MATURITY STAGE STUDY OF THE BLUE-SPOTTED MASKRAY, *Dasyatis kuhlii* IN INDONESIAN WATERS

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ABSTRACT

A study on the most common rays occurred in Indonesian waters, *Dasyatis kuhlii,* was conducted at several areas in Indonesia from 2003 to 2006. A total of 1056 individuals, consisting of 523 females and 533 males were measured from some areas in western Indonesia including the Java Sea, the Malacca Strait, South Java, East Sumatra, West Kalimantan and South Natuna waters. Size ranges of *D. kuhlii* were varied among regions. In general, mature individuals were caught more often than neonates in all areas. The minimum size was 130 mm disc width (DW), and maximum size was 415 mm DW. Females usually produce one pup in its reproduction cycle and the smallest recorded pregnant female was 240 mm DW, while the largest was 317 mm DW. Males attain maturity at size between 215 and 295 mm DW. There were differences in size at first maturity for *D. kuhlii* caught from each area. The rays seemed to be mature earlier at the Java Sea, West Kalimantan, East Sumatra and the Malacca Strait, as an indication of their adaptation methods for fishing pressure and environmental degradations in their habitats.

Keywords: Maturity stage, reproduction cycle, *Dasyatis kuhlii*

INTRODUCTION

The blue maskray whipray, *Dasyatis kuhlii*, is one of the most common rays occurred in Indonesian waters. This small-size ray is known distributed throughout the Indo–West Pacific from India to Melanesia, including southern Japan and Australia (Last & Compagno, 1999; White *et al.*, 2006b). As demersal fishes, *D. kuhlii* can be found on insular and continental shelves to a depth of 90 m. This species is commonly caught as by catch by various fishing gears such as bottom trawls, bottom lampara nets, the Danish seine nets and trammel nets. This species, together with *D. zugei, Himantura gerrardi* and *H. walga,* contributed about 75% of the total batoids caught by fisheries in eastern Indonesia during a study from 2001 and 2006 (White & Dharmadi, 2007). While in a study in western Indonesia from 2003 to 2005, *D. kuhlii* also contributed about 55% of the total abundance of recorded chondrichthyans during the study (Adrim & Fahmi, 2007).

Elasmobranch fisheries in Indonesia has become international concern due to its status as the highest total catch of cartilaginous fishes in the world (Bonfil, 1994; Stevens *et al.*, 2000) Some authors suggested that elasmobranchs are fully exploited in Indonesian waters with indications of depletion in some areas, especially in the Java Sea and adjacent waters (Bonfil, 2002; White *et al.*, 2006b). Some common species become the targets of fishing due to the high value of their fins or skins (i.e. rhynchobatids and some dasyatids). However, management and conservation actions are difficult to implement for such species when basic data on biology and diversity of elasmobranch are either very few or not available in the region. Therefore, some high-valued species are already threatened before any management responses could be put into place (Camhi *et al.*, 1998).

Studies on elasmobranch biology and life histories conducted in the Pacific region over the last few decades have included age and growth, reproduction, diet analysis to provide knowledge for sustainable fishing and management (Seki *et al.*, 1998; Oshitani *et al.*, 2003; Joung *et al.*, 2004). Study on reproductive cycle, gestation period, size at maturity and number of pups are basic knowledge for understanding species life history (Simpfendorfer, 1992; Liu *et al.*, 1999). Knowing size at first maturity is essential that allows us to examine mature and spawning stocks for managing the species exploitation (Jennings *et al.*, 1998). Furthermore, Frisk *et al.* (2001) suggested that further knowledge on age, fecundity, mortality and growth is crucial to realize conservation for elasmobranchs. This study is a complement of previous studies on biology of *D. kuhlii* in Indonesia (White & Dharmadi, 2007) and provides detailed information on maturity stage of the species from several areas in western Indonesia.

MATERIALS AND METHODS

Data collection and measurements

Data were collected from many fish landing sites in Sumatra, Java and Kalimantan from June 2003 to October 2006. Fishing areas were based on where fishers landed their catches at

particular landing sites, e.g. the west north Java region was taken from data collected at Muara Angke and Muara Baru landing sites; east north Java region was from Pekalongan, Batang, Rembang and Brondong landing sites; south Java region was taken from Binuangeun and Palabuhan Ratu; the Malacca region was from Belawan and Tanjung Balai; east Sumatra region was from Bangka and Lampung; west Kalimantan region was from Mempawah and Sungai Pinyuh landing sites; and south Natuna region was taken from data collected at Sei Kakap landing site.

Analysis of variance (ANOVA) was used to compare the significance of differences mean disc width of *D. kuhlii* among region, and post hoc tests was performed using Fisher's least significant difference (LSD) test to compare the mean values among region to find out where exactly the significant differences are (Howell, 1997; Zar, 1999). The maturity stages of males are based on the calcification condition of their claspers and divided into three categories i.e. Claspers Not Calcified (NC), Not Fully Calcified (NFC) and Fully Calcified (FC) (Dharmadi & Fahmi, 2006; White *et al.*, 2006a; White & Dharmadi, 2007). Immature males are indicated by the small, flexible and uncalcified claspers. Claspers swiftly lengthen and harden when males reach maturity. Males were considered fully mature if their claspers are elongate, rigid and calcified (Stevens & McLoughlin, 1991). The maturity stages of females were determined by the presence of embryos, large developing ova and enlargement of their uteri (Wetherbee *et al.*, 1997; Hazin, 2001; White *et al.*, 2002).

The examination of female reproduction was conducted only when the species was being processed in the market and embryos were counted if existing. Size at first maturity of males was assessed by plotting clasper length against body size (total length or disc width), according to the calcification of the claspers. Whilst the 50% of males attain maturity (the DW_{50} at maturity) was derived from a logistic regression (White *et al.*, 2006a), where the proportion (P_{DW}) of those rays that were mature at size DW was calculated as follows:

$$p_{DW} = \frac{1}{1+\exp\left[-\ln(19)\frac{(DW - DW_{50})}{(DW_{95} - DW_{50})}\right]}$$

DW_{50} and DW_{95} are constants and ln is the natural logarithm. Maximum likelihood estimates of the parameters were acquired using the SOLVER in MS Excel program and calculating the likelihood of immature (1- P_{DW}) and mature individuals (P_{DW}). The estimates of the parameters were determined as the median values resulting from 200 sets of randomly-resampled data, drawn from the size data on the observed maturity stage for males. The 95% confidence intervals were estimated as the 2.5 and 97.5 percentiles from the results of the 200 estimates.

RESULTS AND DISCUSSION

A total of 1056 individuals of *Dasyatis kuhlii*, consisting of 523 females and 533 males were measured was recorded from twelve landing sites in west central Indonesia. In general, size ranges of *D. kuhlii* from the study areas were from 130 to 465 mm DW for females and from 130 – 415 mm DW for males, with a large number of individuals recorded in the 260 - 279 mm DW size class (Fig. 1). Whilst size ranges of each fishing region and the mean values of their disc widths are showed in Table 1. The ANOVA test showed a significant difference among the mean disc width of *D. kuhlii* from each region ($P<0.05$). The mean disc width of *D. kuhlii* from East Kalimantan was the largest and mean disc width of the species from West Kalimantan was the smallest (Table 1).

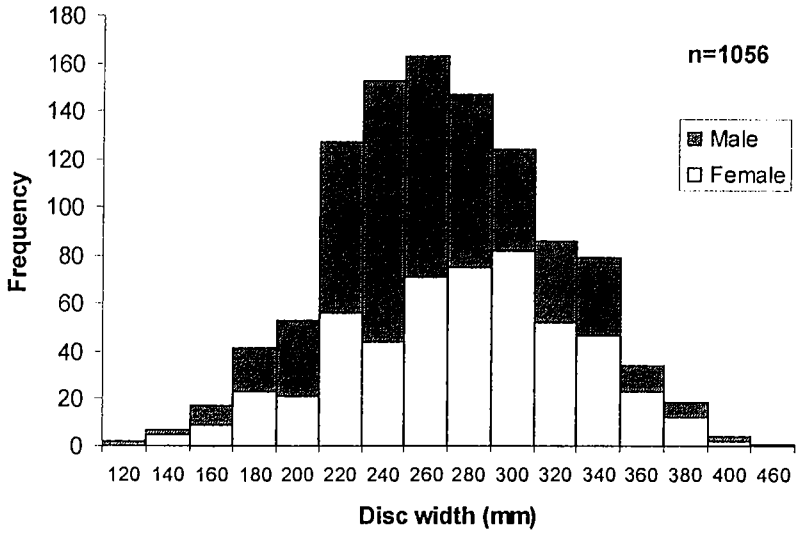

Figure 1. Stacked bar graphs of disc width frequency of *Dasyatis kuhlii* from six fishing areas in western Indonesia

Table 1. Size ranges of *Dasyatis kuhlii* caught from each fishing area in western Indonesia

Fishing area	Female	Male	Mean			St. Dev
			Female	Male	Total	
West North Java	165-363	145-372	266.2	245.3	253.3	37.9
East North Java	130-370	130-330	278.5	251.2	265.7	38.2
South Java	150-395	200-360	288.9	293.2	290.9	55.2
Malacca	130-355	185-339	277.2	264.5	272.1	42.7
East Sumatra	160-400	160-350	273.8	254.1	263.8	53.8
West Kalimantan	250-295	160-275	248.7	239.5	242.2	21.6
East Kalimantan	265-395	265-390	332.0	324.0	326.6	30.2
South Natuna	228-465	140-380	328.2	316.2	320.3	55.2

The mean disc width of *D. kuhlii* from west and east north Java regions were a slight larger than those recorded by Mardlijah and Pralampita (2004) from the Java Sea in 2002. Whilst the size range of *D. kuhlii* (Java form) recorded from a study in eastern Indonesia in 2002 and 2003 (White & Dharmadi, 2007) was about similar to those recorded from the west and east north Java, south Java, Malacca and east Sumatra regions, whiles size range of *D. kuhlii* (Bali form) was about similar to those recorded in south Natuna.

The smallest pregnant female recorded was 210 mm DW with one embryo inside the uterus (male, 100 mm DW) and the largest pregnant female was 385 DW (female, 145 mm DW), both sizes were recorded from Batang landing site (east north Java region). Due to the small number of pregnant females being recorded, estimation for female maturity could not be determined based on the fishing region, but in general females attain their maturity in western Indonesia at size between 210 and 240 mm DW. This size range was larger than those recorded by Mardlijah and Pralampita (2004) in the Java Sea in 2002. The number of pups varied between one and two, but usually pregnant females only have a single embryo. The largest embryo recorded was a female embryo (160 mm DW) from a 320 mm DW mother, while the smallest young was 130 mm DW. Therefore, the size at birth was possibly between 130 and 160 mm DW. This size range is about similar to *D. kuhlii* (Java form) recorded by White and Dharmadi (2007). The range of size at birth of *D. kuhlii* (Java form) in White *et al.* (White *et al.*, 2006b) was a bit wider, which was from 110 to 160 mm DW.

Size at first maturity of males varied among regions. The smallest mature males from west north Java region, east north Java, south Java, East Kalimantan, West Kalimantan, the Malacca Strait, east Sumatra, and south Natuna region were 215, 215, 275, 295, 220, 250, 240 and 280 mm DW, respectively. In contrast, the largest immature males from those regions were 250, 270, 280, 310, 245, 250, 255, and 320 mm DW, respectively (Figure 2). Therefore, it can be

concluded that males *D. kuhlii* attain their first maturity in Indonesia at size between 215 and 295 mm DW, depending on the region. The DW_{50} at maturity with 95% confidence intervals (CI) of males *D. kuhlii* from each region are presented in Table 2.

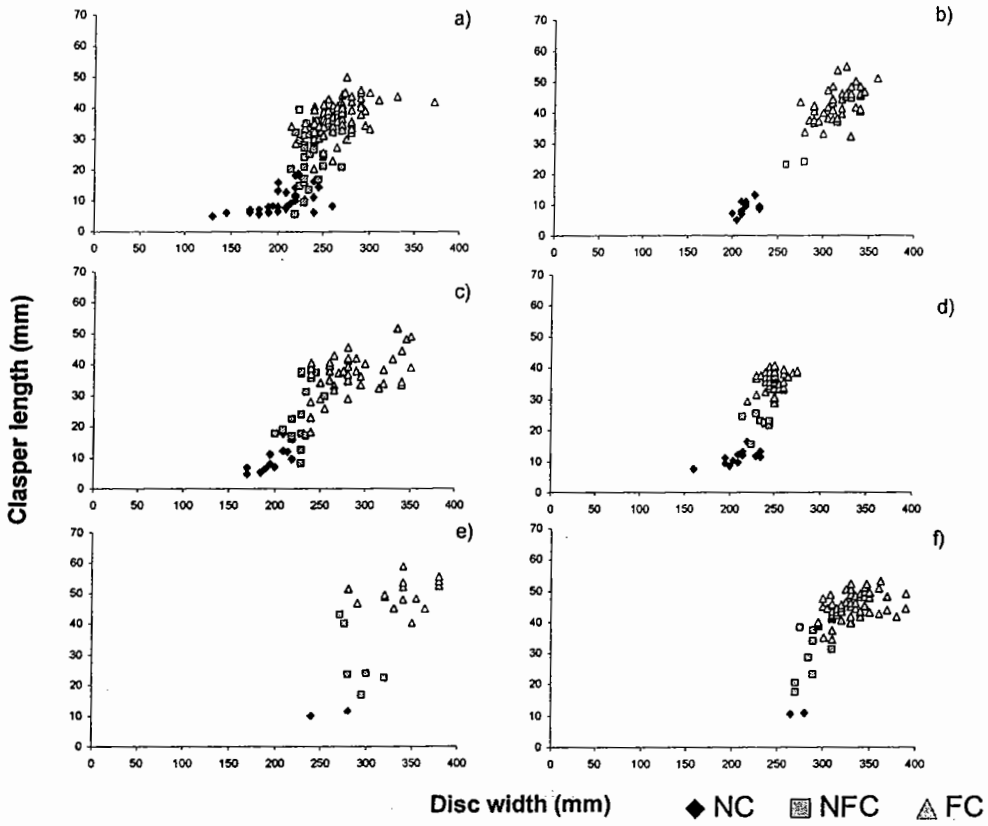

Figure 2. Size at maturity of males *D. kuhlii* from: a. north Java; b. south Java; c. east Sumatra; d. west Kalimantan; e. South Natuna; and f. east Kalimantan (NC = not calcified; NFC = not fully calcified; and FC = fully calcified).

Table 2 shows that males *D. kuhlii* from east Sumatra region attained maturity earlier than those species from other regions, following by west north Java and west Kalimantan, respectively. On the other hand, males from south Natuna and east Kalimantan regions attained maturity at later size. Males *D. kuhlii* are known attained maturity at size about 250 mm DW (Last & Compagno, 1999) but in White *et al.* (2006b), males *D. kuhlii* (Java form) attain maturity at size between 220 and 230 mm DW, while the Bali form is at size between 310 and 320 mm DW.

Table 2. The size at 50% of males *D. kuhlii* (DW_{50}) attained maturity (with 95% CI) from each fishing region in Indonesia

Fishing region	DW_{50} (mm)	95% Confidence interval (CI)	
		Lower	Upper
West North Java	246.3	205.2	279.1
East North Java	252.2	204.9	296.7
South Java	256.6	220.8	296.9
Malacca	252.2	221.2	278.0
East Sumatra	235.5	202.4	258.9
West Kalimantan	245.3	202.4	277.1
East Kalimantan	288.3	251.6	317.9
South Natuna	304.8	251.8	347.1

According to Last and Compagno (1999), differences in color morphs of *D. kuhlii* in the Indo Pacific region could lead to the possibility of more than one species of *D. kuhlii* occur in the region. On the other hand, White *et al.* (2006b) identified at least two forms of *D. kuhlii* in eastern Indonesia, which differ both maximum sizes and sizes at maturity, i.e. the Java form (attains at least 380 mm DW) and the Bali form (attains at least 450 mm DW). The size differences of size at maturity of *D. kuhlii* may lead to the assumption that *D. kuhlii* from west and east north Java, south Java, Malacca, East Sumatra and west Kalimantan regions were morphologically the same species or within the same population structure with *D. kuhlii* (Java form), due to the similarity in size at maturity. However, *D. kuhlii* from south Natuna and East Kalimantan could be in separate group due to the differences in the body size. *D. kuhlii* from those regions (south Natuna and east Kalimantan), which is differ from *D. kuhlii* (Java form) in the size at maturity, may be similar to *D. kuhlii* (Bali form). However, the color morphs and disc shape between *D. kuhlii* (south Natuna and east Kalimantan) and the the Bali form species were visually different. The blue spots on the dorsal surface of *D. kuhlii* from south Natuna and east Kalimantan were darker than *D. kuhlii* (Bali form) and their disc shapes were less similar (Figure 3). Therefore, there is a possibility that *D. kuhlii* from south Natuna and east Kalimantan may be in separate group from both the Java and Bali forms.

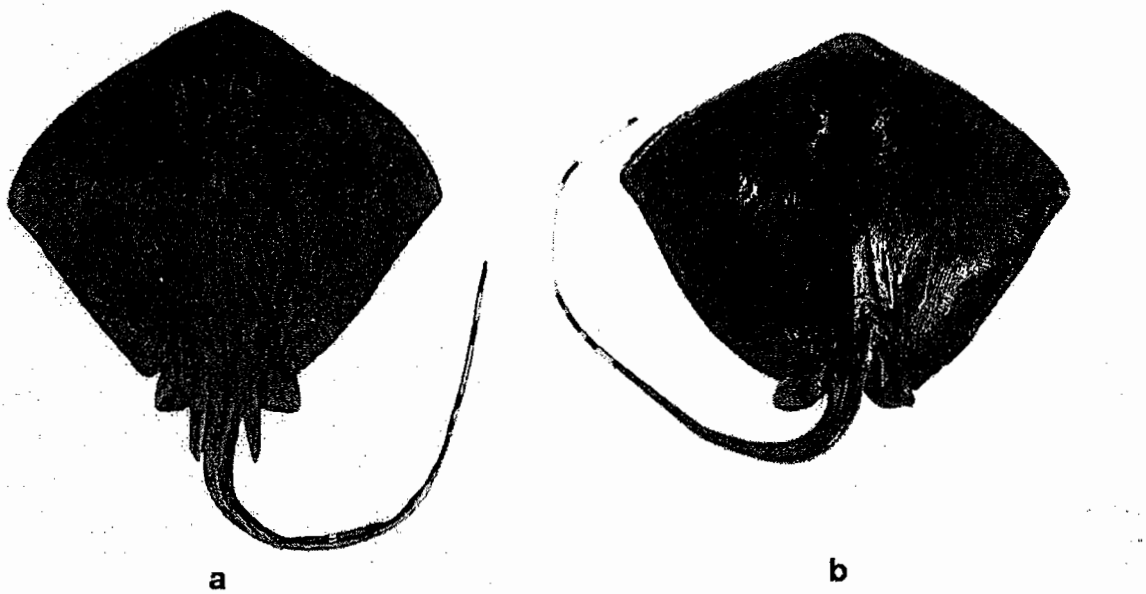

Figure 3. *Dasyatis kuhlii*: a) south Natuna form; b) Bali form

Another assumption is related to the differences in their habitats, life histories and fishing pressure. Suitable habitat may affect to the species growth and productivity. Fishes will grow up and attain at larger size in a good habitat where foods are available rather than those living in a pressured environment and lack of food in their natural habitat. The flexibility in the life history of many species may lead to adaptation to inhabit in various habitats and environments, and the differences in size at maturity among species from different regions are a manifestation of the plasticity of the species reproduction (Lucifora *et al.*, 1999). Therefore, quantity and size of species can vary between stocks or populations and also between areas (Lucifora *et al.*, 1999; Andrade & Campos, 2002). Fish can attain its maturity in earlier stage as an adaptation from fishing pressure. According to Stearns *in* Lucifora *et al.* (1999), size at maturity responds very quickly both to natural selection and to additional selective pressures such as those caused by fisheries. Motta *et al.* (2005) suggested that the mean length at sexual maturity of a population in a high fishing pressure area decreases in response to the removal of large individuals in that area. For instance, the thorny skate *Amblyraja radiata* reached sexual maturity at different sizes in two areas in the north-west Atlantic and it was suggested that local environmental conditions, life-history and their flexibility to fishing were important factors in determining the differences (Templeman, 1987). The thornback ray (*Raja clavata*) from the North Sea were also mature at earlier age due to the heavy fishing pressure (Walker *in* Stevens *et al.*, 2000). Therefore, the earlier size at maturity of *D. kuhlii* population in east Sumatra may be indicated by the fishing pressure in the area as their adaptation to their environment. In contrast, *D. kuhlii* population

from south Natuna was possibly in suitable habitat where the fishing pressure is low and other environmental factors are suitable for the fishes to grow and reproduce.

CONCLUSIONS

There were two possibilities in the difference of size at maturity of *Dasyatis kuhlii* from some fishing regions in Indonesia, i.e.: 1) the possibility that *D. kuhlii* in Indonesia may consist of more than one species, however, this statement need to be clarified by further studies on morphology and genetics; 2) the possibility of the difference of fishing pressure to population of *D. kuhlii* in those areas compared with others in west central Indonesia may lead to the variation in the life history and growth rate of the species.

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