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# ASPECTS OF THE MORPHOMETRY, GROWTH-RELATED PARAMETERS AND REPRODUCTIVE CONDITION OF AGAMA LIZARDS IN AGO-IWOYE, NIGERIA

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## ABSTRACT

Immature, adult males and females of the lizard, *Agama agama* (L.) collected at Ago-Iwoye, Nigeria during the second and third quarters of 1987, differed most in snout-vent lengths (SVL). They averaged 59 ± 3mm, 125 ± 2mm and 104 ± 3mm SVL respectively and also differed in dimensions and weights of other body structures. These structures, including scales, eyes, tail and hind limb, correlated well with SVL and grow allometrically in relation to it. They can therefore be used to separate *Agama agama* into age-sex classes. Females are capable of breeding at 91mm SVL and those in breeding condition differed from non-reproductive members in weights and dimensions of gonadal structures ($P<0.001$) but not SVL and body weight ($P>0.10$). Males in reproductive condition differed from non-reproductive ones in SVL, body weight and reproductive parameters ($P<0.001$).

## INTRODUCTION

In tropical Africa, where it is widely distributed, the Agama or rainbow lizard, *Agama agama* (Family — Agamidae) is the most common reptile due to its tolerance of a considerable range of climatic conditions (Harris, 1963). Despite its abundance and common occurrence, this lizard has been little studied. Its breeding biology in Kenya (Marshall and Hook, 1960), growth and cyclic behaviour in Liberia (Daniel, 1960), and general biology in Ghana (Chapman and Chapman, 1964) have been studied and reported. Tinkle (1969) reviewed life history strategies of lizards and postulated that *Agama agama* is early-maturing, short-lived, multiple-clutched and acyclic in breeding.

Reported investigations of *Agama agama* in Nigeria were carried out in widely-separated periods of time. Harris (1963, 1964) described the anatomy, general habits, territorial behaviour and reproductive biology of the lizards collected from Ibadan and Lagos, Nigeria. The diurnal activity pattern, and population density were investigated by Halstead (1970) and Ekundayo and Otusanya (1969). Male *Agama agama* are usually bigger than females in size and are polygynous. The ratio of males to females varies between 1:3 in the rainy season to 1:4 in the dry season. These lizards are inactive at dawn. Thereafter, activities increase and peak in the late afternoons.

The size distribution and morphometrics, growth rate, and reproductive parameters of this species have been little studied. Information on sizes of lizards at specific stages of sexual maturity and known ages are required by those conducting field research on population and general ecology of these lizards. Life history data are also needed to test hypothesis on reproductive strategy of *Agama agama*.

In this paper, results of a preliminary investigation of the growth relationships and morphometrics, age-sex differentiation criteria and reproductive condition of *Agama* lizards collected between March and August 1987 on the Ogun State University Mini-Campus, Ago-Iwoye, Nigeria, are presented.

## STUDY AREA AND METHODS

The study site, the Ogun State University Mini-Campus, Ago-Iwoye, occurs in the southern Nigerian Rain Forest belt. Open spaces between buildings on the Mini-Campus are interspersed with grasses and planted shrubs and the roads are bordered by unpainted concrete drains.

Eighty-two lizards collected from different sites on the Mini-Campus were each studied as a unit for morphometric features, growth and its indices and reproductive activity. Lengths of the following expressed to the nearest mm or 0.1mm were recorded for each lizard caught: snout-vent (SVL), hind limb (HLL), intact tail (TL), eye diameter (ELD), and scale (SL) removed from the dorsal part of the tail near its junction with the trunk. Dimensions of ovarian follicles or oviductal ova were recorded for females.

Weights of: the whole body (GBW), eye (ELW), paired ovaries and oviduct with follicles and eggs, paired testes (TW) and the epididymis (EW) were recorded to the nearest 0.1g or 0.01g for the applicable sex. The epididymis: testis weight ratio (ETR) was determined for males.

Lizards were categorised as immature, and adult (sexually-mature) males and females on the basis of gonadal maturity. Breeding females were either vitellogenic with developed, yolked ovarian follicles; or ovigerous with oviductal eggs. Non-breeding females were those which had undeveloped, milky-white ovarian follicles and no oviductal eggs. Male

| Attribute | Immature (14) | Adult males (40) | Adult females (28) |
|---|---|---|---|
| SVL (mm) | $59 \pm 3^{c}$ | $125 \pm 3^{a}$ | $104 \pm 2^{b}$ |
| Scale length (mm) | $1.1 \pm 0.1^{b}$ | $3.5 \pm 0.1^{a}$ | $2.8 \pm 0.1^{a}$ |
| Eye diameter (mm) | $4.2 \pm 0.1^{b}$ | $8.1 \pm 0.1^{a}$ | $7.4 \pm 0.1^{a}$ |
| Eye weight (g) | $0.12 \pm 0.01^{b}$ | $0.36 \pm 0.02^{a}$ | $0.28 \pm 0.01^{a}$ |
| Body weight (g) | $8.2 \pm 1.4^{c}$ | $68.1 \pm 3.4^{a}$ | $40.2 \pm 1.7^{b}$ |
| TL:SVL ratio | $1.78 \pm 0.06^{a}$ | $1.44 \pm 0.04^{b}$ | $1.65 \pm 0.05^{a}$ |
| HLL:SVL ratio | $0.30 \pm 0.01^{a}$ | $0.27 \pm 0.01^{b}$ | $0.25 \pm 0.01^{b}$ |

TABLE 1: Mean dimensions, weights and morphometric measurements (± S.E.) of body structures of Agama lizards belonging to different age-sex classes. Number of lizards in each category is shown in parentheses.
Mean along rows with same superscript are not different (P>0.05).

*Agama agama* were placed in breeding categories on the basis of their body weights, testes weights and ETR. Breeding males were those that had higher-than-average values of the 3 parameters while non-breeding ones had lower values.

Frequency distributions of lizards according to their SVLs, TL:SVL and HLL:SVL ratios were inspected to determine the utility of the variables as age-sex class indicators. The relationship between some of these and other variables where lengths were expressed in cm and weights in g., was examined by correlation and regression. The occurrence of allometry between any 2 body dimensions compared was proven by: (i) testing for deviations of observations from simple size allometry (Simpson *et al.*, 1960), and (ii) testing the homogeneity of regression and correlation coefficients of juveniles, adult males and females by means of an F-test and a $X^2$-test criterion respectively (Steel and Torrie, 1980). Constants of the allometric growth formula, $Y = bX^a$ are indicated.

Pair-wise and multiple comparisons were made using the t-test and one-way analysis of variance (ANOVA). Mean separations were accomplished with Duncan's New Multiple Range Test. Results of statistical tests were considered significant at $P<0.05$; highly significant at $P<0.01$.

## RESULTS

### Size Distribution of *Agama agama*

The snout-vent length (SVL) showed the sharpest modal separation of the lizard age-sex classes. The general distribution modes of low SVL, intermediate SVL, and high SVL fitted those of immature (55mm), adult females (105mm), and adult males (135mm) respectively (Fig. 1a). The smallest-sized juvenile was 45mm SVL while the biggest was 75mm SVL. Sizes for adult males and females were between 84-148mm and 89-119mm SVL respectively. The TL:SVL distribution was trimodal (Fig. 1b), while the general distribution of HLL:SVL quotients was unimodal (Fig. 1c).

Means of snout-vent length, body weight and other variables for sampled lizards categorised into the 3 age-sex classes are shown (Table 1). Immature, adult male and adult female lizards differed in SVL, eye diameter, eye weight, scale length and gross body weight which were highest in adult males (all tests one-way ANOVA, $P<0.01$). They also differed in HLL:SVL and TL:SVL ratios (F tests, $P<0.01$), which were greatest in immature lizards.

Body weight ranges were 2.5-18.4g for the immature, 22.6-54.0g for adult females and 21.1-107.8g for males. The upper limits of ranges of the eye diameter, eye weight, scale length, hind limb length and tail length for immature lizards were respectively 5mm, 0.2g, 1.5mm, 21mm and 142mm. The minimum values of these parameters for the sexually-mature were 6mm, 0.1g, 1.0mm, 22mm and 122mm consecutively.

### Growth Relationships and Morphometric Analysis

There was no systematic deviation of observations from a simple allometric relation for each dependent variable versus the snout-vent length, as no trend or curvature was apparent from a plot of these deviations. Regression coefficients, a, for relationships considered for each age-sex category, which also constitute the constant of allometry since all values were log-transformed, were homogeneous for the regressions on SVL of scale length ($F_{2,76} = 0.02$, $P>0.10$), eye diameter ($F_{2,76} = 0.11$, $P>0.10$) and eye weight ($F_{2,76} = 0.33$, $P>0.10$).

The correlation coefficients and constants which specified the growth relationship between the SVL and these dependent variables are shown (Table 2). Allometry constants were positive and above 1 for scales, eye weight, and pooled body weights, but, below 1 for the eye diameter, the tail, and the immature lizards' hind limb length in relation to the SVL. The allometry constant was negative for adult hind limbs. Correlation between snout-vent length and each of the following : scale length, eye diameter, eye weight, and tail length; was significant ($P<0.05$) for juvenile and adult *Agama agama* except for eye diameter of females whose correlation with SVL was not significant ($P>0.10$). Body weights of the individual age-sexes correlated poorly with total body length ($P>0.10$).

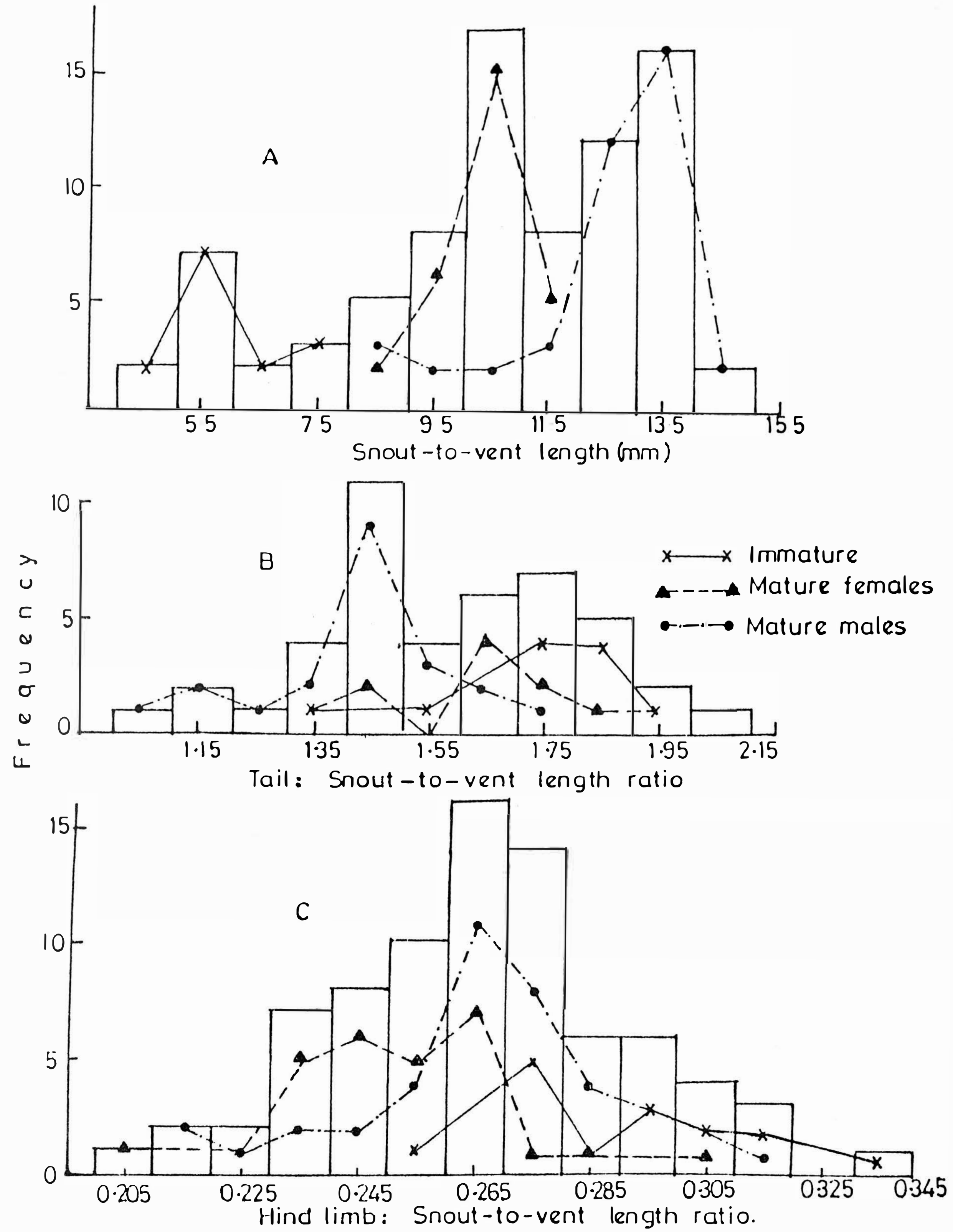


Fig. 1 Distribution of all sampled Agama lizards (histogram) and of the component age-sex classes (frequency polygons) according to their Snout to vent lengths (A) TL:SVL ratio (B) and HLL to SVL ratio (C).

| Dependent variable (Y) | Males r | Males b | Males a | Females r | Females b | Females a | Immature r | Immature b | Immature a | Overall (pooled) r | Overall (pooled) b | Overall (pooled) a |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale length | 0.69 ** | 0.01 | 1.37 | 0.65 ** | 0.01 | 1.44 | 0.63 * | 0.01 | 1.40 | 0.91 ** | 0.01 | 1.55 |
| Eye diameter | 0.84 ** | 0.22 | 0.52 | 0.31 n.s. | 0.15 | 0.70 | 0.69 ** | 0.14 | 0.60 | 0.89 ** | 0.10 | 0.82 |
| Eye weight | 0.48 ** | 0.02 | 1.12 | 0.47 * | 0.02 | 1.66 | 0.76 ** | 0.01 | 1.38 | 0.83 ** | 0.01 | 1.41 |
| Hind limb length | 0.97 ** | 33.57 | −1.02 | (males and females pooled) | | | 0.94 ** | 0.45 | 0.75 | 0.48 ** | 1.02 | 0.42 |
| Tail length | 0.53 * | 3.30 | 0.68 | 0.63 ** | 3.02 | 0.74 | 0.72 ** | 3.02 | 0.71 | 0.75 ** | 4.73 | 0.52 |
| Body weight (versus t. body length) | 0.14 n.s. | 10.14 | 0.58 | 0.36 n.s. | 10.91 | 0.38 | 0.51 n.s. | 0.05 | 1.79 | 0.88 ** | 0.01 | 2.76 |

TABLE 2: Correlation coefficients and constants of the allometric growth relationship, $Y = bX^{a}$ between SVL or total body length (X) and other variables (Y) for the 3 Agama lizard age-sex classes.
n.s., not significant; * significant ($P<0.05$); ** highly significant ($P<0.01$).

There was distinct discontinuity in the regression lines fitted for the SL-SVL relationship, between juveniles and adults (Fig. 2). The correlation coefficients ($X^2 = 0.49$, 2d.f., $P>0.75$) and regression slopes ($F_{2,76} = 0.02$, $P>0.10$) of each age-sex category did not differ from each other and from the composite. The pattern was the same for eye diameter and weight, which were not plotted.

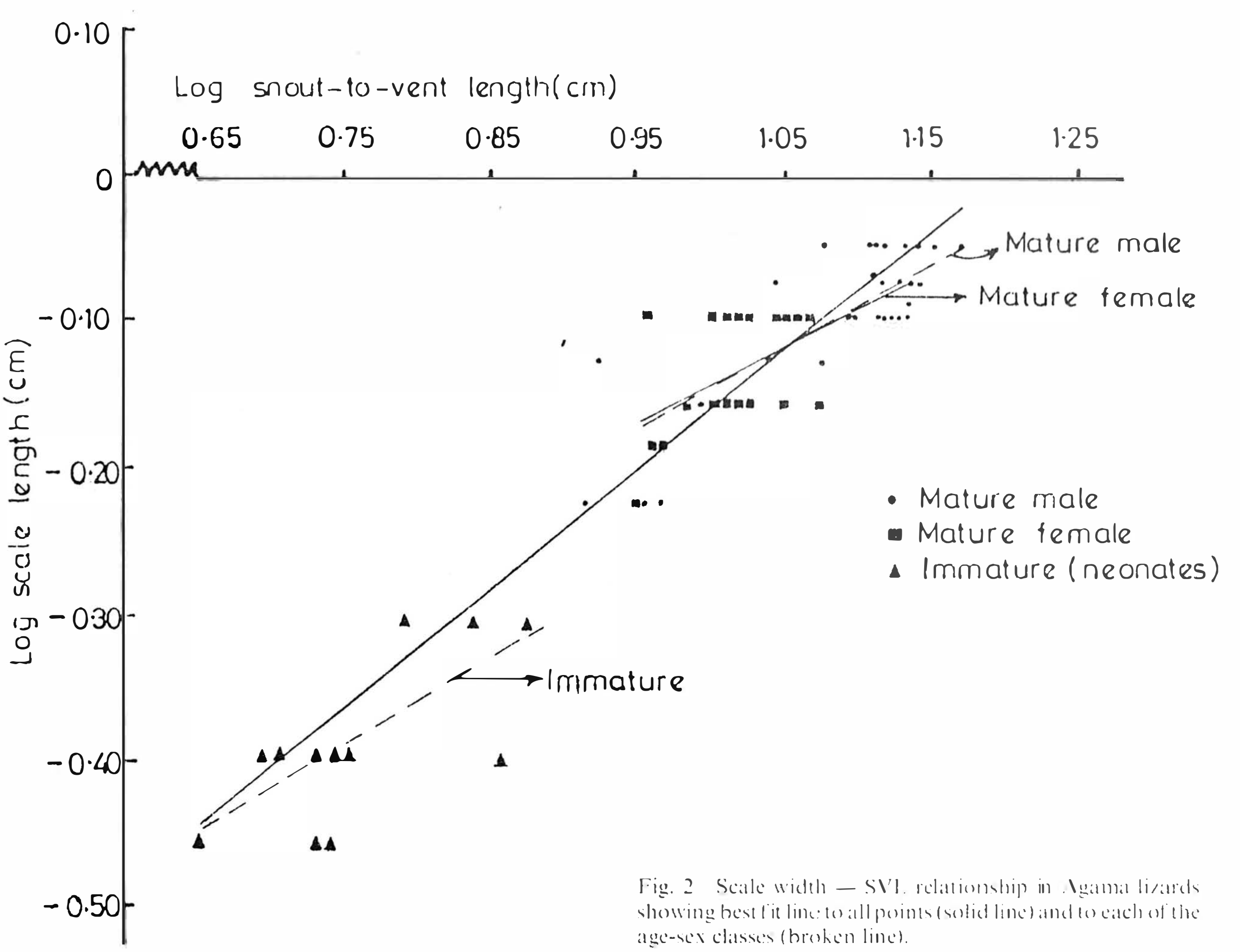


Fig. 2 Scale width — SVL relationship in Agama lizards showing best fit line to all points (solid line) and to each of the age-sex classes (broken line).

| Breeding category | SVL (mm) Range | SVL (mm) Mean ± S.E. | Body wt. (g) Range | Body wt. (g) Mean ± S.E. | Ovary wt. (g) Range | Ovary wt. (g) Mean ± S.E. | Oviduct wt. (g) Range | Oviduct wt. (g) Mean ± S.E. | Ovum length (mm) Range | Ovum length (mm) Mean ± S.E. |
|---|---|---|---|---|---|---|---|---|---|---|
| Ovigerous (8) | 91 – 111 | 103 ± 2 | 32.4 – 44.1 | 38.7 ± 1.3 | 0.15 – 0.30 | $0.20^{b}$ ± 0.02 | 3.41 – 10.70 | $7.05^{a}$ ± 0.92 | 16.0 – 24.0 | $18.4^{a}$ ± 1.3 |
| Advanced vitellogenic (8) | 100 – 116 | 108 ± 2 | 36.2 – 60.0 | 45.4 ± 3.0 | 3.20 – 4.80 | $4.45^{a}$ ± 0.25 | 0.60 – 1.00 | $0.86^{b}$ ± 0.05 | 7.0 – 10.0 | $8.8^{b}$ ± 0.4 |
| Early vitellogenic (7) | 92 – 109 | 102 ± 2 | 26.7 – 55.3 | 38.1 ± 3.9 | 0.80 – 1.90 | $1.21^{b}$ ± 0.17 | 0.20 – 0.90 | $0.44^{b}$ ± 0.08 | 4.0 – 7.5 | $5.8^{bc}$ ± 0.5 |
| Non-breeding (5) | 89 – 119 | 104 ± 7 | 22.6 – 52.7 | 37.4 ± 5.9 | 0.10 – 0.40 | $0.23^{b}$ ± 0.05 | 0.01 – 0.10 | $0.05^{b}$ ± 0.02 | 2.0 – 3.5 | $2.5^{c}$ ± 0.4 |

TABLE 3: Dimensions and weights of the body and reproductive parameters of female Agama lizards belonging to different breeding categories. Number for each category is shown in parentheses.
Means along columns with same superscript(s) are not different (P>0.05).

### Reproductive State and Size at Maturity of *Agama agama*

We observed that breeding females constituted 82 per cent of females caught while males in breeding condition made up 55 per cent of males sampled. Breeding lizards belonging to both sexes were found during the months of study (April-August).

*Female:*

There was no difference in the SVLs ($F_{3,24} = 0.85$, $P>0.10$) and body weights ($F_{3,34} = 1.25$, $P>0.10$) of non-breeding, early-vitellogenic, late-vitellogenic, and ovigerous females who differed significantly (F-tests, $P<0.001$) in weights of the ovary and oviduct, and size of follicles or ova (Table 3). Among breeding females with mean SVL of 103 ± 2 (S.E.)mm, none less than 91mm SVL contained vitellogenic follicles or oviductal eggs. Advanced vitellogenic females had the greatest ovary weights while oviductal weight was highest in ovigerous females whose ova were largest.

Mean ova per ovigerous female lizards sampled was 6. Three non-breeding females (mean SVL 103mm) with distended oviducts had mean oviductal and ovarian weights of 0.01g and 0.15g respectively. Six eggs laid by a gravid female lizard on 22 June hatched on 18 and 19 August, 1987. The snout-vent lengths of the hatchlings at emergence ranged between 37-39mm (Mean 38 ± 3mm).

*Male:*

Males in breeding condition differed from the non-breeding in SVL ($t = 4.15$, d.f.37, $P<0.001$), body weight ($t = 5.69$, d.f.37, $P<0.001$), and epididymis: testes weight ratio ($t = 6.96$, d.f.37, $P<0.001$). They had consistently higher values of these variables than the non-breeding males (Table 4). The smallest male in breeding condition had a snout-vent length of 125mm and 3 other males had SVLs greater than 125mm but lower than 130mm. Four non-breeding males with atrophied testes and epididymis had SVLs ranging between 131mm and 142mm (Mean 136 ± 2mm) and ETR and testes weights averaging 0.08 ± 0.02 and 0.25 ± 0.05g respectively.

| Breeding category | SVL (mm) Range | SVL (mm) Mean ± S.E. | Body wt. (g) Range | Body wt. (g) Mean ± S.E. | Testis wt. (g) Range | Testis wt. (g) Mean ± S.E. | Epididymis wt. (g) Range | Epididymis wt. (g) Mean ± S.E. | ETR Range | ETR Mean ± S.E. |
|---|---|---|---|---|---|---|---|---|---|---|
| Breeding (22) | 125 – 148 | 133 ± 1 | 64.2 – 107.8 | 81.5 ± 2.6 | 0.30 – 0.90 | 0.56 ± 0.04 | 0.10 – 0.20 | 0.12 ± 0.01 | 0.25 – 0.33 | 0.22 ± 0.01 |
| Non-breeding (18) | 84 – 142 | 117 ± 4 | 19.6 – 75.0 | 53.6 ± 4.4 | 0.10 – 0.50 | 0.25 ± 0.03 | 0.01 – 0.05 | 0.02 ± 0.01 | 0.03 – 0.25 | 0.08 ± 0.02 |

TABLE 4: Dimension and weights of the body and reproductive parameters of breeding and non-breeding male Agama lizards. Number for each category is shown in parentheses.

## DISCUSSION

The snout-vent length has utility as an age predictor in *Agama agama* because it differed well between immature and adults. However, the TL:SVL and HLL:SVL distributions are poor indicators of age or age-class because there was considerable overlap between the tails of the individual distributions of immature, adult male and adult females.

On the basis of SVL only, juveniles can be easily separated from sexually-mature lizards on the field since these are individuals with SVLs of 75mm or less. Adult males with sizes greater than 125mm SVL can be differentiated from females whose maximum recorded dimension in Ago-Iwoye was 119mm SVL, a greater length than the 116mm SVL for females in Ibadan (Harris, 1964). Males and females within the 84-120mm SVL range can be partially separated on the basis of body weight since no female heavier than 60g was sampled, neither has any been reported in earlier studies. Chapman and Chapman (1964) used mostly weight as criterion of size in their study although body weights alone may not be reliable for this purpose because they are affected by the condition of the animal. Finally, presence of anal pads in the vent region of males (Harris, 1963) can be employed in identifying the sexes where there is overlap in size or weight of the animals.

Overlap in the tail lengths of immature and adult lizards might be due to the differential growth rate of each age-sex tail. Chapman and Chapman (1964:122) observed that the rate of increase in tail length was less in old females compared to males so that female tails were shorter. Overlap in tail length between older juveniles and sub-adult females might thus occur. Similar overlaps occurred for eye weight and scale length the implication of which is that these variables cannot be used in isolation to separate lizard age-classes.

The tests of deviation of observations from allometry and of homogeneity of allometry constants indicated the occurrence of an allometric growth relationship between the dependent variables and SVL of *Agama* lizards. The ontogenetic changes in the dimensions of the eye, tail and hind limb in relation to the SVL indicate that there was decrease in the sizes of these, relative to the latter. These structures grew at a slower rate although, they did not cease growth because their absolute dimensions were greater in older and larger-sized lizards than in younger, smaller-sized ones. A negative coefficient of allometry indicates that the organ or structure showing it grows smaller as the dimension of the other structure it is being compared with increases (Simpson *et al.*, 1960: 404). It is highly unlikely that the hind limbs of adults decreased as their SVLs increased, rather, the hind limbs probably ceased growing altogether on, or after adulthood was attained. This readily explains the positive allometry constants for immature lizards and all the lizards sampled since, the immature phase represents the period of most active hind limb growth. The scale length, eye weight and overall body weight increased at a faster rate than the SVL.

The composite regression equations for the growth relationships of *Agama agama* considered can be used to fit all lizards because the correlation and regression coefficients of the individual age-sexes were homogeneous.

Compared to the incubation period of 58 days for eggs in this study, eggs brooded in the laboratory by Harris (1964) whose oviposition dates were unknown, hatched before 32 days. The sizes of the hatchlings at emergence were, however, similar in both cases. Growth trajectories based on data from these two studies shows that females of size 90mm SVL are about 14 months old while males at 125mm SVL are aged circa 22 months.

The lack of disparity in body weights of the breeding and non-breeding females suggests compensatory weight loss by breeding females aimed probably at reducing the risk involved in carrying a weight heavier than the normal for the population. The values of some reproductive parameters for females in Ago-Iwoye is in consonance with those for female *Agama agama* in Ghana (Chapman and Chapman, 1964). In both instances, females with maximum ovary weight of 4.0g and oocyte dimension of 12mm were advanced vitellogenic; those with ovary weight circa 0.16g were ovigerous; while an ovary weight of 0.5g or less was characteristic of non-breeding females. As evident from this study, females that have recently oviposited have; ovary weights similar to ovigerous ones, no oviductal eggs, oocytes with same dimensions as non-breeding members and oviducts more distended than those of vitellogenic and non-breeding female *Agama agama*. These criteria are useful in delineating breeding categories of female lizards.

Lizard testicular condition and weight vary with spermatogenic activity (Licht *et al.*, 1969). Occurrence of spermatozoa in the testicular lumina, hypertrophy of the epididymis, and subsequent spermiation are indicative of reproductive readiness. The epididymis: testes weight ratio and testicular weight are, therefore, good indicators of breeding condition of male lizards. We separated male *Agama agama* into breeding categories on these basis. The occurrence of males in breeding condition in all our monthly samples in the southern Nigerian Rain Forest where, the lizard has been observed to breed all the year round (Harris, 1964, Ekundayo and Otusanya, 1969), probably attests to the acyclic nature of breeding reported for the species (Tinkle, 1969, Tinkle *et al.*, 1970).

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# IDENTIFICATION OF INDIVIDUAL ADDERS (*VIPERA BERUS*) BY THEIR HEAD MARKINGS

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## ABSTRACT

During a study of adders (*Vipera berus*) in Wyre Forest, a systematic method was developed to identify individuals in the field. It was revealed that no two adders possessed identical head markings. It was shown that a photographic record was a reliable aid to identification. Furthermore it was observed that over the period of study adders retained their individual head markings.

## INTRODUCTION

This paper originates from a study of the adder, (*Vipera berus*), in Wyre Forest, Worcester, U.K., which began in 1981 and is now in its 8th year. During the early stages of this work the great diversity of head markings found on the adder became apparent. In attempting to follow the movements and specific seasonal behaviour of a sizeable population of adders, it was preferable if a simple method of identifying adders in the field was available, which allowed for positive identification of individuals without the associated problems of handling and disturbance.

## STUDY AREA

The study area was centred upon a plantation of Japanese Larch (*Larix kaempferi*), in which a number of old coppice stools remained from a previous stand of sessile oak (*Quercus petraea*) that occupied the site prior to 1970.

## METHOD

During the active period regular visits were made to the main study area. Notes were taken recording time, weather conditions, ambient and ground temperatures.