



Reproductive adaptation: a description of claspers of the Spadenose shark and Milk shark from Gujarat

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To ensure reproductive success, sharks have adapted several strategies. It was observed that male sharks of *Scoliodon laticaudus* Müller & Henle, 1838 and *Rhizoprionodon acutus* (Rüppell, 1837) landed along a few centres of Gujarat coast, have highly calcified claspers which morphologically resembled ossified webbed foot. The morphological and anatomical study revealed that the terminal end of the clasper has been modified into an umbrella like organ called rhipidion which probably ensures that the clasper stays within the cloaca of the female until the sperm is delivered. The landed sharks were all mature. This recent observation of catch of many mature individuals near the coastal waters throws some light on the breeding season and breeding area of sharks along Gujarat coast. With episodes of extinction and threat to the existence of several species of sharks today, this reproductive adaptation of the sharks might helps them to survive and sustain adverse conditions.

[**Keywords:** Breeding season, Male reproductive organ, Maturity, Rhipidion]

Introduction

The reproductive success of sharks is due to adaptations which reduce their losses to predation and enhance the survival of their offspring. The most significant of these adaptations are internal fertilization¹ and the production of small numbers of large sized young ones, which hatch or are born as active, fully developed, miniature sharks (pups) providing better chance of survival against predation². Sharks are either oviparous or viviparous. Viviparity is more advanced than oviparity and can be classified into placental and other forms such as yolk sac, histotrophy and oophagy^{2,3}. This is a significant reproductive adaptation where embryos, grow inside the mother's body and stay protected from potential predators, competitors and other challenges, thus getting a better chance of survival. Therefore, a thorough understanding of the biology and ecology of sharks is essential for developing effective conservation and management strategies⁴. The spadenose shark, *Scoliodon laticaudus* Müller & Henle, 1838 and the milk shark, *Rhizoprionodon acutus* (Rüppell, 1837) (family Carcharhinidae) inhabit the inshore waters at a depth range of 10-20 m along Gujarat coast. *S. laticaudus* is a small species which grows up to a length of 74 cm. The males

mature at 36 cm and females at 33-35 cm^{5,6}. Similarly, *R. acutus* is a medium sized shark which grows to a little over 1m. In African waters, this species reaches a larger size possibly of 178 cm^{3,7}. This common continental shelf species is born at 35 to 40 cm in Australia and 25 cm in Africa, and matures at approximately 75 cm. These sharks are vulnerable to the fishing gears (artisanal and commercial fishing sector) operated in coastal waters. Due to dwindling population and increasing vulnerability, *S. laticaudus* has been evaluated as Near Threatened⁸ in the global scenario, whereas; *R. acutus* has been assessed as Least Concern⁸. The present paper deals with the reproductive adaptation observed in males of *S. laticaudus* (spadenose shark) and *R. acutus* (milk shark) from Gujarat waters.

Materials and Methods

The sharks of both the species, having webbed footed claspers were landed at Veraval, Jhaleswar and Mul Dwarka fish landing centers by a single day fiber boat (locally known as "Hodi") operating at a depth of 15m (20°43'29" N and 70°34'33" E) using 85 mm mesh size gill nets called "Choklajal" in the coastal waters during June 2013. For detailed studies, a total of 77 fresh specimens of *S. laticaudus* and 55 of

R. acutus were collected from the landing centers. They were packed in ice in an insulated box and carefully transported to the laboratory for analysis. The sharks were photographed; length measurement (total length and clasper length) and weight were recorded and finally dissected to study the anatomy of the reproductive system. Claspers and cloaca were examined for the presence of milt. Males were determined as matured if the claspers were elongated and calcified. Females were cut open after recording the total length and weight and examined for the condition of the ovaries, uteri and embryos. Tissue sections from the claspers were processed for microscopic examination.

Results and Discussion

The male: female ratio of *S. laticaudus* was found to be 1:1.75. Out of 28 males (36-65 cm) of *S. laticaudus*, 20 (36-45 cm) were found to be mature, having very hard and elongated claspers (7 % of the total length). All the female specimens examined were found to be mature, out of which, 15 were found to be pregnant. On the contrary, out of 55 samples of *R. acutus* examined (TL: 45- 80 cm), males showed dominance with 40 (52-65) specimens and remaining as females with an overall sex ratio of 1:0.37 (M:F). All the males and females were found to be mature with 5 of them being pregnant.

The copulatory organs in male sharks are known as claspers, which originate from the median edges of the pelvic fins and are usually tubular in appearance. The anterior opening of the clasper is called as apopyle and the posterior opening as hypopyle (Fig. 1). The

hypopyle helps in deposition of sperms into the cloaca of the female and thus helps in fertilization. However, all the mature males of both the species showed a strange feature in their clasper morphology which deviated from its normal tubular, tapering appearance and were looking more like an avian webbed foot towards its distal end (Fig. 2). The claspers were articulated with the pelvic girdle, calcified, rigid and festooned not only with a hook and a spine but also with a rhipidion. In immature elasmobranchs, the claspers were found to be very soft, small and flexible.

Anatomy of the claspers revealed that they have grooves on their dorsal side, which were open at both the ends. The back bone of the clasper stem cartilage was round in cross section at its base and gradually became more oval towards the distal end. It was surrounded by two more elements known as dorsal and ventral marginal cartilages (Fig. 3). The terminal



Fig. 2 — An unusual webbed foot and claw- shaped appearance of clasper of *Scoliodon laticaudus*

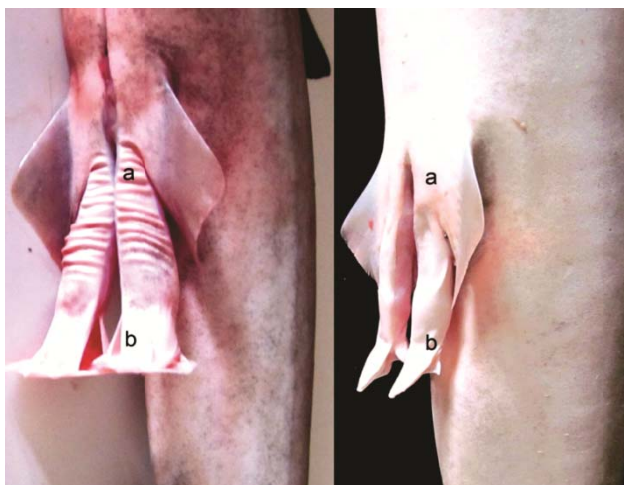


Fig. 1 — Clasper of mature male sharks i.e. *Scoliodon laticaudus* (left) and *Rhizoprionodon acutus* (right) (a. Apopyle; and b. Hypopyle)

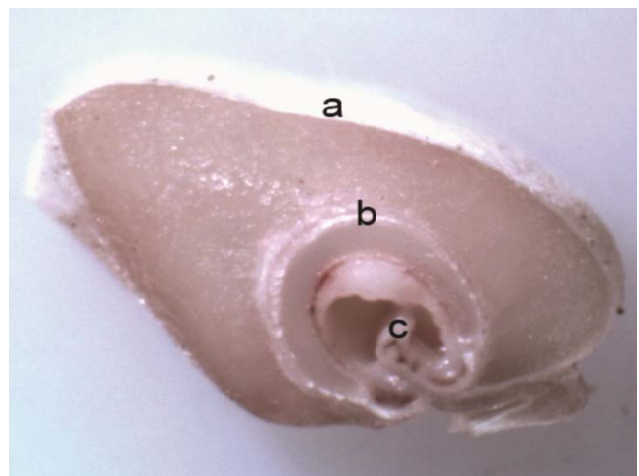


Fig. 3 — A tissue section of the clasper of *Scoliodon laticaudus* (a. dorsal marginal cartilage; b. ventral marginal cartilage; and c. stem cartilage)

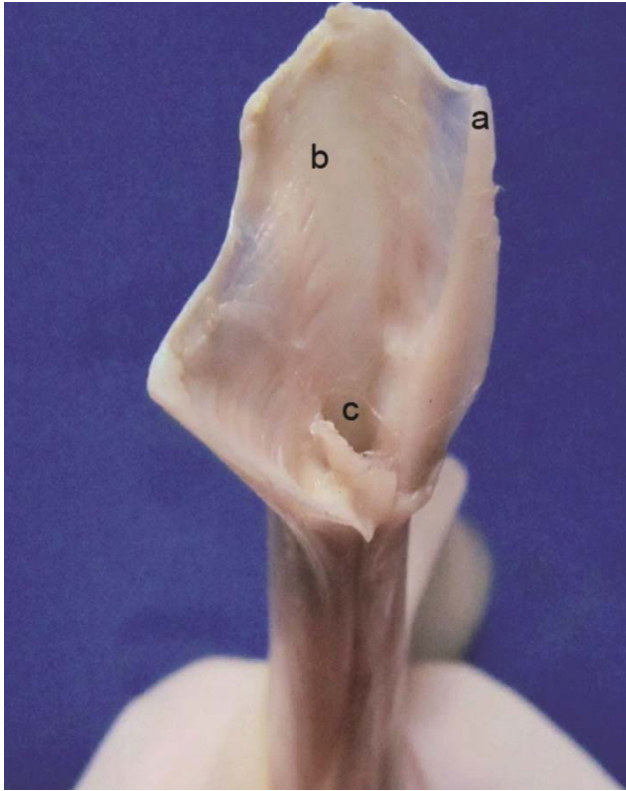


Fig. 4 — The terminal elements of a clasper (a. claw; b. rhipidion; and c. groove)

elements, called as claw and rhipidion were fused to these cartilages on the dorsal side of the clasper and spine was fused to the ventral cartilage. The claw was a partially calcified cartilaginous structure. The ventral terminal cartilage was long and formed a groove which helps to pass the spermatozoa to the cloaca. The rhipidion was an ear-shaped cartilaginous plate which possibly ensures that the clasper stays within the cloaca of the female during copulation until the sperm is delivered⁹ (Fig. 4). The opening of the terminal rhipidion served to anchor the clasper within the reproductive tract of the female, often with a sharp hook or spur¹⁰. The pelvic fins were extended laterally outward from the two skeletal elements known as propterygium and metapterygium and were composed of radial elements that articulate with fin rays called ceratotrichia⁹ (Fig. 5).

The well developed calcified claspers with cartilaginous claw observed in both spadenose shark and milk shark may be an important reproductive adaptation. The calcification and rigidity of the claspers and the ability of the rhipidion to splay open and erect the spur are the best standards for determining maturity in elasmobranchs¹¹. The spread

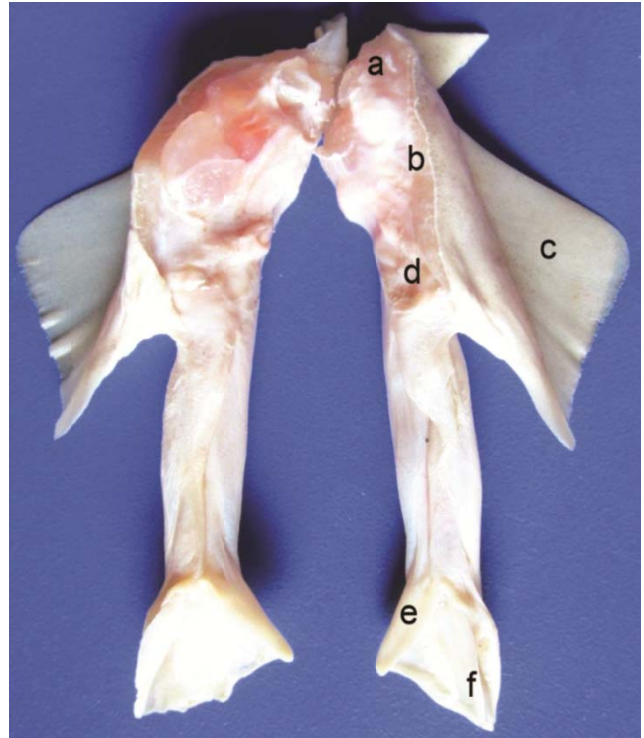


Fig. 5 — A dorsal view of the skeletal elements of the pelvic fin with clasper of *Scoliodon laticaudus* (a. Iliac process; b. Propterygium; c. Ceratotrichia; d. Metapterygium; e. Spine; and f. Hook)

area of rhipidion in both sharks is large area of the clasper at its tip, for holding the female and delivery of sperm, may be considered as a maturity index. The spread area of rhipidion of *S. laticaudus* and *R. acutus* varied from 2.7 cm² to 3.15 cm².

Catch of mature individuals of both the species having highly calcified claspers with rhipidion revealed them as breeding populations and this is a reproductive strategy to ensure reproductive success for the species to sustain. As the observation was made from traditional boat coinciding with the ban period, it indicates the reproductive season and its success. It appears that the mature individuals come close to the shallow coastal waters for breeding while the juveniles remain off shore. The observation also indicates the probable breeding season and breeding area of sharks along the Gujarat coast. However, a detailed study is required regarding the reproductive biology of the sharks to confirm their breeding behaviour and season.

Conclusion

The present study reveals an interesting aspect of morphological adaptation in two sharks i.e.,

S. laticaudus and *R. acutus* where claspers have been found to have highly calcified ear shaped structure called rhipidion probably to prevent dislodgement of clasper from cloaca during copulation and thus ensure the delivery of sperm into female. Predominance of matured specimens from traditional gears during monsoon season indicates the reproductive segregation behavior in these two shark species, the adults of which move close to shore for copulation. Further study should be conducted to locate the exact breeding grounds and season of sharks along the coast of Gujarat to conserve the dwindling population for sustainable future.

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Conflict of Interest

The authors do not have any conflict of interest.

Author Contributions

SS and GD has substantially contributed in the investigation and writing of original draft; SJK has contributed in the review and editing of the manuscript; PUZ contributed in the supervision of investigation.

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