

Observations on the Courtship, Nests and Young of *Siren intermedia* in Southern Florida

Two spent female *Siren intermedia* were found attending eggs in early February in a S Florida water hyacinth community. Embryos from both nests tended to hatch synchronously, averaged 11.5 mm in total length and showed more advanced development than those reported from Arkansas. The two attendant females had several distinct epidermal marks, which closely matched the cornified beaks and vomerine teeth of conspecifics, and possibly were made by courting males. Examinations of 487 additional *S. intermedia* collected from this site indicated that bite-marks were restricted to breeding females. The larger body size and enlarged masseter muscles of male *S. intermedia* probably are related to social interaction and sexual activity.

INTRODUCTION

In reviews of the biology of sirenid salamanders, Martof (1972, 1973a,b, 1974) stated that reproductive data were especially fragmentary. Circumstantial evidence concerning modes of fertilization in sirenids is confusing and contradictory, and to date all known attempts to induce breeding in captive sirenids have failed (Noble, 1931; Noble and Marshall, 1932; Noble and Richards, 1932; Bishop, 1943; Ultsch, 1973; Goin *et al.*, 1978; Hanlin and Mount, 1978). More is known about *Siren intermedia* than about any other species, yet nothing is known of its courtship or mating behavior. Nests of *S. intermedia* have been found in the field on several occasions (Noble and Marshall, 1932; Hubbs, 1962). In most instances an adult *S. intermedia* was seen with the embryos or larvae, but the sex of the attending adult was never determined. Here I report observations of the nests and young of *S. intermedia* in Florida, and comment on courtship and sexual dimorphism in this species.

MATERIALS AND METHODS

Observations were made in a water hyacinth (*Eichhornia crassipes*) community in a canal at Rainey Slough, Glades Co., Florida. This site is the southernmost locality known for *Siren intermedia* in Florida (Martof, 1973a), and all three species of sirenid salamanders occur there (J. S. Godley, pers. observ.). The herpetofauna of the Rainey Slough hyacinth community was sampled intensively from 1974-1977 with a 0.56 m² hyacinth sieve, similar in design to that described by Goin (1942). A detailed description of the study site and sampling methods is provided elsewhere (Godley, 1980, 1982).

Two nests of *Siren intermedia* were collected during the study. Some embryos from both nests were preserved immediately; others were kept alive for developmental studies and positive identification. In the laboratory, embryos from each clutch were incubated at 23 C in 1-liter glass dishes with well water, and serially preserved before and after hatching. A subsample of 10 individuals from each nest was measured with an ocular micrometer to estimate the mean size and range of eggs and hatchlings.

RESULTS AND DISCUSSION

On 8 February 1976 two *Siren intermedia* nests were found among water hyacinths ca. 4 m from shore in water 35-40 cm deep and having a 12.8 C temperature. Nest A rested on an 8-10 cm layer of fibrous peaty material that covered an area 0.4 m². The peaty mat was suspended by hyacinth roots 4 cm below the water surface and was covered by a cluster of small (4-6 cm) hyacinths. The sieve, positioned beneath both the hyacinths and the submerged peaty shelf, was lifted upwards draining the water. A siren squirmed away from beneath the center of three isolated hyacinths which then rested on the peaty substratum. Subsequent dissection revealed this *S. intermedia* (USNM 224035, SVL = 151 mm, fresh wet mass = 23.26 g) to be a spent female with flaccid ovaries, small nonyolky oocytes and regressed oviducts. A nest of 206 eggs was found beneath the hyacinths. No nest cavity was apparent but the peat was dense and fibrous. The eggs (USNM 224039-059) were in a single mass, 65 x 60 mm and layered ca. three eggs deep in the center. No other eggs were found in the immediate vicinity. The eggs adhered to one another, to the peaty substratum, and to rootlets of the three surrounding hyacinth plants. The outer capsules of 10 eggs ranged in size from 5.9-7.5 mm (\bar{x} = 6.55 mm). Outer capsules of isolated eggs tended to be larger than those adherent to one another. At hatching 3 days later, 10 larvae averaged 11.5 mm total length.

Nest B was 2.3 m from nest A in a similar microhabitat except that the main egg mass was located against the base of a grass clump (*Spartina* sp.), which was rooted in a 6-10 cm layer of suspended peaty material. The main egg mass (USNM 224062-129) contained 362 *Siren intermedia* embryos (\bar{x} diam of 10 outer egg capsules = 6.50 mm; \bar{x} total length of 10 hatchlings = 11.6 mm). This egg mass was 3-4 layers deep, measured 80 x 95 mm, and rested on a depressionless peaty substratum. The eggs adhered to one another, the peat, and the roots of the *Spartina* and two adjacent hyacinth plants. An additional 18 eggs (USNM 224061) were found loosely grouped 15 cm from the center of the main egg mass on the opposite side of the *Spartina* clump. One other egg (USNM 224061) was located 20 cm from the main egg mass in the opposite direction. Assuming these eggs were laid by a single female, her egg complement was spread over a linear distance of 35 cm and contained at least 381 eggs. When the hyacinth sieve containing this nest was lifted, a siren glided away from the main egg mass. This siren also was a spent female *S. intermedia* (USNM 224036; SVL = 167 mm; fresh wet mass = 35.62 g).

In the laboratory a total of 36 embryos from *Siren intermedia* nest A hatched over a 6-day period and 135 from nest B over a 16-day period. A majority of embryos from both clutches hatched synchronously (75.0% of A on day 1, 67.4% of B by day 3). Unfortunately, nest B developed a fungal infection midway through laboratory incubation, which may have impeded the hatching of some embryos from that clutch. Noble and Marshall (1932) noted that a clutch of *S. intermedia* from Arkansas hatched over a 10-day period but provided no information on rate of hatching or incubation temperature.

The excellent descriptions (Noble and Marshall, 1932) of the eggs and of the early ontogeny of *Siren intermedia* from Arkansas closely match the findings reported here. However, Florida specimens showed more advanced development. These specimens had well-developed dorsal fins and forelimb buds at hatching and the tails accounted for 26% of their total length (Fig. 1). These young more closely resembled those in Figure 2C (4 days posthatching) of Noble and Marshall (1932) than the ones in their Figure 2B (at hatching). By 10 days posthatching, all four digits of Florida *S. intermedia* larvae were distinct (not 25 days as in those of Noble and Marshall, 1932), and the mouth was perforate. The color patterns of the Florida hatchlings were similarly advanced.

At least three factors may account for the observed differences in developmental rate and stage of hatching between the two samples: (1) differences in incubation temperature; (2) laboratory-induced premature hatching of Noble and Marshall's Arkansas material or late hatching of the Florida specimens, and/or (3) genetic dif-

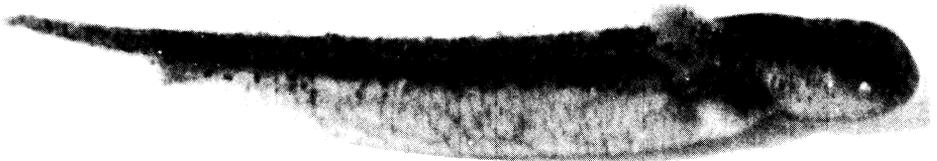
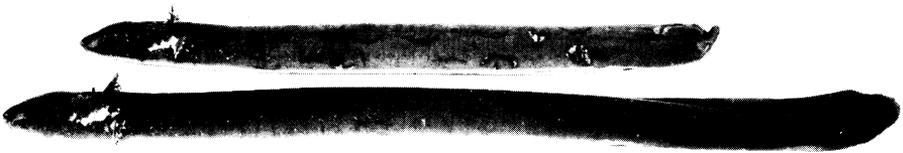


Fig. 1.—*Siren intermedia* larvae from nest B at day of hatching. Compare with Figure 2 of Noble and Marshall (1932: 6). Bar equals 2 mm. Photo by R. W. McDiarmid

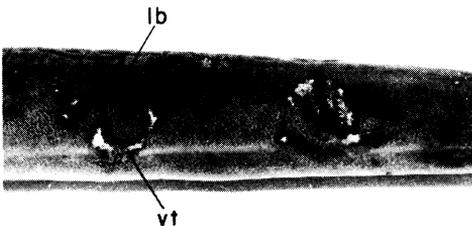
ferences in developmental rates between the taxonomically distinct populations (see Martof, 1973a). At present, data necessary to evaluate these three hypotheses are lacking.

Both females *Siren intermedia* collected with eggs had several unusual epidermal markings not previously seen on most individuals from Rainey Slough (Fig. 2A,B). These marks appeared to be the result of bites and typically consisted of a broader 9-mm semicircle and an opposing, smaller mark. These smaller marks were of two kinds: either a shallow, 2-3 mm indentation and/or a 4-5 mm V-shaped mark that occasionally broke through the epidermis (Fig. 2B). These marks match closely the broad lower beak and narrower upper beak and/or vomerine dental array, respectively, of adult *S. intermedia* (Fig. 2C). The female from nest A (USNM 224035) had 20 distinct bite-marks between the forelimbs and cloaca, and two posterior to the cloaca. Several deep gashes were near the cloaca. All bites apparently were made with the head of the attacking siren held perpendicular to the long axis of the female's body. Most bites (N = 20) were directed towards her lateral aspect, but two were directed towards her

A.



B.



C.

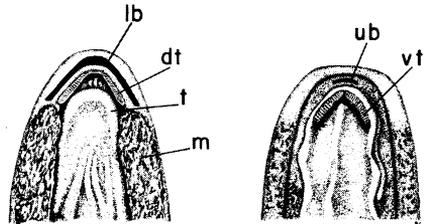


Fig. 2. — Bite-marks on *Siren intermedia* found attending nests. Bar equals 1.0 cm in all figures. (A) Lateral view of female *S. intermedia* USNM 224035 (top) and USNM 224036 (bottom). Both individuals have partially regenerated tails. (B) Close-up of deeper bite-marks near the cloaca (cl) of USNM 224035. The bite to the left includes marks that match the broad lower beak (lb) and the V-shaped vomerine dental array (vt) of *S. intermedia* (see Fig. 2C). Scars to the right include a series of bites. Photos taken 11 February 1976 by R. W. McDiarmid. (C) Partially dissected head of an adult male *Siren intermedia* (USNM 226395) showing the size and position of the keratinized but flexible upper and lower beaks, and the vomerine tooth rows. Dentary tooth rows (dt) are recessed below the lower beak. Tongue (t) and jaw muscle mass (m) shown for orientation. Drawing by Bill Clark

dorsum. Of these lateral bites, 10 were made with the attacker's head held upright (*i.e.*, with respect to the female, the broad lower beak was ventral in position to the upper beak), and 10 were inflicted with the head held upside down (lower beak mark was dorsal to upper beak mark). The female from nest B (USNM 224036) was a darker specimen and its bite-marks were less distinct. This larger female (Fig. 2A) had a total of 13 marks similar in size and position to those on female A. However, female B had four bite-marks on her dorsum immediately behind the gills but none posterior to the cloaca.

I examined the concordance between bite-marks, sex and reproductive condition by necropsying 489 preserved *Siren intermedia* collected at Rainey Slough from 1974-1976 (Godley, unpubl. data). In this population reproduction is synchronous. Vitellogenesis begins in October, some mature females contain ovulatory follicles from late December through March, and all females are spent by April. In this sample, four individuals bore noticeable bite-marks in addition to the females cited above (whose bites were recognizable after 6 years in alcohol). These four individuals included one ovulating and one partially spent female collected 25-26 January 1975, and two spent females collected 15 February 1976. These females had respectively 3, 4, 5 and 15 bite-marks which were similar in size and position to those reported above. No males had bites attributable to conspecifics.

I suggest that these bite-marks were inflicted by courting male *Siren intermedia* and that biting is a vigorous and important component of courtship in this species. R. Altig (pers. comm.) attempted to induce courtship and egg deposition in *S. intermedia* from Illinois by injection of gonadotropins. He observed a male approach perpendicular to the long axis of a gravid female, raise his body off the substratum and bite her dorsum. Altig believed that biting was an initial component of courtship, but no further sexual activity was observed. Gehlbach and Walker (1970) mentioned that *S. intermedia* from Texas occasionally bit each other in aquaria but did not indicate the sexes involved or the social context.

Several authors have noted the marked sexual dimorphism in *Siren intermedia* from Texas (Davis and Knapp, 1953; Martof, 1973a; Gehlbach and Kennedy, 1978) and *S. lactertina* from Alabama (Hanlin and Mount, 1978). In these populations, adult males tend to be larger than adult females, and possess enlarged masseter muscles which impart a distinct lumpy appearance to the temporal regions of the head. This dimorphism probably is related to social interaction and reproductive activity. Larger body size in males may be selectively advantageous if males compete for females or if females assess male fitness based on some size-related feature. The enlarged masseter muscles of males may be important in biting other males if they are territorial (*cf.* Gehlbach and Walker, 1970) or females during courtship.

Acknowledgments.—I thank W. E. Ackerman, D. Appelquist, J. Bell, J. D. Douglass and G. E. Woolfenden for help in collecting specimens, and R. Altig for his notes on *Siren intermedia* courtship. D. R. Jackson and R. W. McDiarmid improved earlier drafts of the manuscript. The Department of Biology, University of South Florida, and the Archbold Biological Station provided partial support.

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- J. STEVE GODLEY, Department of Biology, University of South Florida, Tampa 33620, and National Fish and Wildlife Laboratory, National Museum of Natural History, Washington, D.C. 20560. Submitted 1 June 1982; accepted 22 November 1982.