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Heads You Lose, Tails You Win: Notes on a Tail-assisted Foraging Behavior in *Varanus* (*Odatria*) *kingorum*

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Abstract - This article describes a tail-assisted foraging behavior in *Varanus kingorum*, a small rock-dwelling varanid from Australia. Numerous captive specimens were observed skillfully using their tails to extract prey from tight crevices which were otherwise unreachable by the lizards. This behavior was displayed by individuals of both sexes and all age groups, and it is therefore hypothesized that it is, at least to some extent, genetically fixed.

Introduction

Varanid lizards are a diverse group of reptiles not only in regards to variation in size within the family, but also in their use of different structural habitats within their natural range. Four main structural habitat types have been identified that are "characterized by the physical environment" (Bedford & Christian, 1996): arboreal, arboreal/semi-aquatic, terrestrial, and rock-dwelling (Greer, 1989; Collar *et al*., 2010; Collar *et al*., 2011). While varanids may not appear to differ widely in their overall appearance to the herpetological layperson at first glance, each species has evolved specialized morphological and behavioral adaptations for survival in its preferred habitats.

Tail morphology in particular can give hints as to which structural habitats are used by a species, and studies have shown that certain tail characteristics correspond to specific habitats and lifestyles in varanids (Bedford & Christian, 1996). While arboreal species such as members of the *Varanus prasinus* complex feature prehensile tails which aid in climbing (Greene, 1986; 2004), highly aquatic species such as *V. mertensi*, *V. niloticus* and *V. salvator* have developed laterally compressed tails which make swimming more efficient (Bedford & Christian, 1996). *Varanus acanthurus*, a primarily terrestrial species, uses its spiny tail to block the entrances to burrows, presumably for protection from predators (Wilson & Knowles, 1988; Auffenberg, 1994). Lastly, rock-dwelling species of the subgenus *Odatria* including *V. glebopalma*, *V. glauerti*, *V. pilbarensis* and *V. kingorum* have developed very long tails in relation to their snout to vent lengths (SVL), which act as counterbalances when moving around rocky habitats (Bedford & Christian, 1996).

Tail usage for purposes other than aiding in locomotion, security, or fat storage have been described for several varanid species (Hermes, 1981; Gaulke, 1989; Eidenmüller, 1993; Horn, 1999; Keith & Ginsburg, 2010; Wickramasinghe *et al*., 2010). Three of these reports describe the usage of the tail to extract prey items from burrows and crevices which were otherwise unreachable (Gaulke, 1989; Eidenmüller, 1993; Horn, 1999). Eidenmüller (1993) reported this behavior in captive *V. acanthurus*, with lizards using their tails to extract crickets from under cork slabs. Here, a similar tail-assisted foraging behavior is described in captive specimens of *V. kingorum*, the smallest (to 35-40 cm in total length [TL]) of the four aforementioned rock dwelling species within the subgenus *Odatria*, with a tail that can reach 2.3 times its SVL (Storr, 1980; King, 2004).

Captive Husbandry

Varanus kingorum (Fig. 1) was first acquired by the author in 2009 and has since been bred consistently through multiple generations. Incubation period has ranged from 89 to 126 days at a temperature of 29 +/- 2 °C. Snout to vent lengths and tail lengths of hatchlings

Fig. 1. *Varanus kingorum* have extraordinarily long tails which they can use to extract prey from otherwise unreachable crevices.

have averaged around 5.0 cm and 9.5 cm respectively, and therefore fall within the ranges reported by others (Eidenmüller, 1999; Retes & Bennett, 2001; Eidenmüller, 2003).

Adult pairs are kept in adequately sized enclosures with a thick layer (ca. 15-25 cm) of mostly inorganic substrate such as sand of varying grain sizes with a smaller share of organic matter. Heat-tolerant plants such as *Callistemon sp.*, cork tubes, rocks, and stacks of flat wood arranged to imitate rock crevices that would be used in the wild, are also provided. The wood and rock stacks increase usable surface area, create artificial crevices, and depending on their construction and arrangement, offer tight-fitting refuge sites with different humidity levels and temperature gradients. The heights of these artificial crevices range from 1.5 cm on one side, narrowing down to 0 cm on the other.

Their diet consists of cockroaches (*Blaptica dubia*), house and field crickets (*Acheta domesticus*, *Gryllus assimilis*) and the occasional baby mouse, which have not been accepted with gusto by most individuals of *V. kingorum* in the author's collection. Cockroaches are offered from forceps or placed in a food bowl, but crickets are released into the enclosure for the lizards to hunt freely. *Varanus kingorum* is a fast and agile hunter that preferably grabs its prey by the head and consumes it in typical varanid fashion.

Behavioral Observations

Not all crickets introduced to the enclosures are consumed immediately and some take refuge in narrow, dark, and humid locations. Crickets are relatively easily captured by the lizards from within cork tubes and are sometimes dug out from under rocks and wood slabs resting atop the sand substrate. However, the lizards face a problem when prey items seek refuge inside crevices too narrow for them to enter with their heads (Fig. 2a). This sometimes occurs when crickets hide in the narrow ends of the crevices created by the wood or rock stacks.

A clever solution to this problem has been observed in multiple *V. kingorum* of both sexes and all age classes. If a lizard realizes it cannot reach the cricket with its jaws, it switches to a different tactic. First, the lizard backs off, forming a semicircle with its body, with the tail tip facing the crevice where the cricket is located. It then begins to rapidly undulate the tip of its tail to force the cricket out of its safe hiding spot in the narrow part of the crevice (Fig. 2b). This works very efficiently, and in most cases the crickets are distracted by the fast moving tail and flee the crevice. The escape route for the cricket is defined by the body positioning of the lizard, which forces it to run directly towards the lizard´s head, where it is then quickly grabbed and consumed (Fig. 2c). This all occurs inside the crevice provided it is large enough to accommodate the lizard. If the prey hides under smaller objects, the lizards perform the same behavior, sometimes reaching under the object with their tails from one side with the head on the other side waiting for the prey to emerge. The entire process can occur very quickly and be over in a matter of seconds.

Discussion

As a species, *V. kingorum* appears to display this behavior instinctively, as individuals of all age classes, from hatchlings to adults have been observed hunting crickets in this manner. The frequency of its usage was

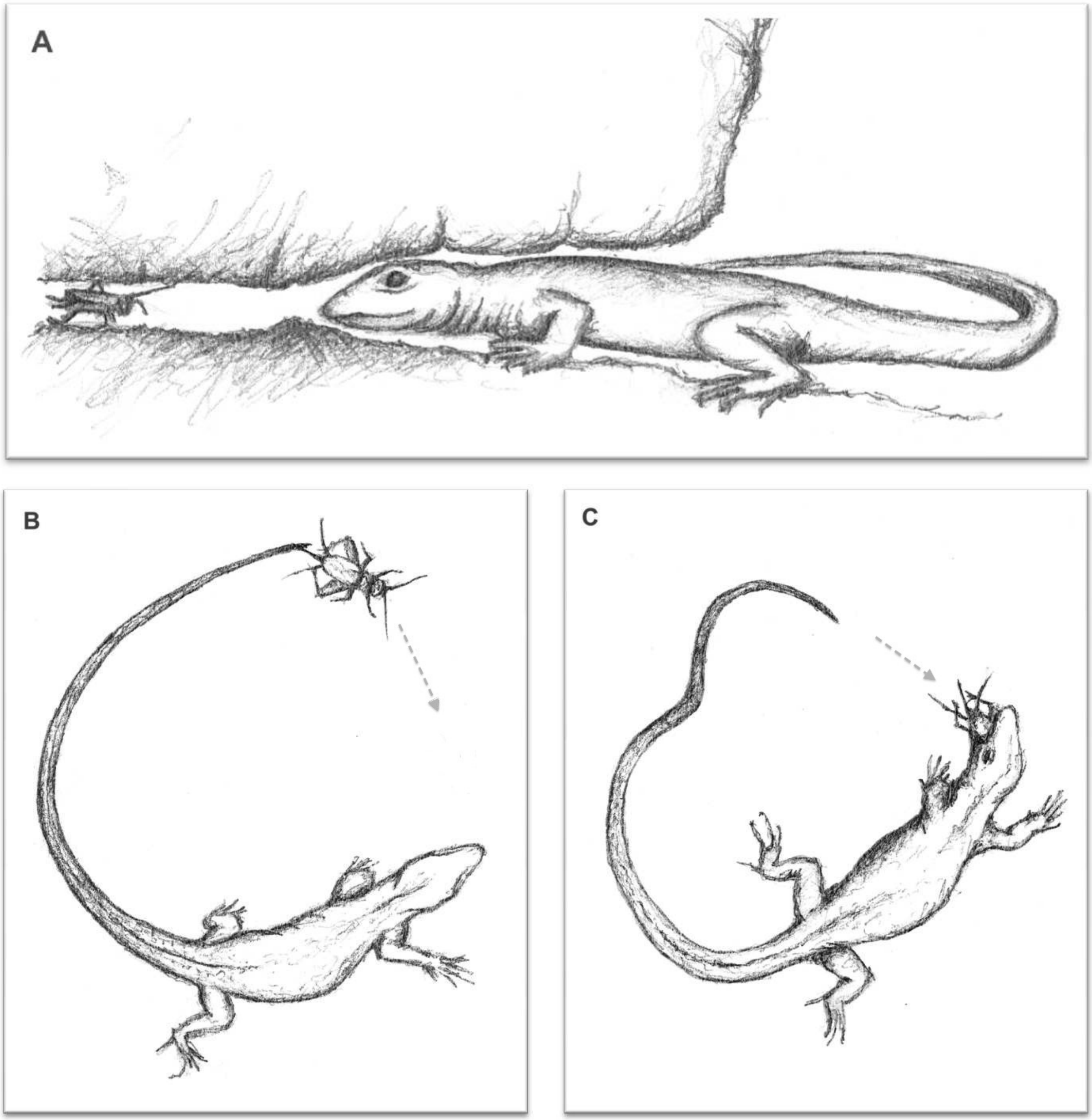

Fig. 2. Sketch of the tail-assisted foraging behavior. A) The prey item is visually and, or olfactorily located; however, the crevice is too narrow for the lizard to enter with its head. B) The lizard forms a semicircle with its body and rapidly undulates its tail tip to force the prey item out of its hiding spot. C) When fleeing the hiding spot, the prey is quickly grabbed and consumed by the lizard.

lower in hatchling individuals, most likely because they can easily access most crevices on account of their small size. The behavior is not randomly performed, and lizards do not check every available crevice in this manner just to see whether there is prey inside. Instead, this tail-assisted foraging behavior is utilized purposefully when prey has been visually and, or olfactorily located by the lizard.

As this brief report and other publications (Eidenmüller, 1993; Horn, 1999) have shown, this behavior, or similar types of tail-assisted foraging are displayed by several varanid species belonging to different subgenera. The facts that juvenile and adult *V. kingorum* readily performed this behavior and it has been observed in multiple individuals suggests that it is at least to some extent genetically fixed and not something which is individually learned over time (*e.g.*, Mendyk & Horn, 2011). Whether this type of tail-assisted foraging behavior evolved early on in the history of varanid lizards or independently in several species, remains speculative for now.

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