Morphometric Parameters and Growth Pattern of Edible Palm Beetle (*Oryctes owariensis)* and Compost Beetle (*Oryctes boas)* in Niger Delta, Nigeria

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Abstract
Morphometric parameters of two species of edible beetles studied were the palm beetle (PB) (Oryctes owariensis) and compost beetle (CB) (Oryctes boas). External morphological features showed that male adults of O. owariensis were bigger than the male adults of O. boas by having mean body weight of 9.21g and 8.02g respectively. Body length of O. owariensis ranged between 41.9-78.6mm; while body width ranges between 12.8-38.5mm; whereas O. boas had body length ranged between 59.7 – 68.4mm and body width ranged 26.8 – 34.2mm. Mean width and length of horns of O. owariensis was 5.97mm and 17.8mm respectively; while mean width and length of horns of O.boas was 4.80mm and 14.6mm, respectively. Ranking of larvae of O. owariensis and O. boas revealed that the larvae developed through three instars (1^{st}, 2^{nd} and 3^{rd}) to be adults in both species. The head capsule of the 1^{st} instar larvae of both species had equal mean width of 3.0mm; while the mean length of head capsule ranged between 2.5 - 3.5mm; Mean body weight was 0.15g and 0.25g for O. boas and O. owariensis in that order. Body length ranged between 35-44mm and 37-44mm for O. boas and O. owariensis respectively; while body width ranged between 10-13mm for both species. The 2^{nd} instar larvae possessed equal mean length of 7.5mm for both species, whereas mean width of head capsule was 7.5mm and 6.5mm for O. owariensis and O. boas respectively. Mean body weight was 0.65g for O. owariensis and 0.70g for O. boas. The body length ranged between 41-55mm and body width ranged between 15mm-13mm for the two species. Headcapsule of 3^{rd} instar larvae had mean width ranged between 12.5-13mm; mean length was 12mm for both species; mean body weight was 13.75g and 14g for O. owariensis and O. boas respectively. Body length ranged between 55-123mm for O. owariensis and 52-113mm for O. boas respectively. Both species had equal body width ranged between 15-31mm. Growth pattern of the larvae of both species did not conform with Dyar's rule but it agreed with Przibram's rule under natural conditions in the field.

Key words: *Morphometric parameters, Oryctes owariensis, O. boas and Edible*

Introduction:
The genus *Oryctes* has two important species of edible beetles. One is identified as *O. owariensis* which is a common pest of raffia palms (*Raphia hookeri*) and matured oil palms (*Elaeis guineensis*) in the Niger Delta of Southern Nigeria (Hill and Wallace, 1999). Whenever these palms are deliberately cut down by humans to obtain wine from the sap of the raffia palms or they are destroyed by natural disaster such as windstorm, the affected palms are susceptible to infestation by *O. owariensis* in the field (Thomas *et al*, 2017 and

Thomas and Kiin-Kabari, 2018). The second species is the *Orcytes boas* which is harvested in large numbers from decomposed organic wastes (Thomas *et al*, 2017). Although all the development stages of *O. owariensis* are edible, the larvae are more cherished as food by humans because they are easily gathered in large numbers than the adults and pupae; whereas it is only the larvae of *O. boas* that are often harvested by children and women among the Ijaw, Ibibio, Ogoni, Igbo and Itsekiri in the palm belt of Niger Delta in order to supplement the shortage of meat products during the dry season when the ecosystem is dried (Ene, 1963; Akingbohugbe, 1989 and Thomas *et al*, 2017). There is a third species of beetles (*O. rhinoceros*) which is often found in the Niger Delta, which are obviously bigger than the *Oryctes* beetles and also possess heavy horns been used to destroy younger palm seedlings, thereby creating occasional entry points for the African palm weevil (*Rhynchophorus phoenicis*) in raphia palm (Bedford 1980, Defoliart, 1989 and Thomas, 2003). Earlier reports (FAO/UN 2015) had confirmed that the larvae of the two species of beetle (*O. monoceros* and *O. boas*) are good sources of supplementary protein that contains essential amino acids (inclusive of methionine cysteine and histidine) which are limiting factors in many food stuffs in the world (Thomas and Kiin-Kabari, 2018). Therefore deliberate effort is made towards conservation of these edible insects and the host palms that are currently threatened by rapid deforestation of the tropical swamps in Niger Delta of Nigeria arising from oil pollution (Thomas, 2018). There are aspects of the biology and taxonomy of these two related species of *Oryctes* beetles that have great resemblance in morphology which makes it difficult to be differentiated (Thomas *et al*, 2016). Therefore, the objective of this study was to examine some morphometric features of the male adults and larvae of these beetles which will be useful in identification of their sexes for breeding under laboratory conditions, to mitigate protein – energy deficiency in developing economics in Africa.

Materials and Methods:

A total number of sixty beetles (n=60) which comprised of thirty male adults and larvae (n=30) of *Oryctes owariensis* and thirty male adults and larvae *(n=30) of O. boas* were studied. The *O. owariensis* were collected by harvesting infested raffia and oil palms (*Raphia hookeri*) at Iwofe in Port Harcourt Municipality of Rivers State and Anyama – Ijaw Community in Southern – Ijaw Local Government Area of Bayelsa State in the Niger Delta of Southern Nigeria. The adults and larvae of *O. owariensis* were collected by using a sharp axe and cutlass to fell the infested raffia and oil palms and cut-open the trunks and picked by hands in gloves and put into separate plastic containers which had several perforations on the lid for aeration, and transported to the laboratory within 6 – 12 hours. On the other hand, the male adults and larvae of *O. boas* were collected by digging decomposed sites of sawdust and organic wastes at Agudama - Epie in Yenagoa Municipal Council Area of Bayelsa State of Nigeria. An electronic mettler balance was used to record the weight; while a meter rule was used to measure the length and width of each larva and adult. A vernier caliper was used to take the length and width of the horns of the adults and the head capsule of the larvae. The means and standard deviation of the two sets of samples were calculated. In order to ascertain whether the pattern of growth of the larvae of *O. owariensis and O. boas* agreed with Dyar's rule or not; the size of the width of the head capsule was used to calculate the growth ratios for the 2nd and 3rd instar, based on the formular by Klingenberg and Zimmerman (1991).

$$\text{Dyar's coefficient} = \frac{size\ of\ width\ of\ head\ capsule\ (Post\ moult)}{size\ of\ width\ of\ head\ capsule\ (Pre-moult)} = Percentage\ increament$$

The pattern of development of the larvae of the two species of beetles (*O. owariensis* and *O. boas*) were subjected to Przibram's rule by evaluating the increase in mean body weight which was presumed to increase in successive instars by a power of 2.09 (Rice, 1968). Based

on Dyar's law (1890), the size of the width and length of the head capsule was used to rank the larvae in to three stadia in relation to body weight, body length and body width. The pattern of infestation of these insects on their host palms was also observed.

Results and Discussion:

The results in Table 1 revealed that the male adults of palm beetle (*O. owariensis*) were generally bigger than the male adults of the compost beetle (*O. boas*) because the mean body weight of *O. owariensis* was 9.21g, while the mean body weight of *O. boas* was 8.03g. The horns of the male adult of *O. owariensis* were also longer than the horns of *O. boas* based on the fact that male adults of *O. owariensis* had mean length of 17.8 mm and mean width was 5.97mm; whereas the horns of the male adults of *O. boas* had shorter horns of 14.6mm and smaller width of 4.80mm respectively. Furthermore, the body length and width of the adults of *O. owariensis* were also greater than *O. boas*, because *O. owariensis* ranged between 41.9 – 78.6mm in length and 12.8 – 38.5mm in width, whereas the adults of *O. boas* had body length ranged between 59.7 – 68.4mm, while the width ranged between 26.8 – 34.2mm for *O. boas*. Plates (1a & b) are showing the external morphological features of male adults of *O. owariensis and O. boas, respectively*.

The male adults of *O. owariensis* were black in colour (plate 1a), while the male adults of *O. boas* were dark-brown in colour, (plate 1b) whereas the larvae of *O. boas* was light – brown in colour, while the larvae of *O. owariensis* are whitish in colour (plates 2a & b). The observed differences in the coloration of the body and sizes of the *Oryctes beetles* were attributed to the impact of environmental factors affecting the different micro-habitats in which it lives. The *O. owariensis* larvae feeds on the decaying internal tissues of the infested palms by chewing its fibrous tissues with the heavily clawed mandibles to produce a soft black paste which blends with the mud, thereby re-cycling the nutrients of the decayed palms into the soil. It also produced brownish fecal pellets as wastes, while the larvae of *O. boas* which feed on the manure of decayed organic wastes produced black fecal pellet as digestive wastes.

Table 1: Morphometric Parameters of Male Adults of *Oryctes owariensis* and *O. boas*

S/n	Parameters	*O. Owariensis*	*O. Boas*
1.	Mean body weight (g)	9.21 ± 0.69	8.03 ± 2.27
2.	Mean length of horns (mm)	17.8 ± 1.25	14.6 ± 0.94
3.	Mean width of horns (mm)	5.97 ± 0.49	4.80 ± 1.01
4.	Body length range (mm)	41.9 – 78.6	59.7 – 68.4
5.	Body width range (mm)	12.8 – 38.5	26.8 – 34.2

Plate 1a: Male Adult of *O. owariensis having black colour* (mag. x 1)

Plate 1b: Male Adult Stages of *O. boas* having dark-brownish colour (mag. x 1)

The results in Table 2 showed that at the first instar, there was little difference in the size of the head capsules of the larvae of *O. owariensis* and *O. boas* because both species had equal mean width of 3.0mm. However, *O. owariensis* had greater mean length of 3.5mm, whereas the mean length of *O. boas* was 2.5mm of the head capsule. The first instar of *O. owariensis* also had mean body weight of 0.25g, while *O. boas* had mean weight of 0.15g. It was also observed that the first instar larvae of both species were almost equal in the body length and body width as *O. owariensis* ranged between 37-44mm in body length and 12-13 in body width respectively, while *O. boas* ranged between 35-40mm in body length and 10-12mm in width respectively. At the second instar, there was little difference in mean width of the head capsule of the larvae of these beetles. *O. owariensis* had mean width of 7.5mm, while *O. boas* had mean width of 6.5mm of the head capsule; whereas both larvae possessed equal mean length of 7.5mm of head capsule. The mean body weight was almost equal in both larvae which had mean body weight that ranged between 0.65-0.7g for *O. owariensis* and *O. boas* respectively. It was noted that both larvae were almost equal in total body length and width which ranged between 41-55 in length and 13-15mm in width for *O. owariensis* and *O. boas* in that order.

Table 2: Morphometric Parameters of Larvae of *O. owariensis* and *O. boas*

Larval instars	Size of Head capsule		Mean body weight + SE (g)	Body length (mm)	Body width (mm)
	Mean width + SE (mm)	Mean length + SE (mm)			
1st instar					
O. owariensis	3.0 ± 0.5	3.5 ± 0.25	0.25 ± 0.5	37 – 44	12 – 13
O. boas	3.0 ± 0.5	2.5 ± 0.35	0.15 ± 0.25	35 – 40	10 – 12
2nd instars					
O. owariensis	7.5 ± 0.52	7.5 ± 0.16	0.65 ± 1.22	41 - 55	13 – 15
O. boas	6.5 ± 0.75	7.5 ± 0.2	0.7 ± 0.2	41 – 52	13 – 15
3rd instars					
O. owariensis	13 ± 1.32	12 ± 0.12	13.75±0.11	55 – 123	15 – 31
O. boas	12.5 ± 0.10	12 ± 0.15	14± 0.25	52 – 113	15 – 30

The 3rd instar larvae were almost equal in size of head capsule for both species because *O. owariensis* and *O. boas* larvae had mean width of 13mm and 12.5mm respectively, but they

had equal mean length of 12mm for both species. This revealed that, the mean width of the 3rd instar larvae were more than the mean length in both species of beetles. The mean weight was almost equal because *O. owariensis* had mean body weight of 13.75g, while *O. boas* had mean weight of 14g which was slighter heavier than *O. owariensis,* which equally had body length ranged between 55-123mm in length, whereas the *O. boas* had shorter body length that ranged between 52-113mm. The 3rd instar larvae of both species also possessed equal body width of 15-31mm.

Infestation of Palms by *Oryctes* Beetles

Field observations during this study revealed that *O. owariensis* infestation occurs after *Rhynchophorus phoenicis* had infested the wounded portion of the matured raffia palm trunk or oil palm and used it to complete its life cycle for development (Eggs → Larvae → Pupae → Adults). Subsequently, the newly formed adults of *O. owariensis* emerges from the cocoons through the bark of the trunk and fly out to the ecosystem to continue another life cycle. The adults often locate the sites of decaying tissues of another palm or it crawls forward in the same infested palm to create new holes to commence breeding by copulation of male and female adults. Then, the female adults will lay new eggs in the decayed tissues. Each egg hatches to small first instar larva (L_1) which feeds by using its mandibles to chew the fibrous tissues of the palm and develop through two (2) molting stages ($L_1 \rightarrow L_2 \rightarrow L_3$) and become a final instar larva. The final instar develops to become a pre-pupa which builds a cocoon to cover itself and underwent morphological changes to form a new adult which crawls out of the cocoon and fly out to the outside environment. These observations agreed with earlier reports which stated that *Oryctes* beetles utilizes the decayed tissues of infected palms for breeding and the adults which are nocturnal flies long distance at night to locate new host plants (Defoliart, 1989 and Thomas, 2003).

Plate 2a: 3rd Instar Larvae of *O. boas having light brownish colour* (mag. x 1)

Plate 2b: 3rd Instar Larvae of *O. owariensis having whitish colour* (mag. x 1)

The pattern of growth of the larval stages of *Oryctes* beetles based on Dyar's rule which stated that the head capsule of an insect grows in geometrical progression with constant growth ratio for a given species of insects or arthropods. The results in Table 3 showed that the growth ratios of the larvae of *O. owariensis* and *O. boas* were not constant but reduced from 2.5 to 1.73 as it molted from the second instar to the 3rd instar of *O. owariensis*. Similarly, the growth ratio of *O. boas* also reduced from 2.6 at the 2nd instar to 1.9 at the 3rd instar larva. Therefore, theses values have shown that the pattern of growth of the larvae of both species did not agree with Dyar's rule. It is therefore seen as an exception to Dyar's rule as was observed in millipedes (Bhakat, 1987).

Table 3a: Determination of growth ratios of larvae of *O. owariensis* (Dyar's rule)

Larval instars	Mean width of head capsule	Growth ratio (r)
1st	3.0	-
2nd	7.5	2.5
3rd	13	1.73

Table 3b: Determination of Growth Ratio of larvae of *O. boas* (Dyar's rule)

Larval instars	Mean width of head capsule	Growth ratio (r)
1st	3.0	-
2nd	6.5	2.6
3rd	12.5	1.9

Further application of the values of the mean body weight of the larval instars of *O. owariensis* and *O. boas* (Table 2) to ascertain whether it agreed with Prizbram's rule (1935) which stated that the weight of an insect is doubled at each instar, while all linear dimensions are increased by the ratio of 1.26 or $\sqrt[3]{2}$. The results in Table 4 showed that the total body weight of both *O. owariensis* and *O. boas* were doubled after moulting to the proceeding instar. For instance, the mean body weight of *O. owariensis* increased from 0.25g to 0.65g at the second larval instar and further increased to 13.75g at the third larval instar. In the same way, the total body weight of *O. boas* increased from 0.15g to 0.7g at the second larval instar and further doubled its weight to 14g at the third larval instar. Therefore, these values have confirmed that the pattern of growth of both *O. owariensis* and *O. boas* conforms with Prizibram's rules as it develop under natural conditions in the field. The findings in this study corroborated with the report of Rice (1968) which stated that the growth pattern of larvae of decapod crustacean (*Streptogonopus phipsoni*) obeyed Przibram's rule.

Table 4: Growth pattern of Orcytes beetles (Przibrams Rule)

Larval instars	Mean body weight (g) of *O. owariensis*	Growth ratio
1st	0.25	-
2nd	0.65	0.50
3rd	13.75	1.3
Larval Instars	**Mean body weight (g) of *O. boas***	**Growth ratio**
1st	0.15	-
2nd	0.7	0.3
3rd	14	1.4

CONCLUSION

The findings of this study have confirmed that the male adults and larvae of *O. owariensis* which infest raffia palm (*Raphia hookeri*) and the mature trunks of oil palm (*Elaies guineensis*) in the Niger Delta of Southern, Nigeria are bigger than the male adults and larvae of the compost beetle (*O. boas*) which are found in decayed organic wastes. The mean body weight of the male adults of *O. owariensis* was 9.32g with body length ranged between 41.9-78.6mm and body width ranged between 12.8-38.5mm; while the mean body weight of the

male adults of *O. boas* was 8.02g, having body length of 5.97-68.34mm and body width ranged between 26.8-34.2mm. In addition, the male adults of *O. owariensis* were distinguished by the black colour, while the male adults of *O. boas* had dark-brownish and shinning colouration. The first, second and third instars of these two beetles had little differences in sizes of head capsule, body weight and length. The larvae of *O. owariensis* were distinguished by having whitish colouration, whereas the larvae of *O. boas* appeared light-brownish in colour when harvested from the field. The pattern of growth of the adult and larvae of both species did not conform with Dyar's rule, but it agreed with the Przibram's rule when it develops under field conditions.

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