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Diversity of lepidopteran stem borers on monocotyledonous plants in eastern Africa and the islands of Madagascar and Zanzibar revisited

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Abstract

Surveys were completed in Eritrea, Ethiopia, Kenya, Madagascar, Mozambique, Tanzania, Uganda and Zanzibar to assess the lepidopteran stem borer species diversity on wild host plants. A total of 24,674 larvae belonging to 135 species were collected from 75 species of wild host plants belonging to the Poaceae, Cyperaceae and Typhaceae. Amongst them were 44 noctuid species belonging to at least nine genera, 33 crambids, 15 pyralids, 16 Pyraloidea species not yet identified, 25 tortricids and three cossids. The noctuid larvae represented 73.6% of the total number of larvae collected, with 66.3, 3.5 and 3.8% found on Poaceae, Cyperaceae and Typhaceae, respectively. The Crambidae, Pyralidae, Tortricidae and Cossidae represented 19.8, 1.9, 2.5 and 0.1% of the total larvae collected, respectively, with

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90.4% of the Crambidae and Pyralidae collected from Poaceae, and 99.7% of the Tortricidae collected from Cyperaceae. The lepidopteran stem borer species diversity in the wild host plants was far more diverse than previously reported.

Keywords: stem borer, Noctuidae, Pyralidae, Crambidae, Tortricidae, Cossidae, Poaceae, Cyperaceae, Typhaceae, biodiversity, East Africa

Introduction

Lepidopteran stem borers feed inside stems of monocotyledonous plants belonging to the Poaceae, Cyperaceae and Typhaceae. Five species are reported to attack cereal crops in East and southern Africa: the noctuids *Busseola fusca* (Fuller) and *Sesamia calamistis* Hampson, the pyralid *Eldana saccharina* Walker and the crambids *Chilo partellus* (Swinhoe) and *C. orichalcociliellus* (Strand) (Ingram, 1958; Nye, 1960; Polaszek, 1998; Guofa *et al*., 2002). In rural Africa, cereal crops grown by small-subsistence farmers are usually grown in small plots surrounded by land occupied by wild host plants which harbour stem borers. Wild habitats are thus considered in some areas as reservoirs for various stem borer pests (Bowden, 1976; Sampson & Kumar, 1986; Polaszek & Khan, 1998).

Surveys for stem borers on wild host plants have been carried out since the 1950s in East and southern Africa (Ingram, 1958; Nye, 1960; Seshu Reddy, 1989; Randriamananoro, 1996; Polaszek & Khan, 1998; Haile & Hofsvang, 2001; Mazodze & Conlong, 2003). In these surveys, 22 lepidopteran stem borer species belonging to the Noctuidae (11 species), Pyraloidea (nine species), Tortricidae (one species) and Cossidae (one species) were recovered from 36 host plant species. It was concluded that African stem borer species are generally polyphagous, as, for example, the economically important *B. fusca* and *S. calamistis* were collected from 25 and 28 host plants, respectively (Polaszek & Khan, 1998).

In 2002, a study was completed in Kakamega Forest, Western Kenya, to assess the genetic structure of populations of *B. fusca* collected from two cereal crops (*Zea mays* L. and *Sorghum bicolor* L. Moench.) and two wild grasses (*Sorghum arundinaceum* (Desv.) Stapf and *Setaria megaphylla* (Steud.) Th. Dur. and Schinz). Two genetically and faunistically independent components were identified. One consisted of *B. fusca* on cultivated plants and the second of at least eight other noctuid stem borer species belonging to different genera on wild grasses (Epinette, 2003) indicating an unsuspected diversity of stem borers in the wild habitats surrounding cereal crops. It is suggested that, in the past, lepidopteran stem borers found in wild habitats were frequently misidentified.

As a follow-up, surveys to correctly identify and catalogue lepidopteran stem borer species, and their favoured wild plants were initiated in East and south-eastern Africa, and the Indian Ocean islands of Madagascar and Zanzibar. This baseline information is a prerequisite for understanding the role of crop field utilization by lepidopteran stemborers. Host switches by stem borers have occurred in the past. For example, in the 1940s, *E. saccharina* was recorded from sugarcane in South Africa, and since the early 1970s has been the major pest of this crop despite it still being found in its indigenous sedge hosts (Conlong, 1990). This paper reports results generated during 28 months of extensive survey in Kenya mainly but also in Eritrea, Ethiopia, Madagascar, Mozambique, Uganda, Tanzania and Zanzibar.

Materials and methods

The surveys were completed in major cereal growing areas which include commercial and subsistence growers. In Kenya, several surveys were conducted between January 2003 and April 2005 while in Eritrea a survey was undertaken in October 2004, Ethiopia in November 2004, Madagascar in January 2004, Mozambique in April 2005, Uganda in April 2004 and March 2005, Zanzibar in May 2004 and Tanzania in June 2004 and February 2005. A total of 274 localities with varying ecological conditions were visited in the seven countries (table 1). They are located between 15°86′N and 26°02′S, 29°43′E and 49°23′E and at altitudes varying between 0 and 2396 m above sea level. Annual rainfall varied between 501.0 mm and 1621.0 mm, minimum temperature between 6.5°C and 22.6°C, maximum temperature between 18.9°C and 33.0°C and moisture index between 0.33 and 1.26.

At each locality, wild host habitats (i) in and around crops, (ii) in open patches along forest roads, (iii) on banks of streams or rivers and (iv) in swamps were visited. A selective rather than random sampling procedure was adopted to increase the chance of finding borers as earlier studies reported lower stem borer densities on wild host plants compared with those of adjacent cultivated cereals (Nye, 1960; Schulthess *et al*., 1997; Gounou & Schulthess, 2004). In all habitats, plant species belonging to the Poaceae, Cyperaceae and Typhaceae were carefully inspected for stem borer infestations or damage symptoms such as scarified leaves, dry leaves and shoots (dead hearts), frass or holes bored. Infested plants were cut and dissected in the field. Recovered larvae were all reared until pupation on artificial diet (Onyango & Ochieng-Odero, 1994) or sections of fresh maize stems. Pupae were kept separately in plastic vials until adult emergence. Adults were used for morphological identification.

During this study, no plant was given host status until the larvae recovered from it were reared through to adult stage. We consider that a host plant is a plant used for food in natural conditions even if we are not certain that the borer species larvae collected would have completed their development on the plant species they were collected from. Adult moths belonging to the Noctuidae family were identified to species level (P. Moyal,). Traditional morphological classification has been followed even though there is a need for a modern phylogenetic revision of the family (Holloway, 1998), which was beyond the scope of this study. Some non-noctuids such as *C. partellus, E. saccharina, Phragmataecia boisduvalii* Herrich-Shäffer (Cossidae) were easy to identify morphologically, while others were identified to subfamily (Crambinae, Pyralinae, Phycitinae,

Table 1. Lepidopteran stem borers diversity and abundance per country.

	Eritrea	Ethiopia	Kenya	Madagascar	Mozambique	Uganda	Tanzania	Zanzibar
No. localities	23	33	77	23	30	47	27	14
No. host plants P/C/T*	8/5/1	8/2/1	33/11/1	8/8/0	15/2/1	11/5/1	10/8/1	4/2/0
No. stem borers	896	754	16 156	284	933	2746	2021	884
Noctuidae	799 (5)	724 (9)	11 435 (32)	85 (3)	542 (11)	2440 (20)	1382 (14)	758 (3)
Bf/Sc/Cp/Co**	346/0 /38/0	129/50 /22/0	267/382 /2076/1250	0/2 /0/88	0/0 /82/165	39/10 /132/29	0/0 /29/380	0/1 /49/88
Crambidae	55 (2)	22 (1)	3939 (25)	156 (3)	278 (6)	225 (10)	448 (4)	127 (2)
Pyralidae	0	5 (2)	435 (15)	16 (1)	94 (3)	59 (3)	4 (1)	28 (1)
Tortricidae	42 (4)	3 (2)	323 (18)	27 (6)	19 (3)	3 (2)	187 (3)	1 (1)
Cossidae	0	0	24 (2)	0	0	19 (2)	0	0

* Poaceae/Cyperaceae/Typhaceae. ** *Busseola fusca/Sesamia calamistis/Chilo partellus/C. orichalcociliellus* group.
Numbers in brackets refer to number of species.

Schoenobiinae), family (Cossidae, Tortricidae) and superfamily levels (Pyraloidea). *Chilo orichalcociliellus* can easily be confused with several other related species of *Chilo* because specific characters used to identify *Chilo* species appear very variable (Blezynski, 1970). It was decided to record all these species as *C. orichalcociliellus* group. Upon completion of the identification process, the voucher specimens, dry and also (when possible) preserved in absolute ethanol, were deposited at the Museum National d'Histoire Naturelle Paris, France and at the International Centre of Insect Physiology and Ecology Museum in Nairobi, Kenya.

The identified borers were then grouped in their respective host plant and used to calculate the following parameters:

N1: number of localities where the plant was found infested, times this plant was found infested, number of countries where this plant was found infested;
IA: individual abundance = number of stem borer lifestages found on the plant;
N2: number of stem borer species found in each host plant;
M: number of stem borer species found only on this host plant.

Rare host plant species are defined as host plant species found infested from only one locality, and dominant host plant species are defined as host plant species found infested from a minimum of five countries.

Results

A total of 24,674 larvae belonging to at least 135 species were collected: 43 Noctuidae (two *Acrapex*, three *Busseola*, four *Carelis*, three *Manga*, one *Poeonoma*, 11 *Sciomesa*, 12 *Sesamia*, four species close to *Busseola*, temporarily named *Busseola* sensu lato, one *Speia* and three species yet to be identified), 64 Pyraloidea (13 Crambinae, 20 Schoenobiinae, two Gallerinae, 14 Phycitinae, 15 species not yet identified), 25 Tortricidae and three Cossidae (tables 1, 2 and 3). Crambinae and Phycitinae were recovered only from Poaceae, the Schoenobiinae from Cyperaceae and Typhaceae, while Gallerinae were recovered from all the three plant families. Tortricidae represented 2.5% (618 larvae) of the total collection; only one species was found on Poaceae while the remainder were collected from Cyperaceae. The 618 larvae belonged to at least 25 different species. All three cossid species were recovered from Poaceae.

Noctuid larvae dominated the stem borer community and constituted around 58% of the total collection in every country surveyed except Madagascar where they made up only 30% of the total collection. Although much less common than noctuids, crambid species were found in all countries, with 20 species in Kenya. Species belonging to Pyralidae and Tortricidae were much less abundant and constituted less than 3% of the total collection. Eighteen species of Tortricidae were found in Kenya. Cossidae larvae were scarce and only three species were identified.

Plant species found infested during the survey are listed in table 2. Seventy-five species of wild plant hosts were identified, of which 54 belonged to 26 genera of the Poaceae. Twenty species of four genera belonged to the Cyperaceae, while only one species of Typhaceae was found infested. Seven plant species were identified as hosts in 20 localities spread over five countries and we consider them as dominant species; five of them (i.e. *Echinochloa pyramidalis*, *Panicum maximum*, *Pennisetum purpureum*, *Rottboellia cochinchinensis* and *Sorghum arundinaceum*) belonged to the Poaceae. The other two important species were *Cyperus dives* and *Typha domingensis*. These seven plant species yielded 16,440 larvae (67% of the total) belonging to 54 stem borer species, of which 18 were obtained only from these plants, with species diversity varying between six on *T. domingensis* and 23 on *P. maximum*. Infestation of many plant species were localized with about 32 of them, considered as rare species, found infested in single localities. These hosts yielded about 706 larvae (2.9% of the total) belonging to 32 stem borer species (13 of them only on these plants) with species diversity varying between one (25 plant species) and seven (*Cyperus atroviridis*). The Poaceae hosted 90.2% (35 species) of the noctuids and 92.5% (42 species) of the Pyraloidea; the Cyperaceae 4.5% (14 species) and 5.8% (21 species) and Typhaceae 5.3% (three species) and 1.7% (three species) (table 3). The highest number of monophagous stem borers was found on *Setaria megaphylla* (12 species) followed by *Cyperus articulatus* (nine species).

The stem borer species of economic importance recovered from wild host plants are also reported in tables 1, 2 and 3. *Busseola fusca* was collected from four host plants, namely *P. purpureum*, *Arundo donax*, *S. arundinaceum* and *S. megaphylla*. It accounted for 29.5% of the total in the *Busseola* genera and 4.3% of all the noctuid larvae collected. However, in Eritrea and Ethiopia, it accounted for 31% (475 larvae) of the total noctuids collected (table 1). In Kenya, it accounted for 1.6% of the total noctuid larvae recovered,

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Table 2. Lepidopteran stem borers and their wild host plants from eastern and south-eastern Africa.

Plant species	N1	Noctuidae														Pyraloidea													
		Acrapex	*Busseola fusca*	*Busseola*	*Carelis*	gen. sp.?	*Busseola* sensu lato	*Manga*	*Poeonama*	*Sciomesa*	*Sesamia calamistis*	*Sesamia*	*Speia*	1A	N2	M	*Chilo partellus*	*C. orichi* group	Crambinae	Schoenobiinae	Phycitinae	*Eldana saccharina*	Gallerinae	gen. sp.?	Tortricidae	Cossidae	1A	N2	M
Poaceae																													
Andropogon amethystinus Steud.*	1,1,1											+		3	1	0		+	+								2	1	0
Arundo donax L.	14,17,3		+							+	+	+		531	4	0	+										60	1	0
Brachiaria brizantha (A. Rich.) Stapf*	2,3,1																		+					+			8	2	1
Cenchrus ciliaris L.	1,1,1									+				1	1	0													
Chloris gayana Kunth*	2,2,2									+				6	1			+	+								3	1	0
Cymbopogon giganteus Chiov.*	1,1,1																		+								2	1	1
Cymbopogon nardus (L.) Rendle*	5,8,2			+			+							85	2	0					+						1	1	0
Cynodon aethiopicus Clayton & Harlan*	6,12,1									+				183	1	1													
Cynodon dactylon (L.) Pers.*	1,2,1										+	+		13	1	0													
Cynodon nlemfuensis Vanderyst var. *nlemfuensis**	1,3,1			+						+		+		22	3	0													
Digitaria ciliaris (Betz) Koell*	1,1,1																	+									3	1	0
Digitaria milanjiana (Rendle) Stapf*	3,5,1											+		29	1	0		+	+								15	4	1
Echinochloa colonum (L.) Link	1,1,1										+	+		112	2	0													
Echinochloa haploclada (Stapf) Stapf	3,6,1									+		+		31	2	1													
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	20,29,5			+			+			+	+	+		738	7	2	+	+	+		+	+	+	+		+	376	8	2
Eleucine indica (L.) Gaerin subsp. *indica**	1,1,1																	+									4	1	0
Eriochloa fatmensis (Hochst. & Steud.) W.D. Clayton	3,7,1											+		211	2	0													
Eriochloa meyerana (Nees) Pilg.*	3,10,1									+	+	+		141	2	0					+						14	1	1
Euclaena mexicana Schrader*	2,3,2									+				35	1	0		+	+								10	1	0
Hyperthelia dissoluta (Steud.) W.D. Clayton*	1,2,1											+		3	1	0		+						+	+		6	2	0
Hyparrhenia anthistirioides (A. Rich.) Stapf*	1,1,1									+				2	1	0													
Hyparrhenia diplandra (Hack.) Stapf*	1,1,1																	+	+								1	1	0
Hyparrhenia papillides (A. Rich.) Stapf*	1,1,1			+										4	1	0					+						4	1	0
Hyparrhenia rufa (Nees) Stapf	3,3,2																+	+	+								9	1	0
Hyparrhenia sp.*	1,1,1																							+			4	1	0
Ischaemum fasciculatum (Brongn)*	1,1,1									+				2	1	0													
Leptochloa obtusiflora Hochst*	1,1,1																							+			1	1	1
Miscanthus violagus (K. Schum.) Pilg.*	2,2,2											+		10	2	0			+		+						20	2	1
New grass (Ripango)*	1,1,1																		+								2	1	0
Neyraudia arunaniacea (L.) Henr.*	1,1,1				+									10	1	0													
Panicum deustum Thunb.	13,24,3			+				+		+				868	4	2		+	+					+			35	3	1
Panicum maximum Jacq.	46,64,5			+		+	+	+		+	+	+		4195	12	4	+	+	+		+			+	+		1752	11	2
Panicum merkeri Mez*	4,7,1			+				+			+	+		89	3	0		+	+								16	1	0
Panicum poaeoides Stapf*	1,1,1											+		16	1	0													
Panicum porphyrhizos Steud.*	1,2,1										+	+		31	1	0													
Paspalidium geminatum (Forssk.) Stapf*	1,2,1										+	+		29	1	0													
Paspalum virgatum Sw.*	1,1,1																	+	+								19	1	0
Pennisetum hohenackeri Steud.*	5,8,1						+			+				192	2	0								+			8	1	0
Pennisetum clandestinum Chiov.*	2,3,1			+				+						22	2	0													
Pennisetum macrourum Trin.	5,8,2			+					+	+				87	2	0													

Pennisetum polystachion (L.) Schult*	2,2,2									+	+		7	2	0		+	+								31	2	0
Pennisetum purpureum Schumach.	56,81,6		+	+		+			+	+	+	+	4882	13	3	+	+	+							+	292	4	1
Pennisetum trachyphyllum Pilg.	7,13,2					+				+			777	4	1															
Pennisetum unisetum (Nees) Benth*	1,2,1						+						30	1	0															
Phragmites australis (Cav.) Steud.*	8,8,1									+		+	45	2	0															
Phragmites mauritianus Kunth.	8,9,4			+	+					+	+	+	31	4	0	+		+		+					+	13	4	0
Rottboellia cochinchinensis (Lour.) Clayton	30,46,6				+					+	+	+	28	3	0	+	+	+		+						345	6	2
Setaria incrassata (Hochst.) Hack.	1,2,1	+											38	1	1					+						6	1	
Setaria megaphylla (Steud.) T. Duran & Schinz*	11,21,6		+		+	+	+	+		+			2279	10	6		+	+					+			106	5	5
Setaria plicatilis (Hochst.) Engl.*	2,5,1			+				+					186	2	0			+								2	1	0
Setaria sphacelata (Schumach.) Moss	2,2,2				+					+			10	2	0															
Sorghum arundinaceum (Desv.) Stapf	55,86,5		+	+				+			+	+	250	5	0	+	+	+		+	+				+	2288	7	0
Sorghum halepense (L.) Pers.	1,1,1															+		+								8	1	0
Sporobolus macranthelus Chiov.*	1,3,1	+											90	1	1															
Vassia cuspidata (Roxb.) Griff.	1,2,1										+	+	24	1	0															
Cyperaceae																															
Carex chlorosaccus C.B. Clarke*	1,1,1																		+							14	1	1
Schoenoplectus maritimus (L.) K. Lye*	2,2,2									+			3	1	0									+		4	1	1
Schoenoplectus corymbosus (Roem. & Schult) J. Ryan var. *brachyceras**	5,7,3											+	3	1	0				+					+		90	7	2
Scleria racemosa Poir*	3,3,2				+								14	1	1								+			14	1	1
Cyperus alopecuroides Rottb.*	2,2,1																		+		+	+				11	2	0
Cyperus articulatus L.*	10,17,4									+	+	+	453	5	3				+					+		210	10	5
Cyperus atroviridis C.B. Clarke*	1,3,1									+	+	+	62	3	0						+	+		+		39	4	1
Cyperus dereilema Steud.*	3,5,2				+					+	+	+	14	2	1				+				+			28	2	1
Cyperus dichroöstachyus A. Rich.*	3,5,2				+					+			49	2	1				+					+		40	2	1
Cyperus distans L.	10,13,1										+	+	6	1	0				+					+		41	3	0
Cyperus dives Del.	21,29,6									+	+	+	135	4	0				+		+	+		+		104	6	0
Cyperus exaltatus Retz.*	2,4,1										+	+	15	2	0				+		+	+		+		125	6	0
Cyperus grandis C.B. Clarke*	1,1,1																		+							10	1	0
Cyperus imbricatus Retz.*	1,1,1																						+			31	1	0
Cyperus involucratus Rottb.*	5,7,2									+	+	+	16	2	0								+			7	2	2
Cyperus latifolius Poir.*	4,7,1									+	+	+	4	2	0				+		+	+		+		76	9	0
Cyperus maculatus Boeck.	2,3,1										+	+	8	1	0									+		32	1	0
Cyperus papyrus L.	1,1,1									+			7	1	0						+	+				12	1	0
Cyperus prolifer Lam.*	1,1,1																		+					+		51	2	1
Cyperus rotundus L.*	4,6,1									+	+	+	35	3	0									+		7	1	0
Typhaceae																															
Typha domingensis Pers.	38,56,6									+		+	+	963	3	1			+		+	+				97	3	2

N1, number of localities where the plant was found infested, times this plant was found infested, number of countries where this plant was found infested; IA, individual abundance = number of stem borers found on the plant; N2, number of stem borer species found in each host plant; M, number of stem borer species found only on this host plant; * Wild host plant recorded for the first time.

Table 3. Lepidopteran stem borer diversity and abundance per host plant families.

	Poaceae	Cyperaceae	Typhaceae	N
Noctuidae				
Acrapex	168 (2)			168 (2)
Busseola	2643 (3)			2643 (3)
Busseola fusca	781			781
Carelis	221 (3)	63 (3)		284 (4)
gen. sp.?	252 (3)			252 (3)
Busseola sensu lato	1875 (4)			1875 (4)
Manga	4086 (3)			4086 (3)
Poeonoma	921 (1)			921 (1)
Sciomesa	2877 (8)	571 (7)	364 (1)	3812 (11)
Sesamia	3335 (9)	190 (4)	546 (1)	4071 (12)
Sesamia calamistis	341	104		445
Speia			53 (1)	53 (1)
N	16 378 (39)	824 (14)	963 (3)	18 165 (44)
Pyraloidea				
Crambinae	4891 (13)			4891 (13)
Chilo partellus	2423			2423
Schoenobiinae		258 (18)	87 (2)	345 (20)
Phycitinae	390 (14)			390 (14)
Gallerinae	6 (1)	77 (2)	10 (1)	93 (2)
Eldana saccharina	6	75	10	91
gen. sp.	124 (14)	7 (2)		131 (16)
N	5411 (42)	340 (21)	97 (3)	5848 (64)
Tortricidae	2 (1)	616 (24)		618 (25)
Cossidae	43 (3)			43 (3)

Numbers in brackets refer to number of species.

with 1.3% from *S. megaphylla* in one locality only, and for less than 0.7% in other countries from the mainland. *Sesamia calamistis* was collected from 24 host plants with 341 and 104 larvae from the Poaceae and Cyperaceae, respectively. It accounted for 10.2% of all collected larvae belonging to *Sesamia* genera and for 2.3% of all the noctuids. *Chilo partellus* was obtained from eight host plants from the Poaceae only, with most of the larvae found on *S. arundinaceum* (89.7%). *Chilo partellus* accounted for 49.5% of the Crambinae and 41.3% of the Pyraloidea larvae collected. Larvae of the *C. orichalcociliellus* group were found on 18 host plants, only from the Poaceae, with a majority of the larvae (79.4%) found on *P. maximum*. They accounted for 41% of the Crambinae and 34% of the Pyraloidea larvae collected. *Eldana saccharina* was found on eight host plants from Poaceae, Cyperaceae and Typhaceae, though most (82%) were recovered from Cyperaceae species.

Discussion

This study showed that both stem borer diversity and host plant range in eastern Africa are much higher than earlier reported (Ingram, 1958; Nye, 1960; Seshu Reddy, 1989; Randriamananoro, 1996; Polaszek & Khan; 1998, Haile & Hofsvang, 2001; Mazodze & Conlong, 2003). Among 75 plant species found infested, 51 of them had never been reported as hosts of stem borers. The number of known host plants therefore increases to 87 and is expected to increase as this study continues to cover new areas. The Poaceae had 2.5 times more host species than the Cyperaceae. In previous surveys, only five species within the Cyperaceae were reported as host plants, resulting in a Poaceae/Cyperaceae host plant ratio of 5.7. Location in less accessible swampy areas coupled with less conspicuous damage symptoms makes it difficult to detect infested Cyperaceae plants and might explain the apparent discrepancy between these results. There were seven dominant and 32 rare host plant species. However, with the present survey methodology it cannot be determined if the dominant species are preferred more by the ovipositing female moth or whether they are more suitable for survival of its offspring. Fifty years ago, *S. arundinaceum, P. purpureum* and *P. maximum* were reported as the dominant species for stem borers in East Africa (Nye, 1960).

Localities surveyed during the course of this study fall into a wide variety of climatic conditions. However, stem borer larvae were found principally on host plants with robust and thick stems growing in wetter parts of all localities (forest roads, banks of streams or rivers, swamps), confirming observations made by Nye (1960) and Bowden (1976).

Even though this is just a preliminary estimate for all countries surveyed (except for Kenya which was sampled several times), the present study provides a first general overview on the stem borer species diversity in East and southern Africa. Nevertheless, the number of stem borer species recorded here is almost five times higher than the number reported in previous surveys (Ingram, 1958, Nye; 1960, Seshu Reddy, 1989; Randriamananoro, 1996; Polaszek & Khan, 1998; Haile & Hofsvang, 2001; Mazodze & Conlong, 2003). The low number of stem borer species recorded in previous surveys may be attributed to restricted distribution of stem borer species, concentration on specific species of stem borer only and/or limited number of habitats surveyed. Also, the biased sampling method used in this survey allowed for much larger sample sizes and considerably higher numbers of larvae than the 1000 and 5000 larvae collected by Ingram (1958) and Randriamananoro (1996).

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Table 4. Lepidopteran stem borers records previously published from Eastern and south-eastern Africa.

References	Janse, 1937–1969	Tams & Bowden, 1953	Bowden, 1956	Ingram, 1958	Nye, 1960	Fletcher, 1961	Viette, 1967	Blezynski, 1970	Berio, 1973, 1976	Laporte, 1975/76	Seshu Reddy, 1989	Rougeot, 1984	Rougeot *et al.*, 1991	Polaszek & Khan, 1998	Haile & Hofsvang, 2001	Krüger, 2005	Present study	Known species from EA
Distribution	SA	EA, SA	Ta, Ug	Ug	Ke, Ta, Ug	Ke, Ug	Ma	EA	Ta	Et	Ke, Ug	Et	Et	Ke	Er	SA	EA	
Noctuidae																		
Acrapex	10					5	4		11			16	2			2	2	52
Busseola	5	1	2	2	3	1					2			1	1		3 (1)	5
Carelis																	4 (1)	
Conicofrontia	3	1							1									3
gen. sp.?																	3	
Busseola sensu lato																	4 (4)	
Manga						2											3 (2)	3
Poecopa						1												1
Poeonoma		1		1		1								1			1	1
Sciomesa		3				5	3		1	1		3	1				10 (4)	18
Sesamia	4	13		7	5	9	4			1	6		4	1	1	4	12 (5)	32
Speia		1															1	1
Pyraloidea																		
gen. sp.?																	16	
Crambidae																		
Crambinae				3	4			13			2			2	2		13	?
Schoenobiinae																	20	?
Pyralidae																		
Galleriinae				1	1									1			1	?
Phycitinae				5	1						1						14	?
Tortricidae																	25	?
Cossidae														1			3	?

EA, East Africa; Er, Eritrea; Et, Ethiopia; Ke, Kenya; Ma, Madagascar; SA, South Africa; Ta, Tanzania; Ug, Uganda.

About 68% of all the species were found in Kenya, which was extensively surveyed. Thus, this report very likely underestimates the stem borer species diversity in East and south-eastern Africa. At the family level, published information on diversity is very scarce. The noctuids are the best described family among lepidopteran stem borers (Janse, 1937–1939; Tams & Bowden, 1953; Fletcher, 1961; Viette, 1967; Berio, 1973, 1976; Laporte, 1975, 1976; Rougeot, 1984; Rougeot *et al*., 1991; Krüger, 2005) (table 4). However, of the 43 noctuid species recovered during this study, 18 had never been reported before although previously 132 species have been known from East and south-eastern Africa. More faunistic surveys are therefore required for accurate estimation of the noctuid species diversity, particularly for the rare species (*sensu* Coddington *et al*., 1996), which are thought to contribute significantly to the species diversity in the tropics and are usually specialized species (cf. *S. megaphylla* guild). Information on host plant species diversity is completely lacking for other stem borer families with the notable exception of *Chilo* in the Crambidae. Blezynski (1970) in his world review reported 13 species of *Chilo* for East and south-eastern Africa. In the present study, at least 10 species were recovered, from a number of different host plants, which reflects the diversity of this genus in Africa.

The present study provides for the first time a general overview on the host range of the different lepidopteran stem borer families. Although noctuids were found on all three plant families surveyed, they appeared more abundant (90%) and diversified (39 species) on the Poaceae. The results showed that the remaining lepidopteran stem borer families and subfamilies have restricted host plant ranges. These results confirm the patterns of host-plant use reported for Lepidoptera, where over 80% of species are regarded as monophagous or oligophagous, and less than 20% polyphagous (Bernays & Chapman, 1994).

Several previous reports documented the wild host range of cereal stem borers (Ingram, 1958; Nye, 1960; Atkinson, 1980; Seshu Reddy, 1989; Polaszek & Khan, 1998; Haile & Hofsvang, 2001; Mazodze & Conlong, 2003). This study confirmed the polyphagy of *S. calamistis* and *E. saccharina* and that the last species is primarily an insect of Cyperaceae though it can be found on the other two plant families, as reported by Atkinson (1980), Mazodze & Conlong (2003) and Gounou & Schulthess (2004). On the other hand, *B. fusca* and *C. partellus* showed oligophagous status as they were respectively found on four and eight host species only belonging to Poaceae. Like *C. partellus*, species of the *C. orichalcociliellus* group are oligophagous. Even though almost all wild hosts recorded in the previous surveys were examined during this study, there was evidence of discrepancies between the results, suggesting misidentification of some species in earlier studies, a concern that was raised by Polaszek & Khan (1998). A proper identification of lepidopteran stem borer pests is essential for accurate assessment of their host ranges as well as the importance

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of wild host plants on uncultivated land as a source of pests for adjacent crops. Although *B. fusca* appears uncommon among wild host plants in Kenya, Mozambique, Tanzania and Uganda, it was common on wild hosts in the north-eastern part of Africa, particularly in Eritrea, where it accounted for 43% of the noctuid larvae found. This supports the hypothesis that the host range of most oligophagous and polyphagous insects is dynamic and often location and time-specific (Polaszek & Khan, 1998).

Data on resource availability do suggest, quite strongly, that if plant species are extremely abundant and long-lived, insects are able to specialize on them and often do so (Bernays & Chapman, 1994). The colonizations of *E. saccharina* in South Africa and more recently Zimbabwe from wild sedges onto sugarcane confirmed this assumption (Mazodze & Conlong, 2003). In the course of a recent extensive survey carried out in Kenya in cereal growing areas, several wild lepidopteran stem borers (i.e. *Busseola* sp. nr *phaia*, *S. nonagrioides* Lefebvre, *Sciomesa piscator* Fletcher) were commonly recovered in maize fields (Ong'amo *et al*., 2006). These species together with other stem borers that are currently restricted to wild hosts may have the potential to shift to cultivated cereals in cases of serious habitat fragmentation since under laboratory conditions, they easily develop to adulthood on maize stems.

It is assumed that wild hosts adjacent to cultivated crops can provide an important refuge for both the borers and their natural enemies (Polaszek & Khan, 1998). The present study, however, revealed that recognized noctuid stem borer crop pests are not abundant on wild hosts compared to wild noctuid species. Currently, information on diversity and abundance of stem borer natural enemies in natural habitats is minimal. Further studies on host plant–stem borer–natural enemy associations under different local conditions are needed for a better understanding of the role of wild habitats as a source of pests and natural enemies on adjacent crops.

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