BIOLOGICAL STUDIES OF *Gasteroclisus rhomboidalis* (COLEOPTERA: CURCULIONIDAE) ON *Amaranthus* SPECIES

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ABSTRACT

In West Africa, the foliage of both wild and cultivated varieties of Amarnathus species is used widely as vegetable and as fodder for cattle. This widely cultivated vegetable is severely attacked by the snouted beetle, Gastreoclisus rhomboidalis. A comprehensive study on some aspects of the biology of G. rhomboidalis has been carried out. The full life cycle of the beetle (from copulation and oviposition through the various immature stages to the emergence of adult beetles) was investigated. It took on the average 40 days for the adult beetle to emerge from the day of oviposition. Studies on the feeding habit of the beetles revealed that the beetles fed heavily on the leaves and can inflict an enormous destruction on the host plant over a short period of time. Generally; the studies have been able to confirm that the larva and adult beetles are the most potent destroyers of the host plant. While the adult beetle fed heavily on the leaves and tender plant stem, the larva when hatched in the plant stem, destroyed the host plant (particularly during the tender ages of between 2 - 3 weeks) with its boring activities causing the plant to wilt and die.

Keywords: *Gasteroclisus rhomboidalis,* Beetles, Coleoptera, Curculionidae, *Amaranthus*

INTRODUCTION

In Nigeria, widely cultivated *Amaranthus* species include *Amaranthus viridis, A. gangenticus, A. tricolor* and *A. hybridus. A. spinosus* grows wild. Both wild and cultivated varieties of *Amaranthus* spp. are infested by the general crop pests like grasshoppers, bugs and beetles. One of these beetles, which can be said to have assumed a serious pest status, because of its attacks on the cultivated varieties of African spinach, is *Gasteroclisus rhomboidalis* (Curculionidae). Harm is done to the spinach plant by the adult beetles which feed on the leaves or bore the leaf axils and stems to deposit eggs and by the resulting larvae which tunnel inside the host plant stem tissues in the course of their growth and development (Eluwa, 1977). The said boring and tunnelling activities cause leaf withering and outright snapping and premature death of infested stands of the spinach. In addition, the boring and tunnelling activities of beetles could predispose the crops to bacteria and fungi infections.

The importance of cultivated varieties of A*maranthus* as fodder for cattle and part of human diet (Keay, 1973; Eze, 1986; Purseglove, 1987) lies in the fact that they provide much needed materials (pot herb) for man early in the wet season and at a time when other routine vegetables are normally not yet available. This is because *Amaranthus* crops grow very well with little moisture (unlike other vegetable crops that are strictly rain-fed) in the southern part of the country, where the rainy season lasts between the months of April and September in the year.

Relatively little is known about the biology of *Gasteroclisus rhomboidalis* in West Africa. Accordingly, the objective of the present study is to investigate various aspects of the biology of this relatively important pest. To this end, we undertook a comprehensive study of the life cycle of the beetle from copulation and oviposition through the various immature stages to the emergence of adult beetles. It is anticipated that these biological studies would provide useful information on the stages that are the most potent destroyers of the host plant and a guide to possible control of the pest apart from their intrinsic value of providing scientific information on the habit of the beetle.

MATERIALS AND METHODS

The studies were carried out under natural environmental and room conditions at Nsukka, Nigeria. Details of the plant cultivation are contained in (Ekechukwu, 2002). Hundred (100) adult beetles were collected from different host spinach plants (both in the wild and cultivated garden) either during the morning hours (before full sunshine) between 6.30am and 9.00am local time or in the evening, between 6.30pm and 8.00pm local time, when the beetles are known to be least active. These were segregated randomly into the 2 cages (labelled 1 [60 beetles] and 2 [40 beetles]) and placed outside. The beetles were then observed regularly (both during the day and night periods) for copulation and oviposition and for the full life cycle studies. Other studies undertaken include sexing (involving measurement of beetle snouts, observation of pygidum and body size and behavior); three different methods were adopted to ascertain the sexes of the adult beetles, viz., the measurement of the snouts of the beetles, the observed shapes of their pygidum and the relative positions of the beetles during copulation. Two different samples of beetles collected randomly were used in the measurement of the snouts of the beetles and in observing the shapes of their pygidum. Feeding habit of adult beetles was also studied. The areas of the eaten and uneaten portions of each leaf were calculated using the trapezium rule (Swokowski, 1984) and Weight Gain due to Feeding was determined Using the grametric technique (Croseley, 1963)

RESULTS AND DISCUSSION

Life Cycle: During copulation, the smaller male beetle mounts the female from the back clasping its body firmly with its claws. The male's lower abdominal sternite bearing the genitalia bends downward to engage into the female genital opening. The duration of copulation observed for 100 of the experimental beetles is recorded in Table 1. The observed engagement period lasted between 5 and 10 minutes with a mean engagement time of 6.8 ± 1.96 minutes. It was observed that copulation occurred during the daytime.

The various oviposition times observed for the beetles are shown in Table 2. The female beetles were observed boring holes with their snouts on the tender parts of the host plant. This occurred mainly during the night period, between 21 and 6 hours (i.e. 9 pm and 6 am) local time. A typical illustration of oviposition holes made on host plant by the adult beetles is shown in Figure 1. After making the hole, the female beetle turned round and placed its ovipositor inside the hole to deposit egg (usually one egg per hole). Subsequently, the beetle usually plugged the orifice of the oviposition hole with the remains of pulverized plant materials produced while making the oviposition hole.

Table 1: Duration of copulation observed for *G. rhomboidalis*

Duration of Copulation (Minutes)	Number of Beetles
5	40
6	15
7	10
8	10
9	10
10	15
Total	100
Mean	6.8
Std Dev	1.96

Table 2: Oviposition time observed for *G. rhomboidalis*

Duration of Oviposition (minutes)	Number of Beetles
3	15
4	15
5	25
6	10
7	10
8	5
9	10
10	10
Total	100
Mean	5.9
Std Dev	2.31

Figure 1: Oviposition holes made on host plant by the adult beetles

The observed oviposition time was between 3 and 10 minutes, with a mean time of 5.90 ± 2.31 minutes. It was observed occasionally that the male beetle remained on the back of the female while the latter drilled the egg hole and even when ovipositing.

The total number of oviposition holes observed per plant (during the 5 days of observation) varied widely from 0 – 12 holes (irrespective of the plant height). Table 3 showed the distribution of the oviposition holes observed for the two cages (1 and 2) respectively.

Table 3: Distribution of oviposition holes

Plant number	Number of oviposition holes per plant	
	Cage 1	Cage 2
1	0	12
2	8	6
3	9	4
4	7	5
5	10	0
6	12	3
7	3	4
8	10	10
9	6	-
10	0	-
11	6	-
12	10	-
Total	81	44
Mean	6.75	5.5
Standard Deviation	3.96	3.85

Figure 2: Freshly laid eggs of *G. rhomboidalis*

For cage 1 containing 12 plant seedlings, a total of 81 holes were observed with a mean number of holes (6.75 ± 3.96 holes). Cage 2 containing eight plant seedlings recorded a total of 44 holes with 5.5 ± 3.85 mean number of holes.

The total number of oviposition holes observed per plant (during the 5 days of observation) varied widely from 0 – 12 holes (irrespective of the plant height). Table 3 showed the distribution of the oviposition holes observed for the two cages (1 and 2) respectively. For cage 1 containing 12 plant seedlings, a total of 81 holes (distributed as shown) were observed with 6.75 ± 3.96 mean number of holes. Cage 2 containing eight plant seedlings recorded a total of 44 holes (distributed as shown) with 5.5 ± 3.85 mean number of holes.

The eggs of the beetles were delicate, ovoid in shape with cream-white colour (Figure 2). The eggs measured between 1.5 and 2.0 mm in length and approximately 0.5mm in width. The eggs were deposited one per hole most of the time but on few instances two eggs were seen per hole. There were instances where 4 to 5 eggs were seen in a clearly big hole. A clear observation showed that in such instances, the oviposition holes were made so close to one another such that about 4 to 5 holes merged into one big hole. It was noticed that at room temperatures fluctuating between 27^{o} – 34 ^{o}C, moistened fertile eggs hatched within 2 - 5 days, with an average of 3 eggs hatching per day (Figure 3). But under the same fluctuating temperature, unmoistened eggs shriveled after 2 or 3 days as in some cases in the experiment. This was in agreement with an earlier observation (Eluwa, 1977). Based on the temperature variations, it may be suggested that an average temperature of about 25.5^{o}C and moisture was needed for the eggs of *G. rhomboidalis* to develop. In effect, the plugging of the oviposition holes by the beetle after egg laying may be to retain moist conditions as well as maintain a relatively good temperature.

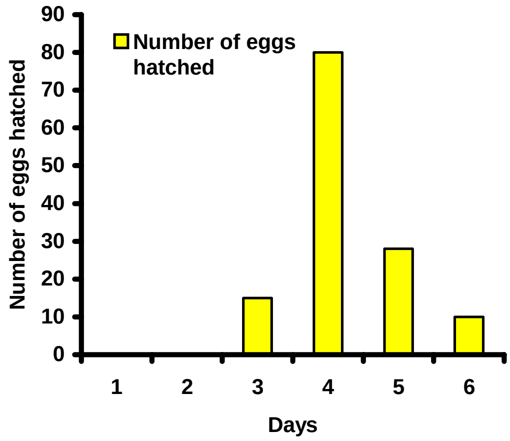

Figure 3: Number of eggs hatched

Figure 4: Typical larval instars of *G. rhomboidalis*

The emergent larvae were apodous, tiny and cream-white in colour, measuring about 0.5mm in diameter and 2.5 mm long approximately. They had brown head capsule, which darkened with age. Several larval instars were observed. Typical larval instars are shown in Figure 4. After hatching, the apodous larva fed on the plant tissues in the downward direction, which later turned into tunnels in which the larva lived. These tunneling activities when done on a plant seedling less than 3 weeks of age resulted in wilting and eventual premature death of the whole host plant. The leaves invariably wilted and dropped off the plant.

Figure 5: Exarate pupa of *G. rhomboidalis*

No pupal chamber was observed as in some other weevils. The young pupa was cream in colour, measuring roughly 11.6mm long and 3.4mm wide. The colour of the pupae darkened just before emergence as adult beetles. All the adult features were seen present in the pupa but not joined to the body (exarate pupa) i.e. the appendages are free of any secondary attachments to the body. Typical exarate pupa is shown in Figure 5. The pupal period lasts for between 10 and 12 days. The observed pupal duration is shown in Figure 6.

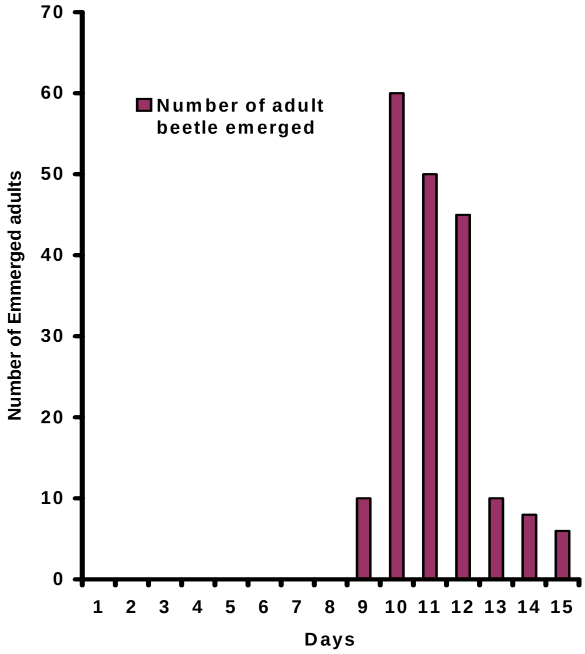

Figure 6: Number of adult beetle emerged

The duration of emergence of the adult beetle from the day of oviposition was on the average about 40 days (ranging from 26 - 44 days). The adult emergence from the pupa occurred both during the day and night, with more emergence occurring during the night period. Out of the 196 pupa observed, 130 emerged as adult beetles during the night period while 66 emerged during the day. The adult emergence occurred between 2 – 4 days of pupal development into adult. Typical male and female adult beetles are shown in Figure 7.

Sexing: Three different methods were adopted to ascertain the sexes of the adult beetles, viz., the measurement of the snouts of the beetles, the observed shapes of their pygidum and the relative positions of the beetles during copulation. Two different samples of beetles collected randomly were used in the measurement of the snouts of the beetles and in observing the shapes of their pygidum.

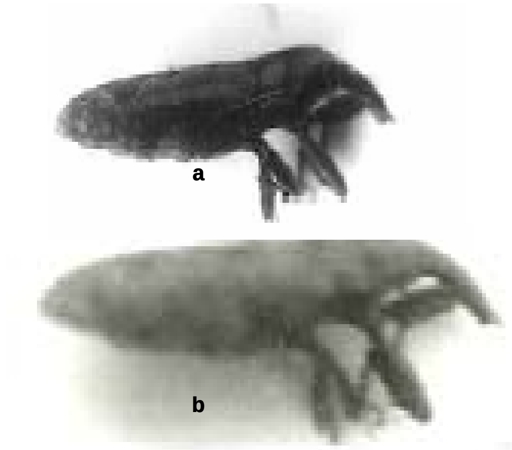

Figure 7: Adult male (a) and female (b) of *G. rhomboidalis*

The measured snout sizes are given in Table 4. These results are very remarkable in the distinction of the snout sizes for the female and male beetles. The results agree clearly with previous observations in snouted beetles (Skaife, 1953) where it was reported that male beetles have rough, short and broad snouts relatively, compared to the smoother, longer and narrower snouts in the females.

Table 4: Measured snout sizes of adult *G. rhomboidalis*

Beetle No	Length of snout (mm)	Width of snout (mm)
1	4	1
2	4	1
3	3	1.5
4	4	1
5	3	1.5
6	3.5	1
7	4	1
8	3	1.5
9	3	1.5
10	3	1.5
11	4	1
12	4	1
13	3	1.5
4	4	1
15	3	1.5
16	3	1.5
17	4	1
18	3	1.5
19	4	1
20	3	1.5

Total No. of Beetles = 20 [No. of female = 9; No. of male = 11]; Sex ratio [female: male] = 1: 1.22

Table 5: Shape of pygidium of adult *G. rhomboidalis*

Beetle No	Pygidium Shape (NF) F	Pygidium shape [RB = M]
1	NT	
2		RB
3		RB
4		RB
5	NT	
6		RB
7	NT	
8	NT	
9	NT	
10	NT	
11	NT	
12	NT	
13		RB
14	NT	
15	NT	
16	NT	
17		RB
18		RB
19		RB
20	NT	

NT = Narrow and Tempering; RB = Round and Broad; F = Female; M = Male; Total No. of Beetles = 20 [No of female = 12; No of male = 8]; Sex ratio [male: female] = 1: 1.5

Table 6: Quantity of leaves consumed by the beetles in terms of body weight (For 14-day-old beetles)

Beetle No	Age of Beetle	Weight before feeding (g)	Weight after feeding (g)	Weight Gain/loss *(g)*
1	14 days	0.0540	0.0566	0.0026
2	14 days	0.0668	0.0700	0.0032
3	14 days	0.0709	0.0740	0.0031
4	14 days	0.0624	0.0661	0.0037
5	14 days	0.0743	0.0800	0.0057
Total		0.3284	0.3467	0.0183
Mean		0.0693	0.0693	0.0037

Table 7: Quantity of leaves consumed by the beetles in terms of body weight (For 7-day-old beetles)

Beetle No	Age of Beetle	Weight before Feeding (g)	Weight after Feeding (g)	Weight Gain/loss (g)
1	7 days	0.0818	0.08300	0.00120
2	7 days	0.0845	0.08460	0.00010
3	7 days	0.0665	0.07640	0.00990
4	7 days	0.0700	0.06860	-0.00140*
5	7 days	0.0684	0.06770	-0.00070*
Total (Weight gain)		0.2328	0.24400	0.01120
Mean (Weight gain)		0.0776	0.08133	0.00373
Total (Weight loss)*		0.1384	0.13630	-0.00210
Mean (Weight loss)*		0.0692	0.06815	-0.00105

*NB: * Beetles did not feed, thus there was a net weight loss.*

Of the 20 beetles studied, 11 were consequently confirmed as males (with snout dimensions of 4mm x 1mm) while 9 were ascertained females with snout sizes of 3mm x 1.5mm in most cases. The observed shapes of the pygidium for another set of randomly collected beetles as presented in Table 5, shows that 12 had narrow tapering (NT) pygidium and are thus females while 8 had round broad (RB) pygidium and thus confirmed males (Daramola, 1975). It was also observed that for the 40 beetles in Tables 4 and 5, the ones identified as males were usually smaller than their female counterparts. Amongst the 40, in copular position, in all cases, it was found that the smaller (male) beetles were on top the bigger females (Eluwa, 1977).

Table 8: Quantity of leaves consumed by the beetles in terms of area of the leaf consumed

Beetle No.	Leaf Area before eaten (mm^2)	Leaf Area after eaten (mm^2)	Quantity of leaf eaten (mm^2)
1	14488	11460	3028
2	25929	23256	2673
3	25074	23121	1953
4	16912	13363	3549
5	56160	51084	5076
6	29835	29680	155
7	36861	31910	4951
8	15288	14008	1280
9	22540	16456	6084
10	28030	27930	100
Total	271117	232268	28849
Mean			2884.9

Feeding Habit of the Beetles: The feeding habit of the beetles as indicated by changes in their body weight when fed for 2 age groups of 5 beetles each, aged 14 days and 7 days are presented in Tables 6 and 7 respectively. An average weight gain of 0.0037 g approximately was recorded for both age groups of beetles when allowed to feed over a 24-hour period. This would suggest comparable food consumption rates for both age groups of beetles and thus indicative of the fact that the feeding habit of the beetles is not age dependent. However, a closer observation of the body weight variations shows that the five 14-day-old beetles had more comparable body weight gain amongst each other (Table 6) than the 7 day olds which varied more widely in their feeding rates (Table 7). Two of the 7-day-old beetles did in fact show a net weight loss (Table 7), which may be attributable to some physiological inability that may have caused them not to feed at all. It is suspected that the caging of the beetles under laboratory conditions may have imposed on the beetles, environmental limitations that may affect some physiological behaviour of the beetles including their feeding habit. The younger beetles are anticipated to be more susceptible to these imposed environmental restrictions, hence their haphazard feeding habit.

From Table 8, which presents the quantity of leaves consumed by 10 different beetles in terms of the surface area of the leaves consumed, an average leaf surface area of 2885 mm^2 was consumed per beetle over 24-hour duration. The beetles here showed largely comparable feeding rates. This clearly indicates that the beetles are heavy feeders on these leaves and can inflict an enormous destruction on the host plant over a short period of time.

Conclusion: A comprehensive study on some aspect of the biology of *G. rhomboidalis* has been carried out. The full life cycle of the beetles (from copulation and oviposition through the various immature stages to the emergence of the adult beetles) was investigated. It took on the average 40 days for the adult beetle to emerge from the day of oviposition. Studies on the feeding habit of the beetles revealed that the beetles fed heavily on the leaves and can inflict an enormous destruction on the host plant over a short period of time. Generally; the studies have been able to confirm that the larva and the adult beetle are the most potent destroyers of the host plant. While the adult beetle fed heavily on the leaves and tender plant stems, the larva when hatched in the plant stem destroyed the host plant (particularly during the tender ages of between 2-3 weeks) with its boring activities, causing the plant to wilt and die.

It is recommended for further investigations, possible control measures fro the protection of the host plant, particularly the plant stem. In this regard, of interest for investigation are the larva and its boring activities on the host plant with its high destructive potency. A more detailed study of the various larval stages to determine the most potent larval stage is recommended

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