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Physical factors determining spawning site selection in a Central American hole nester, *Cichlasoma nigrofasciatum*

Robert J. Lavery
Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7, Canada
Address for correspondence: Department of Biology, Queen's University, Kingston, Ontario K7L 3N6, Canada

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Synopsis

Most Central American cichlids spawn in caves. There has been considerable work documenting where cichlids lay their eggs, and how this may be beneficial to the offspring. However, it has yet to be determined which physical factors of a spawning site influence choice. This study examines the importance of light intensity, potential position of eggs, and number of entrances on spawning site selection in the convict cichlid, *Cichlasoma nigrofasciatum*. The results suggest that cave light intensity and entrance number determine spawning site selection in this species. Both factors are important in concealing the brood and offering it maximum protection from predators.

Introduction

All Central American cichlid fishes are biparental substrate brooders, and the majority of those studied spawn in naturally occurring caves or ones they excavate themselves (Barlow 1974). Females occupy the cave, providing direct care of eggs and embryos, while males patrol the periphery of the territory (Barlow 1974, McKaye 1977). Predation on the young can be extremely high and has been implicated as an important factor behind the necessity for biparental care (Barlow 1974). Concealment spawning (Wickler 1966) may also reduce predation on the young, especially at the egg and embryo stages. To be effective, the spawning site should probably have certain protective features. However, there has been little work done on the important physical factors determining spawning site selection by cichlids.

Weber & Weber (1971) found that convict cichlid, *Cichlasoma nigrofasciatum*, pairs preferred to spawn on the interior of a hollow artificial spawning site, but did not show a preference between the interior horizontal, vertical or diagonal surfaces of this site. Patterson (1985) found that convict cichlids preferred caves over stone habitats; furthermore, the cave habitat supported higher densities than the stone. In nature, the midas cichlid, *Cichlasoma citrinellum*, spawns preferentially on the ceiling of natural caves (Barlow 1976). McKaye (1977) found the size of the cave opening was positively correlated with the size of the cichlid species inhabiting the cave. These studies, however, have not examined which characteristics of a spawning site determine its choice. Therefore, this study was designed to determine whether light intensity, potential position of eggs, and the number of possible entrances are impor-

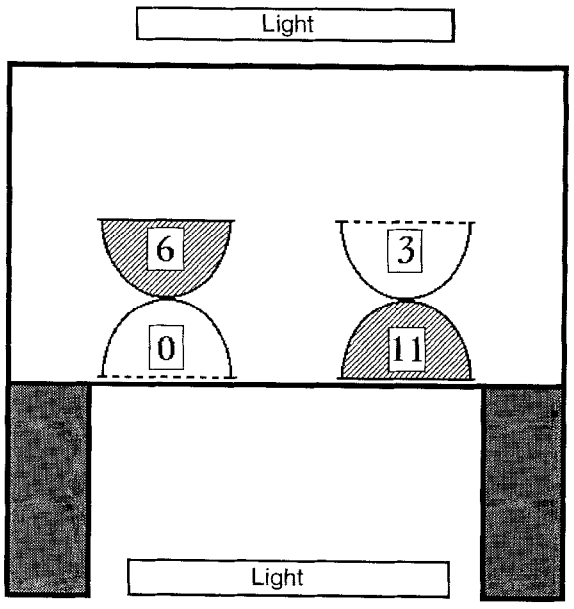

Fig. 1. Schematic diagram illustrating the tank set-up (front view) and results of experiment 1. Hatched areas represent dark sites; clear areas = illuminated sites; broken lines on spawning sites = transparent plastic; solid lines = opaque plastic. Boxed numbers represent the number of pairs that spawned on the clay pots in those sites.

tant factors in the selection of a spawning site by cave spawning convict cichlids. These factors are the most salient features defining a cave.

Methods

Experiment 1

I provided breeding pairs with four possible spawning sites. The design enabled light intensity (light or dark) and potential position of eggs (floor or ceiling) to be tested independently (Fig. 1). It has been hypothesized, mostly in the aquarium literature, that cichlids spawn on the ceiling or walls of caves to minimize the accumulation of detritus on the eggs. Moreover, because all natural caves are dark, cave spawners may be responding either to darkness or the confines of the cave; this design effectively separates these two confounding variables and allows the importance of light intensity to be tested independently of confinement. Choice of spawning site was determined by egg location.

Each 54 litre aquarium (60 × 30 × 30 cm high) contained 4 possible spawning sites consisting of two identical spawning platforms differing only in their orientation (Fig. 1). The platforms were made from the two halves of a 10 cm diameter clay pot, cemented to each other with silicone sealant. One open concave side was then covered with transparent plastic (light) while the other was covered with opaque plastic (dark). Convict cichlids will not spawn on this plastic. The opaque plastic shielded the interior of the pot from the light (above and below). Light was provided by fluorescent tubes, located 10 cm above and below the spawning sites, on a 12: 12 light-dark schedule. Light intensity measured from the centre of the pots averaged 50 lux for the dark sites, and 1000 lux for the illuminated sites. The fish and some light could still enter the interior from the original top of the pot. Nylon mesh cemented to the outer convex sides of the pots prevented the pairs from spawning there. The entire set-up was covered with opaque plastic, thus preventing room light from entering the aquarium. Gravel covered the bottom of the tank except where the spawning sites touched the bottom glass.

Twenty pairs were tested in the test aquaria. The mean ± SD weight and total length of males were 12.29 ± 2.73 g and 8.69 ± 0.64 cm, respectively, while females averaged 7.14 ± 1.13 g and 7.29 ± 0.39 cm. Spawning sites were checked daily for eggs. The fish were fed once daily on commercial dried food (Tropic Aquaria Ltd, stock no. A149).

Experiment 2

Pairs were offered a choice between caves with one or three entrances into the dark cavity. I hypothesized that cichlid pairs would prefer the cave with only a single entrance because it is easier to defend. Choice was determined by egg location. A clay flowerpot, measuring 12.5 cm in diameter, was placed upside down at each end of a 96 litre aquarium (92 × 35 × 30 cm high). One pot had one triangular entrance (5 × 5 × 5 cm) cut along the

rim while the other had three of these entrances evenly spaced about the rim. Measurable differences in light intensity between the two pots were minimized by embedding the pots in the gravel substrate, and by not covering a 2 cm circular hole in the top of the overturned pot. Light intensity measured from the interior centre of each site averaged 10 lux. Overhead fluorescent light was provided on a 12 : 12 light-dark cycle.

Twenty pairs were tested. The mean ± SD weight and total body length of males were 9.18 ± 2.91 g and 7.9 ± 0.71 cm, respectively, while females averaged 6.32 ± 1.51 g and 6.99 ± 0.55 cm. Two juvenile *C. nigrofasciatum*, 3–4 cm in total length, serving as target fish, were added to each aquarium. The pairs were checked daily, and fed on commercial dried food.

Results and discussion

Figure 1 shows convict cichlids preferred to spawn in the dark sites (Binomial test, $p = 0.0026$). There was no significant difference between the frequency of spawning on the floors and ceilings of these sites (Binomial test, $p = 0.8238$). The location of the egg patch within a given site appeared random.

The results of Experiment 2 show that 18 of the 20 pairs spawned in a single entrance cave as opposed to a cave with three entrances (Binomial test, $p = 0.0004$).

The results of experiment 1 suggest convict cichlids respond to reduced illumination (darkness) when selecting a site. There was no difference in the frequency of spawning on the floors and ceilings of these spawning sites. Likewise, Weber & Weber (1971) found that convict cichlids did not avoid spawning on the floors of their artificial site. Therefore, it seems unlikely cichlids spawn on the ceilings or sides or caves to avoid the accumulation of debris. The high incidence of spawning on the ceiling of caves in nature is probably reflective of the unsuitability of cave floors as spawning sites; floors are usually the soft bottoms of lakes and streams.

Experiment 2 suggests that convict cichlids also are influenced by the number of entrances to a cave when selecting a spawning site.

Both experiments suggest convict cichlids choose spawning sites that potentially offer their eggs and embryos maximal protection from predators. Dark cavities conceal the brood and make them less conspicuous to visual predators, while single entrances reduce the probability of intrusion and are probably more easily defended by females inside and males outside the cave.

The spawning site may be important for free-swimming young as well; Barlow (1976) has observed that *C. citrinellum* young feed near the entrance of the cave. If a potential predator approaches, one or both parents retreat into the cave, and signal to their young. The young respond by following the calling parents into the cave (Barlow 1976). Similarly, Patterson (1985) has noted that convict cichlid pairs often kept their embryos and young in the cave in high density pools. Spawning site characteristics may be important in these cave spawning cichlids, given that the threat of predation may be reduced, if pairs select favourable sites.

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