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Some Parasitoids of Lepidopterous Stem Borer Pests on Maize in Southern Ghana

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ABSTRACT
Studies were carried out in Southern Ghana (7 Administrative Regions) to assess the diversity and level of parasitism of some parasitoid species of stem borer pests of maize. Two surveys, one in the major season and the other in the minor season were carried out in seven regions in Southern Ghana in 1996. Maize fields were sampled for stem borers. Parasitoids collected were identified up to species level. The rate of parasitism of the stem borers by the parasitoids was also determined. The main pests collected were: Eldana saccharina walker, Sesamia spp., Busseola fusca (Fuller), and Chilo aleniellus (Strand). Parasitism was recorded in more fields in the minor season than in the major season. In both seasons, percentage parasitism ranged between 0 and 100%. Syzeuctus sp was found parasitizing E. saccharina. Other parasitoids reared from stem borers were Enicospilus (Ophion) sp, Dolichogenidia sp. and Aphanogmus fijiensis. Syzeuctus sp. was the most abundant and most distributed parasitoid species followed by S. parasitica. Hence, the two species (Syzeuctus sp. and S. parasitica) should be mass produced and released into maize fields to augment the number of parasitoids in the field in integrated pest management scheme, when pest population is high.
Key words*: Stem borer, parasitoid, Eldana saccharina, hyperparasitism, gregarious.*

INTRODUCTION

Although, maize is grown on large scale in west and Central Africa, the maximum yield of the crop has not been achieved due to factors such as poor quantity and distribution of rainfall, infertile soil, diseases, poor scientific farming methods as well as pests. Of the factors listed, pests are the most serious agents reducing crop yield in recent years. The crop is attacked by a wide range of pests. Sown seeds are often dug up by squirrels, mice and birds. The ripening ear is attacked by various grazing caterpillars, some beetles, and the ripe grains may be infected by *Sitophilus* weevils in the field [1]. Foliage grazing by grasshoppers, leaf worms (Lepidoptera), and leaf beetles may be conspicuous but seldom have any effect on yield [1]. Worldwide, more than 200 species of insects are recorded as damaging the maize plant.

Out of these damaging insect pests, the lepidopterous stem borer complex is probably the most serious pest of maize and damage levels are often high, with different species of Pyralidae and Noctuidae being the key pests in different areas. In Ghana, the major maize stem borers are: the Noctuids (Agrotids) *Sesamia* spp and *Busseola fusca* (Fuller); and the Pyralid *Eldana saccharina* Walker, and *Chilo* spp [2]. These stem borer pests are known to cause considerable damage to the maize plant and thus reducing yield. Feeding by borer larvae on maize plants leading to tunneling usually results in crop losses as a consequence of death of the growing plant parts above the soil (dead hearts), early leaf senescence, reduced translocation, lodging and direct damage to the ears [3]. At later stages, the tunneling and girdling activities of the larvae often result in stalk breakage.

Considering the devastating effects of lepidopterous stem borers on maize, a lot of efforts are being made to control the pests. Notable among these are: chemical control, control using resistant varieties, control by cultural practices and biological control which employs such modes as use of predators, pathogens and parasitoids. Though, chemical control has been profusely used, no meaningful success has been made despite the environmental hazards that it creates. Similarly, despite the fact that control using resistant plant varieties and cultural practices were reported to show levels of controlling effects on the stem borers [4] and [5], these control measures have several deficiencies. Therefore, researchers are now shifting to the use of biological control using predators, pathogens and parasitoids. Of the three biological control measures the use of parasitoids has received extensive research work elsewhere.

Parasitoids are basically insects whose larvae may feed internally (endoparasitoids) or externally (ectoparasitoids) [6] on other arthropods. They may be about the same size as their hosts, kill their hosts, and require only one host (prey) for development into a free-living adult [6] Hyperparasitoids are parasitoids that attack other parasitoids. Superparasitism occurs when more individuals of the same parasitoid species are present in a single host than can complete development in a normal way. A solitary parasitoid is a parasitoid in which only a single individual normally completes development per host whilst in gregarious parasitoids, more than one individual of the same species normally complete development in a single host [6]. In spite of the positive achievements of biological control using parasitoids reported elsewhere, in Ghana very little is known about parasitoids reared locally from lepidopterous stem borers on maize. Furthermore, introduced exotic parasitoids have failed to establish themselves and therefore were not effective as control agents. Meanwhile, in the ecosystems in Ghana, there are species of parasitoids causing mortality to the stem borers [7]. However, their diversity and level of parasitism are not known. In order to have more in-depth knowledge of parasitoids of lepidopterous stem borer pests in Southern Ghana, this study was designed to generate information on the diversity and level of parasitism of parasitoids of maize stem borer complex (in Southern Ghana).The specific objectives are to:

- identify the parasitoid species that attack the lepidopterous maize boring pest species in maize fields,
- determine the rate of parasitism of these stem borers by the parasitoids
- Determine the abundance of the parasitoid species.

The hypotheses posed were that:

- The differences between the mean rate of parasitism for the various stem borers and the two seasons are not significant
- There is no difference in the abundance of the various parasitoids for the two seasons

MATERIALS AND METHODS

Two surveys were carried out each covering 6 administrative regions of Ghana. Both surveys took place when the maize plants were at the after-tasselling stages (i.e. stage 5 = tassel or silking stage; stage 6 = cob or beans formation or milking stage; stage 7 = end of milking or soft dough stage; stage 8 = hard dough stage; stage 9 = matured maize stage; stage 10 = harvesting stage). The major season's survey took place from 17th to 22nd, July whilst the minor season's survey occurred between 12th and 18th December 1996.

Roadside fields at the right growth stage were selected at approximately 20-30km intervals. The field selection was made independent of maize variety, but majority of farmers in Ghana planted 90 day maize varieties. In all 46 fields were sampled for the major season whilst 40 fields were sampled during the minor season survey. Attempts were made to sample the same fields in regions that were visited the second time during the minor season survey, but other fields were sampled when necessary.

Infestation level was estimated by examining 30 plants randomly selected in each field. Plants which showed dead hearts, frass, borer holes, eggs, larvae, pupae and feeding damage were considered to be infested. A maximum of 10 plants were dissected and the stem borer larvae and pupae in them collected, separated into the various species (*Sesamia* spp, *Eldana saccharina*, *Busseola fusca* and *Chilo aleniellus*) and counted. The larvae were fed on maize stem pieces in the laboratory under room conditions. The percentage field infestation was then calculated for each field. The rates of parasitism for the larvae and pupae were also calculated. Parasitoids that emerged from dead larvae and pupae for the different stem borer species were kept separately and labels put on their containers showing the location from which they were collected. Each one was then identified up to the species level with reference to keys provided by Polaszek (1994), and Polaszek and Lassale (1995). The abundance of each parasitoid species was determined. To find the rate of parasitization, larvae that died, but did not produce any parasitoids were dissected and those found containing parasitoid pupal cases were considered parasitized. The data collected was analyzed by using two-way analysis of variance (ANOVA)

RESULTS AND DISCUSSION

Throughout the research for the two seasons the stem borer species collected were: *Sesamia* species, *Eldana saccharina*, *Busseola fusca* and *Chilo aleniellus*. The results showed that there was higher average field infestation by stem borers in the minor season [34.58% (3. 33 – 96. 67%)] than in the major season [8.77% (0 – 40%)]. Similarly more stem borers were collected in the minor season [a total of 416 larvae (*Sesamia* spp. = 70; *E. saccharina* = 187; *B. fusca* = 140 and *C. aleniellus* = 19)] compared to the major season [a total of 219 larvae (*Sesamia* Spp = 52; *E. saccharina* = 116; *B. fusca* = 40 and *C. aleniellus* = 11)]. This might be due to the fact that, the second (minor) season crop was exposed to a population of borers that had built up considerably from the previous season [8].

During the major season, no parasitism was recorded on *Sesamia* and *Chilo* species (Fig.1) whereas in the minor season, parasitism was recorded on all the four (4) stem borer species. Generally, higher parasitism was recorded for all the stem borers in the minor season than the major season (Fig. 1). The highest parasitism (mean of 7.7) was recorded on *B. fusca* in the major season and on *E. saccharina* (mean of 32.1) in the minor season. However, calculated F-value for neither the stem borers ($df_{3/3}$ = 1.98 at P = 0.05) nor the seasons ($df_{1/3}$ =5.07 at P = 0.05) was significant. In spite of this the mean value of 23.1 parasitism recorded for E. saccharina suggested that there were parasitoid species in the environment controlling the population of the pest. For both seasons, field parasitism ranged between 0 and 100%. This also suggested that parasitoids were good mortality factors reducing the population of stem borers especially, *E. saccharina* and *B. fusca* in certain times of the year in some localities.

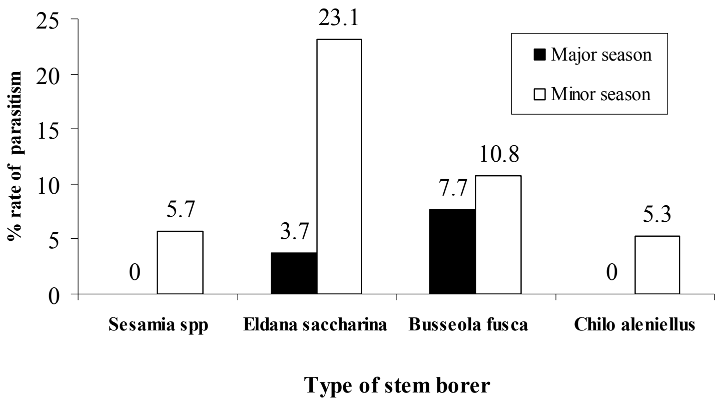

Fig. 1: Mean rate of parasitism of larval stem borers in the two seasons

Parasitoids reared from the stem borers belonged to two major orders, namely Diptera and Hymenoptera. The major family under the dipterans was Tachinidae. Under the Hymenopterans the major parasitoids collected belonged to the families: Ichneumonidae, Eulophidae, Braconidae and Ceraphronidae (Tables 1 and 2). The main species belonging to the family Tachinidae was *Sturmiopsis parasitica* reared from *E. saccharina, B.fusca and Sesamia larvae.* For *Ichneumonidae, Syzeuctus* sp was the main species reared from *Eldana saccharina* and B. fusca larvae whereas *Enicospilus* (*Ophion*) sp. was reared from *Sesamia* sp. For Eulophidae, *Pediobius furvus* a gregarious parasitoid was reared from *B. fusca* pupae. For family Braconidae, *Dolichogenidia* sp was collected from the stem borer tunnel whilst for the family Ceraphronidae, *Aphanogmus* species was also collected from stem borer tunnel. Those parasitoids that were reared in both seasons were: *Sturmiopsis parasitica* (Curran), *Syzeuctus sp* and *Pediobius furvus* Gahan.

Table 1: Parasitoid species and their host stem borers in the major season

PARASITOID		HOST	
Order + Family	**Species**	**Species**	**Stage**
Order: Diptera			
Family: Tachinidae	*Sturmiopsis parasitica*	*Eldana saccharina*	**Larva**
Order: Hymenoptera			
Family: Ichneumonidae	*Syzeuctus* Sp	*Eldana saccharina*	**Larva**
Family: Eulophidae	***Pediobius furvus***	***Busseola fusca***	**Pupa**

Results of the percentage number of parasitoids collected from the various stem borer species were presented in Figs. 2 and 3. *Syzeuctus* sp proved to be the most common parasitoid attacking E. saccharina in the two seasons (1.72% for major season and 10.70% for minor season). A calculation of number of each parasitoid species per field also showed that *Syzeuctus* species (0.54 per field) was the most abundant. However, the calculated figures were generally very low (Fig. 4). When analysis of variance was done it was not significant for either parasitoids ($df_{2/2}$ = 1.47, P = 0.05) or the seasons ($df_{1/2}$ =5.63, P = 0.05).

Table 2: Parasitoid species and their host stem borers in the minor season

PARASITOID		HOST	
Order + family	**Species**	**Species**	**Stage**
Order: Diptera			
Family: Tachinidae	S. parasitica	*E. saccharina*	**Larva**
	S. parasitica	*B. fusca*	**Larva**
	S. parasitica	*Sesamia* Sp	**Larva**
Order: Hymenoptera			
Family: Ichneumonidae	*Syzeuctus* Sp	*E. saccharina*	**Larva**
	Syzeuctus Sp	*B. fusca*	**Larva**
	Enicospilus Sp (*Ophion* Sp.)	*Sesamia* Sp.	**Larva**
Family: Eulophidae	*P. furvus*	*B. Fusca*	**Pupa**
Family: Branconidae	*Dolichogenidia* Sp	*	*
Family: Ceraphronidae	***Aphanogmus fijiensis***	*	*

Note: * = Collected from stem borer tunnel.

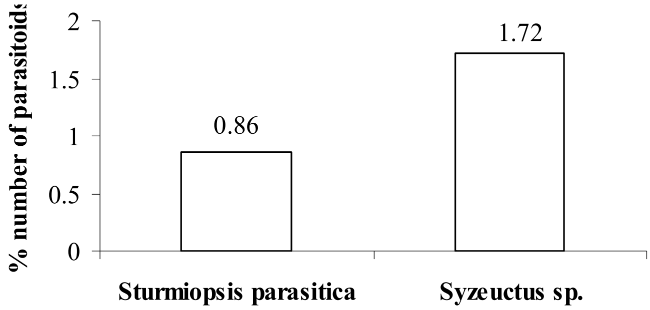

Fig. 2: Percentage number of parasitoids collected from *Eldana saccharina* in the major season

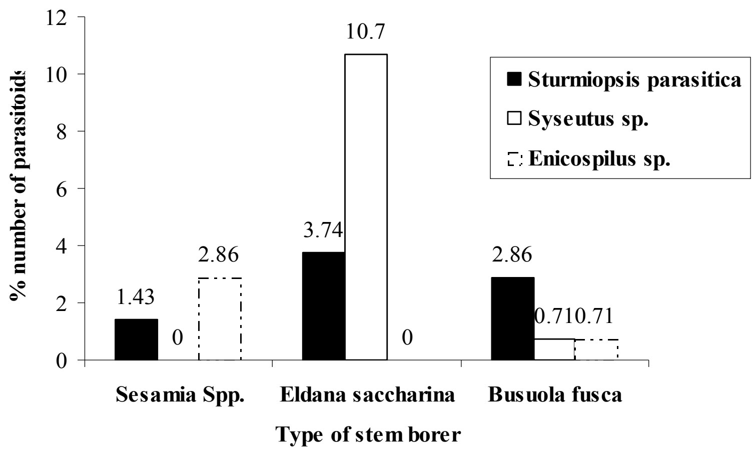

Fig. 3: Percentage number of parasitoids collected from various stem borers during the minor season

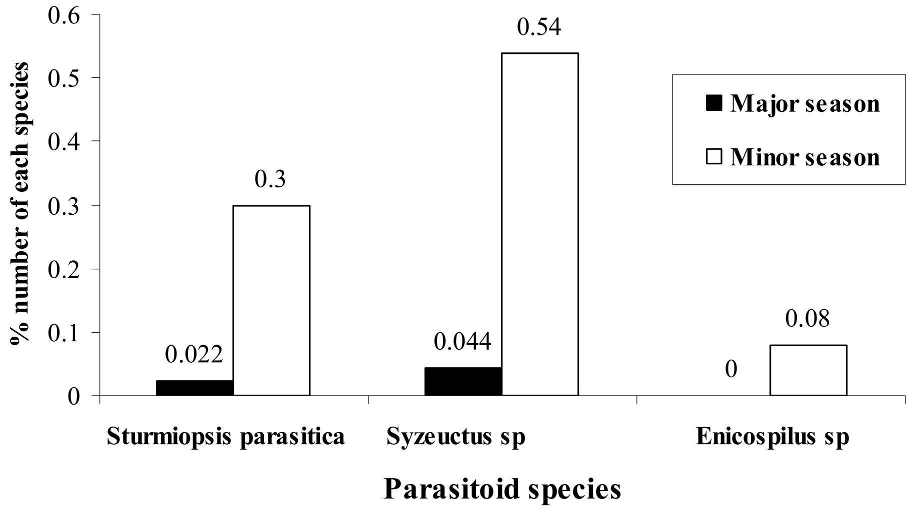

Fig. 4: Abundance of larval parasitoid species in the two seasons

In Africa *S. parasitica* is believed to be the most widespread and commonly recorded parasitoid species of tachinid stem borers. The natural host range of this species in Africa, as recorded by [9] and [10] include *B. fusca*, *C. orichalcociliellus*, *C. partellus*, *Coniesta ignefusalis*, *E. saccharina*, *S. calamistis* and *S. monagroides*. This study in a way confirmed these assertions because *S. parasitica* was reared from *E. saccharina, B. fusca* and *Sesamia* spp.

Aphanogmus fijensis was recorded in South Africa as an important hyperparasitoid of *Cotesia sesamiae*. It also attacks cocoons of Cotesia karak (Telenga) a parasitoid of *Helicoverpa armigera* Hubner. In Mauritius, *A. fijiensis* was found attacking *C. flavipes* [11] and *Microgaster anticornis* Granger [12]. In Fiji and Solomon Islands, *A. fijiensis* was found attacking *Apanteles tirathabae* Wilkinson [13]. According to [14] *A. fijiensis* was recorded as the most abundant hyperparasitoid of *B. fusca* attacking *C. sesamiae* cocoons. In this study, two to four individuals of *A. fijiensis* per cocoon were reared. Also, [14] discovered similar numbers per cocoon. Meanwhile, in this study *A. fijiensis* could not be categorized as either primary or secondary parasitoid [15] due to the fact that it was reared from neither stem borer nor a parasitoid, but rather its pupae were collected from the stem borer tunnel in the plants

Pediobius furvus is a gregarious pupal parasitoid. It was reared from three *B.fusca* pupae; two in the major season and one in the minor season. It is believed that *P. furvus* was introduced from East Africa into Madagascar as a biological control agent against *S. calamistis* in maize [16]. It has been recorded on all pyralid and noctuid stem borers on all major graminaceous crops [17]. It is believed that *P.furvus* is widely distributed in Sub-Saharan Africa. In this study, *P.furvus* was reared from only *B.fusca* pupae. Meanwhile, [14] observed that *P.furvus* was a rare species. In this study also, it was rarely found. However, a very large number of *P. furvus* (105-152) was collected from one *B. fusca* pupa. Such large numbers in one pupa could be attributed to the large size of *B.fusca* pupa compared to that of *Sesamia* spp, *E.saccharina* and *C.aleniellus*.

During the minor season, the most widely distributed parasitoid species was *Syzeuctus* sp. (9farms) followed by *S. parasitica* (8farms), *Enicospilus* sp and *Dolichogenidia* sp (3farms each), *A. fijiensis* (2farms) and *P.furvus* (1farm). In the major season, each parasitoid species was reared from one farm each. For both seasons, *Syzeuctus* sp was the most abundant parasitoid species. However, it was more abundant during the minor season than the major season. Again, *S. parasitica* was the second most abundant parasitoid species for the minor season. The results suggested that *Syzeuctus* sp and *S. parasitica* were the two most important larval parasitoids attacking maize stem borers in southern Ghana.

The results also indicated that *E. saccharina* was the most attacked stem borer species by the parasitoids (Figs. 1 to 3). *Eldana saccharina* is known to spin a protective silken cocoon around itself and for lining the tunnel for protection against enemies. It also secrets a brownish liquid from the mouth when disturbed. This liquid repels other insects or predators from attacking it [18]. Despite these protective mechanisms, *E. saccharina* was still parasitized by a good number of *Syzeuctus* sp (10.70%) and to a lesser extent, *S. parasitica* (3.74%) during the minor season. This suggested that the parasitoids might have good attacking mechanisms to overcome the defensive devices of the pests (*E. saccharina*).

Sturmiopsis parasitica uses planidial-ingress method to attack its larval host. That is, the females attach themselves to host frass to larviposit, where the mobile progeny (maggots) deposited at the entrance within the host tunnel find the host itself. It is believed that this method of attack by *S. parasitica* on *E. saccharina* was somehow effective. On the other hand the attack method of *Syzeuctus* sp. was not known. However, it was hereby considered that the strong, long ovipositors of the female *Syzeuctus* sp. might be effective in probing and piercing through the protective silken material and subsequently parasitizing the larvae of *E. saccharina.*

Throughout the research, no parasitoid was reared from *C. aleniellus*. The results indicated that, the number of *C. aleniellus* collected was negligible compared to the other stem borers. This suggested that *C. aleniellus* might not yet be an important stem borer pest in Southern Ghana. However, parasitoid pupa cases were retrieved from some of the *C. aleniellus* larvae collected (Fig.1). For both major and minor season surveys, no egg batch was collected due to the fact that the surveys were conducted when the crop had already tasseled, a time that eggs are seldomly found. Hence, no egg parasitoid was reared.

CONCLUSIONS

Indications were that in Southern Ghana higher rates of plant infestations of stem borers as well as higher numbers of the stem borers could be recorded in the minor season than in the major season. Further indications were that parasitism in more fields could be recorded during the minor season than in the major season, pointing further to the fact that parasitoids were more active during the minor season than in the major season in southern Ghana. This was attributed to high pest population in the minor season due to plenty of food for the parasitoids. Therefore, if maize stem borer control measures using parasitoids could be effectively put in place in the minor season, the pest number might be brought down to a manageable level that is not injurious to the maize plant.

Syzeuctus sp and *S. parasitica* were found to be the main parasitoids attacking stem borers, especially *E. saccharina* in Southern Ghana. The findings of this study indicated that *P.furvus* was the main pupal parasitoid attacking *B.fusca* in Southern Ghana. Since *P.furvus* is a gregarious parasitoid, large number of the parasitoid could be mass-produced in a relatively short time using few pupae of *B. fusca.* This could help reduce the population of *B. fusca* considerably in Southern Ghana

RECOMMENDATIONS

Since higher rates of plant infestations as well as higher numbers of stem borers were recorded in the minor season than in the major season, it would be more advisable for peasant farmers who could not afford controlling the pest in the two cropping seasons to concentrate their control in the minor season where pest problems were higher. Also, in spite of the fact that no egg parasitoids were found throughout the study period, it would be very prudent undertaking a major work that concentrates on stem borer egg parasitoids.

Once *Syzeuctus* sp and *S. parasitica* had been found to be the main parasitoids attacking stem borers, especially *E. saccharina* in Southern Ghana, then, the two species (*Syzeuctus* sp. and *S. parasitica*) could be mass produced and released into maize fields to augment the number of parasitoids in the field in integrated pest management scheme, when pest population was high, to cause reduction in the number of pests, especially *E. saccharina* infesting maize below the economic injury level in Southern Ghana.

Though *Dolichogenidia* sp and *A. fijiensis* were not reared from any particular stem borer species, it is known that *Dolichogenidia* is a very important parasitoid of stem borers in Sub-Saharan Africa. However, *A. fijiensis* is known to be a hyperparasitoid attacking cocoons of *Cotesia* spp. (Moutia and Courtois, 1953). So, a more comprehensive work should be done in Southern Ghana to find out the trophic status of *Dolichogenia* and *A.fijiensis*.

Since high parasitism of stem borers especially *E.saccharina* and *B.fusca* (up to 100%) were recorded in some fields suggesting that parasitoids were mortality factors reducing stem borer populations in some localities in Southern Ghana, it is hereby recommended that benchmark sites be chosen in some selected localities where such high rates of parasitism were recorded to determine the success level of the parasitoids as agents of stem borer control in Southern Ghana. It was further recommended that, further surveys be carried out in which sampling should cover early stages (seedling or pre-tassel stages) of the crop.

In order to have comprehensive biological control using parasitoids, exotic parasitoids that had co-evolved with the pests should be screened and the most effective ones introduced into Southern Ghana to control stem borers especially *Sesamia* sp whose natural rate of parasitism was found to be very low. However, in doing so, care must be taken to avoid hyperparasitism.

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