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Intraspecific effects of population density on the feeding habits, activity and growth in the giant african land snail *Archachatina marginata* Swainson (Pulmonata: Achatinidae)

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ABSTRACT: The effect of different population densities in relation to feeding, activity and growth rates of *Archachatina marginata* were found to be inversely related with increase in population density. Snails were more active and grew faster in lesser populated vivaria. Ripe pawpaw and plantain fruits were preferred mostly and they supported faster growth and development. The growth analysis between the weight and shell circumference gains were correlated which suggested that the nutrients absorbed enhanced uniform development of the shell and body tissues. The difference between the day and night-time activities of the snail was significant. Snails were more active at night during which feeding, copulation and movement mostly takes place. The activities of both the juveniles and adult snails were reduced in vivaria pre-treated with mucus in relation to untreated vivaria. Unfavourable environmental conditions led to aestivation a physiological adaptive process exhibited by some snails during this study.

Key Words: Giant African snail; *Archachatina marginata*; Feeding habits; Population density.

Introduction

The *Archachatina maginata* is a pulmonate gastropod mollusc belonging to the family Achatinidae and order Stylommatophora. The abundance and availability of the snail species depends on their power of dispersal and environmental situations and effect. Africa is the ancestral home of the giant land snail. (Mead, 1952). The achatinid pulmonate are distributed throughout the world in the tropical and sub-tropical regions where most of the general of the family are confined to Africa and Middle America (Pilsbry, 1904).

The giant land snail is omnivorous and also considered as a scavenger. According to Ajayi *et al* (1978), the foods taken by the snail are numerous. It has a radula situated on the odontophore which it uses to scrape food items (Villee *et al*, 1984). They feed mostly on fresh vegetable, fruits and decaying matter. Leaves of *Talinum triangulare, Laffa officinalis, Carica papaya* etc. The crop juice and digestive glands contain enzymes such as amylase, proteinase, cellulose etc. which assist in digestion (Odiete *et al*, 1982).

The population dynamic and activity of the snail are mainly influenced by climatic conditions. During the rainy season (April-September), the temperature is favourable and humidity is high and they are mostly seen. But during dry seasons or in arid locations, environmental conditions get severe and they go into a state of aestivation. This occurs when the snail withdraw into its shell and the aperture is closed with a mucous film which dries to form a calcified slime known as epiphragm (Segun, 1975).

The giant land snail has gained national and international status. As food, they constitute a cheap source of protein of several West African indigenes and sought after as a delicacy in some European countries. It is also consider as a delicacy for the Yoruba (Yoloye, 1984).

Due to its gross anatomy, they have been used in various experimental projects. The properties of the nerve cells and neurosecretary cells have been studied and it is also used as a source of enzymes. Though much work has been done on the biology of this animal, this work entails an intensive study on the relationship of growth, activity and feeding habits towards intraspecific population densities and it also takes into account the effect of pretreatment of mucus on the activity of the animal.

Materials and Methods

Source of Maintenance of the Snails

The giant land snails, *Archachatina marginata* were purchased at the Bariga market after they were collected from a forest near Ijebu-Ode. Fifty medium size snails weighing between 60.1g – 72.1grams along with five big size snails weighing between 268.4g – 317.9 grams were got. The second set of snails composed of ten adults and ten juveniles were later purchased during the course of the work for the mucus pretreatment investigation.

The snails were acclimatized for 2 weeks in a stocking vivarium of length 115cm, width 58cm and height 54cm. The snails were fed and the vivarium was regularly cleaned to prevent fungal and bacterial growth or infections.

Measurement of Growth, Activity and Feeding

The measurement of the growth, activity and feeding was carried out under two conditions which were the crowding effect and control. The former had a population of 10 snails in each of the 5 small vivaria of length 29cm, height 20cm and width 19cm. The latter had a population of only 2 snails in each. Five different food items were placed in each vivarium.

Growth was estimated by both the differences between the maximum shell circumference and weight at the beginning and the end of the work. The circumference and was obtained when the diameter (breadth) was obtained on the measuring board to the nearest centimeter and multiplied with 3.14; ($C = \pi x d$)

Where; C = circumference

$\pi = 3.14$

d = maximum shell diameter.

The activity of the snails were measured at every 2 hours interval for 24 hours for 3 days a week. Snails activities were separated into day and night-time components. The snails were scored as active when their tentacles were fully everted and moving. They were scored half when their tentacles were everted, but not moving.

The feeding habit and food preference was determined based on the food by which the snails acquired the most growth (weight and shell diameter gain) and also based on the acceptance (by eating) or rejection (by not eating) of food. The difference between the initial weight of food given and final weight of food left over was gotten which was the accepted food. The percentage of accepted food was then calculated. This work was carried out within the duration of 10 weeks.

Mucus Pretreatment Effect

The activity of the snails were also measured by pretreatment of mucus. Four vivaria were set up, of which two were pretreated by placing in five large snails and the other two untreated. Five of the adult snails were placed into a pretreated vivarium and the other five placed into untreated vivarium. The juvenile snails were also subjected to similar condition.

The snails were also scored as active when their tentacles were fully everted and moving. They were scored half when their tentacles were everted but not moving. Analysis of the results were based on the sum active occasions for each vivarium, that is the vivarium and not the individual snail in the sampling unit. The maximum active occasion was 10. Recordings of the activity of the snails were made at regular interval at every 6 hours for 3 days.

Correlation Analysis

The correlation coefficient (r) was calculated between the weight gain and shell circumference gain. This was necessary to explore the correlation (relationship) existing between them e.g. linear relationship.

The formula is:

$$r = \frac{\Sigma xy - \frac{\Sigma x \, \Sigma y}{n}}{\sqrt{\left(\Sigma x^2 - \frac{(\Sigma x^2)}{n}\right)\left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)}}$$

Where; x = weight gain

y = shell circumsference gain

Σx = summation of x

Σy = summation of y

Σx^2 = summation of the square x

Σy^2 = summation of the square y

Σxy = summation of xy

r = correlation coefficient

Results

Intraspecific Effect of Population Density on Growth

Crowding Effect: The means of weight, shell circumferences, weight and shell circumference gains and their percentages for the 10 snails each in various vivaria were recorded in Table 1.

Table 1: Means of weights, shell circumferences, weight and shell circumference gains and their percentages for 10 snails in each various vivaria.

Vivaria with 10 snail specimen each	Weight (g)	Weight Gain (g)	Weight Gain Percentage	Shell Circumfe-rence	Shell Circumfe-rence Gain (cm)	Shell Circumfe-rence Gain Percentage
1. Fed with pawpaw leaves	65.39±3.5	9.55±1.1	14.66±2.0	15.92±0.6	1.87±0.2	11.8±1.6
2. Fed with ripe plantain	65.81±3.3	15.64±1.0	23.83±1.9	16.09±0.6	3.78±1.0	23.4±5.5
3. Fed with cocoyam & organic soil	66.43±3.8	12.15±0.7	18.36±1.5	16.22±0.8	2.58±0.4	15.87±1.8
4. Fed with cassava leaves	64.87±3.4	10.85±1.3	16.8±2.6	15.97±0.7	2.05±0.3	12.85±1.7
5. Fed with ripe pawpaw fruit	65.27±1.5	14.71±1.5	22.53±1.8	15.92±0.6	3.51±0.7	22.08±3.8

The highest recorded weight and shell circumference gain values came from snails fed with ripe plantation which was 15.64 ± 1.0g and 3.78 ± 1.0cm respectively followed by those fed with ripe pawpaw fruits which were 14.71 ± 1.5 and 3.51 ± 0.7 respectively.

Control: The means of weights , shell circumferences, weight and shell circumference gains and their percentage of the control snails in the various vivaria each were recorded in Table 2.

Table 2: Means of weights, shell circumferences, weight and shell circumferences gains and their percentage of control snails in various vivaria.

Vivaria with 10 Snail Specimen each	Weight (g)	Weight Gain (g)	Weight Gain Percentage	Shell Circumfe-rence (cm)	Shell Circumfe-rence Gain (cm)	Shell Circumfe-rence Gain Percentage
1. Fed with papaw leaves	64.35±1.3	13.0±0.3	20.2±20.1	15.9±0.3	2.45±0.1	15.7±0.6
2. Fed with ripe plantain	65.15±1.3	20.45±0.2	31.4±0.3	15.95±0.07	5.3±0.3	33.25±1.9
3. Fed with cocoyam & organic soil	64.7±1.6	15.05±0.2	23.25±0.9	15.95±0.2	2.95±0.2	18.5±1.9
4. Fed with cassava leaves	67.05±1.9	12.9±1.0	19.25±2.1	16.45±0.2	2.6±0.1	16.0±1.0
5. Fed with ripe pawpaw fruit	65.5±4.4	20.0±0.6	30.55±1.2	16.15±0.5	4.9±1.0	30.25±5.2

The highest increase in weight and shell circumference gains were recorded in vivarium 2 (fed with ripe plantain) which was 20.45 ± 0.2g and 5.3 ± 0.3cm respectively followed by those fed with ripe pawpaw fruits which was 20.0 ± 0.6 and 4.9 ± 1.0 respectively.

Fig. 1 also displays the component bar chart showing the percentage shell circumference gain while Fig. 2 displays the percentage weight gain.

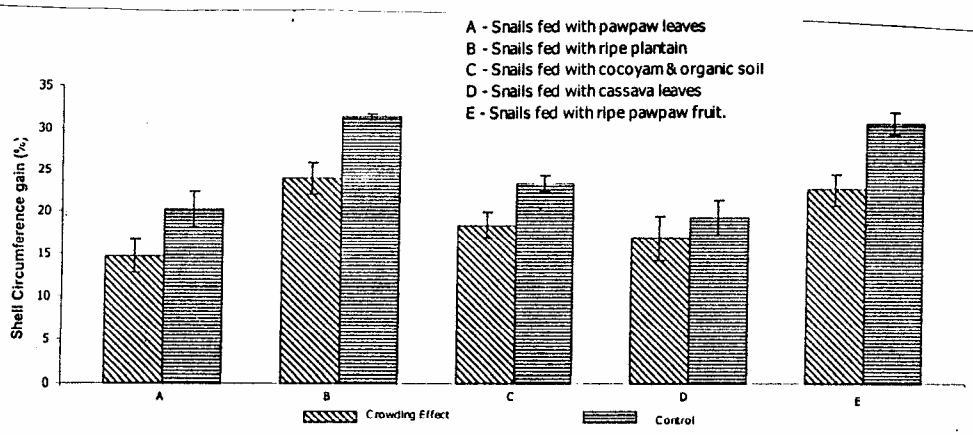

Fig. 1: Compdhent bar Chart showing average percentage shell circumstance gain by A. marginata fed with different food items

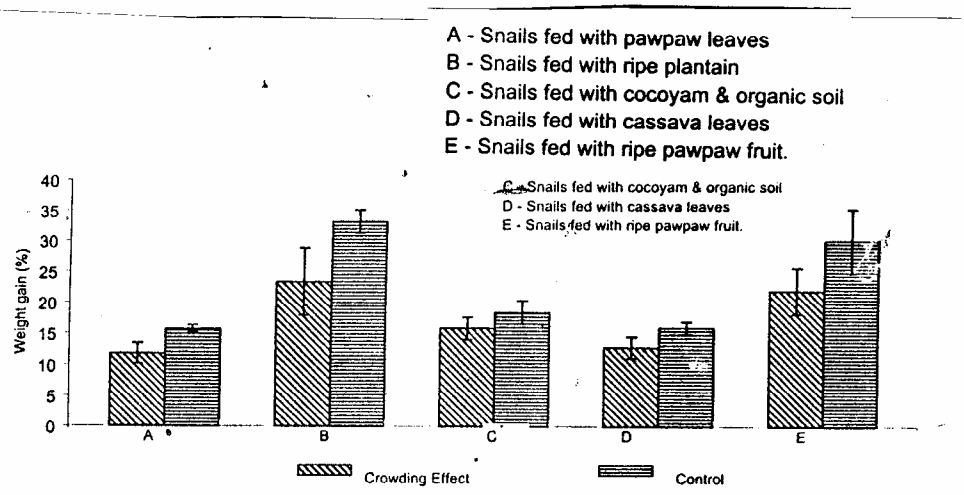

Fig. II: Component bar chart showing average percentage weight gain by A. marginata fed with different food items

Feeding Habit Preference

The highest acceptance of food was also recorded from snails fed with ripe plantain which was 81% followed by those fed with ripe pawpaw fruit which was 72%. The lowest recordings was made by snails fed with pawpaw leaves which was 39% shown on Table 3.

Table 3: Summary of feeding preference of *A. marginata* based on accepted and rejected food items for 10 weeks (crowding effect).

Food Items with 10 snail specimens each	Total Food weight (g)	Total Food Weight rejected (g)	Total Food weight accepted (g)	Aceptance percentage (%)
1. Pawpaw leaves	15,000	9,150	5,850	39
2. Ripe Plantain	15,000	2,850	12,150	81
3. Cocoyam & Organic soil	15,000	6,150	8,850	59
4. Cassava leaves	15,000	7,950	7,050	47
5. Ripe pawpaw fruit	15,000	4,200	10,800	72

For the controlled snails, the highest acceptance recorded was 88% from those fed with ripe plantain followed by those fed with ripe pawpaw fruit which was 83% and the lowest was 42% snails fed with pawpaw leaves (Table 4).

Table 4: Summary of feeding preference of *A. marginata* based on accepted and rejected food items for 10 weeks (control).

Food Items with 2 snail specimens each	Total Food weight (g)	Total Food Weight rejected (g)	Total Food weight accepted (g)	Acceptance percentage (%)
1. Pawpaw leaves	3,000	1,740	1,260	42
2. Ripe Plantain	3,000	360	2,640	88
3. Cocoyam & Organic soil	3,000.	1,200	1,800	60
4. Cassava leaves	3,000	1,320	1,680	56
5. Ripe Pawpaw fruit	3,000	510	2,490	83

Intraspecific Effect of Population Density on Activity

Crowding Effect: The mean activity of the 10 specimen of snails in each of the 5 vivaria are shown on Table 5.

Table 5: Mean activity of 10 specimen of snails each in 5 different vivaria (Crowding Effect)

Vivarium 1. Snails fed with pawpaw leaves			Vivarium 2. Snails fed with ripe plantain			Vivarium 3. Snails Fed with cocoyam and organic humus soils		
Day Time Active Occasion	Night Time Active Occasion	Total Active Occasion	Day Time Active Occasion	Night Timer Active Occasion	Total Active Occasion	Day Time Active Occasion	Night Time Active Occasion	Total Active Occasion
3.7±0.9	5.9±0.7	9.6±1.0	4.8±0.6	8.2±0.9	13.0±0.9	4.9±0.8	6.6±0.8	11.4±1.1

Vivarium 4. Snail fed with cassava leaves			Vivarium 5. Snails fed with pawpaw fruits		
Day Time Active Occasion	Night Time Active Occasion	Total Active Occasion	Day Time Active Occasion	Night Time Active Occasion	Total Active Occasion
4.0±0.8	6.3±0.9	10.3±1.1	4.6±0.8	7.1±1.2	11.7±1.0

The highest total active occasions and night-time active occasions were measured for specimen in vivarium 2 (fed with ripe plantain) which were 13.0 ±0.9 and 8.2±0.9 respectively. The highest day-time active occasions was recorded in vivarium 3 (fed with cocoyam and organic humus soil) which was 4.9±0.7.

Control: With the snails now reduced to 2, the highest recorded total active occasions was recorded for vivarium 3 (fed with cocoyam and organic humus soil) which was 14.5 ± 5.0. These mean activity of the 2 specimen of snails are shown on Tablke VI. Snails fed with cocoyam and organic soil got the highest day-time active occasion of value 6.0 ± 3.2 while those fed with ripe plantain recorded the highest night-time occasion which was 9.0 ± 2.1.

Table 6: Mean activity of 10 specimen of snails each in 5 different vivaria (control).

Vivarium 1. Snails fed with pawpaw leaves			Vivarium 2. Snails fed with ripe plantain			Vivarium 3. Snails fed with cocoyam and organic humus soil		
Day time active occasion	Night time active occasion	Total active occasion	Day time active occasion	Night time active occasion	Total active occasion	Day time active occasion	Night time active occasion	Total active occasion
4.0±3.2	7.0±2.6	11.0±3.2	5.5±3.7	9.0±2.1	14.5±4.4	6.0±3.2	8.5±2.4	14.5±5

Vivarium 4. Snail fed with cassava leaves			Vivarium 5. Snails fed with pawpaw fruits		
Day time active occasion	Night time active occasion	Total active occasion	Day time active occasion	Night time active occasion	Total active occasion
3.5±3.4	8.0±2.6	11.5±4.1	5.0±4.1	8.0±2.9	13.0±5.4

Mucus Pretreatment Effect

The activities of both the adult and juvenile snails reduced during subsequent days. The total mean number of active occasions of the juvenile snails in the treated and untreated vivaria were 5.78 ± 1.1 and 7.67 ± 1.1 respectively while the significant reduction in the treated vivarium was 25%. The total mean activity of the adult snails both in the treated and untreated vivaria were 6.28 ± 1.0 and 8.11 ± 0.6 respectively while the significant reduction was 23%. This is shown on Table 7.

Table 7: Mean of active occasions of juvenilke and adult snails in mucus treated and untreated vivaria and reduction and significance percentage.

Specimen	Treated vivarium	Untreated vivarium	Reduction in treated vivaria & significance (%)
Juvenile Snails	5.78±1.1	7.67±1.1	25
Adult Snails	6.28±1.0	8.11±0.6	23

Correlation Analysis

This was analysed between the weight gain and shell circumference gain in the *A. marginata* fed with different food substances. Table 8 shows the analysis.

Table 8: Correlation analysis of the weight gain and shell circumference gain of *A. marginata*.

Analyzes	Symbol	A	B	C	D	E
Correlation coefficient	R	0.5	0.2	0.2	0.66	0.83

A = fed with pawpaw leaves
B = fed with ripe plantain
C = fed with cocyam and organic humus soil
D = fed with cassava leaves
E = fed with pawpaw fruits.

The correlation coefficient was highest in the snails fed with ripe pawpaw fruits and lowest in both the snails fed with ripe plantain and organic humus soil.

Discussion

Comparative study based on five different food items were made in relation to feeding habit, growth and activity at different population densities. Those fed with ripe plantain achieved the highest weight and shell circumference gains followed by those fed with ripe pawpaw fruits.

The lowest recordings were made by those fed with pawpaw and cassava leaves. The acceptance percentage recordings also followed similar results with snails fed with ripe plantain and pawpaw fruits are preferred mostly by snails and they support faster growth and development. This agrees with the findings of Ajayi *et al* (1978), that leaves of *Talium sp*, Bryophyllum sp. And *Luffa* sp. Did not support growth of *Archachatina marginata* very well but pawpaw fruit did very well.

The results of the growth of snails subjected to crowding effect were lesser than those in the control, although there were enough food supplied. Growth was faster and higher for snails in vivaria of lesser density. Similar observations were also made by Cameron and Carter (1978) on *Cepaea nemoralis* subjected to different population densities. This growth inhibiting effect in the vivaria with high denstities may be due to the influence of other snails or the accumulation of by-propducts of the high density cultures such as faeces and nitrogenous wastes. The food may be contaminated with the waste products of other snails and snails do not usually eat food items contaminated until fresh supply is made which has a negative effect on their growth and development.

This weight and shell circumference gains were shown to be positively correlated in all the vivaria fed with different food items. This indicates that as weight increases so does the shell circumference. The highest correlation was got for snails fed with ripe pawpaw fruits and cassava leaves. This suggests that the nutrient contents were absorbed by the snails in right proportion to enhance the shell and body development uniformally. The lowest correlation was got for snails fed with ripe plantation and cocoyam and organic humus soil which indicates that either there was slightly more increase in body weight than shell circumference generally or vice versa.

Results of activity showed that snails were more active at night than day. This is due to the fact that most of their activities takes place during the night. According to Plummer (1975) and Odiete (1988) copulation in *A. marginata* usually occur at night and early morning. Feeding and movement usually takes place at night (Ajayi *et al*, 1978). The highest mean night-time active occasion was recorded from snails fed with ripe plantain that also had the highest total active occasion. This coincides with the observation that they also had the highest growth recorded therefore had enough metabolic energy for higher activities. The highest day-time active occasion was got from the vivarium which had soil. The snails were found feeding on the humus soil high in organic content during most of the day, thereby increasing their activity over other vivaria.

The mucus pretreatment effect showed a general reduction in the activities of both the juveniles and the adult snails specimen which has a reduction percentage of 25% and 23% respectively. This reduction in activity may be due to specific growth and activity inhibiting pheromones or substances in the mucus secreted. This could be very important in the development and distribution of the snails. Since they do not exhibit parental care, those inhibiting substances may cause the juvenile snails to move away from the hatching sites and get evenly distributed in the environment thereby reducing the effect of high population density. Therefore this phenomenon is geared in reducing competition and poor hygienic situations associated with overcrowding which has a negative effect on the growth, development and well-being of the snails.

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