A report on male *Anolis sagrei* saurophagy in Chiayi County, Taiwan

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ABSTRACT – Five hundred and two Brown anoles (*Anolis sagrei*) were collected for stomach content analysis from an area surrounding a plant nursery (23°25'51"N, 120°28'30"E) in Santzepu, Sheishan District, Chiayi County, as part of an ongoing study on this invasive species in Taiwan. The stomachs of five *A. sagrei* males contained vertebrate prey, which were isolated for identification to establish a basis upon which future studies can be based. These prey were identified as three hatchlings of *A. sagrei*, a *Hemidactylus frenatus* hatchling, and a skink hatchling – most likely that of *Sphenomorphus indicus*. The results of this study seems to indicate that male *A. sagrei* saurophagy is more likely in cleared open habitats, with no ground cover, than in habitats with ground covering.

As a whole, lizards exhbit a wide range of variation in what they eat; some have a catholic diet, while others are specialists that prey only on specific types of prey (Mattison, 1997). Only a few lizard species, such as *Lialis burtonis* (Pygopodidae), specialize in preying on other lizards (Pianka & Vitt, 2003). Some intermediate sized species like the Western collared lizard (*Crotaphytus insularis*) and the Leopard lizard (*Gambelia wislizeni*) prey on smaller lizards (Pianka & Vitt, 2003; Smith, 2003), although their diet is not restricted to them (Mattison, 1997). A few species such as the Virgin Islands crested anole (*Anolis cristatellus wileyae*) (Owen & Perry, 2005), Northern curly-tailed lizard (*Leiocephalus carinatus*) (Schoener *et al.*, 2002), and Rainbow skink (*Mabuya margaritifer*) (Spawls *et al.*, 2002) will occasionally prey on smaller lizards. It is thus clear that although not all lizard species prey on lizards (saurophagy), it is not that out of the ordinary that some lizards will prey on smaller lizards.

The Brown anole (*A. sagrei*), also known as *Norops sagrei* (Köhler, 2000; Lee, 2000), is a recently recorded invasive lizard species in Taiwan (Norval *et al.*, 2002). In an attempt to gain a better understanding of the food resource utilization of *A. sagrei* in Santzepu, Sheisan District, Chiayi County, a stomach content analysis was done on 502 individuals, consisting of males (n=255) and females (n=247), that were killed with ether. Since the identification of the prey items that were taken from the stomachs of these lizards were usually only extended to the class or order levels, it was decided to isolate all the vertebrate prey from the other prey items for a more in-depth examination to establish a basis upon which future studies on predation on vertebrates by this species in Taiwan can be based.

METHODS

Study site

The Brown anoles were collected along the road; from agricultural fields; along a creek; and from a cemetery in the area surrounding a plant nursery (23°25'51"N, 120°28'30"E) in Santzepu, Sheishan District, Chiayi County.

Field methods and data analysis

Meteorological data, reported for Chiayi City which is located about 5 km from the study area, was obtained from the Taiwanese Central Weather Bureau website.

Between January 10th 2002 and March 28th 2003, a sample of about 30 Brown anoles (*A. sagrei*), consisting of both males and females, were collected monthly by hand or with a fine meshed fishing scoop net. At the point of capture, the GPS location was recorded with a GARMINI 2 PLUS handheld reader (datum: WGS84), the specimen was allocated a field number, and the date and time was recorded.

Upon returning from the study area, each lizard was killed with ether; the SVL and TL were measured to the nearest mm with a transparent plastic ruler; the tail was scored as complete or

Specimen Field No.	Collection date and time	SVL(mm)	TL (mm)	BM (g)	GPS location
GN0010	2002-01-11; 12:30 h	47	86	2.3	23°25'43"N, 120°29'02"E
GN0180	2002-06-06; 10:03 h	50	93	4.1	23°25'43"N, 120°28'54"E
GN0314	2002-09-29; 16:35 h	48	94	3.0	23°25'46"N, 120°28'58"E
GN0394	2002-12-05; 10:56 h	55	109	5.2	23°25'44"N, 120°28'55"E
GN0426	2002-01-23; 14:11 h	49	100	3.3	23°25'48"N, 120°29'07"E

Table 1. The collection data and measurements of the five *A. sagrei* males, that had vertebrate prey in their stomachs.

broken; the animal was weighed to the nearest 0.1g with an YC-model e68 digital scale and dissected by making a mid-ventral incision. The stomach was removed for stomach content analysis and placed in a vial filled with 75% alcohol. At the end of the collection period the stomach content of every lizard was spread in a petri dish and all the prey items were identified down to order level and, if possible, to family level. All the specimens, except for the stomach contents and the stomachs (preserved only in 75% alcohol), were first fixed in 10% formalin and then preserved in 75% alcohol. In addition to the morphology, the head, sub-caudal, and sub-digit scalation were used for the identification of the saurian prey isolated from the other prey items, and the SVL and TL of the complete saurian prey (n=2) were measured to the nearest mm with a transparent plastic ruler. Abbreviations are as follows: *Abbreviations:* SD – standard deviation; SVL – snout-vent length; TL – tail length; BM – body mass

RESULTS

The average temperature for the study period was 22.71°C; June 2002 being the hottest month and February 2003 being the coldest; and during the same period 1453 mm rain fell, of which the most fell in July 2002.

Five *A. sagrei* males, about 1% of all the lizards, had vertebrate prey in their stomach contents, and had a SVL, TL, and body mass that ranged from 47 to 55 mm, 86 to 109 mm, and 2.3 to 5.2g respectively; with an average SVL, TL, and body mass of 49.8 mm (SD=3.114), 96.4mm (SD=8.62), and 3.58g (SD=1.112) respectively (Table 1).

GN0010 was collected from a betel-nut palm (*Areca catechu*) plantation on a hill. But unlike in other betel-nut palm plantations, the farmer kept the area very tidy and the ground was virtually bare. GN0180 was collected in a field used for the cultivation of bamboo (*Bambusa atrovirens*). The areas surrounding the bamboo stands were bare because the farmer regularly raked the leaves and other litter into piles around the bases of the bamboo stalks. This practice is often observed in fields where bamboo is cultivated in Taiwan. GN0314 and GN0394 were collected from the border of a field that was left to lie fallow since August 2002. Prior to that, the field was a lemon (*Citrus limonia*) orchard. The trees were grown in rows, and along the western part of the orchard many were overgrown by *Mikania micrantha.* In general, through out the lemon orchard, species like *Amaranthus spinosus*, *Bidens pilosa*, *Celosia argentea*, and *Chloris barbata* grew in the lanes among the trees. Although the farmer did spray herbicides from time to time, which reduced the vegetation in the lanes, some form of vegetation litter always covered the ground. Many of the *C. limonia* were infected by *Anoplophora malasiaca* and were dying. All the trees were thus uprooted and piled in the center of the orchard in July 2002 (Fig. 1), and were burned at the end of the year. To the end of the study no attempts were made by the farmer to cultivate any crops in the field. GN0426 was collected from an orange (*Citrus aurantium*) orchard, where the farmer regularly raked the ground among the trees, and the ground was thus bare at all times.

The only vertebrate prey items recorded in this study were three *A. sagrei* hatchlings, a tropical house gecko (*Hemidactylus frenatus*) hatchling, and a skink – most likely a hatchling of an Indian forest skink (*Sphenomorphus indicus*); and belonged to three families – the most common of which was Polychrotidae. Vertebrate prey comprised about 0.16% of the total number of items in the lizards' stomachs, and only 0.17% of

Figure 1. The lemon (*Citrus limonia*) orchard after the trees have been uprooted and piled in the middle of the field. This field is bordered on three sides by betel-nut palms (white arrows), which are used by *A. sagrei* males as perches.

the prey items (all stomach items except the consumed sloughs).

Since the digestive process was very advanced, it is not possible to give an exact predator/prey SVL ratio of the scincid, and two of the *A. sagrei* hatchlings. As for the remaining *A. sagrei* hatchling (GN0394) and the *H. frenatus* hatchling (GN0010); the predator/prey SVL ratios were 3.24:1 and 3.13:1 respectively.

DISCUSSION

The Brown anole (*A. sagrei*) is a sit-and-wait predator (ambush predator) that feeds during the entire day (Schwartz & Henderson, 1991), and as ambush predators, they would be expected to prey on more active prey (Huey & Pianka, 1981), that is mobile, on the surface, and visually conspicuous (Pianka & Vitt, 2003).

Anolis sagrei saurophagy has been recorded before and involved cannibalism on other anoles (Lee, 2000; Nicholson *et al.*, 2000; Campbell & Gerber, 1996; Campbell, 1999; Gerber, 1999). Intraguild predation by *A. sagrei* on *A. carolinensis* hatchlings has been shown to be severe enough to result in the rapid decline of sympatric populations of *A. carolinensis* in Florida, USA (Meshaka *et al.*, 2004). Although *A. sagrei* cannibalism is not out of the ordinary, Gerber (1991) has demonstrated that adult male *A. sagrei* selectively prey on hatchling *A. carolinensis*.

Although *H. frenatus* is primarily a nocturnal gecko (Cox *et al.*, 1998; McCoid and Hensley 1993; Meshaka *et al.*, 2004), McCoid and Hensley (1993) has reported a shift in activity patterns by the hatchlings and juveniles of this species in Guam, and suggested that it may be a heretofore unrecognized activity shift in young of *H. frenatus* to reduce cannibalism. Such activity patterns have not been confirmed in the present study area, but it is worth noting that *H. frenatus* has been observed on the trunks of *A. catechu* during the day (Norval, pers. observation). Still, the hatchling that fell prey to GN0010 could have been disturbed in its shelter by anthropogenic activities. Many of the fields are bordered by betel-nut palms, which are used by *A. sagrei* as perches. Another factor that could thus contribute to the risk of predation by *A. sagrei* on small lizards is the response of these lizards to agricultural activities such as tilling. As stated above, *A. sagrei* often utilizes the vegetation bordering fields as perches, and emigration of small lizards, such as the hatchlings of *A. sagrei*, to these areas would naturally lead to an increase of predation by adult *A. sagrei* males. This was more than likely the case for GN0314 and GN0394, because although throughout the year individuals were collected from this area, these two saurophagy cases were recorded after the orchard was cleared and the uprooted trees were burned. *Anolis sagrei* hatchlings were observed in this area, and had to emigrate to the areas bordering the cleared orchard when all the available cover was removed.

Since none of the predation events were observed, one can only speculate about how they occurred. But interestingly, all the saurophagy cases I recorded were in areas with no or little ground covering, and very high anthropogenic disturbances. As part of another study, 230 *A. sagrei* were collected between January 2004 and February 2005 from a small betel-nut palm plot (15 x 40m) in the same study area for stomach content analysis. And although the understory vegetation was sparse from time to time, the ground was never bare. Not a single case of saurophagy was recorded (Huang & Norval, unpublished data)! It thus seems that *A. sagrei* saurophagy is more likely in cleared open habitats, with no ground cover, than in

habitats with ground covering. And from a conservation perspective, farmers in Taiwan should be encouraged not to remove all the ground covering in areas where *A. sagrei* occurs to lessen the risk of hatchlings of indigenous species falling prey to large *A. sagrei* males.

The question still remains, why would some *A. sagrei* males be cannibalistic? According to Rodriguez Schettino (1999), one *A. sagrei* of each sex occupies a territory, in which may be established a family composed of one male, several females (of which one dominates), and juveniles and hatchlings that may stay in the territory for several weeks before they disperse to other areas. Paterson & McMann (2004) have demonstrated that *A. sagrei* males can distinguish between neighbours and non-neighbours, and Tokarz (1992) found that *A. sagrei* males behaved differently with familiar females than with unfamiliar females. So, if *A. sagrei* males have the ability to distinguish among familiar and nonfamiliar classes of males and females, would they also be able to distinguish between their own offspring and that of others? An empirical study to determine if *A. sagrei* males are able to recognize their own offspring would not only determine if *A. sagrei* males are capable of kin-recognition, but it would also help clarify the question of whether cannibalism is truly just opportunistic predation, or whether it is a form of intraspecific competition.

As far as can be determined, this appears to be the first published description of a gekkotan and scincid falling prey to Brown anoles.

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