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Status of *Eldana saccharina* (Lepidoptera: Pyralidae), its host plants and natural enemies in Ethiopia

Y. Assefa[1], D.E. Conlong[1,2]* and A. Mitchell[3]

[1]School of Biological and Conservation Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa: [2]South African Sugarcane Research Institute, Private Bag X02, Mount Edgecombe 4300, South Africa: [3]Agricultural Scientific Collections Unit, Orange Agricultural Institute, New South Wales Department of Primary Industries, Forest Road, Orange, NSW 2800, Australia

Abstract

Surveys for sugarcane stem borers were undertaken in Ethiopia to determine the prevalence and distribution of these and their natural enemies in crops and indigenous host plants. *Eldana saccharina* Walker was not recovered from sugarcane, but was present in three indigenous wetland sedges, *Cyperus papyrus, C. fastigiatus* and *C. dives* in the southern, central and northern part of the country. The latter indigenous host plant was present in waterways adjacent to sugarcane on the commercial sugar estates. The tachinids *Schembria eldanae* Barraclough and *Actia* sp. were common parasitoids of *E. saccharina* larvae in these indigenous sedges. The braconid *Dolichogenidea* sp. was recovered from *E. saccharina* larvae in *C. dives*. Pathogens comprising *Beauveria bassiana, Bacillus thuringiensis* and *Entomophthora* sp., were found to be important mortality factors of *E. saccharina* larvae in the indigenous sedges. The occurrence of *E. saccharina* in Ethiopia is reported for the first time, and the host plant preferences of the borer and its indigenous natural enemies found during the surveys are recorded. In addition, its potential threat to sugarcane production in Ethiopia is discussed.

Keywords: *Eldana saccharina*, Ethiopia, parasitoid, natural enemies, sedges, sugarcane, wetlands

Introduction

The African sugarcane borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae), is indigenous to Africa and surrounding islands where it feeds on a variety of host plants (Carnegie, 1974; Betbeder-Matibet, 1981; Conlong, 1997, 2001; Polaszek & Khan, 1998; Mazodze & Conlong, 2003). Wetland sedges (Cyperaceae, Juncaceae, Typhaceae) make up a large proportion of its natural host plants (Atkinson, 1979, 1980; Conlong, 2001; Mazodze & Conlong, 2003) and it also occurs in a number of grasses (Poaceae) (Betbeder-Matibet, 1981; Maes, 1998). The borer was first described from sugarcane in Sierra Leone over 100 years ago (Walker, 1865). Since then it has been reported from throughout much of sub-Saharan Africa (Girling, 1972; Waiyaki, 1974; Atkinson, 1980; Betbeder-Matibet, 1981; Maes, 1998). In southern Africa, *E. saccharina* was collected from Mozambique in 1903 and from South Africa in 1928, but the insect was first noticed as a pest of sugarcane in 1939 when an outbreak occurred on mature sugarcane in South Africa (Dick, 1945). Since 1970, however, *E. saccharina* has been of major concern to the South African sugar industry and it is now a serious pest over much of the sugarcane growing regions of South Africa (Paxton, 1982; Webster *et al*., 2005). In Zimbabwe, where the pest had been encountered

*Author for correspondence
Fax: +27 (0)31 5087597
E-mail: Des.Conlong@sugar.org.za

in sedges prior to 1998, a severe outbreak was reported in 1998 from sugarcane (Mazodze *et al*., 1999), from where it has spread to other estates in the area (Mazodze & Conlong, 2003).

The trend in East Africa is similar to what was observed in southern Africa. In East Africa, *E. saccharina* was collected in 1900 in Tanzania and in 1931 in Kenya but heavy infestation by the pest was recorded only in 1966 in a sugarcane estate in Tanzania (Waiyaki, 1974). In repeated surveys conducted in Uganda from 1965 to 1968 *E. saccharina* was recovered from maize, sorghum, sugarcane and wild sedges at scattered points, but it was not regarded as a serious pest at that time (Girling, 1972). However, in 1970 it caused serious damage to sugarcane in some parts of Uganda (Girling, 1972), and is still considered a pest in sugarcane in western Uganda (Conlong & Mugalula, 2001).

Currently, this insect is an important pest of graminaceous crops in many widely separated parts of Africa (Conlong, 1997; Bosque-Perez & Schulthess, 1998; Kfir, 1998; Seshu Reddy, 1998). These records show that *E. saccharina* is spreading as a crop pest throughout sub-Saharan Africa. It is thus important that baseline biological surveys in crop and indigenous host plants be conducted to assess the status of *E. saccharina* and its natural enemy complex in Ethiopia, to determine whether it threatens sugarcane production in the country, and if it is amenable to control through habitat manipulation (Conlong & Kasl, 2000) and/or cultural control (Carnegie, 1974).

This paper presents results of exploratory surveys for *E. saccharina*, its host plant complex and its parasitoids, in sugarcane growing areas of Ethiopia.

Materials and methods

Survey sites

Surveys were completed in the three sugarcane estates (Finchawa, Metehara and Wonji) and in peasant farms in the three major sugarcane-growing regions of Oromiya, Amhara and Southern Nations Nationalities and Peoples' Region (SNNPR). All sites are situated in mid altitude (1500–2000 m asl) and lowland areas (below 1500 m asl) and receive an annual rainfall ranging between 950 to 1500 mm (Habtu *et al*., 1996).

The estates are government owned farms that grow sugarcane commercially in an area more than 24,000 ha in extent. Sugarcane on the estates is irrigated from two big perennial rivers (Awash and Finchawa). These farms each have their own mills and are the sole suppliers of sugar for local consumption and the export market.

The small-scale farms are peasant plots as small as 0.01 ha, and rarely exceed 0.5 ha in area. Peasants grow sugarcane in their gardens under rain-fed conditions, but some irrigate when fields are close to water sources. In the small-scale farms, sugarcane is planted near or mixed with other crops such as sorghum, coffee, maize, fruit and vegetables. The sugarcane produced by these farmers is sold to suburban settlers for chewing and rarely to traders. None of the produce is supplied to mills for sugar production. Approximately 5144, 1013 and 6679 ha of land is allocated for small-scale sugarcane production in Oromiya, Amhara and SNNPR regions, respectively (EASE, 2003).

Survey methods

Surveys were conducted twice, during December 2003 to February 2004 and November to December 2004. In these surveys, sugarcane of different ages, and indigenous host plants (large grasses and sedges) in wetlands, lakes, water channels and border rows were examined for possible infestation by *E. saccharina* and presence of any natural enemies.

Survey regions were identified from sugarcane production statistics (EASE, 2003). Within these regions, survey sites were selected on the basis of the presence of known host plants and accessibility. In localities visited, fields of sugarcane and indigenous host plants were inspected for signs of stem borer infestation, such as the presence of larval frass and/or adult exit holes, and selected on the basis of presence of such infestation signs. After identification of infested fields, the geographic coordinates (altitude, latitude and longitude) were recorded using a GARMIN 12X portable geographic positioning system (GPS) and an altimeter. Levels of infestation were estimated from 25 to 100 randomly selected sugarcane and/or wild host plants from different corners of the selected fields. By counting the number of bored plants, and relating that to the total number of plants examined per field, % stalk infestation was calculated. Stalks were examined *in situ*. For square and rectangular sugarcane fields, 30 of the 100 sample plants were randomly inspected by walking from the top left corner diagonally to bottom right corner of the field and the other 30 samples were from the top right corner diagonally to the bottom left corner. The remaining 40 samples were inspected by walking through the field from the centre of each side of the field. This method and the number of plants inspected were modified when sampling from irregular shaped fields and small sugarcane plots. To determine the existence of any borer and/or natural enemy life stage, ten infested sugarcane plants (or 100 wild host plant stalks) were harvested, dissected and carefully examined for any borer and/or natural enemy life stage present. Any live stem borer stage found was collected and placed into a 30 ml plastic vial containing a piece of sugarcane stalk, sedge or artificial diet (Graham & Conlong, 1988). The vial was sealed with a perforated lid. The perforation was covered with very fine mesh stainless steel gauze. Dead or diseased larvae, cocoons of parasitoids, predators and pupae were placed in empty 30 ml plastic vials, and sealed with the perforated lid. The vials were numbered. These numbers corresponded with numbers on a data sheet, where relevant information about the samples collected was recorded. These data included information on host type, part of the plant where the specimen was found, amount of damage, name of the organism if known, developmental stage, and date and area of collection.

In surveys of border rows, wetlands, waterways near sugarcane fields and large water bodies, 100 indigenous grass host plant stems were collected and inspected for borers and their natural enemies, as described above for sugarcane. In *Cyperus* spp. the insect is known to bore into the umbels and rhizomes (Conlong, 1990). Hence, the umbels and rhizomes not covered with water were inspected. In large indigenous grasses, attention was given to the stalks only. All specimens found were treated as described above.

The collected specimens were shipped to the South African Agricultural Research Council's Plant Protection

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Table 1. Indigenous host plants examined for *Eldana saccharina* in various regions of Ethiopia, number of life stages found and infestation levels in surveys conducted during 2003 and 2004. Names in bold are names of the regions.

Locality	Position	Altitude (m asl)	Host plant	Part of the plant	No. of borers found	% Infestation
Amhara						
Betemengist Sefera	11°29′N; 37°33′E	1705	*Cyperus dives*	Umbel	3	52
			C. papyrus	Umbel	38	68
			C. fastigiatus	Umbel	6	75.8
Lake Tana	11°35′N; 37°23′E	1700	*C. papyrus*	Umbel	79	44.1
Mankusa	10°40′N; 37°11′E	1850	*Pennisetum purpureum*	Stalk	0	0
Oromiya						
Wonji estate	08°31′N; 39°12′E	1500	*C. dives*	Umbel	11	Data not
			Typha latifolia	Above-ground part	0	taken
Metehara estate	08°49′N; 39°58′E	960	*C. dives*	Umbel	3	17.5
Finchawa	09°52′N; 37°19′E	1635	*Sorghum arundinaceum*	Stalk	0	0
Ziway	07°55′N; 38°43′E	1647	*T. latifolia*	Above-ground part	0	0
			P. purpureum	Stalk	0	10
SNNPR						
Lake Awasa	07°03′N; 38°28′E	1685	*C. dives*	Umbel	36	100

Research Institute (ARC-PPRI) Quarantine Laboratory in Pretoria, where they were reared through to either borer or parasitoid adults. These adults were identified by staff of the Biosystematics Division of the ARC-PPRI in Pretoria, and Dr D. Barraclough, School of Biological and Conservation Sciences, University of KwaZulu-Natal, Durban, South Africa. Voucher specimens of species identified are kept at the South African Sugarcane Research Institute (SASRI), Mount Edgecombe, KwaZulu-Natal, South Africa.

Results

Eldana saccharina *in indigenous host plants*

Indigenous host plants attacked by *E. saccharina* and damage intensities observed in the surveys are shown in table 1. *Eldana saccharina* was recorded from three wetland sedges. At Metehara (08°49′N; 39°58′E) and Wonji (8°31′N; 39°12′E) it was collected from *Cyperus dives* C.B.Cl. (Cyperaceae). In wetlands at Betemengist Sefera (11°29′N; 37°33′E) bordering the Nile River, *E. saccharina* was collected from *C. dives, C. papyrus* L. and *C. fastigiatus* Rottb. (Cyperaceae), while at Lake Awasa (07°03′N & 38°28′E) it was in *C. dives* and at Lake Tana (11°35′N; 37°23′E) it was found in *C. papyrus*. Wild grasses in farm fields and wetlands were examined for infestation by the borer, but none of these were attacked by *E. saccharina*.

In the sedges attacked, larvae and pupae of *E. saccharina* were all recovered from the umbels of mature plants. Rhizomes not covered with water were checked for infestation but no boring or life stage of *E. saccharina* was found. The infestation in sedges by *E. saccharina* ranged from 17.5 per 100 umbels in *C. dives* at Metehara estate, Central Ethiopia, to 100 per 100 *C. dives* umbels searched in Lake Awasa, Southern Ethiopia.

Eldana saccharina *in sugarcane fields*

Forty-five peasant sugarcane fields and 174 sugarcane plots in the three estates were inspected and all were free of infestation by *E. saccharina*. Stalk borings were, however, found in most of the fields, but no *E. saccharina* life stages were collected from them.

Natural enemies of Eldana saccharina

In surveys of indigenous host plants, three parasitoids and three pathogens were recovered from *E. saccharina* larvae found in the umbels of *C. papyrus*, *C. dives* and *C. fastigiatus* (table 2). *Schembria eldanae* Barraclough (Diptera: Tachinidae) and *Actia* spp. (Diptera: Tachinidae) were common larval parasitoids in *C. papyrus* umbels, with parasitism levels of 5.26% and 6.33% respectively, being recorded at the time of surveys. The bacterium, *Bacillus thuringiensis* Berliner (Eubacteriales: Bacilliaceae), and a fungus, *Entomophthora* sp. (Entomophthorales: Entomophthoraceae), have also been found attacking *E. saccharina* in *C. papyrus* umbels, with percent parasitism of 10.13% and 5.26% respectively. A solitary braconid, *Dolichogenidea* sp. (Hymenoptera: Braconidae) was recovered from *E. saccharina* larvae in *C. dives* in Lake Awasa and the fungus *Beauveria bassiana* Bals. (Deuteromycotina: Hyphomycetes), was recovered from *E. saccharina* larvae in *C. papyrus* in Lake Tana. However, the percent infestation at the time of the surveys by these natural enemies was relatively low, at 2.78 and 1.27% respectively.

Discussion

Eldana saccharina *in indigenous wild host plants*

Previous studies on biological control agents in southern Africa have shown that there are high levels of parasitism of *E. saccharina* in indigenous hosts, while very little is found in cultivated sugarcane (Conlong, 1990, 1994). Similar results were obtained from surveys in Kenya (Conlong, 2000) and Uganda (Conlong & Mugalula, 2001). This study expands the host plant and natural enemy distribution knowledge of *E. saccharina* to relevant areas in Ethiopia, and provides the first records of host plant–*E. saccharina*–natural enemy interactions in this country. As a result, three different parasitoids, and three pathogen species were found attacking

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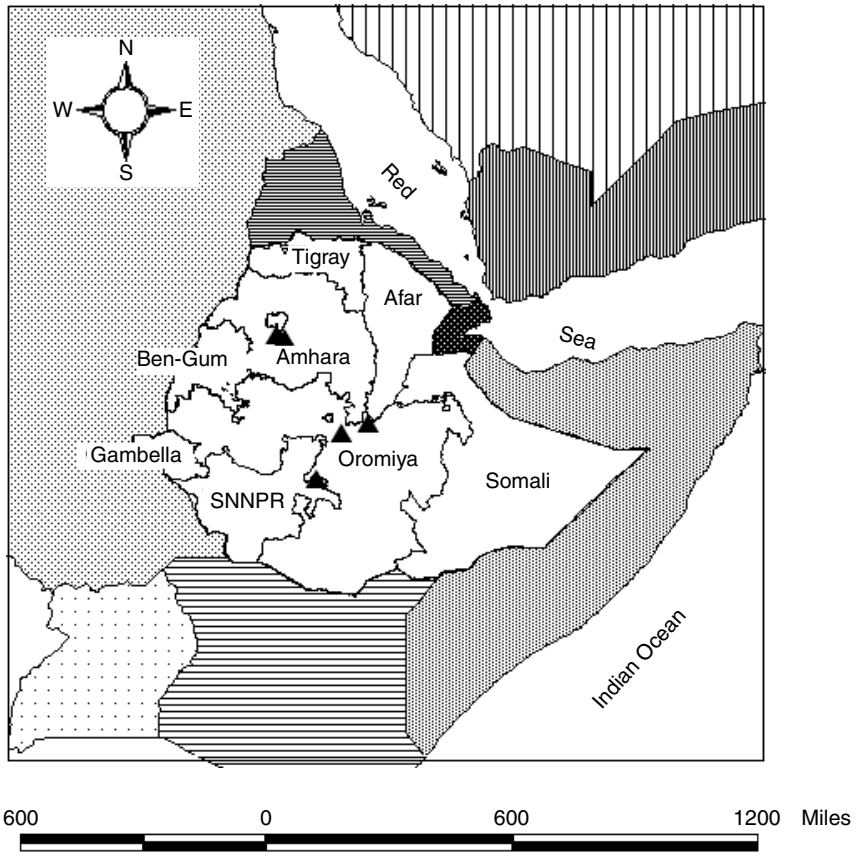

Fig. 1. Map of Ethiopia showing localities where indigenous host plants were found infested by *Eldana saccharina*. ▲ Distribution of *E. saccharina*, □ regional map of Ethiopia, ▩ Djibouti, ▤ Eritrea, ▤ Kenya, ▥ Saudi Arabia, ▨ Somalia, ▩ Sudan, □ Uganda, ▥ Yemen.

Table 2. Natural enemies of *Eldana saccharina* recorded during surveys in indigenous sedges in various parts of Ethiopia in 2003 and 2004. Names in bold are names of the regions.

Location	Position	Altitude (m asl)	Natural enemy	No. found	Life stage attacked	Host plant	% Parasitism
Amhara							
Betemengist Sefera	11°29′N; 37°33′E	1705	*Schembria eldanae*	2	Larvae	*Cyperus papyrus*	5.26
			Entomophthora sp.	2	Larvae	*C. papyrus*	5.26
			Entomophthora sp.	1	Larvae	*C. fastigiatus*	16.60
Lake Tana	11°35′N; 37°23′E	1700	*S. eldanae*	4	Larvae	*C. papyrus*	5.06
			Entomophthora sp.	3	Larvae		3.80
			Beauveria bassiana	1	Larvae		1.27
			Bacillus thuringiensis	8	Larvae		10.13
			Actia sp.	5	Larvae		6.33
SNNPR							
Lake Awasa	07°03′N; 38°28′E	1685	*Dolichogenidea* sp.	1	Larvae	*C. dives*	2.78

larvae of *E. saccharina* in umbels of *C. papyrus*, *C. dives* and *C. fastigiatus*. It appears that these wetland sedges are the dominant hosts of *E. saccharina* in Ethiopia, and more importantly, also the habitat of very effective natural enemies of *E. saccharina* within them (Conlong, 1990). The same species of sedges were recorded to be the predominant hosts of this pest in other parts of Africa (Girling, 1972; Atkinson, 1979, 1980; Mazodze & Conlong, 2003), especially in the southern and eastern regions (Conlong, 2001). In contrast, wild grasses, *Pennisetum purpureum* Moench. (Poaceae) and *Sorghum arundinaceum* (Desv.) Stapf. (Poaceae) that were reported to host *E. saccharina* in West Africa (Girling, 1972; Betbeder-Matibet, 1981; Maes, 1998; Polaszek & Khan, 1998; Conlong, 2001) were free from the pest in Ethiopia.

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It is important to have a detailed knowledge and proper understanding of the potential hosts of stem borers to effectively prevent or reduce damage in graminaceous crops (Polaszek & Khan, 1998). Studies on the ecology and natural enemy complex in indigenous host plants will provide an insight into the type of natural enemies to use in managing the pest in crop plants (Conlong, 1997), and in developing habitat management strategies (Conlong & Kasl, 2001). This study has provided evidence that *E. saccharina* occurs in selected sedges in Ethiopia, and that there are indigenous parasitoids attacking its life stages in these host plants. However, for a scientifically sound incursion plan to be developed to prevent possible infestation of sugarcane by *E. saccharina*, there is a need to conduct a more detailed study on the diversity of indigenous host plants of *E. saccharina* in Ethiopia and the population dynamics over time of the pest and its natural enemies in these indigenous habitats.

Eldana saccharina *in sugarcane*

Available reports from other African countries suggest that *E. saccharina* is an indigenous pest that in most countries has established in sugarcane and other introduced graminaceous crops in which it thrives (Polaszek, 1998). Repeated area-wide surveys on lepidopterous stem borers of maize and sorghum conducted in Ethiopia (Gebre-Amlak, 1985; Getu *et al*., 2001; Tefera, 2004) have shown that *E. saccharina* is not amongst the complex of stem borers attacking these grain crops. This study shows that this is also the case for Ethiopian sugarcane, even though *E. saccharina* is the major borer in umbels of large sedges growing in irrigation channels in sugarcane estates and along river and lake banks amongst peasant sugarcane fields. Whether or not it will spread into sugarcane and other cereal crops remains to be seen, but the possibility of invading sugarcane certainly exists, as recent history shows. In Zimbabwe, where the borer was first observed in sedges close to sugarcane in 1987, a severe outbreak in sugarcane by *E. saccharina* was reported from two fields in 1998 (during a severe drought), and has since then spread throughout their industry (Mazodze *et al*., 1999; Mazodze & Conlong, 2003). The same may happen in Ethiopia should current biotic and/or abiotic factors change to favour the incursion of *E. saccharina* into sugarcane. Climate and sugarcane expansion and related agronomic factors should continually be monitored in order to predict the relevant changes, and to take corrective action before serious infestation occurs.

As sugarcane production in Ethiopia is dependent on furrow irrigation from springs and rivers, it is not unusual to see small-scale sugarcane fields located in or near swampy areas. The biggest sugarcane estates, Metehara and Wonji, are also established on the banks of the Awash River, which is their sole source of water for irrigation. These swamps, channels and riverbanks are natural habitats of sedges from which *E. saccharina* was collected. Should encroachment of the crop into indigenous host plant habitats of the insect take place, then there is a real danger of the insect moving into the crop, as hypothesized by Conlong (1997).

This move can be further exacerbated by having over-aged cane left standing in the field. In southern Africa and Uganda it has been clearly demonstrated that *E. saccharina* prefers older sugarcane (Nuss *et al*., 1986; Conlong & Mugalula, 2001). In the Ethiopian estates sugarcane is left in the field before harvest for up to 22 months and in small-scale farms it will be harvested only when there is a market for it. These practices make this sugarcane vulnerable to *E. saccharina* attack. The sugar estates and small-scale farmers in Ethiopia should be mindful of this fact, and manage their harvesting accordingly; to minimize the chance of *E. saccharina* colonization and population build up.

One of the reasons that *E. saccharina* prefers older sugarcane is because in these older plants, nutrients are no longer used for plant growth, especially nitrogen (Nuss *et al*., 1986), which then becomes available for insect use. It has also been shown that *E. saccharina* infestations increase as nitrogen fertilizer application rates increase (Carnegie, 1981). Reduction of nitrogen fertilizer to $30\,kg\,ha^{-1}$ is recommended to reduce *E. saccharina* problems in sugarcane (SASA, 1994). Ethiopian sugar estates, however, practice the blanket application of high amounts of fertilizer, 200–$700\,kg\,ha^{-1}$ of ammonium sulphate nitrate (ASN), which contains 26% nitrogen (Kedru, 1993). This additional nitrogen, which the sugarcane plant cannot use, will certainly increase the chance of colonization and survival and growth of *E. saccharina* in this sugarcane. Careful monitoring and application of high nitrogen fertilizers should be practiced, so that only the amount needed by the plant is applied, leaving no available nitrogen in the plant that can be exploited by the insect.

In South Africa, sugarcane varieties show different levels of resistance to *E. saccharina* (Nuss *et al*., 1986; Keeping & Rutherford, 2004). The number of internodes bored, larval mass and *E. saccharina* population was found to vary between varieties (Nuss *et al*., 1986; Bond, 1988; Rutherford *et al*., 1993; Keeping, 1999). Thus, it is recommended to regularly monitor sugarcane fields adjacent to the water bodies for infestation by *E. saccharina* and to avoid planting varieties showing *E. saccharina* susceptibility in fields bordering indigenous host plant stands to minimize the chance of colonization by the borer.

Natural enemies of Eldana saccharina

The present surveys in Ethiopia revealed a number of parasitoids and pathogens attacking *E. saccharina* in its indigenous host plants. As there was no available information on *E. saccharina* in Ethiopia, the natural enemies recorded in these surveys are all new records for the country. The tachinids *S. eldanae* and *Actia* spp. were the common larval parasitoids in *C. papyrus* umbels. The former larval parasitoid was described by Barraclough (1991) from *E. saccharina* in *C. papyrus* in KwaZulu-Natal, South Africa. Currently *S. eldanae* is known as a parasitoid of *E. saccharina* on *C. papyrus* in few localities in South Africa (Harris, 1998), Kenya (Conlong, 2000) and Uganda (Conlong & Mugalula, 2001). *Actia* spp. are reported to be parasitoids of the important stem borer species in Sierra Leone, Cameroon and Uganda (Harris, 1998). However, there was no information available on the existence of these parasitoids in eastern Africa (Conlong, 2001). The other parasitoid recovered in these surveys is the solitary braconid, *Dolichogenidea* sp., from *E. saccharina* larva in *C. dives* at Lake Awasa. Parasitoids in this genus are known for their large ovipositor, used to reach concealed living hosts, and are reported from important stem borers (van Achterberg & Walker, 1998). Recently, *Dolichogenidea fuscivora* Walker (Hymenoptera: Braconidae) was reported from *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in eastern Ethiopia

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(Tefera, 2004). The record on this parasitoid from *E. saccharina* in the current survey in the southern part of the country indicates a wide distribution and host range of *Dolichogenidea* spp. This merits further study of this parasitoid group as biocontrol agents in the management of stem borers in Ethiopia.

Similarly, emphasis needs to be given to the bacterial and fungal pathogens that are important mortality factors of *E. saccharina* in its indigenous sedge host plants. The conspicuous symptoms of *Entomophthora* sp., seen occasionally in infected *E. saccharina* larvae in South Africa (Carnegie, 1981), were more frequent in *C. papyrus* umbels in Lake Tana. In addition, the impact of the *B. thuringiensis* isolate from Ethiopia needs to be studied. Jacobs (1989) in South Africa, found some *B. thuringiensis* isolates to be highly toxic to *E. saccharina* larvae. Also, *B. bassiana* was reported to attack *E. saccharina* both in its natural habitat and in cultivated crops in South and West Africa (Conlong, 1990, 2001). The presence of *B. bassiana* in Ethiopia shows the wide adaptation of the pathogen in diversified habitats.

It is evident that in its indigenous host plants in Ethiopia, *E. saccharina* has a complex of indigenous natural enemies keeping it in check. This is in keeping with the surveys of this kind completed in other African countries, where rich natural enemy guilds have been discovered (Conlong, 2000, 2001). Of particular interest is the presence of the tachinids *S. eldanae* and *Actia* spp. In previous surveys, the former has always been a component of the parasitoid guild attacking *E. saccharina* in eastern and southern Africa (Conlong, 2001), while the latter has formed part of the guild attacking *E. saccharina* in western Africa (Conlong, 2001). In a review on biocontrol of *E. saccharina*, Conlong (2001) associated the very different parasitoid fauna collected from *E. saccharina* in West Africa, compared to East and southern African regions, to the possible biotypical differences in *E. saccharina* populations. This view was further supported by the results of molecular analyses on populations of *E. saccharina* from the different parts of Africa (King *et al*., 2002; Assefa *et al*., 2005). Occurrence of parasitoid faunas from different regions of the continent in Ethiopia, therefore, could be related with the existence of different biotypes of *E. saccharina* in this region and merits further study.

These surveys highlight the existence of a rich natural enemy guild that is keeping the pest in check in its natural habitat. However, identification of the natural enemy complex existing in the country and the pest–parasitoid relationships in the natural habitat requires regular and extensive surveys of the natural host plants of *E. saccharina*. Such studies were found to reveal the key natural enemies that keep *E. saccharina* in check in its natural habitat (Conlong, 1990) so that they could be collected and tested against this borer in crop hosts.

Conclusions

This paper provides the first evidence that *E. saccharina* is not attacking sugarcane in Ethiopia, but that it is present in the indigenous sedges *C. papyrus*, *C. dives and C. fastigiatus* throughout the Ethiopian sugarcane growing regions. In addition, it provides the first evidence that these indigenous sedge species house a complex of natural enemies that attack *E. saccharina*. These natural enemies have been found previously in other African countries but their known distribution is now expanded into Ethiopia. The complex comprises insect parasitoids *S. eldanae*, *Actia* spp. and *Dolichogenidea* sp., and pathogens *B. thuringiensis*, *B. bassiana* and *Entomophthora* sp. attacking the larval stages of *E. saccharina*. These natural enemies limit *E. saccharina* population growth in these plants, which makes this indigenous host plant habitat a very important potential source of control measures to prevent *E. saccharina* incursions into sugarcane.

Sugarcane farmers in Ethiopia should be aware that *E. saccharina* has moved from natural hosts to sugarcane in South Africa, Zimbabwe, Uganda and Kenya. Factors preventing it from moving into sugarcane fields in Ethiopia need to be studied and preventative methods followed. Agronomic practices that tend to increase *E. saccharina* populations in sugarcane need to be discouraged, especially in times of drought. The diversity of natural enemies in the country need to be further investigated in time and space, and the natural enemies in their indigenous habitat have to be tested for their role in the management of *E. saccharina* in sugarcane.

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References

Assefa, Y., Conlong, D.E. & Mitchell, A. (2005) Mitochondrial DNA variation among populations of sugarcane borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Proceedings of the South African Sugarcane Technologists' Association* **79**, 382–385.

Atkinson, P.R. (1979) Distribution and natural hosts of *Eldana saccharina* Walker in Natal, its oviposition sites and feeding patterns. *Proceedings of the South African Sugarcane Technologists' Association* **42**, 111–115.

Atkinson, P.R. (1980) On the biology, distribution and natural host-plants of *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Journal of the Entomological Society of Southern Africa* **43**, 171–194.

Barraclough, D.A. (1991) A new species of Tachinidae (Diptera) parasitic on the sugarcane borer *Eldana saccharina* (Lepidoptera: Pyralidae) in Natal, South Africa. *Bulletin of Entomological Research* **81**, 133–136.

Betbeder-Matibet, M. (1981) *Eldana saccharina* Walker. Borer of the stalk of sugarcane in Africa. *L'Agronomie Tropicale* **36**, 279–293.

Bond, R.S. (1988) Progress in selecting for *Eldana* resistance. *Proceedings of the South African Sugarcane Technologists' Association* **50**, 129–133.

Bosque-P'erez, N.A. & Schulthess, F. (1998) Maize: West and Central Africa. pp. 11–27 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

Carnegie, A.J.M. (1974) A recrudescence of the borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Proceedings of the South African Sugarcane Technologists' Association* **37**, 107–110.

Carnegie, A.J.M. (1981) Combating *Eldana saccharina* Walker: a progress report. *Proceedings of the South African Sugarcane Technologists' Association* **44**, 116–119.

Conlong, D.E. (1990) A study of pest–parasitoid relationship in natural habitats: an aid towards the biological control of *Eldana saccharina* (Lepidoptera: Pyralidae) in sugarcane. *Proceedings of the South African Sugarcane Technologists' Association* **64**, 111–115.

Conlong, D.E. (1994) A review and perspectives for the biological control of the African sugarcane stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Agriculture, Ecosystems and Environment* **48**, 9–17.

Conlong, D.E. (1997) Impact of ecology and host plant shifts of *Eldana saccharina* (Lepidoptera: Pyralidae) on its biological control in graminaceous crops. *Proceedings of the South African Sugarcane Technologists' Association* **71**, 94.

Conlong, D.E. (2000) Indigenous African parasitoids of *Eldana saccharina* (Lepidoptera: Pyralidae). *Proceedings of the South African Sugarcane Technologists' Association* **74**, 201–211.

Conlong, D.E. (2001) Biological control of indigenous African stemborers: what do we know? *Insect Science and Its Application* **21**, 1–8.

Conlong, D.E. & Kasl, B. (2000) Stimulo-deterrent diversion to decrease infestation in sugarcane by *Eldana saccharina*. *Proceedings of the South African Sugarcane Technologists' Association* **74**, 212–213.

Conlong, D.E. & Kasl, B. (2001) Stimulo-deterrent diversion of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) and *Xanthopimpla stemmator* (Hymenoptera: Ichneumonidae): preliminary results. *Proceedings of the South African Sugarcane Technologists' Association* **75**, 180–182.

Conlong, D.E. & Mugalula, A. (2001) *Eldana saccharina* (Lep: Pyralidae) and its parasitoids at Kinyara sugar works, Uganda. *Proceedings of the South African Sugarcane Technologists' Association* **75**, 183–185.

Dick, J. (1945) Some data on the biology of sugarcane borer. *Proceedings of the South African Sugarcane Technologists' Association* **19**, 75–79.

Ethiopian Agricultural Sample Enumeration (EASE) (2003) *Statistical report on area and production of crops*. Federal Democratic Republic of Ethiopia Central Agricultural Census Commission, Addis Ababa, Ethiopia.

Gebre-Amlak, A. (1985) Survey of lepidopterous stem borers attacking maize and sorghum in Ethiopia. *Ethiopian Journal of Agricultural Science* **7**, 15–26.

Getu, E., Overholt, W.A. & Kairo, E. (2001) Distribution and species composition of stem borers and their natural enemies in maize and sorghum in Ethiopia. *Insect Science and Its Application* **21**, 353–359.

Girling, D.J. (1972) *Eldana saccharina* Wlk. (Lepidoptera: Pyralidae), a pest of sugarcane in East Africa. *Proceedings of the International Society of Sugarcane Technologists* **14**, 429–434.

Graham, D.Y. & Conlong, D.E. (1988) Improved laboratory rearing of *Eldana saccharina* (Lepidoptera: Pyralidae) and its indigenous parasitoid *Goniozus natalensis* Gordh (Hymenoptera: Bethylidae). *Proceedings of the South African Sugarcane Technologists' Association* **62**, 116–119.

Habtu, A., Sache, I. & Zadoks, J.C. (1996) A survey of cropping practices and foliar diseases of common beans in Ethiopia. *Crop Protection* **15**, 179–186.

Harris, K.M. (1998) Diptera. pp. 265–281 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

Jacobs, S.J. (1989) Micro-organisms as potential biological control agents of *Eldana saccharina* (Lepidoptera: Pyralidae). *Proceedings of the South African Sugarcane Technologists' Association* **57**, 92–94.

Kedru, K. (1993) *Wonji/Shoa sugarcane factory agricultural division plantation manual*. Vol. 1. Nazareth, Ethiopia.

Keeping, M. (1999) Field screening of sugarcane varieties for resistance to the stalk borer, *Eldana saccharina* (Lepidoptera: Pyralidae). *Proceedings of the South African Sugarcane Technologists' Association* **73**, 102–103.

Keeping, M.G. & Rutherford, R.S. (2004) Resistance mechanisms of South African sugarcane to the stalk borer *Eldana saccharina* (Lepidoptera: Pyralidae): a review. *Proceedings of the South African Sugarcane Technologists' Association* **78**, 307–318.

Kfir, R. (1998) Maize and grain sorghum: southern Africa. pp. 25–27 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

King, H., Conlong, D.E. & Mitchell, A. (2002) Genetic differentiation in *Eldana saccharina* (Lepidoptera: Pyralidae): evidence from the mitochondrial cytochrome oxidase I and II genes. *Proceedings of the South African Sugarcane Technologists' Association* **76**, 321–328.

Maes, K.V.N. (1998) Pyraloidea: Crambidae, Pyralidae. pp. 87–98 *in* Polaszek A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

Mazodze, R. & Conlong, D.E. (2003) *Eldana saccharina* (Lepidoptera: Pyralidae) in sugarcane (*Saccharum* hybrids), sedge (*Cyperus digitatus*) and bulrush (*Typha latifolia*) in south-eastern Zimbabwe. *Proceedings of the South African Sugarcane Technologists' Association* **77**, 266–274.

Mazodze, R., Nyanthete, C. & Chidoma, S. (1999) First outbreak of *Eldana saccharina* (Lepidoptera: Pyralidae) in sugarcane in the south-east lowland of Zimbabwe. *Proceedings of the South African Sugarcane Technologists' Association* **73**, 107–111.

Nuss, K.J., Bond R.S. & Atkinson, P.R. (1986) Susceptibility of sugarcane to the borer *E. saccharina* Walker and selection for resistance. *Proceedings of the South African Sugarcane Technologists' Association* **60**, 153–155.

Paxton, R.H. (1982) Eldana borer (*Eldana saccharina*): the results of surveys. *Proceedings of the South African Sugarcane Technologists' Association* **56**, 99–103.

Polaszek, A. (1998) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. 592 pp. Wallingford, Oxon, CAB International.

Polaszek, A. & Khan, Z.R. (1998) Host plants. pp. 3–11 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

Rutherford, R.S., Meyer, J.H., Smith, G.S. & Van Staden, J. (1993) Resistance to *Eldana saccharina* (Lepidoptera: Pyralidae) in sugarcane and some phytochemical correlations. *Proceedings of the South African Sugarcane Technologists' Association* **67**, 82–87.

Seshu Reddy, K.V. (1998) Maize and sorghum: East Africa. pp. 25–29 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

South African Sugarcane Association (SASA) (1994) *Eldana* borer-control measures. Information Sheet: SASA Mount Edgecombe, Natal, Republic of South Africa.

Tefera, T. (2004) Lepidopterous stem borers of sorghum and their natural enemies in eastern Ethiopia. *Tropical Science* **44**, 44–46.

Van Achterberg, C. & Walker, A.K. (1998) Braconidae. pp. 137–186 *in* Polaszek, A. (*Ed.*) *African cereal stem borers: economic importance, taxonomy, natural enemies and control*. Wallingford, Oxon, CAB International.

Waiyaki, J.N. (1974) The ecology of *Eldana saccharina* Walker and associated loss in cane yield at Arusha-Chini, Moshi, Tanzania. *Proceedings of the International Society of Sugarcane Technologists* **15**, 457–462.

Walker, P.T. (1865) List of specimens of lepidopterous insects in the collection of the British Museum. *British Museum (Natural History)*. Part 32. Supplement Part 2, 632–633.

Webster, T.M., Maher, G.W. & Conlong, D.E. (2005) An integrated pest management system for *Eldana saccharina* in the Midlands North region of KwaZulu-Natal. *Proceedings of the South African Sugarcane Technologists' Association* **79**, 347–358.

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