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Studies on *Gasteroclisus rhomboidalis* (Boheman.) (Coleoptera: Curculionidae)—a pest of the African ‘spinach’

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Introduction

In West Africa, the foliage of both wild and cultivated varieties of *Amaranthus* sp. or spinach greens (Amaranthaceae) are widely used as vegetables and as fodder for cattle (Hutchinson & Dalziel, 1954, Tindall & Sai, 1965). Recently in Nsukka area, the outright snapping or ‘breakover’ of young crops of *A. viridis* and total premature death of others have attracted the author’s attention and the causative agent for these damages has been found to be a stem-boring weevil, *Gasteroclisus rhomboidalis*. All developmental stages of the beetle are passed within the stems of the host plant and the reported damages result mainly from the feeding activities of beetle larvae.

In Ghana, *G. rhomboidalis* is listed as a pest of *Amaranthus caudatus* and as an occasional feeder on leaves of wild *Solanum* sp. (Forsyth, 1966). In the British Museum, a specimen of the beetle is claimed, with reservation, to have been bred out from a leguminous pod in the Sudan Republic while the larvae of two other species of the weevil from South Africa are reported to live in the stems of Compositae (R. T. Thompson, personal communication). In East Africa, *G. aethiopicus* Petri and *G. subacutus* Petri are claimed to feed on roots of *Aspilia* sp. and leaves of *Ipomoea batatas* respectively (Le Pelley, 1959). Apart from the foregoing observations, published accounts on the biology of any species of *Gasteroclisus* do not seem to be available. The investigations reported here were therefore undertaken in order to provide preliminary information on the biology of this apparently common and widespread pestiferous weevil.

Materials and methods

Adult beetles were collected from live shoots of cultivated and wild varieties of *Amaranthus* sp. growing in gardens and fallows within the University campus and nearby village homes. The beetles were then transferred to an insect cage, 55 cm × 30 cm × 30 cm, placed in an open garden at the University campus and fed regularly with leafy shoots of *A. viridis* preparatory to the experiments.

Life history

Singly-potted flourishing seedlings of *A. viridis*, raised in an insect-proofed enclosure, were submitted once to adult beetles for possible oviposition overnight in the usual cage. On the following morning, treated seedlings were ridden of any adhering beetles, labelled and transferred to taller insect cages (100 cm × 30 cm × 30 cm) built from experience to accommodate full-grown stands of experimental host plants. The cages were left in the open vegetable garden and the plants observed and tended regularly until emergence of

adults. Records were kept of emergence of beetles, breakages, premature withering and premature death of shoots of treated host plants. In addition, prematurely dead stands and mature plants from which beetles had already emerged, were thoroughly examined by dissection.

For accurate record of incubation period of eggs, selected *A. viridis* seedlings, submitted for oviposition overnight, were dissected on the succeeding morning for ova. Where found, eggs were removed with a moist fine paint brush and placed on humid filter paper laid on wet cotton wool inside Petri dishes. The egg-dishes were placed in a separate insect cage shaded from direct rays of the sun inside the experimental garden until hatching. Prevailing temperatures were recorded by a thermograph kept in the latter cage.

To get an overall view of the intermediate developmental stages of the beetle, non-experimental mature stands of *Amaranthus* sp. were uprooted during their growing season, examined for adult emergence holes and then dissected. All stages of the beetle encountered were collected and recorded for further studies. Larvae were boiled in caustic potash in order to separate the head capsules whose widths were later measured with a micrometer inside a binocular microscope.

Activities

In the field, the activities of adult beetles were repeatedly observed at convenience especially in the mornings and evenings during the 2 year period of study and on-the-spot records made of them.

Results and discussion

Field and cage behaviour

During collecting, beetles were found relatively motionless within bunches of terminal unfolding leaves of host plants or on surfaces of young leaves and among the inflorescence of mature greens, often with the smaller male riding on the female (fig. 1). Those not in copula adopted the 'resting' posture or crawled among the same terminal leaves and inflorescence, at times feeding. On a few occasions, beetles were seen boring (with their snout) into tender portions of host stems apparently as an oviposition response. In general, they remained in more exposed positions in the mornings and evenings and tended to shelter under leaves whenever the sun's rays became intense.

When disturbed in either the field or cage, adult beetles folded their legs, dropped to the ground or floor of the cage and feigned death. In the field, adults about to be hand-picked vigorously tried to hide themselves behind stems or leaves away from the prospective collector, and if ultimately held at the sides, the beetle would surprisingly hold tenaciously to its resting platform. Under prolonged captivity, adults which normally showed no marked tendency to fly, more readily took to their wings as soon as the least opportunity to escape occurred.

Life history

Ovoid delicate creamy-white eggs averaging 1.15 mm in length and 0.55 mm in width, were deposited singly in separate shallow excavations ('egg-holes') made with the snout of the beetle in leaf petioles or in the very

tender stems of host plants. Only on very few occasions were up to two eggs found deposited side by side within any single egg-hole. After deposition of an egg, the orifice of the oviposition hole was usually plugged with the remains of pulverized plant matter produced in course of the drilling of the egg-hole. Only one egg-hole, located ventrally, was usually found on any one leaf stalk of the host plant and such an affected leaf almost invariably bent over at the point of oviposition within the first day of egg-laying.



FIG. 1. Adult *G. rhomboidalis* in riding position on leaf of host plant, with dents eaten by beetles noticeable on the margins.

At temperatures fluctuating between 19°C and 30°C (mean 22·8°C), eggs isolated and moistened soon after laying, hatched in 2 to 3 days (mean 2·8 days). At relative humidities fluctuating between 60–90% in the same garden, unmoistened eggs shrivelled up within 2 days. The result suggests that between 19°C and 30°C at least, high humidity was essential for development of eggs of *G. rhomboidalis* and that the observed plugging of oviposition holes by adults and the bending over of leaves at the points of oviposition apparently ensured that, in nature, adequate humidity conditions were attained for egg development.

The first instar larva was a tiny creamy-white grub about 0·5 mm in diameter and 2·3 mm long, including the coffee-brown head capsule. In nature, first instar larvae emerged within the oviposition holes and began soon after hatching to feed on host plant tissues in the downward direction. In each case, this feeding activity resulted in the creation of a definite tunnel in which the larva is housed. Where larval tunnelling is commenced in the petiole, an affected leaf invariably wilted and abscised soon after its larval content had crossed into the stem proper. This is the first obvious sign of larval attack.

The full-grown larva was creamy, about 13 mm long, 3 mm in diameter and wriggled freely in the larval gallery (fig. 2). The head capsules of first instar larvae (realized directly from eggs) were about 3 mm wide. The widths

of head capsules of over 300 samples of all the larval stages of the beetle ever encountered in this study ranged between 3 mm and 15 mm. The figures showed so much overlap, apparently in conformity with differences in sizes of the sexes so obvious among adults, that the exact number of larval instars undergone by the beetle could not be established by this method (Stevenson, 1967).



FIG. 2. Larva of *G. rhomboidalis* lying *in situ* in larval gallery of half stem of host plant.

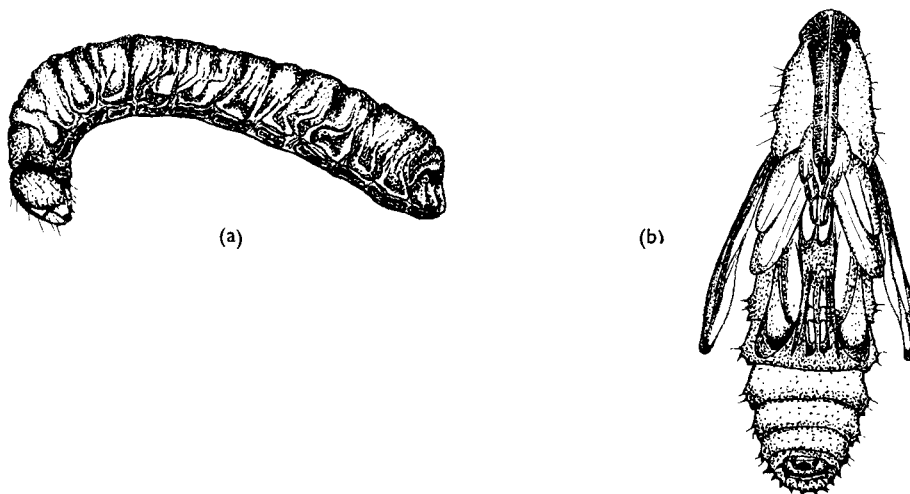


FIG. 3. *G. rhomboidalis*: (a) full-grown larva, lateral view; (b) pupa, ventral view.

The young pupa (fig. 3) was also creamy, about 11.5 mm long, 3.5 mm wide at the level of the wing buds but became dark brown just before emergence as adult. Pupation did not occur in a pupal chamber as in the weevil *Pissodes engelmanni* (Stevenson, 1967). Resulting adult beetles, 12–13 mm long from

the tip of the snout to that of the abdomen and 3.75–4 mm in diameter (males and females), ate their way out of the stem leaving definite emergence holes (fig. 4) some 4.5 mm to 6 mm in diameter. In 96 positive cases, adults emerged after a mean of 36.37 days (range 28–46 days) from date of oviposition. Of these, the relatively shorter life cycles were recorded from experiments performed during the sunny period of the year, November to June, and the longer ones from those of the rainy period, June to August of 1973 and 1974. Adults normally emerged at night and crawled up to the terminal leaflets or inflorescence of the host plant where they are readily seen on the following morning. On emergence, the beetles are dark gray to black but they become whitish brown after a few hours exposure to the atmosphere.



FIG. 4. Surface view of stem of host plant showing emergence hole of adult *G. rhomboidalis*.

Larval damages

A comparative study of sections from damaged and undamaged stems of infected host plants showed that, in the course of development, weevil larvae ate up the pith and virtually all the primary vascular bundles of the respective plants (fig. 5). In the average-sized stem, for instance, the mature larva consequently came to lie in a self-made gallery about 75 mm to 95 mm long, 35 mm in diameter and encircled only by cortical and secondary tissues about 11 mm thick. The actual measurements of Tissue–Gallery–Tissue were maximum 11 mm : 36 mm : 11 and minimum 8 mm : 34 mm : 8 mm with the eaten-up zone constituting approximately 42% of the cross-sectional area of the average normal stem.

Multiple infection was quite common in both experimental and ordinary plants. Between June and September 1973 and 1974, 152 stands of cultivated *A. viridis*, randomly picked from neighbours' vegetable gardens, were dissected for various stages of the beetle. These were plants the tops of whose primary and branch shoots had been cut, as is the practice, and used for food during their growing season. Older stands had 0 to 8 emergence holes per plant.

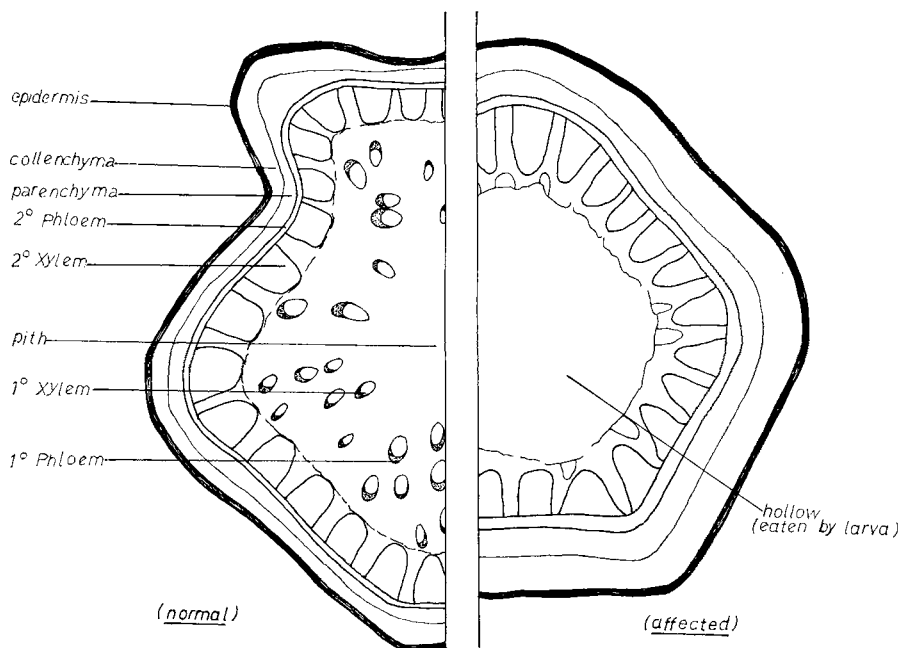


FIG. 5. T. S. stem of *Amaranthus viridis*, normal and affected by larva of *G. rhomboidalis*.

Fully-formed but yet unemerged adults were rarely encountered suggesting that adults worked for their exit from the larval gallery as soon as they became transformed. All 152 stands dissected contained 1–16 beetle larvae per plant, 80 per cent of them with 1–6 pupae per plant as well.

Dissections of multiple-infected host plants showed that individual larval galleries ultimately and indistinguishably ran into one another while columns of mining dust 5–10 mm tall accumulated at intervals. These accumulations seemed to constitute vital plugs apparently to prevent easy access of developing beetles to potential predators. On the average, infestation could be so intense that an outwardly healthy-looking crop could have the internals of more than half its main stem eaten up by beetle larvae, at times extending below the ground level. Yet, externally there was neither gall formation as in weevil *Lixus camerunus* (Usua, 1969) nor exudation of sap and wet mining dust as in *Sternochetus* (= *Cryptorhynchus*) *Iapathi* (Harris & Coppel, 1967) on stems of infected host plants to indicate beetle attack. Similarly, no definite moulted larval head capsules such as could be used to confirm number of larval moults (Kishi, 1971) were recognized in the larval galleries.

Stems of young host plants ruined internally by larval tunnels readily snapped at their weakest points (fig. 6) some 19 days (range 16–22 days) after egg-laying. Under heavy larval invasion, the young plants soon after snapping shrivelled completely along with their invaders. Under light infestation, left-over stumps could sustain their larval contents as for the resulting adults to emerge successfully after the normal developmental period. Later examination of infested plants showed that, after adult emergence, most larval galleries got invaded by fairly many wood lice, collembolans and fungi.



FIG. 6. Comparison of a normal and damaged (by *G. rhomboidalis* larvae) host plants of the same age.

Economic importance

The local importance of the spinach greens as vegetables for man, fodder for cattle and green feed for poultry need not be re-emphasized here. But it is pertinent that in certain parts of Nigeria, the African spinach, on account of its low water tolerance, relative fast growing ability and therefore potential for rapid returns, becomes the first available and most marketable vegetable soon after the dry season each year. Consequently *G. rhomboidalis* may legitimately be regarded as an important agricultural pest since

- (i) adults feed mainly on leaves of the crop (fig. 1)—the very product for which this vegetable is grown by man. The only alternative food plant on whose leaves adult beetles were found nibbling on a few occasions is *Corchorus olitorius* Linn. (Tiliaceae);
- (ii) the boring activities of adult weevils lead to premature withering of leaves and shoots of host plants while the resulting egg-holes serve as ready channels for entry of liable microarthropods and parthogenic fungi;
- (iii) the feeding of larvae on the very stele of host plants would obviously reduce plant vitality and productivity and promote premature breakage, if not total death, of young crops.

Summary

Eggs of *G. rhomboidalis* are usually laid singly in separate excavations made with the snout of the beetle in either leaf petioles or tender portions of shoots of host plants, *Amaranthus* sp. At field temperatures fluctuating between 19°C and 30°C and in contact with water, eggs hatched in a mean of 2.8 days while unmoistened ones shrivelled up.

Beetle larvae bore and feed on the stele of host plants where development, up to adulthood, is completed in self-made larval galleries. On the average, the larvae are capable of consuming 40% and above of the cross-sectional areas of stems of infected host plants. In nature, multiple infection of host plants was quite common with 1-16 beetle larvae/plant rather usual. Consequently, the stem of virtually every healthy-looking host plant is internally traversed by larval galleries, at times even below ground level.

Adults bite their way out of the stem after a mean of 36-37 days from date of oviposition.

Larval damages to host plants are the gravest and bring about premature breakage and/or death of crops, stunted growth and reduced yield of the wanted leaf products.

Acknowledgments

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