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Habits of Five Brazilian Snakes with Coral-snake Pattern, Including a Summary of Defensive Tactics

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Habitat, activity period, food, predators, and defensive behavior are briefly described for five species of snakes with coral-snake pattern, sympatric in southeastern Brazil: *Micrurus frontalis, M. lemniscatus, Erythrolamprus aesculapii, Oxyrhopus guibei,* and *Simophis rhinostoma.* Defensive behaviors were analyzed by numerical methods in order to evaluate the degree of similarity between these species. The similarity between defensive displays is supposed to be due either to phylogenetic affinity or to mimetic convergence.

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Introduction

The long-standing problem of coral-snake mimicry was recently discussed by Greene and McDiarmid (1981) and Pough (1988). Aside from the controversy on the mimicry phenomenon itself (see Pough, 1988), discussion of this issue is frequently hindered by the lack of observations on the habits of the species involved (Bailey, 1966; Roze, 1982; Greene, 1988; Pough, 1988), as well as lack of information on snake behavior (act systems of Carpenter and Ferguson, 1977 or phenotypic survey of Greene, 1988).

This paper reports on general habits and presents a summary of defensive tactics of five species of snakes with coral-snake pattern, the elapids *Micrurus frontalis* and *M. lemniscatus*, and the colubrids *Erythrolamprus aesculapii, Oxyrhopus guibei*, and *Simophis rhinostoma* (for use of the name *O. guibei* instead of *O. trigeminus* see Zaher and Caramaschi, 1989). These snakes are sympatric in southeastern Brazil and were observed in the field at several localities in the States of São Paulo and Minas Gerais.

Material and Methods

We recorded general habitat, substrate, period of activity, size, and prey items, as well as information on predators. Additional prey items were recorded from preserved snakes from the same or nearby

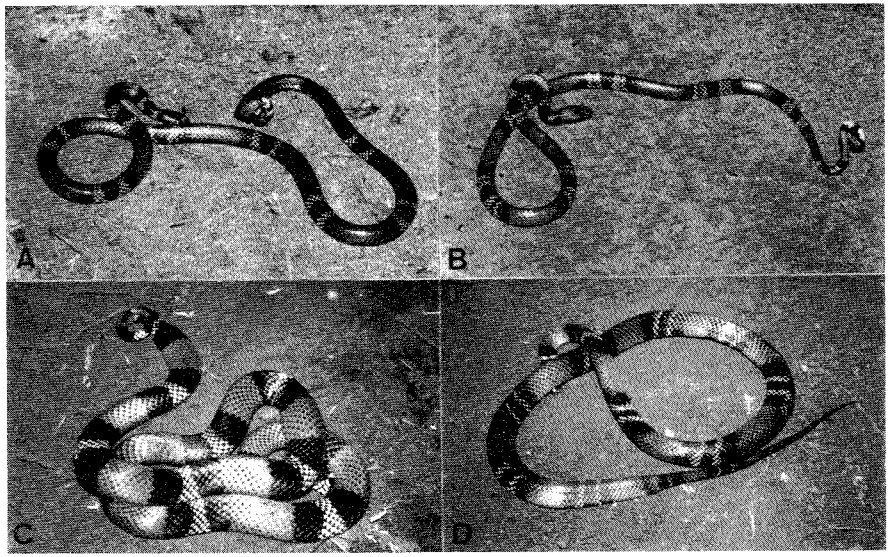

Fig. 1. Defensive behaviors of four species of snakes with coral-snake pattern, sympatric in southeastern Brazil. (A) Tail display and S-coil posture in a 72 cm SVL male *Micrurus frontalis*, and (B) a 62 cm SVL female *Simophis rhinostoma*. (C) Dorsoventral body compression, tail display, and hide head posture in a 78 cm SVL female *Erythrolamprus aesculapii*. (D) Dorsoventral body compression and hide head posture in a 51 cm SVL female *Oxyrhopus guibei*. (Defensive mechanisms after Greene, 1988). All snakes from the State of São Paulo, ZUEC voucher numbers: Mf (736), Sr (684), Ea (852), and Og (808).

localities. We elicited defensive behavior of the snakes both in the field and in captivity by approaching, poking and/or grabbing the snake, causing escalation of defensive tactics, e.g. from fleeing to biting (*Micrurus* bit leather gloves or sticks). The specimens shown in Fig. 1 were preserved as vouchers in the Museu de História Natural, Universidade Estadual de Campinas (ZUEC).

Categories of defensive behavior follow the phenotypic survey of antipredator mechanisms in Greene (1988). Phenotypic categories were coded as present or absent, and the similarity coefficient among the five snake species was calculated and grouped through UPGMA and cophenetic factor was calculated (Sneath and Sokal, 1973). This method allows for quantitative comparisons of defensive behaviors displayed by snakes (see examples of defense similarity in Greene, 1979 and Pough, 1988).

Results

We observed *Micrurus frontalis* (Fig. 1A) and *M. lemniscatus* on the ground in open formations, disturbed and cultivated areas, and forest edges, in Minas Gerais (Jaboticatubas) and São Paulo (Atibaia, Campinas, and Rio Claro). Both diurnal and nocturnal activity was recorded for both *M. frontalis* (n=4) and *M. lemniscatus* (n=3), mainly during the rainy season (November-February). Total lengths of observed individuals ranged from about 25 to 77 cm for *M. frontalis*, and 30 to 90 cm for *M. lemniscatus*. For three specimens of *M. frontalis* prey items were amphisbaenians, *Amphisbaena dubia*, *A. mertensi*, and *A. steindachneri* (one each);

for two *M. lemniscatus*, prey were *A. dubia* and a gymnotiform fish, *Gymnotus* sp. (one each). Remains of a. *M. lemniscatus* were found in the stomach content of a laughing falcon, *Herpetotheres cachinnans*, together with remains of an *Oxyrhopus* cf. *guibei* and an *Apostolepis assimilis*, from Rio Verde, Goiás.

Erythrolamprus aesculapii (Fig. 1C) was observed on the ground in small forest tracts, at forest edges, and in disturbed and cultivated areas in São Paulo (Campinas, Jundiaí, Valinhos, Mogi das Cruzes, and Rio Claro). We recorded only diurnal activity (n=10), throughout the year, most records (8) being made during the rainy season. Total lengths of observed individuals ranged from about 25 to 80 cm. Prey items for six specimens were colubrid snakes, *Oxyrhopus guibei* (n=2), *Liophis miliaris* (n=1), and *Liophis* sp. (n=3). Remains of an *E. aesculapii* were found under the roost of a roadside hawk, *Buteo magnirostris*, in Campinas.

Simophis rhinostoma (Fig. 1B) was observed on the ground in disturbed and cultivated areas, except for one snake seen at forest edge, in São Paulo (Campinas, Mogi das Cruzes, and Rio Claro), and Minas Gerals. We recorded only diurnal activity for this snake. Total lengths of observed individuals (n=9) ranged from about 25 to 78 cm. No prey items were recorded but two captive individuals ate small frogs and lizards.

Oxyrhopus guibei (Fig. 1D) was recorded on the ground in small forest tracts, at forest edges, open areas, and disturbed and cultivated areas throughout most of the year in São Paulo (Campinas, Jundiaí, and Rio Claro). We observed mostly nocturnal activity (n=14), but four snakes were seen moving by day, three of which were apparently basking on the ground in sun patches at the forest edge. Total lengths of observed individuals ranged from about 20 to 125 cm. Prey items of seven snakes were murid rodents, *Bolomys lasiurus* (n=2), *Calomys laucha, Mus musculus,* and *Rattus* sp., besides a nestling dove, *Leptotila* sp., and an iguanid lizard, *Tropidurus itambere* (one each). This snake was preyed on by the laughing falcon (n=1) and by *E. aesculapii* (n=2).

The defensive tactics of the five species of snakes with coral-snake pattern are summarized in Table 1, and the cluster analysis performed on the Ochiai similarity coefficients is shown in Fig. 2. Some components of the defensive repertory,

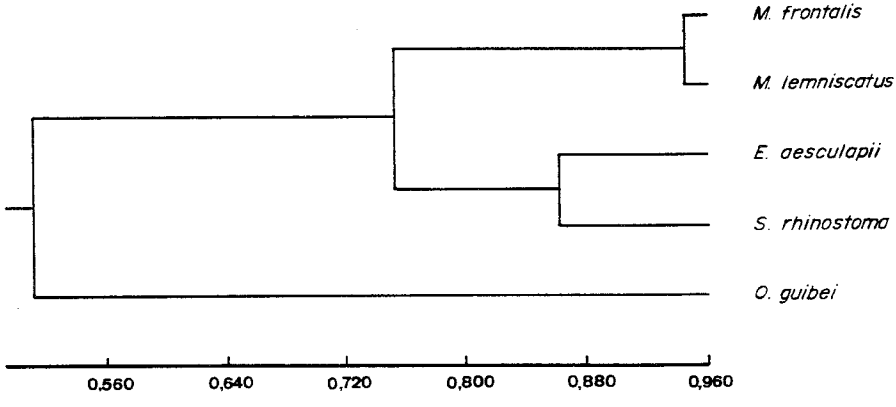

Fig. 2. Degree of similarity based on phenotypic categories in five sympatric species of snakes with coral-snake pattern, grouped through UPGMA.

Table 1. Summary of defensive tactics (as defined in the phenotypic survey of Greene, 1988) observed in five species of snakes with coral-snake pattern, sympatric in southeastern Brazil. Categories are arranged in the approximate order they may appear during the defensive escalation by the snake. Mf = *Micrurus frontalis*, Ml = *Micrurus lemniscatus*, Ea = *Erythrolamprus aesculapii*, Sr = *Simophis rhinostoma*, Og = *Oxyrhopus guibei*; + present, - not observed; number of studied individuals in brackets.

Defensive mechanisms	Snake species				
	Mf (5)	Ml (4)	Ea (6)	Sr (6)	Og (8)
Aposematic coloration	+	+	+	-	-
Concealing color (masquerade)	-	-	-	+	+
Immobility	+	+	+	+	+
Locomotor escape	+	+	+	+	+
Dorsoventral neck compression	-	-	+	-	-
Dorsoventral body compression	+	+	+	+	+
Inflate body	-	-	-	-	+
Tail display	+	+	+	+	-
Body thrash	+	+	+	+	+
Tail vibration	-	-	-	+	-
Coil body	+	+	+	+	+
Hide head	+	+	+	+	+
Elevate head and neck	-	-	+	+	-
S-coil	+	+	+	+	-
False strike	-	-	+	+	-
Strike	-	-	+	+	-
Bite	+	+	+	+	-
Evert hemipenis	+	-	-	-	-
Cloacal discharge	-	-	+	+	+
Constrict	-	-	-	-	+

including tail display in three species, are shown in Fig. 1. (There was considerable individual variation in the repertory of defensive tactics of a given species, as well as the order of their appearance; see also Greene, 1988 and Herzog and Schwartz, 1990).

Discussion

Our observations on the general habits of the five snake species with coral-snake pattern in southeastern Brazil mostly agree with published observations on the same or related species in other areas, such as northern and northeastern Brazil (Cunha and Nascimento, 1978; Vanzolini, 1986; Vanzolini et al., 1980; Vitt and Vangilder, 1983), Ecuador (Duellman, 1978), and Venezuela and Guiana (Beebe, 1946). Of interest is the record of a gymnotid eel as prey of *M. lemniscatus*; this fish was observed as prey of another coral snake, *M. surinamensis* in northern Brazil (Cunha and Nascimento, 1978), and both these snakes and two additional species of *Micrurus* also prey on another elongated fish, the swamp eel *Symbrancus marmoratus* (Beebe, 1946; Roze, 1982; Dixon and Soini, 1986; Vanzolini, 1986).

The dove nestling preyed on by *O. guibei* may indicate climbing ability for this snake.

The laughing falcon is regarded as a specialized predator feeding mainly on snakes (e.g. Schubart et al., 1965; Howell, 1957; Sick, 1985; Brugger, 1989) and finding three red snakes, two of them with coral-snake pattern, in one stomach is of interest to the coral mimicry issue (see Pough, 1988). However, the possibility of the falcon picking up already dead snakes should be considered (in Brazil, peasants hang killed snakes on fences or other visible places "for the hawks", pers. obs.). Crested caracaras, *Polyborus plancus,* are widely known in south-eastern Brazil for their habit of following after plowing tractors and picking up the unearthed and mutilated amphisbaenians and snakes, as well as other soil-inhabiting animals (pers. obs.). Therefore, the stomach contents of birds of prey in disturbed areas should be interpreted with caution in terms of the circumstances under which the prey was taken (a summary of bird predation on snakes with coral-snake pattern is found in Brugger, 1989).

The degree of similarity between species within a coral snake or another presumed mimetic assemblage may be assessed by the method here outlined. Using the act systems of Carpenter and Ferguson (1977) we obtained a figure very similar to our Fig. 2, notwithstanding the differences between the two sets of behavioral categories. The phenotypic survey of Greene (1988) has the advantage of being designed for antipredator mechanisms.

Some of the similarities between the five species with coral-snake pattern here studied probably are due to behavioral convergence (Greene, 1979, 1988; Pough, 1988) but other may represent phylogenetic affinities (this latter is the case for the two *Micrurus*, which differ by the apparent absence of hemipenis eversion in *M. lemniscatus*). Tail display occurs in three of the four genera, all of them terrestrial snakes (see Greene, 1979).

The apparently close similarity between defensive displays of *Erythrolamprus* and *Simophis*, the former in the Xenodontini (Dowling and Duellman, 1978; Myers, 1986) and the latter in the Colubrini (Cadle, 1984) probably is due to mimetic convergence (Mertens, 1956; Pough, 1988). On the other hand, *Oxyrhopus guibei* of the Pseudoboini is the behaviorally least fitted species to this presumed coral snake mimetic assemblage, notwithstanding its similar color pattern. We think that the defensive dissimilarity may be due to this latter snake's habits (a constricting, nocturnal snake) common to the Pseudoboini stock (see Bailey, 1966; Cadle, 1985; Jenner and Dowling, 1986) and perhaps to different adaptive responses to predator pressures.

The similarity here indicated between *Micrurus*, *Erythrolamprus*, and *Simophis*, including their activity within the same habitats, seems to support the hypothesis of mimicry among this snake assemblage (Mertens, 1956; Wickler, 1968; Pough, 1988).

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