OBSERVATIONS ON THE REPRODUCTIVE BIOLOGY OF THE COWNOSE RAY, *RHINOPTERA BONASUS*, IN CHESAPEAKE BAY[1,2]

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ABSTRACT

Cownose rays, *Rhinoptera bonasus*, are abundant in Chesapeake Bay during summer. We made observations on the reproductive biology of specimens collected primarily from commercial pound nets and haul seines from May through October 1976-78. Clasper development suggested that males began to mature at disc widths (DW) of 75-85 cm. Males judged as mature averaged about 90 cm DW. Macroscopic inspection of the oviducts suggested that females began to mature at 85-92 cm DW. Females judged as mature averaged 96 cm DW. Only the left reproductive tract in female cownose rays appeared functional and only one embryo per gravid female was observed. A total of 67 embryos ranging 18-440 mm DW were collected and the sex ratio of the embryos was 1:1. Gravid females carried three-quarter term embryos in May and parturition occurred in late June and July. Full-term embryos averaged about 40 cm DW. Gestation of another group of embryos began by August. Growth of these embryos was rapid and they were relatively large when cownose rays left the Chesapeake Bay in October. Cownose rays exhibited aplacental viviparity. Yolk reserves supplied the initial energy demands of the embryos (up to about 20 cm DW), but histotrophic secretions of uterine villi provided nutrition for the young through the remainder of gestation.

The cownose ray, *Rhinoptera bonasus*, a large myliobatoid ray, which attains a maximum weight of 23 kg, is abundant in Chesapeake Bay during summer (Schwartz 1965; Musick 1972) where it preys heavily on commercially important shellfish (Merriner and Smith 1979). Because of the severe damage to shellfish beds and the paucity of information on the biology of the cownose ray, the Virginia Institute of Marine Science began a study on the life history of the cownose ray in 1976. Prior to our work, information on the cownose ray's reproductive biology was primarily limited to observations of single gravid females, usually included in more general literature (Gudger 1910; Bigelow and Schroeder 1953; Joseph 1961; Hoese 1962; Bearden 1965; Orth 1975), and size at maturity was unknown (Bigelow and Schroeder 1953). Schwartz's (1967) brief abstract represented the most complete statement on the species' reproductive cycle. Here, we report on the reproductive biology of the cownose ray, specifically on 1) the estimated size at maturity for both sexes, 2) the definition of the gestation period, and 3) the description of the embryonic development.

MATERIALS AND METHODS

Most cownose rays were taken from pound nets in the lower Chesapeake Bay during three summers, 1976-78, but some rays came from haul seines used in spring along the Virginia-North Carolina coast, and from gill nets and rod and reel catches. Disc width (DW = distance between tips of the pectoral fins) was measured in mm on a measuring board. References to specimen size (including embryos) hereafter are disc width measurements.

We judged male cownose rays sexually mature if 1) the clasper rhipidion was fully developed and easily spread and 2) clasper cartilages were well calcified (rigid). We measured clasper length as the distance from the junction of the clasper and pelvic fin to the distal end of the clasper. Criteria modified from Smith (1975) were used to determine the following stages of sexual maturity for females:

1) immature - ovaries thin and flaccid; uterus thin and elongate, lining appears rugous.

2) maturing - ovary slightly developed, yellowish ova visible, ova <1 cm diameter; uterus somewhat dilated, trophonemata (uterine villi) small, generally <0.5 cm long.

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3) mature - ovary with large yellowish ova >1 cm diameter; uterus well-developed and rich in trophonemata, generally >1 cm long.

Uteri and oviducts were opened and inspected for ova or embryos. Embryos were weighed and measured for disc width (mm). Yolk-sac volume (mL) was measured by volumetric displacement in a graduated cylinder.

RESULTS AND DISCUSSION

Like many other elasmobranch populations which occur along the east coast of the United States, cownose rays are highly migratory and exhibit a northward coastal migration in spring and a southward movement in fall (Schwartz 1965; Smith 1980). Our earliest spring collection of adult rays occurred during 2-5 May 1977 on the North Carolina Outer Banks. Our latest fall collection of adult males was on 7 September 1978 in the lower York River, while the latest fall collection of adult females occurred on 12 October 1977 near Cape Henry, VA, at the mouth of the Chesapeake Bay. Adult rays were absent from pound net catches in the lower bay after mid-October; furthermore, they were unavailable to us until the following spring when they migrated back into Chesapeake Bay.

Size at Maturity

At the onset of sexual maturity, terminal cartilage elements develop distally on the claspers of male elasmobranchs (Bigelow and Schroeder 1953), and the allometric growth of these appendages has been used to determine the attainment of sexual maturity in various elasmobranchs (e.g., Clark and Von Schmidt 1965; Struhsaker 1969; Gilbert and Heath 1972). In male cownose rays the ratio of clasper length to disc width increases slightly at 75-85 cm DW suggesting the onset of sexual maturity (Fig. 1). Males <75 cm (n = 68) appear immature; their testes are thin, white and ribbonlike and their claspers are narrow and flexible. Males ranging 80-98 cm ($\bar{x}$ = 89.8 cm; n = 115) appear mature; their testes are pinkish white in color and greatly swollen, and their claspers are rigid and well-calcified. Based on clasper length to disc width ratio and cursory observations of the testes, we estimated that male cownose rays begin sexual maturation at about 80 cm and most are probably mature at disc widths >84 cm.

Considerable discrepancies exist in the literature concerning size of female cownose rays at sexual maturity. Gudger (1910) claimed a female about 60 cm wide gave birth to a pair of young. Bearden (1965) reported four premature young from a female measuring 712 mm (disc width?) taken in South Carolina. Joseph (1961) and Orth (1975) collected gravid females in Chesapeake Bay of 89 and 90 cm, respectively. We classified females <84 cm (n = 86) as immature (immature ovaries are thin and flaccid, and immature uteri are thin and elongate). Females that we judged as mature ranged 84.5-100 cm ($\bar{x}$ = 96 cm; n = 117). Mature ovaries possess yellowish ova >1 cm in diameter; the left uterus of mature females is well-developed and rich in trophonemata (uterine villi), which are generally >1 cm long, red in color, and spatulate distally. We classified eight specimens (range: 84-92 cm) as maturing females. Although ova <1 cm in diameter are visible in the ovary, the left uterus is not well-developed and the trophonemata are generally <0.5 cm long. The smallest gravid female measured 87 cm. Based on these observations we estimated that female cownose rays begin sexual maturation at 85-90 cm and are mature at disc widths >90 cm.

Only the left reproductive tract appears functional in female cownose rays. There is no macroscopic evidence of follicular development in the right ovary. The right uterus in mature specimens shows some distension (ca. 3 cm wide), but does not exceed the breadth of the left uterus. Embryos and ova occur only in the left uterus, although we found an empty shell capsule in the right uterus of several gravid females. Nonfunctional right reproductive tracts have been reported in the roughtail stingray, *Dasyatis centroura*, (Struhsaker 1969) and the bluntnose stingray, *D. sayi* (Gudger 1912; Hamilton and Smith 1941; Hess 1959).

Reproductive Cycle

Numerous literature accounts reported on the capture of singular gravid cownose rays (Smith 1907; Gudger 1910; Bigelow and Schroeder 1953; Joesph 1961; Hoese 1962; Bearden 1965; Orth 1975) and these provided fragmentary information on the ray's gestation cycle. Schwartz's (1967) abstract defined June through October as the breeding cycle and closely parallels our results, although we disagreed on size at parturition. We collected 67 embryos (range: 18-440 mm; sex undetermined for 3 specimens) from the lower Chesapeake Bay and vicinity. Data for 19 embryos (all specimens sexed, length undetermined for 8 specimens) taken in April 1978 near Cape Lookout, NC, were provided to us by W.

S. Otwell[4] (Fig. 2). Only one embryo per gravid female was observed. The overall sex ratio of embryos (40♂:43♀) did not differ significantly from 1:1.

Gravid female rays migrate into Chesapeake Bay in spring with well-developed embryos that we designated as approximately three-quarter term.

[4]W. S. Otwell, formerly of North Carolina State University Food Science Laboratory, Morehead City, NC; presently at University of Florida, Food Science Department, Gainesville, FL 32611, pers. commun. April and May 1978.

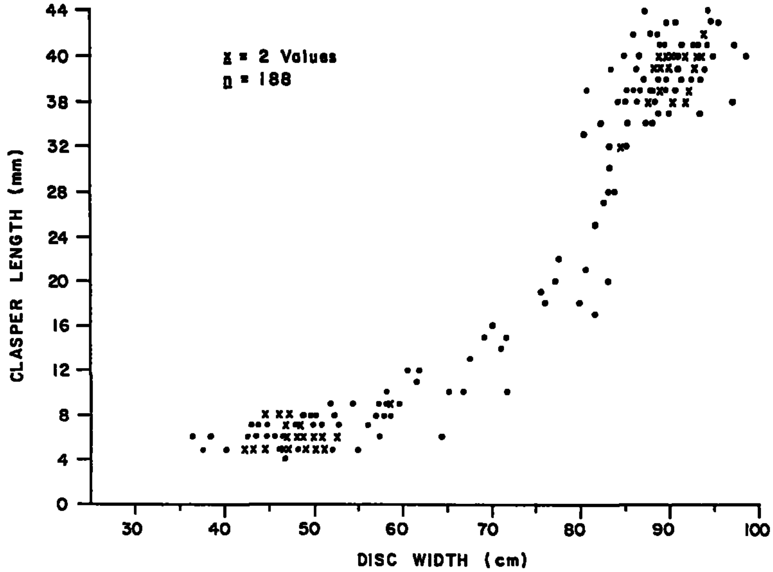

FIGURE 1.—Relationship of clasper length (mm) to disc width (cm) for 188 male *Rhinoptera bonasus*.

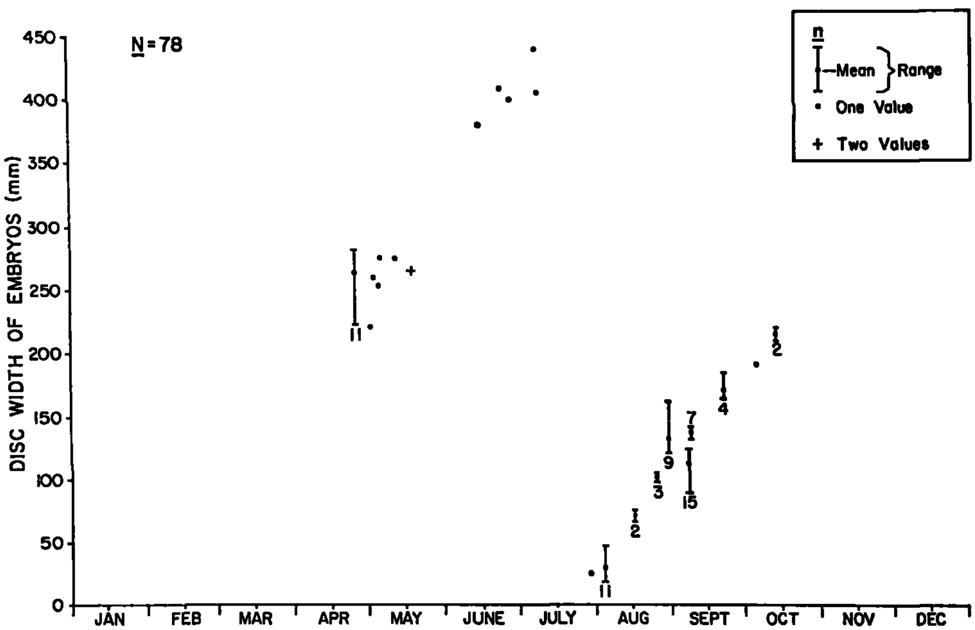

FIGURE 2.—Relationship of disc width (mm) to date of capture for *Rhinoptera bonasus* embryos collected 1976 through 1978.

Embryos collected in early May on the Outer Banks and in the lower York River average 259 mm (range: 221-276 mm; n = 7), and those collected from Cape Lookout, NC, in mid-April (Otwell fn. 4) average 264 mm (range: 222-281 mm; n = 11) (Fig. 2). By late June and early July the embryos are full term ($\bar{x}$ = 413 mm; n = 4). Parturition occurs at this time and the first free-swimming young appear in pound net catches. Embryo weight gain in spring is noteworthy; three-quarter term embryos in April and May average 310 g (range: 192-392 g; n = 16), while the weight of full-term individuals in late June increases fourfold averaging 1,291 g (range: 1,134-1,409 g; n = 3). Schwartz (1967) reported that term individuals average 305 mm DW, however, embryos we considered full term are considerably larger (ca. 400 mm) and the smallest free-swimming ray we collected was 323 mm. Perhaps, the embryos Schwartz (1967) considered full term were taken in early June and were not yet ready for parturition.

Female rays ovulate following parturition. We found encapsulated uterine eggs in specimens taken on 28 June and 21 July. In early August the embryos are 20-30 mm wide and have lost the shell capsule. By late August they average 125 mm (Figs. 2, 3). When adult rays leave the Chesapeake Bay in late September and early October, the embryos are relatively large, up to 220 mm.

Reproductive cycles of large elasmobranchs are often difficult to describe because during certain stages of pregnancy, individuals may be inaccessible as a result of schooling and migratory behavior (Holden 1974). Since cownose rays leave Chesapeake Bay by November and do not return until May, we could not determine precisely the length of gestation. Nevertheless, an 11-12 mo gestion period seems most probable. Within this context, the rapid embryonic growth observed in summer would slow during winter. A slowdown or cessation of intrauterine growth would be expected if gravid females experience high energy demands during an extensive migration to distant wintering grounds, possibly northern South America as suggested by Schwartz (1965). Thus, the embryos from late summer and fall

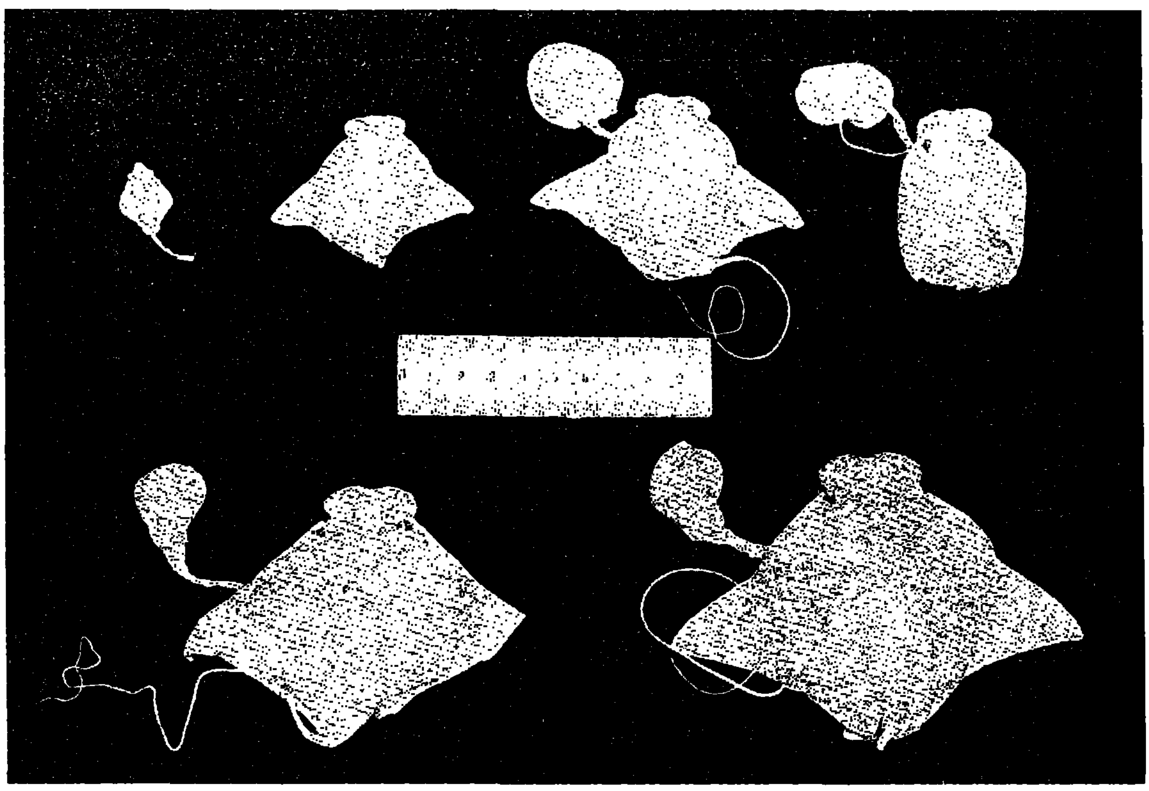

FIGURE 3.—Series of *Rhinoptera bonasus* embryos ranging from 18 to 140 mm disc width collected in late summer and fall.

would be born the following summer when the adults return to Chesapeake Bay, a gestation period of 11-12 mo beginning in July or August and ending in June or July.

The relatively large size of cownose ray embryos in late September and early October suggests the possibility of two 5-6 mo gestation periods. Parturition might occur on the cownose rays' wintering grounds followed by the gestation of another brood of embryos destined for birth the following summer. This hypothesis is not unprecedented, since the presence of well-developed young in the spiny butterfly ray, *Gymnura altavela*, during May in Delaware Bay and during February off the coast of North Carolina (27 fathoms) led Daiber and Booth (1960) to propose two 5-6 mo gestation periods per year for this species. Precise definition of the cownose ray gestation cycle will require collecting gravid female rays on their wintering grounds.

Embryonic Development and Nutrition

The shell capsule of the cownose ray, which we observed twice in utero, is of a greenish amber, thin diaphanous material, and is about 10 cm long. One capsule held a single ovum, while the capsule from a second female contained three ova. Ova are yellow, extremely flaccid, and about 3-4 cm in diameter.

The embryos in late summer and fall possess yolk stalks and yolk sacs, although these often become detached during collection (Fig. 3). The smallest embryos we collected are about 20 mm wide, batoid in appearance, and unencapsulated. Numerous external branchial filaments (ca. 15-30 mm long), which emerge from the gill slits, are highly conspicuous on small embryos (18-75 mm). These filaments are absent in embryos larger than 89 mm.

Three-quarter term embryos are upright in the uterus (ventral surface of the embryo on the ventral wall of the uterus) with the rostrum pointed forward. The pectoral fins are folded dorsally. The tail and heavily sheathed spine are bent forward along the dorsum of the disc. The yolk sac and stalk are almost completely absorbed; only about 3 mm of the umbilicus protrudes from the abdomen.

Full-term embryos are similarly oriented. However, the umbilicus is completely absorbed, leaving only a small scar that is evident on free-swimming young. Pigmentation is that of the adults, i.e., chocolate-brown dorsally, white ventrally, and black caudally. Several tooth plates were discovered in the left uterus from which a full-term young was removed, confirming Bigelow and Schroeders' (1953) report that tooth replacement begins in utero.

During the early stages of gestation the uterus is rigid and thick-walled, but it gradually expands to accommodate the developing young. Just prior to parturition, it is extremely distended (ca. 15 cm at its greatest breadth), thin-walled, and flaccid.

Myliobatoids overcome spatial restrictions in utero by rolling the pectoral fins dorsally or ventrally, along the anterioposterior axis (Gudger 1951), and some studies report that larger than average females carry more and larger offspring (e.g., Babel 1967). Although we observed multiple encapsulated ova in cownose rays, and others have cited the occurrence of multiple embryos in utero (Smith 1907; Gudger 1910; Bearden 1965), we never found more than one embryo per gravid female. Setna and Sarangdhar (1949) and James (1962, 1970) made similar observations for the Javanese cownose ray, *R. javanica*, from the Indian Ocean. Our data for term embryos ($n = 4$) are insufficient to corrolate embryo size with parent's size; however, we suspect that in general only one cownose ray embryo is carried to term.

Embryonic nutrition is from yolk and histotrophe. Yolk of the late summer and fall embryos ($n = 33$) gradually diminishes between August and October (Fig. 4), and most yolk reserves are probably utilized when embryos are about 20 cm. Histotrophe, a viscid, yellowish secretion of the uterus (as also cited by Schwartz 1967), also nourishes the embryos. The amount of histotrophe, although not quantified, increases considerably as gestation progresses. Trophonemata, the uterine villi that produce histotrophe, are deep red, flattened in cross section and spatulate distally. They attain their greatest length (ca. 2-3 cm) in females with near full-term embryos. The trophonemata occasionally invade the gill slits.

In summarizing chondrichthyan, fetal-maternal relationships, Wourms (1977) noted that the efficiency of placental analogues, the villiform trophonemata, far surpasses that of the yolk-sac placenta exhibited by some carcharhinids. In cownose ray embryos, yolk apparently provides initial nutritional requirements. Embryos may augment yolk supplies during the first month of gestation by absorbing histotrophe via the external branchial filaments, as was suggested for *Urolophus halleri* by Babel (1967). After October, histotrophe supplies nourishment for the remainder of the gestation period, probably engulfed via the mouth, spiracles, and gill slits.

Viviparity and the use of nursery areas that are relatively free of predators, e.g., Chesapeake Bay, no doubt protect young cownose rays. Large carcharhinids, of which batoids are purported to be a

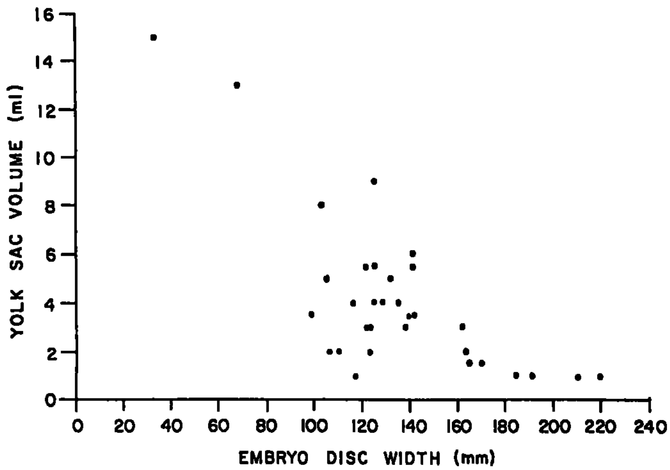

FIGURE 4.—Relationship of yolk-sac volume (mL) to disc width (mm) for *Rhinoptera bonasus* embryos collected in late summer and fall.

favorite prey (Darnell 1958; Budker 1971) are abundant seaward of the Virginia capes during summer (Lawler 1976), but generally only the sandbar shark, *Carcharhinus plumbeus*, and the bull shark, *C. leucas*, frequent the Chesapeake Bay proper (Schwartz 1960; Musick 1972). Although gravid female sandbar sharks utilize the eastern shore of the Chesapeake Bay (Lawler 1976), they may not pose a threat to cownose rays, since the female sandbar sharks generally abstain from feeding while on their pupping grounds and males tend to avoid such areas (Springer 1960). Bull sharks (Schwartz 1959) may represent the only major predators of rays in Chesapeake Bay during summer.

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