REPRODUCTIVE BEHAVIOR OF *CYCLORAMPHUS DUBIUS* MIRANDA-RIBEIRO (AMPHIBIA, ANURA, LEPTODACTYLIDAE)

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ABSTRACT. *Cycloramphus dubius* Miranda-Ribeiro, 1920 is a frog species from the coastal Atlantic Forest in Southeastern Brazil. It uses waterfalls of forested rivulets as breeding sites. The eggs are placed outside of water, between rock crevices or roots constantly wetted by water dripping. Clutches have about 60 eggs, and the tadpoles grow attached to rocks, out of water. Males of this species exhibit parental care, biting and/or pushing away strange objects approaching the egg masses. Two types of calls were identified in the spectrograms. The "advertisement calls" consist of juxtaposed pulses lasting 200ms; the "aggressive calls", also have the short pulses structure, and last around 300ms. The aggressive calls are emitted during territorial invasion.
KEY WORDS. Amphibia, Anura, Atlantic Forest, breeding site, territoriality, parental care

Species of the genus *Cycloramphus* Tschudi, 1838 are restricted to the coastal Atlantic Forest, Brazil (HEYER 1983). MIRANDA-RIBEIRO (1926) referred to direct development in two uncertainly determined species of *Cycloramphus*. LUTZ (1929) described the reproductive behavior of *Cycloramphus brasiliensis* Steindachner, 1864. Besides these ancient and brief studies many details of the reproductive traits of the species of the genus *Cycloramphus* remain unknown. Herein are described some reproductive characteristics, as paternal care and territorial behavior, of *Cycloramphus dubius* (Mir.-Rib., 1920).

AREA DESCRIPTION AND METHODS

A population of *Cycloramphus dubius* was studied on a small tributary of the Rio Quilombo, Santos municipality, São Paulo State, Brazil (23°47'S - 46°18'W), at different times from 1988 to 1991. The local is typical Atlantic Rain Forest (80m elevation, 3,400mm rain/year). The streams where the species lives have a sandy or granite rock bed. They undergo large and sudden alterations in volume by local rain events, but, under normal conditions, are about 20 cm in depth and 1.4 m wide. In the field, it was performed direct observation on calling and offspring guarding males. In order to study males aggressive behavior, some egg masses was touched with sticks and introduced foreign living individuals of

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the same species was introduced in previously occupied sites. Males also were tested in response to call playback. One clutch was collected and kept in a terrarium under laboratory observation. Vocalizations were recorded with a UHER 4000 IC set at 19cm/s, and spectrograms were made using a Sound Spectrograph series MD-700 from Voice Identification Inc.. A voucher specimen is housed at the Museu de História Natural, Universidade Estadual de Campinas (ZUEC 6690).

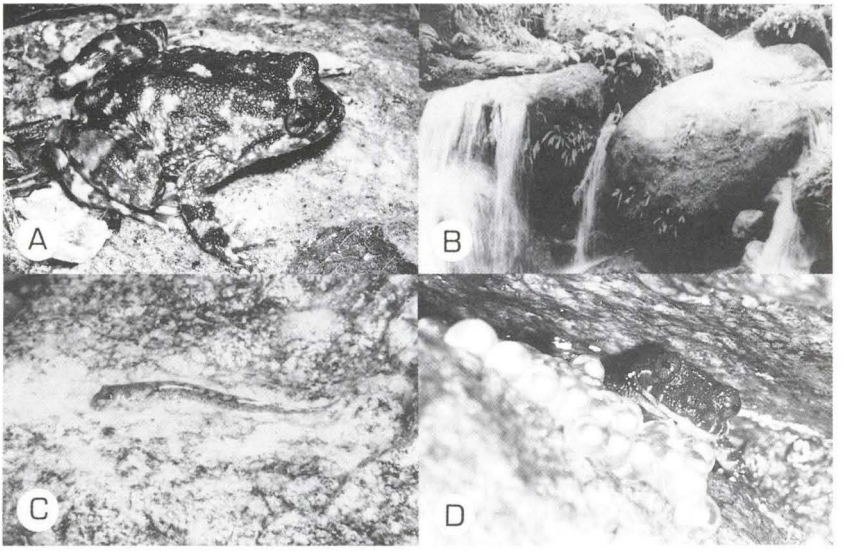

Fig. 1. Environment and life stages of *Cycloramphus dubius*; (A) adult male (ca. 48mm); (B) waterfall in the study site used by the species for reproductive activities; (C) tadpole on a wet rock surface (ca. 29mm); (D) clutch guarded by an adult male (photo by E. Ramirez).

RESULTS

Male *Cycloramphus dubius* (Fig. 1A) are about 46mm long and flattened dorso-ventrally. Small noisy waterfalls (Fig. 1B) are used by the species as breeding sites. Reproductive activity of the species occurs throughout the year, as indicated by the presence of calling males, clutches and tadpoles. Clutches (Fig. 1D) were found in narrow crevices of rocks and between roots. All 16 clutches found were outside of water, in places with constant water dripping or waterfall spray, but never in places subject to washing by water flow. Clutches contain 30 to 80 eggs ($\overline{X}=60.3$; $SD=22.7$; $N=4$). The eggs are deposited in a single layer, weakly adherent to the substrate and to one another. The yolk portion of the eggs is cream color and measures about 3mm in diameter, each egg having a transparent gelatinous-like capsule. The occurrence of gelatinous spheres without yolk (nurse eggs) and unfertilized eggs in the clutch is common. Embryos develop within the egg capsules until stage 25 (GOSNER 1960), when they reach about 19mm. The

tadpoles of *C. dubius* (Fig. 1C) were found out of water, feeding above wet rocks.

From the 16 clutches encountered, 15 had a male sitting by the side (Fig. 1D). The males remained with their eggs both day and night. In the field two tests was performed with males that were near their clutches: 1) a cloth tied to the end of a stick was hung over a clutch. The male, distant 10cm away, jumped on to the cloth, bit and pushed it away. About half the clutch was collected and the male was expelled. On the following day a male, probably the same one, was guarding the remaining eggs and, also at this time, responded aggressively, biting the cloth on the stick. 2) It was introduced, separately, males near a guarded clutch. One of the introduced males jumped in the direction of the clutch and the guardian reacted by emitting vocalizations (Fig. 2E) and engaged in a fight. When it was induced a foreign male to approach another resident male without eggs, the resident reacted by emitting calls (Fig. 2E), biting and pushing the intruder away. Adult males vocalize at night from rock crevices of the waterfalls, whereas diurnal vocalizations are rare. The advertisement calls (Fig. 2A-D) of *C. dubius* is emitted with an average rate of one call every 25 seconds. Each note consisted of juxtaposed pulses lasting about 200ms. During call emission, there is a discrete modulation of the highest frequencies. The first pulse has a frequency range between 1.2 and 3.1kHz; the last pulse has a lower frequency range between 1.5 and 2.3kHz. Although the call resembles a pure sound structure, it consists of pulses separated by very short time intervals. The intervals between the pulses are irregular (1.2 to 3.8ms), with marked variability in the lower note frequencies (Fig. 2A,C). The call emitted by a guardian when disturbed by the introduction of another male into its rock crevice was characterized by a multipulsed note with longer duration and wider bandwidth frequency (Fig. 2E), which was interpreted as an aggressive call. These vocalizations consist of calls given at a faster rate (around 1.2 seconds between the calls) than the advertisement call; the pattern of emission appears to be related to the degree of aggressiveness of the emitter. The duration of the aggressive call is around 300ms and the pulses are emitted in ascendant frequencies between 1.0 and 2.0kHz. In response to playback of the aggressive calls a guardian emitted longer notes, in a faster rhythm: around 400ms duration with about 700ms between notes (Fig. 2F).

DISCUSSION

Some reproductive characteristics described for *Cycloramphus brasiliensis* by LUTZ (1929) are similar to those of *Cycloramphus dubius*, including egg laying sites and clutch size. LUTZ (1972) briefly wrote about the genus *Cycloramphus*: "the large forms lay the spawn on the ledges of rocks and the male parent guards it". WELLS (1981) considered parental care behavior in frogs as uncommon and, in general, related to the terrestrialism of pre-metamorphic developmental phases, mainly in tropical regions. Terrestrial salamanders with parental care, generally, have large eggs, low fecundity and an enhanced embryonic period. Among them, behavior such as parental care could reduce the risk of embryo loss during the long embryonic period (NUSSBAUN & SCHULTZ 1989). These statements could also be

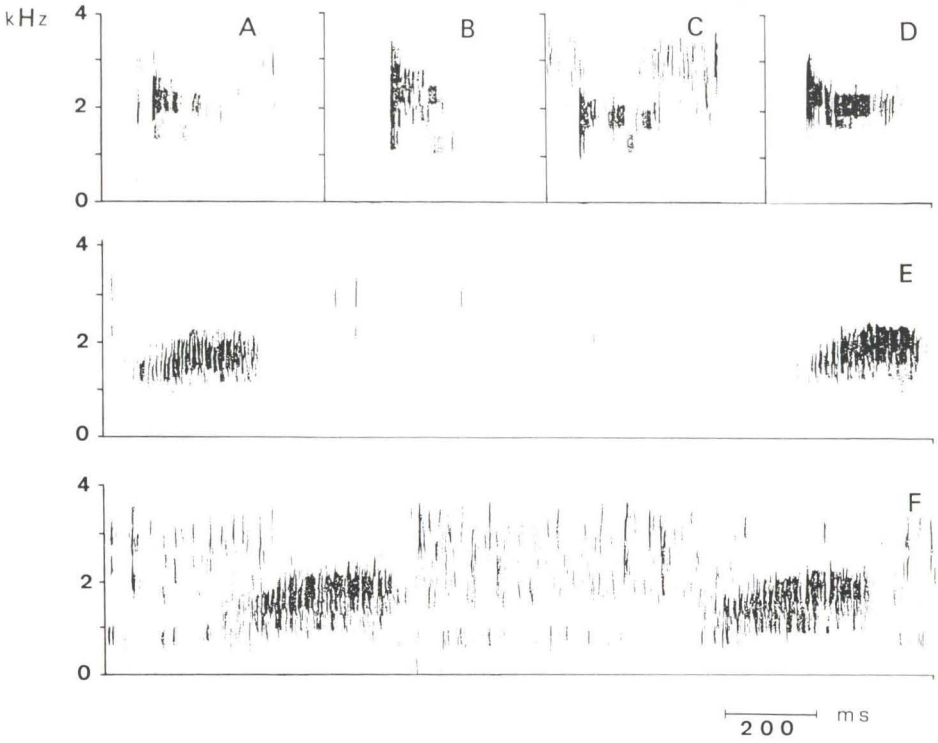

Fig. 2. Spectrograms of the vocalizations of *Cycloramphus dubius*. (A-D) Different physical structures of advertisement call found in the population; (E) aggressive calls emitted by a resident male in presence of another male; (F) aggressive calls emitted in response to playback of aggressive calls. The irregular marks of sounds up to 3.7kHz represent waterfall noise. Air temperature 19°C, water 17°C.

true for *C. dubius* as evidenced by the similarities in egg/clutch size and developmental characteristics. In *C. dubius*, as well as many species with paternal care, the males also exhibit territorial behavior (WILLIAMS 1975). A general characteristic of frog territorial behavior is the guarantee of access to limited resources (WELLS 1977). Suitable laying sites appear to be a limited resource for *C. dubius* because, in spite of the numerous crevices between rocks, the majority of them became inundated during rains or are outside of splash zones. The advertisement calls of *C. dubius* studied were similar to those described by HEYER & MELLO (1979), later considered by HEYER (1983) as *Cycloramphus boraceiencis*. The advertisement call is quite variable in some parameters. The aggressive calls are also variable and are influenced by the behavioral context, such as the presence of intruding males. ROSE & LEMON (1974) recognized space maintenance by the existence of distinctive types of vocalization exclusively emitted in eminent physical combats, which were suppressed after elimination of the neighbor calling male, as was found in *C. dubius*. Aggressive response to conspecific aggressive calls was demonstrated for *Hyla ebraccata* by WELLS & SCHWARTZ (1984); and for *Hyla minuta* by CARDOSO & HADDAD (1984), two

species whose males also show fighting behavior. Two characteristics appear to be common in these aggressive calls: the lengthening of call duration and the increasing rate of emission. This report is a first approach to describe the reproduction of *C. dubius*, additional field experiments are needed to explain the main function of paternal care in this species.

ACKNOWLEDGMENTS. W.W. Benson and W.R. Heyer provided comments on early drafts; E. Ramirez helped the field works; I. Sazima made the black and white pictures from slides; C.F.B. Haddad presented helpful comments. K. Facure helped in the project. FAPESP financially supported the study (Grant IC 89/2628-6 to AAG and AP 86/2455-6 to AJC) and the Smithsonian Institution (Short Term Visitor Program) permitted examination of the original records of *C. dubius* and *C. boraceiensis*.

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Recebido em 20.XI.1994; aceito em 25.VI.1995.