The ecology of parental care in a terrestrial breeding frog from New Guinea

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Summary. *Cophixalus parkeri* is a terrestrial breeding microhylid frog from the montane moss forests of northeastern New Guinea. The pattern of parental care in this species and its adaptive significance was studied in the field and in the laboratory. Egg brooding, is performed by the male in most cases, and much less frequently by the female. The parent remains with the clutch throughout the 85–100 day prehatching period. Egg removal experiments demonstrated that survivorship of embryos significantly decreased in the absence of the attending parent. Mortality of unattended embryos may be caused by a variety of factors, including fungal infection, egg cannibalism, predation by arthropods, and abnormal development.

Brooding adults can provide protection to their developing offspring via several possible mechanisms eg. aggressive defense of territories on which eggs are deposited, ingestion of potential arthropod predators, and egg turning (Fig. 2).

Several differences were found in the quality and quantity of food ingested by brooding versus non-brooding adults collected in the same locality during the same period. On average, brooding adults consumed less food and of lower quality than non-brooding adults (Table 1). These differences in diet were correlated with length of time parents had attended their eggs before they were examined (Fig. 3). The reduced food intake during egg brooding is reflected by significantly smaller fat bodies and less carcass fat in egg brooders relative to nonbrooding adults (Table 1). These results are discussed in terms of relative costs and benefits of parental care in this species.

Introduction

The parental association of adult anurans with their offspring is relatively uncommon. Only 10 to 15% of the 2,700+ species of frogs have been observed to exhibit parental care, but this behavior is widely distributed among the taxa, occurring in 70% of the families of frogs (McDiarmid 1978). Several recent papers have reviewed parental care patterns in anurans (Salthe and Mecham 1974; McDiarmid 1978; Lamotte and Lescure 1977; Ridley 1978; Wells 1981). With a few exceptions, e.g. Woodruff (1977), McDiarmid (1978), Kluge (1981), and Townsend (in press), the literature consists largely of descriptions of various associations of an adult with its offspring, with little documentation of advantages to the offspring.

Twelve New Guinea microhylid frogs have been reported in the literature (Tyler 1963; Zweifel and Tyler 1982) or observed by me to associate with eggs or hatchlings. Probably most if not all of the 70 other described and dozens of undescribed species also perform parental care (Tyler 1976).

*Cophixalus parkeri* a small microhylid frog from the montane areas of eastern New Guinea was chosen for a detailed study of parental care.

The objectives of this paper are to describe parental egg brooding in the New Guinea microhylid frog, *Cophixalus parkeri*, and to determine the adaptive significance of parental care in this species by answering the following questions: To what extent does this behavior affect the offspring’s survivorship? Which factors decrease the survivorship of the unattended offspring? How can the parent reduce the mortality of its offspring? What are the potential costs of parental care?

Materials and methods

**Study area**

The study area consisted of a gradually inclining 10 km segment of a montane cloud forest in the northeastern portion of Papua New Guinea (146°40' east, 7°10' south; elevation 2,400–2,850 m). Average annual rainfall (1974–1978) was 2,959 mm (range: 2,677–3,492). The mean minimum monthly...
temperature for the same period was 7 °C (range: 2.5-12 °C), and the mean maximum monthly temperature was 16 °C (range: 12.5-25.5 °C). In addition to C. parkeri, other anurans occurring in the general vicinity of my study area are 4-6 species of Hylidae and 8-12 species of described and undescribed species of Microhyliidae. For a more detailed description of floral and faunal characteristics of the general area, refer to Gressitt and Nadkarni (1978).

Field and laboratory observations

I found clutches of Cophixalus parkeri eggs in the field from November 1975 to October 1978 and recorded details of the microhabitat characteristics of the oviposition sites and the developmental stage of the eggs. In some cases I collected attending adults and their eggs or hatchlings. The specimens were killed with chloroform and fixed by abdominal injection of buffered 10% formalin solution and later preserved in 70% ethanol. Snout-vent lengths of preserved specimens were measured using a dial caliper. Sex was determined by internal examination of gonads. Stomachs were excised and contents examined under a binocular dissecting microscope. The size of food items, eggs, and gonads were measured using an ocular micrometer.

Field and laboratory experiments

Removal of brooding parent in the field. Forty clutches of Cophixalus parkeri were uncovered during a 6 day period in April 1978. In 20 clutches the attending parent was removed. The clutches were then covered with moss. Twenty other clutches, found in the same area were used as controls, and the parents were left with their eggs. The locations of both experimental and control clutches were marked. Both groups of clutches were reexamined 2, 6, and 10 weeks after initiation of the experiment. Determination of egg mortality was based on discoloration and decomposition of eggs and of egg capsules and, absence of movement or heartbeat of embryos. The presence of mold, arthropods, and other potential mortality agents also was noted.

Egg turning in the laboratory. Fifteen clutches of early stage embryos were collected in the field and transported to the laboratory. The eggs were kept near normal conditions of temperature (16 ± 3 °C). Each clutch was divided into two groups of equal numbers of eggs. Both experimental and control clutches were rinsed in sterilized distilled water and placed between two layers of sterile cotton gauze, soaked in sterile distilled water. The experimental clutches were turned manually with a small nylon spatula once a day for approximately 1 min. The control clutches were uncovered for 1 min, but not turned. Viability of eggs in both sets of clutches was monitored at 10 day intervals for 60 days.

Determination of feeding and nutritional state. Twenty-seven brooding and 37 non-brooding specimens were all collected during the same 6 week period in the same general locality and microhabitat (underneath the moss-leaf litter) at the same time of the day (1000-1600 h) and examined in the laboratory. The stage of embryonic development of the eggs in each nest was recorded at the time of collection. The 64 specimens were killed and injected abdominally with 10% formalin within 4 h of collection. Stomach contents were examined, and the total length of prey items was determined using an ocular micrometer. Plant and animal material were separated manually under a microscope dried, and weighed. The carcasses and abdominal fatbodies were excised, dried, and then weighed. The dried cases were placed in Soxhlet Extractors for 48 h. The carcass fats and ether-soluble fats were removed using anhydrous ethyl ether as a solvent.

Results

Life history and parental care patterns of Cophixalus parkeri

Cophixalus parkeri spends the daylight hours 10-30 cm underneath the moss-leaf litter layer on the forest floor. At night individuals climb to nearby perches on low growing vegetation. All individuals are highly philopatric and remain near the same perch site for most or all of their lives. Individuals actively defend perch sites against intrusion by conspecifics.

Female Cophixalus parkeri deposit an average of 18 large (3.0-4.0 mm), heavily yolked eggs in a depression within the moss layer or, less frequently, in decaying leaf litter. I have found eggs throughout the year, suggesting that breeding is seasonal. Development is direct; the eggs hatch as tailless miniature adults. Of 135 clutches observed in the field 132 had a single adult associated with eggs or hatchlings, and three of the 135 clutches were found without an attending adult. The adult invariably was found in contact with a tightly packed egg mass, usually lying directly on top of the eggs. Based on repeated observations of clutches throughout the developmental period it was evident that the parent remained close to its eggs during the 85-100 day prehatching period. In 86% of 72 clutches examined in detail, the male was the attending parent. Females were found with eggs in the remaining 14% of the clutches. Except during oviposition, the male and female were never observed with the same clutch of eggs. In those cases where I made repeated observations of the same clutch, I always observed the same parent tending the eggs. The froglets remained with the parents during the 30-40 day period of absorption of the abdominal yolk mass and then dispersed. I observed newly hatched froglets sitting on top of the attending adult C. parkeri (Fig. 1), but actual transport of the young was not observed.

Effects of egg brooding on survivorship of offspring

The results of parent removal field experiments clearly indicate that the presence of an adult enhances offspring survivorship. In only 3 of the 20 clutches in which the parents were removed did