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OBSERVATIONS ON THE REPRODUCTIVE BIOLOGY OF THE BLACKCHIN GUITARFISH, *RHINOBATOS CEMICULUS* E. GEOFFROY SAINT-HILAIRE, 1817 (CHONDRICHTHYES, RHINOBATIDAE) FROM THE COAST OF SENEGAL (EASTERN TROPICAL ATLANTIC)

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ABSTRACT

The blackchin guitarfish, *Rhinobatos cemiculus*, is commonly caught off the coast of Senegal. Adult males and females studied were over 1550 mm and 1630 mm total length (TL), respectively, with the largest male and the largest female recorded measuring 2330 mm and 2450 mm and weighing 28.1 kg and 55.0 kg, respectively. Females were significantly heavier than males. The diameter of ripe oocytes ranged from 42 to 46 mm (mean: 43.45 ± 1.05). They weighed from 33.0 to 36.1 g (mean: 34.17 ± 0.92). The smallest specimens observed were 400 and 420 mm TL and weighed 210 and 145 g, respectively. Egg weight increased with female TL. Gestation lasted from 5 to 8 months. An embryonic diapause was observed when the Senegalese waters were relatively cold, between December and March. A calculated chemical balance of development based on mean dry weights of the fully developed fetuses and the egg weight was 1.85. Ovarian fecundity was not significantly higher than uterine fecundity. The two categories of fecundity ranged from 16 to 24 and there was no relationship between them and female TL.

KEYWORDS: Chondrichthyes, Rhinobatidae, *Rhinobatos cemiculus*, Reproductive biology, Senegal, Eastern tropical Atlantic.

INTRODUCTION

Two rhinobatids, the common guitarfish, *Rhinobatos rhinobatos*, and the blackchin guitarfish, *R. cemiculus* are found off the coast of Senegal (Cadenat, 1950, Blache et al., 1970, Séret and Opic 1990, Capapé et al., 1994). Some aspects of the reproductive biology of *R. rhinobatos* from this marine area were previously reported by Capapé et al. (1999). On the contrary, Capapé et al. (1994) gave only little information concerning its sympatric species *R. cemiculus*.

New captures of the blackchin guitarfish from Senegalese waters have allowed these preliminary data to be expanded. Size at sexual maturity, size at birth, maximal size, reproductive cycle, relationship size *versus* weight and fecundity are presented in this paper. These data are compared with previous data reported by Capapé and Zaouali (1994) on *R. cemiculus* caught off Tunisian coasts.

MATERIAL AND METHODS

The blackchin guitarfish were caught off the coast of Senegal from 1994 to 2000 (Fig. 1). A total of 79 specimens (28 males and 51 females) were examined. These specimens were generally captured by demersal gill-nets, in shallow coastal waters at a depth of about 80 m, on sandy-muddy bottoms, and rarely among macroalgae. They were landed at different fishing sites from the Cape Verde Peninsula, but most of our observations were made at Ouakam, 5 km from Dakar (Fig. 2).

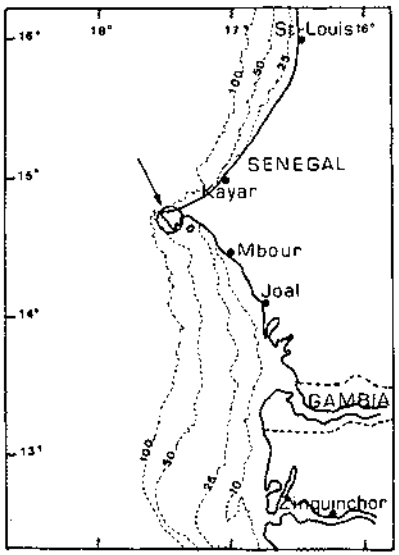

Fig. 1. Coast of Senegal with fishing sites and the Cape Verde Peninsula pointed out (arrow) (redrawn from Kébé and Le Reste, 1993).

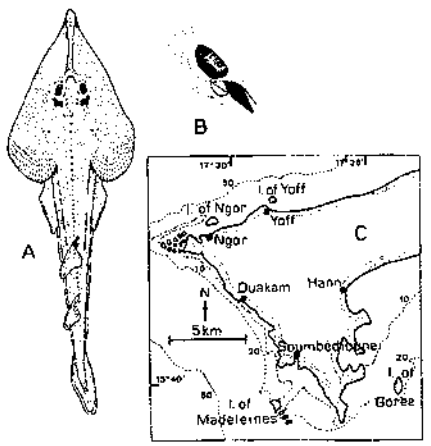

Fig. 2. A. General morphology of an adult female Rhinobatos cemiculus. *B. Narine with nasal valve (arrow). A and B partially redrawn from Capapé et al. (1981).*
C. Western part of the Cape Verde Peninsula, showing landing sites (redrawn from Sourie, 1954).

Months	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Categories													
Juvenile males	5		1	3	3	1	2	-	-	-	2	3	20
Adult males	3	1	-	2	-	1	-	1	-	-	-	-	8
Juvenile females	2	3	1	3	3	1	1	2	2	1	-	2	21
Subadult females	1	2	1	2	1	3	1	2	-	1	-	1	15
Adult females	2	2	2	2	1	2	1	2	-	-	-	1	15
Total	13	8	6	12	8	8	4	5	3	2	2	7	79

Table 1. *Monthly collection of male and female Rhinobatos cemiculus caught off the coast of Senegal.*

The monthly collection, the sex and the condition of the observed specimens are each presented in Table 1. In addition, 24 embryos and two fetuses were studied. Embryos still had an umbilical stalk and a yolk stalk. These features were completely resorbed in the fully developed fetus. A scar marked the place where the umbilical stalk had been. The yolk stalk was reabsorbed in an internal vitelline vesicle.
Following Compagno's (1984) method for sharks, the specimens were measured to the nearest millimetre for total length. They were weighed to the nearest gram. Measurements also included clasper length (CL, mm), from the forward rim of the pelvic girdle to the tip of the claspers according to Collenot (1969), and the diameter of ripe and developing oocytes. All the oocytes, the embryos and the fully developed fetuses were measured and then weighed to the nearest decigram after being removed from the ovaries and the uteri.
The onset of sexual maturity in males was determined by the relationship between CL and TL. Bass *et al.* (1975) noted that the claspers of juveniles are short and flexible, adding that males are adult when their claspers are rigid, elongated and calcified. Two categories of males were distinguished.
The size of females at sexual maturity was determined from the condition of ovaries and the morphology of the reproductive tract. Three categories of females were distinguished.
To investigate the embryonic development and the role of the mother during gestation, a chemical balance of development (CBD) was considered. CBD is based on the mean dry weight of fertilized eggs and fully developed fetuses. CBD can be computed as the mean dry weight of fully developed fetuses divided by the mean dry weight of fertilized eggs. Water content of 50% in ova and 75% in fully developed fetuses can be taken as standard values, based on chemical analyses of the small spotted catshark, *Scyliorhinus canicula*, by Mellinger and Wrisez (1989). CBD is a tentative estimate.
Tests for significance ($p < 0.05$) were performed by using an analysis of variance and a Student *t*-test. In the weight-total length relationship, comparisons of curves were made by ANCOVA.

RESULTS

Size at sexual maturity

Males

In *R. cemiculus* there are apparently no seasonal changes as there are in other elasmobranchs (Mellinger, 1989). On the contrary, two stages of male development were considered, a juvenile stage and an adult stage (Fig. 3). The juvenile stage included all the males between 400 and 1520 mm TL; the adult stage, all the males over 1550 mm TL. Twenty juveniles and eight adults were observed.

Females

The females were separated into three categories: juveniles, subadults and adults. The smallest females exhibited conspicuous vitellogenic activity from 1120 mm TL. They probably entered a maturation stage at this size. The smallest adult female with ripe oocytes ready to be ovulated was 1630 TL and weighed 14.4 kg. It contai-

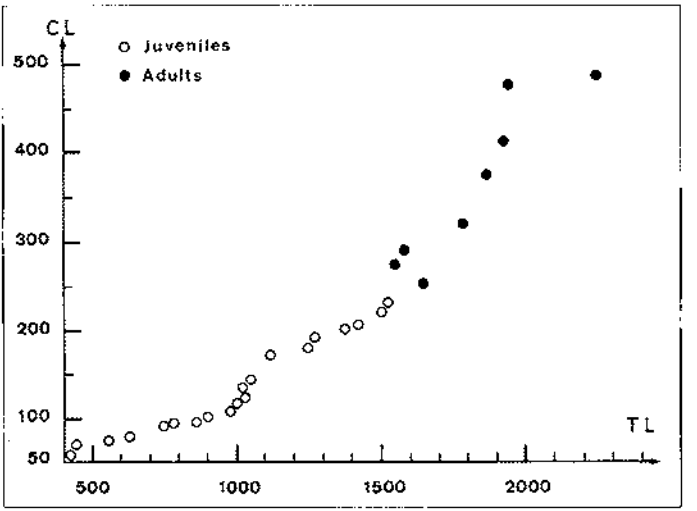

Fig. 3. Relationship clasper length (CL) versus total length (TL).

ned encapsuled eggs in its uterus and was at the beginning of gestation. The smallest gravid female with developing embryos was 1960 mm TL and weighed 20.8 kg. The adult females observed ranged between 1630 and 2450 mm TL, and weighed from 14.4 to 55.0 kg.

Reproductive cycle

The reproductive patterns observed in *R. cemiculus* from both the Senegalese and the Tunisian coasts (Capapé and Zaouali, 1994) are similar to those of other congeneric species, such as *R. horkelii* from Brazil (Lessa, 1982) and *R. rhinobatos* from Egypt (Abdel-Aziz et al. 1993), the Tunisian coasts (Capapé et al. 1997) and the coast of Senegal (Capapé et al., 1999). Two ovaries and two uteri were both functional (Fig. 4). Vitellogenesis proceeds in parallel with gestation. The ovaries produced oocyte clutches similar in size and in weight. Only one of these clutches developed into ripe oocytes, the other degenerated. Table 2 shows that females with encapsulated eggs in their uteri were observed from December to March, and that females with embryos at different stages of development were observed from April to July. In August, two females exhibiting ripe oocytes probably ready to be ovulated were landed at the fishery site of Ouakam. Twenty oocytes were measured from one female. Their diameters ranged from 42 to 46 mm (mean: 43.45 ± 1.05) and their weights from 33.0 to 36.1 g (mean: 34.17 ± 0.92). The uteri of these two females did not contain embryos or fetuses, only a uterine liquid secretion. Moreover, the uteri were distended and their internal walls developed villi. These features suggested that these females had recently expelled their fetuses, naturally or under fishing pressures, which remains questionable. However, the females were close to the time of parturition, which probably would have occurred at the end of summer. In most of the pregnant females, both developing and ripe oocytes

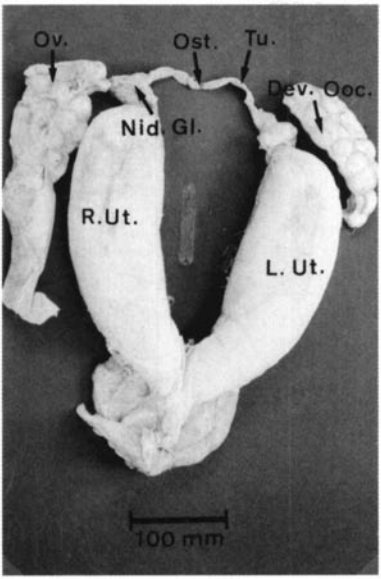

***Fig. 4**. Genital apparatus removed from a pregnant female* Rhinobatos cemiculus *showing ovaries (Ov.) with developing oocytes (Dev. Ooc.), ostium (Ost.), tuba (Tu.), conspicuous nidamental glands (Nid. Gl.) and both right (R. Ut.) and left uteri (L. Ut.) containing developing embryos.*

were distributed equally in each ovary, which was also the case for uterine content, eggs and developing embryos. The smallest specimens observed were 400 and 420 mm TL and weighed 210 and 145 g, respectively. They exhibited an unhealed scar on their ventral face and an internal vitellin vesicle. They were observed in December, probably having been born that same year and being close to size and weight at birth.

Number of females	Month of catch	Ovarian activity	Diameter of oocytes (mm)	Uterine content	Uterine content (LT, mm)
2	Jan.	Resting	-	Eggs	-
2	Feb.	Resting	-	Eggs	-
2	May	Resting	-	Eggs	-
2	Apr.	Vitellogenesis	12-15	Embryos	35-38
1	May	Vitellogenesis	20-21	Embryos	58-59
2	Jun.	Vitellogenesis	25-28	Embryos	88-92
1	Jul.	Vitellogenesis	34-38	Embryos	210-240
2	Aug.	Vitellogenesis	35-38	?	?
1	Dec.	Resting	-	Eggs	-

***Table 2**. Reproductive cycle of female* Rhinobatos cemiculus. *Condition of ovaries and uteri during gestation.*

Weight growth-total length relationships

The relationship weight growth *versus* total length did not show significant differences in intercept between males and females. On the other hand, significant differences did appear in slope between them ($p < 0.05$).
The relations are (Fig. 5):
for males: log TW = 2.927 log TL - 5.259; r = 0.992; n = 28
for females: log W = 3.137 log TL - 5.879; r = 0.987; n = 50.

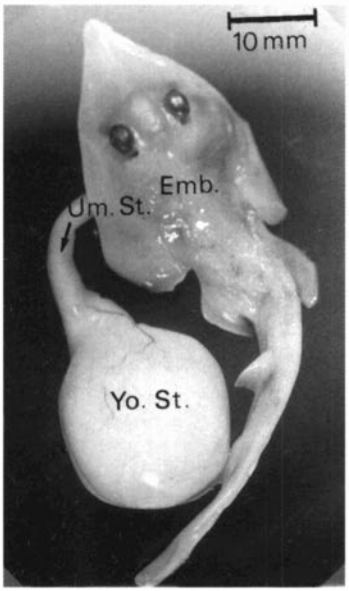

Fig. 5. *Relationship total weight (TW)* versus *total length (TL), expressed in logarithmic coordinates, for males and females.*

Chemical balance of development

From capture to handling, the specimens were not adequately handled to preserve the egg capsule. Nevertheless, in all the observed females, the egg yolk was entirely conserved and not spilled. Thus, we were able to count the number of eggs from each uterus. On the other hand, it was impossible to weigh each egg. An egg mean weight was computed by dividing the weight of the total content for the each uterus by the number of eggs.. The results are summarized in Table 3. This mean weight increased with female size. It ranged from 27.90 to 39.20 g. To calculate CBD, we have only considered the highest value of egg mean weight, 39.20, and the lowest value of two neonates, 145 g, observed. The CBD is 1.85.

Month of catch	Female total length (mm)	Female total weight (kg)	Left uterus			Right uterus		
			Total weight (g)	Number of eggs	Egg mean weight	Total weight (g)	Number of eggs	Egg mean weight
Mar.	1565	14.000	232.2	8	27.90	199.5	7	28.50
Mar.	1630	14.400	285.5	10	28.55	295.0	10	29.50
Feb.	1660	15.440	367.5	13	30.62	390.8	13	30.06
Janv.	1760	19.000	417.5	12	32.11	318.5	10	31.80
Dec.	1900	28.800	393.0	11	35.72	?	?	?
Feb.	2450	55.000	366.0	10	36.60	392	10	39.20

Table 3. *Eggs mean weight calculated for each uterus in gravid female R. cemiculus caught off the coast of Senegal.*

Fecundity

Two categories of fecundity, ovarian and uterine, were considered. Ovarian fecundity was based on the number of ripe oocytes ready to be ovulated in the two ovaries. In the two adult females described above, 20 ripe oocytes were counted. The

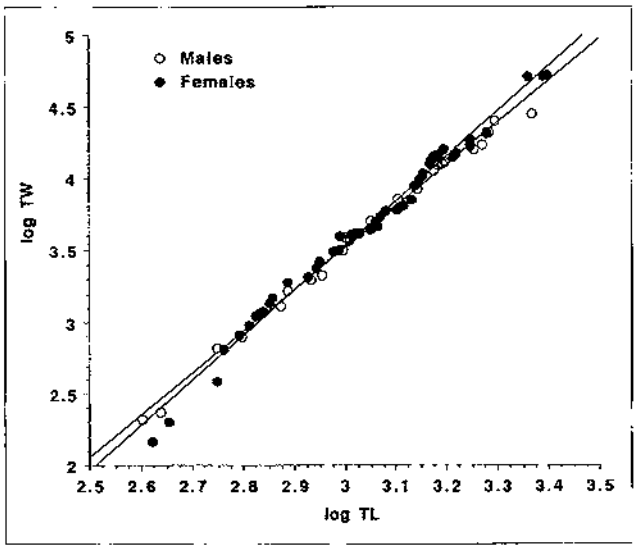

Fig. 6

number of developing oocytes was practically the same. Counted in four females, it ranged from 20 to 22. Uterine fecundity was based on uterine content, i.e. the number of eggs or embryos counted in the two uteri, and ranged from 16 to 24. The two categories of fecundity are not significantly different and there is no relation between female size and the two categories.

DISCUSSION

The blackchin guitarfish is strictly an Atlanto-Mediterranean species that lives in warm temperate and tropical waters. In the eastern Atlantic, it is only recorded south of the Strait of Gibraltar until Angola. In the Mediterranean, its occurrence was previously restricted to just off the coasts, primarily off the southern shore, of the western basin. Recently, it was recorded off the Libyan coast (Lamboeuf et al., 1995) and until the eastern Levantine Basin (Golani, 1996).

According to our observations, the species is caught off the coast of Senegal, but less commonly than its sympatric species, the common guitarfish, *R. rhinobatos*. It is particularly sought by fishermen for local consumption. The fins are especially valued and are collected and prepared under the vernacular native name of 'laâf' and exported (Gueye-Ndiaye, 1993). At Ouakam, the livers were removed from a great number of specimens. The liver oil was locally extracted by hand and used to protect fermented dried fish from infestation (Gueye-Ndiaye et al., 1996). The smallest specimens were generally discarded by fishermen, which explains why the adults of both sexes were more represented in our sample.

Off Senegal, males matured to a smaller size than females. Thus, the females were larger and heavier than the males. This phenomenon is another instance of size sexual dimorphism, which Mellinger (1989) suggested was practically the rule in elasmobranchs except in some scyliorhinids, such as *S. canicula*.

Off the Tunisian coasts, average sizes at sexual maturity of males and females were 1000 mm and 1100 mm TL, respectively. Thus, they matured to a smaller size than the specimens from our area and they also reached a smaller maximal size, the

maximum TL for males and females being 1920 mm and 2320 mm, respectively. Off Senegal, the maximal size for males and females was 2330 and 2450 mm, respectively. These intraspecific geographic variations could be due to sampling. Capapé et al. (2000) showed that the common torpedos, *Torpedo torpedo*, from the Tunisian coasts were smaller than those from the coast of Senegal. On the other hand, Capapé et al. (2002) showed that Senegalese smoothback angelsharks, *Squatina oculata*, were smaller than the Tunisian specimens. This phenomenon is due to fact that females of greater size produce heavier eggs. Likewise, larger specimens developed from heavier eggs. This is not the case for *R. cemiculus*. Eggs produced by female *R. cemiculus* from the Tunisian coasts are heavier than those produced by the same species from the coast of Senegal. However, the specimens from the latter area are larger than those of the former area. The CBD value calculated for *R. cemiculus* from the coast of Senegal showed that the role of the female during gestation is more important than that observed for the female *R. cemiculus* from the Tunisian coasts. Generally, in pure lecithotrophic species (*sensu* Wourms, 1977, 1981) which produce heavy eggs, the mother's role during gestation is considerably reduced. The mother protects the embryonic development and provides inorganic nutrients (Guallart and Vicent, 2001). On the other hand, in pure matotrophic species, the role of mother prevails (Hamlett et al., 1985; Wourms et al., 1988), so egg weight is rather low, fetus weight is relatively high and CBD reached high values, as was the case, for instance, in dasyatids (Capapé, 1993; Capapé and Zaouali, 1995), in the butterfly ray, *Gymnura altavela* (Capapé et al., 1992) and in the spinner shark (Capapé et al., 2003).

The role of the mother during gestation explains why, especially among large specimens, females were heavier than males in the studied sample.

The reproductive cycle of *R. cemiculus* is difficult to delineate. Females at the beginning of the gestation, i.e. with eggs in uteri, were observed from December to March. Females with early developing embryos were observed soon after, in April, which means that gestation started in spring. Parturition probably occurred in August. Consequently, the duration of the gestation was between five to eight months. In Tunisian waters, Capapé and Zaouali (1994) noted that gestation lasted a maximum of eight months.

Moreover, during approximately four months the eggs in the female *R. cemiculus* from Senegal did not develop and remained undamaged. This phenomenon occured during a period when the inshore waters are relatively cold in Senegal. It was described for the first time by Lessa (1982) in *R. horkelii* from Brazilian waters and was called embryonic diapause. The females suppress ova development during several months enabling them to produce young when environmental features are most favourable. An embryonic diapause was observed in *R. rhinobatos* from Senegal (Capapé et al., 1999). In Tunisian waters, it was not clearly defined in *R. rhinobatos* by Capapé et al. (1997) and it was not observed in *R. cemiculus* by Capapé and Zaouali (1994). This is probably due to fact that these two sympatric species inhabit, reproduce and develop throughout the year in the Lagoon of Bibans (southeastern Tunisia) which is a restricted and protected area (Medhioub and Perthuisot, 1977; Guélorget et al., 1982).

This favourable environmental area could explain in part why the *R. cemiculus* fecundity is lower in specimens from Tunisian waters than those caught off the coast of Senegal.

A significant increase of egg weight *versus* female size was observed in *R. cemiculus* from the studied area. A similar phenomenon was also observed in *Torpedo torpedo* from Senegal (Capapé et al., 2000) and from Tunisia (Quignard and Capapé, 1974), although it was not observed in *R. cemiculus* from this latter area (Capapé and Zaouali, 1994).

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