IJABR Vol. 9(2): 51 - 64 (2018)

Original article

DIETARY SELECTION AND SOME CURIOUS DIET-RELATED HABITS IN *Agama agama,* AGAMIDAE (LINNAEUS, 1758) IN THE SAVANNAH BELT OF NIGERIA

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Received: October, 2018; Accepted: November, 2018; Published: December, 2018

ABSTRACT

In addition to providing data of prey items, field surveillance of foraging activities in lizards offers information on behavioural responses to changing habitat; food resource conditions, such as, prey density; and the manner the prey is captured. The present work, conducted near suburban settlements and towns in the Savannah belt of Nigeria, West Africa, sought to use a natural history approach, with a mix of analytical methods in order to enhance the characterization of the dietary ecology of *A. agama* through direct field surveillance of foraging habits. This work reports, possibly for the first time, some age-sex differences in diet-related behaviour of *A. agama*. Surveillance was made four times in each of four sites, over four seasons, during June, 2015 to May, 2017. Five transects of 100 meters each, spaced at 20-meter intervals were established in each of the four sites. On every surveillance occasion, bouts of 30-minute walks were made on each transect, pausing for longer periods whenever needed. Observations were completed mainly with unaided eye, except for infrequent use of binoculars. Five dietary items, namely dipterans, hymenopterans, isopterans, fungus, and orthopterans had the highest frequency of selection ranks, in the order listed. The young & juvenile lizards (of both sexes) displayed a rather peculiar manner of catching their dipteran prey, described here as *The Agama Predatory 'Dance'* Significantly greater proportion of young & juvenile lizards deployed this technique more than the adults (Fisher's exact test, $P = 0.002$; Test for difference = 0 (vs not = 0); Z = -3.46; P-Value = 0.001). Other diet-related observations noted included cannibalism and pest tendencies. Perhaps, degraded habitat and poor food resource conditions were related to certain bizarre dietary behaviours seen in *A. agama.*

Key words: Ecology, diet, behaviour, Rainbow lizard, West Africa

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INTRODUCTION

The agamid lizards, genus *Agama* (Agamidae), are present in open habitats throughout much of West Africa ([1]; [2]). A common species *Agama agama,* the one of interest in the present study, is colonizing new territories, specifically, the Santo Antão Island of the Cape Verde archipelago [3], the subtropical region of Florida, southern United States [4]. There has also been a report of recent invasion of *A. agama* in the island of Madagascar [5]. In Nigeria, *A. Agama* tends to be commensal, enjoying relative human accommodation in townships and villages.

A. agama has been described as omnivorous, feeding mainly on invertebrates, especially insects, beetles, spiders, ants [6], and even fruits and vegetative plant material, berries, seeds and plant flowers; as insectivorous [7]. In eastern Nigeria, [8], working on the species, notes its rather high intake of non-winged arthropods, but explained low dietary contribution of flying arthropods, dipterans in particular, to the preys' ability for flight, hence able to escape predation by *A. agama*. Other workers, e.g., [3] consider *A. agama* as a dietary opportunist, taking whatever prey items its local niches offer but, showing preference for insects.

Much of the works done in attempt to understand the diet of *A. agama* have focused on methods of stomach contents or fecal pellet analysis ([9]; [10]; [11]). Field surveillance of lizards foraging activities has also been used for the analysis of dietary habits of lizards [12]. Several workers, including [9] and [13] have argued against the sole use of stomach or fecal matter as the method might lead to under-representation of some food items.

The goals of the present work were to characterize the dietary ecology of *A. agama,* through a natural history perspective, by direct field surveillance of foraging habits, focusing on, not only on what the lizards take of dietary items but, also on the analysis of certain curious habits that were observed during the feeding behavior, as well as, to determine specific age-sex class differences in foraging habits of the species.

MATERIALS AND METHODS

Study Area

During the last 30-40 years, enormous human population and livestock increase, and consequently overgrazing and over cultivation, have caused much degradation of the Nigeria's natural savannah fields into arid wasteland dominated by agricultural weeds. Much soil has also been lost to various forms of erosions. However, there was still a presence of indigenous trees and

groundcover vegetation of herbs and grasses. The trees included *Tamarindus spp, Parkia biglobosa, Albazzia chevalier*, *Sclerocarya birrea*, and *Acacia albida.* There were four study sites, two to the west of Kano, namely, Jan Guza (11^0 59' 35.22" N; 8^0 19' 49.20" E; 479.75m ASL), Rijiar Zaki (11^0 58' 59.53" N; 8^0 23' 18.80" E; 467.25m ASL), and two other sites were to the east of the city at the towns of Gezawa (12^0 05' 26.59" N; 8^0 45' 48.88" E; 448.36m ASL) and Zakirai (12^0 05' 27.57" N; 8^0 53' 13.88" E; 410.87m ASL). All four localities on the map are given in Figure 1.

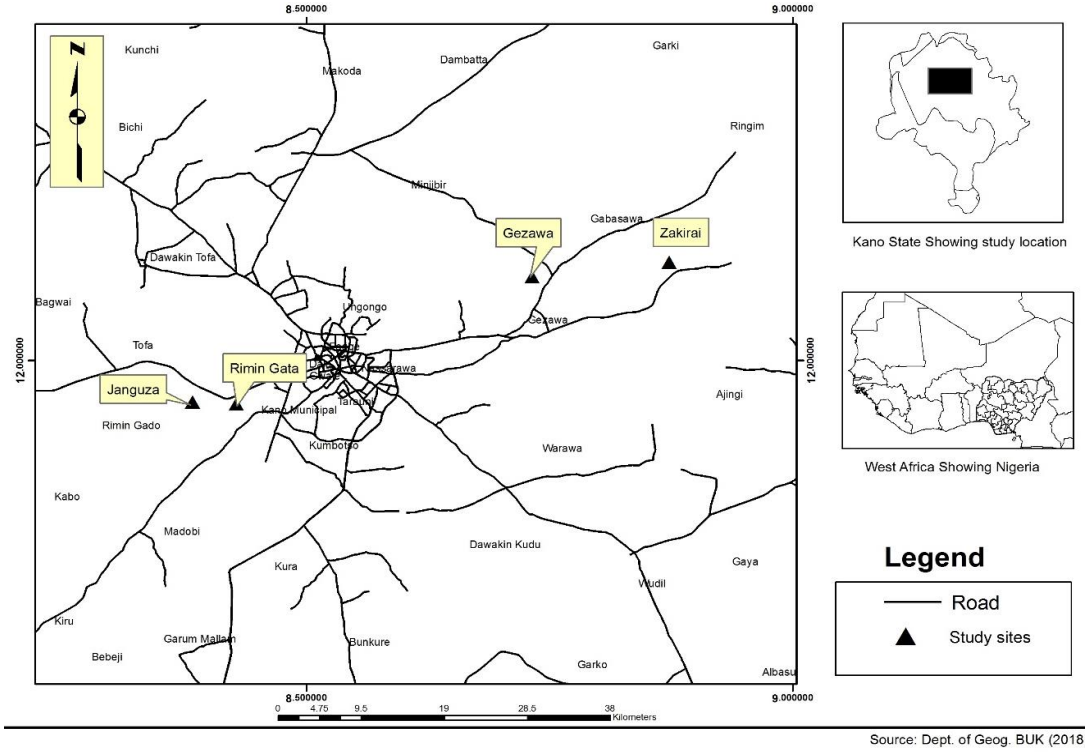

Figure 1. Study sites at Jan Guza, Rijiyar Zaki, Gezawa and Zakirai, west and east of Kano, Nigeria.

There were not many marked differences amongst the sites, except the two at Rijiar Zaki and Jan Guza appeared more moistened and had more of clay soil than the sandy type at Gezawa and Zakirai. Crops are grown during May to early October, and include Guinea corn, *Sorghum bicolor;* Ground nuts*, Arachis hypogea;* and occasional water melon, *Catullus lanatus.* Main arthropod taxa in all sites included diptera, hymenoptera, isoptera and orthorpteran. There were also coleopterans and others.

Foraging Surveillance

Field surveillance of *A. agama* foraging habits, focusing on at least five lizards

in each age-sex class (adult male, adult female and young & juveniles = 15 lizards) was made on four occasions during four seasons (June to October, 2015 Rain season; November 2015 to May 2016 Dry season; June 2016 to October 2016 Rain season; and November 2016 to May 2017 Dry season = 16 occasions per site). Thus, each site had 15 lizards in each of 16 occasions (= 240 lizards), hence a total of 960 lizards for all four sites over the two-year duration of the study.

Five transects of 100 meters each, spaced at 20 meters were established in each site. Transect could pass over brick wall, thickets or ditches. Bouts of 30-minute walk were made on each transect, pausing for longer period whenever the need arises. The bouts per site would last at least three hours, mostly within the local times 6.00 - 10am and 5.00 -6.00pm, and at times, starting earlier and lasting the entire day, especially when the desired number of lizards was not recorded or, when there were some curious diet-related activities to record. Lizard were targeted for observation provided they fit the desired age-sex class. All observations were mostly completed with unaided eye, except for infrequent use of binoculars when the details of lizard activity could not be determined from afar.

Invertebrate prey items were identified to orders; vegetated materials were noted as dicot or monocot; while seeds were distinguished into dicot and melon seeds. Vertebrate preys were simply listed by their common names. All proportional values were arch sine square root transformed prior to statistical analysis. Statistical tests, including Fishers exact test, and of test variances (GLM model), were done using Minitab-18 Statistical package.

RESULTS

Overall food selection was in favour of arthropods, especially insects, but diet was diverse and included vegetated plant materials, and even vertebrate preys (with additional observations outside fixed study sites). The ranking of food items by frequency of selection is given in Table 1. There was preference to the white mycelia, probably, *Sclerotinia sclerotiorum* that grows on damaged and poorly weeded leaves, over some arthropods. Generally, arthropod dietary items ranked over plant material except for vertebrate prey items that included eggs, passerine birds and chicken nestlings. (Table 1).

Table 1. Frequency rank of some selected dietary items in all age-sex classes of *A. agama.* Rank values were derived from aggregate foraging lizards for four localities near villages in grass-fields of Nigeria.

Dietary Item	Diptera	Hymenoptera	Isoptera	Fungus	Orthoptera	Coleoptera	Blattodea	Dicot seeds	Lepidoptera larva	Odonata	Lepidoptera adult	Dictyoptera	Monocot vegetative	Dicot vegetative	Unknown larvae	Young lizard	Melon seeds	Dicot flowers	Soft-shelled eggs	Bird nestlings
Rank of Selection Frequency	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Age-sex class differences in dietary selection are shown in Figure 2. Mean percent frequency intake of dipteran flies was significantly higher ($P<0.05$) in young & juvenile than in either adult males or females. Similarly, intake of fungal mycelia was significantly more by young & juveniles and adult females than by adult males. Dietary items that included nestlings of passerine birds and chickens were almost the exclusive to the menu of adult males, as no young or female lizards were seen to take those items (Figure 2.). Seasonal differences with respect to intake of vegetated materials were significant ($P<0.05$) with more taken during the dry season rather than in the rainy season when they were most abundant. Additional details concerning the selection and foraging behavior of *A. agama* are given below.

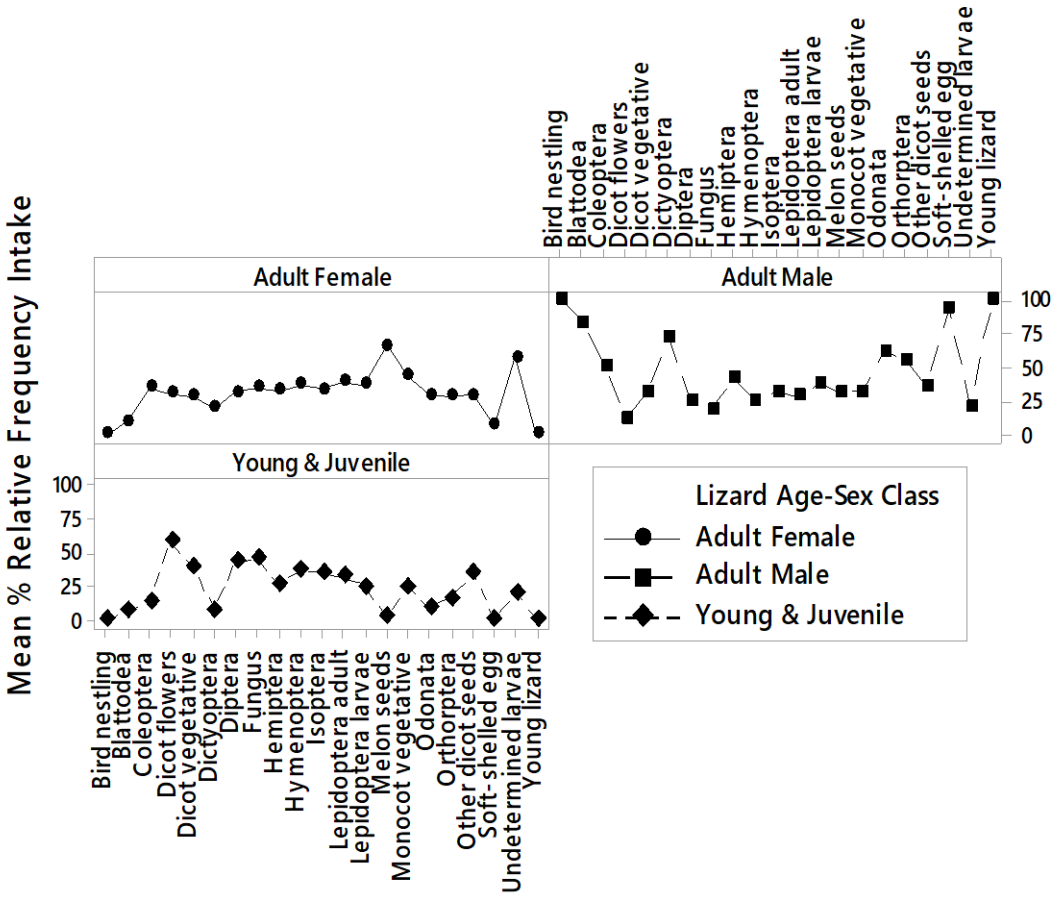

Figure 2. Age-Sex class differences in mean percent relative intake of dietary items in *A. agama*. Values are aggregate for all four sites of study near Kano, Nigeria.

PREDATORY 'DANCE' OF THE YOUNG & JUVENILE LIZARDS

The young & juvenile lizards of both sexes displayed a rather peculiar manner of hunting their dipteran or other small winged prey in situations of low prey density, i.e., fewer than ten insects per m^2, and at greater frequency than adult lizard age-sex classes. This maneuver is described in the present work as, *"The Agama Predatory 'Dance'"*. On targeting a prey, the lizard would remain quiet; thorax, neck and head segments raised slightly above ground, not directly gazing at the target, which is usually further than 12cm, and

may be up to 30cm away. It would then initiate a clockwise, sideways glides in an almost zig-zag fashion, and might make some quick and short forward jolts of about 4-8cm long, and backward retreats (also, 4-8cm) of the entire body, making progress in a general semi-circular fashion. In this manner, it would complete a few degrees, at times up to 170 degrees; then would finally leap forward (a culminating, very fast strike during which the prey is finally captured), and 97 percent of the attempts (for all observations), nipping successfully at the prey (Figure 3). Ordinarily, in a non-predatory situation, common flies, mosquitoes and other dipterans would escape most disturbances and attacks targeting their positions.

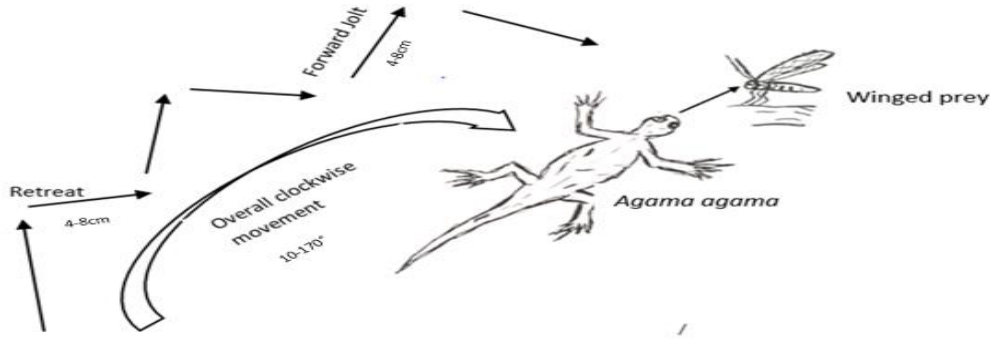

Figure 3. Predatory 'dance' maneuvers of young & juvenile *A. agama* lizards targeting a winged invertebrate prey, at low prey population density of lower than 18-20 insects per meter. Lizards movement starts from lower left, culminating in the capture of the prey at top right.

Because the proportions of adult males (14%) and adult females (15%) that deployed the predatory 'dance' maneuvers during prey capture were nearly the same, the age-sex classes of the lizards were reduced from three to two, by pooling both adult groups into one. Hence, left with two age-sex classes, namely, adults (of both sexes) and young & juveniles (of both sexes). Post arch sine square root transformation, The Fishers Exact Test was used to determine equality of proportions. For this, the null hypothesis was: two lizard population proportions were equal (H_0: $p_1 = p_2$). The Fisher's exact test statistics was P value = 0.002 and Test for difference = 0 (vs not = 0): Z = -3.46; P-Value = 0.001 (Table 2). Obviously, a

significantly greater number of the young and juvenile lizards had deployed the predatory 'dance' much more than the adult segment of the lizard population (Table 2).

Table 2. Aggregate sites record of age-sex classes of *A. agama* deploying varying degrees (in percentage) of predatory 'dance' maneuvers in the capture of winged prey items.

Lizard (age-sex) class	N	Number of lizards (all sites) showing degree (percent) of prey capture by Predatory 'Dance'						Proportions (and %) displaying Predatory 'Dance'	Comparison of Adults (pooled) vs Young & Juveniles
		100%	80%	60%	40%	20%	0%		
Adult Males	54	-	-	-	-	8	46	14 (25)	Fisher's exact test, P =0.002. Test for difference = 0 (vs not = 0): Z = -3.46; P= 0.001.
Adult Females	26	-	-	-	-	4	22	15 (58)	
Young & Juvenile	80	19	3	10	22	8	18	77 (96)	

Other Dietary Observations: Is the Common Rainbow Lizard a Pest?

Unconfirmed reports from people in both urban and rural areas during 2015 to 2017 that *A. agama* does take the nestlings of chickens and those of small song birds in home yards and gardens, but dismissed the claims because of the possibility that other culprits, such as feral cats, might be involved. Two cases, outside the present study transects at Gezawa, and very recently, on Monday, March 26, 2018, when at about 9.00am a volunteer graduate student, called from his home to report that a mature *A. agama* cock had attacked a two-day old chick, severed the head and escaped, while still holding the severed head of the chick in its mouth. Perhaps, in the absence of any disruption, the lizard might probably devour the entire chick. A week later, children playing in another, separate rural homestead, reported seeing the torso of a young chick, and believed a mature lizard cock was the perpetrator. Such reports of depredation of nestling birds, including the ones confirmed totaled nine cases.

Cannibalism or Male Infanticide?

Two occasions of attack and fatality against young lizards by mature males in September 2016 and August, 2017, both at the Jan Guza site were observed. The victims were probably males, but this could not be ascertained as the cocks made away with their preys. These were the only incidents noted throughout the years of this field study (June, 2015 to May, 2017). There were reports from individuals in the local communities that such behavior, though uncommon, does occur.

The Cliff Jump/Drop of the Male

Adult male lizard would occasionally jump up vertically against a wall or tree trunk (up to a meter or more) or fall down (usually two to three meters, but up to five); not crawl or slither but, simply a free fall to the ground by the ventral side, with a heavy thud, to get at its prey or chase off another male intruder. In 12 of 19 (63%) such steep drops, the prey was relatively large, a blattodean, orthorpteran or mantodean (Rijiar Zaki site, August 2016). There were two drops targeting other males, and five others seemingly unconnected to any predatory or territorial efforts.

Perpetual Feeding by Some Young and Juvenile Lizards

On some days, mostly during the rainy season, search and pursuit of flies and ants appeared to continue for much of the daylight time, exceeding eight hours, observed in five of a dozen animals (41%) at the Gezawa site. Predation was mostly within shaded areas; beneath rocks and in crevices of walls and cracks of trees; and on shaded cliffs, and also on the ground, only breaking off from the effort for less than 15 minutes at a time.

Relishing on White Mold and Other Fungal Mycelia

Mature females and young & juvenile lizards, (and not as often, mature males), appeared to relish frequently on immature (not yet sporulating) white mold and other fungal mycelia, halting only when the supplies are exhausted. The white mycelia, probably, *Sclerotinia sclerotiorum*, often grows on spinach; weeded, damaged and poorly uprooted but, still moist herbs and leaves; also grows on some legume leaves, as well as, on plant vegetable wastes thrown away from large cafeteria (in, and outside the aforementioned study sites), and in residential areas.

Times of Feeding Activities

This varies with the season in the dry savannah of Nigeria. During late dry season (March to May) when the air and most surfaces get hot, feeding starts as early as 5.20am, nearly an hour before sunrise, with ambient temperature about 20 to 25^0C. However, heavy rains over a few days during the peak season in July and August would moderate the temperatures making the early mornings damp and cool. On such days, lizard feeding activities start much later, at about 9am. Feeding and all other activities, except under shaded

areas, decline or come to a total halt from about midday, until nearly 5pm local time (except in the Harmattan cold dry months of December, January and February). Even in shaded areas lizards would retreat into tree fissures, brick holes and beneath large boulders, apparently seeking cranny microhabitats that offer reduced temperatures. During these retreat periods, adult males are more conspicuous than either mature females or young & juveniles. Late November to mid-February temperatures are generally low in the Kano area, and early morning and late afternoon feeding activities for *A. agama* are conversely reduced.

DISCUSSION

Frequency ranking of selected dietary items is most likely a reflection of both preference and availability of those items, the reality of what the habitats offer. This goes to show the opportunistic and generalist tendencies of the species [3]. It was not clear why the lizards did not depredate on berries, like tomatoes, which has been reported in the literature [14], though the items were available during the rains in at least in one of the study sites, namely, Jan Guza. Perhaps, this is an indication of preferential food selection in the presence of good supplies of insect.

The degree of deployment of the predatory 'dance' had varied between the sites – perhaps an indication of prey density, since the 'dance' would not be deployed where the fly density exceeds 15 per square meter, and in some of the sites the number of lizards deploying the 'dance' at a particular percentage level was very low, to zero. For instance, only three young & juvenile lizards from all the four sites fell into the 80% level of 'dance' display category. Hence, allowed the pooling of the entire data for all sites together. Because the predatory 'dance' was deployed mostly by the very young lizards, and very infrequently seen in adults, and even then, only a slight hint or caricatural form of it (the rotational component being less than 25 degrees, compared to up to 170^0 in some young lizards), this author thinks the dance maneuver is an innate predatory strategy vital for that critical stage of early growth, rather than a learnt behavior. Obviously, the predation strategy is lost or, simply not deployed as the lizard matures, probably passing through an ontogenetic transition. It is interesting, and should be emphasized that this prey capture strategy is not deployed where the prey abounds, such as near a butcher's table and kitchen garbage dump, and was never seen used against a non-winged prey or fly larvae. In situations of prey abundance, with flies in close proximity, the strategy simply involves strikes, capture and pause, and a repeat cycle for the next prey, with flies picked up the same way as ants, without any elaborate body jolts, retreats, and clockwise rotation. It is not clear how the young *A. agama* predatory 'dance' immobilizes or, somehow, predisposes its winged prey

invertebrates to capture. It is a curious habit calling for further examination. This author is also unaware of previous reports of this predatory 'dance' or other elaborate body maneuvers involved in predation by *A. agama*.

[8] in a study of *A. agama* in south eastern Nigeria has explained his observations of low representation of mosquitoes and house flies in the diet of *A. agama*, to the winged morphology of the insects – being more active compared to the non-winged tailor ants and termites, and thus able to escape some capture by the lizards. On the contrary, my observations do not support the data that the ability of flight in dipterans was of any benefit against their fate as prey insects to *A. agama*. As noted above, I have observed some of these young and juvenile lizards feed for hours, and take their fill on nothing else but winged flies.

Evidence of depredation of chicks and bird nestlings by *A. agama* represents a new dimension to the dietary spectrum and behavior of *A. agama*, and if the trend continues, might earn it the status of a new pest, and open it to attacks and possibly localized decimation in rural steads where the chickens are highly valued. This predatory evidence might also suggest a declining food resources base for the lizard as more agricultural weeds, marginal vegetation and other insect habitats give way to new farms and developments. Evidence of cannibalism by *A. agama* was recorded only twice throughout the duration of the present study, and this is consistent with data in the literature ([15]; [3]), i.e., although cannibalism in the species does occur, it is a rare event.

The steep jumps and drops observed were peculiar to adult male *A. agama*. Although associated with prey capture in more than half of the events, there were times when no particular activity could be linked to this vertical jump or drop. In some instances, a mature cock would jump off over three meters to pursue and chase off another male intruder, in one instance for as far as 186m on the ground. While the jump upwards may be mostly linked to prey, the drop down might probably help in intimidating other males to keep off that particular territory. Interestingly, five cases of mature female involvement in territorial defense, far less frequently than male cocks.

The feeding frenzy noted in about 25 percent of young and juveniles observed may probably be linked to high demands of their metabolic functions at critical growth phase. The interesting thing about white mycelia, *Sclerotinia sclerotiorum*, and other fungal species on which *A. agama* often relishes, is the potential difficulty in trying to identify it in fecal content analysis, thus, underscoring the value of direct foraging surveillance.

Although there are reports of nocturnally foraging *A. agama* under artificial light conditions [6], night foraging was not observed in this grass

belt of Nigeria, notwithstanding that *A. agama* is probably the most common and abundant of all commensal animals, and could easily forage at any time undisturbed by near absence of natural predators. There is however, the exception of foraging at dawn, pre-sunrise, about 5.40am local time, during a period one month, April, or so before the onset of rains. In this period the 9:00am temperature could reach up to 30^0c, and would keep rising, and may exceed 40^0c post midday, a condition that becomes unbearable for most living organisms, anyway. It is therefore conceivable that *A. agama* gets active early in the morning, before sunrise, and withdraws to a cooler microhabitat before the ambient air gets too hot.

CONCLUSION

From the foregoing observations, young and juvenile lizards of *A. agama* would take to foraging on most prey insects regardless they are winged or not, but when the winged prey population gets low, more than 70% of the young and juvenile lizards would deploy a rather curious, elaborate behavior, in order to capture their prey. I described this elaborate maneuvers as "*Agama* predatory 'dance"'. These physical maneuvers are rarely deployed by the adult lizards or, if deployed, only in its caricatural, crude form, prompting the conclusion that the *A. agama* predatory 'dance' is an innate rather than a learnt behavior. Finally, based on the present data, and others in the literature, *A. agama* could be described as an insectivorous, commensal, reptile with opportunistic dietary tendencies. The dietary opportunism in *A. agama*, evident in its depredation of local reptilian fauna in Santo Antão Island [3], calls for close monitoring of the species, especially as it is beginning to colonize new territories - the southern Florida and Madagascar examples, lest it becomes a threat to the stability of local ecosystems. It is equally of interest that when natural diet insect populations of *A. agama* drop, the lizard could resort to depredating nestlings of chickens and songbirds, which might probably lead to it's being targeted for elimination in rural homesteads.

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