Male-male ritual combat in the colubrid snake *Chironius bicarinatus* from the Atlantic Forest, southeastern Brazil

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The reproductive behavior in snakes comprises courtship, mating and in some species includes male ritual combats (Carpenter, 1977). A ritual combat involves interaction sequences between two male snakes, which appear to be a contest for superiority or dominance (Carpenter, 1977, 1984). The general features of ritual combats include body contact during some phases of the contest, the opponents exerting pressure by pushing, topping or entwining, which appear to be attempts to physically subdue the opponent (Carpenter, 1977). This behavior generally occurs during reproductive periods and is mainly related to mating (Capula and Luiselli, 1997; Schuett, 1997; Schuett et al., 2001). The ritual combat is widespread among snakes and has been recorded in Boidae, Colubridae, Elapidae, and Viperidae (Shine, 1978, 1994). Most of the records on ritual combats are for snake species from North America, Europe and Australia, records for neotropical snakes being scarce (Shine, 1994; Capula and Luiselli, 1997; Almeida-Santos et al., 1998, 1999).

Here we described the male-male combat in *Chironius bicarinatus*, a common colubrid snake from Atlantic forest in southeastern Brazil (Dixon et al., 1993; Marques et al., 2001). This large snake (about 1800 mm) is diurnal, semi-arboreal and feeds on frogs (Dixon et al., 1993; Sazima and Haddad, 1992; Marques et al., 2001). The description was based on a sequence of 14 photographs of two males of *C. bicarinatus* taken by Ivan T. Intelizano

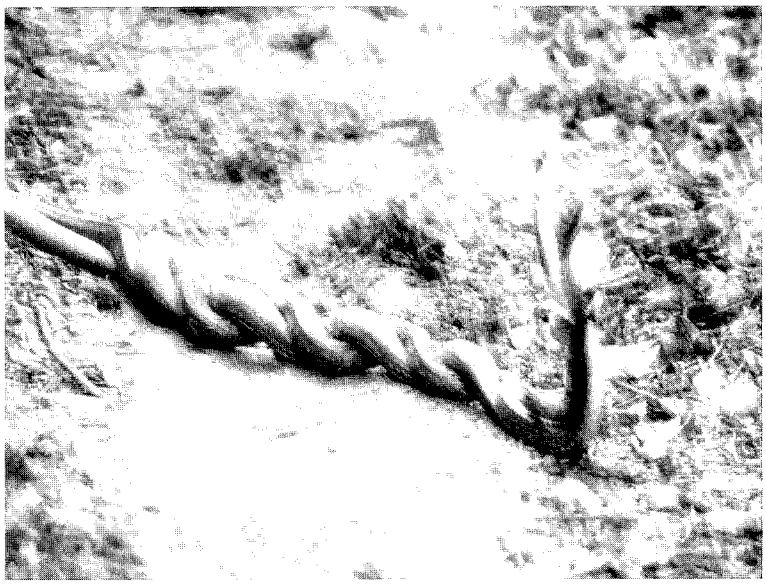

Figure 1. Record of ritual combat in *Chironius bicarinatus* (photo by Ivan T. Intelizano).

in the field (fig. 1). The two males (total length >1.5 m) were found on November 2000, during the afternoon, on a track crossing a stretch of Atlantic forest of the Serra do Mar at Tapirai, São Paulo (23°57′S, 47°29′W), southeastern Brazil. We selected eight of these photographs to illustrate the main features of the ritual combat.

The two males were already engaged in the combat when found. Their bodies were partially entwined and the anterior portion of their trunks was upright (fig. 2A). The subsequent stages of the combat sequence show both males with their anterior body intertwined and turning, and the extent of the interlacing of their bodies varying from time to time (fig. 2B-H). Each male attempted to obtain a position higher than its opponent by displaying its head and anterior trunk as high as it could. The male which dominated the combat maintained its head higher than that of its opponent. While swaying back and forth the dominant attempted to push the anterior trunk of its opponent down (topping behavior, see fig. 2E, H). The other male ("subordinate") behaved similarly towards its opponent (fig. 2 A, B, C, F, G). At the end of the observation the males were horizontally aligned with their bodies tightly intertwined, but their anterior trunks were still upright (fig. 1). Throughout all combat stages both males remained with the anterior portion of their trunks upright and their head momentarily tilted backward (fig. 1 and 2F, G). When the snakes failed to maintain the upright position and tumbled, they quickly returned to the upright position and the whole sequence was repeated. No bites were recorded during the combat, which was highly ritualized.

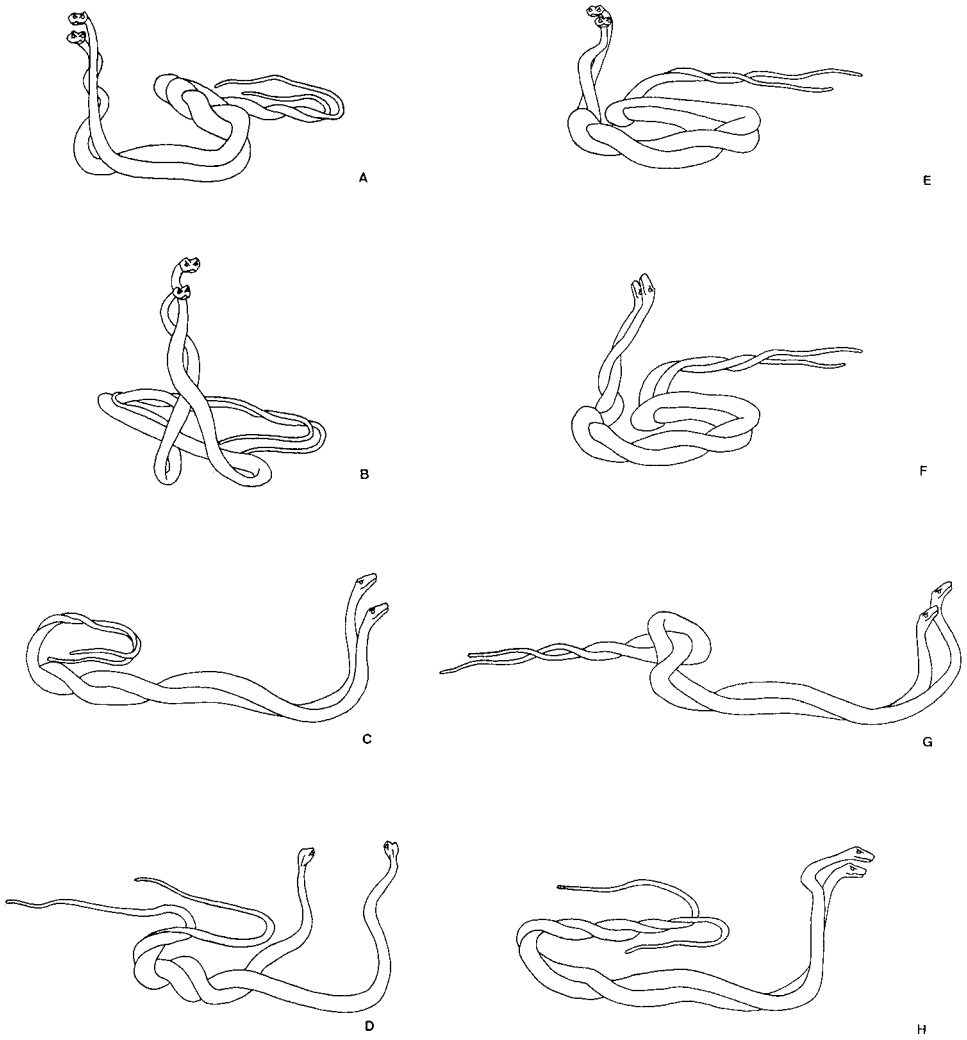

Figure 2. *Chironius bicarinatus* adult males displaying postures adopted during ritual combat. The dominant male always keeps its head higher than that of its opponent and their bodies are always entwining (loosely or tightly). A, B, C, F, G — dominant male rises with subordinate male following; E, H — topping attempt; D — tumble and recovery begin (drawn from photographs).

The observation lasted 30 minutes. While engaged in the combat, the two snakes shifted their postures from time to time but usually confined the combat activity to a limited area. As inferred from the photographs, the snakes were approximately the same size. No female or other snakes were recorded in the vicinity of the two *C. bicarinatus* males during the ritual combat, but with his attention centered on combat, any other snake might be overlooked by the observer.

Chironius bicarinatus has a seasonal reproductive cycle, with vitellogenesis occurring at the onset of the rainy season (October to December) (Marques, 1998). The male-male combat here recorded in November coincides with the reproductive period of this species. The same occurs with *C. carinatus* as the male-male combat in this species was recorded in March (Starace, 1998), when females were found in reproductive stage with vitellogenic follicles (cf. Dixon et al., 1993). Thus, male-male combat in both *Chironius* species is likely related to mating. Male-male combat recorded for *Chironius carinatus* from Amazonia, is illustrated in Starace (1998). The illustration shows that ritual combat in *C. carinatus* is similar to the one described here.

The males of both *C. bicarinatus* and *C. carinatus* attain larger body size than females (Dixon et al., 1993). In smaller species of *Chironius*, such as *C. flavolineatus* and *C. quadricarinatus*, females seem to attain larger size than males (Dixon et al., 1993). In *C. flavolineatus* a complex courtship involving six males and one female was recorded in the field (Feio et al., 1999), in which a male would pull another male in direct contact with the female. In this latter case, there was a dispute but not a ritual combat as that recorded for *C. bicarinatus* and *C. carinatus*. Male-male combat is widespread among snakes, and its phylogenetic distribution suggests that this trait has evolved (and/or been lost) several times within snake phylogeny (Shine, 1994; Schuett et al., 2001). This variation may be found within the genus *Bothrops* for example, in which only a few species seem to display male-male combat (Almeida-Santos and Salomão, 2002) and probably within the genus *Micrurus* as well (Marques, 2002; pers. obs.). Perhaps a similar situation occurs within the genus *Chironius*, in which the males of most species attain larger sizes than females and are likely to display male-male combat.

Four distinct patterns are recognized in male-male combats based on the postures adopted by the combatants (Bogert and Roth, 1966; Carpenter and Ferguson, 1977). Type 1 includes most of the colubrids that display with their tails and posterior portions of their bodies entwined and their heads and necks raised slightly above ground. Other families of snakes exhibit types 2, 3 or 4 and show distinct postural pattern as follows: in type 2 the combatants elevate the head horizontally above ground, in type 3 the males raise and intertwine of their anterior trunk and tilt the snout upwards or oriented vertically and posterior portions of trunk may be free or loosely, and in the type 4 the males exhibit high vertical stance of the head and intermittently loosely intertwined the anterior trunks (see Bogert and Roth, 1966; Carpenter and Ferguson, 1977). Colubrids rarely elevate their heads much above the ground, but one exception may be *Elaphe longissima* (Bogert and Roth, 1966; Capula and Luiselli, 1997). The combat in *Chironius* differs from those recorded for most other colubrids (and is similar to that of *Elaphe longissima*), because the males raise their anterior trunks and hold their head tilted backwards momentarily. A posture in which the anterior trunk is upright and the head tilted backwards is typical for viperines as well as for some elapids (*Dendroaspis*, *Ophiophagus*). Additionally, the vertical stance during topping behavior recorded for *Chironius* is typical for viperids (Bogert and Roth, 1966; Carpenter and Ferguson, 1977). However, the general posture

observed in *Chironius* (with tightly intertwining the posterior portion of the body) differs from these venomous snakes (see Carpenter and Ferguson, 1977). We conclude that the postures adopted by *Chironius* males do not fit into any of the four postural patterns of ritual combat described by Bogert and Roth (1966) and Carpenter and Ferguson (1977). The Colubridae probably are a polyphyletic group (Heise et al., 1995; Kraus and Brown, 1998) in which case it is unlikely that all species would fit into similar postural patterns. A better assessment of the variation and evolution of male-male combat in colubrid lineages must await a better resolution of colubrid phylogenetic relationships.

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