**STUDIES ON THE EFFECT OF VISIBLE LIGHT OF THE ELECTROMAGNETIC SPECTRUM ON**

***Archachatina marginata*’s GROWTH**

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**AUTHORS’ CONTRIBUTIONS: please write this section**

This work was carried out in collaboration between all authors. Author R.K. Odunaike designed the study, wrote the protocol and interpreted the data. Author B.O. Adebesin anchored the field study, gathered the initial data and performed preliminary data analysis. Authors A.A. Inyinbor and A.O. Dada managed the literature searches and produced the initial draft. All authors read and approved the final manuscript.

***Original Research Article***

**ABSTRACT**

Light is of great importance to man, animals and plant, as the growth of plants upon which man depends cannot be accomplished without light. The effect of different frequencies of the visible light in the electromagnetic spectrum on snails (*Archachatina marginata*) was investigated. The analysis involves both the volume (size) and weight changes for a period of 16 weeks. The dark condition yielded the maximum size gain, followed by the yellow light. The blue light on the other hand produces the highest weight gain, followed by the dark condition. Yellow light recorded weight loss on the snails. We observed that natural daylight inhibits snails’ growth rate. Poor correlation between snails’ size and weight gain (*C* = 0.071)suggests that weight gain in snails is not necessarily a function of size. Our results compares well with previous observations that snails grow faster under dark condition. We proposed that more of these studies be initiated over a longer experimental observation period for enhanced and sustainable agricultural productivity.

**Keywords:** *Archachatina marginata; electromagnetic spectrum; visible light; snails; frequencies.*

**1. INTRODUCTION**

Snails are bilaterally symmetrical invertebrates with soft-segmented exoskeleton in the form of calcerous shells. They belong to the phylum Mollusca. In West Africa, snails dwell mostly in humid forest areas from where they are gathered by villagers for consumption and other uses [1] (Fig. 1). However, successive government in Nigeria had embarked on policies and activities geared towards boosting sustainable macro-livestock and micro/mini-livestock production. Akinnusi 1998 [2] had described micro/mini-livestock production as species of animals that are associated with small body size, moderate nutrition and management, The small body size makes them one of the most significant assets since it makes it possible for them to produce and manage on small areas and in clusters [3].

For the purpose of this work, the edible terrestrial snails (*A. marginata*) have been used to perform the experiment. Snails are hermaphrodites having the ability to reproduce with/without sexual interactions when in a group/isolated conditions and raise viable eggs.

The Giant African Snail is a simultaneous hermaphrodite; each individual has both testes and ovaries and is capable of producing both sperm and ova. Instances of self-fertilization are rare, occurring only in small populations. Although both snails in a mating pair can simultaneously transfer gametes to each other (bilateral mating), this is dependent on the size difference between the partners [4]. Snails of similar size will reproduce in this way. Two snails of differing sizes will mate unilaterally (one way), with the larger individual acting as a female. This is due to the comparative resource investment associated with the different genders [5].

Snails have been shown to be rich in protein hence it can compare favourably with crude protein contents in beef, broiler meat, goat meat, mutton and pork [1,6]. It has been reported that snails have low lipid content and saturated fatty acids, which have important health implication and may be beneficial to hypertensive patients and others who do not take fatty foods [7]. The fresh snail meat contains the nutrients as listed in Table 1.

**Table 1: Approximate Nutritional value of Snail (*Archachatina marginata)* meat**

|  |  |
| --- | --- |
| **Nutrient** | **Value** |
| Crude protein | 18.20% |
| Ether extracts | 1.36% |
| Carbohydrate | 2.88% |
| Crude fibre | 0.07% |
| Fat | 1.01% |
| Ash | 1.37% |
| Nitrogen free extract | 4.95% |
| Water | 74.06% |
| Iron | 12.2mg/100g |
| Other mineral constituents | 60.5m/100g |

*(after Agbogidi and Okonta, 2011 and references therein)*

However, in spite of the good nutritional value of snail meat, it is still a scarce commodity in the market. Several factors have been attributed to this – all omitting the physical condition under which snails grow. This necessitated the need for the present research work in other to know under which colour/frequency of the visible light in the electromagnetic spectrum the snails can grow faster. Furthermore, the few recent studies on environmental effects of [electromagnetic fields](http://ec.europa.eu/health/opinions2/en/electromagnetic-fields07/glossary/def/electromagnetic-field-EMF.htm) ([EMF](http://ec.europa.eu/health/opinions2/en/electromagnetic-fields07/glossary/def/electromagnetic-field-EMF.htm)) have mostly focused on extremely low frequency (ELF) fields, such as those generated by overhead power cables. They mostly considered plants and not species that would be expected to be among the most sensitive to EMF. Hence, our investigation of the physical effect of visible light on the growth rate is very crucial and important.



**Fig. 1: An Africa giant snail (*Archachatina marginata)***

*(Source: Authors)*

**2. DATA AND METHODOLOGY**

**2.1 Initial Preparation Stage**

We intend to examine what component of the visible light (i.e. red, orange, yellow, green, blue), white (normal daylight conition), or dark light will aid the growth of snails using *A. marginata* as a case study. Our hypothesis is that snails in the dark coloured chamber (pen) will grow faster than those in other coloured chambers. This is because we believed that snails being nocturnal animals tend to be more active at night and feed well at low temperature and low humidity [8]. The experiment inside the white light serves as the control experiment. However, we ensure the following conditions for optimum result.

(i) Snails need damp, not wet, environment to grow well. We ensure that the water logged soil was drained to make it suitable for them, since snails breathe in air and may drown in water logged environment. In hours of darkness, air humidity over 80% will produce good snail activity and growth.

(ii) A mild temperature (59-750F) with high humidity is best for snail farming though most variety can stand a wider range of temperature. When the temperature falls below 450F, snails are inactive and all growth stops. When the temperature rises above 800F or conditions becomes too dry, snails are dormant until favorable conditions returns. Therefore, we ensure a favorable temperature condition.

(iii) Snails require a three (3) layered substrate- a bottom layer of gravel, a second layer of moist soil (preferably garden soil) and a top layer of dry leafy litters. Snails find it difficult to dig into hard dry soil. This we have done and also ensuring that the pH value of the soil is about 7.

(iv) Nutrition plays an important role in the growth of snails. A. marginata is herbivorous and feed on a wide variety of plants material, fruit and vegetables. We ensure that all the snails in individual chambers are supplied with enough food. Table 2 depicts the list of some of the foods the snails were fed on.

**Table 2: List of plants eaten by *A. marginata***

|  |  |  |
| --- | --- | --- |
| **Species** | **Common**  **name** | **Part consumed** |
| *Bracssica oleracea* | Cabbage | Leaves |
| *Lactica sativa* | Lettuce | Leaves |
| *Magnifera indica* | Mango | Ripe peeling |
| *Talinum traingulare* | Water leaf | Leaves |
| *Anana comosus* | Pineapple | Ripe fruit and  peeling |
| *Manihot esculenta* | Cassava | Leaves |
| *Musa sapientum* | Banana | Ripe peelings and  fruit |
| *Xanthosomas sp* | Cocoyam | Leaves and peeling |
| *Carica papaya* | Pawpaw | Leaves and fruit |
| *Elaeis guineensis* | Palm kernel | Palm kernel meal |

**2.2 Measurement Procedure**

The study was carried out in Ago-Iwoye zone of Ogun State, Nigeria (Georgraphic 6o 57’ N, 3o 55’E); for a total of sixteen (16) weeks between July and September. A total of 140 snails of the same variety (*A. Marginata*) were used. The snails were all about twenty-four months old groomed together under the same climatic/environmental condition. The experiment was replicated twice, and the average value for each set of experiment was employed for the analysis. The mean daily maximum temperature of 24.5 0C is experienced in August when there is dense cloud cover. An annual rainfall of 1120 mm-1140 mm is experienced. The measurement of growth of snails in this experiment was limited only to volume and weight. To measure the volume, we make use of the Eureka measuring Can that is used to measure irregular solids. This is achieved by immersing the snail briefly in water filled Eureka can, and the water displaced measured in a calibrated beaker. This follows the Archimedes Principle. On the other hand, we make use of the spring balance to measure the weight of the snails. The controlled variables (constants) used in this study are:

* Seven wooden chambers (pens) of the same size (partitioned into two parts for the second set of observations).
* Types of snails (all are *A. marginata*).
* Same level of humidity
* The amount and type of soil in each pen.
* All pens were exposed to the same weather condition.

Seven (7) chambers, each partitioned into two were provided, and each partitioned chamber contained 10 snails (indicating 20 snails in each chamber) to enable critical observation on the growth of snails at each level. The groupings were labeled A to G, and each set of experiment were recorded twice, and thereafter, the mean value was taken.

Group A – snails under the Red cultivation chamber, where they receive red reflection from sunlight.

Group B – snails under the Yellow cultivation chamber, where they receive yellow reflection.

Group C – snails under the Green cultivation chamber, where they receive green reflection.

Group D– snails under the Blue cultivation chamber, where they receive blue reflection from sunlight.

Group E – snails under the Orange cultivation chamber, where they receive orange reflection.

Group F – is our control experiment where the snails receive the whole spectrum of sunlight.

Group G – snails under the Dark cultivation chamber, where they receive no reflection.

In order to achieve the desired result, some sandy-loamy soil was dished out in equal amounts to all the cultivation chambers as the first layer. A second layer of moist sharp sand was dished out equally and was spread out uniformly on top of the sandy-loamy. The following steps were taken after the soil preparation was done:

* The chambers (pens) were covered with iron mesh to prevent the snails from escaping.
* An equal amount of water was used to wet each cultivation chamber.
* The distribution of the 140 snails with 20 snails in each cultivation chamber.
* Taking the volume and weight of the snails using Eureka can and spring balance respectively.
* Covering the labeled cultivation chamber with coloured nylons, i.e. red, yellow, green, blue, orange and clear nylons respectively. The dark chamber was well covered with leaves to prevent sunlight from entering it.
* The growths of the snails were observed every two weeks and readings were taken in volume and weight, these lasted for 16 weeks.
* At the end of the experiment the average growth of the snails in each chamber was calculated to determine which chamber have the highest snail growth and weight increase.

**3. RESULTS AND DISCUSSION**

Fig. 1 depicts the plot of volume against the respective experimental coloured chambers, indicating the average initial measurements at the beginning of the experiment, the average final reading at the end of the 16 weeks of experiment, and the differences (revealing the size increase) between the two sets of data. Recall that the measurements were taken every two weeks to give room for appreciable changes in both the volume and the weight. This gives room for an average of eight sets of data viz – 1st, 2nd, 3rd, ... 8th datasets. Hence the difference in snail volume equals average 8th datasets minus corresponding average 1st datasets. The results were for the Red, Yellow, Green, Blue, Orange, Controlled Experiment (natural daylight) and Dark Chambers respectively averaged for the two sets of experimental observations (in the partitioned chambers). The plot revealed that the maximum volume increase (difference) was achieved with the dark coloured chamber (38.47 ml). The least difference between the initial and final average volume values was in the Orange chamber (15.49 ml). Only the dark and yellow (21.23 ml) chambers volume difference magnitudes were higher than that of the control experiment magnitude (20.09 ml). The volume difference magnitudes obtained for the red, green, and blue chambers were a bit lower than the one obtained for the control experiment, and ranges within 17.34-19.54 ml.

The results of the average weight measurement were highlighted in Fig. 3. Here, Snails in the blue chamber had the highest weight gain (19.0 g), followed by those in the dark chamber (14.1 g). On the average, we recorded a weight loss of 7.7 g for the snails in the yellow coloured chamber. Only the green chamber, apart from the yellow chamber recorded weight gain (7.8 g) of lower magnitude than that recorded in the control experiment (10 g). All other electromagnetic spectrum colours in the visible region used in this work recorded higher weight increase that the white light (control experiment), suggesting that white light condition (natural daylight) is not a favorable condition for snail weight increase.

Generally, we observed that the red and yellow coloured chambers were easily dried of water, while the dark, green and blue chambers were relatively cool and retain water for a longer period of time. It was also observed that more eggs were laid by snails in the green and blue chambers, with the green chamber having the largest number of eggs. Studies on snails have shown a clear influence of light type on locomotion, copulation, feeding, postures, as well as oviposition [8]. On the relative comparison between the snail’s size (volume) and weight, Fig. 4 revealed a poor relationship between both parameters. This is further established with a correlation plot (Fig. 5) between the two parameters. Evidently, the correlation coefficient is *C = 0.071.*

In a similar work by Oladogba, 2006 [9], the effect of visible light on the growth of *A. marginata* was investigated for two (2) months. 180 snails were distributed into six (6) chambers, with 30 snails in each chamber. The chambers were covered with red, yellow, green, blue, dark and clear nylons. The growth in volume of the snails were observed and readings taken every one week. He concluded that snails in the yellow chamber grew faster, and followed by those in the dark chambers. His conclusion is somehow closer to the present result, except that we recorded snails’ highest growth rate in the dark chambers, and followed by those in the yellow chambers. The reason for greatest growth rate in the yellow chamber as recorded by Oladogba, 2006 [9] may not be unconnected with the limited time span (8 weeks) used for his observations. It is possible for the snails in the dark chambers to start responding to their environment after the 8 weeks. This is why our observation was extended beyond the 8 weeks, and our result revealed this. We hope to improve the period of observation in future work, say about 52 weeks or more. This is still left open.

In another study by Rotenberg et al., 1989 [8], the effect of light on the behavior of *Biomphalaria glabrata* in snails was investigated. The snails were grouped into three, and each group was exposed to some conditions over a period of 2 days. The conditions are (a) continuous darkness (b) continuous light and (c) normal light cycle. The methodology used is the time-lapse cinematography, using a super-8 movie camera synchronized to an electronic flash and programmed for single frame shooting at 30 second intervals, which provides information (data) on snail movement activity in response to some physical factors. These factors are (i) continuous light/darkness, (ii) light/dark phases, and (iii) light transitions. They reported from their results that snails were significantly more active under conditions of continuous/intermittent darkness than under continuous light. They also observed that changes from light to dark conditions corresponds to increases in snails activities, which persisted for a longer period of time. In the present study, we may infer that it is this activity that leads to increase in size (volume) during the dark condition as recorded in Fig. 2.



**Fig. 2: The rate of volume change in the samples of *A. marginata* for each experimental chamber considered**



**Fig. 3: Bar chart showing the rate of weight change in the *A. marginata* for each experimental chamber**



**Fig. 4: Relative variability between the snails’ weight and volume (size)**



**Fig. 5: Pearson correlation coefficient plot between snails’ weight and volume (size)**

**4. CONCLUSION AND RECOMMENDA-TIONS**

The radiation from electromagnetic (EM) waves is classified by wavelength into radio, microwave, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays. The behavior of EM radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths. Light is electromagnetic radiation, particularly radiation of a wavelength that is visible to the human eye (about 400–700 nm).

The result from this experiment confirms the hypothesis in most literatures that snails in the dark coloured chamber will grow faster than those in other coloured chambers. We also observed that the blue, dark, red and orange light conditions (in that order) yield better snail weight increase than the broad daylight condition. Poor correlation was recorded between snails’ size and weight gain, suggesting that weight gain in snails is not necessarily a function of size. We wish to recommend the result of this study to snail farmers. If farmers are aware of the right component of light that increases the rate of growth of snails, they can rear snail that will mature in a shorter period of time and this can go a long way to improve their standard of living. We would also like to recommend that the result of this study be used to initiate a strategic research for understanding the physical processes of the effect of light on the growth of snails for enhanced and sustainable agricultural productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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