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Diet of Juvenile *Varanus niloticus* (Sauria: Varanidae) on the Black Volta River in Ghana

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Published accounts of the diet of *Varanus niloticus* suggest that it is a generalized feeder, eating a wide range of invertebrates and vertebrates that are caught by hunting and scavenging (reviewed by Losos and Greene, 1988). Examination of the skull has suggested an ontogenetic change in diet from a generalized feeder to one specialized for molluscivory (Rieppel and Labhardt, 1979), but there is no direct evidence of a high degree of molluscivory in this species.

Little is known about the diet of juvenile *V. niloticus*, nor of the juveniles of most other *Varanus* species. Schmidt (1919) examined nine juvenile *V. niloticus* collected in Zaire and reported that only three contained food (mantid, grasshopper, frog, four slugs, crickets and unidentified insects). Auffenberg (1994) examined the stomach contents of 92 juvenile *V. bengalensis* from various locations and found them to be entirely insectivorous, feeding mainly on hymenopterans and coleopterans. His study suggested animals from Pakistan accumulated large amounts of fat in the first few months of life preceding a period of fasting.

Varanus niloticus is heavily exploited throughout Africa for its meat and skin (Luxmoore et al., 1988), but there have been few ecological studies of the animal on which to base conservation strategies (Lenz, 1995). This study investigated the feeding ecology of young *V. niloticus* by examination of diets and fat bodies in a sample taken from a 12 km stretch of the Black Volta River. In this study "juveniles" are animals of the youngest age class (probably no more than four months old), and "adults" refers to all other age classes. Knowledge of the diet of juvenile monitor lizards is of particular interest because very little is known about the ecology of the juveniles of any *Varanus* species.

I report on the alimentary contents of 43 juvenile [mean SVL = 143 ± 2.7 mm (SE); mean mass 41 ± 2.4 g] and five adult (mean SVL 390, ± 32.7 mm; mean mass 1134 ± 373.8g) *V. niloticus*, caught on the Black Volta River between Batoo village (8°17′N, 2°15′W) and Bope camp (8°22′N, 2°17′W) between 9–29 July 1996, and deposited in the Cape Coast University Museum, Ghana. Animals were collected by canoe as they lay in riverbank vegetation. Alimentary tracts of preserved animals were opened and all items removed. Gut contents were rinsed into a strainer with mesh size of approximately 1 mm^2 and examined under low-power magnification. Identifiable fragments were recorded and identified to order. Prey were classified according to residence in the stomach or lower alimentary tract (referred to in this work as "lower gut"), depending on whether the bulk of the item lay proximal or distal to the pylorus, respectively. Recognizable fragments other than single limbs were recorded as prey items. Intact prey items were blotted dry and weighed to the nearest 0.01 g. Visceral fat bodies were weighed to nearest 0.01 g. Means ±1 SE are given.

TABLE 1. Diet of juvenile *Varanus niloticus* ($N = 43$), expressed as percentage of total number of prey items.

Prey taxa	Stomach	Lower gut
Spiders	9.8	16.7
Snails	2	6.9
Crabs	0	9.8
Larvae	6.9	8.8
Frogs	2.9	0
Orthopterans	7.8	15.7
Beetles	0	2.9
Miscellaneous	2.9	6.9
Millipedes	0	0
Fruit	0	0

Almost all animals had fragments of vegetation in the gut, presumably accidentally ingested, which were not analyzed further. The 43 juveniles contained a total of 104 prey items, 34 in stomachs and 70 in lower guts (Table 1). Twenty-five juveniles had empty stomachs, five had empty lower guts and one had no food items in the alimentary tract. For juveniles, mean number of prey was 2.4 ± 0.2, mean number of prey in stomach was 0.7 ± 0.2, and mean number of prey in lower gut was 1.6 ± 0.2. Mean mass of 18 intact prey items from preserved stomachs of juvenile *V. niloticus* was 0.36 ± 0.07 (range 0.03–0.9) g. Using mean juvenile mass (40 g) as predator mass gives mean predator/prey mass ratio of 0.009 ± 0.002 (range 0.001–0.023). There was no relationship between the time of day of capture and number of prey items in the stomachs ($R^2 = 0.018$) or lower guts ($R^2 = 0.086$) of juveniles. Five adults contained 20 prey items (mean = 4.0 ± 1.0, range 0–8), One adult had no food in the entire alimentary tract.

Spiders and orthopterans were the most common prey of juveniles, both occurring in 45% of lizards examined. Larvae (Coloeptera and Leidoptera) occurred in 30% of the sample and snails in 21%. Although 23% of lower guts contained crabs, none were found in stomachs. Miscellaneous prey were unidentified or represented by a single prey item. Adults contained beetles, neem seeds (*Azadirachta indica* family Meliaceae), orthopterans, a millipede and a snail.

Eight juveniles contained fat bodies averaging 0.05 ± 0.03 g (range 0.01–0.22). There was no significant difference in the mass of juveniles with or without fat bodies (Mann Whitney *U*-Test: $W = 447$, $P = 0.76$).

With the exception of caterpillars and some spiders which occur along the riverbank, most prey items are probably found by active foraging within or under the herb layer of the forest. The supposition that juveniles dig for food is supported by the presence of nocturnal, burrowing, lycosid spiders in the diet. In fact many prey items (crabs, orthopterans, beetles and beetle larvae) could have been dug up or caught in burrows. There is no evidence that juveniles catch any food in the water, although it is possible that frogs and crabs are caught there and that other invertebrates are caught after they have fallen into water.

Auffenberg (1994) reported on a sample of 92 preserved juvenile *V. bengalensis* which contained an average of almost 12 items per lizard, with predator-prey mass ratios of 0.006:0.5. He also stated that body fat accounted for over 28% of body mass in juvenile *V. bengalensis* from Pakistan, where the animals do not feed for several months at the age of nine months. In contrast, juvenile *V. niloticus* contained only negligible amounts of body fat. Their relatively low rate of food intake is unlikely to be the result of local food shortages, because all specimens appeared in good condition. Lack of fat accumulation in these animals therefore suggests that they do not undergo extended fasting.

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Traumatic Injuries in Two Neotropical Frogs, *Dendrobates auratus* and *Physalaemus pustulosus*

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Traumatic injuries in amphibians have been attributed to unsuccessful predation events (Martof, 1956; Dubois, 1979; Ouellet, 2000). Other possible sources of injury in amphibians are the result of fighting with conspecifics, mechanical accidents or scarring from infections (Dubois, 1979; Ouellet, 2000). Because most adult frogs do not have claws or teeth that could be used as weapons during combat, conspecific-inflicted injuries are unlikely. Mechanical accidents are possible in frogs, although the most likely source of such injuries are anthropogenic or acquired during the escape from predators. Scarring caused by infection is possible but has not been rigorously investigated as a source of injury in nature. The most likely source of traumatic injury is therefore through interactions with predators (Martof, 1956; Dubois, 1979). However, the majority of large-scale studies of traumatic injuries in anurans have been conducted in temperate areas (Rostand, 1949; Martof, 1956; Dubois, 1979; Ouellet, 2000). It is not known whether predation is the most likely source of traumatic injury in Neotropical anurans.

Before injury rates can be used to test hypotheses about predation, the nature of traumatic injuries and whether they reflect predation pressure in the Neotropics must be examined. If they do reflect predation, we would expect that species with differing levels of predation pressure would have correspondingly different levels of traumatic injury. To examine this, two sympatric species of similarly sized frog, the green poison frog, *Dendrobates auratus*, and the túngara frog, *Physalaemus pustulosus*, were surveyed for relative levels of traumatic injury. *Dendrobates auratus* is a diurnal terrestrial frog with toxic skin secretions containing many alkaloids (Daly and Myers, 1967; Daly et al., 1987). In contrast, *P. pustulosus* is cryptic and does not secrete alkaloids (Daly et al., 1987). Little is known of the predators of dendrobatid frogs in the wild. For *D. auratus*, predator accounts are based on single observations (a fish, *Brycon guatemalensis* in Hedstrom and Bolaños, 1986; a bird, *Baryphthengus marhi* in Master, 1998). The only well-documented predator of *D. auratus* is the theraphosid spider *Sericopelma rubronitens* (Summers, 1999), which is deterred by the frog's toxicity (Gray, 2000). In contrast, *P. pustulosus* is palatable and has a wide range of known predators (Ryan, 1985; Gray et al., 1999). In addition to differences in palatability, these two species have different reproductive strategies and differ in life span (Ryan, 1985; Summers, 1989, 1990). However, they are about the same size and are found syntopically in many of the same habitats. The Panamanian Island of Taboga is home to large populations of both species. On Isla Taboga, both *D. auratus* and *P. pustulosus* are active during the day, which contrasts with the primarily nocturnal behavior of all other studied populations of *P. pustulosus* (Jaegar and Hailman, 1981; Ryan, 1985). *Physalaemus pustulosus* were observed moving about the forest on Isla Taboga, calling and nesting throughout the day in full sunlight. Isla Taboga thus provides a perfect site to make comparisons because both species occur in high densities in the same areas and therefore are exposed to the same conditions. If there are trends in the injury levels that can be correlated with predation for these species from different anuran families, then traumatic injury may be used to understand predation pressure in a wide variety of frogs. This study represents the first population-level examination of traumatic injury in neotropical anurans.

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