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Reproductive biology and diet composition of *Rhynchobatus laevis* (Bloch and Schneider, 1801) (Rhinopristiformes:Rhinidae) from the northern Indian Ocean

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ABSTRACT

Large sized batoids particularly wedgefishes are highly vulnerable to fishing and yet very few studies have been published on their biology. The reproductive biology and feeding habit of *Rhynchobatus laevis* (Bloch and Schneider, 1801) collected off the north-west coast of India, Arabian Sea, northern Indian Ocean is presented. A total of 328 individuals, in the size range from 44.0 to 290 cm total length (TL), 300 to 94000 g total weight (TW) were used for the study. The length-weight relationships were significantly different between the sexes ($p<0.001$). Co-efficients '*a*' and '*b*' of the length-weight relationship were estimated as 0.009412 and 2.830218 ($r^2=0.979$) for females and 0.004032 and 3.031303 ($r^2=0.974$) for males, respectively. The length at maturity (L_m) for females and males was estimated to be 190 and 140 cm TL, respectively. Number of embryos ranged from 4 to 10 and the size at birth was estimated to range between 44 and 50 cm TL. Overall sex ratio favoured females (Female:Male = 1.73:1). There was no significant correlation between maternal TL and number of embryos produced. Dietary analysis of stomach contents (%IRI) revealed that *R. laevis* fed primarily on teleosts (83.4%) and crustaceans (15.1%). This study provides the detailed biological observation on size, sex composition, length at maturity (L_m), length-weight relationship and diet of *R. laevis* from northern Indian Ocean which can be used as essential inputs to formulate effective management plans and conservation strategies for this species in the region.

Keywords: Elasmobranchs, Embryo, Guitarfish, Length at maturity, Length-weight relationship

Introduction

The distribution, biology and status of guitarfishes are poorly known in the Indian Ocean and especially from India, even though they are of high conservation concern. Guitarfishes (Family Rhinidae) comprise at least 10 species and 3 genera and of these, the genus *Rhynchobatus* includes the large guitarfishes. *Rhynchobatus* genus is present from warm temperate to tropical waters (Last *et al*., 2016b) with their taxonomy and biogeography being poorly defined in the Indian Ocean. In fact, the giant guitarfish *Rhynchobatus djiddensis* is now believed to be a complex of several species including the broadnose wedgefish *Rhynchobatus springeri* Compagno and Last, 2010; white-spotted guitarfish or white-spotted wedgefish *Rhynchobatus australiae* Whitley, 1939; the smoothnose wedgefish *Rhynchobatus laevis* (Bloch and Schneider, 1801); *R. cf. djiddensis* 1; *R. cf. djiddensis* 2 and *Rhynchobatus cooki* Last, Kyne and Compagno, 2016 (Bineesh *et al*., 2014; Henderson *et al*., 2016; Last *et al.,* 2016a,b; Jabado, 2018; Purushottama *et al*., 2018).

The *Rhynchobatus* spp. in northern Arabian Sea of Indian exclusive economic zone (EEZ) was historically called as *"Rhynchobatus djiddensis"* and is considered to be widely distributed along the entire Indian coastal waters (Talwar and Kacker, 1984; Raje *et al.,* 2007). Considering that the taxonomic status of *Rhynchobatus* species is not verified and as the specimen studied here does not match well with *R. djiddensis* mentioned in Last *et al.* (2016b), with several differences in colouration, morphometry and genetics, we refer to the species investigated in the present study as *Rhynchobatus laevis* and those reported by Raje *et al*. (2007) from the same region also as *R. laevis*. *R. laevis* is not directly targeted but caught as bycatch in trawl, gillnet and bottom-set gillnet fisheries in India. However, some information on the landings of *Rhynchobatus* spp. ['whitespotted wedgefish' (*i.e. R. djiddensis*) species complex] from northern Arabian Sea coast of India is available. Raje (2006) reported the average annual landings of "*R. djiddensis"* at Mumbai (mostly as bycatch in shrimp trawls) to be nearly 532.3 t (1989-1993) which progressively declined to nearly 75 t during 2012-2016 (CMFRI, 2013; 2014; 2015; 2016). The

decline in landings may be attributed to legal frame work implemented in 2001, under Schedule 1 of the Wildlife (Protection) Act of 1972, by which India banned the exploitation and trade of 10 species of sharks, rays and guitarfishes. There have been very few studies on the biology of *Rhynchobatus* species from Indian waters. Setna and Sarangdhar (1949) studied breeding habits, while Raje (2006) analysed the length-weight relationship and feeding in Mumbai waters (northern Arabian Sea).

Elsewhere, *R. laevis* is an important component of coastal elasmobranch catches in tropical countries including Arabian Sea and the Bay of Bengal in Indian Ocean and off China and Japan in western pacific (Last *et al.,* 2016b). This species has been targeted or exploited as incidental catch, primarily for fins and meat and is also a component of the bycatch in shrimp trawls in India and the 'white fins' are the main priced product. Few data are available on the population status; however, given its susceptibility to capture by multiple gear types, the known heavy fishing pressure from local and foreign vessels in parts of its range and its high value fins, it is highly likely that numbers significantly reduced and localised disappearance occurred (Tous *et al*., 1998; Dulvy *et al*., 2016; Moore, 2017; Jabado, 2018). Serious declines have occurred in populations of similar species for the same reasons, thus *R. laevis* is assessed as 'Critically Endangered' globally due to inferred population declines and continuing, unregulated high levels of exploitation (Kyne and Jabado, 2019). In fact, nearly all of the batoid species studied in other parts of the north-western Indian Ocean were either classed in the IUCN Red List as vulnerable, endangered or data deficient (Moore *et al*., 2012). Information on population size, fishery trends or biological data of *R. laevis* is limited (Setna and Sarangdhar, 1949; Raje *et al.,* 2007) for making any assessment or management recommendations in Indian waters or northern Indian Ocean.

Guitarfishes form one of the most vulnerable groups in elasmobranchs (Dulvy *et al*., 2014; Moore, 2017; Jabado, 2018); their vulnerability compounded by the lack of detailed information on their reproduction, diet or stock status in the Indian Ocean. For this reason, the objective of this work was to focus on the reproduction, maturity and diet of *R. laevis* fished off north-west India, to update the information on life history of the species from the northern Indian Ocean.

Materials and methods

Specimens of *R. laevis* (n = 328) were collected from landings of commercial shrimp trawlers, gillnetters, bag netters operating in the northern Arabian Sea, during 2012-2016. *R. laevis* was landed as bycatch in these fishing vessels which operated at 2-50 m depths. Specimens were collected from New Ferry Wharf (18° 57' 28.85'' N; 72° 51' 02.73'' E), Sassoon Dock (18° 54' 42.43'' N; 72° 49' 33.16'' E), Satpati (19° 43' 30.75'' N; 72° 42' 08.30'' E) and Alibaug (18° 38' 4.25'' N; 72° 52'38.95'' E) fisheries harbours in Maharashtra (Fig. 1).

For each species, the total length (TL) in mm and total body weight (TW) in g were recorded along with the sex of the animal. For easier comparison with other studies, TL has been reported in cm for this study. Based on the

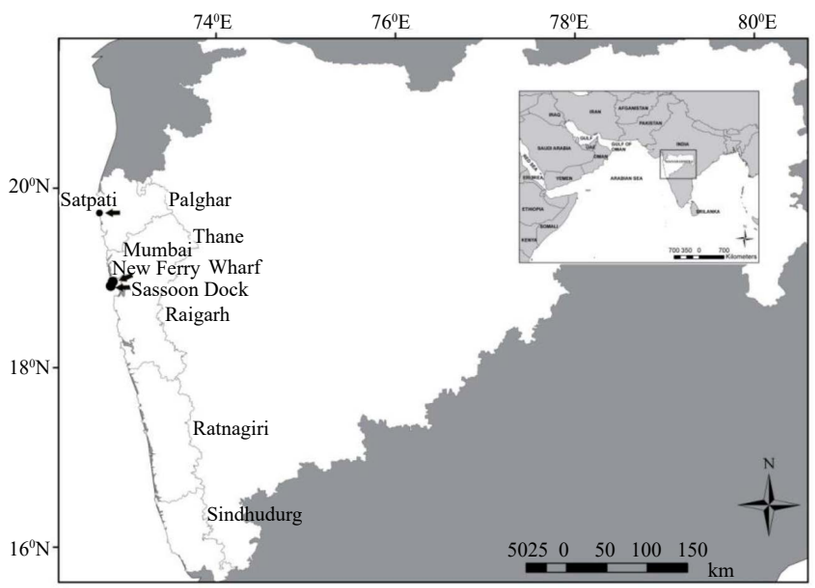

Fig. 1. Map showing the sites where samples of *R. laevis* were landed

state of their umbilical scar (Purushottama *et al*., 2020) as well as TL, the animals were classified as neonates or juveniles.

Normality of the size-frequency distributions for each sex was tested using Shapiro-Wilk test (Shapiro and Wilk, 1965). Sex-based differences in size were tested using a two-tailed Student's t-test. Differences in male and female size-frequency distributions were tested using $\chi 2$ test (Cochran, 1952). Size-frequency distributions were calculated on size class intervals of 20 cm. Sex ratio was tested using a two-sided exact ratio test (Biradar, 2002). Seasonal sex ratios were estimated for pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January) seasons. The correlation between maternal TL and both number of embryos and mean embryo TL was also studied.

Sex of the animal was identified based on external morphological characters. Maturity of the animals was decided based on the scale proposed by Stehmann (2002) which used ovarian and uterine condition in females and extent of clasper calcification in males. Females were classified as immature if they had undeveloped ovaries and thin uteri, or mature if both ovaries and uteri were well developed. Males were classified as immature if they had uncalcified or partially calcified claspers and mature if they had fully calcified claspers. The relationship between inner clasper length (ICL) and TL was studied in males.

The L_m for females and males was derived from a logistic regression as follows: $pL = \{1 + e [{}^{-\ln (19) (TL - TL_{50})} (TL_{95} - TL_{50})]^{-1}\}^{-1}$, where, pL is the proportion of mature specimens; TL_{50} and TL_{95} are constants and 'ln' is the natural logarithm. Maximum likelihood estimates of the parameters were obtained using the routine SOLVER in Microsoft™ Excel and by calculating the likelihood of immature and mature individuals as 1 - pL and pL, respectively. The reported estimates of the parameters were determined as the median values derived from 200 sets of randomly re-sampled data, with the same sample size, drawn from the data on the observed maturity status at TL for female and male guitar fishes. The *c.* 95% confidence intervals (C.I.) were estimated as 2.5 and 97.5 percentiles of the 200 estimates resulting from these re-sampled data (Wood, 2004; White, 2007; Purushottama *et al.,* 2017).

The sex-wise length-weight relationship (LWR) was estimated using the standard equation given by Le Cren (1951): $TW = a {}^{*}TL^{b}$ after logarithmic transformation. The confidence intervals were estimated using the equations given by Montgomery *et al.* (2012). The male and female length-weight relationship was tested for significant difference using the extra sum of squares method (Montgomery *et al.,* 2012).

Diet contents in the stomach of the animals were separated in the laboratory and identified up to the species level wherever possible. The weight of individual prey items was recorded along with their total counts in each stomach. From this, the percent index of relative importance (%IRI) was estimated as $\%IRI = (\%N + \%W)^{*} \%O$ (Pinkas *et al*., 1971), where %N is the percentage number of each prey item; %W the percentage by weight and %O the percentage by occurrence of each prey item. IRI was expressed as %IRI to allow for a comparison of the values between the prey groups (Cortes, 1997).

Results

A total of 328 individuals of *R. laevis* were examined in the field and laboratory, specimen lengths ranged from 45 to 290 cm TL (165.4±4.9 cm) and weight ranged from 300 to 94000 g (25100±1500 g) for females and for males length ranged from 44 to 225 cm TL (116.0±4.1 cm) and weight ranged from 400 to 38000 g (9700±700 g).

Specimens were distributed into 14 size classes of 20 cm intervals each as depicted in Fig. 2. There was significant difference between female and male size-frequency distributions (χ^2 test; $p<0.001$), with more females between 205 and 245 cm TL and 65-165 cm TL for males captured.

Monthly length frequency distribution (pooled years) showed clear trends (Fig. 3) for females and males possibly due to changes in fishing patterns and area being observed in Maharashtra waters, wherein different habitats including shallow and inner continental shelf with muddy and sandy bottoms are fished in different seasons.

The overall sex ratio (F:M) was 1.73:1 in favour of females and was significantly different from 1:1 ($p<0.05$). Sex ratio for the three seasons were: 2.4:1 (pre-monsoon), 0.8:1 (monsoon) and 1.8:1 (post-monsoon). Distribution of females and males of *R. laevis* was significantly different across sampling months (χ^2, d. f. = 9, $p<0.001$).

Weight of *R. laevis* ranged from 300 to 94000 g in females and from 400 to 38000 g in males. The LWRs were estimated from 178 females (45 -275 cm TL) and 104 males (44.0-225 cm TL) and the slopes were significantly different ($p<0.001$).

Females: $TW = 0.009412 \times TL^{2.830218}$ ($r^2=0.979$, 95% C.I. of $b=3.260093$ -3.603260, $n=178$)

Males: $TW = 0.004032 \times TL^{3.031303}$ ($r^2=0.974$, 95% C.I. of $b=3.155264$ -3.487397, $n=104$)

Mean monthly size was significantly different for females and males (χ^2, d. f. =9, $p<0.001$). In this study,

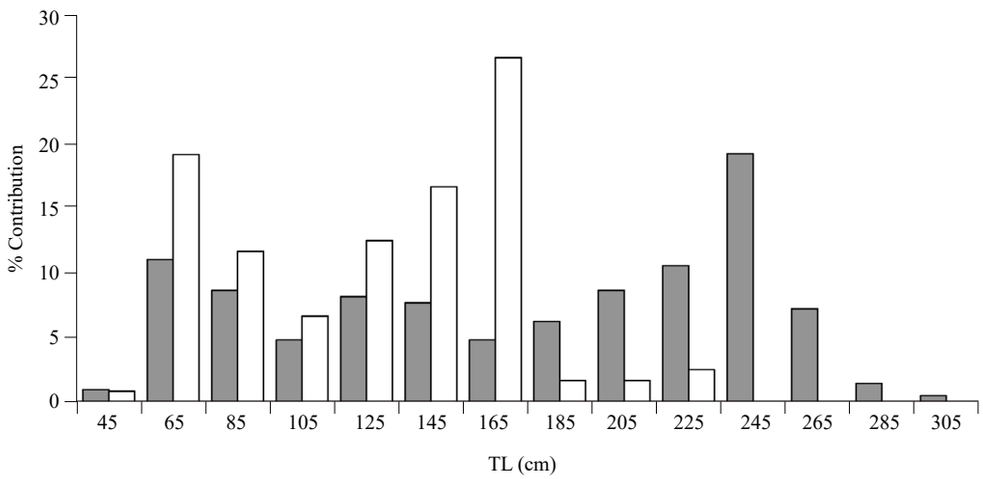

Fig. 2. Size frequency of *R. laevis* [Females (■), *n* = 208; Males (□), *n* =120]

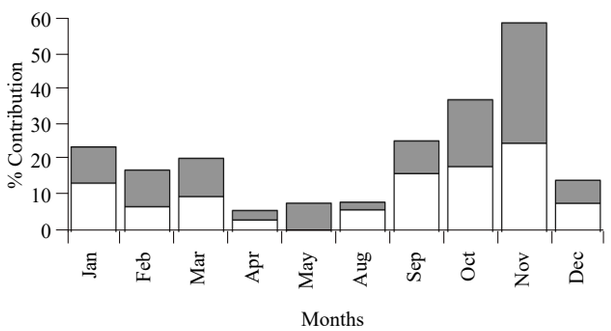

Fig. 3. Monthly percent contribution of females (■, *n*=208) and males (□, *n*=120) of *R. laevis* (January 2012 to December 2016)

21 pregnant females in the size range 180-275 cm TL (236.9±28.7 cm) were recorded. Late term embryos in advanced/fully developed stage were observed during September-December and January. Developing oocytes (60-75 mm dia) were observed in the functional ovary of females (>210 cm TL) and the smallest female containing maturing oocytes was of 180 cm TL. Mostly pregnant females contained 4-9 embryos per uterus, however, maximum embryos observed was 10 in a specimen measuring 180 cm TL and weighing 20.5 kg.

Embryos ranged in size from 18-50 cm TL (31.8±8.3 cm), the length at birth in this species is at *ca*. 44 to 50 cm TL based on length of the largest embryo (50 cm TL), length of smallest free swimming individual (44 cm TL) the length of the largest free swimming individual (58 cm TL) that still had an open umbilical scar. Number of neonates and juveniles (<100 cm TL) were 93 forming 28.4% of total observation and were observed during August-December and January-May.

Ninety-six mature females were observed among the 328 specimens of *R. laevis* examined. L_m of females was estimated at 190 (95% C.I. 185-195) cm TL (Fig. 4a). The smallest mature female recorded was 180 cm TL, while the largest immature female was of 245 cm TL. Since the reproductive cycle of this species did not follow a seasonal pattern, the timing of conception and parturition and the duration of gestation could not be determined. However, in the present study, gravid females were observed in pre-monsoon and monsoon seasons only. Thus, it can be assumed that pre-monsoon (February-May) and monsoon (June-September) are the peak parturition period.

Among the *R. laevis* specimens examined during the study, 50 mature males were observed. The smallest mature male recorded was of 124 cm TL, while the largest immature male was 195 cm TL. Males matured in different size range (125-145 cm TL) and 50% maturity occurred at 140 (95% C.I. 135-145) cm TL (Fig. 4b). In the case of males, all maturity stages of *R. laevis* were presented, maturing size (sub-adult male) class (9.2%) were <129 cm TL. The vast majority of males >140 cm TL possessed fully calcified claspers, while most between 100-119 cm TL possessed partially calcified claspers. The ICL of smallest male was 4 cm TL (specimen of 54 cm TL) while that of largest specimen was 40 cm TL (specimen of 225 cm TL) and there is noticeable increase in the ICL with TL (Fig. 5).

The stomach contents of specimens (44.0-290 cm TL) of *R. laevis* were studied and of these, 45.7% were empty. Only 30.5% (*n*=100) contained prey items which could be identified. The identifiable prey items were found between 80 and 270 cm TL. The %IRI revealed that *R. laevis* fed primarily

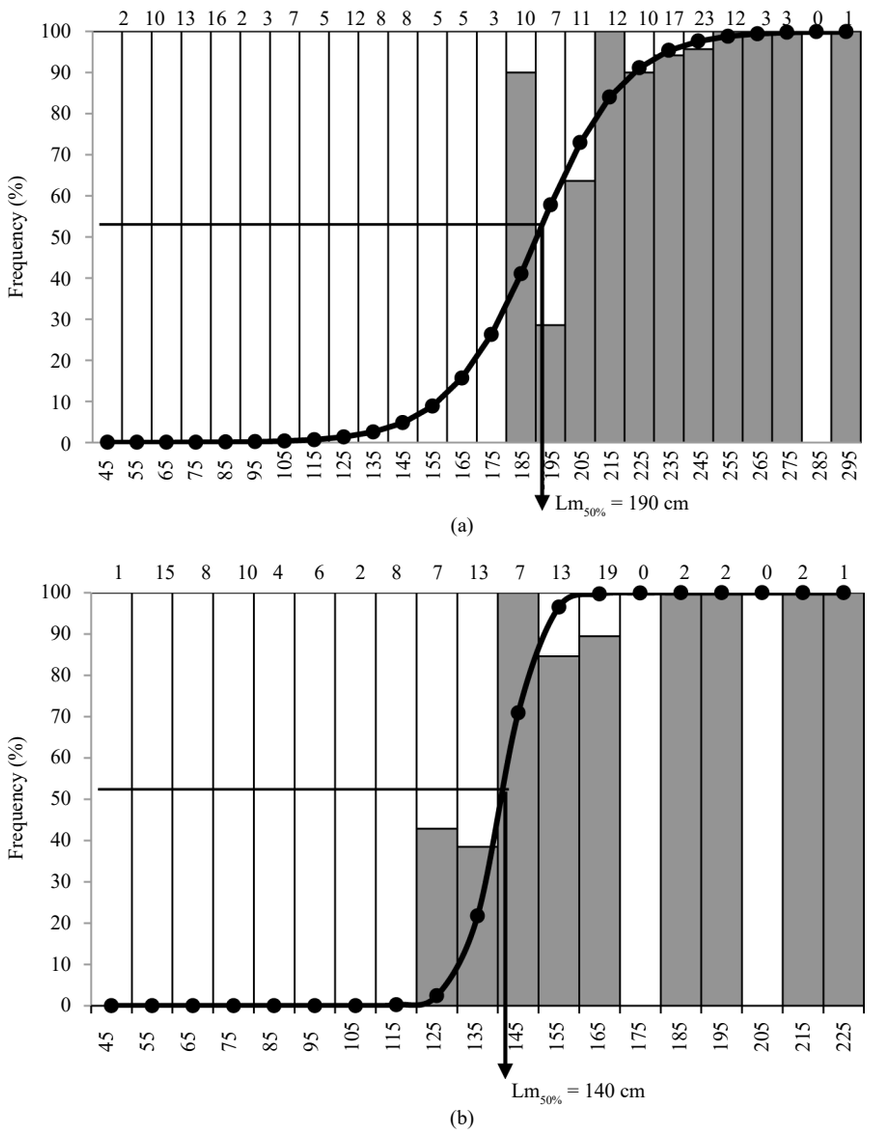

Fig.4. Percentage frequency of occurrence of immature (□) and mature (■) *R. laevis* in sequential total length (TL) classes for (a) females and (b) males. Numbers above each bar represent the sample size in each sequential TL class. Arrows indicate L_m

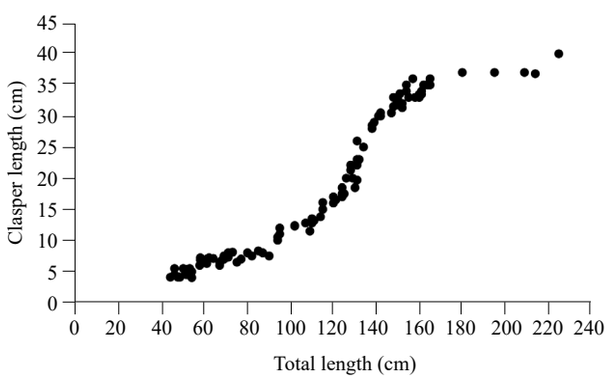

Fig. 5. Inner clasper length *vs*. total length of males of *R. laevis*

on teleosts (83.4%), crustaceans (15.1%) and cephalopods (0.6%). Major prey items included *Harpadon nehereus* (%IRI=72.5), *Parapenaeopsis stylifera* (%IRI = 13.2), *Coilia* spp. (%IRI = 4.6), *Cynoglossus* spp. (%IRI = 3.9) and *Stolephorus* spp. (%IRI = 2.0) (Table 1).

Discussion

R. djiddensis species complex is rarely observed and reported from fishery catches in the present day, other than from northern Arabian Sea, where it was once considered to be common and contributed >500 t yr^{-1} in fishery landings along north-west coast of India

Table 1. Diet composition of *R. laevis* in north-eastern Arabian Sea

Prey item	*%N*	*%M*	*%O*	%IRI
Teleostei				
Engraulidae	15.9	15.6	13.1	2.0
Stolephorus spp.				
Coilia spp.	1.8	202	4.8	4.6
Cynoglossidae	27.7	8.2	22.9	3.9
Cynoglossus spp.				
Synodontidae	2.0	1555	9.8	72.5
Harpadon nehereus				
Other	7.0	8.1	5.7	0.4
Unidentified fishes				
Crustacea				
Sergestidae	4.1	46.6	2.0	0.5
Acetes spp.				
Solenoceridae	2.8	2.7	2.8	0.1
Solenocera spp.				
Penaeidae	2.3	264	10.4	13.2
Parapenaeopsis stylifera				
Palaemonidae	2.2	8.8	1.2	0.1
Nematopalemon tenuipes				
Squillidae	6.2	4.1	6.1	0.3
Oratosquilla spp.				
Other	10.2	6.0	11.5	0.9
Unidentified shrimp				
Other	8.6	12.9	8.3	0.9
Unidentified crab				
Mollusca				
Cephalopoda				
Loliginidae	9.3	5.3	9.2	0.6
Loligo spp.				

(Maharashtra and Gujarat) (Raje *et al*., 2007). Reports on the occurrence of *R. laevis* in the fishery are limited and may be unreported from many regions. Moreover, information on population sizes, fishery trends and biological data of *R. laevis* is limited (Setna and Sarangdhar, 1949; Raje *et al.*, 2007) for conclusive stock assessment or management recommendations. The size range of *R. laevis* observed in this study (44-290 cm TL) differed slightly from sizes of *Rhynchobatus* species complex reported from other regions. Wallace (1967) and Darracott (1977) examined 68 specimens of both sexes, from embryo to adults (55.1-252.2 cm TL) and 131 fish (up to 235 cm TL), respectively, off east coast of South Africa; Moore *et al*. (2012) in Kuwait and Qatar waters (73.0-149 cm TL for females and 81.0-177 cm TL for males, *n*=19) and Jabado (2018) in UAE Gulf waters and Oman (78.9-283.9 cm TL for females, *n*=108 and 59.1-218.1 cm TL for males, *n*=138). However, Setna and Sarangdhar (1949) observed 13 individuals in length range between 213.4 to 297.2 cm TL, while Raje (2006) studied 606 specimens (42.2-170 cm TL for females and 41.7-191 cm TL for males) and Gladston *et al.* (2018) observed 102 specimens (39.5-271 TL for females and 41.4-161 cm TL for males) in Mumbai waters. Furthermore, Weigmann (2016) recorded maximum length of *R. laevis* as 270 cm TL to date but our study recorded 290 cm TL as the new maximum length for this species. The differences in sizes seen could be due to differences in fishing gear selectivity, sample size and growth differences based on habitat (Motta *et al.*, 2005). Differences in female and male size-frequencies might be a result of sexual segregation seen in elasmobranchs usually associated with reproduction, sex specific migration, competition or season (Ford, 1921; Steven, 1933; Springer, 1967; Klimley, 1987; Stevens and Mcloughlin, 1991; Motta *et al*., 2005; Mucientes *et al.*, 2009; Wearmouth and Sims, 2010; Purushottama *et al*., 2017).

The sex ratio in favour of females (1.73:1), indicated potential sexual segregation in this species in the north-eastern Arabian Sea. This observation was further supported by differences in monthly sex ratios also. Seasonal and size-based sex ratios indicated the

possibility of sexual aggregation in sub-adults and adults of *R. laevis*. This further indicated that females appeared to be more vulnerable to fishing than males in the study region. Nevertheless, observations made on *R. djiddensis* by Raje (2006) indicated that females and males appear to be equally distributed in the fishery during 1989-2003. Again Raje *et al.* (2012) made a similar observation with a female to male ratio 1.2:1 based on 606 specimens for 1999-2005 period from Mumbai waters. Our results are in agreement with Stobutzki *et al*. (2002), who also recorded from the bycatch, *R. djiddensis* in the northern Australian shrimp trawl fishery which comprised significantly more females than males. White and Dharmadi (2007) observed more females than males in the samples of *R. australiae*, *Dasyatis* cf. *kuhlii*, *Gymnura poecilura*, *Dasyatis zugei*, *Himantura jenkinsii* and *Pteroplatytrygon violacea* in a study covering 54 batoid species. Detailed information on sex ratios in regional fishery/populations of *R. laevis* throughout its known range would be required to determine any real trends in sexual segregation.

In this study, the length-weight relationship (TL *vs.* TW) of *R. laevis* was significantly different between the sexes. However, Darracott (1977) reported the length-weight relationship (combined sexes) as log W = -4.62 + 2.77 log L (r^2=0.9; *n*=131) for *R. djiddensis*. Co-efficients '*a*' and '*b*' of the length-weight relationship were estimated as -4.48, 2.7 (r^2=0.85, *n*=41) for females and -4.80, 2.84 (r^2=0.88, *n*=37) for males, respectively, which indicated that growth in this fish is following allometry (b<3) and there is no significant difference between females and males. Raje (2006) reported the length-weight relationship (pooled sexes) as log W = -12.1451+2.9794 log L (r=0.97, *n*=418) in Mumbai waters and found that no significant difference in the regression coefficients between sexes. Gladston *et al*. (2018) recorded the length-weight relationship (combined sexes) as log W=0.0034 +3.0557 log L (r^2=0.981, *n*=102). Co-efficients '*a*', '*b*' of the length-weight relationship were estimated as 0.0039, 3.0238 (r^2=0.987, *n*=60) for females and 0.0021, 3.1718 (r^2=0.959, *n*=42) for males, respectively in north-eastern Arabian Sea for *R. djiddensis*. On the contrary, our results show that females of *R. laevis* following allometric growth (b<3; the fish grows faster in length than in weight) and males (b>3; the fish grows faster in weight than in length) in the same study area. Our results on the life history traits and diet are the first reported for *R. laevis* and unfortunately, owing to the lack of biological studies in its geographic distribution, no data exists for comparisons. The differences between female and male LWRs could be attributed to a number of reasons including differing sample sizes, unequal distribution of sizes of each sex in the samples and presence of non-pregnant females or spent fish with lower condition factor (Stevens and Wiley, 1986).

The L_m of females determined in this study was 190 (185-195) cm TL for *R. laevis*. Information on the length at maturity for females of *R. laevis* is limited, but in the same genus, for *R. djiddensis*, Darracott (1977) observed minimum and maximum length of a pregnant female measuring 118 cm TL with 6 embryos and 235 cm TL off the east coast of South Africa, respectively. However, observations made by Raje and Joshi (2003) show that smallest pregnant female observed during 1989-2003 period was 210 cm TL and Raje (2006) in another account opined that length at maturity was also same; whereas Raje *et al.* (2012) recorded only lowest length of matured female (182 cm TL) while studying the breeding behaviour of elasmobranchs in Mumbai waters. These reports, indicate large variations in estimates of L_m of females of the species.

The smallest adult male observed for *R. laevis* in the present study was 124 cm TL, whereas the smallest adult male observed by Raje (2006) and Raje *et al.* (2012) was 132 cm TL for *R. djiddensis*. The L_m of males estimated in the present investigation was 140 (135-145) cm TL. Last *et al*. (2016b) reported that *R. laevis* males mature at 130 cm TL. In the same genus, Wallace (1967) and Darracott (1977) reported that mature males of *R. djiddensis* range from 130 to 136 cm TL in east coast of South Africa and Western Indian Ocean, respectively. Carpenter and Niem (1998) and Last and Stevens (2010) reported that *R. australiae*, males matured at 131 TL and female at 130 cm TL, respectively. However, males mature at a smaller size than female.

In this study, examination of a small number of pregnant females (*n*=21), indicated that the mean number of embryos was 7 (range 4-10) and size at birth ranged between 44 and 50 cm TL. Setna and Sarangdhar (1949) and Raje (2006) observed that the most common number of young ones produced at a time was 8, four from either uterus, although the maximum recorded was 10 and length at birth was 44 to 50 cm TL, while the maximum number of embryos recorded was 12 (Raje, 2006) for *R. djiddensis*. Generally, wedgefishes have limited biological productivity with small litter size and the present results are in agreement to that reported for *R. laevis* in Mumbai waters. In contrast, Wallace (1967) analysed only one gravid female with 4 advanced stage embryos and a small juvenile with umbilical scar (67 cm TL) and suggested the length at birth was 55.1-67 cm TL off the east coast of South Africa for *R. djiddensis*.

Furthermore, since pregnant females were observed in all 3 seasons and contained a wide range of embryonic

developmental stages, *i.e*., from fertilised eggs to late-term embryos, this species appears to have a reproductive cycle not dependent on season. However, Setna and Sarangdhar (1949) had stated that the greatest reproductive activity for *R. djiddensis* appeared to be during the monsoon months for gravid females and those in early or intermediate stages of pregnancy was in August, September and October. For *R. djiddensis*, Wallace (1967) also recorded sexually active adult females during the months of January-March in east coast of Southern Africa. Darracott (1977) during a survey on elasmobranchs observed that maximum number of pregnant *R. djiddensis* were in November in Western Indian Ocean. Raje *et al*. (2007) reported that the peak breeding season for the species was July-October in north-west coast of India. The differences in seasonality of reproductive activity could be due to changes in fishing grounds and wider spatial coverage of fishing vessels than earlier years.

Last *et al*. (2016b) gave basic information on diet of this species, as a feeder of bottom-dwelling crustaceans and fishes. In this study, *R. laevis* was found to feed primarily on fishes (83.4%), crustaceans (15.1%) and cephalopods (0.6%). The major prey items included *H. nehereus* (%IRI=72.5), *P. stylifera* (%IRI=13.2), *Coilia* spp. (%IRI=4.6), *Cynoglossus* spp. (%IRI=3.9), *Stolephorus* spp. (%IRI=2.0), *Loligo* spp. (%IRI=0.6) and *Acetes* spp. (%IRI=0.5). The typical coastal prey items found in the stomachs indicate that *R. laevis* inhabits between 2-50 m depth, undertaking vertical and horizontal migration for breeding, nursery and feeding. In same genera, Wallace (1967) observed remains of crabs, squid and small fish, while Darracott (1977) briefly mentioned the diet of *R. djiddensis*, which included crustaceans, squid and eel in east coast of South Africa. Raje (2006) suggested that *R. djiddensis* fed on fishes (*H. nehereus*, *Coilia dussumieri*, *Tripauchen vagina*, sciaenids and *Bregmaceros macclellandi*) and crustaceans (*Panulirus polyphagus, Nematopalaemon tenuipes*, squilla, *Acetes* spp., *P. stylifera* and other shrimps).

In conclusion, elasmobranchs, including shark-like batoids have low resilience to overexploitation by fisheries because of their atypical life history traits including late attainment of maturity, low fecundity and natural mortality, slow growth, long life spans and the close relationship between the number of young ones produced and the size of breeding biomass (Stevens *et al.,* 2000; Varghese *et al.,* 2016). The restricted coastal habitat, limited life history characteristics, susceptibility to capture in multiple gears and ever growing demand place coastal rhynchobatids amongst the most vulnerable chondrichthyan fishes (Dudley and Cavanagh, 2006). *R. australiae* is commonly caught in the bycatch of the trawl fisheries in northern Australia and is the most sought after elasmobranch in Indonesia for its fins (Chen, 1996; Stobutzki *et al.,* 2002; White and McAuley, 2003). Since, *R. laevis* shares similarity in both habitat and habits with *R. australiae,* it is fished heavily by gillnet fisheries and is also vulnerable to trawl nets and hooks (Compagno and McAuley, 2016). In India mostly gillnet fisheries exploit *R. laevis* and population status elsewhere is unclear. As per the global status of shark-like batoids based on the IUCN Red List of Threatened Species criteria, *R. australiae* and *R. palpebratus* were categorised as 'Vulnerable' and 'Not Evaluated' respectively (Froese and Pauly, 2018).

Taxonomic status of *Rhynchobatus* is unclear in Indian Ocean with several colour-morphs and new reports in fishery landings and possible cryptic species of *R. djiddensis* being reported (Dudley and Cavanagh, 2006; Bineesh *et al.,* 2014; Henderson *et al.,* 2016). Detailed taxonomic studies on the group over a broad geographical range with genetic studies and large-scale sampling is needed to resolve the taxonomic issues of *Rhynchobatus* spp. in Indian Ocean.

The life history patterns of chondrichthyans of Indian waters are poorly understood (Akhilesh *et al.,* 2013; Kizhakudan *et al.,* 2015; Purushottama *et al.,* 2018). Most of the batoids in Arabian Sea are under tremendous fishing pressure (Jabado *et al.,* 2017; Jabado, 2018), especially along Indian coast and declining catches of some batoid species from the Arabian Sea have been reported recently, despite increased effort (Raje and Zacharia, 2009). There is a paucity of detailed, recent studies on the biology and fisheries of inshore (sub-) tropical Indo-West Pacific Ocean batoids outside Australia, with a few exceptions (Raje, 2000; 2003; Raje *et al.,* 2007; White and Dharmadi, 2007; Raje and Zacharia, 2009; Moore *et al.,* 2012; Purushottama *et al.,* 2020). Understanding the life history and habitat characteristics are highly important in sustainable fishery management. This article provides new detailed biological information on *R. laevis* in Indian waters, including sex, size composition, maturity, size of embryos and feeding habits, which is essential for the development of management plans for this poorly known and vulnerable elasmobranch species in India.

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