THE AGONISTIC BEHAVIOUR OF BOSC'S MONITOR (*VARANUS EXANTHEMATICUS* BOSC, 1792) IN CAPTIVITY

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ABSTRACT

This paper summarizes the aggressive interactions observed between Bosc's Monitors (*Varanus exanthematicus*) over a two year period. A synopsis of male-male and male-female combat and the resource over which the conflict took place is given. In male-male combat, the winner of the agonistic bout was usually the larger of the two males; the subdominant male was subsequently excluded from feeding and basking sites. Male-female combat occurred only when the female resisted a breeding attempt initiated by the male.

Our observations document the first recorded instance of female-female combat. The aggressive encounter between females occurred over access to a basking site. In contrast to male-male combat, size did not determine the winner of the female-female bout; rather residency was the most important factor. Although bipedal, or clinch, phase has been observed in all other large monitors for which combat has been described, this phase did not occur in any interactions between the Bosc's Monitors. This lack of a clinch phase may be attributable either to morphological constraints (high snout-vent length:tail length ratio) or to captive conditions.

SINCE the early 1900's, varanid combat behaviour has been the focus of many anecdotal and descriptive reports (e.g. Sterling, 1912; Lederer, 1929; Ali, 1944). Only recently have more quantitative approaches been applied to the study of varanid fighting behaviour (Auffenberg, 1981, 1988, 1994; Daltry, 1991). The agonisitc behavior and combat rituals have been examined in a large number of varanid species (see Horn et al., 1994 for a review) and have been shown to occur frequently between males (e.g. Davis et al., 1986; Tsellarius & Tsellarius, 1997). However, female-female agonistic bouts have rarely been described and have only been observed in captive specimens (Auffenberg, 1981; Delean, 1981; Daltry, 1991).

Adult male varanids are often larger than females (Auffenberg, 1988). An observer can readily determine the sex of the combatants when two large males are fighting; however, in a fight between two smaller individuals, the combatants could be a small male and a female, two females, or two small males (e.g. Ali, 1944). Hence, for most monitor species, it would be extremely difficult to recognize female-female combat in the wild. It is perhaps not surprising, then, that female-female combat has only been observed in captivity where the sex of the participants is known.

This paper describes intraspecific combat behaviour in captive Bosc's Monitors, *V. exanthematicus*, a species that has been little studied in this respect (but see Bayless, 1994), and serves as the first documentation of female-female combat in this species. An extensive description of the combat events is given only for the conflict between females. The observations made herein will be discussed in a behavioural ecological context.

METHODS

Two male and two female *V. exanthematicus* were observed from November 1994 to April 1996. All four Bosc's Monitors were housed separately, except for periods during which one individual was introduced into another's cage. Female A was housed in an 1.8m x 0.46m x 0.5m aquarium and Female B in a wooden enclosure measuring 1.25m x 0.62m x 0.61m. Male SE was housed in a wooden enclosure measuring 2.45m x 1.22m x 1.22m and Male AS in an enclosure of identical measurements as Male SE. The substrate in each of the enclosures was a sand-gravel mixture. Table 1 provides the snout-vent length (SVL), tail length (TL), and weight for the four individuals.

In the summer months, the Bosc's Monitors were kept in isolation at temperatures between 18° and 21°C. Artificial light was provided, and the monitors fasted during this period. For the remainder of the year, when the introduction trials were conducted, the Bosc's Monitors were kept at an ambient temperature of 27° to 29°C with the basking spots reaching temperatures of 32° to 38°C during the light hours. During the dark hours, the ambient low was approximately 21°C. Throughout this period, the light:dark cycle remained at 12L:12D. The staple foods for the monitors were assorted rodents, chicks, earthworms, aquatic snails, hissing cockroaches and giant mealworms.

OBSERVATIONS AND DISCUSSION

Male-male combat: When one male was introduced to the other's cage, combat occurred in a variety of different circumstances: for access to a territory, food, or basking spot. The larger male, Male SE, emerged as the dominant after every contest with Male AS regardless of the resource over which the fight took place. Hence, it seems that size may play an integral role in determining the outcome of a contest between two Bosc's Monitors, as it does in other species of varanids (Murphy & Mitchell, 1974; Daltry, 1991; McCoid & Hensley, 1991). Indeed, size differences between combatants have been used extensively in behavioural ecological studies to predict the winner of contests.

Parker (1974) suggested that size may be a direct measure of an individual's resource holding power (RHP), with larger individuals having a higher RHP in comparison to smaller conspecifics if all else (e.g. resource value, prior experience) is equal. Generally, in a contest where size serves as the only asymmetry between combatants and where the individuals engaged in the fight are able to assess one another's RHP, the larger individual becomes the dominant while the smaller assumes the subordinate role (e.g. Tokarz, 1985 *Anolis sagrei*). Male-male combat in *V. exanthematicus* offers yet another situation in which this pattern seems to holds true.

The contests between male Bosc's Monitors had detrimental effects upon the subordinate, Male AS, who subsequently fed and basked significantly less frequently than did Male SE (Attum, unpublished data), and lost weight. A similar dominant-subordinate relationship was found in captive *V. bengalensis*, where the socially dominant male obtained more food, grew faster, and gained access to the best basking sites at the expense of the subordinate individual (Auffenberg, 1981). This finding implies a significant cost to being the subordinate individual of a pair, namely decreased opportunities to gain access to food and optimal sites at which to thermoregulate.

In order to determine the extent to which the motive for male-male aggression was access to basking sites, three additional basking sites were placed in the arena. Installation of more basking spots within the males' enclosures decreased the frequency of aggression when the opposing male was introduced (Attum, pers. observation). This suggests that increasing the availability of a resource may result in a reduction in male-male competition/combat. Accordingly, we would expect to find common occurrences of male-male combat in environments in which resources are limited (e.g. dry season, reproductive season), while in an environment with plentiful resources,

the frequency of aggressive interactions among male Bosc's Monitors should be relatively low.

The observed male-male contest included four of the five major stages of ritualized combat commonly described for varanids (Horn et al., 1994): [1] display phase, in which the two lizards exhibit head-jerking and tongue-flicking behaviors; [2] encompassing phase, in which the two combatants orient themselves side by side, often engaging in lateral display and intense head-jerking behaviors; [3] catch phase, which involves a series of wrestling bouts where the individuals twist around one another; [4] subpressive phase, in which the victor is determined and subsequently mounts the subordinate lizard. The bipedal embrace, or clinch phase was not present in any of the contests witnessed during this study.

Male-female combat: Male-female combat occurred only when the female resisted a breeding attempt initiated by the male. Male and female *V. exanthematicus* regularly shared basking spots without conflict; the smaller females would often bask on top of the male. Similarly, no aggressive interactions over a food source were ever observed; the females never challenged the males for food and would eat only after the male had finished. Thus, it can be inferred that the male-female combat observed in this study was associated with breeding. The phases of combat observed in the male-female interactions were display, encompassing, catch and subpressive.

Female-female combat: The female-female combat observed herein occurred only over available basking spots. The following is a description of the combat sequence which took place on the only basking site available (large rocks elevated above the substrate); it is probable that the following behaviours were exhibited in order to gain access to a superior position at this single basking site.

Female A was placed into Female B's enclosure. This was the first time the two females had been placed together in the absence of one of the two male *V. exanthematicus*. Immediately after the introduction of Female A, Female B climbed atop Female A's back, covering approximately seventy-five percent of Female A's dorsum. At this point, both Female A and B were aligned and facing in the same direction. Female B then grasped Female A's chest with her front claws, but neither combatant exhibited threat displays (e.g. hissing, gular expansion). Female A failed in multiple attempts to dislodge Female B from her position because Female B's hold was, apparently, too strong. Female B attempted to bite Female A's right front leg but her positioning didn't allow her to do so. Female A then began to move away from the basking site toward the refuge (a drainage tube) with Female B still attached. Female A arrived at the refuge and crawled into it, disappearing completely within the tube; Female B was either forced to release her grip on Female A or did so because of the size restriction of the tube. Following this stage, actual physical combat ceased.

Female B then repeatedly inserted her head into the entrance of the refuge and tongue-flicked continually; Female A responded with threat display behavior (e.g. hissing, gular expansion). After a few moments, Female B withdrew her head from the refuge entrance and returned to the basking spot. A few minutes later, Female A exited the drainage tube and slowly returned to the base of the basking rock, while Female B watched intently. Female A did not attempt to climb onto the basking site rocks but, rather, planted her ventral side onto the substrate, neither touching Female B nor in a position to engage in thermoregulatory behavior. No activity occurred for the next fifteen minutes, at which time observations ended. These two females exhibited display, catch, and subpressive combat behaviors, but the encompassing and clinch phases were not observed in this incident.

The above aggressive interaction occurred in Female B's home cage and may have been initiated

Sex	Identity	SVL (cm)	TL (cm)	Weight (g)
Female	A	35.5	30.4	1270
Female	B	33.2	22.0	954
Male	AS	37.0	37.0	>2000
Male	SE	42.0	38.0	>2000

Table 1. Measurements of *Varanus exanthematicus*

solely by the introduction of Female A (a territory dispute) or may have been a fight over the only available basking site (resource acquisition). This interaction illustrates that, in this instance, the dominant individual is not always the larger: the smaller Female B won the contest against the larger Female A. It seems as though Female A's size advantage was overridden by the fact that she was the intruder in Female B's home cage. This is formally known as the 'resident effect' where the resident has presumably invested more in the resource (territory) than has the intruder, and should therefore be willing to defend the resource at a higher cost than the intruder (Hammerstein, 1981). It follows that the resident, in most cases, will win the contest.

Why the lack of clinch phase in *Varanus exanthematicus?*

Other African varanids, *V. abligularis, V. griseus*, and *V. niloticus*, have been found to engage in all five varanid ritualized combat behaviours (display, encompassing, clinch, catch, and subpressive; Horn et al., 1994). Contrary to these findings, we observed only four of the five phases in *V. exanthematicus*; none of the interactions among the individual *V. exanthematicus* that occurred during this study period included the clinch or bipedal phase of combat. Horn et al. (1994) ascribes the lack of clinch phase in the *Odatria* subgenus to its being a primitive trait; odatrian species have been considered ancestral in many phylogenetic studies (Becker, 1991; King et al, 1991; but see Sprackland, 1991). However, the lack of clinch phase in the *Polydaedalus* clade, to which *V. exanthematicus* belongs, has been speculated as a secondary loss (Horn et al., 1994). Although the observations herein suggest that *V. exanthematicus* does not engage in clinch phase, as predicted by Horn et al. (1994), more observational data is needed before considering this potential loss of a behavioral trait in a phylogenetic context.

Another possible explanation for the lack of clinch phase is morphological constraints in Bosc's Monitors. In comparison with bipedal varanids such as *V. gouldii, V. exanthematicus* has a relatively high SVL:TL ratio. This high ratio of body length to tail length could present a significant constraint on the coordination needed to sustain a bipedal stance for any length of time because the tail is critical for balance during the clinch phase. The *V. exanthematicus* in this study appeared to be barely capable of bipedal stance for more than a few seconds; this stance occurred only when food was presented above them.

The lack of clinch phase could also simply be a byproduct of captive conditions rather than a morphological constraint. The most likely explanation for why it has not been observed in captive Bosc's Monitors is that these individuals are confined to enclosures that are not nearly large enough to enable them to exercise properly (the home ranges of similar large varanids can exceed kilometers) and thus may not facilitate the development of muscle strength that would allow them to stand bipedally. If *V. exanthematicus* engages in the clinch phase, it has yet to be observed.

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