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Mermis sp. [Nematoda: Mermithidae] as a parasite of zonocerus variegatus linnaeus [Orthoptera: Pyrgo morphidae]

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Abstract

Mermis sp. (Nematoda: Mermithidae) was consistently encountered in dissected specimens of *Zonocerus variegatus* (Linnaeus) collected at random from the field in the Ile-Ife area of Nigeria. In this study, parasitization at different locations ranged between 0 to 7.58%. Although this parasite may constitute an important factor in the mortality of *Z. variegatus*, it does not appear to be efficient as a potential biological control tool.

Introduction

The variegated grasshopper, *Zonocerus variegatus* (Linnaeus) continues to constitute a serious pest of food and cash crops in Nigeria. The insect is most prevalent in the southern parts of the country where it defoliates cassava, citrus, cocoa, banana, maize, cowpea, yams, oil-palm seedlings, sweet potato and most vegetables, especially during the dry season (Libby, 1968). It is, therefore, no surprise that the National Agricultural Technical Committee of Nigeria (now known as the National Agricultural Development Council) declared it as a national pest in 1971.

Entomogenous nematodes have formed the subject of several investigations (Phelps and DeFoliart, 1964: Nickle, 1972 and 1974; Poinar Jr., 1972 and 1975). The parasitic ones inhabit the body cavity of insects and play an important role in controlling some species; and members of the family Mermithidae are known as obligate parasites of several orders of insects and other invertebrates. For instance, there are records of *Mermis* species from insects belonging to the orders: Lepidoptera, Hymenoptera, Orthoptera,

and from certain spiders (e.g) - *Zelotes latreillei* (Simon) and *Xysticus* sp. A compilation by Shephard (1974) shows that these parasites have been isolated from insects and other arthropods in Italy, India, United Kingdom, U.S.S.R., U.S.A., Germany, Tanzania, Bengal, Australia and Mexico to mention a few. Mermithids are the commonest nematode parasites of the Acridoidea, but the Spiruridea are also known to utilize acridoids as intermediate hosts (Poinar Jr., 1975).

Studies on the biology of *Z. variegatus* in Nigeria include those of Golding, 1940; Jerath,1965; Oyidi, 1968; Toye, 1971; Taylor, 1972 and that of a research team based at the University of Ibadan (Youdeowei, 1976). Taylor (1964) observed certain "unidentified helminths" as parasites of *Z. variegatus* in Nigeria while Toye (loc. cit.) reported the occurence of "mermithid worms" in the insect. To date, there has not been any published work on the exact taxonomic identity or the biology of these nematode parasites of *Z.variegatus*.

On May 13, 1975, three of the 31 field-collected specimens of *Z. variegatus* meant for an undergraduate entomology practical class at Ife University were found to contain one nematode (nema) each. Consequently, this study was initiated to investigate aspects of the biology of the nematode parasites of *Z. variegatus* in Ile-Ife and environs, as part of a broader study on the determination of the possible role of associated biotic agents in the natural control of this pest.

Materials and methods

Initially, field studies were conducted only in several locations at the Central Campus and the Teaching Farm areas of the University of Ife. In 1977 however, other farms in the neighbourhood such as: Gbongan, Osogbo, Ilesa, and Akure were included in the survey. These towns fall within the forest regrowth vegetation belt of Nigeria.

Natural populations of nymphal and adult *Z.variegatus* were consistently examined for nematode parasites from January to May in 1976 and 1977. Specimens were randomly collected from the field at least twice a week by sweeping; such specimens were subsequently anaesthesized, dissected and examined in the labo-

ratory under a stereomicroscope. Those found to be parasitized were noted and the percent parasitization estimated. Laboratory colonies meant for closer investigation were started from field-collected specimens maintained in 25cm x 25cm x 30cm screen cages, provided with a sliding door and about 6cm deep of moist beach sand to serve as oviposition medium.Such specimens included insects suspected to be parasitized and they were fed on fresh cassava foliage which was watered as necessary. The relative activity of the suspected specimens was first noted in the field before the commencement of detailed laboratory investigations based on dissections and microscopic examination. The parameters investigated included: nature of the parasite, estimate of parasitization percent, the relation of the host's sex to infection, mode of infection, average number of nematodes per infected host, effect of the parasite on the host, frequency of infection in relation to season and environmental factors like moisture, and presence of other parasites. Effort was made to rear the parasitic nema to maturity by allowing post-parasitic juveniles to discharge directly into beach sand moistened with water, or physiological saline solution (6% NaCl). Taxonomic determination to generic level was based largely on the characterization of post-parasitic juveniles using the keys as well as descriptions provided by Nickle (loc. cit.) and Poinar Jr. (loc. cit.). In addition, specimens of the parasite were sent to these two workers for confirmation. All specimens for study were preserved in aqueous solution of 3% formalin and 2% glycerin after Nickle (1974).

Results

Taxonomic Identity

Throughout this study, only one nematode, *Mermis* sp. was encountered. The name was identified on the basis of the following characters: Nemas inhabit the haemocoel of living host; nemas whitish or light yellow, filiform in shape, elongate and threadlike (Fig. 1); average length based on 85 random specimens is 7.65cm (3.30-20.30cm); all nemas present in the host are juveniles; outer cuticle smooth and not thick; stoma of pre-parasitic and post-parasitic juveniles with a piercing tooth; the latter with 2 lateral lip papillae and 4 cephalic papillae; post-parasitic juveniles without tail appendage.

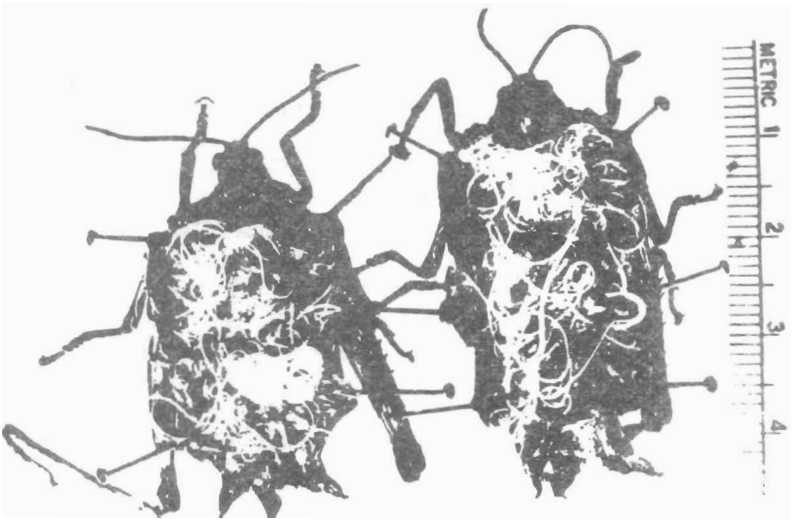

Fig.1 : Z. **variegatus** showing nematode infection (specimen on the left contained 33 nemas while the other contained 25 nemas).

Life Cycle

The pre-parasitic larva hatches from the egg, following which it actively penetrates the gut wall and eventually lodges in the haemocoel. It lives on the host until it emerges as the last larval stage called post-parasitic larva or juvenile. The post-parasitic larva is equipped with a lance-like tooth which it uses to perforate the host cuticle from the inside. In the screen cages, the nema was frequently observed to emerge from the cervical membrane or the inter-segmental membrane of the abdomen of the hosts. The exit of the nema from the host body leaves a hole which brings about loss of body fluids, leading to dehydration and death. Emergent juveniles mature in the soil. The process of oviposition by gravid fe-

males was not observed experimentally. However, mating of adults is known to occur in the soil. The gravid female climbs to the aerial parts of plants during moist weather, deposits her eggs and then goes back into the soil where the adults are free-living for 2-3 weeks (Nickle, 1974). These eggs are ingested by the grasshoppers along with the foliage, following which the pre-parasitic larva emerges and pierces through the gut wall into the haemocoel of the host. Usually, only one nema was observed within each host however, during the latter part of the "season" especially in May, up to 33 were recovered from a single host. Many details of the life history such as period of incubation of the egg, the developmental period from instar to instar, and actual penetration of the gut wall by the nema are still unknown.

Effect of nema on host

Infected *Z. variegatus* were found to be sluggish, pale white to light yellowish and with distended abdomen. Usually their wings appeared crumpled or malformed. The nemas twine round the alimentary canal or otherwise lie freely in the haemocoel. Dissection and microscopic examination of infected and non-infected specimens revealed that infected females lose most of their gonads to nemas as the ovaries degenerate or become atrophied, a situation which, in either sex, is conducive to sterility. In this study, the females suspected to be infected, which were placed under observation together with males suspected to be infected, usually failed to lay eggs. It was observed in the field that certain specimens which were later found to be infected could not complete the imaginal moult. The emergence of the post-parasitic juvenile from infected specimens is usually fatal owing to the loss of tissue fluids from the emergence hole, an earlier depletion of nutrient reserves, and possible infection by secondary micro-organisms.

Relation of host sex to infection by nema

20 random samples of males and females did not show any significant difference in terms of parasitization ($x^2 = 0.2$) Thus there is no difference in the susceptibility of the sexes to infaction by nemas.

Parasitization

A preliminary study which was conducted on the nymphs between October 1975 and January 1976, had shown that early instar nymphs were almost invariably non-infected.

Tables 1, 2, and 3 represent the summary of data accumulated during the study period. In 1976, at the University of Ife, observed parasitization was 0.30% for nymphs and 3.06% for adults (Table 1). In 1977, observed parasitization was 0.11% for nymphs and 0.40% for adults (Table 2). A comparison of differ-

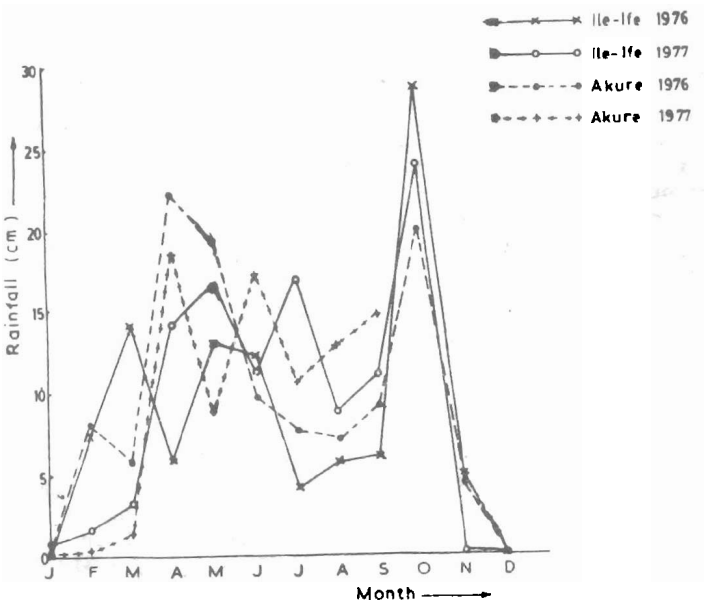

Fig. Rainfall data for Ile-Ife and Akure during 1976 and 1977.

TABLE 1: DETERMINATION OF PARASITIZATION BASED ON DISSECTION OF RANDOMLY FIELD-COLLECTED Z. VARIEGATUS AT UNIVERSITY OF IFE IN 1976

Period	Life stage of insect	No. of observations	Sample size	No. parasitized	Parasitization (%)
15/1/76 to 14/2/76	Nymph	4	658	2	0.30
21/2/76 to 31/5/76	Adult	21	1,668	51	3.06

TABLE 2: DETERMINATION OF PARASITIZATION BASED ON DISSECTION OF RANDOMLY FIELD-COLLCTED Z. VARIEGATUS AT UNIVERSITY OF IFE IN 1977

Period	Life stage of insect	No. of observations	Sample size	No. parasitized	Parasitization (%)
13/1/77 to 19/2/88	Nymph	5	931	1	0.11
1/3/77 to 18/5/77	Adult	29	3,786	15	0.40

ent localities with Ile-Ife during 1977 showed that Akure recorded a parasitization of 7.58% for adults while Osogbo had 1.25%, Gbongan 0.40%, and Ilesa 0.00% compared to Ile-Ife's 0.49% (Table 3). Nymphs were rarely infected (Table 1 & 2). Also, in May, the rate of infection seemed to be higher with the infected hosts apparently containing more nemas per individual. For instance, on 3/2/76, out of the

TABLE 3: SAMPLING OF Z. VARIEGATUS FOR NEMATODES AT SEVERAL LOCATIONS IN ILE-IFE AND OTHER TOWNS IN 1977

Period	Locality	No. of observations	Sample size	No. parasitized	Parasitization (%)
28/3/77 to 16/5/77	Ile-Ife	8	1,012	5	0.49
24/4/77 to 29/4/77	Akure (ca 118) from If	2	211	16	7.58
26/3/77 to 28/4/77	Osogbo (ca 60km from Ife)	2	240	3	1.25
26/3/77 to 18/4/77	Gbongan (ca 20km from Ife)	2	251	1	0.40
26/4/77	Ilesa (ca 30 km from Ife)	1	92	0	0.00

120 adults examined, only one was parasitized and it had only one nema. But on 11/5/76, out of 53 adults examined, 3 were parasitized and these had respectively 10, and 12 nemas. Also on 18/5/76, out of 92 specimens examined, 3 were parasitized and each contained 2, 25,and 33 nemas respectively. However, it may be necessary to further investigate this point.

Discussion

Mermis sp. was the only nema encountered during this study although there may be other nematode parasites of the insect. This is in agreement with recorded observations that mermithids are the commonest nematode parasites of the Acridoidea apart from the Spiruridea which may also utilize them as intermediate hosts (Poinar Jr.,1975). It is noteworthy that *Mermis* is the only genus in the Mermithidae known to deposit eggs on leaves of plants, which eggs are ingested by insects during feeding. This genus is also worldwide in distribution (Nickle,1972).

The above taxonomic determination could not be carried up to the specific level owing to inability to rear the nemas to adulthood as most of the post-parasitic juveniles dried up before they could get into sand and complete their life cycle. The attempts made to extract free-living adults from the top soil of cassava plots (one host environment) proved to be futile - which would suggest that the nemas are few in number. As it is necessary to consider certain features of adult males and females in their determination to specific level, a fresh effort is being made to get emerging post-parasitic juveniles to discharge directly into fine sand which is kept "sterile" and moist all the time.

In the present study, the host insect was collected in the field by random sampling which is the common method of searching for entomogenous nematodes. Although this method often gives a rough estimate of the incidence of parasitism, it can be erroneous. It is known that certain environmental conditions especially moisture may cause some areas of a field to harbour far more parasitized hosts than other parts of the field. Thus, terrestrial insects containing mermithid nemas are often found in the lower, wetter areas of the field since the free-living stages of the parasite require moisture for survival and completion of their life cycle (Poinar, loc. cit.). The data obtained from "dry habitats" should temper those of "wet habitats" if one may obtain an indication of the incidence of parasitism for a locality. Hand-picking of specimens from particular spots may therefore give higher parasitization than now recorded especially if those spots are often wet.

A comparison of different communities with respect to parasitization seems to indicate that there is a location effect which is consistent with earlier reports in the literature (Rees, 1973). For instance, Akure returned a figure of 7.58% while Ile-Ife, Osogbo, Gbongan and Ilesa returned figures ranging from zero to 1.25% (Table 3). These differences can probably be explained on the basis of rainfall distribution. Fig. 2 shows the rainfall data for Ile-Ife and Akure in 1976 and 1977 and from the figure, it is apparent that Akure is wetter from March to May. Thus, the collection site at Akure presumably might have been wetter than the other collection sites.

One of the objectives of the study was to determine the efficiency of these nemas as potential biological control agents of *Z. variegatus*. As for effectiveness, there is no doubt that these nemas are capable of suppressing *Zonocerus* populations to some degree especially as all infected hosts must die shortly after the exit of the post-parasitic juvenile. Considering the fact that both nymphs and adults of the grasshopper defoliate plants, placing reliance on the nemas for control would mean that damage to plants must occur all the same. However, if environmental conditions had been such that early nymphal instars also became infected, the population could have been suppressed at an earlier stage with less crop damage.

It is known that moisture constitutes one of the factors that limit the usefulness of entomogenous nematodes. As the ingestion of viable nematode eggs by the host appears to be a key stage in the infection cycle, the eggs of any desirable candidate must be capable of withstanding dessication for at least several days. For example, the eggs of *Mermis nigrescens* Dufour, a terrestrial mermithid, are known to resist dessication as they contain two protective coverings. The fact that infection of *Zonocerus* by nemas occurs at all during certain dry periods would suggest that the microclimate, like in the canopy of cassava plants, is probably more important than the overall climate. However, it is doubtful whether the eggs of the *Mermis* sp. in this case could remain viable, even after a few days, under the very hot dry season weather if they are not ingested by the grasshoppers soon after being deposited on foliage. That, probably, explains the very low incidence of parasitism during the dry months of December through February.

In conclusion, it would appear that the level of parasitization of not more than 7.58, and usually less than 1%, for any location under investigation is too low to make *Mermis* sp. an efficient biocontrol tool for direct manipulation in the field. It is however possible that, by human intervention, the eggs can be mass-produced and applied so as to infect the early nymphal instars. At the present time, it has been difficult to manipulate the nematode *in vitro* and as such, this must remain a proposition for the future.

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