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Prediction of Optimum Stocking Density in Growing African Giant Land Snails

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Target Audience: Researchers, Poverty Alleviation Agencies, Microlivestock Farmers

Abstract

Over a period of 33 weeks, weekly measurements were taken on 255 Archachatina marginata snails (15, 30, 45, 60 and 75 hatchlings/m^2) randomly drawn from a population of 375 one-week old hatchlings divided into five treatments of 25, 50, 75, 100, and 125 hatchlings/m^2, respectively. The data were subjected to analysis of variance in a completely randomized design to determine the influence of stocking density on snail bodyweight and shell length. Regression functions were applied to predict the optimum stocking density of A. marginata snails reared in the tropics. Results revealed positive and highly significant ($P<0.001$) correlations between age, body weight and shell length at all stocking densities. Especially, in treatment one (25 snails/m^2) it was also shown that shell length had significantly ($P<0.001$) higher influence on the bodyweight compared to the age of the growing snail. Considering the growth trends and the profitability of the business, the optimum stocking density was placed at 38/m^2. The study concluded that, stocking rate is an important environmental variable that affects growth trends in growing snails and that shell length is a good predictor of bodyweight. We recommended an optimum stocking density of 38snails/m^2 for growing A. marginata raised in the humid tropics.

Keywords: Archachatina marginata; Optimum stocking density; Statistical models

Description of Problem

In recent decades, the use of genetic approach in the improvement of growth rate in animals has been greatly successful (1, 2). Growth in animal is a measure of live weight associated with an increase in size. Its trend defines periodic changes that occur in an animal's size in terms of length and weight (3). This growth trend is characterized by several environmental factors such as temperature, feeding pattern, stocking density and diseases in relation with genetic structure and sex (4).

□eng□l and Kiraz (5) noted that since continuous measurement of growth processes is nearly impossible, model measurement by mathematical functions is preferred, because it allows interpolation of non-observed intervals with respect to age or body weight of animals. Several models have been established on growth trends in poultry (3, 6, 7, 8), pigs (9), cattle (10) and sheep (11). However, there is paucity of information on species such as snails.

The African giant land snail (*Archachatina marginata*) is the largest known snail type in Africa (12). It is an herbivorous, non-selective scavenger which dwells naturally in the forest litters of the tropical rainforest zone in Nigeria (13, 14). It contains about 65% crude protein with higher levels of calcium and iron compared to other animal protein sources (12, 15, 16).

Environmental variables are among the determining factors in the survival, growth and sustenance of any existing organism in its niche (17). Hoping to maximize profit and minimize cost, livestock producers increase the stocking density of their animals either, by increasing animal number in decreasing floor area or increasing number in confined floor spaces. The latter may increase the susceptibility of the animals to infections and parasitic diseases, as well as increase the stress-level of the animals, which may lead to lower production efficiency. To counter these problems and to enhance profit margin, the determination of the optimum stocking density for various production environments had been emphasized (18, 19).

Attempts at determining the optimum stocking density of growing snails in Nigeria are on-going. To date, no published report is available on the use of statistical models for predicting the optimum stocking density of snails. This study was therefore designed to statistically ascertain the optimum stocking density of growing *Archachatina marginata* using mathematical functions and relationships existing between growth traits as prediction tools.

Materials and Methods

A total of three hundred and seventy-five (375) day-old *A. marginata* hatchlings (average weight of 13.57±1.18g) were obtained from the green house in the Department of Forestry and Wildlife, University of Calabar, Calabar, Nigeria. The green house is situated about 50m from the University's meteorological research laboratory. Inyang (20) reported the climatic profile of Calabar as being; mean annual rainfall (3050mm), average temperature (26.10°C) and relative humidity (80%) all year. Prior to data collection, the hatchlings were acclimatized to the environment for one week.

The hatchlings were weighed and randomly assigned to one of the five treatments consisting of 25, 50, 75, 100 and 125 hatchlings per square meter. Each treatment was kept in a wooden cage (16cm x 25cm x 25cm) on a floor space of one square meter. The cages were filled with loamy soil up to 15cm thick (21). All treatments were fed *ad libitum* on the same diet formulated from local feed ingredients (Table 1). Their enclosures were kept damp throughout the thirty-three (33) weeks of experiment. Feed offered was supplemented daily with freshly harvested pawpaw leaves. Daily watering and feeding operations were carried out in the evenings (18.00-19.00hrs).

Table 1: Composition of experimental diet

Ingredient	Composition (g/kg)
Groundnut cake	22.00
Cassava flour	52.00
Bone meal	10.00
Oyster shell	10.00
Vitamin premix	6.00
Total	100.00

To adjust for variation in stocking rate, a sample of 225 hatchlings (15, 30, 45, 60 and 75 snails in treatments 1, 2, 3, 4 and 5, respectively) was selected of which data on body weight and shell length were collected. Body weights were measured weekly using a beam weighing balance and shell length using a veneer calliper. Adjusted mean values for each treatment were recorded weekly.

Data collected were subjected to the analysis of variance in a completely randomized design. Phenotypic correlations existing between body weight, hatchling age and hatchling shell length were established using Harvey's (22) least squares mixed model. Three regression functions were also used in predicting body weight of snail hatchling from age, shell length or both parameters.

The functions were:

1. Simple linear regression $Y = a + bX$
2. Allometric regression $Y = aX^b$
3. Multiple linear regression $Y = a + b_1X_1 + b_2X_2$

With the generalized prediction model as;

$$Y_i = a + \sum_{i=1}^{k} b_i x_i + e_{ij}$$

Where, Y = Body weight of i^{th} hatchling, a = intercept, b_1, b_2 = Partial regression coefficients, x_1, x_2 = Age/Shell length, and e_{ij} = Random error (*NID~ 0, δ^2*).

Using these functions, the optimum stocking density was determined based on function which best predicts *A. marginata* weight at the highest correlation coefficients while considering the effect on each stocking rate.

Results and Discussion

Values for the bodyweight and shell length of *A. marginata* hatchlings at the five stocking densities are presented in Table 2. Hatchlings stocked at 25/m^2 and 50/m^2 had similar body weight and shell length. Compared to those at 25 hatchlings/m^2, other treatments (higher stocking densities) showed significantly (P<0.001) lower values. This suggested that the bodyweight and shell length of growing *A. marginata* snails are compromised at stocking densities higher than 50 hatchlings / m^2. The optimum stocking density may be between 25 and 50 hatchlings / m^2.

Table 3 shows the phenotypic correlations (r_p) existing between age, shell length and body weight in growing African giant land snail (*Archachatina marginata*) stocked at different rates. Results revealed positive and significant (P<0.001) relationships between age and body weight (r = 0.97-0.99), age and shell length (r = 0.85-0.99) across treatments. The best correlation was exhibited between shell length and body weight in the treatment stocked at 25snails/m^2. Other stocking densities showed better correlation between snail age and body weight. Statistically, the results indicated that highly significant relationships exist between age, shell length and body weight in *A. marginata* as earlier suggested by the reports of Ejidike *et al.* (17) and Omole and Kehinde (19). The decline in levels of correlation at higher stocking densities suggested the influence of stocking density on the growth pattern and efficiency of growing *A. marginata* reared in a controlled environment in the humid tropics.

Table 2: Mean bodyweight and shell length of *Archachatina marginata* as influenced by stocking density

Treatment	Bodyweight (g)		Shell length (cm)	
	Mean	SE	Mean	SE
1	5.39^a	0.72	30.92^a	0.99
2	5.36^a	0.71	28.44^a	0.98
3	4.78^b	0.68	24.38^b	0.98
4	4.48^c	0.66	19.03^c	0.98
5	4.30^c	0.61	18.82^d	0.97

Different superscripts (a, b, c and d) along columns indicate significant (P< 0.001) differences

Table 3: Phenotypic correlation coefficients (r_p) in *Archachatina marginata*

Treatment (No. of snails / m^2)	Bodyweight and Age	Shell length and Age	Bodyweight and Shell length
25	0.992	0.994	0.992
50	0.982	0.956	0.964
75	0.986	0.962	0.972
100	0.977	0.945	0.982
125	0.971	0.845	0.984

All coefficients were significant at $P<0.001$

The prediction equations for bodyweight and shell length of *A. marginata* using age are given in Tables 4 and 5, respectively. It was observed that for every unit change in age, body weight and shell length increased at an average rate of 0.958 and 0.07mm, respectively with significantly ($P<0.001$) higher rate in snails stocked at 25 / m^2. This observation suggests that snail growth trends in terms of bodyweight and shell length are determined by the stocking rate and tend to decline at higher stocking density. The coefficient of determination (r^2) also indicated that 72-99% variation in body weight can be explained by changes in hatchling age, shell length or by their additive effect. Though snails stocked at 50 / m^2 had average bodyweight similar to those stocked at 25 / m^2, they however had a lower growth rate (0.98 against 1.55), implying that the optimum stocking density might lies between 25 and 50/m^2.

Table 4: Estimates of parameters in simple linear function fitted for age- bodyweight relationship in *Archachatina marginata*

Treatment	Equation	R	R^2	SEE	P-value
1	$Y = 5.42 + 1.55X$	0.99	0.98	2.23	0.001
2	$Y = 12.32 + 0.98X$	0.98	0.96	3.49	0.001
3	$Y = 10.69 + 0.83X$	0.98	0.96	2.83	0.001
4	$Y = 13.19 + 0.35X$	0.98	0.96	3.24	0.001
5	$Y = 11.22 + 0.44X$	0.97	0.94	3.84	0.001

Where: X = Age, Y = Body weight, 1 = 25snails / m^2; 2 = 50 snails / m^2; 3 = 75 snails / m^2; 4 = 100 snails / m^2; 5 = 125 snails / m^2

R = correlation coefficient, R^2 = coefficient of determination, SEE= standard error of estimate

Table 5: Estimates of parameters in simple linear function for age- shell length in *Archachatina Marginata*

Treatment	Equation	R	R^2	SEE	P-value
1	$Y = 3.66 + 0.11X$	0.99	0.98	0.15	0.001
2	$Y = 3.94 + 0.09X$	0.98	0.96	0.10	0.001
3	$Y = 3.89 + 0.05X$	0.97	0.94	0.14	0.001
4	$Y = 3.78 + 0.03X$	0.96	0.93	0.17	0.001
5	$Y = 3.94 + 0.03X$	0.94	0.89	0.19	0.001

Where: X =Age, Y = Shell length, 1 = 25snails / m^2; 2 = 50 snails / m^2; 3 = 75 snails / m^2;
4 = 100 snails / m^2; 5 = 125 snails / m^2

R = correlation coefficient, R^2 = coefficient of determination, SEE= standard error of estimate

Results also demonstrated that for every unit change in shell length, body weight increased at an average of 12.60g against 0.95g for age changes (Table 6). While Table 7 reveals that shell length is a one-dimensional unit compared to bodyweight a three-dimensional unit (based on results of the b-values). Higher correlation coefficients (r = 0.87-0.99) were revealed using the allometric function compared to the simple linear. This result support earlier findings that the allometric function is a better function for estimating correlations between varying dimensional parameters (Olawoyin, 23).

The simultaneous (net) influence of age and shell length on the bodyweight of growing *A. marginata* is shown in Table 8. A unit change in shell length had significantly ($P < 0.05$) higher influence on bodyweight than a unit change in age. This further demonstrated that shell length is a better predictor of bodyweight in growing *A. marginata*.

Table 6: Simple linear function for shell length - body weight in *Achachatina marginata*

Treatment	Equation	R	R^2	SEE	P-value
1	$Y = -47.85 + 14.60X$	0.99	0.99	1.58	0.001
2	$Y = -28.84 + 10.70X$	0.96	0.92	3.22	0.001
3	$Y = -44.84 + 14.47X$	0.96	0.92	3.41	0.001

4	$Y = -26.06 + 10.50X$	0.95	0.89	3.62	0.001
5	$Y = -30.99 + 11.04X$	0.85	0.72	4.14	0.001

Where: X = Shell length, Y = Body weight, 1 = 25snails/m^2; 2 = 50 snails/m^2; 3 = 75 snails/m^2; 4 = 100 snails/m^2; 5 = 125 snails/m^2
R = correlation coefficient, R^2 = coefficient of determination, SEE= standard error of estimate

Table 7: Estimate of parameters in Allometric function for shell length - body weight in *Archachatina marginata*

Treatment	Equation	R	R^2	SEE	P-value
1	$Y = 0.213$	0.99*	0.99	0.02	0.001
2	$Y = 0.423$	0.98	0.96	0.05	0.001
3	$Y = 0.230$	0.96	0.93	0.08	0.001
4	$Y = 0.464$	0.95	0.90	0.09	0.001
5	$Y = 0.377$	0.87	0.76	0.12	0.001

Where: X = Shell length, Y = Body weight, 1 = 25snails/m^2; 2 = 50 snails/m^2; 3 = 75 snails/m^2; 4 = 100 snails/m^2; 5 = 125 snails/m^2
R = correlation coefficient, R^2 =coefficient of determination , SEE= standard error of estimate

Table 8: Estimate of parameters in multiple linear function for age, shell length and body weight in *Archachatina marginata*

Treatment	Equation	R	R^2	SEE	Significant
1	$Y = -34.86 + 0.52X_1 +$	0.94	0.88	2.05	0.001
2	$Y = -11.77 + 0.44 X_1 + 6.15$	0.93	0.86	2.12	0.001
3	$Y = 6.74 + 0.76 X_1 + 1.01 X_2$	0.91	0.83	2.17	0.001
4	$Y = 5.94 + 0.08 X_1 + 2.73 X_2$	0.90	0.81	2.08	0.001
5	$Y = -22.27 + 0.06 X_1 + 8.87$	0.89	0.80	2.05	0.001

Where: X_1 – Age; X_2 – Shell length; Y – Body weight; Av_y – Average body weight; Av_x – Average shell length; 1 = 25snails/m^2; 2 = 50 snails/m^2; 3 = 75 snails/m^2; 4 = 100 snails/m^2; 5 = 125 snails/m^2
R = multiple correlation coefficient, R^2 = coefficient of multiple determination, SEE= standard error of estimate

In all the functions, higher growth trends and correlations were maintained when snails were stocked at 25 / m^2, followed by at 50 / m^2. However, to maximize profit, it would not be economical to stock at 25snails / m^2. More so, since no significant ($P>0.05$) difference was observed in average bodyweight between snails stocked at 25 / m^2 and 50 / m^2 it appears that the optimum density might be between 25 and 50/m^2, possibly at the midpoint of these values; i.e. (25 + 50) / 2 = 37.5 / m^2. Therefore, we deduced that optimum stocking density of growing *A. marginata* would be achieved at 38snails / m^2. This value falls with the recommended range of 35 – 40/m^2 for growing *A. marginata* snail (Omole and Kehinde, 2005). It is expected that at the stocking rate of 38snails/m^2, growth rate will be adequate and profitability will be sustainable.

Conclusion

The study concluded that;

1. Positive and highly significant relationships exist between bodyweight, age and shell length in growing African giant land snail (*A. marginata*).
2. Shell length can be simply used in predicting snail's bodyweight.
3. Mathematical model offers an effective method of determining growth and production efficiencies in snails.
4. At the stocking rate of 38 snails/m^2 growth and production performance of growing snails is not compromised.

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