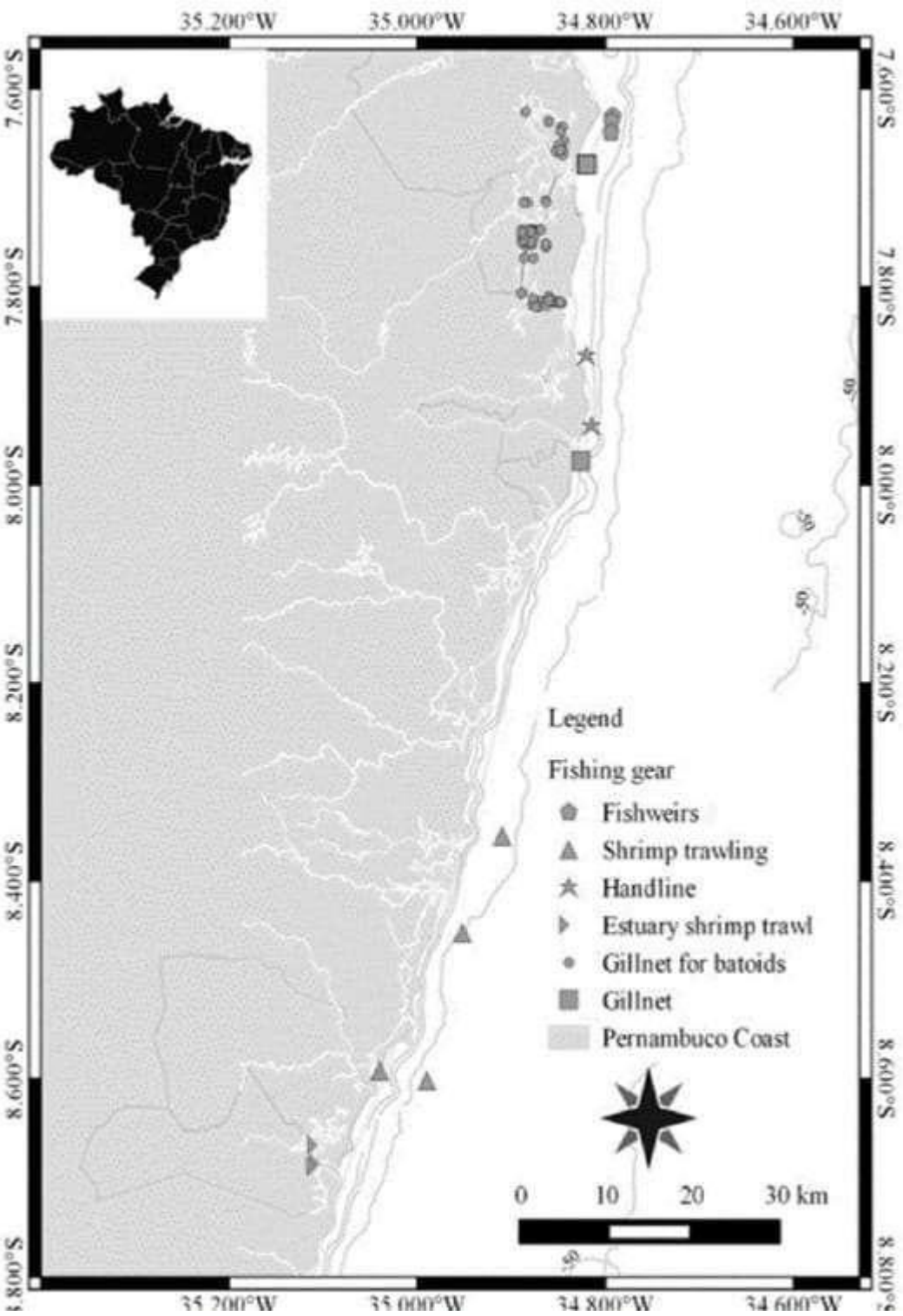


Figure 4: Entangled *Hypanus guttatus* caught by gillnets for batoids in the estuarine area (A) and coastal marine area (B) of the State of Pernambuco.

Figure 5.: Fishing gears and fishing areas for the capture of *Hypnanus guttatus* in the coastal zone of the State of Pernambuco.

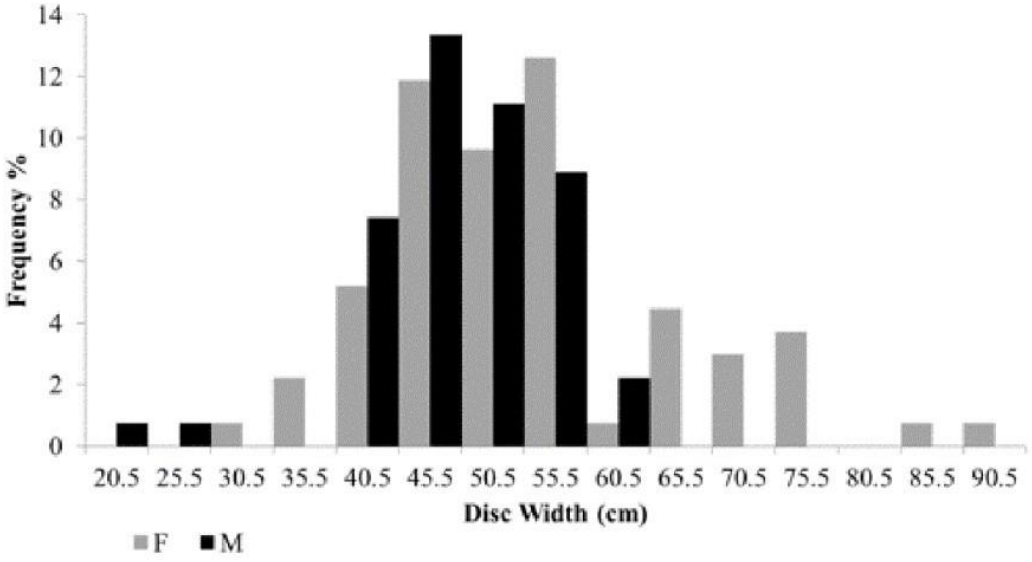


A total of 135 stingrays were analyzed, with disc widths ranging from 18.9 to 87.50 cm. The disc width distribution for males and females was not normally distributed (Shapiro-Wilk (SW) = 0.94, $p < 0.05$). Females reached a greater size than males, and significant differences were observed between the average disc widths of males and females (U - Mann-Whitney, U = 1624.5, $p = 0.005$). The frequency distribution exhibits a bimodal peak in the 40.5 to 45.5 cm

class for males; the second mode corresponds to the 50.5 cm and 55.5 cm DW classes for females (Figure 6).

The sex ratio was 1:1.25 without significant differences between males and females ($\chi 2$ = 1.66; p = 0.22). However, when specific fishing grounds in the Santa Cruz Channel were considered, two sites showed a higher female ratio (1:4.6; p = 0.00064). The disc width (DW) of 75 sampled females ranged from 32.6 to 87.5 cm, with total weight ranging from 2690.00 and 20700.00 g; while for the 60 sampled males, the disc widths varied from18.90 to 61.5 cm, with total weights ranging from 199.02 to 4420.00 g. The total weight and disc width were not statistically different between sexes (ANCOVA, D.F. = 20; p = 0.96). Only one equation was established for both sexes: TW = 0.0633*DW 2.85 (R^2 = 0.88, n = 23).

Figure 6: Disc width distribution of *Hypanus guttatus* caught by gillnet for batoids in the State of Pernambuco. Size class frequency (n = 167) for batoids caught in the State of Pernambuco.



The highest frequencies of *H. guttatus* occurred during periods of low rainfall, corresponding to the dry season in the study area. Females were the most frequent throughout the year, except in October and December. A total of 66.7% of the individuals were mature and 33.3% were immature. The ratio of immature to adult individuals (1:2) was significantly different ($\chi 2$ = 15.0, p = 0.0002). The smallest mature male had a DW of 41.0 cm, while the largest immature male had a DW of 44.5 cm. The smallest mature female had a DW of 44.9 cm, while the largest immature female had a DW of 53.0 cm. The proportion of immature and mature individuals varied according to the fishing spot, and it was found that mature females occur more frequently in areas closer to the sea (Figure 7). Immature and mature males, as well as immature females, were more frequent in the Santa Cruz Channel than in marine areas.

Other Fishing gears

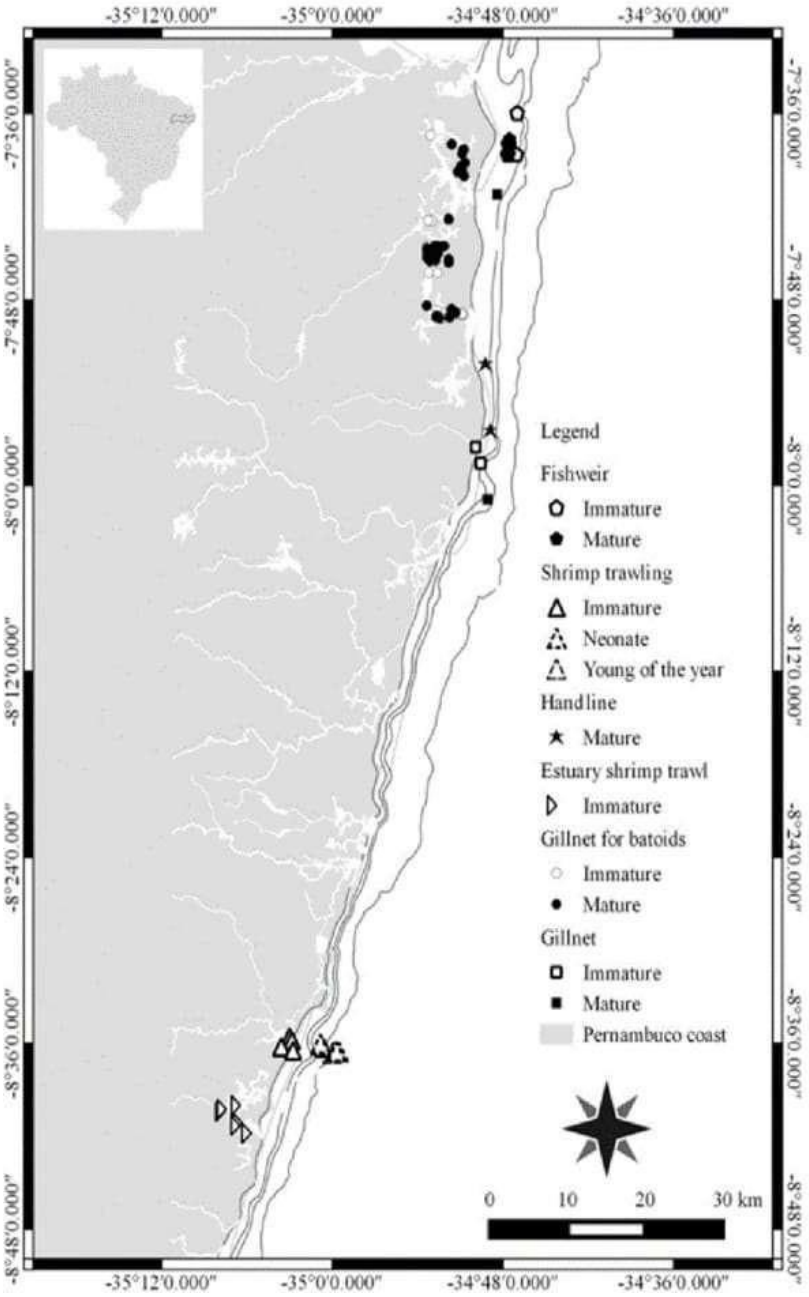
In the shrimp trawls, it is common to capture of neonate, young of the year, and immature individuals of both sexes of *H. guttatus*, which correspond to 78.2% of the total sampled, while 18.2% correspond to mature males. Other batoids species landed from this gear were *Pseudobatos percellens* (Walbaum 1792), *Gymnura micrura* (Bloch & Schneider, 1801), *Urotrygon microphthalmum* (Delsman, 1941), and *Hypanus marianae* (Gomes, Rosa & Gadig, 2000).

Fishweirs captured mature (54.5%) and immature (45,5%) *H. guttatus* (Figure 5). Except for one individual with a disc width (DW) >20 cm, all other immature individuals were

subadult (ranging from 40.0 to 45.0 cm DW). In addition to *H. gutatus*, *Hypanus marianae*, *Hypanus berthalutzae* (Petean, Naylor & Lima, 2020), *Aetobatus narinari*, *Rhinoptera brasiliensis* (Müller, 1836), *R. bonasus* (Mitchill, 1815), and the small shark *Rhizoprionodon porosus* (Poey, 1861) were also captured.

Handlines and gillnets captured mature and immature individuals of *H. guttatus* in equal proportion (50%). The gillnets also capture *Aetobatus narinari* and *Rhinoptera* spp. Landings from estuary shrimp trawls consisted exclusively of immature individuals of *H. guttatus* (Figure 7).

Figure 7: Spatial distribution of *Hypanus guttatus* according to maturation stages established by Melo (2016) in the sampling area with major captures from August 2013 to October 2015 in the state of Pernambuco, Brazil.



DISCUSSION

In northern Brazil, *H. guttatus* is bycatch in the pink shrimp trawl fishery (*Farfantepenaeus subtilis*), gillnets, and handlines. However, the species may become a major target for fishing vessels seeking alternatives to bottom trawling (Frédou and Asano-Filho, 2006). In Venezuela and Colombia, *H. guttatus* is the main batoid species caught by the artisanal fleet (Cordovés et al., 2009). In Margarita Island (Venezuela), the stingray becomes the target species when there are low catches of small sharks (*Rhizoprionodon* spp. and *Mustelus* spp.) and the spotted eagle ray (*Aetobatus narinari*) (Tagliafico et al., 2013).

In Brazil, along the coasts of the states of Pará and Maranhão, *H. guttatus* is caught by bottom longlines and is often present in fishweirs (Piorsky et al.,2009; Palmeira, 2012). The occurrence of *H. guttatus* in fishweirs is common in various regions along the northeastern Brazilian coast such as the state of Pernambuco, where the species was the second most captured stingray in this type of trap. Also, along the state of Ceará, *H. guttatus* is captured in shrimp trawling, gillnets (in shallow coastal waters), handlines (at depths of 15-30 m), and cast nets in estuarine areas (Silva et al., 2001; Basílio et al., 2008). Lessa et al. (2008) observed in Rio Grande do Norte that *H. guttatus* was bycatch in a variety of gears, such as shrimp trawling, beach seines, gillnets, handlines, and longlines.

The number of gillnets deployed has increased by 70% during the study period. As a result, gillnets for batoids were responsible for the largest captures of this species in Pernambuco (Figure 2), highlighting that *H. guttatus* has become a target species in response to the regional demand for food consumption. In the northern and northeastern coasts of Brazil, the species is the most frequent caught and supplies a substantial portion of the growing elasmobranch meat trade in the region (Yokota and Lessa, 2006; Gemaque et al., 2017; Gianeti et al., 2019; Feitosa et al., 2021).

This gillnet is not used exclusively in Pernambuco. In the state of Bahia, Marion (2015) recorded significant captures of *H. guttatus* when using gillnet-for-batoids at Baía de Todos os Santos. Lessa (1997) indicated that *H. guttatus* was the most frequently caught stingray by drift gillnets along the coast of Maranhão. The results of the scientific fisheries conducted along the Pernambuco coast using bottom gillnets indicated that *H. guttatus* was the second most frequent species at depths between 2 to 10 m according to F. M. Santana, Ph.D. (personal communication, November 2015). The species occasionally occurs in gillnet landings in Alagoas (Rangely et al., 2010), in bottom gillnet fisheries in Rio de Janeiro (Tomás et al., 2010) and in Paraná state (Costa and Chaves, 2006).

The common occurrence of immature individuals of *H. guttatus* in shrimp trawling and estuary shrimp trawls in this study has also been recorded in gillnet and cast net landings in the state of Ceará (Silva et al., 2001; Basílio et al., 2008). According to Yokota and Lessa (2007), juveniles of *H. guttatus* represented 88% of artisanal fishing landings in Caiçara do Norte, RN, with 74% of landings attributed to beach trawl nets for shrimp and shrimp bottom trawls (Lessa et al., 2008). The size class that most contributed to the landings in Caiçara do Norte, RN, was 15.0-20.0 cm DW (Yokota and Lessa, 2006). Thus, in many trawl fisheries, the elasmobranch bycatch may exceed the amount captured by directed elasmobranch fisheries (Márquez-Farias, 2002).

When caught in a gillnet for batoids, stingrays become entangled by their caudal spines. Struggling to escape leads to complete entanglement (Figure 4). A similar occurrence was observed in batoids fishing using ray gillnets in India (Sherief et al., 2015). Therefore, this gillnet has captured a higher number of mature individuals than other types of gear. Furthermore, the distribution of *H. guttatus* in the Santa Cruz Channel is a more significant factor in the disc width distribution (Figure 6) than the net's mesh size, as described by Márquez-Farias (2005), regarding gillnet mesh selectivity for *Rhinobatus productus*.

According to Thorson et al. (1983), adults of *H. guttatus* prefer estuarine areas with low salinities. This is because stingrays in low salinity environments retain less urea, as demonstrated for the stingray *Himantura signifer* (Chew et al., 2006). Therefore, the lower urea concentration makes the muscle meat more desirable for human consumption.

The Santa Cruz Channel (in Pernambuco) is U-shaped. This shape creates a semi-open, elongated lagoon-like between Itamaracá Island and the mainland, connecting to the Atlantic Ocean. It terminates and receives runoff from six small rivers (Medeiros, Kjerfve,1993), and the abiotic parameters in the current study are consistent with previous studies in the area (Medeiros and Kjerfve, 2001; Araújo et al., 2012). Two Protected areas for sustainable use are present in this region: the Santa Cruz Estuarine Protected Area (Law No. 9.931/86) (Pernambuco, 1986) and the Santa Cruz Protected Area (Decree No. 32.488/08) (Pernambuco, 2008). However, no regulation exist to protect any elasmobranch species, including stingrays. Overall, as Lessa et al. (2016) indicated, Marine Protected Areas (MPAs) are not aimed to protect threatened and non-threatened species caught as bycatch.

The largest disc width attained by females in this study was of the same magnitude as those recorded for the species in Colombia (Tagliafico et al., 2012), Venezuela (Cordovés et al., 2009) and other parts of Brazil (Menni and Lessa, 1998; Yokota and Lessa, 2006, 2007; Silva et al., 2007). Sexual size dimorphism is a typical characteristic of other members of the Myliobatiformes order, such as *Aetobatus narinari* (Tagliafico et al., 2012), *Urotrygon microphtalmum* (Santander-Neto et al., 2016) and *Myliobatis freminvillei* (Tagliafico et al., 2016). Larger females carrying more embryos can be an evolutionary trait in viviparous elasmobranchs (Wourms and Demski, 1993).

Despite the sex ratio not differing from the expected 1:1 in the total sample of this study, sexual segregation of *H. guttatus* is well documented, with a skewed male ratio in Colombia (Cordovés e tal., 2009) and a skewed female ratio in northeastern Brazil and Venezuela (da Silva et al., 2018; Tagliafico et al., 2013). The balance sex ratio observed in Maranhão (Nunes et al., 2005) corroborates the present study. One factor that may explain these differences is considered by Feitosa et al. (2021) for *H. guttatus*: sex segregation as a behaviour dependent on the ecological relationship with each habitat, rather than an overall pattern for the species.

The higher frequency observed for gillnets-for-batoids from August to March (Figure 6) coincides with the decrease in rainfall and the beginning of the dry season in Pernambuco, as well as the reproductive events of the *H. guttatus* cycle (Melo, 2016). Furthermore, females at the end of the pregnancy period were captured during the dry season in fishing grounds with higher salinity, suggesting that the birth area is nearby. This fact is evidenced by the capture of neonates in coastal zones using shrimp trawls and fishweirs (Figure 2). These results are consistent with the records of young individuals and neonates of *H. guttatus* in shallow coastal areas (Lessa et al., 2008; Gianeti, 2011; Grijalba-Bendeck et al., 2012). Yokota and Lessa (2006), along with other features, identified similar areas as nurseries for *H. guttatus* in Rio Grande do Norte, Brazil.

For elasmobranchs, recruitment is directly related to the size of the parental stock due to their life strategy and the relatively small number of offspring per pregnancy (Holden, 1977). The heavy catch of mature females of *H. guttatus* may affect, in the long term, the reproductive potential of the species due to the low population recovery rate (Barbieri and Lowerre-Barbieri, 2011). In addition, the low fecundity of *H. guttatus* makes the species more vulnerable to fishing pressures and environmental degradation (Melo, 2016). Elasmobranch fishes exhibit low resilience to both direct and indirect impacts due to their life history characteristics, such as slow growth, late maturity, and low fecundity (Camhi, 1998), with many populations currently declining in various parts of the world (Simpfendorfer et al., 2011). In this context, SBEEL (2005) suggested a population decline of *H. guttatus* n the northern part of Brazil.

Batoids make up one of the most severely threatened marine groups (Last, 2007; Dulvy et al., 2021), although little is known about the biology of most species in this group (Pierce,

2009). For *H. guttatus* in Pernambuco, the data presented in this study serve as a starting point for further assessments of this species as a fishing resource. Nonetheless, the increasing number of gillnets that capture the parental stock, along with shrimp trawling operations that catch neonates and young of the year, combined with the environmental degradation of coastal marine areas, may lead to drastic population declines of *H. guttatus* in the study area. Observations by Lessa et al. (2016) on the development of uncontrolled, unrecorded, and unmanaged fisheries can also be extended to gillnets for batoids in Pernambuco state.

CONCLUSION

The longnose stingray, *Hypanus guttatus*, is a commonly captured species in artisanal fisheries in Pernambuco, primarily exploited by gillnets for batoids, known locally as "raieira." In the study area, the coastal and estuarine zones represent critical ecosystems for the species' life history, as these areas serve as essential habitats, including nurseries and feeding grounds. The exploitation of this resource could be monitored through landings to assess the potential impacts of fishing on the local population. The predominance of mature individuals in this fishery may affect the parental stock, which indicates the greater vulnerability of these adults due to these activities.

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