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SOIL MOISTURE AND SEASONAL EFFECTS ON THE MORPHOMETRY OF THE OVIDUCT, PENIS AND RETRACTOR MUSCLE OF THE GIANT AFRICAN LAND SNAILS, *ARCHACHATINA MARGINATA* AND *ACHATINA ACHATINA*

O.G SODIPE [1], O. A. OSINOWO [1], M.O. OZOJE [2], A. B. IDOWU [3] S. A. ONADEKO [4]

[1]Department of Animal Physiology, [2]Department of Animal Breeding and Genetics, [3]Department of Biological Sciences, [4]Department of Forestry. Federal University of Agriculture, Abeokuta, Nigeria.
Corresponding Author: bunmigraphics@yahoo.com **Tel:** +2348034447360

ABSTRACT

This study evaluated the effect of soil moisture and season on the morphometry of part of the reproductive tract of the Giant African Land snails, in a 2 x 2 x 4 factorial experiment with two species (*Archachatina marginata* and a*chatina achatina*), soil moisture at two levels (low – 25ml of water/ week and high – 100ml water/week) and season at four levels (cold dry, hot dry, hot wet and cold wet) constituting the three factors. Result showed that season had a highly significant effect (P<0.001) on the dimension of oviduct, penis and the retractor muscle of *A. achatina* and *A. marginata.* Significant species effect (P<0.001) was observed in the dimension of oviduct, penis and the retractor muscle of *A. achatina* and *A. marginata*. Soil moisture level significantly affected the oviduct weight, penis length and retractor muscle (P<0.01) as well as the retractor muscle weight of *A. achatina* and *A. marginata*. There was significant interactions between season and species for oviduct dimension (P<0.001), penis length and retractor muscle weight (P<0.001), penis weight and retractor muscle width (P<0.01), penis width and retractor muscle length (P<0.05). There was interaction between season and soil moisture for oviduct length, penis length and retractor muscle weight (P<0.01); the weight of the oviduct and retractor muscle. The interactive effect of species and soil moisture significantly affect the penis length and weight (P<0.05) and the width of penis and retractor muscle, while no interactive effect of species and soil moisture (P>0.05) was observed on the oviduct dimensions. There was no significant interaction (P>0.05) between season, species and soil moisture. However, the effect of snail liveweight was highly significant (P<0.001) on the oviduct, penis and retractor muscle dimension. It is concluded that snails reared on high soil moisture condition had higher dimensional values for oviduct, penis and retractor muscle while the seasonal variation also affected the dimension of the organs measured in this study.

Keywords: reproductive dimensions, species, African Land Snails, Moisture, Season

INTRODUCTION

Demand of African Giant Land snails in Nigeria outstrips the supply. Snails are high in protein, iron and low in fat (Adeyeye, 1996; Ademolu *et al.,* 2004; Fagbuaro *et al.,* 2006). It contains almost all the amino acid

needed by human beings. In West Africa, snail meat has traditionally been a minor ingredient in the diet of the people living in the forest zone. To meet the demand, it is essential to encourage high reproductive activity in the snails to produce appreciable number of egg and clutches of egg all season out. African Giant Land snails are hermaphrodites; they have the hermaphrodite gland or ovotestis which produces the ova and the spermatozoa. African Giant Land snails show a wide variation in egg production from species to species. Ajayi *et al.* (1978) observed that *Archachatina marginata* laid 6 – 12 eggs per clutch, this range was in harmony with the one given by Hodasi, (1984), Ubua, (2012a) and Ubua (2012b). Both researchers put the average clutch size as 10 – 15 eggs.

Hence, detailed studies of environmental physiology of snails are needed to boost snail reproduction in order to boost the production capacity of African Giant Land Snails to meet up with the market demand. The objective of this experiment is to determine the effect of soil moisture and season on the size and weight of the oviduct, penis and retractor muscle on the *A. marginata* and *A. achatina* as the organs are of great impact on the reproductive performance of snails.

MATERIALS AND METHOD

Experimental Animals and Management

The experiment was conducted at the Snail Research Unit of the College of Animal Science and Livestock Production, University of Agriculture, Abeokuta. A total of 96 snails weighing between 100 and 200g obtained from the existing stock and the local markets were used. Forty - eight snails from each species were exposed to two different soil moisture levels in 4 replications of 6 snails of each species per replicate, over 4 seasons covering the period of 52 weeks reared in baskets. From data obtained from the Ogun Osun River Basin Authority weather station Abeokuta, the seasons were classified into 4 as illustrated in Table 1.

Table 1. Atmospheric Condition during Experiment

Season	Duration	Range of Mean Temp. 0 C	Range of Mean Rainfall mm	Range of Mean of Relative Humidity %
Cold dry	24th October – 30th December	21.65 – 23.80	82.80 – 23.50	88.80 – 86.30
Hot dry	30th December – 24th March	23.80 – 24.85	23.50 – 48.70	86.30 – 90.40
Cold wet	24th March – 21st May	24.85 – 23.45	48.70 – 66.80	90.40 – 93.20
Hot wet	21st May – 24th October	23.45 – 21.45	66.80 – 81.86	93.20 – 88.65

Source: Ogun-Osun River Basin Development Authority, Abeokuta.

The different soil moisture levels were obtained thus: Top humus soil obtained from the university farm was oven dried. Each basket was filled with top humus soil of 1.65 kg and sprinkled with 400 ml of water initially. Cages on low soil moisture level treatment were sprinkled with 25 ml of water each week while cages on high soil moisture level treatment were sprinkled with 100 ml of water each week.

Data Collection

To monitor the morphometric differences in the snail reproductive organs due to the effect of soil moisture levels and season, a group of snail was dissected at the end of each season.

The following parameters were determined: Oviduct length, oviduct width, oviduct weight, penis length, penis width, penis weight, retractor muscle length, retractor muscle width and retractor muscle weight.

Statistical Analysis

All data generated were subjected to the least square analysis of variance (ANOVA) procedure using the Systat Analytical Computer Package version 5.0 (Systat Inc.,1995). Significant treatment means were separated using Tukey's high significant differences

RESULT AND DISCUSSION

Oviduct

Significant ($P<0.001$) seasonal differences were observed in the oviduct length values (0.87±0.086, 0.78±0.086, 1.54±0.090 and 1.28±0.086 cm), oviduct width values (0.40±0.057, 0.46±0.057, 0.38±0.057 and 1.05±0.057 cm) and oviduct gland weight values (0.12±0.051, 0.11±0.051, 0.27±0.050 and 1.50±0.049 g) in cold dry, hot dry, hot wet and cold wet season, respectively as represented in Figure 1. Significant soil moisture level effects ($P<0.01$) was observed for oviduct weight (0.45±0.029 and 0.55±0.029 g) of snails in low and high soil moisture conditions, respectively as shown in Figure 2. The oviduct length and width of *A. marginata* (1.20±0.086 and 0.55±0.086 cm) was significantly ($P<0.01$) higher than that of *A. achatina* (1.02±0.057 and 0.69±0.057 cm), respectively while oviduct weight of *A. marginata* (0.45±0.049 g) was significantly ($P<0.01$) lower than that of *A. achatina* (0.55±0.049 g) as presented in Figure 3. The result obtained from this experiment agrees with the work of Abiona *et al.,* 2012 who also recorded higher oviduct dimension in *A. marginata* compared to its counterpart (*A. achatina)* of the same liveweight range.

There was significant interactions between season and species for oviduct length ($P<0.001$), width ($P<0.01$) and weight ($P<0.001$) due to the fact that the oviduct length was highest during the hot wet season for *A. achatina* while the width and weight was highest during the cold wet season for *A. marginata.* There were significant interactions between season and soil moisture for oviduct length ($P<0.01$), width and weight ($P<0.001$) which was due to the fact that the oviduct length was highest in snails on the low and high soil moisture conditions during the hot wet season while width and weight was highest in the cold wet season for those on low and high soil moisture condition. There was no significant interaction ($P>0.05$) between species and soil moisture; and between season, species and soil moisture for the oviduct dimension.

With the inclusion of snail liveweight as covariate to model, seasonal differences on oviduct dimension; soil moisture level on oviduct width and weight became insignificant ($P>0.05$). However, the effect of snail

liveweight was significant (P<0.001) on oviduct dimension.

The oviduct length shows that snails in the wet season had higher values than those in the dry season while snails on the high soil moisture level had higher values of oviduct weights than those placed on low soil moisture, which may be due to the active reproductive performance of the snails during the wet season when the soil moisture level is higher compared to what is experienced in the dry season (Segun, 1975). The snails had higher values of the oviduct weight in the wet season than in the dry season. Oviduct exhibits a high degree of development and structural complexity probably related to its participation in the complex reproductive processes, specifically in the transport, fertilization and provision of egg envelopes (Buckland-Nicks and Chia, 1990; Carvalho Thiengo, 1993, Schulte-Oehlmann *et al*., 1994) in which larger dimension of the oviduct will be required for species with larger eggs. The larger size of eggs layed coupled with volume of egg envelopes produced by *marginata* compared to *Achatina* may be the reason for this observation.

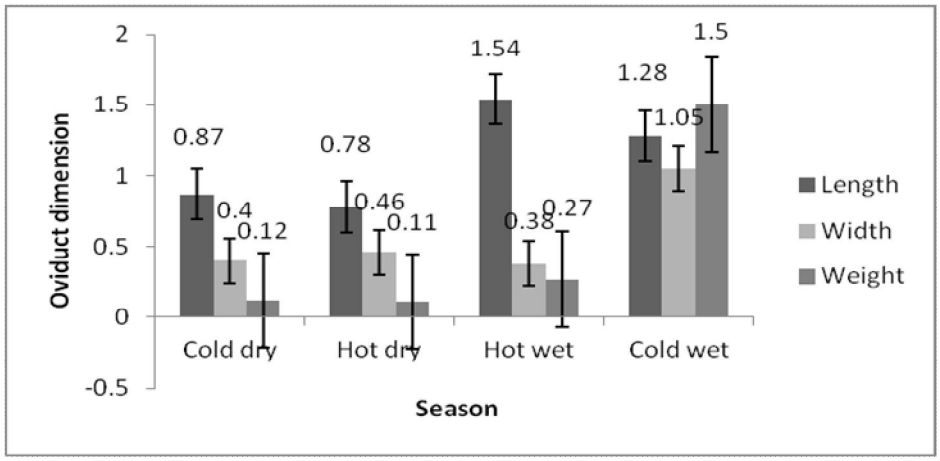

Figure 1. Effect of season on the oviduct dimension

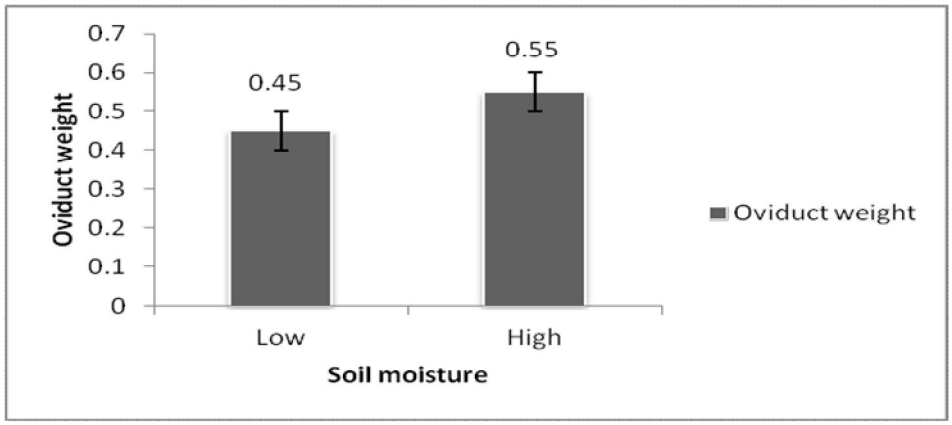

Figure 2. Effect of soil moisture on the oviduct weight

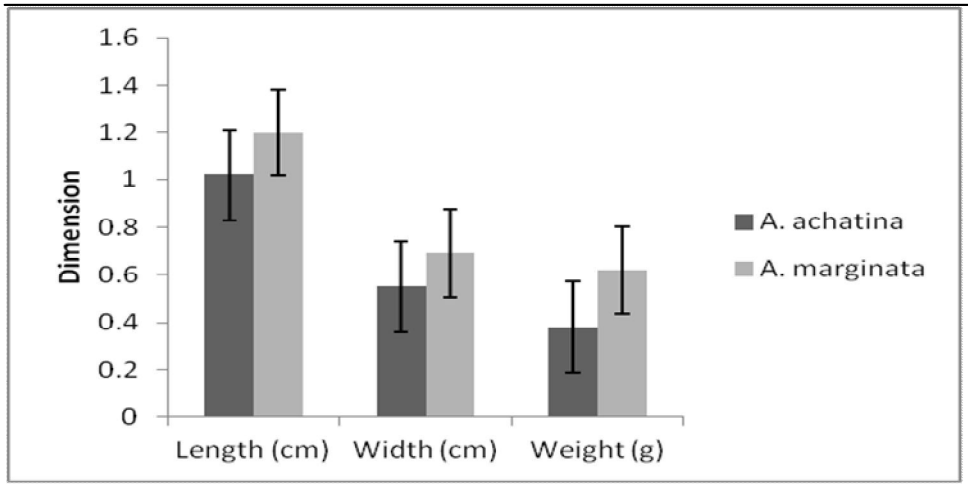

Figure 3. Effect of species on the oviduct dimension and weight

Penis

Highly significant seasonal differences (P<0.001) were observed in the values of penis length (2.64±2.229, 2.51±2.229, 3.24±2.229 and 3.29±2.229 cm) and width (0.82±0.067, 0.68±0.0664, 0.85±0.067 and 1.01±0.064 cm) during cold dry, hot dry, hot wet and cold wet season, respectively as presented in Figure 4. Highly significant (P<0.001) soil moisture level effect was observed in penis length (2.66±0.171 and 3.18±0.167 cm) of snails placed on low and high soil moisture conditions respectively but not in the penis width and weight values (P>0.05) as shown in Figure 5. In Figure 6, a highly significant (P<0.001) species effect was observed in penis length (2.42±0.242 and 3.42±0.231 cm), width (0.75±0.070 and 0.92±0.064 cm) and weight (0.73±0.087 and 1.08±0.062 g) for *A. achatina* and *A. marginata,* respectively. The effect of species was also significant in the result of the penis dimension of the experiment reported by Abiona *et al.(*2012) with *A. marginata* having higher value than *A. achatina.* The differences obtained in penis of the two species could as a result of the fact that the two species do not interbreed with each other. Also, shell architecture of both species which is spine-like and long in *A. achatina* while that of *A. marginata* is robust may be another reason for the dimension seen since organs contained in the shell need to occupy the space provided Abiona (2005).

There were significant interaction between season and species for penis length (P<0.01), width (P<0.05) and weight (P<0.01) due to the fact that the penis dimension was highest for both *A. achatina* and *A. marginata* during the cold wet season. There were significant interactions (P< 0.01) between season and soil moisture for penis length due to the fact that the highest penis length values was recorded in snails placed on the low soil moisture condition during the cold wet season and hot wet season, respectively. Significant interaction between species and soil moisture level was observed in the penis length (P<0.05), weight (P<0.05) and width (P<0.01), which was due to the fact that the *A. marginata* had highest penis dimension under low and high soil moisture condition. There were no significant (P>0.05) interaction between season, species and soil moisture level for penis dimension. With the inclusion of snail liveweight as covariate to model, seasonal difference on common duct

weight; soil moisture level on penis length became insignificant (P > 0.05). However, the effect of snail liveweight was significant (P<0.001) on penis dimension.

The study shows that values of penis length were higher in snails placed on the high soil moisture condition, which may be due to the functional reproductive activity of the snails in the high soil moisture condition of the rainy season. *A. marginata* had higher values of penis length, which might be due to the effect of species variation on the reproductive tract. Values of penis width were higher during wet season compared to the dry season, which may be due to the fact that snails mate during the rainy season.

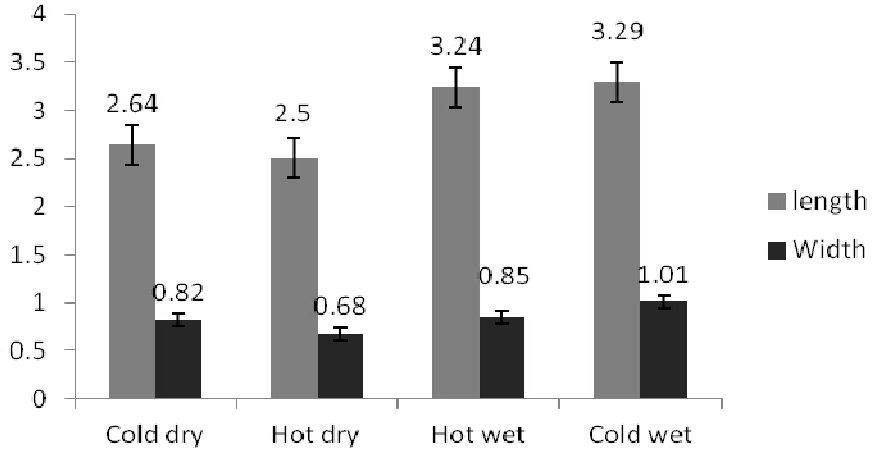

Figure 4.Effect of season on the penis dimension

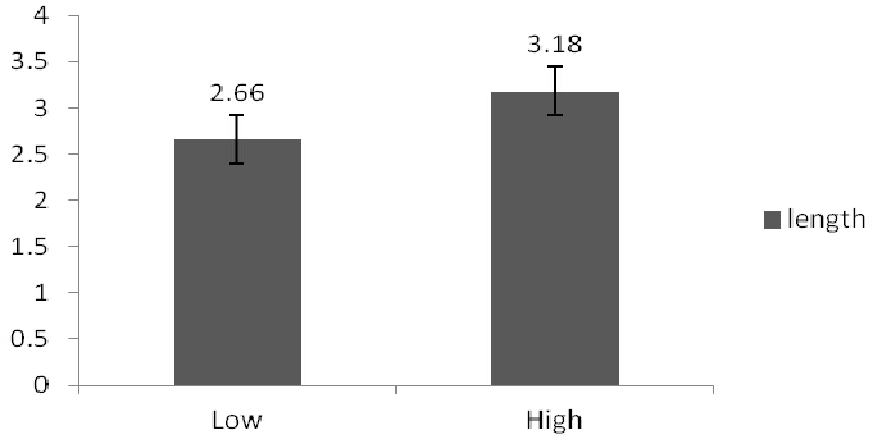

Figure 5.Effect of soil moisture on the penis length

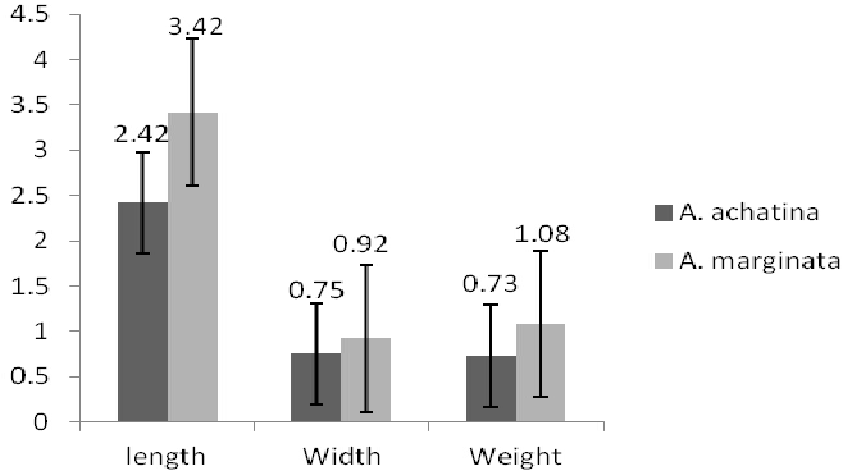

Figure 6. Effect of species on the penis dimension

Retractor muscles

Significant seasonal differences (P<0.001) were observed in retractor muscle length (2.86±0.254, 2.01±0.254, 3.03±0.232 and 3.50±0.232 cm), width (0.45±0.035, 0.37±0.035, 0.38±0.032 and 0.21±0.032 cm) and weight (0.20±0.040, 0.22±0.042, 0.39±0.036 and 0.63±0.036g) during cold dry, hot dry, hot wet and cold wet season respectively as presented by Figure 7. Highly significant species differences (P<0.001) were observed in retractor muscle length (2.38±0.122 and 3.33± 0.119cm) and weight (0.28±0.019 and 0.45±0.019 g); retractor muscle width (0.33±0.017 and 0.38±0.016 cm; P<0.05) for *A. achatina and A. marginata;* respectively as shown in Figure 8. This result obtained agrees with the work of Abiona *et al.,* 2012 who also recorded higher retractor muscle dimension in *A. marginata* compared to its counterpart (*A. achatina)* of the same liveweight range. Figure 9 shows significant soil moisture level effects on retractor muscle length (2.58±0.254 and 3.13±0.244 cm; P<0.01) and weight (0.31± 0.041 and 0.41±0.038 g; P<0.001) of snails on low and high soil moisture conditions, respectively but not in the retractor muscle width (P<0.05).

There was significant interaction between season and species for the retractor muscle length (P<0.05), width (P<0.001) and weight (P<0.001) due to the fact that the retractor muscle length and weight were highest for both *A. achatina* and *A. marginata* during the cold wet season while the width was highest in the cold dry and hot dry season for A. *achatina* and *A. marginata,* respectively. There was significant interaction between season and soil moisture for retractor muscle length (P<0.05) and weight (P<0.01) due to the fact that the values of retractor muscle length and weight were highest in snails placed on low and high soil moisture condition during the cold wet season. Significant interaction (P<0.01) between soil moisture and species was observed for the retractor muscle width due to the fact that the *A. marginata* had highest width value in the two soil moisture regime. There were no significant (P<0.05) interactions between season, species and soil moisture for retractor muscle dimension.

With the inclusion of snail liveweight as covariate to model, species and soil moisture

level effects on length and width become insignificant (P>0.05). However, the effect of snail liveweight was highly significant (P<0.001) on retractor muscle dimension.

The result of this study indicated that the values of retractor muscle length and weight were higher in the wet season than in the dry season, which supports the fact that the reproductive system is functional in the rainy season (Plummer, 1975). The values of retractor muscle length and weight were higher also in the high soil moisture treatment. *A. marginata* had higher values of retractor muscle dimension that may be due to the species variation in the reproductive tract.

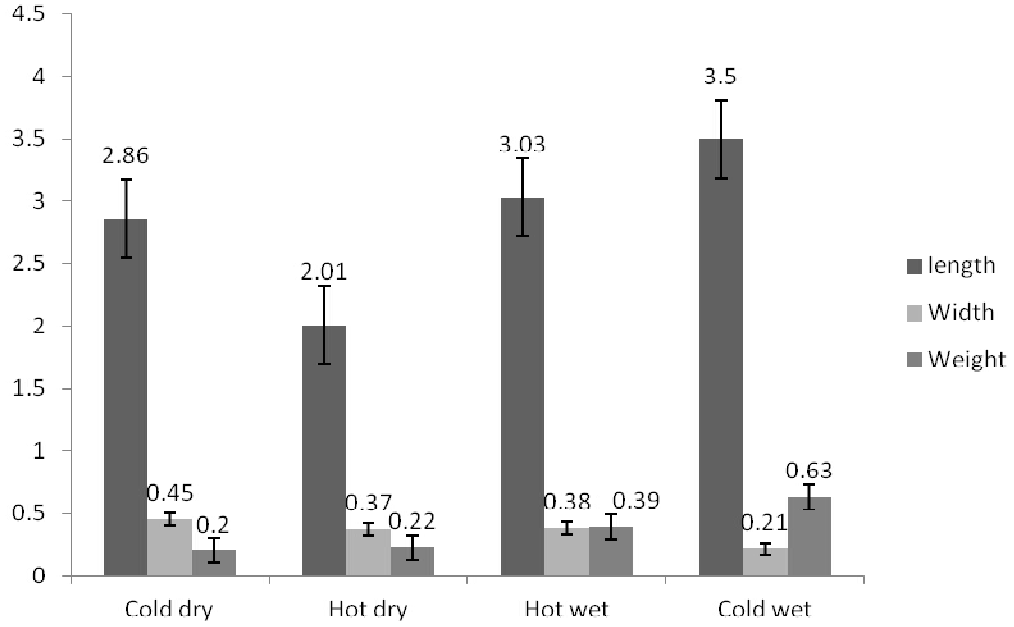

Figure 7.Effect of season on the retractor muscle dimension

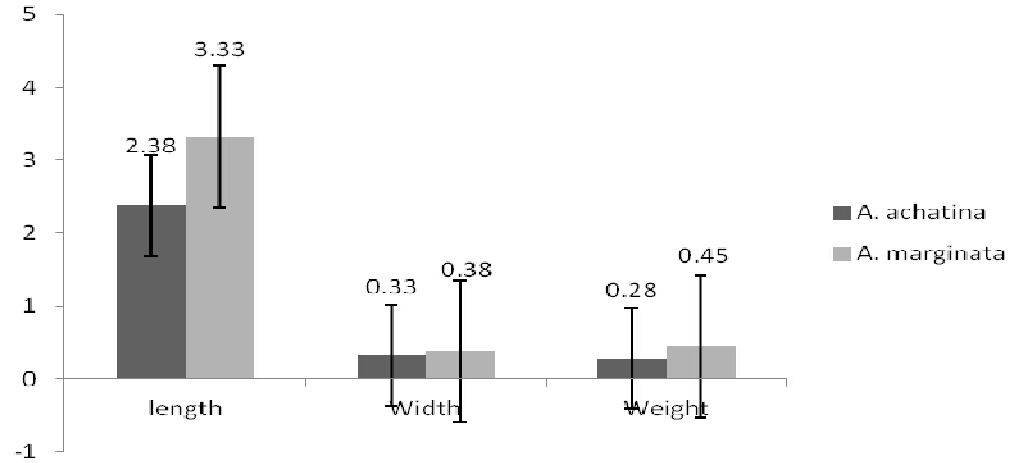

Figure 9.Effect of species on the retractor muscle dimension

CONCLUSION

In conclusion, it was evident from this study that species and soil moisture level affected the dimension of the oviduct, penis and retractor muscle. *A. marginata* had higher oviduct, penis and retractor muscle dimension than *A. achatina.* High soil moisture level lead to higher values of the organs examined. Hence, it could be recommended that *A. marginata* will increase its reproductive potential when reared on soil with optimum moisture which enhances its productivity.

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