

SHORT COMMUNICATION

Caviar in the rain forest: monkeys as frog-spawn predators in Taï National Park, Ivory Coast

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The high predation pressure in aquatic environments is generally assumed to be the ultimate cause of terrestrial breeding in anurans (Downie 1993, Magnusson & Hero 1991, Poynton 1964, Yorke 1983). It has evolved multiple times and is presently found in most anuran families (Bogart 1981, Duellman 1992). It is often associated with higher humidity and thus lower desiccation risk in tropical forests (Duellman & Trueb 1986). Most clutches that are oviposited terrestrially are either hidden in subterranean refuges or attached more or less exposed to vegetation (Duellman & Trueb 1986, Lamotte & Lescuré 1977). Exposed clutches however, face the risk of desiccation, even in rain-forest environments (Rödel pers. obs.) and are still vulnerable to predation. Such disparate groups as various arthropods (Villa 1977, 1980; Villa & Townsend 1983, Vonesh 2000), frogs (Crump 1974), snakes (Roberts 1994,

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Scott & Starrett 1974, Warkentin 1995) and birds (Brosset 1967), have been reported to feed on these clutches. The foam nests, which occur in at least six tropical anuran families, seem to provide better protection. Their drying surface and their more or less liquid interior offers the tadpoles an aquatic environment that is well protected against desiccation and predation (Duellman & Trueb 1986, Seymour & Loveridge 1994). In addition the bubbles of the foam facilitate oxygen diffusion within the nest and may even provide a capacious oxygen store for eggs and hatched tadpoles (Seymour & Loveridge 1994). Few predators have been reported to feed on foam nests, one of which, paradoxically, is a frog (Drewes & Altig 1996). In the Taï National Park, Ivory Coast, we discovered a quite unexpected group of predators preying on foam nests and frog clutches exposed on leaves: monkeys.

Our study area is in the Taï National Park (TNP, 5°08′–6°07′ N; 6°47′–7°25′ W), Ivory Coast. The TNP is the largest protected area of rain forest in West Africa. Our main investigation area is located about 23 km south-east of the small town of Taï and comprises an area of about 30 km² around the Station de Recherche en Ecologie Tropicale (SRET, 05°50.003′ N, 007°20.536′ W). The climate at the study site is characterized by a dry season lasting from December to February (less than 100 mm mo⁻¹) and heavy rainfall in September to October (around 300 mm mo⁻¹). The monthly rainfall during the rest of the year is around 150 mm, whereby July and August are relatively dry months. More detailed descriptions of the TNP are given by Guillaumet (1967) and Riezebos *et al.* (1994). In an area of about 3.5 km² 16 habituated monkey groups of seven different species were regularly observed by students and field assistants. Data on monkeys feeding on frog-spawn were taken *ad libitum* during our work on sooty mangabeys (Range, Seppänen) and frogs (Rödel). Whenever possible, we recorded the sex and age class of the monkeys that preyed on the frog-spawn as well as the habitat, the species and the number of the clutches that were preyed on. Data collection took place from April to November 2000.

Chiromantis rufescens (Günther 1868) is a member of the family Rhacophoridae. It lives in secondary and primary rain forests from Guinea to Uganda (Amiet 1975, Márquez *et al.* 2000, Schiøtz 1967, 1999). Reproduction takes place throughout the entire rainy season from March to November (Rödel pers. obs). The foam nests are attached to leaves, branches, tree trunks or rocks above ponds and puddles at heights varying from several cm to 20 m (Coe 1967, 1974; Rödel pers. obs.). Nests of average size measure 10–15 × 5 × 5 cm and contain about 100–200 eggs with a diameter of 2–3 mm (Amiet 1989, 1991; Lamotte & Vogeli 1956). After 5–8 d the tadpoles wriggle out of the foam or the foam dissolves in heavy rain and the tadpoles drop into the water (Amiet 1975, Lamotte & Perret 1963, Monayong Ako'o 1978, Rödel pers. obs.). *Hyperolius chlorosteus* (Boulenger 1915) and *H. sylvaticus ivorensis* Schiøtz, 1967 are members of the family Hyperoliidae. Both species are endemic to the Upper Guinea rain forest, West Africa (Schiøtz 1999). *Hyperolius chlorosteus* reproduces mainly

during the beginning of the rainy season and is strongly associated with running water. *Hyperolius sylvaticus* starts calling 1–2 mo after the onset of the rains and spawns discontinuously until November above smaller forest ponds and puddles. Both *Hyperolius* species deposit their eggs in a gelatinous mass on leaves above the water surface. After about 4–5 d the tadpoles drop in running (*H. chlorosteus*) or stagnant (*H. sylvaticus*) water (Rödel pers. obs.).

Sooty mangabeys, *Cercocebus torquatus atys* (Audebert 1797), are found in rain forests from Guinea to the Sassandra River, Ivory Coast (according to Kingdon (1997) this is a distinct species: *Cercocebus atys*). Sooty mangabeys are terrestrial and live in large groups of up to 100 individuals (Range 1998). They most often move and forage on the forest floor. Their home range covers up to 8 km² (Rutte 1998). Their known food consists mainly of fruit, seeds (68%) and invertebrates (26%) (Bergmüller 1998). Diana monkeys, *Cercopithecus diana diana* (Linné 1758) live in groups of 10–50 animals in the canopy of rain forests from Sierra Leone to Ivory Coast, West of the Sassandra River (Kingdon 1997). The diet of diana monkeys consists mainly of (ripe) fruit and small invertebrates (Wachter *et al.* 1997).

Sooty mangabeys mainly preyed on the clutches of *Chiromantis rufescens* (Table 1). A *Chiromantis* or *Hyperolius* clutch detected by one of the mangabeys was immediately pulled off from the supporting surface. The foam and eggs of *Chiromantis* were scooped out with the fingers. When all of the eggs had been eaten, the remaining foam was often spread on tree bark or leaves. *Hyperolius* eggs were sucked from the leaf or the whole leaf was eaten. Observations suggest that sooty mangabeys knew where to find frog-spawn. The monkeys checked the vegetation around ponds intensively at least on 25 and 26 September. On these days clutches of *H. sylvaticus* and *H. fusciventris* Peters, 1876 were present at almost all forest ponds in the area, e.g. at one pond nearly all leaves, located at heights from water surface to 2 m, were covered with *Hyperolius* spawn. The monkeys tried to get all of the clutches they could reach, even if they had to jump into the water in order to harvest clutches on plants growing in the pond. On June 5 all *Chiromantis* nests at one forest pond (n = 10) had disappeared after mangabeys had passed the site. Monkeys that were feeding on frog-spawn, and where sex determination was possible, predominantly proved to be adult females (Table 1). On 1 and 20 July we observed females

Table 1. Observations on monkeys feeding on frog clutches in Taï National Park, Ivory Coast. *= *H. fusciventris* were possibly involved as clutches of these two species could not be differentiated, standing a few metres apart; n = number of observations.

Frog	Monkey	Age and sex				n
		Males	Females	Juveniles	Unsexed	
<i>C. rufescens</i>	<i>C. torquatus</i>	0	6	0	>>8	13
<i>C. rufescens</i>	<i>C. diana</i>	0	0	0	> 2	1
<i>H. chlorosteus</i>	<i>C. torquatus</i>	0	1	0	1	2
<i>H. sylvaticus</i> *	<i>C. torquatus</i>	0	3	2	> 20	5

competing for frog's eggs. Mangabeys from three different groups were observed to feed on frog-spawn. Two were neighbouring groups (1 and 2), while the remaining group (3) was separated from the other two by at least 6 km. We once observed diana monkeys, *Cercopithecus diana diana*, feeding on *C. rufescens* foam nests (Table 1).

In the Amazonian lowland forest and in Cameroon about half of the known anuran species spawn terrestrially (Amiet 1989, Crump 1974, Duellman 1992). Terrestrial breeding is generally regarded as an adaptation to a high aquatic predation pressure (e.g. Amiet 1989, Crump 1974, Duellman & Trueb 1986, Hödl 1990). Foam nests allow continued development to a more advanced stage in a relatively protected environment (Dowie 1993). Foam nests are far from immune to predation, however: Yorke (1983) observed 34% mortality caused by fly larvae in 12 foam nests of an Asian racophorid, *Polypedates leucomystax*. For African racophorid foam nests, only a bird (Brosset 1967; cited in Amiet 1989, 1991) and a frog species (Drewes & Altig 1996) are reported as predators. Mortality rates have not been quantified by these authors.

To our knowledge this is the first known observation of monkeys feeding on frog-spawn. In the TNP, frog-spawn forms a regular part of the diet of sooty mangabeys. Feeding on frog-spawn was not noticed during a pilot study on the mangabey group number 1 (Bergmüller 1998, Rutte 1998). This is probably due to the poor habituation of the group at that time and the inconspicuous nature of the behaviour.

During the rainy season, sooty mangabeys face a period of food shortage. According to Bergmüller (1998), June to August represents a time when food is scarce. The breeding season of several frogs with arboreal clutches matches this period. This may make frog clutches, which are rich in protein (Duellman & Trueb 1986) and easy to harvest, even more attractive to the mangabeys. This hypothesis is supported by the fact that adult female sooty mangabeys competed for frog-spawn.

There are several reasons to believe that sooty mangabeys have a profound effect on the survival probability of early embryonic stages in *C. rufescens* and various *Hyperolius* species. Mangabeys have large groups (up to 100 individuals; Range 1998) and a median daily travel route of more than 2 km (Rutte 1998). The density of groups is in the order of one per 3 km² (data: Tai Monkey Project; inferred from home range size, home range overlap and abundance transects). Mangabeys in addition seem to prefer humid and even swampy parts of the forest for foraging and, whenever they discovered frog clutches, they preyed on them.

The quantitative impact of monkey predation on frog clutch survival, the number of monkey and frog species involved, as well as the energetic value of this food source for monkeys, remains to be determined by further research.

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