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Nocturnal Reproductive Behavior in *Semotilus atromaculatus* (Pisces,
Cyprinidae)

NOCTURNAL REPRODUCTIVE BEHAVIOR IN *SEMOTILUS ATROMACULATUS* (PISCES, CYPRINIDAE)

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ABSTRACT

Nocturnal reproductive behavior in *Semotilus atromaculatus* observed and recorded on videotapes is described and compared to that recorded in daylight. The percent of time spent for each of four reproductive activities (breeding male in pit position, nest-building, agonistic displays/combat, and spawning) was comparable to its corresponding diurnal activity. Activities of fishes at night over a nest continued as light intensities were increased gradually with rheostats. As the primary male *S. atromaculatus* was in high color, and color cannot be detected by fishes at low nighttime lumen levels, senses (e.g. olfactory, lateral line, and tactile), other than vision, are instrumental in communication among nocturnal breeding males and females and diurnal breeding ones as well.

INTRODUCTION

Washburn (1945), the only reference found to nocturnal spawning in *Semotilus atromaculatus* (creek chub), stated daylight reproductive activities in the species continued into the night, ceasing when water temperature dropped below 51 F (10.6 C). Recently (1991 and 1993) we observed and videotaped *S. atromaculatus* spawning at night. In this paper nocturnal reproductive activities in this species are described and compared with those that occur diurnally.

MATERIALS AND METHODS

Nocturnal reproductive behavior in *S. atromaculatus* was studied in East Branch Genito Creek (James River drainage), Virginia, Goochland Co., Co. Rt. 641, during 2000-2310 hours EST, 28 March 1991, and during 1945-2345 EDT, 20 April 1993 (water temperature, 15.3 C and 15.9 C, respectively; stream width, 2 m; stream depth, 0.15 m). Videotapes of diurnal reproductive behavior were made from two sites: in the same creek from 1100-1400 hours EDT, 17 April 1989 (water temperature, 17.8 C; stream width, 4 m; stream depth,

0.15 m); and in an unnamed tributary of Falling Creek (York River drainage), Hanover Co., Rt. 667 about 3.2 km N of Ashland, Virginia from 1450-1620 hours EDT, 23 May 1987 (water temperature, 15.0 C; stream width, 1 m; stream depth, 0.25 m).

Behavior was videotaped from above the surface of the water with a Sony television camera (operated at a light gain of 18 decibels at night) and recorded on 3/4 inch videotape. A hydrophone, placed in the nest to monitor sound, was attached to the video recorder.

Splashing of the water by the breeding fish revealed the location of nests. Two light systems were employed. On 28 March 1991, two 7.5 V incandescent spotlights (100,000 candle power each) provided illumination. One spotlight was focused on the streambed halfway between the nest and an undercut bank; the second illuminated the spawning pit of the nest. On 20 April 1993, two 12-V battery-powered halogen spotlights (each 1-million candle power), equipped with rheostats, were focused as described above.

Videotaped nocturnal activities and supplemental data from field notes were compared with field notes and video recordings of diurnal behavior in *S. atromaculatus*. Four reproductive activities were analyzed: breeding male in pit position (i.e., posturing in spawning pit before and after stone excavation and deposition, and spawning attempts), nest-building, agonistic displays/combat, and spawning. The duration of each behavior was timed with a stop watch, and recorded as percent of time of all behaviors during total observation periods. The number of successful spawns and unsuccessful spawns (clasp did not occur) were counted and expressed as percent of total spawning attempts. Average percentages of nocturnal reproductive activities in *S. atromaculatus* were compared to those seen in day (Table 1).

RESULTS

Average percentages of time that a tuberculate male *S. atromaculatus* (in high breeding color) spent in the pit position (33.6) and in nest-building (44.5) at night were comparable to

Table 1. Mean (\pm one standard deviation) and range (in parenthesis) of percent time of selected reproductive behaviors in *Semotilus atromaculatus* (video observation time, night = 39.5 min; day = 34.13 min).

Behavior	% time/behavior	
	Night	Day
	15.6 C \pm 0.4 (15.3 - 15.9)	16.4 C \pm 2.0 (15.0 - 17.8)
♂ in pit position	33.6 \pm 1.8 (32.3 - 34.8)	31.0 \pm 7.5 (23 - 37.9)
Nest building	44.5 \pm 0.6 (44.1 - 44.9)	43.1 \pm 8.8 (33.4 - 50.4)
Spawning clasp	7.7 \pm 0.7 (7.2 - 8.2)	17.3 \pm 6.3 (10.2 - 22.1)
Agonistic encounters	14.0 \pm 0.4 (13.8-14.3)	8.7 \pm 6.2 (1.5-12.5)

those (31.0 and 43.1, respectively) recorded during the day (Table 1). Average percent (7.7) of spawning time at night was about one-half that which that occurred during the day (17.3); however, average percent time engaged in spawning was similar (day, 10.2; night, 7.7) at comparable water temperatures (day 15.0 C and night 15.6 C). Average percent of number of successful spawns (34.0) was greater at night than the average (23.8) recorded for the day (Table 2).

The percent of time the nest attendant male spent in combat with intruder males was related to the number of intruders in the vicinity of the nest (Table 1). Combat at night occupied 14.0% of the attendant male's time (seven intruders), whereas in the daylight at one nest the average percent of combat time was 12.0 (two intruders) and at another 12.5 (four intruders). At a third nest during daylight, where only three contacts were made with a single intruder, combat time was 1.5%.

Clinostomus funduloides (rosyside dace) and *Phoxinus oreas* (mountain redbelly dace), both in high breeding colors and feeding on eggs, were nest associates of *S. atromaculatus* at night as in the day. Like in daylight, agonistic behavior (i.e., parallel swim, head butting and chasing) within each species occurred frequently as males jockeyed for optimum feeding positions over the nest.

Neither of the 7.5 V spotlights without rheostats attracted fishes for over 5 min. As one spotlight was moved upstream toward the nest, the fishes, apparently startled by the illumination, retreated 2 m upstream to an undercut bank. After the majority of the *C. funduloides*, *P. oreas* and female *S. atromaculatus* had returned to the illuminated nest after 5

Table 2. Mean (\pm one standard deviation) and range (in parenthesis) of percent of number of unsuccessful and successful spawning clasps in *Semotilus atromaculatus* (video observation time, night = 39.5 min; day = 34.13 min).

Clasps	% number	
	Night	Day
	15.6 C \pm 0.4 (15.3 - 15.9)	16.4 C \pm 2.0 (15.0 - 17.8)
Unsuccessful	66.0 \pm 2.8 (64 - 68)	76.2 \pm 9 (67.8 - 85.7)
Successful	34.0 \pm 2.8 (32 - 36)	23.8 \pm 9 (14.3 - 32.1)

min, the breeding male *S. atromaculatus* returned and resumed reproductive activities.

With the halogen lamps using rheostats, all fishes continued their activities as illumination was increased to maximum output (i.e., the nest-building male *S. atromaculatus* continued to construct a pit/ridge nest and spawn with females, and *C. funduloides* and *P. oreas* continued to jockey for positions over the pit). Similarly, the fishes continued their activities when light intensities were decreased to zero, and when they were increased again to maximum intensity within 3 min.

The hydrophone did not pickup sound emanations from the fishes.

DISCUSSION

Species-specific behaviors are used as effective management tools in preserving habitats of species (McNeely et al., 1990). Videotaping fishes during the day or night permits analysis of species-specific behaviors that directly relate to their habitat requirements. We propose that non-intrusive light systems (e.g. infrared and image intensifiers, reviewed by Collins et al., 1991) are not required for making observations of certain species at night. Through our observations and reviews of videotapes, we did not perceive an alteration of the activities of fishes over a nest when light intensities were increased gradually with rheostats. The movement of a nest-building male *S. atromaculatus* from the rear of the pit to the upstream slope of the pit where he deposited stones progressed uninterrupted as illumination increased. Similarly, the sinuous swimming of individual *C. funduloides* continued without disruption when the first glow of light reflected from their bodies. *Phoxinus oreas* was not present on the nest at this time.

Instantaneous exposure of fishes to full illumination resulted in a startle response where fishes swam away from the nest. The response was like that produced by sudden

physical movements on the bank during the day. Fishes returned to nests as they accommodated to lights and continued their breeding activities.

Development of color and breeding tubercles are secondary sexual characteristics in male *S. atromaculatus* and other species in *Semotilus* during the spawning season (Lachner and Jenkins, 1971; Ross and Reed, 1978; Woolcott and Maurakis, 1988). It has been assumed that color display is related to visual recognition of males by females (Shute and Shute, 1991). While this may be true, the male *S. atromaculatus* we observed over nests at night, when color cannot be detected (Guthrie, 1986), were as brightly colored as males observed in daylight. Like Ross and Reed (1978), who reported male *Semotilus corporalis* intensified in color during combat, we have observed color intensification in male *S. atromaculatus* during agonistic encounters. Because color intensification in male *S. atromaculatus* has been related to combat behavior, and does not elicit a change in behavior of females in the species (Maurakis and Woolcott, 1992), we propose that color is not involved in attracting females of this species at night, although they may be attracted initially to the male during daylight.

According to Guthrie (1986) the visual system cannot serve as a color receptor in diurnal spawning species that spawn at night, as light lumens are below threshold levels for color detection. As nocturnal spawning behavior in *S. atromaculatus* was similar to that in day, sensory systems (e.g. olfactory, lateral line, and tactile), other than vision, probably are involved in communication among both diurnal and nocturnal breeding males and females.

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