INDIGENOUS AFRICAN PARASITOIDS OF *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE).

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Abstract

Since 1992, surveys for indigenous parasitoids of *Eldana saccharina* Walker in a variety of African habitats have been completed. Thirty species of larval parasitoid have been found in eight countries. Of these, seven occur in South Africa. Of the remaining 23, three can be named to species level, five to genus level, and those remaining can be classified to family level only. In some situations up to 30% parasitism of *E. saccharina* has been recorded.

The paucity of biosystematic and resultant biological data makes laboratory rearing of these animals very difficult. However, the natural abundance of parasitoids found in these short trips to a few countries augers well for a suitable biological control agent to be found.

Introduction

Since its inception in 1981, the biological control programme of the South African Sugar Association Experiment Station (SASEX) against *Eldana saccharina* Walker (Lepidoptera: Pyralidae) has followed two main research options, a 'new association' option and a 'modified' classical biological control option (Conlong and Hastings, 1984). The option followed corresponded almost directly with political changes experienced in South Africa. The 'new association' option (reviewed by Conlong, 1994) received major emphasis during the pre-election phase of the programme (1981-1994). 'Modified' classical biological control (also reviewed by Conlong, 1994) during that time was limited to work in South Africa and a small number of African countries. Since 1995, however, political travel restrictions disappeared. This allowed planned collecting visits to be undertaken into other African countries where *E. saccharina* had been recorded as a pest, and, more importantly, where parasitoids had been recorded (Mohyuddin and Greathead, 1970;Waiyaki, 1974; Nagarkatti and Rao, 1975; Girling, 1978; Scheibelreiter, 1980; Cochereau, 1982; Sampson and Kumar, 1985; Bosque-Perez *et al*., 1994; Gonou *et al*., 1994). As a result, the emphasis moved from 'new associations' to 'modified' classical biological control (1995 to present).

The finding and importation of potentially useful natural enemies is, unfortunately, only the first of a number of steps involved in the successful establishment of a biological control agent in a new environment (De Bach, 1964; Van den Bosch *et al.*, 1982). Good laboratory rearing facilities are important to enable quarantine studies to be completed quickly, and then allow sufficient quantities to be reared for efficient field colonisation trials to be completed. However, for the natural enemy to be reared efficiently, its host or a factitious host also has to be reared. Conlong *et al*. (1984) summarise rearing techniques for five different lepidopteran species used as hosts for rearing four egg and two larval parasitoids. These were developed during the first few years of the biological control programme against *E. saccharina*. Carnegie *et al*. (1985) described the rearing of another larval parasitoid, and field colonisation attempts of all parasitoids reared.

By 1995, eight egg, 12 larval and two pupal 'new association' parasitoids had been imported and tested against *E. saccharina*. Conlong (1997) lists these and provides reasons for their unsuccessful establishment on *E. saccharina* in South African sugarcane fields. During the same time period in South Africa, seven larval parasitoids were found attacking *E. saccharina* in *Cyperus papyrus* (Conlong, 1990), and three egg parasitoids were imported from West Africa where they were collected from *E. saccharina* eggs. Some of these 'modified' classical biological control agents showed early promise, but establishment in sugarcane in South Africa could not be proved. Conlong (1997) lists these and also provides reasons for their apparent unsuccessful establishment.

Lessons learnt during this period have been valuable, and have helped in planning and implementation of surveys for indigenous natural enemies of *E. saccharina* in areas of Africa where it was reported to occur. This paper summarises what was found in eight African countries visited from 1992 to 1999. In addition, the impact of these parasitoids on *E. saccharina* populations at the time of collection, and their fate since being imported to South Africa are also recorded.

Materials and Methods

In all countries visited, host plants of *E. saccharina* were identified, and selected populations of these examined. The plants themselves were then dissected. When borer damage was found, damaged sections of plants were carefully searched for any borer and/or parasitoid life stage. Any insect or arthropod life stage found was carefully collected and placed into a plastic vial (30 ml volume) containing 8-10 ml of diet medium (Graham and Conlong, 1988). The vial was numbered, and this number entered onto a data sheet on which also was entered, corresponding to the number:

- Type of host plant
- Part of host plant where life stage found
- Identification of borer and/or parasitoid if it could be identified in the field
- Type and age of life stage found
- Date of collection

On completion of each visit, collected insects were carefully packed and dispatched to the Plant Protection Research Institute's Quarantine Laboratory in Pretoria. Here they were reared until adults emerged. If parasitoid adults emerged, attempts to rear these were made, and they were identified. Similarly, if borer adults emerged, their identity was confirmed. If parasitoid stages were sent in the collection vials, these were screened for hyperparasitoids, which were immediately killed upon emergence and sent for identification. Any parasitoids that were successfully reared were screened against beneficial borers, and if cleared there, were released to SASEX for mass propagation and release.

All new insect specimens mentioned in this paper were identified by the National Collection of Insects, Biosytematics Division, Private Bag X134, Pretoria, South Africa, who have kept specimens in their collection.

Results

Results of surveys in different African countries are presented in chronological order.

Zambia (1992)

Nakambala Sugar Estate, near Mazabuka, was visited from 2 to 11 September 1992. It is situated on the southern banks of the Kaleya and Kafue Rivers just above flood plain flats. Sugarcane was planted about 6 km from where the estate's main irrigation canal draws water from the Kafue. There were isolated clumps of *C. papyrus* along the banks of the Kafue River. The dominant vegetation on the flats at that time was a variety of small sedges and the bullrush *Typha latifolius*. Grasses on the Kafue River banks were hygrophilous in nature, and dominated by *Echinochloa pyrimidalis*. At the time of the visit, all above ground vegetation except that fringing standing water, and that which was irrigated, was dead. Much of the dead vegetation was burnt, and in *C. papyrus*, large areas were cleared of rhizomes and ground prepared for subsistence crops. Conlong and Way (1992) give a more detailed account of insect surveys conducted on the estate. Table 1 summarises only those results of surveys that were conducted for stalk borers and parasitoids in different suitable host plants on the estate.

The very minor damage found in mature sugarcane was unlikely to have been caused by *E. saccharina*, as none were found in cane. On three occasions, *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) was found in mature sugarcane, and it is probable that this borer caused the damage recorded. Young sugarcane fields were found to have dead hearts, a symptom indicative of *S. calamistis* infestation. When these were dissected, larvae of *S. calamistis* were positively identified, as well as a *Chilo* sp. (Lepidoptera: Pyralidae) larva. The low incidence of *S. calamistis* in mature sugarcane indicates the presence of some regulating factors. At least one was identified when the larval endoparasitoid *Cotesia sesamiae* Cameron (Hymenoptera: Braconidae) emerged from a collected larva.

Vegetation surveys along the major irrigation and drainage canals, storage dams and rivers revealed only *C. papyrus* as a recognised host of *E. saccharina*. It was found at the confluence of the Kaleya and Kafue Rivers, and in the main irrigation canal. As most of the *C. papyrus* umbels had either been burnt or grazed by cattle, surveys for *E. saccharina* and its parasitoids were confined to rhizomes. Table 1 shows that *E. saccharina* infesting rhizomes were parasitised by *Goniozus indicus* Ashmead (= natalensis) (Hymenoptera: Bethylidae), and an unknown ichneumonid (Hymenoptera) parasitoid.

Both these records are firsts, as associations between *E. saccharina* and *G. indicus* had only been recorded in *C. papyrus* umbels, not the rhizomes. The Ichneumonid could not be identified beyond family level, as only one individual was collected.

Table 1. Summary of stalkborer and parasitoid surveys completed at Nakambala Estate, Mazabuka, Zambia from 2 -11 September 1992 (- =nothing recorded; N/A =Not applicable).

Host Plant				Borers Found			Parasitoids Found		
Type	**Age (m)**	**Part**	**% nodes dam.**	**Species**	**No.**	**Per 100 stalks**	**Species**	**No.**	**% paras.**
Sugarcane	±12	Stalk	0.56	*Sesamia calamistis*	3	0.35	*Cotesia sesamiae*	1	33.3
	±3	Stalk	-	*S. calamistis*	7	N/A	-	-	-
				Chilo sp.	1		-	-	-
Cyperus papyrus		Rhizome	N/A	*Eldana saccharina*	46	N/A	*Goniozus indicus (=natalensis)*	1	2.17
							Unknown ichneumonid sp. 1	1	2.17

Kenya

Sugar Estates and Lake Naivasha (1993)

Booker Tate Sugar Estates at Mumias and South Nyanza, were concerned about *E. saccharina* in their sugarcane. In January/ February 1993, a visit was organised to survey their sugarcane and wetland areas to search for parasitoids of *E. saccharina*. More detail is given in Conlong and Gillespie (1993).

The Kenyan sugar zone is situated between 1 130 and 2 750 m above sea level, in western Kenya close to Lake Victoria. Mean annual rainfall is between 1 400 and 1 700mm. Mean monthly temperature maxima vary from 22 to 30°C. Mumias is in the northern area of this zone, and South Nyanza in the south (0° 54' S: 34° 32' E). Opportunity was also taken to visit large *C. papyrus* stands on Lake Naivasha (0° 45' S; 36° 20' E) situated in the great Rift Valley of Kenya. Table 2 summarises results of these surveys.

E. saccharina was present in sugarcane on Mumias Estate and of its outgrowers, but its incidence was very low (Table 2). An unidentified gregarious braconid parasitoid was recovered from *E. saccharina* in this sugarcane. This association has not been recorded elsewhere. Unusually, no *E. saccharina* life stages were found in its normal indigenous hosts, viz. *C. papyrus* and *C. dives* (Table 2) at Mumias.

In contrast to the *C. papyrus* searched at Mumias, this plant at Lake Naivasha was heavily attacked by *E. saccharina*. In addition, *E. saccharina* larvae were attacked by a solitary ichneumonid endoparasitoid, which had not been found before. The parasitoid adults, which emerged during quarantine in Pretoria, were all males, and a laboratory culture could thus not be established.

Mombasa, Kitale, South Nyanza, Lake Naivasha (1994).

An opportunity to continue surveying for parasitoids in Kenya arose in August 1994 (Conlong and Lachimiah, 1994). Lake Naivasha, where an unknown ichneumonid was found during 1993, was revisited to collect more of this parasitoid to attempt laboratory rearing. In addition, areas in Kenya that were climatically similar to sugar producing areas in South Africa were identified and visited. Table 3 outlines results of surveys in all these areas.

A species rich parasitoid fauna was found in the Mombasa area on *Chilo* sp. infesting young maize (Table 3). Unfortunately all *Cotesia* sp. (Hymenoptera: Braconidae) found were subsequently encapsulated by *E. saccharina*, as was *Pediobius furvus* Gahan (Hymenoptera: Eulophidae) from *S. calamistis*. The recovery of *G. indicus* from a *Chilo* sp. larva was the first time this association was found, but later proved to be common in Kenya, and was subsequently found in wild sorghum in

Table 2. Summary of stalkborer and parasitoid surveys completed in different localities in Kenya during January and February 1993.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Damaged	Species	No.	Per 100 stalks	Species	No.	% paras.
Mumias Estate	Sugarcane	± 14	Stalk (n=320)	0.54	*E. saccharina*	5	1.56	Unknown gregarious braconid	1	20
Mumias Outgrowers	Sugarcane	± 15	Stalk (n=250)	0.65	*E. saccharina*	1	0.4	-	-	-
Mumias Estate	Maize and sorghum	Old	Bored stalks only	-	*Chilo* sp. *S. calamistis* Unknown larvae	1 1 2	- - -	- *C. sesamiae* -	- 1 -	- 100 -
Mumias Estate	*Cyperus dives*	Mature	Rhizomes	-	*Chilo* sp. Unknown larvae	3 2	- -	- -	- -	- -
Mumias Estate	*Cyperus papyrus*	Mature	Umbels	-	0	-	-	-	-	-
SONY Estate	Sugarcane	± 15	Stalk (n=150)	0.07	-	-	-	-	-	-
	Maize	old	Stalk (n=20)	3.7	*S. calamistis* *Chilo* sp.	1 7	5 35	- -	- -	- -
SONY Outgrowers	Sugarcane	± 14	Stalk (n=140)	0.03	-	-	-	-	-	-
	Maize	old	Stalk (n=20)	0.7	-	-	-	-	-	-
	Sorghum	old	Stalk (n=10)	4.9	-	-	-	-	-	-
Lake Naivasha	*C. papyrus*	Mature	Umbels (n=206)	16.0	*E. saccharina*	36	17.48	Unknown ichneumonid sp. 2	6	16.67

the Mkuze area of South Africa. The entomophagous fungus, *Beauveria bassiana* has commonly been found on *E. saccharina* in South African *C. papyrus* (Conlong, 1990). *Myosoma nyanzaensis* Quicke and Wharton (Hymenoptera: Braconidae) was reported from *E. saccharina* and *Chilo* sp. (J.W. Smith Jr. pers comm.), but found only from *Chilo* during this survey (Table 3). Only one was collected, so no colony establishment on *E. saccharina* could be tried. The paucity of *E. saccharina* in the Mombasa collections can be ascribed to age of maize sampled. August is early in the maize season, plants are very young and not attractive to *E. saccharina*. They become attractive once cobs are mature. *Cotesia sesamiae* collected from the Kitale area (Table 3) was encapsulated by *E. saccharina* under laboratory conditions.

In the 1980s, *Schembria eldana* Barraclough (Diptera: Tachinidae) was first collected in the Tongaat area of the South African sugarcane belt (from *E. saccharina* in *C. papyrus*) (Barraclough, 1991). The record from Lake Naivasha extends the known range of this parasitoid. The encouraging number of ichneumonid sp 2 which were recovered augured well for colony establishment, but subsequently was unsuccessful during quarantine. Hyperparasitoids emerged from one of the pupae collected.

Tanzania

In November 1994 a collecting trip was organized to sugar estates in Tanzania (Conlong, 1994a). Two estates were visited, Kilombero Sugar Company, which is about 375 km west of Dar es Salaam, on the Ruaha River, and Tanzanian Sugar Planters Company (TPC), situated in the north of Tanzania at the base of Mount Kilimanjaro, close to Moshi. At Kilombero Sugar Company it was reported that *Chilo sacchariphagus* (Lepidoptera: Pyralidae) had been found on the estate. During the visit it was established that no specimen had been sent for positive identification, and the report was thus anecdotal. However, during surveys for *E. saccharina* and its parasitoids, an eye was kept open for this borer. Table 4 summarises the results.

Mature sugarcane at Kilombero was free of *E. saccharina*, and no old borings resembling those made by *E. saccharina* larvae were found. In South Africa, young sugarcane is most commonly attacked by *S. calamistis*. However, at Kilombero, even though this borer was present in maize (Table 4) it was not found in young sugarcane. Instead, a spotted borer, identified as a *Chilo* species, was found (Table 4). This, coupled with the fact that a few stalks of very old cane which were currently being harvested, showed top boring signs similar to that reported to be caused by *C. sacchariphagus* (Way and Turner, 1999), means that the presence of this borer cannot be discounted at this estate. The high proportion of larval cadavers found of this species with symptoms very characteristic of a pathogenic infection, shows that biological control is working, leading to its very low abundance in mature sugarcane (Table 4). *Eldana saccharina* numbers in TPC sugarcane contrasted markedly with those found in Kilombero, being much higher in the former (Table 4).

Table 3. Summary of stalkborer and parasitoid surveys completed in different localities in Kenya during August 1994.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes damaged	Species	No.	Per 100 stalks	Species	No.	% paras.
Patanani (Mombasa)	Maize	± 2	Stalk	-	*Chilo* sp.	31	-	Unknown ichneumonid	1	3.23
								C. sesamiae	4	12.9
								Beauveria bassiana	2	6.45
					S. calamistis	1	-	-	-	-
	Wild sorghum	Mature	Stalk	-	*Chilo* sp.	7	-	*G. indicus*	1	14.3
Mtwapa (Mombasa)	Maize	± 2	Stalk	-	*Chilo* sp.	66	-	*Myosoma nyanzaensis*	1	1.52
								C. sesamiae	2	3.03
								Dead larvae	2	3.03
					S. calamistis	2	-	*Pediobius furvus*	1	50.0
Kitale	Maize	Cob stage	Stalk	-	*Busseola fusca*	59	-	*C. sesamiae*	29	49.2
Mbeche (South Nyanza)	Maize	Old	Stalk	-	*Chilo* sp.	1	-	*Cotesia* sp.	1	100
Kuja River	Sorghum	Old	Stalk	-	*Chilo* sp.	30	-	*Cotesia* sp.	3	10.0
Kanyedoto	*Cyperus fastigiatus*	Mature	Rhizome	-	*E. saccharina*	20	-	Solitary braconid	1	5.0
					S. calamistis	1	-	-	-	-
Lake Naivasha	*C. papyrus*	Mature	Umbels (n=534)	42.5	*E. saccharina*	169	31.65	*Schembria eldana*	5	2.96
								Unknown ichneumonid sp. 2	7	4.14

Umbels of *C. dives* had not yet developed to a stage attacked by *E. saccharina* at the time of the visit to TPC. No individuals could be collected from this natural host plant, thus no natural enemies were found. However, the presence of a tachinid parasitoid from *S. calamistis* collected from maize was encouraging (Table 4), as a major objective of the collections was to find tachinids reported to attack stalk borers. The adult did not emerge from its puparium, so no positive identification could be made.

Ghana and Benin

Contact made with entomologists present at African congresses attended led to the first visits for many years by SASEX entomologists to West Africa. In November 1995 Ghana and Benin were visited to collect *Sturmiopsis parasitica* Curren (Diptera: Tachinidae). This insect had been reported as being a common larval parasitoid of *E. saccharina* in these countries (Scheibelreiter, 1980; Bosque-Perez *et al*., 1994; Gonou *et al*., 1994). Table 5 summarises results of surveys completed. The full trip report is given by Conlong (1995).

In contrast to the East African surveys, these first surveys in West Africa revealed a diversity and impact of parasitoids attacking *E. saccharina* not expected or recorded before. All parasitoids recorded on *E. saccharina* in Ghana and Benin (Table 5) were never before recorded in South Africa. The ichneumonid *Syzeuctus* sp., recovered from *E. saccharina* in Ghana, is an undescribed species (G. Prinsloo, 1996 pers. comm.). It would not show any interest in *E. saccharina* larvae presented to it in the quarantine laboratories, thus a laboratory colony could not be established. Similar fates occurred with *Enicospilus* sp. (Hymenoptera: Ichneumonidae), *Goniozus garoue* (Risbec) (Hymenoptera: Bethylidae) and *Dolichogenidea polaszeki* Walker (Hymenoptera: Braconidae).

The Tachinid sp. in Table 5 could not be identified initially, because of the poor state of the specimens sent to the Biosystematics division by the quarantine laboratories (G. Prinsloo 1996 pers. comm.). As it was collected in localities and from the same hosts from which *S. parasitica* has before been described, it was assumed to be this species. A laboratory colony of it was established in the PPRI quarantine laboratories from 3 mated females, and after two generations in the quarantine laboratory, was released to SASEX for multiplication.

The paucity of parasitoids of *S. calamistis* is also in contrast to what has been found in East and South Africa. The *Cotesia* sp. reported in Table 5 were all found in fields of the International Institute of Tropical Agriculture (IITA), who had imported these from Kenya as biological control agents. It thus seemed as if the importation had established on *S. calamistis* in the vicinity of the IITA station.

Uganda

In May 1996 surveys were completed in Ugandan sugarcane estates (Conlong, 1996). Table 6 summarises results of these surveys for *E. saccharina* and its parasitoids. Kinyara Sugar Works (1° 35' N; 31° 36'E) is in central western Uganda, about 180 km northwest of Kampala, and 1 100 to 1 130m above sea level. Kakira Sugar Works is located 15 km east of Jinja, on the northern banks of Lake Victoria. The estate and outgrowers area lies between latitudes 0° 35' and 0° 43' N and longitudes 33° 17' and 33° 21'E. The oldest estate, Sugar Corporation of Uganda (Ltd.) or SCOUL is situated 30 miles from Kampala, on the road to Jinja.

For a number of reasons, sugarcane at Kinyara Sugar Works was much older than that at any of the other estates. Because of this, *E. saccharina* was plentiful in the sugarcane sampled. Most *E. saccharina* occurred in the oldest sugarcane (Conlong, 1996), and it was in this field that the first indigenous parasitoids were found attacking *E. saccharina*. *Syzeuctus eldanae (=tonganus)* (Kriechbaumer) (Hymenoptera: Ichneumonidae), in addition to being found in the sugarcane, was a common parasitoid of *E. saccharina* in *C. papyrus* in Kinyara, and also at SCOUL (Table 6). The unidentified tachinid collected in sugarcane (Table 6) was one of three different species that were found on Kinyara in *C. papyrus*. It was not certain which species it was. Two of these three species could be identified to genus level (*Actia* sp. and *Ceromya* sp. (Diptera: Tachinidae)). The other was unknown. None of the above species is known from South Africa.

Table 4. Summary of stalkborer and parasitoid surveys completed in different localities in Tanzania during November 1994.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Damaged	Species	No.	Per 100 stalks	Species	No.	% paras.
Kilombero	Maize	± 2	Stalk	-	*C. partellus*	3	-	-	-	-
			Cob	-	*S. calamistis*	1	-	-	-	-
	Sugarcane	± 3	Stalk	-	*Chilo* sp.	6	-	Dead larvae (?virus)	2	33.3
	C. dives	Mature	umbel	-	*E. saccharina*	1	-	-	-	-
T.P.C.	Maize	± 2	Stalk	-	*C. partellus*	4	-	Dead larva	1	25.0
					S. calamistis	1	-	-	-	-
		± 2.5	Stalk	-	*S. calamistis*	9	-	Dead larva	1	11.1
		± 3	Stalk	-	*S. calamistis*	7	-	*C. sesamiae*	2	28.6
								Unkown tachinid	1	11.1
					C. partellus	3	-	*P. furvus*	1	33.3
	Sugarcane	± 3	Stalk	-	*Chilo* sp.	3	-	-	-	-
		± 14	Stalk		*E. saccharina*	22	-	-	-	-

No mating could be achieved with the three tachinid species. Thus laboratory colonies could not be established. *Syzeuctus eldanae* was quite long lived, and adult females were seen probing with their ovipositors through frass into borings made by *E. saccharina* larvae presented to them in sugarcane setts. No offspring were obtained however.

Ivory Coast, Benin, Ghana and Cameroon

In 1981, a SASEX entomologist visited Ivory Coast to collect and dispatch egg parasitoids. In his collections were larval parasitoids, which at that time were not reared. Opportunity was thus taken on this trip to visit the 1981 collection areas, to find the previously recorded larval parasitoids. Table 7 shows than an undescribed species of *Syzeuctus* was found attacking *E. saccharina* larvae in maize. This is the same species reported from the Ghana surveys in 1995 (Table 5), and was again collected from Ghana in 1997 (Table 7). A good number of this parasitoid were thus collected for laboratory colonisation to be attempted. However, the females again failed to show any interest in the hosts they were presented, and a colony could not be established.

Busseola fusca (Fuller) (Lepidoptera: Noctuidae) was found in Ivory Coast sugarcane. This is not the case in South Africa.

The narrow genetic base of the SASEX laboratory colony of *S. parasitica* prompted collected of more material from fields in Benin and Ghana. In addition, a local sugarcane variety had been planted in November 1996 at the IITA station in Benin. This was to determine if *E. saccharina* would attack cane, and if the resident population of *S. parasitica* would find and parasitise the stalk boring larvae. Table 7 shows that this did happen, and also, that a healthy number of *S. parasitica* were collected for infusion into the laboratory culture at Mount Edgecombe. The *Goniozus* sp. collected in 1995 was again collected and identified as *G. garoue* (Risbec) (Hymenoptera: Bethylidae), another parasitoid not present in South African conditions.

When the tachinids *Ceromya* sp. and *Actia* sp. were found in Uganda in 1996, a literature search revealed that an *Actia* sp. had been recorded from *E. saccharina* and *B. fusca* in maize in Cameroon. It was thus opportune to visit this country while in West Africa. Results presented in Table 7 show that the visit was worthwhile, with a substantial number of *Actia* sp. being found. An unidentified tachinid, which attacked larger instar larvae was also found, as well as another unidentified braconid. A visit to the insect collection at the IITA Station in Benin revealed that two *E. saccharina* pupal parasitoids were recorded from Cameroon. Unfortunately this visit was too early in the

Table 5. Summary of stalkborer and parasitoid surveys completed in Ghana and Benin during November 1995.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes damaged	Species	No.	Per 100 stalks	Species	No.	% paras.
Ghana	Maize	±4	Stalk	-	*E. saccharina*	119	-	*Syzeuctus* sp.	16	13.45
								Tachinid sp.	3	2.52
								Unknown braconid	1	0.84
								Dead larvae	2	1.68
					S. calamistis	20	-	-	-	-
					B. fusca	131	-	*Enicospilus* sp.	3	2.29
								Tachinid sp 1	1	0.76
					Chilo sp.	1	-	-	-	-
	Sugarcane	± 11	Stalk	-	*E. saccharina*	4	-	-	-	-
Benin	Maize	±4	Stalk	-	*E. saccharina*	781	-	*Goniozus garoue*	20	2.56
								Tachinid sp.	87	11.14
								Dolichogenidea polaszeki	20	2.56
					S. calamistis	71	-	*Cotesia* sp.	5	7.04
								Tachinid sp.	1	1.41
								Pediobius furvus	2	2.82
					Chilo sp.	7	-	-	-	-
	Sorgho	Mature	Stalk	-	*E. saccharina*	32	-	*C. polaszeki*	3	9.38
								G. garoue	1	3.13
	Pennisetum purpureum	Mature	Stalk	-	*E. saccharina*	2	-	*D. polaszeki*	1	50.0
					S. calamistis	2	-	*Cotesia* sp.	1	50.0

Table 6. Summary of stalkborer and parasitoid surveys completed in various areas of Uganda during May 1996.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Dam.	Species	No.	Per 100 stalks	Species	No.	% paras.
Kinyara	Sugarcane	± 23	Stalk (n=246)	23.79	*E. saccharina*	125	50.81	*Syzeuctus eldanae (= tonganus)*	1	0.8
								Unknown tachinid	1	0.8
	C. papyrus	Mature	Umbels (n=1363)	10.85	*E. saccharina*	147	10.78	*S. eldanae*	8	5.44
								Unknown tachinids	34	23.13
Kakira	Sugarcane	± 20	Stalk (n=229)	0.74	*E. saccharina*	7	3.06	-	-	-
	C. papyrus	mature	Umbels (n=89)	5.6	*E. saccharina*	6	6.74	-	-	-
SCOUL	Sugarcane	±17	Stalk (n=120)	0.05	-	-	-	-	-	-
	C. papyrus	Mature	Umbels (n=309)	8.1	*E. saccharina*	13	4.2	*S. eldanae*	1	7.7

season, as very few *E. saccharina* pupae were found in surveys. Conlong (1997a) details the visit to the above countries.

Uganda

Following the very successful 1996 visit to Ugandan sugar estates, where a number of new *E. saccharina* parasitoids were found, a 1998 visit was planned to obtain larger numbers of these parasitoids. A report detailing the visit is available (Conlong, 1998). Table 8 summarises results of surveys completed in sugarcane and *C. papyrus* of Kinyara and Kakira Sugar Works. In 1996, these estates showed most promise as parasitoid sources.

The very low population of *E. saccharina* collected from sugarcane at Kinyara was probably the reason for not collecting any parasitoids from this species. In contrast to sugarcane, *C. papyrus* surveyed at Kinyara was heavily attacked by *E. saccharina* (Table 8). This can be ascribed to very high nutrient loads in the swamp areas sampled. One area had trees pushed into it and then burnt. High nutrient ash leached into the water in which *C. papyrus* was growing. Another area was on a stream fed by high nutrient effluent overflow from the sugar mill settling ponds.

Parasitoids found during the collection period were the ichneumonid *Syzeuctus eldana (=tonganus)*, and the tachinid *Actia* sp., which were collected during 1996 surveys. Other parasitoids collected for the first time in Uganda included the braconid *Iphiaulax* sp., the bethylid *Goniozus indicus* and the tachinid *S. eldana*. An entomophagous fungus, *B. bassiana*, was also collected for the first time (Table 8). The latter three parasitoids and the fungus are all found in South Africa, being important components of the natural enemy complex attacking *E. saccharina* in its wetland sedge hosts (Conlong, 1990). The presence of the ichneumonids *?Campoplex* sp. and *Venturia* sp. are first records of their association with *E. saccharina* from Uganda.

At Kakira Sugar Works, no *E. saccharina* was found in sugarcane, and very low populations were evident in *C. papyrus* sampled on Lake Victoria (Table 8). The paucity of *E. saccharina* in sugarcane on this estate can be ascribed to two major factors: age of cane harvested and green cane harvesting. The oldest harvested cane checked at the mill was about 18 months old, while the mean age was around 14 months. At this very young cane age, *E. saccharina* is seldom a problem. Kakira Sugar Works and its outgrowers do not burn their cane at harvest. This has allowed an abundance of predatory insects such as spiders (Araneida), ants (Formicidae), earwigs (Dermaptera) and predatory mites (Acarina) to build up in trash left in fields after harvest. The presence of ants and earwigs in at least 70% of the empty borings found in cane indicated that these predators foraged along the cane stalk, and are most likely major predators of immature stages of any stalk borers. In *C. papyrus* umbels, predators, especially ants and earwigs were abundant, notably in the few old borings that were found. Numerous spiders were also evident in umbels. It seems therefore that at Kakira, predators were very efficient at limiting *E. saccharina* populations in both sugarcane and *C. papyrus.*

Cameroon

Sampling sites visited during 1997 were again visited. This visit was aimed at collecting stalk borer pupae, so that pupal parasitoids could be found. Table 9 summarises the survey results. Conlong (1999) gives a detailed account of the visit.

Actia sp. was again very common, and two new ichneumonid species were collected, one from *E. saccharina* and the other from *Sesamia* larvae. In addition, an ichneumonid and eulophid pupal parasitoids emerged from *Sesamia*, and a chalcid pupal parasitoid emerged from *E. saccharina* collected. All parasitoid species collected have yet to be named, either to genus level, or in the case of *Actia*, to species level.

Discussion

It is thus apparent that, in the eight African countries visited, there is an abundance of indigenous parasitoids attacking *E. saccharina.* These parasitoids were collected during short periods of a maximum of six days per site. In addition, the diverse parasitoid fauna, and the completely different parasitoid fauna collected from *E. saccharina* in West Africa compared to East

Table 7. Summary of stalkborer and parasitoid surveys completed in various West African countries during November 1997.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Dam.	Species	No.	Per 100 stalks	Species	No.	% paras.
Ivory Coast (Bouake)	Sugarcane	±13	Stalk (n=34)	-	*E. saccharina*	22	64.7	Dead larva	1	4.5
					B. fusca	1	2.9	-	-	-
	Maize	±4	Stalk	-	*E. saccharina*	165	-	Dead larvae	3	1.8
								Syzeuctus sp.	22	13.3
Ivory Coast (Ferke)	Maize	±3	Stalk	30	*E. saccharina*	10	33.3	*Syzeuctus* sp.	1	10.0
					S. calamistis	1	3.3	Dead larva	1	100
Benin	Sugarcane	12	Stalk (n=70)	23.2	*E. saccharina*	113	N/A	*S. parasitica*	15	13.3
								Dead larvae	2	1.8
				-	*B. fusca*	1	N/A	-	-	-
	Maize	3-5	Stalk		*E. saccharina*	1084	N/A	*G. garoue*	14	1.3
								S. parasitica	178	16.4
								Unknown braconid	5	0.5
								Dead larvae	32	3.0
								Mermithid nematode	1	0.09
								B. bassiana	1	0.09
					S. calamistis	33	N/A	*P. furvus*	1	3.0
								S. parasitica	2	6.1
					B. fusca	1	N/A	Unknown tachinid	1	100
					Chilo sp.	1	N/A	-	-	-
Ghana	Maize	3-5	Stalk (n=170)	-	*E. saccharina*	408	240	*Syzeuctus* sp.	26	6.4
								S. parasitica	32	7.8
								Unknown braconid	6	1.5
								Dead larvae	17	4.2
					S, calamistis	28	N/A	*P. furvus*	1	3.6
								Dead larvae	5	17.9
					B. fusca	55	N/A	Unknown tachinid	2	3.6
								P. furvus	3	5.5
								Dead larvae	1	1.8
					Chilo sp.	1	N/A	-	-	-
Cameroon	Maize	3-5	Stalk	-	*E. saccharina*	502	N/A	*Actia* sp	56	11.2
								Tachinid sp.2	9	1.8
								Unknown Hymenoptera	5	1.0
								Dead larvae	18	3.6
					B. fusca	88	N/A	*P. furvus*	1	1.1
								Ichneumonid pupal parasitoid	4	4.5
								Unknown tachinid	1	1.1
								Parasierola sp.	1	1.1

and South Africa points to there being possible different biotypes of *E. saccharina* present in Africa. The difference in boring behaviour of *E. saccharina* in sugarcane between these areas (Conlong, 1997b) further supports the biotype hypothesis.

Laboratory rearing of the parasitoids found has, for a number of reasons, been very difficult. It is the first time that such detailed surveys have been undertaken for indigenous parasitoids of *E. saccharina*. As a result, much of what has been found is new to science. A summary of the Tables presented above shows that 23 new species of parasitoid attacking *E. saccharina* have been found. Only seven of these (30%) can be described to species level. Eleven (48%) cannot be named past family level. The taxonomic status of these parasitoids is thus poorly understood. This also means that literature pertaining to the biology and life histories of these species is sparse. The lack of literature on which to base laboratory rearing procedures, means that much basic research needs to be undertaken to develop rearing methods.

In addition, when surveys such as these have been completed, many *E. saccharina* life stages are collected. On many occasions, only one individual of a parasitoid species emerged (as can be seen from the above Tables), or individuals of only one sex emerged. It is apparent then that laboratory colonies of these species cannot be initiated. It also happened that one sex emerged before the other sex of a species, or that hosts were parasitised at different times by the same parasitoid species. Emergence of individuals of the particular species would then be over a prolonged period, which could mean that the receptive period for mating has passed before individuals of the opposite sex are available, or ready for mating. A further analysis of the above Tables established that, of the 23 new species of parasitoid found only 10 (43%) produced greater than 10 individuals comprising both sexes. It would be advantageous to determine the period of maximum abundance of these parasitoids, as was done by Conlong (1990) in South Africa, so that maximum use can be made of collection trips. This, however, will only be possible with regular monthly monitoring, which would have to be done at the site concerned. Monthly travel from South Africa to these sites would be too expensive. However, great co-operation from IITA and Kinyara Sugar Works in particular, has allowed seasonal surveys to be conducted in Benin and Uganda.

Conclusions

It is clear that there are numerous indigenous parasitoids of *E. saccharina* available from numerous habitats in Africa, which can be used against this stalk borer in South African sugarcane (so far, 23 new species have been collected from eight countries). However biosystematic, life cycle and phenological knowledge of these species is poor (only 30% of the species collected can be identified to species level). It is not surprising therefore, that laboratory colonisation of these species has not been as successful as hoped.

The basic research needs of good biosystematic support, good life cycle studies and regular field sampling to obtain reliable

Table 8. Summary of stalkborer and parasitoid surveys completed in various areas of Uganda during June 1998.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Dam.	Species	No.	Per 100 stalks	Species	No.	% paras.
Kinyara	Sugarcane	15-17	Stalk	7.6	*E. saccharina*	139	N/A	Dead larvae	2	1.4
	C. papyrus	Mature	Umbels (min= 2129)	38.0	*E. saccharina*	817		*S. eldanae*	15	1.8
								?Campoplex sp.	12	1.5
								Venturia sp.	4	0.5
								Schembria eldana	22	2.7
								Goniozus indicus	1	0.1
								Actia sp.	7	0.9
								Iphiaulax sp.	4	0.5
								Beauveria bassiana	1	0.1
Kakira	Sugarcane	± 14	Stalk (n=179)	0.7	*E. saccharina*	0		-		
	C. papyrus	mature	Umbels (n=1320)	2.1	*E. saccharina*	7	0.5	Dead	1	14.3
	Maize	±5	Random stalks		*Busseola fusca*	19	N/A	*Procerochamias nigromachulatus*	2	10.5
								C. sesamiae	1	5.3

phenological data need greater investment. These functions are beyond the resources of an applied institution such as SASEX , but can be provided by contracted professional research institutions such as universities, where specific research projects on these subjects can be completed by individual researchers for higher degrees.

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Table 9. Summary of stalkborer and parasitoid surveys completed in various areas of Cameroon during March 1999.

Location	Host Plant				Borers Found			Parasitoids Found		
	Type	Age (m)	Part	% nodes Dam.	Species	No.	Per 100 stalks	Species	No.	% paras.
Cameroon	Maize	3-5	Stalk	N/A	*E. saccharina*	706	N/A	*Actia* sp	144	20.4
								D. polaszeki	1	0.1
								Unknown ichneumonid	1	0.1
								Unknown chalcid	1	0.1
					S. calamistis	26	N/A	Unknown ichneumonid	2	7.7
					Sesamia sp.	74		Unknown eulophid	3	4.1
								Actia sp.	1	1.4
								S. parasitica	1	1.4

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