

Catch composition, sex ratio, and clasper maturity of wedgefish (*Rhynchobatus* spp.) landed in Tegalsari, Central Java, Indonesia

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Abstract. Indonesia has been considered the largest producer of shark and rays, as well as wedgefish (*Rhynchobatus* spp.) (Dent et al 20015). The high demand of wedgefish fins with high economic value in shark fin market, has promoted overexploitation and threatens the wild populations. However, the scientific information on the wedgefish fishery in Indonesia is limited, particularly as a basic input for sustainable management. This study aims to determine the catch composition, sex ratio, and clasper maturity of wedgefish caught from the Java Sea. Fish landing data were intensively collected from January to February 2020 at the Tegalsari Fishing Port. Additional monitoring data of wedgefish landing at some fishing ports from April 2019 to February 2020 was used as secondary data. Then the data was analyzed on catch composition, sex ratio, and clasper maturity level of the fish. The results showed that wedgefish landed in Tegalsari Fishing Port consisted of three species: *Rhynchobatus springeri* (37%), *Rhynchobatus laevis* (37%), and *Rhynchobatus australiae* (26%). The sex ratio (male : female) of the wedgefish was 1:3. The maturity levels of males wedgefish were composed of 42% NC (Non- Calcification), 51% NFC (Non-Full Calcification), and 7% FC (Full Calcification). The non-calcification category has the clasper length between 3-15 cm with 50-115 cm total length (TL). The non-full calcification category of the fish had a clasper length of 16-28 cm with 85-148 cm TL. The full calcification category had 29-50 cm clasper length with 120-296 cm TL. Meanwhile, based on monitoring landing data from April to December 2019, the maturity level of males wedgefish were 26% NC, 25% NFC, and 49% FC. The non-calcification, non-full calcification and full calcification categories had the clasper length of 3-15 cm (50-246 cm TL), 5-23 cm (54-227 cm TL), and 7-30 cm (55-296 cm TL), respectively. Spatial and temporal variations of the fishing ground affect the relationship of the total body length and the claspers' maturity of the wedgefish.

Key Words: clasper maturity, overexploitation, *Rhynchobatus* spp., species composition.

Introduction. Wedgefish (Rhinidae) are listed in the CITES Appendix II in 2019 (IUCN 2020), which means the international trade is still allowed but needs to be regulated and monitored to attain sustainable harvest and legal trade. Based on IUCN (2020), wedgefish has been listed as Critically Endangered due to significantly decreased population numbers and are threatened by habitat loss. The wedgefish population's decline is due to fishing pressure and limited management, making the wedgefish a target for catching and bycatch of trawl, longline, and net fishing gear (Giles et al 2016; Moore 2017). These conditions are contributing to the depletion of wedgefish populations, together with the long reproductive cycles, low fecundity, and slow sexual maturity (Last et al 2016).

The thing that underlies the fishing activity of the wedgefish is the high price of fins. In addition to the fins, other parts of the body, such as skin, bones, and meat are also sold and utilized locally (Simeon et al 2019). The intensity of the wedgefish trade determined the over-exploitation of wedgefish (Jabado 2019). Overexploitation can threaten the wedgefish populations in nature (Dulvy et al 2014; FAO 2015).

Indonesia is one of the world's largest exporters of shark fins (Musick 2005). The trade value of shark fins was IDR 124 billion from the year 2000 to 2011 (Dent & Clarke 2015). According to Jabado (2019) about 100,000 tons of shark were caught annually in Indonesia, from which 18 % of the catches were wedgefish. The international market price of the wedgefish is high, of about US\$ 964/kg in the shark fin market in Hong Kong (Jabado 2019).

In Indonesia, the Java Sea has been considered the main fishing area for wedgefish, and the fishermen mostly used boat seine net fishing gear (Simeon et al 2019; Fahmi et al 2008; Nurdin & Hufiadi 2006; Yuwandana et al 2020). Most of the wedgefish from the Java Sea fishing grounds were landed on several fishing ports in the Central Java Province. Tegalsari fishing port is a landing center for wedgefish in this province, and is mainly caught using the seine net fishing gear (cantrang) (Yuwandana et al 2020; Hendrayana & Hartanti 2018).

Scientific information and baseline data are the important basis for sustainable fisheries management, particularly to achieve the sustainability of the wedgefish fishery. Previous studies focused on identifying of the wedgefish species (MD-Zain et al 2018; Jabado 2019; Compagno & Last 2010). The study of Simeon et al (2019) on wedgefish, conducted in the West Nusa Tenggara and Aceh Provinces focused on the length distribution of the fish. Yuwandana et al (2020) conducted a preliminary study of the wedgefish fisheries' condition in Central Java's northern waters and the catch per unit effort (CPUE) of the fish. However, the research focusing on the biological aspect of the wedgefish is limited. According to Morato et al (2001), to evaluate the fish stocks status, the biological information, particularly the length and composition of fish, sex ratio, and maturity category are necessary. The species-specific records, catch, and landing data are useful to evaluate the natural sustainability of the wedgefish (Moore 2017). Therefore, this study aims to investigate the catch composition, sex ratio, and clasper maturity of the wedgefish landed at Tegalsari Fishing Port.

Material and Method. This research was conducted in Tegalsari Fishing Port, Central Java Province, Indonesia (Figure 1), and the landing monitoring data from April 2019 to February 2020 was used in this study. Mostly, the wedgefish landed in this fishing port is caught by boat seine net. We analyzed dominant species of wedgefish, which consisted of 3 (three) species: *Rhynchobatus australiae*, *Rhynchobatus springeri*, and *Rhynchobatus laevis*. The wedgefish species samples were then identified according to Jabado et al (2019), and the following parameter, total length of the fish (TL in cm), sex ratio, and clasper maturity were determined for this study.

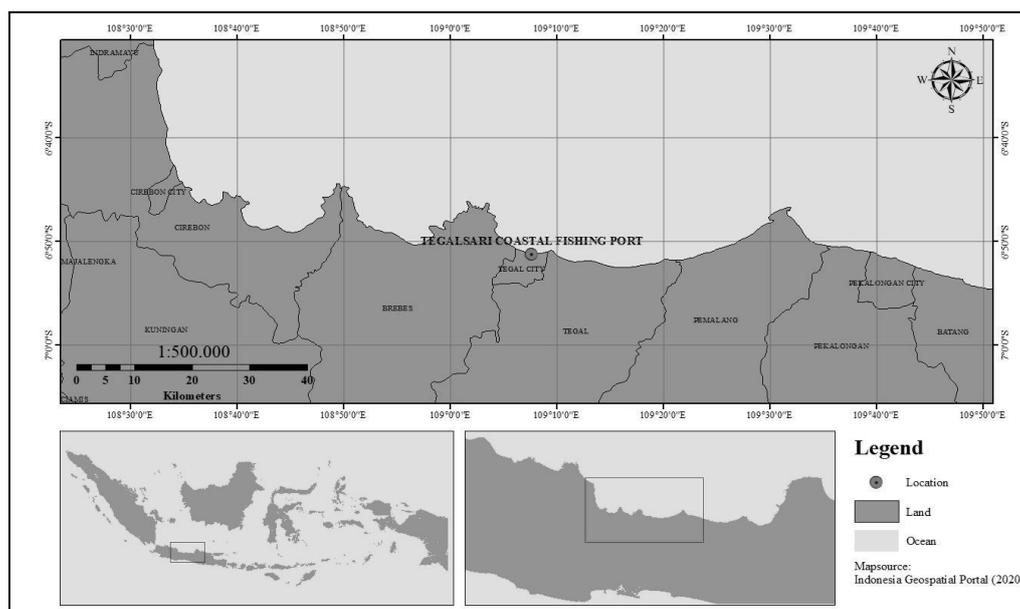


Figure 1. Research location at Tegalsari Fishing Port, Central Java, Indonesia (Source: Indonesia Geospatial portal 2020).

Catch composition analysis. We used Microsoft Excel 2010 for the analysis, and then the data was described by descriptive statistics. The length-frequency distribution of the samples was analyzed by the following formula (Walpole 1992):

$$K = 1 + 3.3 \log_n$$

$$i = \frac{r}{K}$$

where:

K = class summary
 n = total data
 i = interval class
 r = maximum - minimum

Sex ratio analysis. The sex ratio is used to evaluate the recruitment process and population balance between males and females in the wedgfish population (Dharmadi et al 2000). The sex of wedgfish is recognized by observing secondary sex organs, namely the clasper for males. The sex ratio was calculated by comparing the number of individual males and females of the fish sample, according to this formula (Effendie 2002):

$$x = \frac{J}{B}$$

where:

X = sex ratio
 J = males
 B = females

Furthermore, the sex comparison test was conducted by chi-square analysis ($\alpha=0.05$) (Sugiyono 2004):

$$X^2 = \sum_{i=1}^K \frac{(f_o - f_n)^2}{f_n}$$

where:

X^2 = chi-square
 f_o = frequency observed
 f_n = the expected frequency

Clasper maturity analysis. The maturity for the male individuals was determined by assessing the development stage of secondary reproductive organs (clasper). The clasper length measurement used the clasper insertion in the clasper's pelvic fin and apex (Dharmadi et al 2016). The data of male wedgfish was classified based on the clasper's maturity level and by comparing the clasper's size obtained from this study with the level of maturity of the clasper based on related references. The maturity level of the clasper was observed directly and divided into three levels, namely: NC (Non-Calcification), clasper was relatively small and flexible, NFC (Non-Full Calcification), with clasper of medium-size and partially rigid, and FC (Full Calcification), where the clasper had a generous size and was rigid (Dharmadi et al 2007; Ebert 2005) (Figure 2). Then, the correlation of total body length and clasper length of the fish samples was analyzed using statistical analysis software (SAS) University Edition.

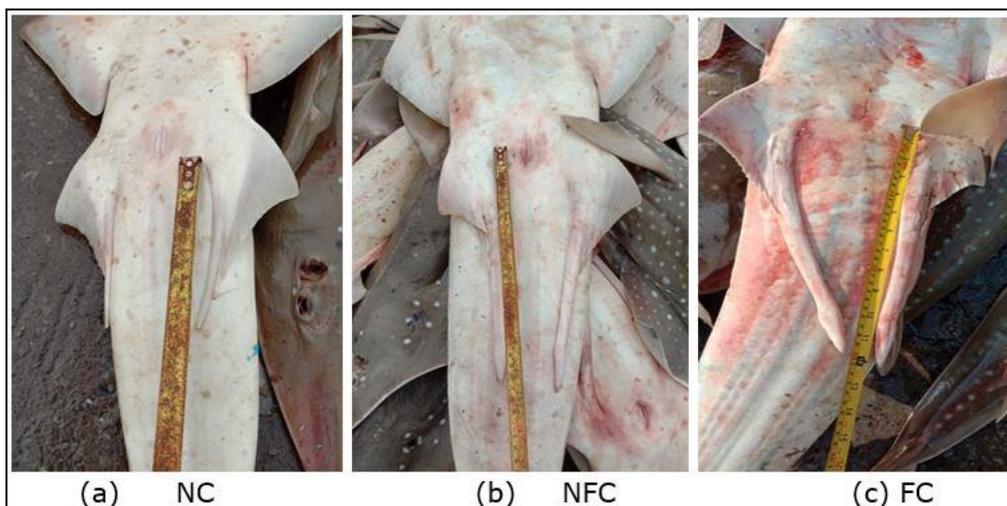


Figure 2. Clasper maturity of *Rhynchobatus* spp.

Results and Discussion

Catch composition. We recorded 2233 individuals of wedgefish between April 2019 to February 2020. Catch composition showed catches consisted of 3 species of wedgefish. There were 835 individuals of *Rhynchobatus springeri* (37%), 813 individuals of *Rhynchobatus laevis* (37%), and 585 individuals of *Rhynchobatus australiae* (26%) (Figure 3 and Figure 4). We found that *R. springeri* dominated catches composition during the research. All the wedgefish caught in this area were a bycatch of the boat seine-net fishing gear. The local fishers call this gear as “Cantrang”. The nets were set at depths between 20 and 30 m. The fishing grounds where wedgefish were caught is in the Java Sea, Bangka Belitung Waters, and Karimata Strait, situated in the shallow water area and dominated by muddy bottom sediment.

The dominant catches of the wedgefish species were *R. springeri* followed by *R. laevis*. Some studies reported that *R. springeri* and *R. laevis* were commonly found in coastal and inshore habitats at a depth of 16-40 meters and <60 meters (Compagno & Last 2010; Kyne et al 2020). However, another study conducted by Yuwandana et al (2020) showed that the dominant species of wedgefish landed in Central Java Province was *R. australiae*. This difference in dominant species is probably due to differences in fishing ground and season. Yuwandana et al (2020) recorded the wedgefish data on three landing sites along the Central Java provinces, where the fish were caught from a larger area of fishing ground from Karimata Strait to the coastal waters of Eastern Kalimantan. In this study, the catches were recorded only at the Tegalsari fishing port, from fishing grounds in the Karimata Strait, Bangka Belitung Waters, and the Java Sea. Thus, it seems that spatial distribution of *R. springeri* and *R. laevis* was dominant in the western part of the Java Sea to the Karimata Strait.

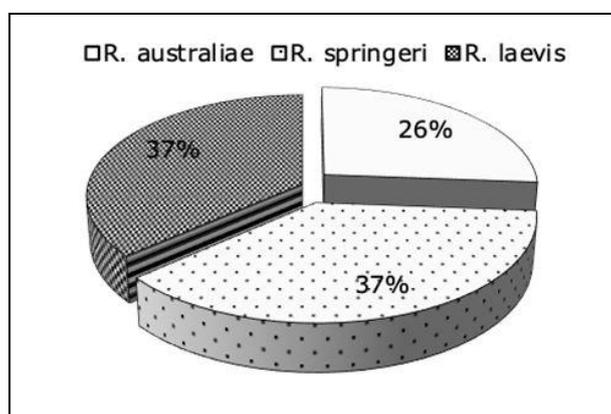


Figure 3. Species composition of *Rhynchobatus* spp.

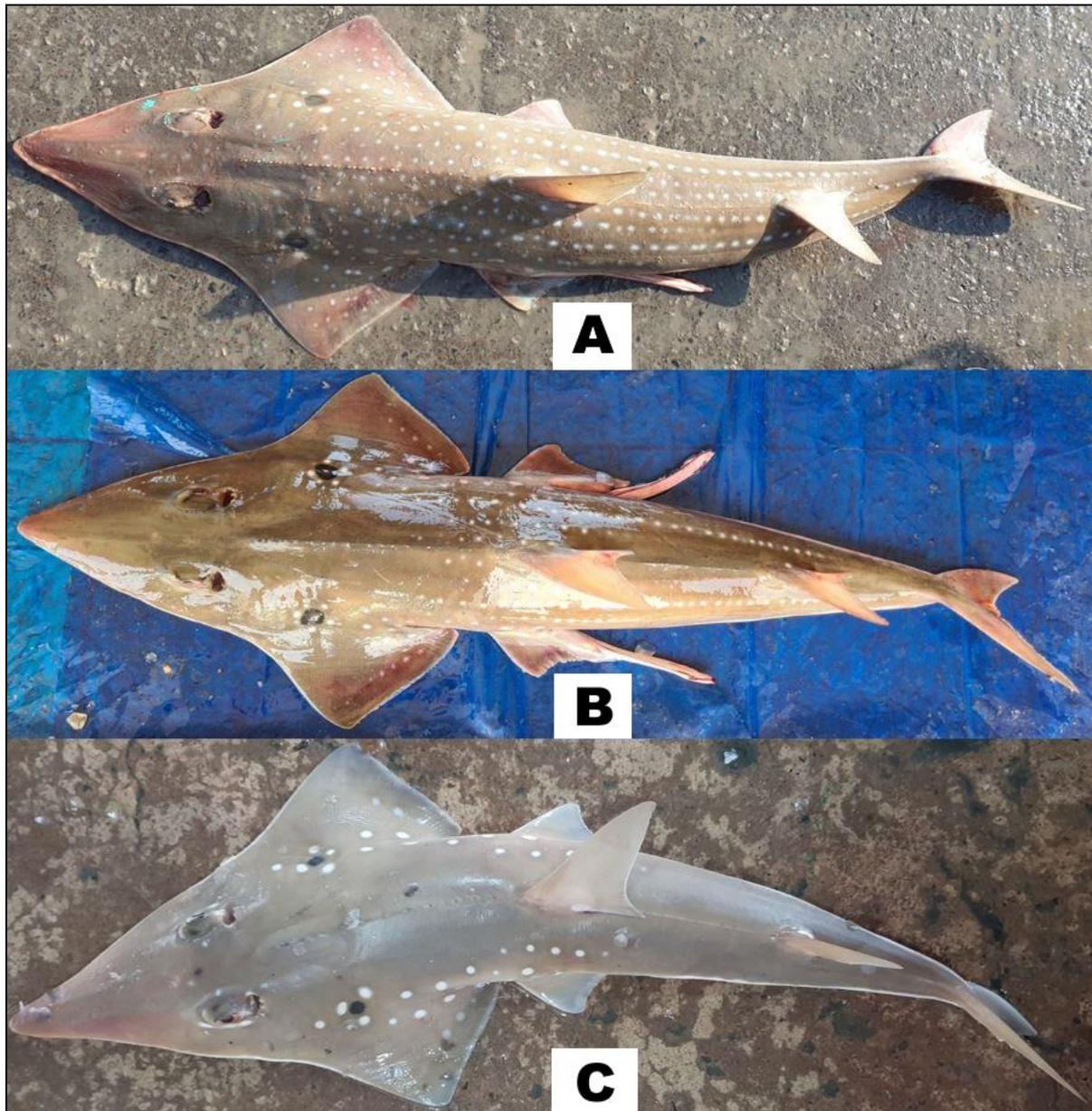


Figure 4. Species of *Rhynchobatus* spp. landed in Tegalsari Fishing Port: (A). *R. springeri*, (B) *R. laevis*, and (C) *R. australiae*.

Length frequency of catches varied between 43-305 cm TL (Figure 5). Other studies, e.g. Simeon et al (2019), reported that the total length of *R. australiae* was 100-330 cm TL, while White and Dharmadi (2007) reported 46-300 cm TL. The dominant total length size of the catches of *R. laevis*, *R. springeri*, and *R. australiae* were 64-84 cm, 106-126 cm, and 85-105 cm, respectively. The largest size of *R. laevis* was 305 cm TL. Meanwhile, the largest size of *R. springeri* was 276 cm TL and *R. australiae* had a maximum of 300 cm TL. The maximum length was different from other studies, while based on the metadata of FishBase, the maximum lengths reported were: 270 cm TL for *R. laevis*, 215 cm TL for *R. springeri*, and 300 cm TL for *R. australiae* (Froese & Pauly 2019). The variation of the total fish length could be due to the different areas of sampling. According to Azua et al (2017), the different total lengths of certain species depended on the waters area of fishing (sampling) condition.

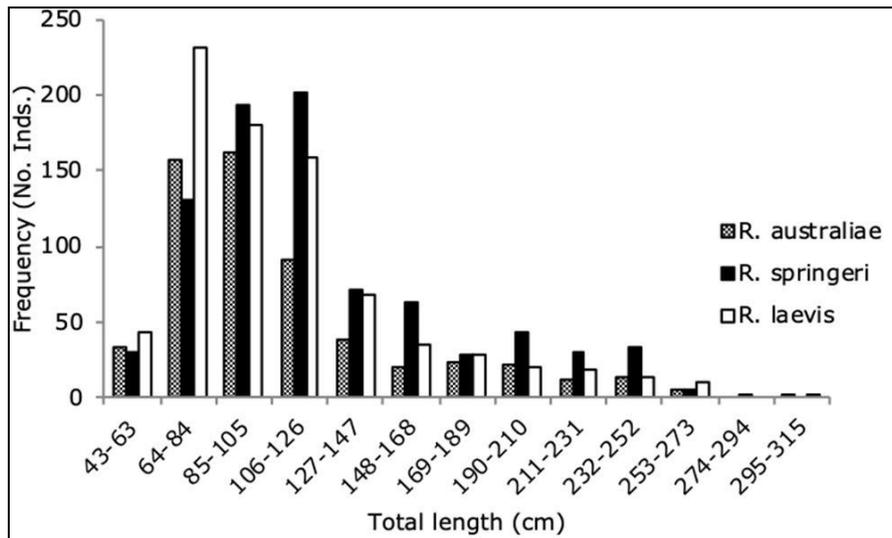


Figure 5. Length frequency distribution of the wedgefish species of *Rhynchobatus* spp.

Sex ratio. The sex distribution consisted of 1682 females and 551 males with length frequencies recorded from 43 to 305 cm TL and 50 to 296 cm TL (Figure 6). Male wedgefish were mainly caught at the total lengths of 106-126 cm TL. In comparison, the total length of female wedgefish was mostly around 85-105 cm TL. The size range of wedgefish landed at Tegalsari Fishing Port was similar to the sizes reported by Simeon et al (2019). In the study of Simeon et al (2019), wedgefish landed in Tanjung Luar were at a size range of 100-280 cm TL (males) and 100-320 cm TL (females). This study confirmed that the variation of the fish length depends not only on fishing ground or habitat, but also on sex. Female individuals could reach bigger sizes than males.

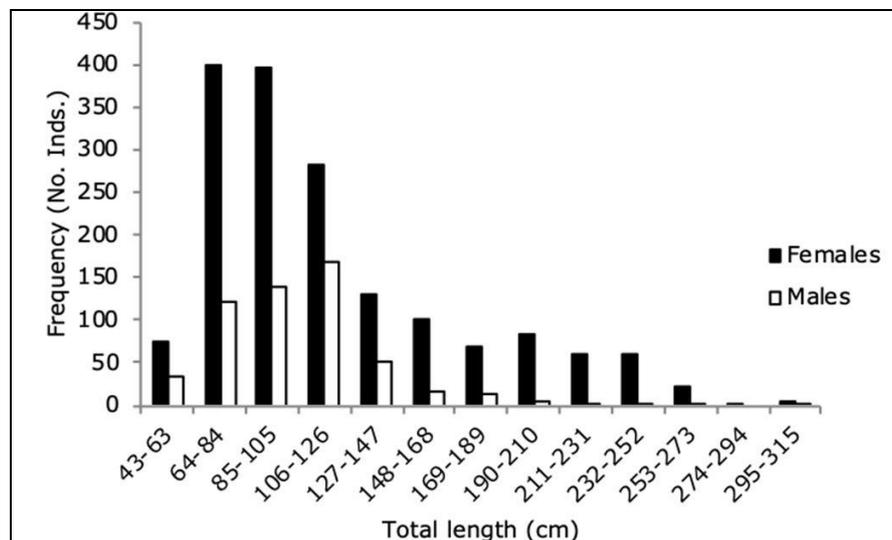


Figure 6. Length frequency distribution of females and males of *Rhynchobatus* spp.

Figure 7 shows the sex ratio of female and male wedgefish. The number of female individuals was dominant (75%) compared to male fish (25%), the sex ratio of males to females being 1:3. This shows that the sex ratio is unbalanced in the wedgefish population from the study area. The ratio of males was significantly different from females ($X^2=572.84$; $X^2_{0.05}=3.84$). The population of wedgefish in this area might not be in a stable condition. According to Ball and Rao (1984), the balanced sex ratio is showed when male and female fish are in the ratio of 1:1. These conditions are the same as the results of the study of Simeon et al (2019), where females dominated the sex ratio of the wedgefish with a ratio of 86% females and 14% males. Therefore, if these conditions persist without fisheries management, they will threaten the natural existence of the fish

in the area (Pulungan et al 1994; Purwanto et al 1986). In addition to capture activities, differences in sex ratio can also be caused by differences in sexual behavior and environmental conditions (Ball & Rao 1984). More research is needed to evaluate the sex ratio balance of wedgefish.

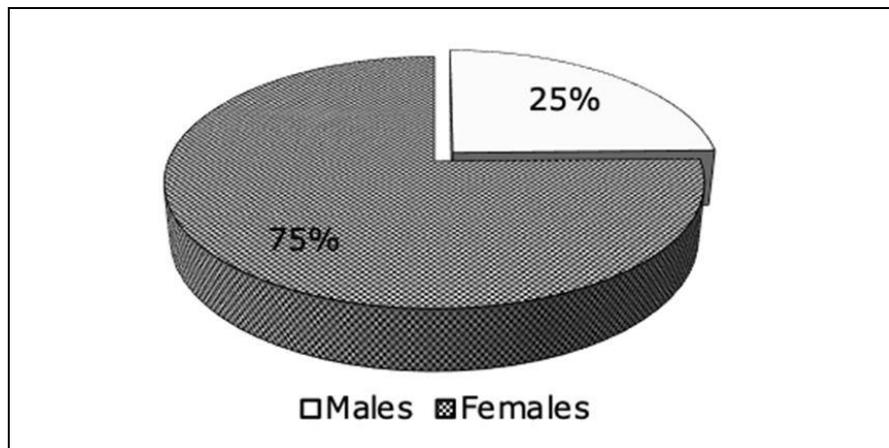


Figure 7. The sex ratio of *Rhynchobatus* spp.

Clasper maturity. The two-month landing monitoring from January to February 2020 showed that the clasper maturity condition of the fish consists of 102 individuals in NC (Non-Calcification) condition or 42%, 125 individuals in NFC (Non-Full Calcification) (51%), and 17 individuals in FC (Full Calcification) (7%) (Figure 8). The total body length of the most caught wedgefish in NC condition was in the size range of 70-89 cm TL, NFC condition in the size range of 110-129 cm TL, and FC condition in the size range of 130-149 cm TL and 170-189 cm TL. Based on this data, males were mostly caught in juvenile length sizes (immature condition).

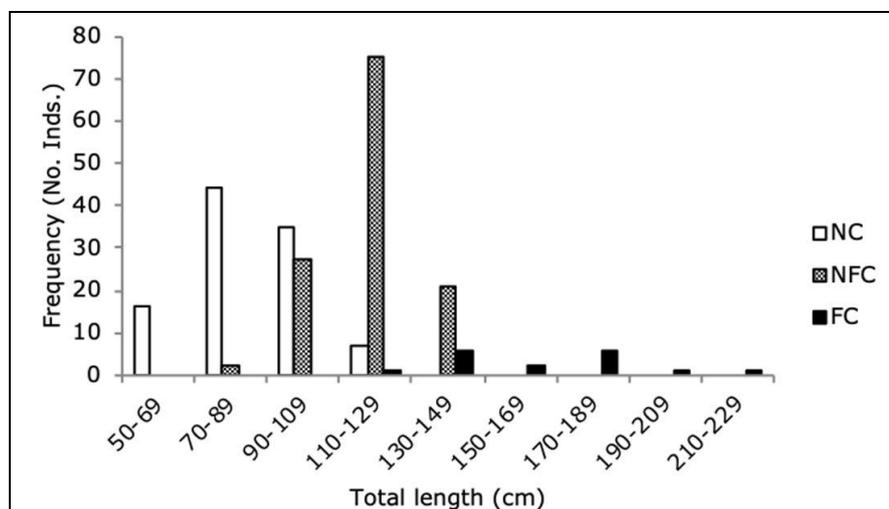


Figure 8. Clasper maturity of *Rhynchobatus* spp. (January – February 2020).

The smallest length of the male wedgefish sample was 50 cm TL with a clasper length of 3 cm, whereas the largest body length was 220 cm TL with a clasper length of 50 cm (Figure 9). The average length of the clasper was 18-20 cm. The wedgefish in the NC category were with a clasper length between 3-15 cm and 50-115 cm TL. The NFC category had a clasper length of 16-28 cm and 85-148 cm TL, and the FC category had a clasper length of 29-50 cm and 120-220 cm TL. The total body length and clasper length indicated a linear relationship with a high coefficient correlation value ($r=0.88$). The proportion of wedgefish with rigid claspers increased as the body length increased. According to Portnoy et al (2012), the age and size of fish affects sexual maturation. Based on D'Alberto et al (2019), the larger wedgefish are potentially more productive

than smaller ones. Compagno and Last (2010) reported that the minimum length size at maturity of the male wedgefish was 113 cm TL. Meanwhile, the study of White and Dharmadi (2007) showed that the minimum maturity size of the male fish was 130 cm TL. The smaller size of length at sexual maturity of the male fish indicates the level of fishing pressure. Maturity at an earlier age is a natural response of the fish on increasing fishing pressure (Rochet 2000). According to White et al (2006), the Java Sea has a high intensity of fishing activities, and it has been indicated that the fish stocks are being overexploited.

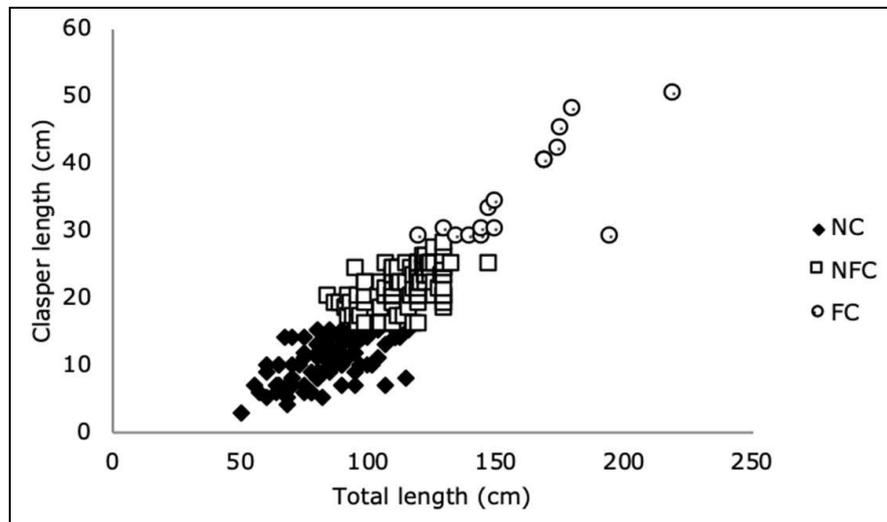


Figure 9. Relationship between total length and clasper maturity length (NC, NFC, and FC category) of *Rhynchobatus* spp. (January – February 2020).

Meanwhile, based on data collected from April to December 2019 in this area, clasper maturity of the fish consists of 79 individuals in NC condition (26%), 78 individuals in NFC condition (25%), and 150 individuals in FC condition (49%) (Figure 10). Most male wedgefish were caught in mature condition. The length size of wedgefish with NC condition was dominantly at 50-74 cm TL, the NFC condition at 75-99 cm TL, and the FC category at 100-124 cm TL.

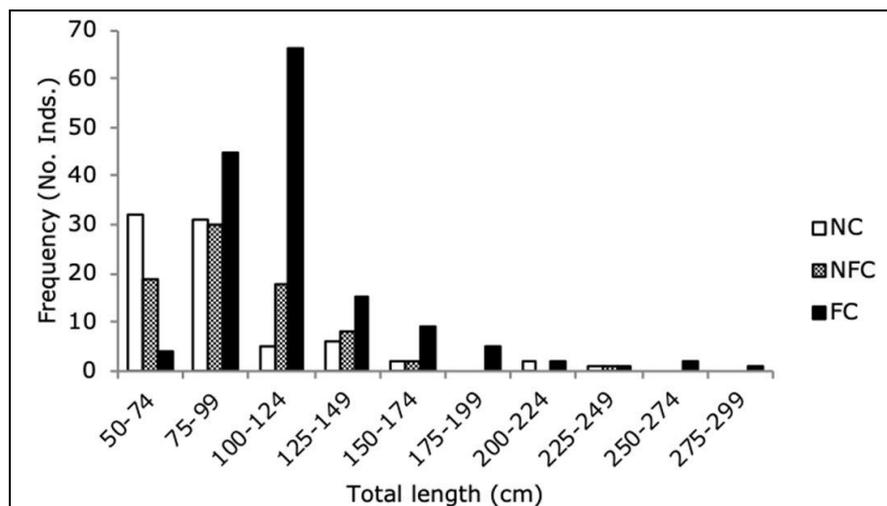


Figure 10. Clasper maturity of *Rhynchobatus* spp. (April - December 2019).

The smallest length of males wedgefish caught had 50 cm TL with a clasper length of 5 cm, and the maximum body length was caught at 296 cm TL and had a clasper length of 20 cm (Figure 11). The mean clasper length was 13.92 cm. The wedgefish were in the NC category with a clasper length between 3-15 cm and 50-246 cm TL. The NFC category had a clasper length of 5-23 cm with 54-227 cm TL, and the FC category had a clasper

length of 7-30 cm with 55-296 cm TL. The total body length and clasper length had a linear relationship with the low correlation value ($r=0.32$), which means that the fish body length did not relate to the clasper's maturity. The difference in the clasper maturity based on primary and secondary data is probably due to capture season and fishing ground variations.

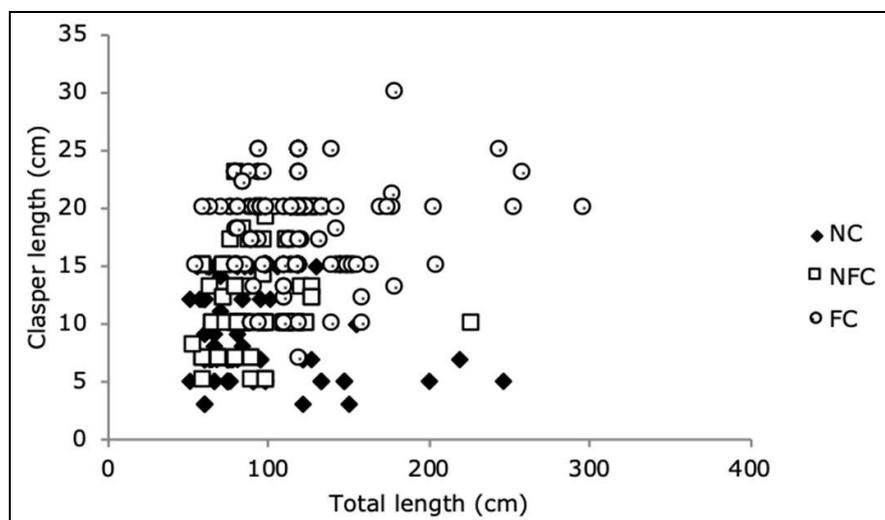


Figure 11. Relationship between total length and clasper maturity length (April - December 2019).

There were differences in the clasper maturity level of the wedgefish, which was analyzed based on long term monitoring data (April - December), then short term (January - February) in this study. The variations of oceanographic conditions of the fishing areas affect the maturity parameters of the maximum length, length of maturity, and fecundity (Parsons 1993; Fahmi et al 2009). We assumed some sub-population clusters delimited by the geographic boundaries of the fishing grounds. Claspers from the wedgefish which were caught from the same sub-population tended to be uniform in growth. We found that from January to February, during this field study, fishers prefer to conduct their fishing activity on the western coast of the Kalimantan Island. From March to December, the fishing activity was conducted on larger fishing areas. It was also indicated by differences in species composition of the catch, based on sampling in other fishing ports across Indonesia (Yuwandana et al 2020; Simeon et al 2019). However, further research is needed to understand the sub-population boundaries of wedgefish along the Java Sea.

There were seasonal variations on the maturation condition of the wedgefish. We found that most of the male wedgefish were in mature clasper condition from August to November (Figure 12). There was a gradual fall in the frequency of mature wedgefish from December to February. In February, despite capturing many wedgefish, most of the fish were in immature condition. The male's maturity season coincided with the study of Simeon et al (2019), whereas the wedgefish that landed from November to December had a large size. The fish length is strongly related to the maturity stages, so it could be used to estimate the sexual maturity condition (Bhagawati et al 2017). Clasper maturity condition is related to the mating season (Teshima 1981; Whitney & Crow 2007; Kajiura et al 2000; Tricas et al 2000; Gelsleichter et al 2002). Male wedgefish produce more testosterone so that the amount of semen in the clasper is high during the mating season (Snelson et al 1997).

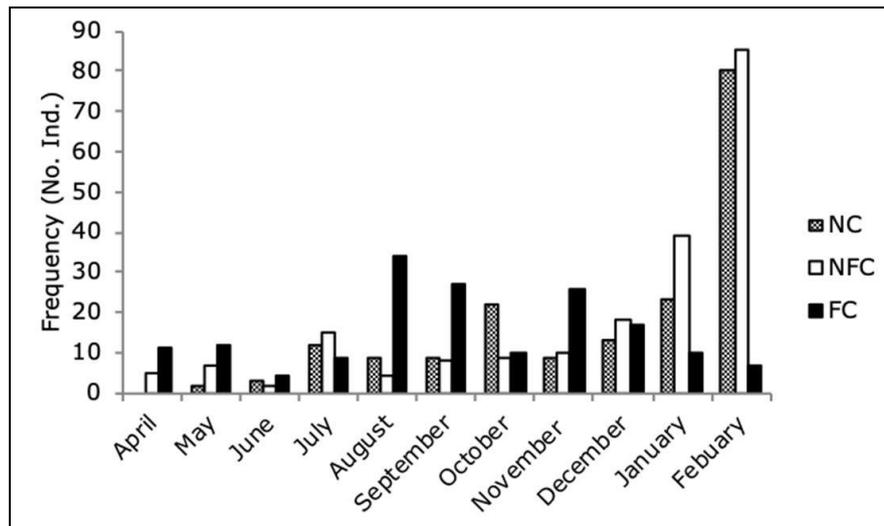


Figure 12. Clasper maturity distribution from April 2019 to February 2020.

Conclusions. In conclusion, the wedgefsh landed in Tegalsari Fishing Port are identified as three species: *Rhynchobatus springeri*, *Rhynchobatus laevis*, and *Rhynchobatus australiae*. The sex ratio of wedgefsh was unbalanced, where female wedgefsh were more dominant than male wedgefsh. There were variations of the body length and clasper's maturity relationships of the wedgefsh based on spatial and temporal monitoring data. A positive relationship of those parameters was showed based on monitoring data from January to February 2020 in the Tegalsari fishing port, while the negative ones were indicated by monitoring data from April to December 2019, from some fishing ports. Thus, one could conclude that spatial and temporal variations of the fishing ground affects the relationship of the total body length and clasper maturity of the wedgefsh. This study recommends reducing the fishing pressure during the mating season of the wedgefsh from August to November. An open-closed fisheries management measure should be implemented during the critical life stages of the fish (spawning and nursery seasons). The development of a marine protected area in their critical habitat would also be of great help for the wedgefsh populations.

Acknowledgements. The authors thank the Marine and Fisheries Agency of Tegal Municipality and Tegalsari Fishing Port for their support. We would like to thank to the Wildlife Conservation Society – Indonesian Program and Rekam Nusantara Foundation (Bogor) for funding, support, and collaboration in this study.

Conflict of Interest. The authors declare no conflict of interest.

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Received: 02 November 2020. Accepted: 21 December 2020. Published online: 09 December 2021.

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How to cite this article:

Wulandari T. L., Taurusman A. A., Nurani T. W., Yuwandana D. P., Muttaqin E., Yulianto I., Simeon B. M., 2021 Catch composition, sex ratio, and clasper maturity of wedgefish (*Rhynchobatus* spp.) landed in Tegalsari, Central Java, Indonesia. AACL Bioflux 14(6):3487-3499.