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CAUDAL LURING IN TWO NEOTROPICAL PITVIPERS, *BOTHROPS JARARACA* AND *B. JARARACUSSU*.—The behavior known as caudal luring has been reported for several boid, viperid, and elapid snakes (Neill, 1960; Heatwole and Davison, 1976; Pough, 1988). Among species of the Neotropical viperid genus *Bothrops* (sensu stricto cf. Campbell and Lamar, 1989), caudal luring has been disputably reported for juvenile *B. atrox* (Heatwole and Davison, 1976). Caudal luring has also been reported for juvenile *Bothriechis lateralis* (as *Bothrops lateralis*) and *B. bicolor* (Murphy and Mitchell, 1984) and adult *Bothriopsis bilineata* (as *Bothrops bilineatus*) (Greene and Campbell, 1972).

I report here on caudal luring in juvenile *B. jararaca* and *B. jararacussu*, two related species from southeastern South America (Campbell and Lamar, 1989; O. Pesantes, pers. comm.). An account of the behavioral biology of *B. jararaca* is provided by Sazima (1989a, 1989b), but the natural history of *B. jararacussu* remains largely unreported (Amaral, 1977). The tail tip of juvenile *B. jararaca* is usually whitish to yellowish (Fig. 1A) or greyish to blackish (although some individuals have tail mottled and similar to the general body colors), and that of juvenile *B. jararacussu* is yellowish to light brown (see body colors in Campbell and Lamar, 1989). As the snake grows, the tail tip becomes suffused with darker color (Fig. 1B) and no longer stands out from the otherwise cryptic color pattern.

Materials and methods.—Field observations on *B. jararaca* were made during the rainy season (Oct.–Feb. 1988 and 1989), in the Atlantic forest at the localities of Serra do Japi and Ubatuba, São Paulo, southeastern Brazil. Six juvenile *B. jararaca* (248–320 mm SVL) observed in the laboratory came from these localities, and the Serra de Paranapiacaba and Campinas, also in São Paulo. Two juvenile *B. jararacussu* (265 and 325 mm SVL) also observed in the laboratory came from the localities of Iguape and Registro, also in the Atlantic forest in São Paulo.

Individuals of both species were maintained in 40 × 30 × 30 cm glass terraria, with leaf litter and plants from original sites. After acclimation (4–7 d), the snakes were tested for their ability to lure by offering small to medium-sized frogs (20–45 mm SVL) into the terraria (see Greene and Campbell, 1972, and Jackson and Martin, 1980 for methods). The potential prey were the hylids *Hyla minuta* and *Ololygon fuscovaria*, and the leptodactylid *Physalaemus cuvieri*, species sympatric with the pitvipers. Two *O. fuscovaria* and one *P. cuvieri* were found in the stomach contents of three juvenile *B. jararaca* (265–323 mm SVL) during a dietary study of this snake (I. Sazima and G. Puorto, pers. obs.). Each snake was tested from two to five times and three trials were photographed (two *B. jararaca* and one *B. jararacussu*). Observations were made usually from behind a screen in order to avoid disturbing the animals. Snakes were also observed in the absence of prey, and special attention was paid to the position and possible movements of their tails when visible within the coils.

Frogs and mice were also presented to larger

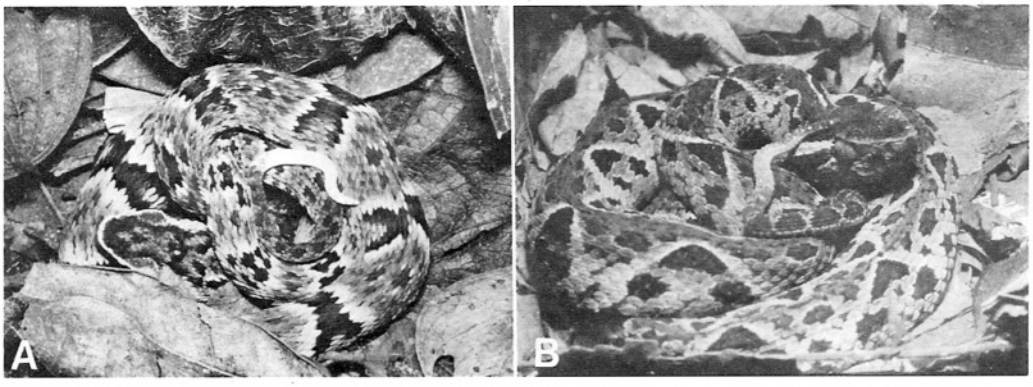

Fig. 1. Caudal luring in juvenile *Bothrops*. A) Female of *B. jararaca* (293 mm SVL), shortly after displaying caudal luring behavior; note light color of tail tip and its conspicuousness against the cryptic body color pattern of the snake (specimen ZUEC 862). B) Female *B. jararacussu* (325 mm SVL) performing caudal luring (specimen ZUEC 683).

specimens (394–592 mm SVL) of both *B. jararaca* (n = 7) and *B. jararacussu* (n = 2) from the same sites in order to test the assumption that larger snakes do not lure. This assumption was based on the observation that food items differ for juvenile and larger and adult *B. jararaca*, and that previous observations under field conditions did not reveal caudal luring by larger and adult snakes (Sazima, 1989b; pers. obs.). Voucher specimens are in the Museu de História Natural, Universidade Estadual de Campinas, São Paulo, Brasil (ZUEC).

Results and discussion.—Caudal luring behavior was displayed by all but one of the juvenile snakes when introduced prey moved around for a few minutes. Luring movements were performed by individuals with each of the three basic tail tip color morphs (whitish, blackish, and mottled brownish). Only coiled individuals displayed caudal luring (Fig. 1). Before luring, a snake orients its head towards a frog and rearranges its coils, if needed, so that its tail is exposed (Fig. 1B).

The caudal luring postures and movements of juvenile *B. jararaca* and those of *B. jararacussu* are similar, and include: 1) movements of the basal portion of the tail, cephalad along the anterior portion of the coiled body (Fig. 2A–B); 2) undulations, mostly horizontal, that progress along the tail tip (Fig. 1B); and 3) partial rotations around the longer axis of the tail tip (Fig. 2C–E). Movements 1 and 2 often occurred concomitantly and bore a remarkable similarity to an insect larva slowly crawling over the snake's body. Movements 2 and 3 occurred mainly when the snake maintained its tail tip close to its head (Fig. 1B). The Nearctic viperid *Sistrurus miliarius* (Jackson and Martin, 1980), and the Australasian elapid *Acanthophis antarcticus* (Carpenter et al., 1978) also display some of the caudal movements reported here. However, in neither species of *Bothrops* did I observe the erect tail posture described for *A. antarcticus* (Carpenter et al., 1978) and for the crotaline *Agkistrodon bilineatus* (Neill, 1960).

Caudal luring by juvenile *B. jararaca* was observed twice in the field during the early evening. I observed this behavior in a juvenile male (ca 300 mm TL) coiled on the ground at the edge of a pond near the forest (Campinas, 10 Nov. 1988, ca 1930 h). Célio F. B. Haddad (pers. comm.) observed a juvenile female (ca 50 mm TL) wriggling its tail while coiled among branches of a shrub, about 60 cm above ground, also at the edge of a pond near the forest (Serra do Japi, 14 Feb. 1989, ca 2100 h). In both instances there were treefrogs calling and moving close to the snakes (20–40 cm). The coiled postures and caudal movements of these juvenile snakes were similar to those described for laboratory tested individuals. Unfortunately, even the subdued light from our flashlights apparently disturbed the snakes and caused them to cease tail movements, precluding further observation.

I never observed caudal luring movements by juvenile *Bothrops* in the absence of potential prey. Larger or adult snakes of both species of *Bothrops* were never observed to display caudal

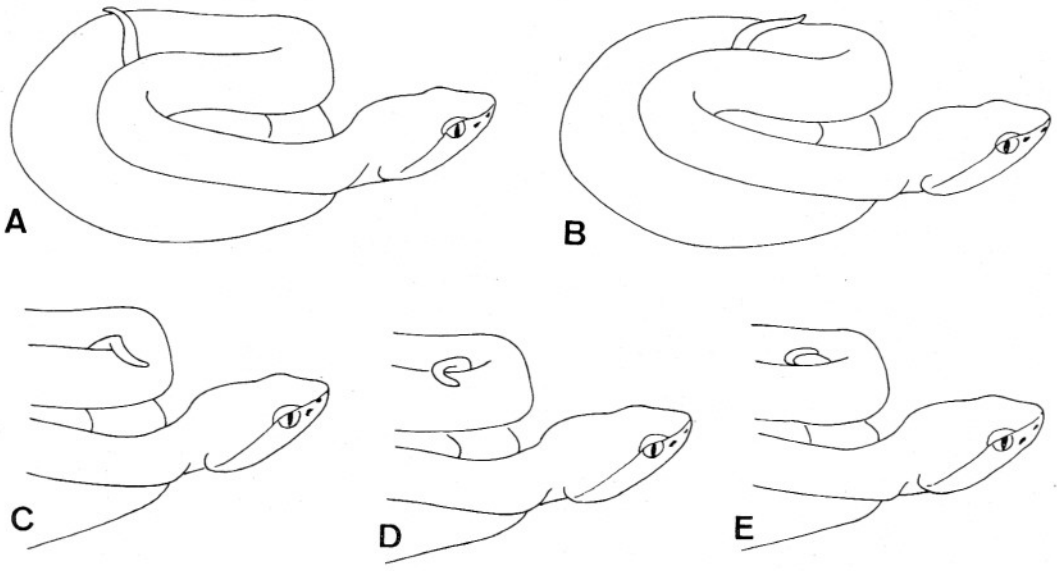

Fig. 2. Caudal luring in juvenile *Bothrops jararacussu*. A–B) Movements of the tail tip along body coil. C–E) Undulations along tail tip and partial rotations along long axis of tail tip (same specimen as in Fig. 1; drawn from photographs).

luring in presence of frog or rodent prey (Sazima, 1989b, pers. obs.). One juvenile *B. jararaca* (253 mm SVL) from Paranapiacaba did not wriggle its tail; instead, it waited for prey to approach before striking or actually pursued the prey. The behavior of this snake raises the possibility that caudal luring is variable among individuals (another Paranapiacaba snake did lure habitually), or populations. Fitch (1960) noted an apparent interpopulational variation of tail wriggling in young copperheads, *Agkistrodon contortrix*.

Successful luring, i.e., the frog approaching the tail tip and being seized by the snake, was observed twice for *B. jararaca* and once for *B. jararacussu*. The frogs were struck and invariably held between the jaws until immobilized and then swallowed head- or tailfirst. Fitch (1960) comments on this holding of frogs and lizard prey in contrast to releasing of rodents, by juvenile copperheads; Ananjeva and Orlov (1982) relate this difference in other viperids to the degree of potential harm a given prey type may pose to the snake (Klauber, 1972; Sazima, 1989b).

Venom properties of young *B. jararaca* differ from those of adult individuals in coagulant and fibrinolytic activities, as indicated by in vitro tests (Rosenfeld et al., 1959) and snakebite clinical features (Ribeiro and Jorge, 1989). These differences along with the caudal luring behavior may be related to feeding of juvenile *B. jararaca* on insect-eating ectothermic prey. In a preliminary study of stomach contents of 29 individuals of *B. jararaca*, frogs, as well as centipedes and a bird, were the major prey (75%) of juveniles (265–370 mm SVL, n = 14), whereas larger and adult snakes (652–1110 mm SVL, n = 15) preyed mostly on rodents (80%), as well as a lizard, a frog, and a bird (I. Sazima and G. Puorto, pers. obs.). The caudal luring by and the diet of juvenile *B. jararaca* are consistent with the suggestion that snake species which lure only as juveniles shift to other prey types as they grow (Greene and Campbell, 1972; Heatwole and Davison, 1976; see also Mackessy, 1988, for venom ontogeny and diet shift in *Crotalus viridis*).

Only lizard and frog prey are reported to elicit caudal luring by pitvipers (Neill, 1960; Greene and Campbell, 1972; but see Ananjeva and Orlov, 1982), but Laurie J. Vitt (pers. comm.) observed a *Bothrops atrox* in the field luring a cricetid rodent near Altamira, Pará, northern Brazil. His observation, aside from being an additional instance of caudal luring noticed in the field and a definite record of caudal luring by *B. atrox* (Heatwole and Davison, 1976),

indicate that caudal luring by crotaline snakes is used on a wider array of prey than previously reported.

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Literature Cited

Amaral, A. 1977. Serpentes do Brasil: Iconografia colorida. Instituto Nacional do Livro and Editora Universidade de São Paulo, São Paulo, Brasil.

Anonjeva, N. B., and N. L. Orlov. 1982. Feeding behaviour of snakes. Vertebr. Hung. 21:25–31.

Campbell, J. A., and W. W. Lamar. 1989. The venomous reptiles of Latin America. Cornell University Press, Ithaca, New York.

Carpenter, C. C., J. B. Murphy and G. C. Carpenter. 1978. Tail luring in the death adder, *Acanthophis antarcticus* (Reptilia, Serpentes, Elapidae). J. Herpetol. 12:574–577.

Fitch, H. S. 1960. Autecology of the copperhead. Univ. Kansas Publ. Mus. Nat. Hist. 13:85–288.

Greene, H. W., and J. A. Campbell. 1972. Notes on the use of caudal lures by arboreal green pit vipers. Herpetologica 28:32–34.

Heatwole, H., and E. Davison. 1976. A review of caudal luring in snakes with notes on its occurrence in the Saharan sand viper, *Cerastes vipera*. *Ibid.* 32: 332–336.

Jackson, J. F., and D. L. Martin. 1980. Caudal luring in the dusky pygmy rattlesnake, *Sistrurus miliarius barbouri*. Copeia 1980:926–927.

Klauber, L. M. 1972. Rattlesnakes, their habits, life histories, and influence on mankind. 2nd ed. University of California Press, Berkeley, California.

Mackessy, S. P. 1988. Venom ontogeny in the Pacific rattlesnakes *Crotalus viridis helleri* and *C. v. oreganus*. Copeia 1988:92–101.

Murphy, J. B., and L. A. Mitchell. 1984. Miscellaneous notes on the reproductive biology of reptiles. 6. Thirteen varieties of the genus *Bothrops* (Serpentes, Crotalidae). Acta Zool. Pathol. Antverp. 78:199–214.

Neill, W. T. 1960. The caudal lure of various juvenile snakes. Quart. J. Florida Acad. Sci. 23:173–200.

Pough, F. H. 1988. Mimicry of vertebrates: are the rules different? Amer. Nat. 131 (suppl.):67–102.

Ribeiro, L. A., and M. T. Jorge. 1989. Alteração do tempo de coagulação sanguínea em pacientes picados por *Bothrops jararaca* adulta e filhote. Revta. Hosp. Clín. Fac. Med. S. Paulo 44:143–145.

Rosenfeld, G., O. G. Hampe and E. M. A. Kelen. 1959. Coagulant and fibrinolytic activity of animal venoms: determination of coagulant and fibrinolytic index of different species. Mem. Inst. Butantan 29:143–163.

Sazima, I. 1989a [1988]. Um estudo de biologia comportamental da jararaca, *Bothrops jararaca*, com uso de marcas naturais. Mem. Inst. Butantan 50:83–99.

———. 1989b. Comportamento alimentar da jararaca, *Bothrops jararaca*: encontros provocados na natureza. Ciência e Cultura 41:500–505.

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