ELDANA SACCHARINA (LEPIDOPTERA: PYRALIDAE) IN SUGARCANE (SACCHARUM HYBRIDS), SEDGE (*CYPERUS DIGITATUS*) AND BULRUSH (*TYPHA LATIFOLIA*) IN SOUTH-EASTERN ZIMBABWE

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Abstract

Random surveys of potential cultivated and indigenous host plants of *Eldana saccharina* Walker, a recent pest of sugarcane in Zimbabwe, were completed. Samples of *E. saccharina* were collected monthly, from February 2002 to January 2003 from four sugarcane sites and from *Cyperus digitatus* Roxb. subsp. *auricomus* (Sieber) Kuk. (Cyperaceae), an indigenous host plant, to study population fluctuations and parasitism of this pest. Included are data from *Typha latifolia* L. subsp. *capensis* (Typhaceae), which was sampled regularly from October 2002, following the discovery that large numbers of *E. saccharina* were feeding on the roots of this plant that were not submerged in water.

Two new Cyperaceae are added to the list of known host plants of *E. saccharina*, *viz. C. digitatus* and *Cyperus involucratus* Rottb, as is *T. latifolia. E. saccharina* was not found in *Cyperus articulatus* L., nor in *Sorghum arundinaceum* (Graminae).

E. saccharina damage increased with crop age, and dropped dramatically following harvest. Numbers of *E. saccharina* followed the same pattern. However, the percentage internode damage showed no clear pattern and appeared to remain unchanged. Of the internodes bored, 77% were in the bottom third of the sugarcane stalk, 21% in the middle third and 2% in the top third. Infestations were higher in sugarcane than in *C. digitatus*. In *C. digitatus* most *E. saccharina* were found in almost equal numbers in the rhizome and the base of the main stalk. First and second instar larvae attacked only the inflorescence. In *T. latifolia, E. saccharina* were mostly in the root and the thickened lower part of the stalk. There were no *E. saccharina* in the inflorescence. No parasitoids of *E. saccharina* emerged from larvae and pupae collected from sugarcane or indigenous host plants during the 12 months of sampling. A final instar *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) larva, recovered from a sugarcane field, was parasitised by *Cotesia sesamiae* Cameron (Hymenoptera: Braconidae). *Beauveria bassiana* (Bals.) Vuill, was identified from two dead *E. saccharina* larvae collected in July 2002 from the bottom and middle stalk portions of sugarcane. Only one *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) larva was found in sugarcane during the sampling period.

Keywords: sugarcane, stalk borers, stem borer, *Eldana saccharina*, parasitoids, biological control, indigenous host plants

Introduction

The African sugarcane stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae) was first recorded as a pest of sugarcane in Zimbabwe in March 1999, when a severe outbreak occurred in two adjacent fields at Triangle Estate (Mazodze *et al*., 1999). In other parts of Africa, this indigenous insect is a long-established and serious pest of sugarcane and, to a lesser extent, maize and sorghum (Girling, 1972; Waiyaki, 1974; Atkinson, 1979, 1980). A survey carried out in sugarcane and sedges (*Cyperus* spp.) in May 1987 by two entomologists from the South African Sugar Association Experiment Station (Dr AJM Carnegie and Mr GW Leslie) revealed that sugarcane in Zimbabwe was not being attacked by *E. saccharina* at that time. However, a few larvae were found in a sedge, *Cyperus digitatus* Roxb. subsp. *auricomus* (Sieber) Kuk. (Cyperaceae), at Christine Dam on Triangle Estate (Anon, 1988). *E. saccharina* is therefore regarded as a recent pest of sugarcane in Zimbabwe, and there is little information on its biology and ecology under local conditions.

Surveys completed in Zimbabwean commercial sugarcane since the outbreak of *E. saccharina* in 1999 showed that the borer is now widespread throughout the industry (Anon, 2001, 2002, 2003). Estimated losses in recoverable sugar of 0.9% were recorded for 2000 and 2001 and 1% for 2002 (Anon, 2001, 2002, 2003). *E. saccharina* is currently regarded as the most serious pest of sugarcane in Zimbabwe. This study reports the results of random surveys undertaken to identify indigenous host plants of *E. saccharina* in the area, to monitor changes in populations of the pest and to determine levels of parasitism at selected sites.

Predators of this borer in South Africa were investigated thoroughly by Leslie (1981), when ants (Formicidae), spiders (Arachnidae), cochroaches (Blattidae) and earwigs (Dermaptera) were frequently found in empty tunnels made by the borer in sugarcane stalks. In the southern African region, much effort was focused on the biological control of *E. saccharina* using parasitoids (Conlong and Hastings, 1984; Carnegie *et al*., 1985; Conlong *et al*., 1988; Conlong, 1990). Two parasitoids of *E. saccharina* were recorded in Zimbabwe in 1999, one an unidentified ichneumonid recovered from *C. digitatus* at Section 4, Hippo Valley Estate, and the other an unidentified braconid wasp recovered from young sugarcane at Section 6, Triangle Estate (Anon, 2001). In the latter recovery, the borer may have been misidentified, and could possibly have been *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae). It is hoped that parasitoids from an indigenous host plant will be effective in sugarcane in some form of 'modified' classical biological control, as argued by Conlong (1990), and this study therefore included two indigenous host plants in regular surveys in the search for parasitoids. In South Africa, more parasitoids have been found in indigenous host plants than in sugarcane (Conlong, 1990; Waage and Hassel, 1982; Cock, 1986). This stresses the importance of gathering sound information about the insect's ecology if successful biological control programmes are to be developed.

Materials and Methods

Indigenous host plants

Random surveys were done in mid-June 2002 to identify indigenous host plants of *E. saccharina.* Searches were concentrated mainly on sedges, large grasses, and bulrush in areas surrounding sugarcane fields, particularly along rivers, streams, drainage lines and around dams. *E. saccharina* was expected to be present in the larval and/or pupal stages during this period (Anon, 2001, 2002, 2003). At each randomly selected site, about 200 plants of each species were uprooted and each whole plant inspected for *E. saccharina* damage. Larvae and pupae found were recorded, as were other borer species recovered.

Live *E. saccharina* (larvae and pupae) were collected in 30 ml plastic vials containing laboratory-prepared diet medium (Graham and Conlong, 1988), to check for parasitism. Dead borers were collected in empty vials and monitored for the emergence of pathogens or parasitoids.

E. saccharina *infestations and parasitoids in sugarcane, sedges and bulrush*
From February 2002 to January 2003, *E. saccharina* was sampled monthly, from four sugarcane fields, three on Section 7, Triangle Estate, in early, mid and late cut sugarcane of variety NCo376 (fields 242, 250 and 269 respectively), and one mid cut field of sugarcane variety N14, on Section 4, Hippo Valley Estate (field 458), and also from one site of *C. digitatus* on Hippo Valley Dam 4 (close to field 458). A *T. latifolia* site at Nhoro Dam, Section 12, Hippo Valley Estate, was sampled regularly from October 2002.

Sugarcane
In sugarcane, the same section of field (about 3 hectares) was sampled once per month to obtain a 200 stalk sample. Stalks were sampled at random by pacing every 10th row, removing the first sample stalk from the edge of the field and thereafter one stalk every 10 paces, to the end of the row. Ten random stalks were sampled from each of 20 rows paced. The first row sampled was either close to bush/wetland or another sugarcane field. Similarly, the first stalk per row was either from the field edge close to another sugarcane field or close to bush/wetland, so that if a parasitoid was recovered from cane close to bush/wetland, and the same species of parasitoid was not found further into the field, it could be inferred that it originated from that bush/wetland. The number of internodes on each stalk was counted, and the stalk was then split longitudinally. Each stalk was then divided into thirds, giving the bottom, mid and top portions each an equal numbers of internodes. Before the stalk was dissected, any pupae in the leaf sheaths on the outside of the stalk were collected and their position on the stalk recorded. Pupae were placed into empty 30 ml plastic vials (one pupa per vial), and each larva was similarly placed into a vial containing laboratory prepared diet medium. Eggs were not sampled since these are very difficult to find under field conditions (Waiyaki, 1974; Atkinson, 1980; Carnegie and Smaill, 1982). The vials were then labeled, giving details of date, field number and sample number. Separate records were also made of sample number, date, field number, position on the plant, and instar stage ('1-6' for larvae and 'P' for pupae). Dead larvae were collected in empty numbered 30 ml plastic vials. Larvae were categorised as small (first and second instars), medium (third and fourth instars) or large (fifth and sixth instars). The sampling procedures used were similar to those described by Conlong (1990) and Conlong and Mugalula (2001).

All live and dead *E. saccharina* samples were sent to the South African Agricultural Research Council's Plant Protection Research Institute (ARC-PPRI) quarantine laboratory in Pretoria for authoritative identification of any parasitoids that emerged. Should a parasitoid emerge, the vial number could be cross-referenced with the field records to obtain more information about its host, e.g. instar stage, the portion of the stalk from which the host was recovered, and also whether the stalk was taken from the field edge close to bush/wetland or close to another sugarcane field.

Indigenous host plants
For sedges and bulrush, a stratified random sampling method was used, and 200 plants were inspected each month. The area of sedges or bulrush was divided into three strips (strata), so that stratum 1 was closest to the sugarcane field and stratum 3 furthest away. For bulrush, where there was no adjacent sugarcane, stratum 1 was closest to the dam water and stratum 3 furthest away. About 66 plants were uprooted at random from each of the three strata.

For sedges, the plants were divided into rhizome (R) (representing the true stem), stalk (S) (representing the true leaf) and flower base (F), whereas for bulrush they were divided into root (including thickened basal part of stem), rest of stem and inflorescence. Larvae and pupae found were counted, collected into vials and recorded as described for sugarcane. Samples were sent to the ARC-PPRI quarantine laboratory in Pretoria for authoritative identification of parasitoids.

Statistical analyses
E. saccharina infestations in the host plants were expressed as number of *E. saccharina* per 100 plants. One-way Analysis of Variance (ANOVA) was used to compare numbers of *E. saccharina* from different parts of the plant using MSTAT.

Results and Discussion

Indigenous host plants of E. saccharina
Table 1 lists the indigenous plant species randomly sampled for the presence of *E. saccharina* and other borers (n = 200 per site). The sedge, *C. digitatus*, was the only known local indigenous host plant of *E. saccharina* in Zimbabwe, although this information was not formally published. Two more indigenous wild host plants of *E. saccharina*, *viz*. bulrush, *Typha latifolia* L. subsp. *capensis* (Rohrb.) N. E. Br. (Typhaceae), and *Cyperus involucratus* Rottb. (Cyperacaeae) are now added to the list of host plants of *E. saccharina* in Zimbabwe. Relative to other borers, large numbers of *E. saccharina* were found in *T. latifolia,* particularly where the bases of the plants were not submerged in water. This is the first report of *E. saccharina* feeding on a member of the family Typhaceae. In South Africa, Atkinson (1980) found species of Typhaceae to be non-hosts. No *E. saccharina* were found infesting *Cyperus articulatus* L. (Cyperaceae) and wild sorghum, *Sorghum arundinaceum* (Desv.) Stapf. (Poacaeae), although the latter has been recorded as a host in east and west Africa (Girling, 1972). In the Cyperaceae, the borer attacked the rhizome, the stalk base and the basal parts of the inflorescence, the latter being associated more frequently with first and second instar larvae. In *T. latifolia*, *E. saccharina* occurred in the root and thickened part of the stalk, and a little above it on the main stalk, and no borer was found in the inflorescence.

Table 1. Number of sites sampled, mean numbers of borers per 100 plants and percentage plants damaged from list of indigenous plants occurring mostly in wetland areas around sugarcane fields in the south-east Lowveld of Zimbabwe that were randomly sampled for the presence of borers in mid-June 2002 (n=200). (Plant species were identified by plant biosystematists based at the Harare Botanic Gardens, Zimbabwe.)

Common name of plant	Botanical name	Number of sites sampled	Eldana per 100 plants	Chilo per 100 plants	Sesamia per 100 plants	% plants bored (all borers)
Wild Sorghum	*Sorghum arundinaceum*	4	0	5	0	18
Sedge	*Cyperus digitatus*	3	1	1	0	9
Sedge	*Cyperus articulatus*	4	0	1	0	6
Sedge	*Cyperus involucratus*	4	1	1	0	4
Bulrush	*Typha latifolia*	3	5	1	1	10

Stalk borer infestations and parasitoids in sugarcane, selected sedges and bulrush
Sugarcane: The percentage stalk damage and numbers of *E. sacccharina* generally increased with cane age at all the sites sampled, and declined significantly following harvest (Figures 1; 2 and 3).

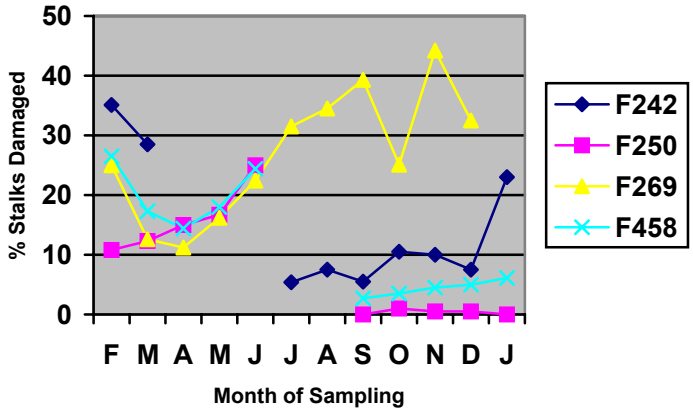

Figure 1. Percentage stalks damaged by *E. saccharina* and month of sampling in sugarcane fields 250, 269, 242 and 458, harvested in July, December, April and July respectively. Data were collected from February 2002 to January 2003.

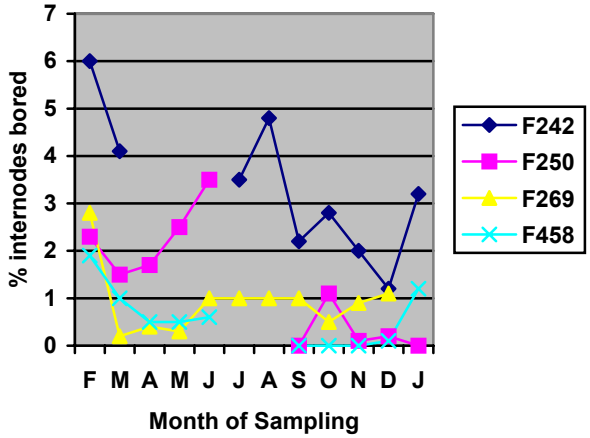

Figure 2. Percentage internodes bored by *E. saccharina* and month of sampling in sugarcane fields 250, 269, 242 and 458, harvested in July, December, April and July respectively. Data were collected from February 2002 to January 2003.

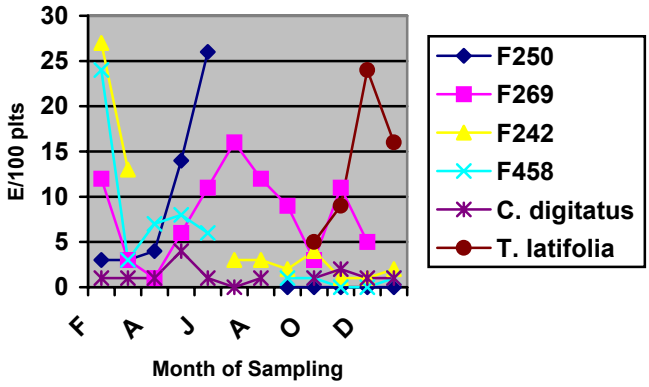

Figure 3. Changes in *E. saccharina* (larvae and pupae) numbers (expressed as E/100 stalks) in sugarcane fields 250, 269, 242 at Section 7, Triangle Estate, and field 458 at Section 4, Hippo Valley Estate, harvested in July, December, April and July respectively, in *C. digitatus* close to field 458, and in *T. latifolia* close to Nhoro Dam at Section 12, Hippo Valley Estate. Data were collected from February 2002 to January 2003.

The percentage internodes damaged did not show any clear pattern of increasing or decreasing with cane age. Generally, *E. saccharina* numbers were very low in *C. digitatus* compared with sugarcane. Although sampled late, the numbers of *E. saccharina* in *T. latifolia* were comparable with those in sugarcane.

Over the 12 months of sampling, no parasitoids of *E. saccharina* were recovered from any of the sites. For sugarcane, this paucity of parasitoids probably explains the steady increase in *E. saccharina* infestations in the industry since first discovered in 1999 (Anon, 2003). In July 2002, the entomopathogenic fungus *Beauveria bassiana* (Balls.) Vuill was identified from two dead and visibly mycosed *E. saccharina* larvae recovered from the bottom and mid parts of the stalk. Not much research has been done to investigate the potential of this fungus for biocontrol of *E. saccharina.* However, a recent co-operative project on entomopathogens of crop pests, of which SASEX is a partner and which is funded by the South African Government's Innovation Fund, will address this shortcoming. In Zimbabwe, ants (Formicidae), coackroaches (Blattidae), earwigs (Demaptera) and spiders (Arachnidae) were frequently found in empty *E. saccharina* tunnels in the sugarcane stalks. In South Africa, these are all important predators of *E. saccharina* (Leslie, 1981).

One-way ANOVA showed that there were significant differences in numbers of internodes damaged in the bottom, mid and top portions of the sugarcane stalk ($P<0.001$; Bartlett's Chi-square = 204). About 77% of internodes bored were in the bottom third, 21% in the middle third and only 2% in the top third of the stalk (Figure 4). This means that *E. saccharina* prefers the bottom portion of the stalk. These observations agree with those of Atkinson (1979) and Conlong (2001) on the same insect in sugarcane in South Africa, suggesting that Zimbabwe is probably dealing with the same *E. saccharina* biotype, and that an exchange of research information would benefit both countries. There were no significant differences between counts of pupae outside and inside the stalks ($P>0.05$), and counts were generally too low to investigate whether the inside or outside count depended on pest density.

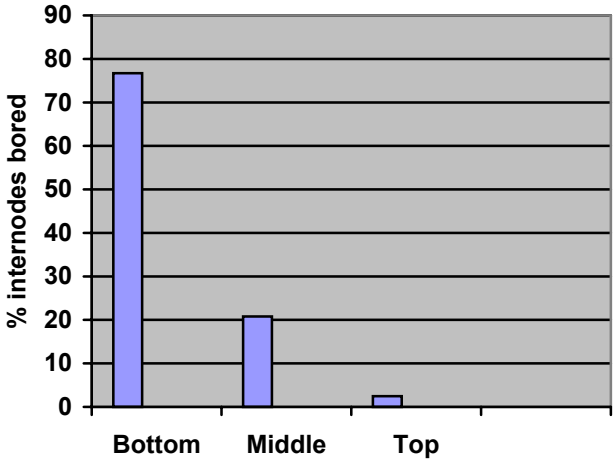

Figure 4. Percentage internodes bored in different portions of the sugarcane stalk parts. Data were pooled for all four sugarcane sites.

Few *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) borers were found, as very young sugarcane (before stalk elongation) was not sampled, and this borer is known to prefer young sugarcane (Williams *et al*., 1969). One large *S. calamistis* larva, collected in February 2002 from the middle portion of the stalk, was parasitised by a braconid wasp, most probably *Cotesia sesamiae*.

One large *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) larva was found in May 2002 in five-month old NCo376 (Triangle, Field 269) in the top portion of the stalk. This is the first documented record of *C. partellus* attacking sugarcane in Zimbabwe. This borer has not caused economic damage in other parts of Africa in sugarcane (Carnegie and Leslie, 1990).

Cyperus digitatus: For *C. digitatus*, *E. saccharina* numbers and month of sampling are shown in Table 2. The very low numbers found probably indicate that *C. digitatus* is not a preferred host plant of *E. saccharina*. The borer occurred in the rhizome, the base of the stalk and at the base of the inflorescence. Over the period sampled, the numbers of *E. saccharina* collected from rhizome and stalk were not significantly different ($P>0.05$), but significantly less *E. saccharina* occurred in the inflorescence ($P<0.05$). There were only two incidences of *E. saccharina* feeding in the inflorescence and, in both cases, first and second instar larvae were involved. Data were insufficient for a chi-square test to be done to investigate whether particular stages were associated more with a certain section of the plant. Not a single parasitoid was found during the 12 months of sampling, probably because few *E. saccharina* were found. Rather than aiming for information on infestation levels, the focus of future sampling will shift from random sampling of plants to searching for as many *E. saccharina* as possible to increase the probability of finding parasitoids.

Table 2. Counts of E. saccharina in the rhizome, stalk and inflorescence of *C. digitatus* at Hippo Valley Estate, Dam 4, during February 2002 to January 2003. No sampling was done in September as the plants were submerged in water (n 200).

Site of damage	Month of sampling											Mean
	F	M	A	M	J	J	A	O	N	D	J	
Rhizome	1	0	1	4	2	0	2	1	0	1	0	1.1
Stalk	0	1	1	4	0	0	0	0	3	0	1	0.9
Flower	0	1	0	0	0	0	0	0	0	0	1	0.2
E/100	1	1	1	4	1	0	1	1	2	1	1	0.7

Typha latifolia: Sampling in *T. latifolia* only began only in October 2002, following the discovery that *E. saccharina* feeds on this host plant. The data so far (Table 3) show that this plant is probably a favoured host, particularly when the bases of stalks and roots are not under water. No stage of *E. saccharina* was found in the infloresence. The number of *E. saccharina* in the root (including the thickened part of stem) was significantly higher than in the rest of the stalk ($P<0.01$). Although reasonable numbers of *E. saccharina* have so far been found in this host, again the focus of future sampling must shift from random sampling of plants to active searching for the borer. Large numbers of *S. calamistis* were also recorded from this plant. Only one *C. partellus* larva was found in October 2002, feeding in the thickened part of the stalk.

Table 3. Counts of *E. saccharina* in the root (includes thickened part of stalk), stalk and inflorescence of *T. latifolia* at Hippo Valley Estate, Section 12, Nhoro Dam, from October 2002 to January 2003 (n=200).

Site of damage	Month of sampling				Mean
	O	N	D	J	
Stolon	9	11	41	27	22
Stalk	0	6	7	6	5
Flower	0	0	0	0	0
E/100	5	9	24	16	13

Conclusions

E. saccharina was found to attack the sedges *Cyperus digitatus* and *C. involucratus*, and bulrush *T. latifolia.* This is the first report of *E. saccharina* feeding on Typhaceae. In the sedges, the borer was predominantly in the rhizome and base of the main stalk, and in bulrush it was predominantly in the root and thickened basal part of stalk, although the main stalk was also attacked. The inflorescence in *T. latifolia* was not attacked, whereas in the sedges young larvae were associated with the base of the inflorescence. *E. saccharina* was widespread at both estates, with percentage stalk damage increasing with cane age. Percentage internode damage appeared largely unchanged, probably due to the spread of the pest.

Regular surveys should continued for a further 12 months, with emphasis for indigenous host plants shifting from random collection of plants to active searching for *E. saccharina* to increase the chances of obtaining parasitoids. The study will also provide important baseline information against which future control measures can be compared. There is the need to evaluate a number of host plants of *E. saccharina* to establish which are preferred for oviposition and for feeding, and to identify host plants that can be included in habitat management studies.

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