Communal egg-laying and nest-sites of the Goo-eater, *Sibynomorphus mikanii* (Colubridae, Dipsadinae) in southeastern Brazil

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FOR oviparous reptiles without parental behavior, female nest-site selection plays a significant role in the evolution of life histories (Resetarits, 1996; Shine, 2004). Nevertheless, nest-sites and oviposition modes of neotropical snakes are relatively unknown, mostly because mothers are so successful at hiding their eggs that nests are rarely found in nature. Additionally, much emphasis has been placed on life history components such as body size, number and size of offspring, and age at maturity (Stearns, 1992; Resetarits, 1996).

Snakes oviposit under rocks, logs, or any other surface cover, in preformed subterranean chambers (Packard & Packard, 1988) and within nests of other animals such as alligators (Hall & Meier, 1993), ants and termites (Riley *et al.,* 1985). With regard to oviposition modes, snakes oviposit both in solitary and communal nests (Vaz-Ferreira *et al.,* 1970; Graves & Duvall, 1995; Blouin-Demers *et al.,* 2004).

Communal oviposition is a widespread phenomenon and occurs when several females, conspecifics or not, share the same nest cavity to deposit their eggs (Graves & Duvall, 1995). Among neotropical species, reports of nest-sites and communal nests are scarce and are mostly related to colder climates (e.g. Vaz-Ferreira *et al.,* 1970; Cadle & Chuna, 1995). Recently, Albuquerque & Ferrarezzi (2004) reported one communal nest for the neotropical colubrid snake *Sibynomorphus mikanii* in an anthropized area in southeastern Brazil. Herein we describe another three nest-sites, nesting areas and oviposition modes of the goo-eater snake *S. mikanii* in southeastern Brazil.

S. mikanii is a dipsadine colubrid snake that feeds on slugs (Laporta-Ferreira *et al.,* 1986; Oliveira, 2001) and is distributed in Central, Atlantic and Meridional Brazilian uplands in cerrado and tropical forest areas (Franco, 1994). Females oviposit from September (early spring) to February (mid-summer) and clutch size varies from three to 10 eggs, averaging 5.9 eggs (Oliveira, 2001).

On 5th February 2007, 41 eggs and 11 empty shells (Fig. 1C) were found together inside a hole, 20 cm below ground surface, at the edge of a degraded wood inside Instituto Butantan (IBSP), São Paulo city, Brazil. The nest (hereafter nest #1) was situated 17 m away from the wood and 9 m away from the backyard of a house on a slightly steep slope (Fig. 1A). A small hole (50 mm diameter), at the side of the nest may have provided access for the snakes (Fig. 1B). Temperature at the same depth around the nest averaged 27.3°C (range = 27 - 28°C). Four empty shells contained fluids indicating recent hatchings whereas seven were completely desiccated. Two dead hatchlings were found near the nest (± 1 m away). Nest #2 and #3 were discovered by a farmer in two different spots, in a 5000 m² house backyard, in Vargem city, Brazil. Nest #2 was discovered under dry grass accumulated after ground weeding and contained nine eggs. Nest #3 was found 30 m away from nest #2 under a large rock (30 x 60 x 15 cm) and had a total of 12 eggs. Eggs were donated to IBSP on 1st March 2007,

some days after collection and by this time one egg had hatched. In the laboratory, we counted four fresh empty shells and 17 eggs (three dehydrated and one parasitized by fungi). In both backyards, dogs circulated freely over the nesting areas. After the donation of the eggs, the farmer found a dead hatchling of *S. mikanii* near nest #3. Eggs were measured, weighed (Table 1), and incubated in laboratory at 27 °C (temperature of nest #1). Fungal infection precluded eight eggs (19.5 %) from nest #1 and five eggs (45.5 %) from nest #2 and #3 from hatching. Eggs were dissected but we were unable to find or to identify the

embryos. One hatchling from nest #2 died half emerged from the eggshell. Thus, 33 successful hatchings from nest #1 occurred between 6th February and 16th April 2007, whereas from nest # 2 and #3 five occurred between 1st March and 31st May 2007. Hatchlings were measured, weighed, and sexed by eversion of hemipenis (Table 1). Based on mean clutch size of the species (5.9 eggs [Oliveira, 2001]), we inferred that nearly seven to nine different oviposition events may have occurred in nest #1 (six to 17), one to two in nest #2 (one to three), and two in nest #3 (two to four) in the current reproductive season. These
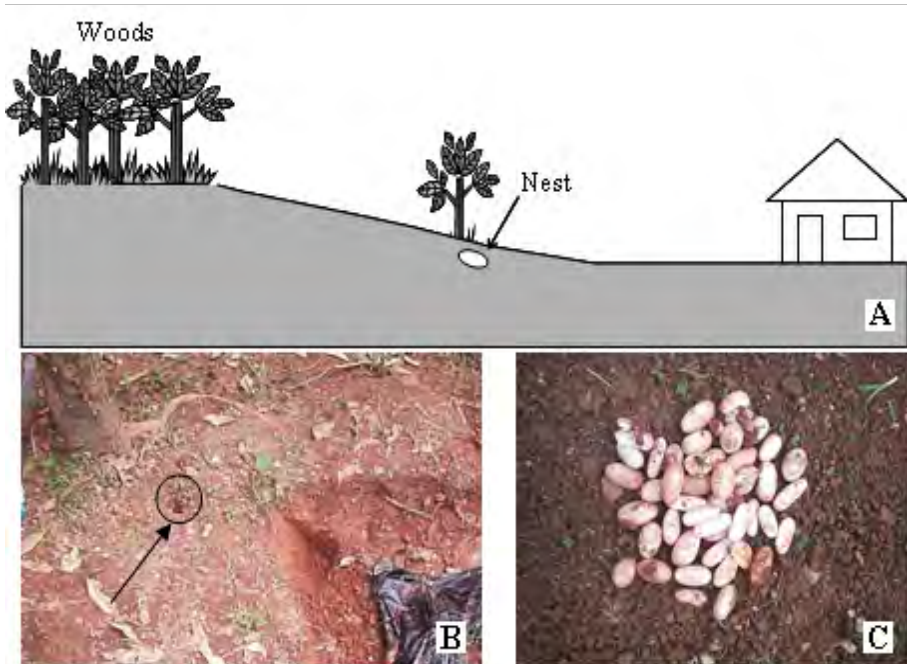

Figure 1. (A) Diagrammatic vertical section of the terrain surrounding nest #1; (B) view of the destroyed nest and its likely entrance; (C) Eggs of *Sibynomorphus mikanii* found within nest #1.

assumptions are strengthened if we take into consideration hatching dates (seven in nest #1 and three in nest #2 and #3). Although communal oviposition in nest #1 and #3 is evident, there is some doubt over nest #2 as it is quite possible that one single female laid the nine eggs.

Nest-sites and nesting areas are described for few species of neotropical snakes (e.g. Vaz-Ferreira *et al.,* 1970; Cadle & Chuna, 1995; Albuquerque & Ferrarezzi, 2004). Despite the fact that some snakes dig a hole in the soil to oviposit (e.g. Burger & Zappalorti, 1986), most species

apparently are unable to construct a nest and rely on pre-existing sites for oviposition (Packard & Packard, 1988). This seems to be the case for *S. mikanii* (Albuquerque & Ferrarezzi, 2004; this study). Although eggs of nest #1 were found inside a hole, it is unlikely that any female of *S. mikanii* actually excavated it because the soil was very compacted. Moreover, in the laboratory, gravid *S. mikanii* tend to hide the eggs under the water bowl or under rocks instead of burying them (H.B.P. Braz & S.M. Almeida-Santos, unpublished data). In addition, other dipsadine snakes also oviposit in

pre-existing sites (Brandão & Vanzolini, 1985; Riley *et al.,* 1985; Cadle & Chuna, 1995; Greene, 1997).

Thermal conditions are often suggested as a factor driving maternal choice of nest-site (Blouin-Demers *et al.,* 2004; Shine 2004) because incubation temperature affects offspring phenotypes (Deeming, 2004) and therefore may influence organismal fitness (Elphick & Shine, 1998; Brown & Shine, 2004). Females frequently oviposit in forest clearings (Fowler, 1966; Brodie *et al.,* 1969; Covacevich & Limpus, 1972; Burger & Zappalorti, 1986; Albuquerque & Ferrarezzi, 2004) and nests located in these areas generally are hotter than nests located in shaded areas because shading reduces insolation and heating of

the soil (Magnusson & Lima, 1984; Shine *et al.,* 2002). As well as nest #1, several nests have also been found in slopes (e.g. Brodie *et al.,* 1969; Covacevich & Limpus, 1972; Burger, 1976; Albuquerque & Ferrarezzi, 2004; James & Henderson 2004) and factors like direction and slope influence the absorption of solar radiation (Burger, 1976). Thus, mothers may have selected these sites in seeking to maximize sunlight exposure to accelerate embryonic development or optimize phenotypic traits of the resulting hatchlings. Therefore thermal conditions could also be a major factor influencing communal nesting behavior. Temperatures in communal nests are usually higher than in solitary ones (e.g. Blouin-Demers *et al.,* 2004) due to metabolic heat

Measurements	Nest #1	Nest #2 and #3
Eggs	n = *41*	*n* = 13
Length (mm)	27.9 ± 2.7	25.7 ± 3.0
Width (mm)	14.5 ± 2.0	12.6 ± 0.9
Mass (g)	3.5 ± 0.9	2.5 ± 0.4
Hatchlings	*n* = 33	*n* = 5
SVL (mm)	171.8 ± 13.5	170.0 ± 5.8
TL (mm)	34.0 ± 4.7	29.4 ± 2.6
Mass (g)	2.3 ± 0.4	2.0 ± 0.5
Sex (male/female)	19/14	2/3

Table 1. Measurements of eggs and hatchlings of three natural nests of the goo-eater snake *Sibynomorphus mikanii*. SVL = Snout-vent length; TL = Tail length.

generated by embryos (Burger, 1976; Ewert & Nelson, 2003). Therefore, communal nesting might be adaptive because higher temperatures in nests enhance hatchling phenotypes (Blouin-Demers *et al.,* 2004). However, studies on the thermal and hydric requirements of *S. mikanii* embryos would be needed to test these hypotheses. In parallel, egg aggregations also offer other potential advantages such as protection (Graves & Duvall, 1995; Jackson, 1998) and predator satiation (Eckrich & Owens, 1995; Graves & Duvall, 1995). If communal oviposition offers such advantages to hatchlings (e.g. phenotype improvement, predator satiation), why, then, would one female oviposit in a solitary nest as is likely to have occurred in nest #2? Blouin-Demers *et al.* (2004) suggested that the disadvantages of solitary nests may be compensated by lower risk of egg parasitism by

fungi. Additionally, in communal nests availability of water is less than in solitary nests (Marco *et al.,* 2004; Radder & Shine, 2007). This modifies hydric exchange between the eggs and the environment and the consequences to hatchling phenotypes may be more detrimental to aggregated eggs (Marco *et al.,* 2004). Thus it is reasonable to suggest that there are trade-offs between these two modes of egg-laying that result in similar fitness payoffs (Blouin-Demers *et al.,* 2004).

In summary, there are two (but nonexclusive) reasons for the occurrence of communal nesting behavior: scarcity of suitable nesting sites (e.g. optimum moisture and temperature; protection against predators) or adaptive behavior; that increases reproductive success due to aggregation in large clusters. Our findings plus literature data indicate a preference of gravid *S. mikanii* to nest

communally even when similar potential nest-sites were present in nesting areas. We suggest that such widespread behavior might result from adaptation. However, the adaptive significance of communal oviposition remains unknown.

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