
ICLCBA
International Conference on Lepidopterous Cereal stem and cob Borers in Africa

2005

Leading scientists from Africa, Europe, United States of America and Australia, have converged in 2005 in Nairobi to assess the advancements so far made in the research on cereal stem and cob borers. This group of pests causes significant damage to maize, sorghum and sugarcane, which are of great economic importance, especially in the African continent.

The International Centre of Insect Physiology and Ecology (*icipe*) and Institut de Recherche pour le Developpement (IRD, a French Institut), were organizing the forum, which was titled the International Conference on Lepidopterous Cereal stem and cob Borers in Africa (ICLCBA). It was helt at the ICIPE Duduville campus in the Thomas Odhiambo Conference Centre from 24th-28th October 2005.

The purpose of ICLCBA was to provide a platform for effective communication and exchange of information and ideas between scientists who are working or have worked on lepidopterous cereal stem and cob borers in Africa.

Participants at the conference have discussed a wide range of topics including faunistics and systematics of Lepidopterous cereal stem and cob borers and their natural enemies in Africa; population genetics and phylogeography of borers and parasitoids; spatio-temporal distribution of main borer and parasitoid species; modeling and sampling methods.

The scientists were also looking at the biology and ecology of the borers' life cycle; their behavioural ecology and patterns of interaction with wild and cultivated host plants, and the multitrophic interactions between the plants, the pests and the biological control agents.

The economic importance, pest status and crop loss, as well as the relation between borers and mycotoxin-producing fungi and storage pests, were also assessed at the ICLCBA forum. More precisely, the following themes have been developed:

1. Faunistics and systematics of African Lepidopterous cereal stem and cob borers and their natural enemies

2. Population genetics and phylogeography of borers and parasitoids

3. Spatio-temporal distribution of main borer and parasitoid species
* modelling and sampling methods

4. Biology and ecology of borers
* life cycles
* behavioural ecology and patterns of interaction with wild and cultivated host plants
* multitrophic interactions

5. Economic incidence
* pest status and crop loss assessment
* interactions between borers and mycotoxin-producing fungi and storage pests
* trans-boundary pest invasion

6. Management tools and options
* Integrated Pest Management
* biological control (predators, parasitoids, pathogens)

* cultural control
* habitat management
* chemical control
* botanicals
* host plant resistance
* transgenic
* phytosanitory regulations

About 50 persons have participated coming from the following countries: Australia, Benin, Cameroon, Ethiopia, France, Kenya, Mozambique, South Africa, Tanzania, Uganda and Zimbabwe.

The purpose of this International Conference was to provide a forum for effective communication and exchange of information and ideas between scientists who are working or have worked on African Lepidopterous cereal stem and cob borers; and to promote advancement and dissemination of knowledge relevant to the needs of Africa to manage such pest insects.
The proceedings of the ICLCBA have been published in a special volume of the "*Annales de la Société Entomologique de France*", an International Journal in Entomology.

Photo Antony Kiama Kagunda

Participant names from left to right:

1st row: Jiang Nanqing (ICIPE, Kenya), Fritz Schulthess (ICIPE, Kenya), Jean-Marc Leblanc (IFS, Sweden), Jean-François Silvain (IRD/CNRS, France), Prof. Christian Borgemeister (DG of ICIPE, Kenya), H. E. Hubert Fournier (French Ambassador, Kenya), Charles Omwega (ICIPE, Kenya), Bruno Le Rü (IRD/ICIPE, Kenya), Serge Snrech (French Embassy, Kenya), Paul-André Calatayud (IRD/ICIPE, Kenya).

2nd row: Difabachew Belay (ICIPE, Ethiopia), Nathalie Faure (IRD/CNRS, France), Victor Mgoo (ICIPE, Tanzania), Adenirin Chabi-Olaye (IITA, Benin), Peter Lomo (JKUAT, Kenya), Brigitte Frérot (INRA,

France), Teddy Matama-Kauma (NARI, Uganda), Beatrice Pallangyo (NBCP, Tanzania), Melaku Wale (ARARI, Ethiopia), Gerald Juma (IRD/ICIPE, Kenya), Anani Bruce (ICIPE, Kenya), Catherine Gitau (ICIPE, Kenya), Domingos Cugala (EMU, Mozambique), Duna Mailafiya (IRD/ICIPE, Kenya), Amélia Sidumo (EMU, Mozambique), Meshak Obonyo (ICIPE/IRD, Kenya).

3rd row: George Ong'amo (IRD/ICIPE, Kenya), Johnnie van den Berg (NWU, South Africa), Nguya Maniania (ICIPE, Kenya), Anne-Emmanuelle Félix (INRA/IRD, France), Antoine Branca (IRD/CNRS, France), Peter Njagi (ICIPE, Kenya), Vhulike Kutywayo (CABI, Kenya), Peter Chinwada (UZ, Zimbabwe), Abdalla Ali (ICIPE, Zanzibar), Charles Midega (ICIPE Mbita, Kenya), Komi Agboka (IITA, Benin), Mathay Chimtawi (ICIPE, Kenya), Nicholas Otieno (IRD/ICIPE, Kenya), Leonard Ngala (IRD/ICIPE, Kenya), Edwin Akhusama (IRD/ICIPE, Kenya).

4th row: Stéphane Dupas (IRD/CNRS, France), Pascal Moyal (IRD/CNRS, France), Rose Ndemah (IITA, Cameroon), Kate Muirhead (UA, Australia), Yosseph Assefa (UK-Z-N, South Africa), Mohamed Sallam (BSES Limited, Australia), Des Conlong (SASRI, South Africa), Eric Muchugu (ICIPE, Kenya), Joseph Baya (ICIPE, Kenya), Michel Sezonlin (IRD/IITA, Benin), Amos Alakonya (KEPHIS, Kenya),Komi Fiaboe (ICIPE, Kenya), Anderson Kipkoech (ICIPE, Kenya).

L'IRD et l'*icipe* ont organisé, du 24 au 28 Octobre 2005, une Conférence Internationale sur les Lépidoptères foreurs de Graminées en Afrique : ICLCBA, l'abréviation anglo-saxonne de « International Conference on Lepidopterous Cereal stem and cob Borers in Africa ». Cet évènement a eu lieu dans le Centre de Conférence Thomas Odhiambo de l'*icipe* (Nairobi, Kenya).
Environ 50 personnes étaient présentes et 11 pays étaient représentés comme l'Afrique du Sud, l'Australie, le Bénin, le Cameroun, l'Ethiopie, la France, le Kenya, le Mozambique, l'Ouganda, la Tanzanie et le Zimbabwe.

Photographie Antony Kiama Kagunda

Nom des participants de gauche à droite :

1ère ligne: Jiang Nanqing (ICIPE, Kenya), Fritz Schulthess (ICIPE, Kenya), Jean-Marc Leblanc (IFS, Suède), Jean-François Silvain (IRD/CNRS, France), Prof. Christian Borgemeister (Directeur Général de l'ICIPE, Kenya), S. E. Hubert Fournier (Ambassadeur de France au Kenya), Charles Omwega (ICIPE, Kenya), Bruno Le Rü (IRD/ICIPE, Kenya), Serge Snrech (Conseiller de coopération et d'action culturelle de l'ambassade de France au Kenya), Paul-André Calatayud (IRD/ICIPE, Kenya).

2ème ligne: Difabachew Belay (ICIPE, Ethiopie), Nathalie Faure (IRD/CNRS, France), Victor Mgoo (ICIPE, Tanzanie), Adenirin Chabi-Olaye (IITA, Bénin), Peter Lomo (JKUAT, Kenya), Brigitte Frérot (INRA, France), Teddy Matama-Kauma (NARI, Ouganda), Beatrice Pallangyo (NBCP, Tanzanie), Melaku Wale (ARARI, Ethiopie), Gerald Juma (IRD/ICIPE, Kenya), Anani Bruce (ICIPE, Kenya), Catherine Gitau (ICIPE, Kenya), Domingos Cugala (EMU, Mozambique), Duna Mailafiya (IRD/ICIPE, Kenya), Amélia Sidumo (EMU, Mozambique), Meshak Obonyo (ICIPE/IRD, Kenya).

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4ème ligne: Stéphane Dupas (IRD/CNRS, France), Pascal Moyal (IRD/CNRS, France), Rose Ndemah (IITA, Cameroon), Kate Muirhead (UA, Australie), Yosseph Assefa (UK-Z-N, Afrique du Sud), Mohamed Sallam (BSES Limited, Australie), Des Conlong (SASRI, Afrique du Sud), Eric Muchugu (ICIPE, Kenya), Joseph Baya (ICIPE, Kenya), Michel Sezonlin (IRD/IITA, Bénin), Amos Alakonya (KEPHIS, Kenya),Komi Fiaboe (ICIPE, Kenya), Anderson Kipkoech (ICIPE, Kenya).

Le colloque s'est articulé autour de cinq sessions principales, qui correspondent aux grands axes de recherche actuels sur les foreurs :

1- Faunistique et systématique des Lépidoptères foreurs de tige et d'épi des céréales, ainsi que de leurs ennemis naturels ;
2 - Etude de la génétique des populations et de la phylogéographie des foreurs et de leurs parasitoïdes ;
3 - Biologie et Ecologie des foreurs ;
4 - Incidence économique des foreurs en Afrique ;
5 - Méthodes de lutte et stratégies de contrôle.

L'objectif de cette conférence était de réunir les chercheurs dont leurs études portent ou ont porté sur les Lépidoptères foreurs de graminées afin de promouvoir les échanges scientifiques entre partenaires du Nord et du Sud, et entre ces derniers. Parallèlement, il convenait de profiter de la tenue de ce colloque pour mieux faire connaître et mieux intégrer l'équipe de recherche de l'IRD au sein de la communauté des entomologistes africains travaillant sur les foreurs des graminées. Ces deux objectifs ont été à l'évidence atteints et la jeune génération des entomologistes africains a découvert avec un intérêt manifeste les résultats des travaux que l'équipe IRD mène depuis 2001 en partenariat avec l'*icipe* et l'IITA.
La publication dans une revue internationale (les *Annales de la Société Entomologique de France*) des comptes-rendus du colloque a permis à nos travaux et à ceux de nos partenaires une excellente diffusion au sein de la communauté des entomologistes africains, et plus largement tropicaux.

L'équipe IRD remercie les institutions qui ont contribué au succès de ce colloque, qu'il s'agisse de l'IRD, de l'Ambassade de France au Kenya, de l'IFS, ou de l'*icipe*, ainsi que toutes celles et ceux qui ont mis leur bonne volonté au service de cet évènement.

Conference Programme

Sunday 23 October 2005

Arrival of participants

Monday 24 October 2005

0900-1000 Registration

Inaugural Session

Chair: Paul-André Calatayud, IRD/ICIPE, Kenya

1000-1010 Introduction and opening remarks
Prof. Christian Borgemeister, Director General, ICIPE
1010-1020 *H.E. Mr Hubert Fournier, Ambassador of France in Kenya*
1020-1030 *Dr. Jean-François Silvain, Head of IRD Research Unit, France*

1030-1100 Tea/Coffee Break

1100-1130 IFS: 30 years of young scientist support
Dr. Jean-Marc Leblanc, IFS/IRD, Sweden

1200-1400 Lunch Break

First Session: Faunistic and systematics of lepidopterous cereal stem and cob borers and their natural enemies

Chair: Jean-François Silvain, IRD/CNRS, France

1400-1420 Diversity of lepidopteran stem borers in eastern Africa revisited
Bruno Le Rü, IRD/ICIPE, Kenya
1420-1440 History of the systematics of African Noctuid stem borers of monocot plants
Pascal Moyal, IRD/CNRS, France
1440-1500 A review of sugarcane stemborers and their natural enemies in Asia and Indian Ocean islands: An Australian perspective
Mohamed N. Sallam, BSES Limited, Australia

1500-1530 Tea/Coffe break

Second Session: Population genetics and phylogeography of borers and parasitoids

Chair: Stéphane Dupas, IRD/CNRS, France

1530-1550 Mitochondrial DNA sequence variation among populations of african sugarcane stalk borer *Eldana saccharina* (Lepidoptera : Pyralidae)
Yoseph Assefa, University of KwaZulu-Natal, South Africa
1550-1610 Phylogeographic pattern and regional evolutionary history of the maize stalk borer *Busseola fusca* (Lepidoptera : Noctuidae) in subsaharan Africa
Michel Sezonlin, IRD/IITA, Benin
1610-1630 Phylogeography of Busseola fusca: What are telling us microsatellite data?*Jean-François Silvain, IRD/CNRS, France*

Chair: Mohamed N. Sallam, BSES Limited, Australia

1630-1650 From population to species: morphological and molecular diversity in East African stem borer species of the genus Manga Bowden (Lepidoptera: Noctuidae). 1 - Morphological diversity

Chair: Pascal Moyal, IRD/CNRS, France

1650-1710 From population to species: morphological and molecular diversity in East African stem borer species of the genus *Manga* Bowden (Lepidoptera: Noctuidae). 2 - Molecular diversity
Pascal Moyal, IRD/CNRS, France
1710-1730 Genetic variation in the Cotesia flavipes complex of parasitic wasps: towards the effective biological control of stemborer pests in Australia
Kate A. Muirhead, The University of Adelaide, Australia

1800-2000 Cocktail

Tuesday 25 October 2005

Management tools and options (session sixth to be continued)

Note: The following three presentations covering Management tools and options have brought forward at the request of the speakers.

Chair: Paul-André Calatayud, IRD/ICIPE, Kenya

0900-0920 Combined use of trap and repellent plants in a 'push-pull' strategy to control cereal stemborers (Lepidoptera: Pyralidae; Noctuidae) in Africa
Zeyaur R. Khan, ICIPE, Kenya
0920-0940 Vetiver grass (*Vetiveria zizanioides*), a component of a habitat management system for *Chilo partellus* in maize
Johnnie van den Berg, North-West University, South Africa
0940-1000 Will *Bt*-maize solve the stem borer problem in Africa?
Johnnie van den Berg, North-West University, South Africa

1000-1030 Tea/Coffee Break

Second Session: Population genetics and phylogeography of borers and parasitoids

Chair: Des E. Conlong, South African Sugarcane Research Institute, South Africa

1030-1050 Genetic diversity of *Sturmiopsis parastica* Curran (Diptera: Tachinidae)
Yoseph Assefa, University of KwaZulu-Natal, South Africa

1050-1110 The use of PCR-RFLP and multiplex PCR on Polydnavirus markers for a faster identification of *Cotesia sesamiae* (Hymenoptera: Braconidae) and *C. flavipes*
Stéphane Dupas, IRD/CNRS, France

1110-1130 Experiments on scope for genetic enhancement of the parasitisation potential of four native strains of *Trichogrammatoidea* sp. nr. *lutea* in Kenya
Joseph M. Baya, ICIPE, Kenya

1200-1400 Lunch Break

Third Session: Spatio-temporal distribution of main borer and parasitoid species

Chair: Bruno Le Rü, IRD/ICIPE, Kenya

1400-1420 Distribution and importance of lepidopterous cereal stemborers in Kenya
Josephine Songa, Kenya Agricultural Research Institute, Kenya

1420-1440 Predicting spatial patterns of cereal stem borers under current and future climate scenarios in East and Southern Africa
Eric I. Muchugu, ICIPE, Kenya

1440-1500 Distribution and relative importance of cereal stemborers and their natural enemies in the Amhara State of Ethiopia
Melaku Wale, Amhara Regional Agricultural Research Institute, Ethiopia

1500-1530 Tea/Coffee Break

Chair: Fritz Schulthess, ICIPE, Kenya

1530-1550 The synchrony of stemborer and parasitoid populations of coastal Kenya
Nanqing Jiang, ICIPE, Kenya

Fourth Session: Biology and ecology of borers

1550-1610 Biogeography and ecological characteristics of East African noctuid stem borers
Bruno Le Rü, IRD/ICIPE, Kenya

1610-1630 The role of wild grasses on densities of lepidopteran stem borer pests along altitudinal gradient in Kenya
Georges O. Ong'amo, IRD/ICIPE, Kenya
1630-1650 Diversity and abundance of wild host plants (Poaceae, Cyperaceae, Typhaceae) of Lepidopteran stem borers in two cereal growing localities from Kenya
Nicholas A. Otieno, ICIPE, Kenya

Wednesday 26 October 2005

Chair: Rose Ndemah, IITA, Cameroon
0900-0920 Who chooses the host plant - the moth or the larva?
Des E. Conlong, South African Sugarcane Research Institute, South Africa

Chair: Pascal Moyal, IRD/CNRS, France
0920-0940 Differences in ovipositional response between wild and laboratory-reared *Busseola fusca* (Lepidoptera: Noctuidae)
Gerald Juma, IRD/ICIPE, Kenya
0940-1000 Sexual dimorphism of antennal and tarsal chemosensilla and chemosensory equipment of the ovipositor in the African stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae)
Paul-André Calatayud, IRD/ICIPE, Kenya

1000-1030 Tea/Coffee Break

1030-1050 Sex pheromone, reproductive isolation and populations in Lepidoptera
Brigitte Frérot, INRA, France

Chair: Brigitte Frérot, INRA, France
1050-1110 Specific Mate Recognition System of an African stem borer: *Busseola fusca*
Anne-Emmanuelle Félix, INRA/IRD, France
1110-1130 Reproductive compatibility and variation in survival and sex ratio of West and Eastern African strains of *Cotesia sesamiae*, a larval parasitoid of cereal stem borers in Africa
Saka Gounou, IITA, Benin
1130-1150 Performance of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) on stem borers of cereals and wild crops
Meshack Obonyo, ICIPE/IRD, Kenya

1210-1400 Lunch Break

Afternoon free (for visiting ICIPE facilities and/or round tables)

Thursday 27 October 2005

Chair: Adenirin Chabi-Olaye, IITA, Benin

0900-0920 Host suitability studies, introduction and establishment of the exotic stem borer parasitoid *Cotesia flavipes* in Zimbabwe
Peter Chinwada, University of Zimbabwe, Zimbabwe

0920-0940 *Trichogramma bournieri* (Hymenoptera : Trichogrammatidae) and *Chilo sacchariphagus* (Lepidoptera : Crambidae) in sugarcane in Mozambique - a new association
Des E. Conlong, South African Sugarcane Research Institute, South Africa

0940-1000 Suitability of the Egg Parasitoid *Trichogramma bournieri* Pintureau & Babault (Hymenoptera: Trichogrammatidae) for the control of East African Stemborers
Yaovi Anani Bruce, ICIPE, Kenya

1000-1030 Tea/Coffee Break

Chair: Nanqing Jiang, ICIPE, Kenya

1030-1050 Differences in calyx fluid proteins of two *Cotesia sesamiae* (Hymenoptera : Braconidae) biotypes : implications to biological control of *Busseola fusca* (Lepidoptera : Noctuidae)
Catherine W. Gitau, ICIPE, Kenya

1050-1110 Role of micro-organisms in host-parasitoid coevolution process: Example of a cereal stemborers parasitoid in Kenya: *Cotesia sesamiae*
Antoine Branca, IRD/CNRS, France

1110-1130 A model for the study of *Wolbachia* induced Cytoplasmic Incompatibility in arrhenotokous haplodiploid populations
Antoine Branca, IRD/CNRS, France

Fifth Session: Impact assessment

1130-1150 Tritrophic interactions between lepidopterous stemborers, storage beetles and mycotoxin producing fungi in pre-harvest maize
Fritz Schulthess, ICIPE, Kenya

Sixth Session: Management tools and options

1150-1210 The effect of grassy field margins on soils, stemborer attacks and yield of maize in the humid forest of Cameroon
Rose Ndemah, IITA, Cameroon

1210-1400 Lunch Break

Chair: Charles Omwega, ICIPE, Kenya

1400-1420 Relationships of soil fertility proprieties and stemborers damage to yield in maize-based cropping system in Cameroon
Adenirin Chabi-Olaye, IITA, Benin

1420-1440 Effect of nitrogen fertilizer and pesticide on maize stemborer population and parasitism with maize growth in Zanzibar
Abdalla I. Ali, ICIPE, Kenya

1440-1500 Maize-legumes-cassava intercropping in the control of maize cob borers with special reference to *Mussidia nigrivenella*
Komi Agboka, IITA, Benin

1500-1530 Tea/Coffee Break

Chair: Fritz Schulthess, ICIPE, Kenya

1530-1550 Effect of intercropped maize and trap cropping on stem borer damage and yield
Amalia Sidumo, Eduardo Mondlane University, Mozambique

1550-1610 Impact of wild grasses planted as border rows on stemborer infestations in Uganda
Teddy O. Matama-Kauma, Namulonge Agricultural Research Institute, Uganda

1610-1630 Habitat management affecting infestation of maize by stem borers and borer parasitism
Difabachew Belay, ICIPE, Ethiopia

Chair: Bruno Le Rü, IRD/ICIPE, Kenya

1630-1650 Economics of biological control of cereal stem borers in Kenya
Anderson K. Kipkoech, ICIPE, Kenya

1650-1710 Impact of the parasitoid *Cotesia flavipes* Cameron (Hymenoptera : Braconidae) on the spotted stemborer *Chilo partellus* (Swinhoe) (Lepidoptera : Crambidae) in Eastern Uganda
Samuel Kyamanywa, Makerere University, Uganda

Friday 28 October 2005

Fifth Session (continued)

Note: The following presentation covering Economic importance (see Fifth Session) has been rescheduled at the request of the speaker.

Chair: Bruno Le Rü, IRD/ICIPE, Kenya

0900-0920 Losses caused by stem borers to transplanted sorghum crops in northern Cameroon
Bertrand Mathieu, CIRAD-CA, Cameroon

Sixth Session (continued)

Chair: Rose Ndemah, IITA, Cameroon

0920-0940 Assessment of the impact of natural enemies on stem borer infestations and yield loss in maize using selected insecticides in Mozambique
Domingos Cugala, Eduardo Mondlane University, Mozambique
0940-1000 Release, establishment and spread of *Cotesia flavipes* (Cameron) (Hymenoptera : Braconidae) in Tanzania
Beatrice Pallangyo, National Biological Control Programme, Tanzania

1000-1030 Tea/Coffee Break

Chair: Fritz Schulthess, ICIPE, Kenya

1030-1050 Release and establishment of *Cotesia flavipes* (Hymenoptera : Braconidae) an exotic parasitoid of *Chilo partellus* (Lepidoptera : Crambidae) in Eastern and Southern Africa
Charles Omwega, ICIPE, Kenya
1050-1110 Yield Loss due to the stemborer *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) at different nitrogen application rates to maize
Victor Mgoo, Sokoine University of Agriculture, Tanzania
1110-1130 Towards transgenic stem borer resistant maize in Kenya
Stephen Mugo, CIMMYT, Kenya

1200-1400 Lunch Break

Chair: Mohamed N. Sallam, BSES Limited, Australia
1400-1500 Round table: Discussion about perspective

1500-1530 Tea/Coffee Break

1530-1700 Round table: Discussion about perspectives
Closing remarks by Jean-François Silvain (IRD/CNRS, France)

1900-2300 Closing dinner

Acknowledgements: Thanks are given to the French Embassy, the International Foundation for Science (IFS) and the Directorate General of International Cooperation of The Netherlands (DGIS) for the financial supports they have provided.

Abstracts

1. Faunistic and systematics of Lepidopterous cereal stem and cob borers and their natural enemies

Diversity of lepidopteran stem borers in eastern Africa revisited

Bruno P. Le Rü (1), G.O. Ong'amo (1), P. Moyal (2), L. Ngala (1), B. Musyoka (1), Z. Abdullah (3), D. Cugala (4), B. Defabachew (5), T. A. Haile (6), T. Kauma Matama (7), V.Y. Lada (3), B. Negassi (8), K. Pallangyo (9), J. Ravololonandrianina(10), A. Sidumo (4), C. Omwega (11), F. Schulthess (11), P.-.A. Calatayud (1) & J.-F. Silvain,(2)

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(3) Ministry of Agriculture, Plant protection division, P.O. Box 1062, Zanzibar, Tanzania (4) Eduardo Mondlane University, Faculty of agronomy and forestry engineering, Av. J. Nyerere, Campus Universitario 1, Maputo, Moçambique
(5) Ethiopian Agricultural Research Centre, Melkasa, P.O. Box 436, Ethiopia
(6) University of Asmara, P.O. Box 1220, Asmara, Eritrea. (7) National Agricultural Research Organisation (NARO), Namulonge Agricultural Res. Inst. P.O. Box 7084, Kampala, Uganda
(8) Ministry of Agriculture, DARHRD Agricultural Research, P.O. Box 4627, Asmara, Eritrea (9) Biocontrol Programme, P.O. Box 30031, Kibaha, Tanzania
(10) Ministère de l'Agriculture, Service de la protection des végétaux, B.P. 1042, Antananarivo 101, Madagascar
(11) ICIPE, PO Box 30772, Nairobi, Kenya

Accurate knowledge of the stem borers found in the wild habitat is considered essential in the design and development of control strategies. A survey was carried out in Eastern Africa (Eritrea, Ethiopia, Kenya, Madagascar, Mozambique, Tanzania, Uganda, Zanzibar) between January 2003 and April 2005 to appraise the Lepidopteran stem borers guild in wild host plants. Seventy eight species of wild host plants belonging to Poaceae, Cyperaceae and Typhaceae families were found infested. However there was variation in stem borer species diversity among these plants, with *Panicum maximum* Jack being the richest. 23,994 larvae belonging to 135 species of lepidopteran stem borers have been collected, 43 Noctuidae belonging to 9 genera, 64 Pyraloidea belonging to Crambidae and Pyralidae families, 25 Tortricidae and 3 Cossidae. Host plants of at least 110 of these stem borer species have never been reported previously. The noctuid larvae represent 72.4 % of the total collection with 64.8, 3.6 and 4.0 % found on Poaceae, Cyperaceae and Typhaceae respectively. The Crambidae, Pyralidae, Tortricidae and Cossidae represent 22.8, 2.0, 2.5 and 0.1 % respectively of the total collection, with 92.6% of the Crambidae and Pyralidae collected from Poaceae, and 99.7% of the Tortricidae collected from Cyperaceae. The wild host-ranges of the 5 main stem borer pests in East Africa are recorded. The lepidopteran stem borers guild is far more diverse than previously reported.

History of the systematics of African Noctuid stem borers of monocot plants

Pascal Moyal

IRD/CNRS, Laboratoire Populations Génétique Evolution- Avenue de la terrasse, B.P. 1, 91198 Gif-sur-Yvette cedex, France

From the description of the genus *Sesamia* in 1852 to the last diagnoses of African species, the history of the systematics of the difficult group of African Noctuid stem borers is recounted. The misidentifications that confused the taxonomy of these taxa and the new light shed when genitalia observation was first used are described. Some difficulties that still remain to classify the 157 species described by now are emphasized and possible improvement by the combined use of morphological and molecular analyses is stressed.

A review of sugarcane stemborers and their natural enemies in Asia and Indian Ocean islands: An Australian perspective

Mohamed N. Sallam

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This paper provides a review on stemborer pests of gramineous crops in Asia and Indian Ocean Islands which have the potential to invade Australia. Information on the geographical distribution, host plants and potential of invading Australia is provided for 24 stemborer species with special reference to those mainly attacking sugarcane. A literature review of all natural enemies of 18 key pest species is provided. About 800 records of parasitoids, predators and pathogens of these pests are listed, with information on the host stage they attack, host plant or crop where they were recorded and country of record. The list includes all records of indigenous natural enemies, as well as introduced ones that are recorded to have established in the country of introduction. This information will facilitate quick decision making in case of a sudden detection of an exotic borer in Australia. A knowledge of possible biological control options is essential to determine which natural enemies are to be considered for introduction following an incursion. Efforts from biological control programs attempted overseas are highlighted to provide insight into the complexity of this approach, and to assist in arriving at a correct decision within an acceptable length of time. The Braconid, *Cotesia flavipes*, stands out as a promising candidate for introduction into Australia following a borer incursion. Studies are currently being conducted on a native *Cotesia* species in Australia, which may be able to parasitize larvae of exotic borers, therefore minimizing the need for other parasitoids introductions.

2. Population genetics and phylogeography of borers and parasitoids

Mitochondrial DNA sequence variation among populations of african sugarcane stalk borer *Eldana saccharina* (Lepidoptera : Pyralidae)

Yoseph Assefa (1), D.E. Conlong (1, 2) & A. Mitchell (3)

(1) School of Biological and Conservation Sciences, University of KwaZulu-Natal, Private Bag X01, Pietermaritzburg, Scottsville, 3209, South Africa
(2) South African Sugarcane Research Institute, Private Bag X02, Mount Edgecombe, 4300, South Africa
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Eldana saccharina Walker is an indigenous insect that is widely distributed throughout sub-Saharan Africa. Studies have shown that populations from west Africa have distinct behavioural differences compared to populations from east and southern Africa. In addition, the parasitoids guilds attacking these populations in the different regions are markedly different.
The parallel geographical variation in these patterns between several widespread populations of *E. saccharina* evoked the hypothesis of diversification. A molecular analysis on the Cytochrome Oxidase c subunit I (COI) region of the mitochondrial DNA was conducted on populations of *E. saccharina* from western, eastern, northern and southern Africa to evaluate this hypothesis. The phylogenetic tree constructed by use of Neighborhood Joining (NJ) and unweighted pair-group method with arithmetic average (UPGMA) clustered the 30 specimens in to three groups. Results presented of the current study thus reveal the presence of genetic variation in *E. saccharina* populations, which is related to geographic variation. This is discussed.

Phylogeographic pattern and regional evolutionary history of the maize stalk borer *Busseola fusca* (Lepidoptera : Noctuidae) in subsaharan Africa

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We used partial mitochondrial DNA sequences (cytochrome *b*) to study the phylogeographic and demographic history of *Busseola fusca* (Lepidoptera : Noctuidae) one of the major cereal pest in subsaharan Africa. 489 individuals of this species collected in 98 localities in southern, central, eastern and western Africa countries were sequenced. Nested clade phylogeographical analysis (NCPA) separated *B. fusca* populations in three mitochondrial main clades (*W*, *KI*, *KII*) and identified a certain amount of genetic structure within each of them. Besides, this analysis showed that *KI* and *KII* clades are partly sympatric and well separated from the West African clade (*W*). Mismatch distribution analysis and the negative values of Tajima D index

are consistent with a demographic expansion hypothesis for these three clades. Significant genetic differentiations were revealed at various hierarchical levels by analysis of molecular variance (AMOVA). Hypotheses about the geographic origin of the three main clades are provided.

Phylogeography of *Busseola fusca*: What are telling us micosatellite data ?

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The noctuid stem borer *Busseola fusca* occurs throughout sub-Saharan Africa, where it is considered as a major pests of maize and sorghum. Populations occurring in western and eastern Africa have slightly different ecological preferenda. A phylogeographic study based on the analysis of Cytochrome *b* sequences revealed three separated clades. We developped and used seven microsatellite loci for a genetic analysis at the nuclear level. Preliminary results showed a strong genetic structuration between populations from West Africa and populations from Central, South and East Africa. Western populations seemed to form an homogeneous group. Central, South and Eastern populations are more diverse and can be grouped into different geographic units. We are now looking for fine-scale genetic and geographic structuration.

From population to species: morphological and molecular diversity in East African stem borer species of the genus *Manga* Bowden (Lepidoptera: Noctuidae). 1- Morphological diversity

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Larvae of noctuid stem borers were collected in wild monocot plants in Eastern Africa, from Ethiopia to Mozambique, and reared to adult stage. Three species of the African genus *Manga* Bowden (Lepidoptera: Noctuidae) were found, in host plants belonging only to the Poaceae family. *M. melanodonta* (Hampson) was collected in stems of *Panicum maximum* Jacq., *Setaria megaphylla* (Steud.) Dur. et Schinz and *Setaria plicatilis* (Hochst.) Hack; *M. nubifera* (Hampson), and *M. fuliginosa* n. sp, both only in stems of *P. maximum*. The second species was in the past sunk as synonym of *M. melanodonta*, but the present study shows it has to be considered as a different species. The new species is described as well as features not yet known of the other species (female habitus and male and female genitalia of *M. melanodonta* and *M. nubifera*), and also the larva, which was similar for the three species. The *Manga* genus is revised, the different species are presented and *M. bisignata* Laporte is sunk as synonym of *Busseola quadrata* Bowden.

From population to species: morphological and molecular diversity in East African stem borer species of the genus *Manga* Bowden (Lepidoptera: Noctuidae). 2- Molecular diversity

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The diversity of *Manga* species collected in East Africa, from Ethiopia to Mozambique, was studied at the molecular level using the mitochondrial gene Cytochrome b. A complex history made of successive fragmentation events was revealed. The combination of three forces appeared to have shaped this diversity: the main paleo-climatic events (succession of dry and humid periods), the geological barriers, particularly the Rift valley, and specialization on new host plants. A molecular clock proved to be acceptable for all species except for the species that first diverged, *Manga fuliginosa*. The dates of the major paleo-climatic events of the last 5 million years appeared to correspond to the observed divergence events when using an evolution rate of 1.15% per million year, with a correction for *M. fuliginosa*. The isolation by the Rift valley favoured diversification in some instances, and the adaptation of *Manga melanodonta* to new host plants enabled the colonization of humid environments. A scenario of the evolution of the group is proposed, from its origin in Austral Africa about 5 million years ago and its northward expansion, until the recent migrations of *Manga nubifera* during the last million year.

Genetic variation in the *Cotesia flavipes* complex of parasitic wasps: towards the effective biological control of stemborer pests in Australia

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The *Cotesia flavipes* species complex of parasitic wasps are economically important worldwide for the biological control of lepidopteran stemborer species associated with gramineous crops. The complex currently comprises three species: *C. flavipes* Cameron, *C. sesamiae* (Cameron) and *C. chilonis* (Matsumura). The absence of clear diagnostic characters to separate the species and inaccurate identification have confounded past efforts to assess the impact of specific introductions. Moreover, small- and large-scale geographic populations have exhibited differences in host/habitat preference and host range. Molecular markers are being developed to characterise genetic variation and phylogenetic relationships among worldwide populations of the *C. flavipes* complex, and correlate these with host and/or habitat preference. The status of *C. flavipes*-like species in Australia will be determined for the preparedness of stemborer incursion into Australia. Genetic differentiation between populations may have potentially important implications for host utilisation and thus, the diagnosis of appropriate strains for biological control against specific host species.

Genetic diversity of *Sturmiopsis parastica* Curran (Diptera: Tachinidae)

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The African sugarcane stalk borer, *Eldana saccharina* Walker, is reported to show high levels of genetic differentiation in its indigenous range. This evoked the hypothesis that one of its biological control agents, *Sturmiopsis parasitica* Curren, might have undergone genetic differentiation in response to the differentiation in its host. This thought was supported by the fact that in West Africa, *S. parasitica* parasitised predominantly *E. saccharina*, while in Zimbabwe it was found only from *Busseola fusca* Fuller. To confirm this hypothesis, mitochondrial DNA sequences in cytochrome oxidase I were sequenced. Phylogenetic analysis of the sequences using maximum parsimony clustered the specimens into two groups. The genetic divergence observed suggests the presence of intraspecific polymorphism in *S. parasitica*. These results are presented and discussed.

The use of PCR-RFLP and multiplex PCR on Polydnavirus markers for a faster identification of *Cotesia sesamiae* (Hymenoptera: Braconidae) and *C. flavipes*

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Cotesia sesamiae and *C. flavipes* (Hymenoptera: Braconidae) are the two main larval parasitoids of cereal stemborers in Subsaharan Africa. One is endemic and the other was introduced. The two species exhibit very similar ecological niches, especially in lowland areas. It can be feared that the introduced insect drive to extinction it's indigenous homologue. To address this hypothesis, a better characterizaton of their ecological niche and long term field surveys are needed. Polydnavirus are obigatory symbionts used by the wasp to regulate their host's physiology during parasitization. *C. sesamiae* and *C. flavipes* harbor different viruses, named CsBV and CfBV respectively. Their genome is integrated in the genome of the wasp and they can be used to distinguish the two species. Sequences differences between CsBV and CfBV were observed in the polydnavirus gene CrV1. Two fast and cost effective molecular techniques were developed to distinguish the two viruses. The first is a classic PCR-RFLP technique. The second is a multiplex PCR technique. It is based on differences in PCR amplimer size due to the specificity of the reverse primer annealing at different position in the two species of virus. Both allowed the fast distinction between *C. flavipes* and *C. sesamiae* from extracted DNA as well as from pieces of tissue from the abdomen. The method

costs less than one US $ per insect. It could be used for the survey of future biological control introductions.

Experiments on scope for genetic enhancement of the parasitisation potential of four native strains of *Trichogrammatoidea* sp. nr. *lutea* in Kenya

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The African bollworm, *Helicoverpa armigera*, is reckoned as an important cob borer on maize, besides causing substantial yield losses on sorghum in several countries in Eastern Africa. The scope for genetic enhancement of the parasitisation potential of promising native strains of *Trichogramma* for mass production and inundative release for *Helicoverpa* biocontrol in the region was assessed in the laboratory. Adults of four chosen Kenyan strains of the commonly occurring trichogrammatid species, *Trichogrammatoidea* sp. nr. *lutea* Girault, were cross-mated in reciprocal combinations. Significant differences were observed between inbred and reciprocal crosses in fecundity and progeny female ratio, besides in overall progeny production and progeny adult longevity. Genotypic and phenotypic variance-covariance matrices generated for six life-history traits and their fitness components showed high positive correlations for most traits in both inbred and reciprocal heterogamic crosses. Fecundity and number of female offspring were the most important factors in the heterogamic crosses. Significant differences occurred between homogamic crosses and most reciprocal heterogamic crosses in the major biological attributes. These results confirm the scope for seeking genetic enhancement through inter-population crossing among native trichogrammatid species for improving the field impact potential.

3. Spatio-temporal distribution of main borer and parasitoid species (modelling and sampling methods, GIS)

Lepidopteran cereal stemborers and their natural enemies in Madagascar

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Surveys have been conducted in maize fields in six regions in Madagascar (i.e., the south highland, the south and south-west, the south-east, the mid-east, the mid-west and the north-west) to assess the distribution of cereal stemborer species and their natural enemies. From April 2003 till June 2005, maize fields were visited every 10 kilometers along major roads. Three borers species were identified. *Sesamia calamistis* and *Sciomesa biluma* were only present in high elevation while *Chilo orichalcociliellus* was found in five areas excepted in the south-east. Two gregarious eulophids, *Pediobius furvus* and *Tetrastichus howardi*, were

obtained from *S. calamistis* and *S. biluma*, and the solitary ichneumonid, *Syzeuctus gaullei* from *Chilo orichalcociliellus* larvae. In general, infestations and parasitism were low.

Distribution and importance of lepidopterous cereal stemborers in Kenya

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Stemborer densities, species composition and parasitism as well as damage to maize plants and yield were evaluated in small scale farmers' fields in Central, Eastern, and Western Kenya during 5 seasons, and in Coastal Kenya over 8 seasons. In Central and Eastern Kenya, *Chilo partellus* was the dominant species with less than 1 borer/ plant, followed by *S. calamistis* and *B. fusca* with densities of less than 0.1/plant. In Central Kenya, the density and the relative importance of *Ch. partellus* increased across the seasons, while in Eastern Kenya they decreased while that of *B. fusca* increased. There was no consistent trend for *S. calamistis*. In Western Kenya, *B. fusca* was the dominant species, with a density of less than 0.1 per plant. Eastern Kenya had the highest parasitism, followed by Central and Western. Parasitism was mainly on *C. partellus*, with larval parasitoids *C. flavipes* and *C. sesamiae* being the most common in Eastern and Central, while in Western, *C. sesamiae* was dominant. The most common pupal parasitoid was *Dentichasmias busseolae.*

Predicting spatial patterns of cereal stem borers under current and future climate scenarios in East and Southern Africa

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The management of both pests and natural enemies species requires an understanding of the factors determining their distribution. Statistical models offer methods for formulating the species habitat link and means for predicting where species should occur. This paper describes an integrated approach to species habitat mapping in east and southern Africa region using generalized regression analysis and spatial prediction (GRASP). The approach uses separate statistical models for each stem borer and parasitoid species to predict the species richness and abundance in each grid cell in a geographic information system (GIS). Allocation of these grid cells to species composition allows "hot-spots" of feasible areas for bio-control to be defined. Examples of use of this information for pest management are presented. This paper explores species habitat under different global climate change scenarios.

Distribution and relative importance of cereal stemborers and their natural enemies in the Amhara State of Ethiopia

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The distribution and relative importance of lepidopteran and coleopteran stemborers and their natural enemies were studied in cereal growing zones of the Amhara State of Ethiopia from 2003/04. In eastern Amhara, the species composition was 91% *C. partellus*, 8% *B. fusca* and 1% *S. calamistis*. in western Amhara, sorghum was only attacked by *B. fusca* while on maize, 61% were *B. fusca* and 39% *S. calamistis*. Borer density generally increased significantly with crop growth stage. On maize, *S. calamistis* was most abundant at the flag leaf or early tasseling. In eastern Amhara, *C. partellus* parasitism by *Co. flavipes* varied among districts ranging from 5% to 39%. In western Amhara, unidentified nematodes extensively infected medium sized *B. fusca* larvae during the wet months. Taylor's power law showed aggregated distribution for *C. partellus* and random for *B. fusca*.

The synchrony of stemborer and parasitoid populations of coastal Kenya

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The spatial synchrony of the exotic stemborer *Chilo partellus*, and the indigenous *Sesamiae calamistis* and *Chilo orichalcociliellus*, the indigenous and introduced larval parasitoids *Cotesia sesamiae* and *Co. flavipes*, respectively, was studied using 3-year data collected in coastal Kenya. Spatial correlation function (SCF) and spatial cross-correlation function were applied. An autoregressive model was used to study the effect of climatic stochasticity or population density-dependent factors on the stemborer and parasitoid populations. It appeared that *Ch. partellus* populations are not stabilized yet. Although, their niches overlap on several plant species, the periodic cross-correlation between *Ch. partellus* and *Ch. orichalcociliellus* with distance showed that these two species may differ in their mobility (dispersal). *Co. sesamiae* showed to have more impact on the spatial pattern of *S. calamistis* than on the other stemborer species. By contrast, for *Ch. partellus* and *Ch. orichalcociliellus*, the spatial pattern were closely linked with *Co. flavipes.*

4. Biology and ecology of borers (life cycle, behavioural ecology and patterns of interaction with wild and cultivated host plants, multitrophic interactions)

Biogeography and ecological characteristics of East African noctuid stem borers

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Surveys were carried out in Kenya, Tanzania and Uganda to establish the ecological characteristics such as host plant range and preference, feeding behaviour, reproductive strategies of African noctuid stem borers. Fifty wild plant species belonging to Poaceae, Cyperaceae and Typhaceae were found to harbour stem borers in the six vegetation mosaics surveyed. A total of 37 noctuid species belonging to 9 genera were identified from a total of 14116 larvae collected. Eighteen new species were found. The species diversity varied among vegetation mosaics [Zambezian miombo woodland (alpha = 0.88) and Guineo-Congolian mosaic (alpha=3.22)] and host plants [*Cynodon aethiopicus* (alpha= 0.14) and *Cyperus latifolius* (alpha =1.59)]. Most borer species were found in the wetter parts of the vegetation mosaics and appeared to be specialist feeders: 25 species were monophagous and among the oligophagous species there was a marked preference for one or two host plants.

The role of wild grasses on densities of lepidopteran stem borer pests along altitudinal gradient in Kenya

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Presence of non-crop hosts of stemborers in the cereal-growing areas has always been considered detrimental in serving as a stemborer reservoir. Surveys to determine the role of these hosts on the dynamics of stemborer pest populations was carried during the cropping and non-cropping seasons along varying altitudinal gradients in Kenya. A total of 35 wild plant species were found infested by the end of survey from which 45 stemborer species [Noctuidae (26), Crambidae (14) and Pyralidae (5)] including the four important pest species; *Busseola fusca* (Fuller), *Sesamia calamistis* Hampson (Noctuidae), *Chilo partellus* (Swinhoe) and *Chilo orichalcociliellus* (Strand) (Crambidae) were recovered. Contrary to the earlier reports, *B. fusca* was recovered only from *Sorghum arundinaceum* (Desv.) and *Phragmites mauritianus* Kunth unlike *S. calamistis* and *C. partellus* which each occurred in more than four non-crop hosts. However, the total larvae of respective pest species were very low and

may not sustain pest populations in the subsequent generation converse to reports from West Africa where *S. calamistis* and *Eldana saccharina* Walker are the main pest species. These results support the increasing evidence which suggests that the host range of economically important stemborers vary between location and seasons. Importance of the non-crop hosts as well as the diversity of stemborer species along the altitudinal gradient is discussed.

Diversity and abundance of wild host plants (Poaceae, Cyperaceae, Typhaceae) of Lepidopteran stem borers in two cereal growing localities from Kenya

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Wild Habitats are currently assumed to constitute important refuge for lepidopteran stemborer pests during non-cropping season. However, information on the diversity and abundance of potential wild hosts of stem borers, a vital understanding of the role of wild habitat on the pest dynamics, is limited. A study was done in two ecologically different localities: Kakamega in western Kenya (Guineo-Congolese mosaic) and Muhaka in Kenya coast (Inhambane mosaic) to assess the diversity and abundance of wild host plants in the cropping and non-cropping seasons. There was no evidence in variation in diversity and abundance of wild host plants between cropping and non-cropping seasons in Kakamega, wild host plants covered 2% and maize 43% of the surface and. In Muhaka, diversity of wild host plant species varied between the cropping and non-cropping seasons. Plant cover also varied between 12% to 16% higher than that of maize which had 2%. Implication of these results is discussed.

Who chooses the host plant – the moth of the larva ?

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Eldana saccharina Walker has a wide host range encompassing four plant Families. Morphological studies show *E. saccharina* female moths have a prehensile ovipositor, with sensory hairs at its tip enabling oviposition in cryptic positions. Cage studies show that females will oviposit on plants, in leaf curls, behind leaf sheaths and cracks in stalk rinds, mostly in dead or mature tissues. However, they also oviposit under plant pots, on plant pot rims, and in the corners of cages, away from any host plants. Freshly eclosed *E. saccharina* larvae, in contrast, showed distinct preferences for plant leaf and sheath material of a number of host plants. They chose green plant material over dead plant material, and plant material

from sedges above material from sugarcane, above material from indigenous grasses. These results are discussed in the context of host plant selection by stalk borer adults and the subsequent survival of their larvae on the plants selected.

Differences in ovipositional response between wild and laboratory-reared *Busseola fusca* (Lepidoptera: Noctuidae)

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The stem borer, *Busseola fusca* (Fuller)(Lepidoptera: Noctuidae), is an important pest of maize and sorghum in East Africa. In order to understand how the insect selects its host plant for oviposition, it has been necessary to verify first if the laboratory-reared *B. fusca* differ from natural population in ovipositional response. We carried out experiments to investigate the ovipositional response towards different supports including maize plant, their original host plant, as well as towards extracts of the plant surface. Wind tunnel studies were also undertaken to study the attraction of female moths to maize volatiles. Further, responsiveness of the antennal olfactory receptors to known components of plant volatiles was studied using electroantennographic techniques. In all the studies, a population of *B. fusca* caught from the wild and laboratory mass-reared moths were used.
The laboratory-reared insects have lost the host plant specificity for oviposition, accepting an artificial support totally outside their original host plant, showing no oviposition preference for artificial stems imbibed with plant extracts and fewer exhibiting an oriented flight behaviour toward maize plants under wind tunnel conditions. However, the laboratory-reared females conserved the same antennal sensitivity towards host plant volatiles than wild ones. All the results indicate that laboratory-reared *B. fusca* insects differ from wild population in the host plant specificity and this limits their representativeness of the species in the wild. Therefore it is important to use wild insects in future studies on host plant selection process for oviposition.

Sexual dimorphism of antennal and tarsal chemosensilla and chemosensory equipment of the ovipositor in the African stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae)

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The number and the distribution of chemosensilla located on different organs of *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) males and females were described using scanning electron microscopy, selective staining, and contact electrophysiology. The antennae as well as the fifth tarsomere of the prothoracic legs of both sexes bear contact chemosensilla identified as of the uniporous chaetica type and chemosensilla belonging to the multiporous trichoidea type. A sexual dimorphism was found in the number and the size of sensilla on the antennae and the fifth tarsomere. The distal part of the ovipositor possesses uniporous contact chemosensilla of the chaetica type. The possible involvement of these sensory structures in *B. fusca* oviposition site selection is discussed.

Sex pheromone, reproductive isolation and populations in Lepidoptera

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Sex pheromones released by females mediate reproduction in most of the moth species. They were largely studied for the last 30 years with the aim of providing new tools for monitoring the species damaging crops.
The first identifications from *Bombyx mori* and *Cydia pomonella*, have associated a single component as a sex pheromone of each species leading to the thought that each species was characterised by its own specific component. However the idea did not last very long and a short time later, it was clearly demonstrated that the moth sex pheromone was a complex blend of different components and that the stimulation of male reproductive behaviour depended on both the quality and quantity of the pheromone released.
Through the examination of Lepidopteran female pheromone components, it has been discovered that they are composed of a limited number of molecules and that different species can produce the same pheromone blend. Thus the specificity of the sexual communication relied on mechanisms other than blend quality and quantity. The processes ranging from diel periodicity to courtship behaviour will be described. In contrast, within the same species, different pheromone populations have been discovered for a long time. Recent advance in pheromone collection allowed the study of individual production and evidenced that pheromone population can be correlated with host plant specialisation, addressing questions on polyphagia and species notion.

Specific Mate Recognition System of an African stem borer: *Busseola fusca*

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Busseola fusca, Hübner (Lepidoptera: Noctuidae) is the most important African stem borer damaging maize and sorghum. Pheromone identification already conducted on wild *B. fusca* populations showed no marked differences in the female sexual pheromone. This pheromone is a blend of Z11-14: Ac., major and E11-14: Ac. and Z9-14: Ac., minors and a new component revealed by INRA Z11-16: Ac. E11-14: Ac. and Z9-14: Ac. vary from 5 to 10% but the biological effect is unknown. Molecular biology studies (IRD) have shown the existence of mitochondrial haplotypes. There exist three different populations within the same species: in the East, type II, major and I, minor and in the West (type west). *B. fusca* used for this study originated either from the ICIPE mass rearing or from the wild. The ICIPE population bearing two haplotypes: I and II was used for determination of the response windows in males using a wind tunnel. The wild populations were only subject to pheromone identification and haplotype characterisation. Male attraction behaviour is typical in Lepidoptera: after a lock-on, a zigzag pathway was attributed to losses of scent and turn back towards the female; after the male attempted to copulate. Attraction tests with synthetic lures showed that variations from 5 to 10% of minor components have biological effects on male mate finding. Cross mate behaviours between ICIPE population and wild insects from Kitale (type I) did not show reproductive isolation. The haplotypes ratio was the same whatever the origin of the strain, ICIPE or wild (37% of type I). No correlation between molecular markers and either female pheromone polymorphism or male behaviours could be identified. Due to a lack of insects, we could not formulate conclusions on the putative reproductive isolation within the haplotypes I and II. Mating behaviour was studied to decipher each step that could account for reproductive isolation. The mating behaviour was described as very simple, without any particular events or male pheromone emission.

Host or Food: Challenges in host searching by *Cotesia flavipes* (Hymenoptera: Braconidae), a larval parasitoid of lepidopterous stalkborers

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The braconid larval parasitoid *Cotesia flavipes* has been used against lepidopterous stalkborers in many biological control programs worldwide with various rates of success. New association biological control of *Diatraea saccharalis* in sugarcane fields with *C. flavipes* in the United States and in Brazil is often cited as one the success stories. The reason of the higher effectiveness of *C. flavipes* in sugarcane fields relative to other Poaceae crops is not well elucidated in this short lived parasitoid. Here, we investigated the time allocation for food and host searching by fed and hungry adult *C. flavipes*. We also compared the effect of frass from different host plants on the survival and reproduction of *C. flavipes*. In a four-arm olfactometer, hungry parasitoids preferentially selected food over host alone, whereas well-fed females were more attracted to host than food. The proportion of sugarcane borers parasitized after one hour of exposure in experimental arenas was higher for fed parasitoids than their hungry counterparts. The performance and fitness of *C. flavipes* on frass from sugarcane stalks was similar to that obtained on honey or sugar solution. In contrast, the longevity of adult parasitoids was reduced on frass obtained from maize and sorghum. These results suggest that *C. flavipes* can find both its food and host in the same habitat in sugarcane fields, thus increasing its biological control potential. Additional food sources might be required to increase the parasitoid survival, fitness, and efficiency in other cereal crops.

Reproductive compatibility and variation in survival and sex ratio of West and Eastern African strains of *Cotesia sesamiae*, a larval parasitoid of cereal stem borers in Africa

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The reproductive compatibility between three different strains of *Cotesia sesamiae* from Nigeria and Kenya was studied. All the three strains were self compatible with the percentage of success ranging from 20 to 45%. Cross-compatibility among strains was very high. The numbers and sex ratio of progenies in all possible crosses and backcrosses were similar. Cross-mating between the Eastern Nigerian and Coastal Kenya strains had the highest reproductive success. F1 hybrids between the Kenyan and the Nigerian strains performed poorly compared to their parents and the other hybrids. The significance of the revealed interspecific variations is discussed in relation to their adaptation to various climate conditions in the biological control of cereal stemborers.

Performance of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) on stem borers of cereals and wild crops

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The braconid larval parasitoid *Cotesia flavipes* was introduced into Kenya from Asia for the control of the invasive crambid stemborer *Chilo partellus*. In Africa, maize fields are often surrounded by land occupied by wild gramineous plants, which harbour borer species not found on crops. The purpose of this study was to assess the suitability of some of these 'wild' borer species (i.e., two populations of *S. nonagrioides* from East and West Kenya, *Busseola phaia*, *Sciomesa piscator*) as well as *Busseolae fusca*, *Sesamia calamistis* and *C. partellus*, which attack cereals, for the development of *C. flavipes*; to study the foraging behaviour of the parasitoid; to identify plant volatiles that could mediate host finding by *C. flavipes*. All species were equally acceptable to *C. flavipes* but only *C. partellus*, *S. calamistis* and the *S. nonagrioides* West population were suitable. *C. flavipes* females were significantly more attracted to volatiles from stemborer-infested than uninfested plants irrespective of borer or plant species. This was probably due to the richer profile of chemicals and especially in green leaf volatiles and terpenoids of stemborer-infested plants. It can be concluded that the unsuitable borer species used in the present experiment form a reproductive sink.

Host suitability studies, introduction and establishment of the exotic stem borer parasitoid *Cotesia flavipes* in Zimbabwe

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Cotesia flavipes Cameron was first released in Zimbabwe in 1999. First recoveries of the parasitoid were made in 2004 with parasitism levels not exceeding 3.5%. By 2005, parasitisam levels had gone up to 23.2% at Bushu, 5.2% at Muzarabani, 23.1% at Musikavanhu. Recoveries were made from non-release areas indicating that the parasitoid is spreading. These releases were predictable from a laboratory study where populations of the crambid stemborer, *Chilo partellus* (Swinhoe) from five release sites (Muzarabani, Sanyati, Musikavanhu, Mamina and Bushu) and one of the noctuid stemborer, *Busseola fusca* (Fuller) were evaluated for their suitability as hosts of *C. flavipes*. Successful parasitoid development occurred only on *C. partellus* but there were no significant differences in parasitism levels among the five populations of the stemborer. Significantly smaller brood sizes (13.0 adults) were, however, produced on Muzarabani *C. partellus* compared to the Sanyati, Musikavanhu, Mamina and Bushu populations. The numbers of *C. flavipes* adult female progeny per brood were lowest (13.5%) on Muzarabani *C. partellus* brood compared to the other four populations where females comprised 73.8-77.7% of the adults in each brood. Total parasitoid egg-adult development did not differ among the five *C. partellus* populations, ranging from 18.1 to 18.5 days.

Trichogramma bournieri (Hymenoptera : Trichogrammatidae) and *Chilo sacchariphagus* (Lepidoptera : Crambidae) in sugarcane in Mozambique – a new association

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Chilo sacchariphagus Bojer, a sugarcane stalk borer indigenous to South East Asia, and the nearby Indonesian Islands, was found in African sugarcane in Mozambique in 1999. Prior to a classical biocontrol programme being implemented against it, intensive pre-release surveys for the presence of any indigenous natural enemies on life stages of the borer were completed. Negligible parasitism of larval and pupal stages was recorded. In contrast, egg batches found were heavily parasitised. Parasitoid adults emerging from the eggs were found to be only the indigenous *Trichogramma bournieri* Pintureau and Babault. Aspects of the biology of *T. bournieri* on *C. sacchariphagus* eggs in Mozambican sugarcane are presented, and the

potential of using this egg parasitoid against *C. sacchariphagus* in an augmentation biocontrol programme is discussed.

Suitability of the Egg Parasitoid *Trichogramma bournieri* Pintureau & Babault (Hymenoptera: Trichogrammatidae) for the control of East African Stemborers

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The trichogrammatid *Trichogramma bournieri* (Pintureau & Babault) is a polyphagous parasitoid of eggs of several cereal stemborer species in eastern Africa. The effect of host species, host age and time of host deprivation on the performance of the parasitoid was studied in the laboratory. Host acceptance and suitability were tested using five stemborer species. The noctuids :*Sesamia calamistis* Hampson, *Sesamia nonagrioides* Tam & Bowden, *Busseola fusca* Fuller and the pyralids: *Chilo partellus* Swinhoe and *Eldana saccharina* Walker were successfully parasitized by *T. bournieri*. Parasitism and sex ratio (expressed as proportion of female progeny) did not differ among species, except for *E. saccharina*, which yielded the lowest values. With increasing duration of host deprivation from 0 to 12 days, longevity increased for the parasitoid, whereas average life-time fecundity decreased per female, indicating resorption of eggs.

Differences in calyx fluid proteins of two *Cotesia sesamiae* (Hymenoptera : Braconidae) biotypes : implications to biological control of *Busseola fusca* (Lepidoptera : Noctuidae)

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The braconid *Cotesia sesamiae* is an indigenous larval of the noctuid *Busseola fusca*, a serious pests of cereals in sub-Saharan Africa. The importance of *C. sesamiae* varies considerably between regions for reasons still not well understood. In Kenya, *C. sesamiae* occurs as two biotypes with different abilities to develop in *B. fusca.* In contrast to western Kenya population, the *C. sesamiae* population from coastal Kenya, where *B. fusca* is not abundant, does not complete development in this host and all its eggs get encapsulated hours after oviposition. Recent studies showed that calyx fluid of the two strains is involved in suppression of the immune system of *B. fusca,* and the proteins are likely to be genetically different. This study compared proteins found in the calyx fluid of these two *C. sesamiae* populations using 2d-Gel electrophoresis. There were more protein spots in protein gels with

calyx fluid samples from western Kenya *C. sesamiae* biotype (Chisq = 7.00; df = 1; P = 0.0082) than the coastal Kenya biotype. Implications of using *C. sesamiae* as a biocontrol agent of *B. fusca* in Africa are discussed in this paper.

Role of micro-organisms in host-parasitoid coevolution process: Example of a cereal stemborers parasitoid in Kenya: *Cotesia sesamiae*

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The parasitoid *Cotesia sesamiae* Cameron (Hymenoptera: Braconidae), one of the principal biological control agents of cereal stemborers in Kenya, is associated with two types of symbiotic micro-organisms potentially affecting its fitness: polyDNAvirus and *Wolbachia* bacteria. In *C. sesamiae*, *Wolbachia* is responsible for cytoplasmic incompatibility between infected males and healthy female. DNA sequencing showed the presence of different *Wolbachia* strains. Their mutual incompatibility can lead to reproductive isolation between parasitoid populations carrying different bacteria strains. PolyDNAvirus are symbiotic viruses of the parasitoid implicated in immune reaction suppression of the host larvae. *Busseola fusca* is the only host among the main Kenyan stemborers capable of an immune response. We observed a strong correlation between polyDNAvirus genotypes and *B. fusca* occurrence, suggesting an adaptive specialization due to the virus. The distribution of *Wolbachia* strains was also correlated to polyDNAvirus distribution in Kenya. The reproductive isolation caused by the bacteria may reinforce the adaptive specialization associated with polyDNAvirus.

A model for the study of *Wolbachia* induced Cytoplasmic Incompatibility in arrhenotokous haplodiploid populations

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Wolbachia is an endocytoplasmic bacteria responsible of various reproduction modification in arthropods. In several species, *Wolbachia* induces a phenomena call cytoplasmic incompatibility (CI) :crosses between *Wolbachia* infected male and healthy female are incompatible. In haplodiploid species reproducing with arrhenotokous parthenogenesis, CI induces a male-biased sex-ratio because incompatible crosses give only males. Here, we computed a stochastic model to evaluate respective influences of demographic and biological parameters on *Wolbachia* fixation probability and on the sex-ratio bottleneck occuring during a *Wolbachia* invasion.

5. Economic importance (pest status and crop loss assessment, interactions between borers and mycotoxin-producing fungi and storage pests, trans-boundary pest invasion)

Losses caused by stem borers to transplanted sorghum crops in northern Cameroon

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In northern Cameroon, the extension of dry season transplanted sorghum beyond its traditional area (typical vertisol), toward vertic soils close to rainfed crop fields, resulted in an increase of damage by stem borers (mainly *Sesamia cretica*). In surveys conducted from 2001-2003 in two sites, *Sesamia* spp. were shown to cause significant yield losses in 25% of the plots sampled, with up to 450 kg ha^{-1} grain loss. Loss assessment experiments were extended to 17 sites during the following two years (2003-2005). This enabled to clarify *Sesamia* spp. populations' dynamics on transplanted sorghum, by analysing losses incurred according to transplanting dates and distance from rainy season fields. The prospect for the use of these results for integrated management of *Sesamia* spp. on sorghum is discussed.

Tritrophic interactions between lepidopterous stemborers, storage beetles and mycotoxin producing fungi in pre-harvest maize

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An overview is given on the interactions between lepidopterous stemborers, storage beetles and mycotoxin-producing fungi in pre-harvest maize. In some areas in Africa humans are chronically exposed to mycotoxins such as aflatoxins, produced by *Aspergillus* spp., and fumonisins, produced by *Fusarium verticillioides*, which have carcinogenic and immunotoxic properties that cause, as anti-nutritional factors, unthrifty growth and immune suppression in young mammals. Surveys in field grown maize in West Africa showed that aflatoxin levels and infestations of the ear by storage beetles increased exponentially and linearly, respectively, with grain damage by stemborers. In addition, plants infected by the endophytic form of *F. verticillioides* had higher egg loads by borers and higher survival and fecundity of their offspring than clean plants. Thus, insects are not only vectors of the fungus but are also attracted by infected plants. Consequently, solving the pest problem would also solve the fungal problems and vice-versa.

6. Management tools and options

The effect of grassy field margins on soils, stemborer attacks and yield of maize in the humid forest of Cameroon

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Two field trials were undertaken during two consecutive seasons in the humid forest zone of Cameroon to investigate the effect of nitrogen fertilizer and border rows with the elephant grass *Pennisetum purpureum* or *Panicum maximum* on soil water, plan nutrients, stem borer infestations, parasitism and maize yield. Soil humidity was significantly higher under grass borders than under the maize. Nitrogen uptake by maize tended to be highest in plots surrounded by elephant grass. *Busseola fusca* numbers and stem tunnelled were 2 times and grain weight 2-2.5 times higher in fertilized plots. In the first season oly, *P. purpureum* increased egg batch parasitism. Multple regression showed that *B. fusca* numbers and plant damage significantly decreased with egg parasitism, plant K and P, but increased with plant N, while yield decreased with pest infestation and plant damage but increased significantly with egg parasitism. The implication of the findings for the feasibilty of this habitat management technology to farmers in southern Cameroon is discussed.

Relationships of soil fertility proprieties and stemborers damage to yield in maize-based cropping system in Cameroon

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Field trials were designed to investigate the effect of N fertilisation and mucuna fallow on maize yield and borer attacks in the humid forest zone of Cameroon. A traditional maize-cassava-groundnut systems was compared with a maize-cassava + 120 Kg N ha^{-1}, a rotation system in which maize-cassava followed a mucuna fallow as well as with a maize monocrop grown after mucuna fallow and with a maize monocrop grown with 120 Kg N ha^{-1}. Average egg batch densities of *B. fusca* were generally higher in monocrops compared to mixed cropping. Between intercrops, there were no differences in egg batch densities for both after a mucuna fallow and with 120 Kg N ha^{-1}. The average yield losses due to borers were 2-5 times higher in the maize-cassava-groundnut system compared to both a maize-cassava after mucuna fallow and maize-cassava grown with 120 Kg N ha^{-1}.

Effect of nitrogen fertilizer and pesticide on maize stemborer population and parasitism with maize growth in Zanzibar

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Stemborer density and species composition were investigated in four regions of Zanzibar during two seasons. Overall, *Chilo partellus* was the dominant species with densities of 1.0~1.5/plant, followed by the indigenous *Sesamiae calamisits* and *Chilo orichalcociliellus*, with about 0.6 and 0.2/plant, respectively. Mean parasitism of *Ch. partellus* by *Cotesia flavipes* was ca 10% in all regions, and that of *S. calamisitis* by *C. sesamiae* about 5%. Grain yield was lower in southern and west Zanzibar corresponding to the higher percentage of internodes and tunnel damaged. Results of nitrogen treatments carried out in the southern region showed that under natural infestions, borer density increased while percentage of bored internodes and tunnel decreased with with nitrogen level.

Yield loss due to the stemborer *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) at different nitrogen application rates to maize

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Field trials were conducted at Kibaha and Morogoro in eastern Tanzania during two seasons to evaluate the effect of nitrogen fertilization (0, 50, 75, 100 kg [N]/ha) on pest abundance, plant damage and yield loss of maize due to stemborers. In general, ear and grain weights increased linearly with nitrogen level. In the infested plot, grain weight increased 2.5 and 1.8 fold from 0 to 100 kg [N]/ha in the short and long rainy season, respectively, at Kibaha, and 1.4 and 1.6 times at Morogoro. Yield loss decreased with an increase in nitrogen application and the effect was stronger under high than low borer infestation levels. The results show the beneficial effect of nitrogen on the plant's ability to compensate for borer damage. Analysis of economic benefits of applying fertilizer and insecticide treatment indicated that using insecticides is not profitable under high-pest-low-soil fertility conditions.

Maize-legumes-cassava intercropping in the control of maize cob borers with special reference to *Mussidia nigrivenella*

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Effects of intercropping maize with cowpea, lima bean, soybean, three leguminous cover crops (*Tephrosia vogelii*, *Canavalia ensiformis*, *Sesbania rostrata*) and cassava on the infestation of *Mussidia nigrivenella* and other cob borers were studied. Field experiments

were conducted in four different locations in Benin using four by two pattern of maize/legumes or cassava planting. Intercrops reduced the number of eggs (>25%) and larvae of *M. nigrivenella* (17.9-53%) compared with the monocrop. Maize/*C. ensiformis* and maize/*T. vogelii* proved to be the most effective combinations for reducing *M. nigrivenella* populations in the different locations. Yield loss and cob damage were significantly affected by the intercrops and varied between 0.9 and 46.8%, and they were significantly correlated with the number of insects in the cob. No parasitized larvae were found in any of the locations. 0.9-46.8%

Effect of intercropped maize and trap crops on stem borer damage and yield

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The effect of natural enemies on the stem borers infestation and yield loss of maize was estimated using insecticide treatments. Field experiments were conducted at low, mid and high elevation zones which have distinct stem borer species composition. A selective organophosphate insecticide, Dimethoate, was used to exclude natural enemies from the plots. Cypermethrin insecticide was applied on other plots to suppress stem borers while untreated plots served as control. In all the study sites more stem borer larvae and pupae were collected from the plots where natural enemies were excluded. Parasitoids and parasitism levels as well as maize grain weight in the yield losses in unprotected plots were significantly high compared to exclusion plots. Yield losses increased from 28.9% in unprotected to 43,3% in exclusion plots. Thus, removing natural enemies from the maize plants led to an increase of stem borer population and yield losses.

Impact of wild grasses planted as border rows on stemborer infestations in Uganda

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Field trials to evaluate the impact of grassy border rows on stemborer infestations in maize were set up at two sites in Uganda during three cropping seasons. Four grass species were chosen and compared with a control without grasses. In the first season, *Busseola fusca* was the major stemborer followed by *Chilo partellus* while in the subsequent season *C. partellus* became the dominant species. Maize with *Pennisetum. purpureum* and *Panixum maximum* borders had lower infestations compared to the control. At harvest stem damage was significantly higher on maize surrounded by *Sorghum arundinaceum* than on sole maize and

maize surrounded by other grass species. These results were not consistent during the three seasons suggesting that grassy border rows are not a reliable technology for the control of stemborers.

Combined use of trap and repellent plants in a 'push-pull' strategy to control cereal stemborers (Lepidoptera: Pyralidae; Noctuidae) in Africa

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The lepidopteran stemborers [*Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) and *Busseola fusca* Füller (Lepidoptera: Noctuidae)] cause major yield losses in subsistence maize production throughout Sub Saharan Africa. A 'push-pull' or stimulo-deterrent diversionary strategy for minimizing damage due to stemborers has been developed in maize-based farming systems for small- and medium-scale farmers of eastern Africa (www.push-pull.net). This strategy involved selection of plant species that could be employed as trap crops to attract stemborer colonization away from the cereal plants, or as intercrops to repel the pests. The two most successful trap crop plants Napier grass, *Pennisetum purpureum*, and Sudan grass, *Sorghum vulgare sudanensis* attracted greater oviposition by stemborers, than cultivated maize. The intercrops giving maximum repellent effect were molasses grass, *Melinis minutiflora* and two legumes, silverleaf, *Desmodium uncinatum* and greenleaf *Desmodium intortum*. 'Push-pull' trials, using the trap crops and repellent plants, significantly reduced stemborer attack and increased levels of parasitism of borers on protected plants, resulting in a significant increase in maize yield. The trap crop and intercrop plants also provide valuable forage for cattle, often reared in association with subsistence cereal production. Intercropping maize with *D. uncinatum* and *D. intortum* not only reduced stemborer colonization on maize but also significantly reduced parasitization of maize by *Striga hermonthica*, a parasitic weed of cereals in Africa. There has been considerable take-up of the habitat management system by farmers in eastern Africa and many farmers in different agro-ecologies in Kenya and Uganda have adopted this technology resulting in increased maize and milk production.

Vetiver grass (*Vetiveria zizanioides*), a component of a habitat management system for *Chilo partellus* in maize

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Apart from its well known soil conservation properties, vetiver grass (*Vetiveria zizanioides*) is reported to be repellent to many insect species. However, infestation of vetiver by pests of other crops has been recorded and concerns were raised about vetiver grass being a refuge for insect pests. In South Africa vetiver grass which is known in Africa for its soil conservation properties is often used as a barrier between crop fields to limit soil erosion. This plant species is therefore common on contours in hilly areas where resource-poor farming activities are practiced. This paper addresses the benefits that vetiver may have in control of pests. *Chilo partellus*, a lepidopterous stem borer of grasses is a pest that is often mentioned in vetiver

literature. This insect is a serious pest of maize, rice and other grain crops in Asia and throughout East and Southern Africa where it can cause total crop failure. These observations prompted research on insect/vetiver grass interactions to determine the response of stem borer moths and larvae when they encounter *V. zizanioides* plants. The response of moths to vetiver grass, which could be either positive or negative, would determine if vetiver grass could be used as trap crop for *C. partellus* in an integrated pest management system. Wild grasses such as Napier grass (*Pennisetum purpureum*) is successfully used in habitat management systems in East and Southern Africa. Studies were therefore conducted to determine preference of female moths for vetiver grass compared to maize and to determine the suitability of vetiver, Napier grass and maize for survival of stem borer larvae. Two-choice preference bioassays and larval survival experiments were conducted. Results indicated that vetiver grass was highly preferred for oviposition but that larval survival on vetiver grass was extremely low. Thus, vetiver has potential as trap crop component in a habitat management system for *C. partellus*. This technology could also have application in rice pest management.

Habitat management affecting infestation of maize by stem borers and borer parasitism

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Effect of intercropping of maize with haricot bean and push-pull on infestation of maize by stem borers and parasitism was studied in a field experiment during the 2004 cropping season at Melkassa. Intercropping had no effect on pest and plant variables as a result of low pest infestation.The land equivalent ratio was higher in inter- than mono-crop. Intercropping maize and sorghum with bean at a 2:1 ratio gave the highest economic value. In the push-pull trials, yield was negatively related to borer infestation and stem damage. Highest yields per plot was recorded from plots with very good establishment of Napier grass and desmodium at neutral pH. Establishment of desmodium and Napier grass varied from site to site, and poor establishment was observed in plots with lower pH. In most cases pH was lower in the control plots than plots with push-pull plants.

Economics of biological control of cereal stem borers in Kenya

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The Asian braconid larval parasitoid *Cotesia flavipes* was released in Kenya 1993 for the control of the invasive cereal stemborer *Chilo partellus*. This study assesses the economic impact of the introduced parasitoid. Temporal data on parasitism and pest density were obtained from ICIPE data bank while socio-economic data were collected through administration of questionnaire to 300 farmers. Economic impact of the project was calculated as the value of the yield loss abated. Yield loss abated was calculated based on the percentage reduction in stem borer density by the parasitoid. Average annual parasitism increased from the time of introduction to 18-35% parasitism by 2004 leading to 33.7% reduction stem borer

density. The Project will accumulate a Net Present Value of US $ 180.7 million in economic benefits in 20 years. The internal rate of return was 78% signifying high return to investment. Introduction of egg and pupal parasitoids is required to push yield loss to insignificant level.

Impact of the parasitoid *Cotesia flavipes* Cameron (Hymenoptera : Braconidae) on the spotted stemborer *Chilo partellus* (Swinhoe) (Lepidoptera : Crambidae) in Eastern Uganda

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A study was conducted in Kumi and Iganga district of eastern Uganda to monitor the impact of the exotic parasitoid *Cotesia flavipes* Cameron (Hymenoptera:Braconidae) on stemborer population dynamics, its spread to other areas and the associated yield advantages from the classical biological control programme. On farm trials were conducted in two sub-counties at each district. One sub-county was a release site and the other a non-release site of *C. flavipes*. Two fields were established at each sub-county. Destructive sampling of maize plants/sorghum initiated 3-5 weeks after plant emergence and continued until harvest to determine stemborer density. Four stemborer species were found on sorghum and maize and they were *Chilo partellus*, *Busseola fusca, Eldana saccharina* and *Sesamia calamistis* in decreasing order of abundance. *C. flavipes* was recovered from all field sites and was the most abundant stemborer parasitoid even at non-release sites. Parasitism rates on *C. partellus* ranged from 3.5% to 73.3% and were generally higher in Kumi than in Iganga district. Maize grain yields were significantly higher in parasitoid release than in non-release areas. The damage due to stemborer was also lower in the release than non-release site. The results show that the introduced parasitoid is beginning to have a negative impact on *C. partellus* population.

Assessment of the impact of natural enemies on stem borer infestations and yield loss in maize using selected intsecticides in Mozambique

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The effect of natural enemies on the stem borers infestation and yield loss of maize was estimated using insecticide treatments. Field experiments were conducted at low, mid and high elevation zones which have distinct stem borer species composition. A selective organophosphate insecticide, Dimethoate, was used to exclude natural enemies from the plots. Cypermethrin insecticide was applied on other plots to suppress stem borers while untreated plots served as control. In all the study sites more stem borer larvae and pupae were collected from the plots where natural enemies were excluded. Parasitoids and parasitism

levels as well as maize grain weight in the yield losses in unprotected plots were significantly high compared to exclusion plots. Yield losses increased from 28.9% in unprotected to 43,3% in exclusion plots. Thus, removing natural enemies from the maize plants led to an increase of stem borer population and yield losses.

Release, establishment and spread of *Cotesia flavipes* (Cameron)(Hymenoptera : Braconidae) in Tanzania

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In 2002, the Ministry of Agriculture and Food Security (MAFS), Tanzania and the International Centre of Insect Physiology and Ecology (ICIPE) initiated a classical biological control strategy against *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) by introducing a larval parasitoid, *Cotesia flavipes* (Cameron) (Hymenoptera:Braconidae). Baseline surveys were conducted in order to determine the distribution, abundance and damage severity of *C. partellus*, and to select suitable sites before releasing the parasitoid. By December 2004, about 2,000,000 cocoons of *C. flavipes* had been imported from ICIPE and released in 43 locations in four agro ecological zones including the eastern, lake, central and northern zones. Post release surveys were conducted between June 2003 and June 2005 to determine the establishment and spread of the parasitoid. Post release surveys revealed the recovery of *C. flavipes* in all release sites, and 144 new locations in six agro ecological zones including the southern highlands where the parasitoid was never released. In 2002 percentage parasitism ranged from 0.5 to 4% and by 2005 parasitism rates were up to 41.7% in some areas.

Release and establishment of *Cotesia flavipes* (Hymenoptera : Braconidae) an exotic parasitoid of *Chilo partellus* (Lepidoptera : Crambidae) in Eastern and Southern Africa

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Cotesia flavipes Cameron (Hymenoptera: Braconidae) was imported into Kenya in 1991 from Pakistan for control of *Chilo partellus* Swinhoe (Lepidoptera: Cambridae). First releases were made at the Kenya coast in 1993 and establishment from this release was documented in 1994. Additional foreign exploration for *C. flavipes* was conducted in the south of India in 1996, which resulted in additional importation of the parasitoid for additional releases in eastern and southern Africa. Region-wide releases commenced with releases in Mozambique in 1996; Uganda and Somalia in 1997. By 2005 many releases had been made in 9 countries in eastern and southern Africa with establishment being reported in 10 countries including Ethiopia where releases were never made. It took up to five years to detect establishment of the parasitoid from time of release.

Will Bt-maize solve the stem borer problem in Africa ?

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South Africa is the only African country where *Bt*-maize, containing the Cry 1A(b) gene that encodes a protein with insecticidal activity against *Busseola fusca*, is used to control this pest. In the short history of *Bt*-maize in South Africa lessons were learnt that are of importance to the rest of Africa where releases of *Bt*-maize is envisaged. Research has shown that *B. fusca* is effectively controlled by Bt-maize but that poor control is often observed with post-anthesis infestations and in poorly-adapted maize hybrids. Late infestations result in survival of larvae and subsequent emergence of moths form diapause larvae inside *Bt*-plants. During surveys in South Africa several Lepidoptera species that feed on *Bt*-maize and are exposed to Bt-toxin was recorded. These were all Noctuidae and included the stem borers, *B. fusca* and *Sesamia calamistis*, two leaf feeders, *Acantholeucania loreyi* and *Helicoverpa armigera*, and a webworm, *Eublemma gayneri*. Cutworm, *Agrotis segetum*, also completed its life cycle on *Bt*-maize seedlings. Results on Lepidoptera diversity in Bt maize will be presented and the potential impact of *Bt*-maize on non-target Lepidoptera discussed.