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The Consumption and Utilization of Leaves of Host Plants in Fifth Instars of Bunaea Alcinoe Stoll [Lepidoptera Saturniidae]

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Abstract
The palatability of most host plants of the Niger Delta edible moth larvae, Bunaea alcinoe, the Saturnid moth larvae account for the defoliation and skeletonization of tender stems, leaves and fruits plants. Also the nutrient compositions of such plants attracted the gravid female moths to oviposit on plants of preference. All instars were voracious feeders especially the first four instars. *B. alcinoe* larvae were exposed to two host plants which they attach both in rainy and dry seasons. Fifty grams of fresh leaves of *Terminalia catappa* and *Gmelina arborea* were respectively offered to thirty fifth instar larvae in the laboratory at 27.5^{O}C and 88.5%Rh in order to assess their consumption and digestibility indices as well as their efficiency of conversion digested food into body matter. There were no significant differences in their consumption indices, though significant differences occurred in their approximate digestibility and in their efficiency of conversion of digested food into body matter.
Keywords: *Bunaea alcinoe*, Leaf consumption, digestion and Food conversion, host plants.

INTRODUCTION

In Nigeria, the Saturnid moth larvae of *Bunaea alcinoe* exert heavy defoliation on their host plants especially under high larval densities. The moths are available mostly in the Niger Delta ecological zone, south east and also in the Middle belts of Nigeria. In the Niger Delta they can completely defoliate whole host plants especially the cabbage plants, *Anthocleista vogeli,* younger plants of the African Almond plant, *Terminalia catappa*, *T. ivorensis, Gmelina arborea*, Queen of the Night and *Anacardium occidentale*. *Tectona grandis* though one of its host plants is not preferred at any time when other host plants are available. Most host plants of the emperor moth larvae are essential economic plants mostly known for their industrial values especially *T. grandis, T. catappa, T. ivorensis and Gmelina arborea*.

The host plants of this edible hexapod are available all over Niger Delta. The adult females and males are not involved in the feeding or damage of leaves of host plants. The damage on foliage is caused by the larvae of *Bunaea alcinoe*. After mating, the females deposit their eggs on the adaxial surfaces of leaves of host plants. Most Saturnids do not construct cocoons; usually the last larval instars prior to pupation descend down from their host plants in search of suitable pupating sites Previous studies on the biology of *Bunaea alcinoe* showed that as soon as they descended from their host plants they ceased eating and commenced migration in search of pupating sites [Ogbalu and Kwokwo, 2018].Sandy, well-drained soils may be a requirement for *Eacles imperialis* in that, like all ceratocampine saturniids, *Eacles* larvae do not construct cocoons but burrow into and pupate within the soil, from which the pupae themselves emerge so that the adults may eclose above-ground. Other moths of the Saturnids include the polyphemus moth, *Antheraea polyphemus* (Cramer), one of the largest and most beautiful silk moths. Just like *B. alcinoe* adults of the Niger Delta zone of Nigeria that have eye spots on their wings, some of the differences being that the later has three concentric layers that make up the two eye spots of orange and black colours and although the male antennae are feathery the female *B. alcinoe* has a filamentous pair of antennae. Their pupae are obtect and their larvae do not produce silk [Ogbalu and Jaja, 2016]. The leaves are rich in nutrients and provide food for the highly voracious larvae which have a 55.4% protein content [Amadi et al., 2005]. The mature larvae of *B. alcinoe* are harvested from trees by women, youths and children that use them to make a living within the rural settings. In the villages they are seen in the local markets. A village family can make up to 50 -100 dollars daily during the rainy season from the moths' harvest. Many methods of preparation of the larvae and pupae include roasting, frying and boiling in stews, porridges and mixing with ingredients such as salts, onions, pepper and tomatoes before consumption. Some villagers even eat them raw after degutting. Since it is eaten raw in some rural settings the microbiological investigations that had been carried out [Amadi et al., 2005]. Ogbalu [2018] He had documented the domestication of the emperor moths. However, there is a dearth of information on their Consumption abilities, Digestibility and Conversion of food materials into body matter in the edible larvae of *Bunaea alcinoe* and there have been no similar studies elsewhere in literature; the objectives were to document the consumption and digestive/conversion indices of the voracious emperor moth larvae of *B. alcinoe*.

MATERIALS AND METHODS.

Fresh leaves of two host plants [*Gmelina arborea and Terminalia catappa*] of *B. alcinoe* were harvested in July, 18th 2015 from the Department of Applied and Environmental Biology of the Rivers State University, Nkpolu-Orowurokwo, Port Harcourt, Nigeria. The leaves were weighed in electronic Sartorius balance. Thirty fifth instar larvae of *B. alcinoe* which were collected from the larval population cultures maintained on their respective host plants at 25.7^{O}C and 88.5% Rh in the Post Graduate Entomology Unit of the department and were individually introduced into trays in each of the sleeve cages. Fifty grams [n=30] of each of the leaves of the host plants [*Gmelina arborea* and *Terminalia catappa*] immersed in 20 ml of distilled water in Khliner jars with the open end cello taped to avoid drowning of larvae and at the same time maintain freshness of the leaves, were offered to each larva. The aforementioned number of larvae was individually maintained in thirty wooden sleeve cages in four replicates. The larvae were maintained on moist filter papers [Whatman No. 1] which were used in lining the white laboratory trays that measured 30 X 20 X 10cm]. Each larva was weighed to record the initial weights and subsequent weights of larvae were recorded at 24, 48, 72 hourly feeding intervals. At 24 hourly intervals, 10ml of distilled water was sprinkled over the leaves and larvae to maintain freshness and humidity of the experimental set up. Fecal pellets were collected and weighed at the end of the feeding durations. There was no data collection when the larvae entered their pupal period, however emerging adults were exposed to feeding on 10% honey solution [Ogbalu, 1998] 24h after emergence and their respective weights were also taken.

Statistical Analyses:

All indices were computed to determine Consumption Index [C.I.], Approximate Digestibility [A. D.] and Food Utilization which was based on the methods of Waldbauer, 1968 and later modified [Ogbalu *et al.,* 1998] basing their computations on mean values thus:

Consumption Index [C. I.] = Mean Fresh Weight of Leaves Ingested / duration of feeding x mean fresh weights of adults during feeding;

Fresh weights of leaf ingested = Initial weights of leaf – Final weights of leaf at the end of the feeding period.

Approximate Digestibility [A.D.] = Mean weights of leaf ingested – Mean weights of fecal pellets / Mean weights of leaf ingested x 100.

Gross Efficiency of Conversion [E. C.] OR Food Utilization [F.U.] = Mean weights gained by insect / Mean weight leaf ingested x 100.

Duncan Multiple Range Test [DMRT] at 5% level was used to assess significant differences among the means.

RESULTS AND DISCUSSION

Food consumption in fifth larval instars of *B. alcinoe* larvae was not as high as in earlier instars as these were more voracious feeders than the latter instars that were about entering into their pupal stages, hence low consumption index at different feeding durations for larvae exposed to *T. catappa* and *G. arborea* leaves [Table 1]. There was no significant difference in the larval feeding at different feeding durations [DMRT, $P<0.05$]. The digestibility of leaves consumed by the larvae was relatively high implying the adequacy and nutritional sufficiency of what they consumed. The respective approximate digestibility showed a progressive increase in the feeding durations from 24-72h in larvae exposed to the leaves of *T. catappa* and *G. arborea*. Food conversion efficiency was high at the end of 72h in all the larvae. Physiologically all digested foods had to be absorbed into the system prior to pupation. In short many lepidopterans engage in a 'flushing exercise' whereby the get rid of food in their guts before pupation. During pupation, there is usually no feeding. Greater quantities of cell walls, foliage or skeletal parts eaten by insects are atimes passed through the gut apparently unchanged and in some cases even fresh leaf fragments were recovered in the fecal portions of the larvae [Ogbalu *et al.,* 1998].

Both insect larvae and adults require carbohydrates for energetic demands, growth, longevity, movement, and reproduction (Nation, 2008; Chapman, 2012). Herbivorous insects that include *B. alcinoe* larvae utilize plant tissues full of carbohydrates (mainly starch and glycosides) which are digested by the activities of different carbohydrases to provide monomers like glucose to be absorbed via epithelial cells. α-Amylases are one of the important classes of digestive enzymes that break down starch within plant tissues to oligosaccharides prior to be further hydrolyzed to glucose by glucosidases . Studies on localization of amylolytic activity in *Panesthia cribrata* Saussure (Blattodea: Blaberidae), Nauphoeta cinerea Oliver (Blattoptera : Blaberidae), and *Lutzomyia longipalpis* (Diptera Psychodidae) indicated the higher activity of α-amylase in soluble and anterior midgut preparations [Chapman, 2012].

Generally the digestive enzymes in insects are adapted to the diet which they feed on. In phytophagous insects, enzymes such as protease, lipase, amylase, invertase, maltase are secreted by hydrolyzing respectively natural proteins, fats, starch, cane sugar and maltose. Some indicators of the efficiency with which digested food had been utilized by the larvae were shown in the high E. C. I. values of 75.6 and 82.5% in the four replicates of larvae exposed to 50g of leaves. Apart from high voracity, their ability to convert food into body matter was efficient even though larvae exposed to T. catappa leaves showed higher E. C. I. values [Tables 1a and b]. This difference will be related to their nutritional contents. Many workers [Zhu et al., 2005; Ajamhassani et al., 2012; Delkash- Roudsari et al., 2014; Zibaee, 2012; Mardani-Talee and Zibaee, 2015] had reported of their findings on the proteolytic activities in moths' midguts and the roles of digestive enzymes in insects generally.

Table 1. Consumption, Digestibility and Food Utilization in Fifth Instars of *B. Alcinoe* Fed on Leaves of Two Host Plants; *G. Arborea* and *T Catappa* [26.5^{o}c and 88.5% Rh].

Table 1a. Data on the Consumption index [c.i.], Approximate Digestibility [A.D.] and Efficiency of conversion of digested food [E.C.I] in *B.alcinoe* larvae Exposed to *G. arbora* Leaves [n=30/replicate].

	C.I			A.D.[%]			E.C.I.[%]
Replicates	24h	48h	72h	24h	48h	72h	72h
1	0.05	0.01	0.06	62.3	80.3	86.7	78.5
2	0.04	0.02	0.06	67.5	82.7	86.5	80.5
3	0.05	0.02	0.07	64.7	83.5	85.6	82.7
4	0.03	0.01	0.07	63.1	87.5	76.4	75.6

Table 1b. data on the consumption index [C.I], Approciamate Digestibility [A.D.] and Efficiency of conversion of digested food [E.C.I] in *B.alcinoe* larvae Exposed on *T.Catappa* Leaves [n=30/replicate].

	C.I.			A.D.(%)			E.C.I.(%)
Replicates	24h	48h	72h	24h	48h	72h	72h
1	0.04	0.03	0.08	61.4	80.5	88.7	86.3
2	0.05	0.03	0.07	63.5	88.8	89.6	87.3
3	0.04	0.02	0.07	67.3	80.7	87.6	83.4
4	0.06	0.03	0.08	65.3	86.8	83.7	78.7

Insects generally require carbohydrates for energetic demands which include mating, flight, growth, longevity [Chapman, 2012]. α-Amylases have been characterized in different orders of insects e.g., Orthoptera, Hemiptera, Heteroptera, Hymenoptera, Diptera, Lepidoptera, and Coleoptera and also in the new insect orders and the findings have cleared different aspects of their physiological roles in insects. In our study, assay of α-amylase in different midgut preparations of *P. brassicae* larvae revealed the higher enzymatic activity in the soluble fraction rather than membrane-bound fraction although anterior- and posterior-midgut preparations showed similar activities of α-amylase. Also, other physiological roles other than digestion may be considered for α-amylases because they are active during non-feeding stages like pupal stage (Zhu et al., 2005).

Conclusion: The leaves of *Terminalia catappa* and *Gmelina arborea* satisfied the nutritional requirements of *Bunaea alcinoe* larvae hence their consumption indices were high as well as their digestibility and their efficiency of conversion of digested food.

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