



Busseola fusca:

a Handbook of Information

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Abstract

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This two-part publication provides a comprehensive review of the biology and management of *Busseola fusca* (Fuller), the African maize stalk borer. The information is presented under subheadings of pest status and crop loss assessment, taxonomic descriptions, pest biology and ecology. Pest management practices involving a range of options—cultural, plant resistance, biological, legislative, and chemical methods—are also reviewed. Part 2 contains an annotated bibliography of nearly 400 references published between 1900 and 1990.

Résumé

Busseola fusca (Fuller), le foreur africain du maïs: un manuel d'informations. Cette publication en deux parties offre une étude globale de la biologie et la lutte contre *Busseola fusca* (Fuller), le foreur africain du maïs. Les informations sont organisées sous des aspects divers: statut du ravageur et estimation de la perte des cultures, descriptions taxonomiques, biologie et écologie de l'insecte, ainsi qu'un aperçu sur les diverses possibilités de lutte contre l'insecte nuisible : pratiques culturelles, méthodes biologiques, législatives et chimiques, y compris la résistance des plantes à l'insecte. La deuxième partie du document comprend une bibliographie annotée de près de 400 références publiées entre 1900 et 1990.

Resumen

Busseola fusca (Fuller), barrenador africano del maíz: manual de información. Esta publicación dividida en dos partes presenta un estudio global de la biología y lucha contra *Busseola fusca* (Fuller) (el barrenador africano del maíz). La información esta organizada bajo diferentes aspectos: estatus de la plaga y estimación de la pérdidas en los cultivos, descripción taxonomica, biología y ecología del insecto. Las practicas de manejo contra la plaga, incluyen una amplia gama de opciones—culturales, resistencia de las plantas, métodos biológicos, químicos y legislativos. La segunda parte del documento contiene una bibliografía detallada de mas de 400 referencias publicadas entre 1900 y 1990.

Busseola fusca (Fuller),
the African Maize Stalk Borer:
a Handbook of Information

K.M. Harris and K.E Nwanze

Information Bulletin no. 33



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Preface

In November 1987, an international workshop on sorghum stem borers was held at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. One of the recommendations of that workshop was that the information on sorghum stem borers, embedded in published and unpublished documents produced since the beginning of this century, should be made more generally accessible to potential users in the fields of research and extension. *Busseola fusca* (Fuller) was identified as the target species to be covered in this, the first information handbook on the main stem borer species. It is a major pest, especially on maize and sorghum, throughout Africa south of the Sahara and therefore merits a review of the information that has been derived from observation and research in Africa over the past 90 years. This handbook is organized into two main parts. The main objective of Part 1 is to provide concise summaries of information, based on a comprehensive, but not exhaustive, review of published and unpublished work. Such a review will hopefully provide a useful basis for decisions that will have to be made at local, national, and regional levels to develop effective management of *B. fusca* and other pests of cereal crops in Africa. Part 2 consists of an annotated bibliography containing nearly 400 references covering 90 years of research on *B. fusca*. A directory of institutions and researchers based on existing information and personal contacts is provided at the end of this publication.

Although this handbook covers a wide range of topics, it can only provide entry points into the store of information on this species, and it will need to be updated as new information becomes available. It is however, increasingly easy to maintain current awareness through information networks, such as the one based on ICRISAT's Semi-Arid Tropical Crops Information Service (SATCRIS) or through access to on-line databases, such as *CAB ABSTRACTS*, which generates the *Review of Agricultural Entomology* (formerly the *Review of Applied Entomology, Series A*). Access to original publications can also be provided through ICRISAT's and/or CAB International's Library Services. The annotated bibliography in this publication is also available from ICRISAT as a CDS/ISIS database.

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The annotated bibliography, which comprises Part 2, was prepared by S. Prasannalakshmi and M. Suguna Sri of ICRISAT's Library and Documentation Services.

Photographs of field symptoms and stacked stems (Figs. 1, 4, and 11) are copyright of K.M. Harris. Additional illustrations have been made available by the Natural History Museum, London, UK (Figs. 5, 6, and 8), R. Chapman (Fig. 7), M.Y. Hudson (Fig. 9), K.F. Nwanze (Fig. 2), O. Ajayi (Fig. 3), and K.V.N. Maes (Fig. 4).

Part 1

**Review of the Bioecology and Management
of *Busseola fusca* (Fuller)**

K.M. Harris and K.F. Nwanze

Introduction

The African maize stalk borer, *Busseola fusca* (Fuller), was described and named by Fuller (1901) and the technical description with type designation published a year later by Hampson (1902). It is a noctuid moth, closely related to the genus *Sesamia*, and its larvae feed inside the stems of grasses and cereal crops, especially maize and sorghum. It was first recognized as a pest of maize in South Africa, where much of the early work on its biology and control was done, but it is now known to be a species that is indigenous to tropical Africa. It occurs widely in mainland Africa south of the Sahara, but not on the islands of the Indian Ocean. It is not known to occur anywhere outside the African continent, although there must be some danger that it could be accidentally introduced elsewhere.

The first detailed review of the biology, ecology, and control of this species by Mally (1920) contains 103 references, mostly to work done in South Africa up to 1919. Since that date, research has been extended throughout most of Africa, especially southern Africa (Zimbabwe, Zambia), eastern Africa (Kenya, Uganda, and Tanzania) and West Africa (Nigeria, Ghana, and Cote d'Ivoire). In recent years particular impetus has been given to the study of this species by scientists working throughout Africa in national programs on cereal crop development, and by international organizations, especially ICRISAT and the International Centre of Insect Physiology and Ecology (ICIPE). Research progress in the 1980s was reviewed by Harris (1989a) who also recently reviewed the bioecology of *B. fusca* (Harris 1989b).

Much information is available on this species and could be used to devise effective pest management strategies, but there are still substantial gaps in our knowledge of this pest, as indicated in the conclusions and recommendations of this handbook.

Pest Status and Crop Loss Assessment

Busseola fusca is of greatest importance as a pest of maize in Africa but it also attacks other culti-

vated crops, particularly sorghum, pearl millet, and sugarcane, and some wild grasses. Damage is caused by the larvae which at first feed on the young leaves (Fig. 1) but soon tunnel into the stems. During the early stages of crop growth, larvae may kill the growing points, resulting in the production of 'deadhearts' (Fig. 2) and a consequent loss of crop stand. At later stages of growth extensive tunneling (Fig. 3) inside the stems weakens them so that they break and lodge. Maize cobs may be directly damaged by tunneling larvae (Fig. 4) and the grain development of sorghum and pearl millet may be indirectly affected by tunneling and breakage of peduncles.

Although it is generally accepted that *B. fusca* is a major pest of maize and an important pest of sorghum, few objective crop loss assessments have been made. Most studies only report infesta-



Figure 1. Leaf damage caused by feeding of early instar *Busseola fusca* larvae, on sorghum.



K.F. Nwanze

Figure 2. Deadheart caused on sorghum by *Busseola fusca* larvae.



O. Ajayi

Figure 3. Tunneling in sorghum by larva of *Busseola fusca*.

tion levels or the degree of crop damage rather than actual grain losses. The most rigorous studies are those of Walker (1960b) in Tanzania, and Walker and Hodson (1976) in Kenya, that indicated a loss of about 12% maize grain for every 10% plants infested. Crop loss experiments on sorghum in Nigeria (Harris 1962) indicated a complex situation where selective oviposition by females on larger plants results in bored stems producing higher grain yields than unbored stems. It is generally true that sorghum is more tolerant of borer attack than maize, and that acceptable yields can be obtained despite high borer populations. Megeasa (1982) reported that in Ethiopia, movement of *B. fusca* larvae into the base of the sorghum head resulted in undersized heads and a 15% grain loss.

Descriptions

Taxonomic descriptions, diagnoses, and keys for identification were published by Tarns and Bowden (1953), and there has been no subsequent taxonomic revisionary work on this species. Kaufmann (1983) suggested that subspeciation may be in progress in Nigeria, but the evidence needs corroboration by further observations and experiments.

Adults

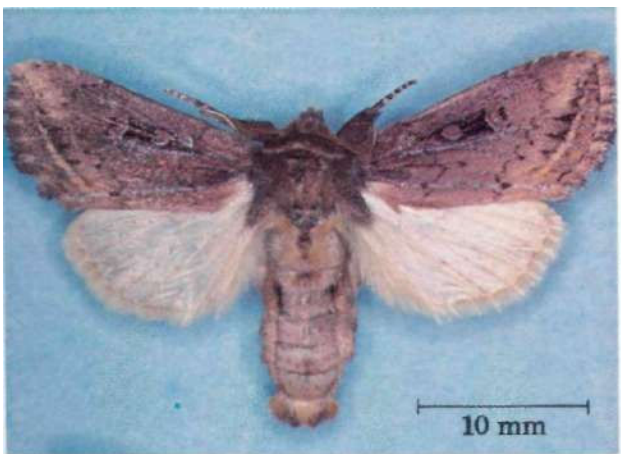
Adult moths are seldom seen in farmers' fields as they are inactive during daylight and are cryptically colored. However, they are attracted to light traps and are sometimes caught in large numbers. The adult wingspan is about 20-40 mm (Fig. 5), with females generally larger than males. The forewings are light to dark brown, with patterns of darker markings, and the hind wings are white to grey-brown. There is much seasonal and geographic variation; moths developing in colder, wetter conditions tend to be darker in color, with heavier black markings (Fig. 6). Wing pattern and color do not therefore provide absolutely reliable characters for positive identification, especially as other species of *Buss-eola* and similar genera, such as *Manga* and *Poconoma*, resemble *B. fusca* in general appearance.



Figure 4, *Busseola fusca* larva on maize cob (left); larva inside tunneled cob (above).

K.V.M. Mates

K.M. Harris



Natural History Museum, UK

Figure 5. *Busseola fusca*, adult male.

Any adult moth reared from maize, sorghum or pearl millet, that matches the above description is most likely to be *B. fusca*, but the identification of any doubtful specimens should be checked by submitting them to a taxonomic specialist.

Eggs

Eggs measure about 1 mm in diameter. They are hemispherical and have about 70 crenulations (ridges) on the egg shell (chorion). They are generally laid in batches of 30-100 on the inner surfaces of leaf sheaths (Fig. 7) or on other smooth surfaces.

Larvae

The stem-boring caterpillars of *B. fusca* are about 40 mm long when full grown (Fig. 8). Their color is variable, but is usually creamy white, often with a distinctive grey tinge, but sometimes with a pink suffusion, similar to that of most *Sesamia* larvae. The head is dark brown and the prothorax is yellowish-brown. Larval chaetotaxy has been described (Tarns and Bowden 1953, Usua 1969,



Figure 6. *Busseola fusca*, live adult male on maize.

1987) and can be used to distinguish *B. fusca* larvae from *Sesamia* larvae, that are otherwise very similar. The arrangement of crochets on the abdominal prolegs readily distinguishes *Busseola* and other noctuid larvae from such pyralid stem borers as *Chilo*. The noctuid prolegs have the crochets arranged in a semicircle, whereas the pyralid proleg crochets are arranged in a complete circle.

Pupae

Pupae are usually shiny yellow-brown (Fig. 9) but their color may vary with location. Female pupae are about 25 mm long, and male pupae are generally slightly smaller. They can be sexed by differences in the positioning of the genital scars, found

on sternum 8 in females and on sternum 9 in males.

The cremaster bears a single pair of simple spines. *Busseola fusca* pupae can therefore be distinguished from those of *Sesamia*, which have a more complex cremaster with two pairs of thorn-like spines.

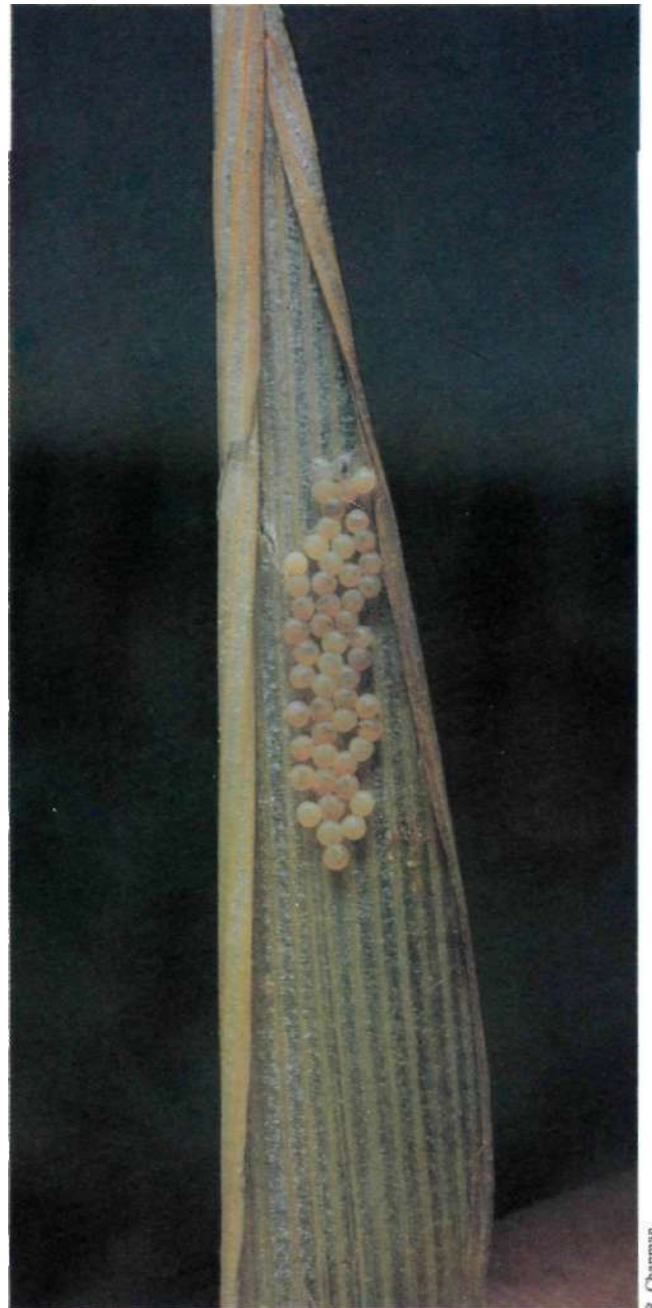


Figure 7. *Busseola fusca*, egg mass under a leaf sheath.



Natural History Museum, UK

Figure 8. *Busseola fusca*, full-grown larva.



M. Y. Hudson

Figure 9. *Busseola fusca*, pupa in larval tunnel in sorghum stem.

Biology and Ecology

The biology of this species was recently reviewed by Harris (1989b) and a detailed study of its ecology on maize in South Africa made by van Rensburg et al. (1987). Earlier key papers include Mally (1920), Wahl (1926, 1930), Hargreaves (1932, 1939), Lefevre (1935), du Plessis (1936), du Plessis and Lea (1943), Bowden (1956b), Swaine (1957), Ingram (1958), Nye (1960), Smithers (1960), Walker (1960b), and Harris (1962, 1964).

Life Cycle

There are local variations in life cycle, determined mainly by climate, but the basic pattern is as follows. Adults emerge from pupae in the late afternoon and early evening and are active at night. During the day they rest on plants and plant debris and are seldom seen unless disturbed, when they fly briefly. Usually on the night of emergence the females release a pheromone to attract males and then mate. During the 3–4 nights following emergence, females lay eggs in batches of 30–100 under the inner surfaces of leaf sheaths, each female laying about 200 eggs in total.

Larvae hatch about a week later and initially disperse over plants before they enter the leaf whorls and start to feed on the leaves. Once established in their host plants, they bore into stem tissues and feed for 3–5 weeks, producing extensive tunnels in stems and in maize cobs. They then pupate in the tunnels, often after first excavating emergence windows to facilitate the exit of adult moths.

Adults emerge 9–14 days after pupation and the life cycle is completed in 7–8 weeks when conditions are favorable. During dry and/or cold weather, larvae enter a diapause of 6 months or more in stems, stubble, and other plant residues before pupating during the next favorable period.

There is still a lack of adequate studies of the biology of *B. fusca* in many areas; the studies that have been undertaken have not used a uniform approach and are often restricted to a particular crop.

Host plants

Busseola fusca belongs to a group of Lepidoptera that has evolved in close association with grasses, and in which the specialized habit of boring into stems has developed. These evolutionary interactions have developed over the last 10–20 million years, and the association of these stem-boring species with cultivated crops, which originated about 5000 years ago, is therefore comparatively recent. The original host plant on which *B. fusca* evolved is not known, but the following indigenous African grasses are recorded as hosts: *Sorghum verticilliflorum* (Steud.) Piper (including *Sorghum arundinaceum*), *Pennisetum purpureum*

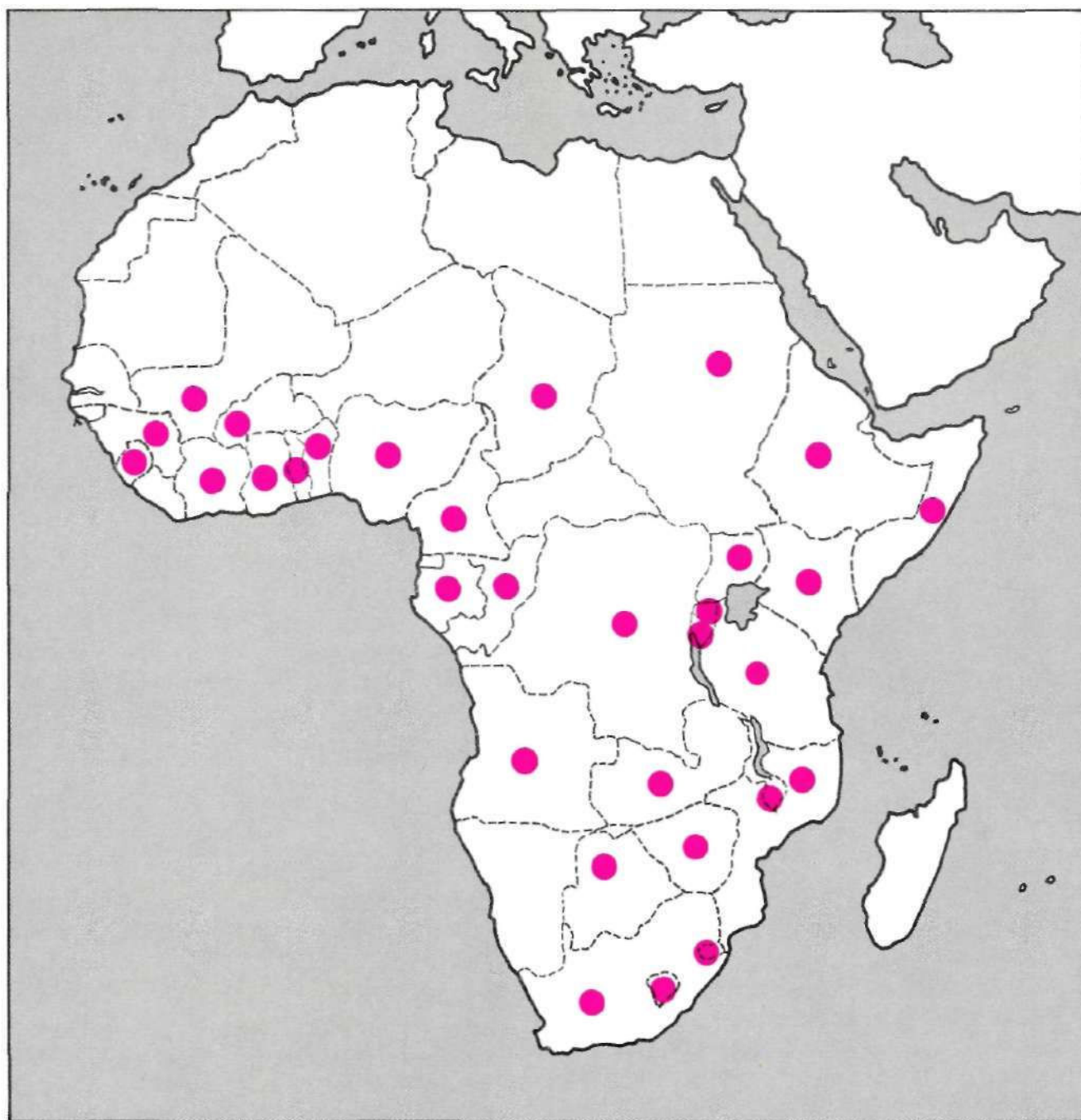


Figure 10. Outline distribution of *Busseola fusca* in Africa indicating recorded presence in countries. (Adapted from IAPSC 1985, and CIE 1988.)

Schum., *Panicum maximum* Jacq., *Hyparrhenia rufa* Nees (Stapf), *Rottboellia exaltata* (L.), and *Phragmites* sp. The original host may well have been one of these, possibly a *Sorghum* or *Pennisetum*.

The main crop hosts are maize and sorghum and, to a lesser extent, pearl millet, finger millet,

and sugarcane. Of these, all except maize and sugarcane are indigenous to Africa.

The interaction of *B. fusca* with maize is particularly interesting as it dates from about 1550 A.D., from the time of the introduction of that crop to Africa from the Americas. The extension of maize cultivation in Africa may have enabled

the borer to follow the crop and become established in new areas, such as South Africa, as suggested by Mally (1920).

Geographical Distribution

Busseola fusca occurs throughout mainland Africa south of the Sahara and has been formally recorded from West Africa (Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Guinea, Mali, Nigeria, and Sierra Leone), from eastern Africa (Ethiopia, Kenya, Somalia, Tanzania, and Uganda), and from southern Africa (Angola, Botswana, Lesotho, Malawi, Mozambique, Rwanda, South Africa, Swaziland, Zaire, Zambia, and Zimbabwe). Distribution maps (Fig. 10) have been published by the Interafrican Phytosanitary Council, IAPSC (1985), and by the CAB International Institute of Entomology, CIE (1988). In West Africa, *B. fusca* occurs from sea level to altitudes in excess of 2000 m but is most abundant in the wetter parts of the tree savannah in Ghana (Tarns and Bowden 1953) and Burkina Faso (Nwanze 1988), and in the drier regions of the tree savannah and thorn scrub savannah in Nigeria (Harris 1962), where sorghum is extensively grown. There is some evidence to suggest that it does not immediately become established as a pest in recently settled areas (Harris 1962, Ingram 1958). In eastern Africa it occurs between 600 and 2700 m and is absent from the coastal areas of Kenya and Tanzania. Nye (1960) suggested that the species is unable to tolerate mean temperatures above 25°C, but this is not so in West Africa where mean temperatures above 27°C are tolerated.

In southern Africa, *B. fusca* is the dominant stem borer at elevations above 900 m in Botswana, Lesotho, Malawi, Mozambique, South Africa, and Swaziland, but it also occurs at lower altitudes in those countries and in Zimbabwe, clearly indicating the ability of this pest to adapt to low-lying and warmer areas (Sithole 1989),

Larval Development and Behavior

The behavior of first-instar larvae is similar to that described for *Chilo partellus* by Chapman et al. (1983) and Bernays et al. (1985) but has not been studied in such detail. Soon after hatching,

the larvae move up to the leaf funnel and feed on the young leaves before penetrating into the stem. Leaf feeding results in characteristic patterns of small holes that appear on the youngest leaves. During the stage of larval feeding in the stem, the growing point may be killed, resulting in a deadheart. Van Rensburg et al. (1987), working on maize in South Africa, recorded that 81% of larvae up to the fourth instar were found in leaf whorls.

The period of larval feeding lasts about 24–36 days and during that time larvae may leave the stem that was initially attacked, especially if it has been severely damaged, and bore into other stems. There is therefore some larval migration within crops. Van Rensburg et al. (1987) noted that previous workers underestimated the extent of this migration, and recorded that 4% of the total number of larvae in a planting of maize migrated to adjacent plants immediately after hatching. They also observed that fifth-instar larvae were evenly distributed in plants reaching a peak at 8 weeks after plant emergence, and that sixth instars were found in considerably larger numbers than previous instars in stems and ears, and were the only instars found in stem bases.

Before pupation, larvae eat away exit holes to facilitate their emergence as adult moths. These holes are characteristically covered by a thin remaining layer of epidermis and are visible externally, giving an indication that pupation has occurred or is about to occur.

Larval Diapause

In dry and/or cold conditions larvae enter diapause for 6 months or more. Usua (1970, 1974) studied the physiology of diapause in detail on maize in southern Nigeria, but there is as yet no clear understanding of the factors inducing and breaking diapause (van Rensburg et al. 1987). Usua (1970) noted that diapausing larvae are present throughout the year, irrespective of the condition of the host plant, but with peak incidence in July and December, and suggested that the induction of diapause is under genetic control. He also observed that the main factor enabling larvae to survive adverse conditions in diapause seems to be their efficient conservation of water. Diapause is normally terminated as rainfall increases during the subsequent growing season.



Figure 11. Stack of dry sorghum stems containing diapausing *Busseola fusca* larvae.

At the end of the diapause period, the availability of free water, which the larvae drink, facilitates rehydration and stimulates pupation (Harris 1962). Subsequent studies by Adesiyun (1983a) showed that contact with water in the vapor state (i.e., higher relative humidity), rather than direct intake, promoted diapause termination.

Unnithan and Reddy (1989) observed diapausing populations of *B. fusca* larvae in sorghum crop residues on Rusinga Island, Lake Victoria, Kenya, and recorded that most of the second generation *B. fusca* in the long-rain sorghum and maize crops entered aestivation diapause in July/August. This diapause terminated from late November onwards, and resulted in peak adult emergence in February. Rainfall alone was not

considered to be the main factor terminating diapause as pupation continued over an extended period, and some larvae pupated even though they had not been exposed to water. However, recent findings by Okuda (1988, 1990) confirmed earlier studies by Adesiyun (1983a) and revealed that water contact is more significant than water uptake as a factor in diapause termination. Gebre-Amlak (1989) also reported that a cumulative rainfall of about 80 mm or above from March onwards was necessary to induce pupation in diapausing larvae in southern Ethiopia.

Carry-over Populations

The main carry-over from one growing season to the next is as diapause larvae in stems, stubble, and other crop residues. Harris (1964) demonstrated that substantial larval populations can survive in stacks of sorghum stems stored during the dry season on farmers' fields and in villages in northern Nigeria (Fig. 11). It has long been known that larvae of this species survive in maize stubble in South Africa (Mally 1920). Some larvae may also survive on wild grass hosts, and it is important to maintain a general ecological approach to stem borer control strategies, as advocated by Bowden (1976). However, it is probably true that in many parts of Africa crop residues are the main source of initial stem borer infestations in subsequent seasons. Recent work in Kenya, reported by Unnithan and Reddy (1989) showed that on Rusinga Island, Lake Victoria, sorghum crop residues (stalks and stubble) ensured carry-over of diapause larvae through the off-season from July/August to February/March in sufficient numbers to establish early and damaging infestation of the following crop.

Adult Emergence, Mating, and Dispersal

Adults mostly emerge between sunset and midnight, and soon after emergence the females release a pheromone, consisting of a 10:2:2 mixture of (Z)-11-tetradecyl acetate, (E)-11-tetradecyl acetate and (Z)-9-tetradecyl acetate to attract males (Nesbitt et al. 1980, Hall et al. 1981). Mating behavior has not been reported in detail.

Soon after mating is completed, female moths disperse in search of suitable host plants for oviposition. The period of oviposition continues over 3-4 successive nights. The extent of adult dispersal during this period has not been established, although the indications are that it is mainly local. Mally (1920) indicated that female moths located and moved to crops from an emergence site at least a mile away. Migration over longer distances has not been reported, although it would seem feasible in some circumstances. Further study of this point is merited, especially since there are occasions when the incidence of *B. fusca* attack on early-sown crops is higher than can be explained by local circumstances.

Oviposition

Direct observations of oviposition have seldom been made, mainly because this is a nocturnal activity of the female moths. Van Rensburg et al. (1987) reported briefly on selective oviposition on maize in South Africa, where the ovipositional response is related to plant age. Maize plants are most attractive to ovipositing moths 3-5 weeks after the crop emerges. Plants younger than 2 weeks or older than 6 weeks were not selected for oviposition, although when younger plants were not available during the second-generation flight, oviposition occurred on plants older than 6 weeks in late sowings. The preferred leaf sheath for oviposition is that of the youngest fully unfolded leaf, so that the oviposition site gradually moves up the plant as the crop gets older. Evidence of selective oviposition on larger plants was obtained in a later study (van Rensburg et al. 1989) by using two maize hybrids with different average stalk circumferences. Significantly more and larger egg masses were laid on the hybrid with thicker stalks. Selection of vigorous plants by ovipositing females in field situations can probably be ascribed to an olfactory response and location of suitable ovipositing sites is probably thigmotactic. Differential oviposition appears to be a mechanism to promote larval survival since larger plants can better tolerate prolonged larval feeding. This phenomenon is also of possible importance in crop loss assessment studies since primary stem borer infestations will tend to be concentrated on potentially higher-yielding plants.

Adesiyun (1983b) reported the results of experiments in northern Nigeria in which ovipositing females chose between sorghum, maize, and millet plants. In field plots and in cages, most eggs were laid on sorghum, followed by maize, and no eggs were laid on millet in field experiments or in cages in a no-choice test.

Kaufmann (1983) reported the development of parthenogenetic eggs. Parthenogenetic development has been recorded in more primitive families of Lepidoptera, and in a species of Australian Geometridae, but this seems to be the only record of parthenogenetic development in any noctuid moth and therefore requires confirmation.

Pathogens, Parasitoids, and Predators

Many pathogens, parasitoids, and predators of *B. fusca* have been reported in Africa but there have been virtually no rigorous assessments of their importance as factors limiting pest populations. Mohyuddin and Greathead (1970) published a useful annotated review, partly based on an unpublished report by Milner (Final report on a survey of the parasites of graminaceous stem-borers in eastern Africa, Kawanda, Uganda: Commonwealth Institute of Biological Control, East Africa Station. 159 pp). They concluded that the most important parasitoids of *B. fusca* in eastern Africa were *Cotesia sesamiae* [= *Apanteles sesamiae*], *Sturmiopsis parasitica*, *Procerochasmias glaucopterus*, and *Pediobius furvus*, and they also noted the parasitoids that they considered to be of minor importance, uncommon and incidental, or of doubtful or ambiguous status. They reviewed information on predators and concluded that ants are important.

The main pathogens, parasitoids, and predators indigenous to Africa are listed in Table 1 with references. This table does not include exotic species that have been introduced to Africa for attempted biological control of stem borers, as these are noted in the section on pest management.

Pathogens/Micro-organisms. The most concerted recent research on pathogens has been based at the Mbita Point Field Station of ICIPE where Odindo (1985) recorded infections of larval cadavers of stem borers, including *B. fusca*, and noted high incidence of bacteria (77.8%) and fungi

Table 1. Natural enemies of *Busseola fusca* indigenous to Africa.

Species	Remarks
PATHOGENS	
<i>Aspergillus flavus</i> Link/A. <i>Sydowii</i> Bainier Sartory) Thorn & Church	Nigeria; but these may not be true pathogens (Harris 1962).
<i>Bacillus thuringiensis</i> (Berliner)	Nigeria (Harris 1962).
<i>Beauveria bassiana</i> (Bals.) Vuillemin	South Africa (van Rensburg et al. 1988).
<i>Beauveria</i> sp.	Kenya (Otieno 1987).
<i>Cordyceps</i> sp.	Extremely rare (Mohyuddin and Greathead 1970).
<i>Nosema</i> sp.	Kenya (Odindo 1985).
PARASITOIDS	
Hymenoptera	
Charopidae	
<i>Charops</i> sp.	Eastern/West Africa (Mohyuddin and Greathead 1970).
<i>Dentichasmias busseolae</i> Heinrich	Eastern/West/southern Africa; but only one record from <i>B. fusca</i> , all others from pyralids (Mohyuddin and Greathead 1970, Mohyuddin 1972).
<i>Enicospilus</i> sp.	Eastern Africa; but uncommon (Mohyuddin and Greathead 1970).
<i>Ichneumon rubriornatus</i> Cameron	South Africa (van Rensburg et al. 1988).
<i>Procerochasmias glaucopterus</i> (Cameron) [= <i>P. nigromaculatus</i> (Morley)]	Eastern Africa; above 1220 m (Mohyuddin and Greathead 1970).
<i>Syzeuctus</i> sp.	Eastern/West Africa; but extremely rare (Mohyuddin and Greathead 1970).
<i>Vadonina</i> sp. [= genus nr <i>Isotima</i> sp.]	Eastern/West Africa; but extremely rare (Mohyuddin and Greathead 1970).
Braconidae	
<i>Amicrocentrum curvinervis</i> Cameron	Uganda (van Achterburg 1979).
<i>Apanteles</i> sp. nr <i>laevigatus</i> (Ratzeburg)	Eastern/West Africa; but rare (Mohyuddin and Greathead 1970).
<i>Bracon sesamiae</i> Cameron/Bracon spp.	South Africa (Cameron 1906, van Rensburg et al. 1988); Eastern Africa (Mohyuddin and Greathead 1970).
<i>Chelonus curvimaculatus</i> Cameron	Eastern Africa; one record (Mohyuddin and Greathead 1970); South Africa (Kfir 1988).
<i>Chelonus</i> sp.	South Africa (Kfir 1988).
<i>Cotesia sesamiae</i> (Cameron) [= <i>Apanteles sesamiae</i> Cameron]	Widespread in Africa; but commoner in wetter parts (Mohyuddin and Greathead 1970). Studied recently in South Africa (van Rensburg et al. 1988, Kfir 1988).
<i>Euvipio rufa</i> Szepligeti	Eastern/West Africa (Mohyuddin and Greathead 1970).
<i>Iphiaulax</i> sp.	South Africa (van Rensburg et al. 1988, Kfir 1988).
<i>Merinotus</i> sp.	Nigeria (Quicke 1983).
<i>Meteorus</i> sp. n.	Kenya; reared once (Mohyuddin and Greathead 1970).
Chalcididae	
<i>Psilochalcis soudanensis</i> (Steffan) [= <i>Invreia soudanensis</i> (Steffan)] [= <i>Hyperchalcidia soudanensis</i> Steffan]	Eastern/West Africa (Mohyuddin and Greathead 1970); but may be mainly a parasitoid of smaller Lepidoptera, especially pyralids (Boucek 1988).
Pteromalidae	
<i>Norbanus</i> sp.	Zimbabwe (CIE unpublished record).
<i>Sphegigaster</i> sp. [= <i>Trigonogastra</i> sp.]	Kenya (Nye 1960); but species of this genus are mainly parasitoids of Diptera, especially agromyzids (Boucek 1988).

Continued.

Table 1. Continued.

Species	Remarks
Eulophidae	
<i>Pediobius furvus</i> (Gahan)	Eastern/West Africa; widespread but more abundant in drier areas (Mohyuddin and Greathead 1970).
<i>Tetrastichus atriclavus</i> Waterston	Eastern Africa; reared once (Mohyuddin and Greathead 1970).
Trichogrammatidae	
<i>Lathromeris ovicida</i> (Risbec)	Uganda; but rare (Mohyuddin and Greathead 1970).
<i>Paracentrobia dimorpha</i> (Kryger) [= <i>Abbella dimorpha</i> Kryger]	Uganda; but rare (Mohyuddin and Greathead 1970).
Scelionidae	
<i>Telenomus busseolae</i> Gahan	Eastern/West Africa (Mohyuddin and Greathead 1970); South Africa (van Rensburg et al. 1988).
Bethylidae	
? <i>Prorops</i> sp.	Tanzania; reared once (Mohyuddin and Greathead 1970).
[Note: This record is almost certainly wrong; <i>Prorops</i> parasitizes Coleoptera.]	
Sphecidae	
<i>Trypoxylon</i> sp.	Ethiopia (Gebre-Amlak 1985).
Diptera	
Tachinidae	
<i>Actia</i> spp.	Eastern/West Africa; but rare (Mohyuddin and Greathead 1970).
<i>Nemoraea discoidalis</i> Villeneuve	Eastern Africa; but rare (Mohyuddin and Greathead 1970).
<i>Siphona murina</i> Mesnil	Eastern Africa; but uncommon (Mohyuddin and Greathead 1970).
<i>Sturmiopsis parasitica</i> (Curran)	Eastern/West Africa (Mohyuddin and Greathead 1970).
[Note: Records of <i>Palexorista imberbis</i> (Wiedemann) (= <i>Drino imberbis</i> Wiedemann) and of <i>Paradrino halli</i> (Curran) (- <i>Drino halli</i> Curran) from Tanzania by Robertson (1975) and of <i>Carcelia evolans</i> (Wiedemann) (= <i>Zenillia evolans</i> Wiedemann) from Zimbabwe by Cuthbertson (1936) have not been confirmed by subsequent rearings and are probably erroneous. Records of <i>Atherigona</i> sp. (Muscidae), of <i>Sarcophaga villa</i> Curran (Sarcophagidae) and of <i>Megaselia scalaris</i> (H. Loew) (Phoridae) as parasitoids of <i>Busseola fusca</i> are also unlikely to be correct. Similarly, the record of <i>Elassogaster arcuata</i> Hendel (Platystomatidae) by van Rensburg et al. (1988) must be confirmed by further observations.]	
PREDATORS	
Hymenoptera	
Formicidae	
<i>Dorylus affinis</i> Schuckard	Nigeria (Harris, 1962).
<i>Cardiocondyla badonei</i> Arnold/ <i>Cardiocondyla emeryi</i> Forell/ <i>Pheidole megacephala</i> Fabricius/ <i>Tetramorium guineense</i> Fabricius	Uganda (Mohyuddin and Greathead 1970).
<i>Dorylus helvolus</i> (Linnaeus)/ <i>Pheidole megacephala</i> Fabricius	South Africa (Kfir 1988).
Orthoptera	
Tettigoniidae	
<i>Clonia vittata</i> Thunberg	South Africa (Akerman 1932).
Dermaptera	
<i>Diaperasticus erythrocephala</i> (Olivier)	Ethiopia (Gebre-Amlak 1985).

(19.2%), and lower incidence of protozoans (7.9%) and nematodes (2.9%). Later, Odindo et al. (1989) reported a survey in western Kenya to determine the prevalence of micro-organisms in late-instar stem borer larvae in the maize crop at harvest and recorded bacteria, fungi, viruses, mermithids, rhabditids, and microsporidia. They concluded that there did not appear to be any epizootics in crop borers in the field and noted that, since stem borer larvae are seldom in contact and usually bore into stems singly, the high larval populations and close contacts that are predisposing factors for the development of epizootics do not operate.

Parasitoids. All recorded parasitoids are insects, mainly parasitic Hymenoptera, but also Tachinidae. Many different species have been recorded, but the validity of some records is doubtful and confirmation by careful observation, rearing, and authoritative identification is needed before some of these published records can be accepted as valid.

Predators. Records of predation are also mainly of insects. There seem to be few records of predation by vertebrates (birds and small mammals), which is surprising since final-instar larvae and pupae must provide a useful food resource, especially during dry periods. Recent work by Kfir (1987) emphasizes the importance of predation by the ant *Pheidole megacephala* Fabricius on hibernating larvae of *B. fusca* in dry sorghum stems. Ants have also been recorded as predators of stem borer eggs.

The general conclusion must be that much remains to be learned about the natural enemy complexes on *B. fusca* populations in various parts of Africa. There certainly seem to be some discontinuities of distribution which may indicate possibilities for biological control and, even if such manipulation is not possible, it is important that existing natural enemy complexes should be conserved by appropriate management.

Population Dynamics

Despite its importance as a pest of African food crops, the population dynamics of *B. fusca* do not seem to have been studied in any detail. At most locations, 2-3 generations are produced but in

relatively humid areas a small population of larvae may pupate and give rise to a fourth adult generation. The first generation adults are produced from the diapausing larvae of the previous crop season, with moth flights occurring a few weeks after rains have begun, when maize/sorghum crops are 3-5 weeks old.

In West Africa, only two generations of *B. fusca* were observed on sorghum at Farako-Ba in Burkina Faso (Nwanze 1985, 1988) although at Zaria, in northern Nigeria, three generations were recorded (Harris 1962), recently confirmed by MacFarlane (1990). In Burkina Faso, larval populations peaked in mid-August and October, but a much earlier population peak occurs at Zaria in late June. Usua (1968b) recorded four larval generations on maize at Ibadan, southern Nigeria; two between April and July, one in September—October, and a fourth in November.

Three generations of *B. fusca* occur in Ethiopia (Gebre-Amlak 1989) with the first in May-June. A second generation occurs in July-September, and a third at the end of October. In South Africa, the number of generations on maize increases from two to three from east (Natal province) to west (Transvaal province), (Barrow 1989, van Rensburg et al. 1985). The first-generation moths emerge between October and December, the second in January, and the third in March. Towards the west, generations tend to overlap and seasonal variations in moth flight periods are less distinct. Similarly in Zimbabwe, two distinct generations are produced but a third generation may develop, depending on prevalent environmental conditions (Sithole 1989). The first-generation moths appear in early November, and the second generation in January-February.

At all locations, most of the last larval generation of *B. fusca* enters diapause. Although it is thought that the onset of diapause may be favored by the ageing of maize plants (Usua 1973), there is evidence that the rainfall gradient may contribute indirectly to geographic variation in population dynamics, and in the number of generations produced.

Pest Management

The overall approach to control of stem borers on crops in Africa must be to devise and implement integrated pest management programs that must

meet local needs and be adapted to local conditions and resources. There is wide scope for the development of such programs, that will be mainly based on nonchemical methods of control. The main elements are summarized below.

Cultural Control

Cultural methods of control have recently been reviewed by Verma and Singh (1989) and by Reddy (1985a), but necessarily relate to cereal stem borers in general, rather than to *B. fusca* in particular.

Crop residues. The importance of crop residues in carrying over larval populations from one growing season to the next has already been noted. Where destruction by burning or deep plowing is feasible, it may be possible to take concerted action to reduce carry-over populations and so limit the most damaging early borer infestations in the following season. However, this may not always be possible, especially in parts of West Africa where dry stems are used for fencing and building. It may then be necessary to devise means of killing diapause larvae without destroying the crop residues. This has been achieved by Adesiyun and Ajayi (1980) by partially burning sorghum stalks, killing 95% of *B. fusca* larvae, while at the same time curing the stalks and making them more suitable for building or for use as firewood. Simply leaving stems lying horizontally exposed to full sun in the fields for a month or so, rather than stacking them vertically, will also reduce the carry-over population, as has been shown in Ethiopia by Gebre-Amlak (1988) and in Nigeria by Harris (1962). Using crop residues for fodder and silage has also been recommended as a method of control (Wahl 1926).

Tillage. Deep plowing to bury maize stubble was one of the earliest control measures used against this pest in South Africa (Mally 1920). Jack (1918) reported that in Rhodesia (Zimbabwe) moths emerging through 5 cm of soil were crippled and that deeper burial of maize stalks under 10-15 cm of soil ensured that no adult moths emerged. Du Plessis and Lea (1943) reported that tillage only gave partial control but Walters (1975) emphasized the role of conventional tillage in controlling *B. fusca* in South Africa. More re-

cent work reported by Kfir (1990) showed that, in the Transvaal, slashing maize and sorghum stems destroyed 70% of the stem borer population and that plowing and discing the crop residues after slashing destroyed a further 24% of the pest population in sorghum and 19% in maize. Macharia (1989), working in Kenya, reported the effects of various crop residue disposal practices resulting in the following reductions of *B. fusca* populations: cutting stumps (64% larvae, 14% pupae), partial burning (65% larvae, 17% pupae), deep plowing (67% larvae, 91% pupae), and harrowing (89% larvae, 97% pupae). Musick and Petty (1973) reported that nontillage increased the incidence of *B. fusca*.

Trap crops. Du Plessis (1936) reported that trap cropping was not effective in South Africa although Jack (1922, 1928) had earlier recommended the use of sorghum or maize as trap crops in Rhodesia (Zimbabwe). Later Jack (1931) reported that maize sown as a trap crop was not effective because late rains delayed germination. There does not appear to have been any further serious consideration of this technique after the 1930s.

Crop rotation. Any crop rotation that extends the period between cultivation of successive maize and/or sorghum crops in the same fields may reduce borer infestations, but local dispersal of ovipositing moths is possible and may cancel out any local effects of crop rotation. There appears to be no information available on the effects of different rotations on *B. fusca* incidence.

Sowing dates. Swaine (1957) found that later sowings of maize in Tanzania were less affected by *B. fusca* than earlier sowings, and Abu (1986) has reported that early sowing of sorghum reduced infestation in Nigeria. In Ethiopia, Gebre-Amlak et al. (1989) observed that infestation of late-sown maize, attacked by second-generation *B. fusca*, was higher (22-100%) than early-sown maize attacked by the first generation (0-22%). In Malawi, Mchowa (1990) studied the effects of four sowing dates on the incidence of *B. fusca* in two varieties of sorghum (Serena and ZSV 1) and found that the incidence of this pest was highest in the first and fourth sowings of Serena, but highest on the second and third sowings of ZSV 1.

The precise effects of different sowing dates, that result from the interactions of ovipositing

females with growing crops, will obviously vary with location and season, and accurate prediction of the resulting levels of infestation will generally require better understanding of those interactions than is currently available.

Removal of deadhearts. In sorghum, removal of deadhearts may kill borer larvae and encourage tillering but infestations are usually well established by the time the deadhearts appear, and prevention of infestation would be a preferable approach. However, some farmers in Nigeria, and probably elsewhere, do remove sorghum deadhearts when weeding and ridging the crop and this practice is probably beneficial, although there seems to be no experimental evidence available.

Removal of alternative host plants and volunteer crop plants. Wild grass hosts and volunteer crop plants are potential sources of infestation. They may be important at some locations but other crops and crop residues are probably much more important sources of infestation.

Water management. While irrigation may cause definite changes in plant growth and development, that may disrupt pest development, pest problems may also become severe under irrigated conditions. There are no reports available on the effects of water management on *B. fusca* infestations, but flooding of sugarcane fields and rice paddies is used in some countries to drown other stem-boring species (NAS 1969). On the other hand, continuous high soil moisture in dryland agriculture, resulting from irrigation, favors the production of several generations of the oriental corn borer, *Chilo agamemnon* Bleszynski in both Israel (Rivnay 1967), and Egypt (Ali 1977).

Fertilizer management. Most of the published studies on the relationship between the use of nitrogen fertilizers and cereal stem borer infestations have been on rice. Similar studies on maize and sorghum are limited and have involved other species of stem borers. There seem to have been no such studies on *B. fusca*.

The general indication is that high soil fertility results in increased stem borer infestation (Lawani 1982). This trend is attributed to better crop growth, which attracts ovipositing moths and increases the rate of larval survival.

Intercropping. Adesiyun (1983b) studied the effects of intercropping sorghum, maize, and pearl millet in Nigeria, and concluded that the almost total inability of *B. fusca* females to oviposit effectively on millet resulted in a reduction in stem borer infestations in sorghum intercropped with millet, a common farming practice in northern Nigeria and in other dry areas of West Africa. Work in Kenya by Amoako-Atta and Omolo (1983) indicated that maize/cowpea/sorghum or sorghum/cowpea intercropping systems gave the best control of *B. fusca*. Similarly, Omolo (1986) showed that sorghum in monoculture and sorghum intercropped with maize suffered more damage by *B. fusca* than sorghum/cowpea or sorghum/cowpea/maize intercrops, but Dissemmond and Weltzien (1986), also working in Kenya, reported that sorghum/cowpea intercropping had no effect on borer incidence. Later work in Kenya (Reddy and Masyanga 1988) on sorghum/cowpea intercropping indicated that alternating two rows of sorghum with two rows of cowpea reduced *B. fusca* damage by 20% compared to monocropped sorghum. In other studies, Omolo and Reddy (1985) showed that *B. fusca* infestations were higher in sorghum or maize monocrops than in a sorghum/maize intercrop.

Plant Resistance

Host-plant resistance has been successfully used in the control of lepidopterous stem borers, and the often-cited example of the European corn borer, *Ostrinia nubilalls* (Hubner) in North America is a classic case. Some progress has also been reported with the spotted stem borer of maize and sorghum, *Chilo partellus* (Swinhoe), in Africa and Asia (Taneja and Leuschner 1985, Reddy 1985b). In general, host-plant resistance as a method of control is environmentally safe, economically acceptable to farmers, and the most compatible with other components in integrated pest management schemes.

Although there were early attempts to develop maize cultivars resistant to *B. fusca* (du Plessis and Lea 1943, Ingram 1958, Walters 1974) it is only within recent years that concerted efforts have been made (Barrow 1985, 1989, Reddy 1985b, Kundu 1985).

A major handicap in breeding for resistance to *B. fusca* has been the lack of efficient screening techniques. Most studies have been conducted

under natural infestations in 'hot-spot' locations where several species of stem borers may infest the same crop. Several attempts were made in South Africa to rear *B. fusca* artificially on meridic diets, but these were unsuccessful due to poor survival of first-instar larvae and the inability to break larval diapause. Barrow (1989), working in South Africa, developed an elaborate method that involves field collection of large numbers of diapausing larvae, storage in a cold room and time-spaced exposure of batches of larvae to laboratory temperatures to induce pupation, moth emergence, and oviposition, followed by egg collection and incubation to produce first-instar larvae which are then used for artificial infestation.

Field infestation is achieved by using a mixture of maize meal (100 g) and first-instar larvae (600 mg) dispensed by a mechanical applicator into the plant funnels. Plants are infested at a height of about 35 cm with two doses of this mixture. This results in infestation rates of about 16-22 larvae per plant. Usua (1968a) used 1-5 larvae per plant and Ingram (1958) used 5 larvae per plant, with varying degrees of success.

Plant reaction to stem borers is measured by various parameters: leaf damage, deadhearts, dead plants, ear damage (in maize), stem tunneling, chaffiness of panicles (*in sorghum*), plant height, and grain-yield reduction. There has been no concerted attempt to standardize rating systems for the measurement of damage and there is an obvious need to reach agreement on methods that will be widely applicable and comparable. Barrow (1985) rated leaf damage in maize on a scale of 1-5 (1 = very little damage; 5 = severe damage) under artificial infestation 25 days after larval feeding, and Kundu (1985), working in Somalia, rated leaf damage on maize under natural infestation 42 days after crop emergence on a 1-9 scale where 1 = free from injury, and 9 = maximum injury. MacFarlane (1990), working on sorghum over 3 years in northern Nigeria, developed a new visual rating system which, in combination with the number of nodes bored, gave the best relationship to grain mass per head.

Screening sorghum germplasm for resistance to *B. fusca* under natural infestation has also been reported from Zimbabwe and Kenya (Sithole 1987, 1988, Gebrekidan 1985), although these studies involve complexes of different stem borer species.

Several maize and sorghum genotypes with low to medium levels of resistance to *B. fusca* have been reported. Barely 1% of the nearly 6000 indigenous sorghum genotypes that were evaluated in Ethiopia were classified as promising tolerant lines (Gebrekidan 1985). In Kenya, 20 sorghum genotypes were reported to have performed well against a complex of four different species of stem borer (Reddy 1985b). Kundu (1985) reported four least-susceptible high-yielding maize cultivars in Somalia against a complex of three borer species that included *B. fusca*. In South Africa, several lines of maize have been identified with intermediate levels of resistance to first-generation (whorl-feeding) larvae, but there is no information on resistance to the second-generation larvae, which cause ear and stem damage (Barrow 1989). There is very limited information on the mechanisms of, and factors associated with, resistance to *B. fusca*. Preference for oviposition sites was reported by van Rensburg et al. (1987) and was attributed to differences in plant age, with plants at 3-5 weeks after emergence being the most attractive. Later studies by van Rensburg et al. (1989), ascribed an olfactory response in the selection of oviposition sites. They detected differences in the number and size of egg batches obtained from two maize hybrids but also associated this to differences in stalk thickness. Barrow (1985, 1989) suggested that one or two factors related to antibiosis were present in maize: a short-lived but effective factor that reduces larval numbers, and a longer-lasting factor that retards larval development. However, both levels were too low for incorporation into breeding material and a program to increase the level of resistance was recommended. Preliminary evidence from maize (Barrow 1989) indicates that inheritance of resistance appears to be additive. Two approaches are currently used to breed for resistance in South Africa: population improvement, and the development of inbreds.

Biological Control

Biological control has been effectively used against stem borers on sugarcane in the Caribbean and might be expected to have potential for use against *B. fusca* and other stem borers of cereal crops in Africa. Mohyuddin and Greathead (1970) in reviewing the situation, noted that a

large number of hymenopterous parasitoids of cereal stem borers are known from Asia, and recommended that five of these [*Cotesia flavipes* Cameron, *C. chilonis* (Munakata), *Bracon chinensis* Szepliget, *B. onuki* Watanabe and *Sturmiopsis inferens* (Townsend)] should be considered for introduction into eastern Africa. They also recommended distribution of *Invreia soudanensis* (Steffan) and *Sturmiopsis parasitica* (Curran) within Africa, as the ranges of these two species seemed to be restricted by geographic barriers. Gilstrap (1985) assessed the potentials for applying biological control against pests of sorghum and indicated excellent prospects for control of *B. fusca* by importation and conservation (but without detailed recommendations), and Betbeder-Matibet (1989) reviewed some of the attempts made to implement biological control of stem borers (but without direct reference to *B. fusca*). Ingram (1983) also reviewed the situation in Africa but did not make any particular comment on *B. fusca*. However, he did emphasize the need for further critical ecological studies to pinpoint areas where additions of further parasitoid species are most likely to be effective. He also stressed that little is known about predation on stem borers, other than occasional references to ants attacking eggs and first-instar larvae. Skoroszewski and van Hamburg (1987) reported the introduction of *Cotesia flavipes* (Cameron) [= *Apanteles flavipes* (Cameron)] against *Chilo partellus* and *B. fusca* on maize in South Africa but, although *C. flavipes* became temporarily established, it was not recovered after the winter.

Maafo (1975) reported that some exotic species of *Trichogramma* showed high fecundity and helped to control stem borers, including *B. fusca*, in Ghana. Kfir (1989) has also reviewed the prospects of biological and cultural control of lepidopterous stem borers (including *B. fusca*) in South Africa, where a number of different exotic parasitoids have been released. To date, few recoveries of these releases have been made.

Chemical Control

The commercial use of insecticides by small-scale farmers to control *B. fusca* is more exceptional on sorghum than on maize. The high cost of chemical insecticides, difficulty of application (Duerden 1953) and timing, unavailability of pesticides in

rural areas, and scarcity of water for sprays, especially in the semi-arid sorghum-producing areas, do not facilitate their use (Nwanze and Mueller 1989).

Currently recommended insecticidal control measures against stem borers have generally been derived from measures initially established for such crops as cotton, tobacco, and groundnut. Several studies on the chemical control of *B. fusca* have been designed; either to determine the relative efficiencies of different chemicals, or to evaluate *B. fusca* control under experimental conditions. The following section provides a brief historic account and a review of recent usage.

The earliest use of insecticides for the control of *B. fusca* was reported from South Africa where maize crops were treated with hycol solution, sheep-dip and several other botanical insecticides such as 'Derrisol[®]', Pulvex[®]', 'Kymac[®]', etc., that are all based on rotenone, a product of the leguminous plant *Derris chinensis* (USADA 1922, Chorley 1932, Ripley 1928, Ripley and Hepburn 1928, 1929, Parsons 1929). Good control of *B. fusca* was achieved by using these chemicals. In the 1950s, DDT at 22.4 kg ha⁻¹ was successfully used in Ghana (Bowden 1956a) and in Uganda (Coaker 1956).

Several later studies indicate that a single dose of carbofuran at 1.0–2.5 kg a.i. ha⁻¹, applied to the planting furrows of maize in South Africa and in Nigeria, gave good control (Walters 1975, van Rensburg and Malan 1982, van Rensburg et al. 1978, Egwuatu and Ita 1982, Drinkwater 1979). Placement of granular dusts of endosulfan, carbaryl, malathion, or fenvalerate in leaf whorls were also reported to control *B. fusca* effectively (Whitney 1970, Adenuga 1977, Adesiyun 1986, Kishore 1989). Spray applications of endrin as a 0.03–0.40% emulsion, or as a 2% dust formulation, were effective in eastern Africa (Walker 1960a).

However, with the changing patterns of maize and sorghum production in many African countries (i.e., on large-scale and parastatal farms) insecticide use will form a vital component in an integrated approach to stem borer control.

Legislative Control

Legislation to control *B. fusca* on maize was attempted in Kenya in the 1920s and 1930s (Ander-

son 1929, Wilkinson 1939). The objective was to restrict sowing maize to the February—May period, when infestation was expected to be low. There seems to be no information available on the effectiveness of these measures and the last recorded implementation of this legislation was in 1937/38.

Other Methods

Light trapping. This technique has been used against stem borers of rice in Southeast Asia but does not seem to have been used against *B. fusca* in Africa. It does not seem particularly appropriate as it would require easy access to electricity, and the range of most traps would be relatively limited.

Pheromone trapping and mating disruption. Campion and Nesbitt (1983) reviewed progress in the identification and use of pheromones for stem borer monitoring, mass trapping, and mating disruption. They concluded that monitoring might help to define periods of moth flight more clearly; that mass trapping is unlikely to provide satisfactory control; and that mating disruption is most likely to be effective when used on maize and other crops grown under plantation conditions. Hall et al. (1981) reported that a synthetic pheromone mixture caught as many male moths as did the natural pheromone.

Integrated Pest Management

Management options for stem borer control on sorghum in the semi-arid tropics of Africa and Asia have recently been reviewed by Nwanze and Mueller (1989), who emphasized that stem borer control strategies must be politically practical, socially acceptable, economically feasible, and technically effective. They excluded consideration of the more exotic control methods such as the use of pheromones, juvenile hormones, and chemosterilants, and concentrated on other, mainly nonchemical methods. Their overall conclusion was that most recommendations are impractical as they do not take sufficient account of the situations, resources, and needs of farmers. Although there is much information available on the possi-

ble methods of control, there is a need to follow a farming systems approach to applied stem borer management research. The most recent attempt to develop such programs has been reported by Saxena et al. (1989) in a joint ICIPE/Kenya Agricultural Research Institute (KARI) pilot project involving 25 farmers at each of two locations, Oyugis and Rusinga, in western Kenya. The combined effects of several components (intercropping, adjustment of sowing date, crop-residue disposal, and host-plant resistance) were tested, and were reported to reduce stem borer damage to sorghum (including damage by *B. fusca*).

Conclusions and Recommendations

During the past 90 years, *B. fusca* has been studied in many different parts of Africa and, as a result, much information is available in published and unpublished records. The extent and nature of that information is shown in this handbook, the first comprehensive compilation on this species since Mally (1920) published his handbook. Much has been added since 1920, and in recent years there has been a marked increase in the number of scientists engaged in research on this pest in Africa. Despite these efforts, *B. fusca* seems to be as damaging a pest today as it was at the beginning of the Century, and there are still many basic questions that remain unanswered. There is therefore a need to focus on critical questions and to avoid the unnecessary repetition of work that has already been done, especially if it is not particularly relevant to effective pest management. Our main conclusion is that there is a need for better coordination of research teams working on this pest and for better targeting of the research effort. Our detailed recommendations are summarized below.

Pest Status and Crop Loss Assessment

There seems little doubt that *B. fusca* is an important pest of maize in many parts of Africa and experiments have shown that substantial yield losses result from moderate infestations. The situation on sorghum is less clear, but there are certainly occasions when yield losses are high. There

is however a real need for more and better critical determinations of yield losses resulting from different levels and types of attack on both crops. Objective crop loss assessment is not easy, but experimental techniques have been developed and should be more widely used. In addition, there is a need for more extensive field assessment of *B. fusca* incidence and importance in farmers' fields to determine which areas are most at risk to attack by this species. The present intensity of research work suggests that South Africa, Nigeria, and Kenya are the three countries most affected, but that may simply reflect the greater numbers of entomologists in those countries.

Biology and Ecology

The biology and ecology of this species have been well studied in a number of African countries but, although much is known, there is a need for confirmatory studies in many areas and additional work will be needed to obtain answers to a number of key questions, including:

- how far do adults fly and what factors affect adult dispersal?
- what are the main requirements for successful mating?
- what factors determine successful oviposition?
- what factors determine the behavior of first-instar larvae and affect their successful establishment on host plants?

- what are the mortality factors affecting population dynamics?
- why are there marked discontinuities in the spatial distribution of *B. fusca*, and why does it occur at lower altitudes in West Africa than in eastern and southern Africa?
- why are some crops seriously damaged by first-generation attack in some years but not in others?

Pest Management

Integrated pest management (IPM) has been the favored strategy for pest control for many years but, apart from recent work by ICIPE in its study villages in western Kenya, there does not seem to have been any concerted effort to develop well-focused IPM strategies for the control of *B. fusca* and other cereal stem borers in Africa. The USAID-funded Sahelian IPM Project work on *B. fusca* and other pests of cereals in West Africa, including work in Burkina Faso, does not seem to have resulted in the formulation of IPM programs for sorghum or maize.

Plant breeding, which may well provide the best control, is handicapped by the lack of efficient screening techniques, due mainly to the inability to break the larval diapause of *B. fusca* and to rear it successfully on meridic diets. Information on the mechanisms of resistance and its inheritance is also very limited.

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- van Rensburg, J.B.J., Walters, M.C., and Stemmet, G.P. 1978.** A preliminary study on the application of carbofuran granules to the soil for the control of grain sorghum pests. Phytophylactica 10(1):28-30.
- van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1985.** Geographical variation in the seasonal moth flight activity of the maize stalk borer, *Busseola fusca* (Fuller), in South Africa. South African Journal of Plant and Soil 2(3):123-126.
- van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1987.** Ecology of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Bulletin of Entomological Research 77(2):255-269.
- van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1988.** Mortality in natural populations of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in South Africa. Phytophylactica 20(1)17-19.
- van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1989.** Selective oviposition by the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa 52(1):105-108.
- Verma, A.N., and Singh, S.P. 1989.** Cultural control of sorghum stem borers. Pages 81—87 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Wahl, R.O. 1926.** The maize-stalk borer (*Busseola fusca*, Fuller). Fanning in South Africa 1(8):279-282.
- Wahl, R.O. 1930.** The maize stalk borer. Farming in South Africa 5(53):205-206.
- Walker, P.T. 1960a.** Insecticide studies on the maize stalk borer, *Busseola fusca* (Fuller), in East Africa. Bulletin of Entomological Research 51(2):321-351.
- Walker, P.T. 1960b.** The relation between infestation by the stalk borer *Busseola fusca*, and yield of maize in East Africa. Annals of Applied Biology 48(4):780-786.
- Walker, P.T., and Hodson, M.J. 1976.** Developments in maize stem-borer control in East Africa, including the use of insecticide granules. Annals of Applied Biology 84:111-114.
- Walters, M.C. 1974.** Mechanisms of resistance to insects and application to maize stalk borer. Proceedings of the 1st South African Maize Breeding Symposium, Potchefstroom. Technical Communication, Department of Agricultural and Technical Services, South Africa 132:83-87.
- Walters, M.C. 1975.** Evolution in tillage techniques and impact on entomological research, with special reference to the maize stalk borer, *Busseola fusca* (Fuller). Pages 235-244 in Proceedings of the first Congress of the Entomological Society of Southern Africa, 1974, Stellenbosch, South Africa (Durr, H.J.R., Giliomee, J.H., and Nesor, S., eds.). Pretoria, South Africa: Entomological Society of Southern Africa.
- Whitney, W.K. 1970.** Observations on maize insects at the International Institute of Tropical Ag-

riculture (IITA) Ibadan. Bulletin of the Entomological Society of Nigeria 2(2):146-155.

Wilkinson, H. 1939. Entomological Section, Annual report. Report, Department of Agriculture, Kenya 2:86-101.

Part 2

**An Annotated Bibliography
of *Busseola fusca* (Fuller)**

1900-1990

Compiled by

S. Prasannalakshmi and M. Suguna Sri

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Introduction

This bibliography is issued as Part 2 of '*Busseola fusca* (Fuller), the African maize stalk borer: a handbook of information.' It contains 396 references and includes both conventional and nonconventional literature collected from published primary and secondary sources, computer-readable databases, and reference lists in papers. Further, individuals known to have interests in work on *B. fusca* were contacted to obtain relevant papers or references. An attempt has thus been to make the bibliography comprehensive.

References in the bibliography are arranged under broad subject headings, and alphabetically by authors under each heading. Subject headings are as in Part 1. However, some headings have been combined in Part 2 to achieve economy. The compilers have specially prepared annotations to entries wherever the original documents were available. In some cases secondary source annotations or abstracts were edited for the bibliography. A few entries do not have annotations as original documents were not accessible. Annotations have been slanted to cover aspects relevant to *B. fusca*. References are cited in ICRISAT style.

References are repeated under more than one subject heading as appropriate. As a result, the number of entries in the bibliography is 447 although the number of unique references is 396. This is also reflected in the author index. Two or more postings against an author does not necessarily mean as many unique references under that author in the bibliography.

The bibliography contains references to literature dealing specifically with *B. fusca*. As a result, some of the references listed in Part 1 may not find a place in the bibliography.

About 60% of the documents listed in the bibliography are held by the ICRISAT Library. The bibliography is also available as an application under the Micro CDS/ISIS database management software for microcomputers developed and distributed by UNESCO, and available free of charge to nonprofit organizations. Interested organizations must apply to the ICRISAT Library to get the *B. fusca* database.

The ICRISAT Library will keep this bibliography updated. However, updates will only be provided on demand, either as hardcopy or on diskettes. The compilers welcome additions to this bibliography.

General

001

Ajayi, O. 1989. Stem borers of sorghum in West Africa with emphasis on Nigeria. (Summary(s) in Fr.) Page(s) 27-31 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 16 ref.

Relative importance, distribution, bioecology, severity of damage, and control measures of stem borers including *Busseola fusca* are reviewed. Requirements for integrated control are outlined.

002

Appert, J. 1964. [Caterpillars mining cereals in tropical Africa.] Les chenilles mineuses des cereales en Afrique tropicale. (In Fr. Summary(s) in En, Es.) Agronomie Tropicale 19(1): 60-74. 11 ref. Infestation of sorghum, maize, sugarcane, and pearl millet by *Busseola fusca* in West Africa is reported. Distinctive characters, distribution, bionomics, severity of damage, and control measures of the pest are discussed.

003

Betbeder-Matibet, M. 1989. [*Busseola fusca*: the maize and sorghum borer.] Foreur du maïs et du sorgho. (In Fr.) Page(s) ? in Insectes nuisibles aux cultures vivrières d'Afrique, de Madagascar et des Mascareignes. Montpellier, France: CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), Département IRAT (Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières).

The description, geographical distribution and host plants, biology, and control measures of *Busseola fusca* are given.

004

Bonzi, S.M. 1977. Situation of grass boring insects [including *Busseola fusca*] in Upper Volta [Burkina Faso] on sorghum, millet, maize and rice. Presented at the Working Meeting about Grass Boring Insects, Nov 1977, Bouake, Ivory Coast. (In Fr.)

005

Breniere, J. 1974. Investigation mission on sorghum and millet borers [including *Busseola fusca*] in Niger from 16 to 27 November 1974. (In Fr.)

Paris, France: Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières. 38 pp.

006

du Plessis, C., and Lea, H.A.F. 1943. The maize stalk-borer *Calamistis fusca* (Hmps.). Bulletin, Department of Agriculture and Forestry, Union of South Africa 238: 51 pp. 15 ref.

Investigations on the life cycle and control of *Calamistis fusca* [*Busseola fusca*] on maize, carried out in the Orange Free State, South Africa during 1931-34 are reported.

007

Duerden, J.C. 1953. Stem borers of cereal crops at Kongwa, Tanganyika, 1950-52. East African Agricultural and Forestry Journal 19(2): 105-119. Infestation, population dynamics, and control measures of *Busseola fusca* (on sorghum and maize) and *Chilo zonellus* are reported. Ploughing in the crop residues and trap cropping were not helpful while burning of windrowed stalks after harvest and weekly dusting with DDT controlled *B. fusca* effectively.

008

Gebre-Amlak, A. 1981. Some studies on maize stalk borer, *Busseola fusca* (Fuller) (Lep: Noctuidae) in southern Ethiopia. M.Sc. thesis, Addis Ababa University, Alemaya, Addis Ababa, Ethiopia.

009

Grist, D.H., and Lever, R.J.A.W. 1969. Pests of rice. London, UK: Longmans, pp. 124-125. Distribution, alternative host plants, biology, and control methods of *Busseola sorghicida* Thunberg [*Busseola fusca*] are reported.

010

Hargreaves, H. 1939. Notes on some pests of maize and millets in Uganda. East African Agricultural Journal 5 (2): 104-109.

Distribution, severity of damage, alternative host plants, life cycle, natural enemies, seasonal incidence, and control methods of *Busseola fusca* on maize in Uganda are reported.

011

Harris, K.M. 1962. Lepidopterous stem borers of cereals in Nigeria. Bulletin of Entomological Research 53(1): 139-171. 19 ref.

Distribution, life cycle, severity of damage, assessment of yield losses, and control measures of *Busseola fusca* are discussed.

012

Harris, K.M. 1985. Lepidopterous stem borers of sorghum. (Summary(s) in Fr.) Page(s) 161-167 in Proceedings of the International Sorghum Entomology Workshop, 15-21 Jul 1984, College Station, Texas, USA. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 34 ref.

Literature on the biology and control of *Busseola fusca* is reviewed.

013

Harris, K.M. 1989. Recent advances in sorghum and pearl millet stem borer research. Page(s) 9-16 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 43 ref.

Literature (since 1980) on stem borers including *Busseola fusca* is reviewed. Advances in knowledge of biology, ecology, and control of the stem borers including *Busseola fusca* are summarized.

014

Hill, D.S. 1975. *Busseola fusca* (Fuller). Page(s) 293-294 in Agricultural insect pests of the tropics and their control. Cambridge, UK: Cambridge University Press.

Distribution, severity of damage, life cycle, and control measures of *Busseola fusca* are briefly discussed.

015

Hill, D.S. 1983. Agricultural insect pests of the tropics and their control. Cambridge, UK: Cambridge University Press, pp. 360-361, 597, 651.

Distribution, pest status, host plants, crop damage, life cycle, and control measures of *Busseola fusca* are discussed. *Busseola fusca* is listed under the pests of both maize and sorghum.

016

ICIPE (International Centre of Insect Physiology and Ecology). 1982. Maize and sorghum stem-borers. Annual Report, International Centre of Insect Physiology and Ecology 1981: 27-28.

Distribution, pest carry over and light trap studies, and screening for resistance, of stem borers including *Busseola fusca* are discussed.

017

Ingram, W.R. 1958. The lepidopterous stalk borers associated with Gramineae in Uganda.

Bulletin of Entomological Research 49(2): 367-383. 9 ref.

Descriptions of adults, life cycles, and control measures of stalk borers including *Busseola fusca* and *B. segeta* are given.

018

Jack, R.W. 1927. Report of the Chief Entomologist for the year 1926. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1926: 23-27.

Use of sweet maize as a trap crop for *Heliothis obsoleta* [*Helicoverpa armigera*] in southern Rhodesia was questionable since it attracted *Glottula fusca* [*Busseola fusca*].

019

Jepson, W.F. 1954. A critical review of the world literature on the lepidopterous stalk borers of tropical graminaceous crops. London, UK: Commonwealth Institute of Entomology. 127 pp.

Identification, host plants, bionomics, population estimation and damage assessment, natural enemies, and control of stem borers including *Busseola fusca* are reviewed. Recommendations for future research on stem borers are outlined.

020

La Croix, E.A.S. 1967. Maize stalk borers [*Busseola fusca*] in the Coast province of Kenya. East African Agricultural and Forestry Journal 33(1): 49-54.

021

Lefevre, P. 1935. [Study on *Busseola fusca* Hmps., pest of maize.] Etude sur *Busseola fusca* Hmps. parasite du maïs. (In Fr.) Bulletin Agricole du Congo Beige 26(4): 448-452. 3 ref.

Maize in Ruand-Urundi [Zaire] was severely infested by *Busseola fusca* in Feb. 1935. The pest could withstand a minimum temperature of 10.7 deg C and a maximum of 28.6 deg C. Biology and control measures of the pest are described.

022

Lounsbury, C.P. 1915. Division of Entomology: annual report 1913-14. Report, Department of Agriculture, Union of South Africa 1913-14: 199-216. Progress was made in the investigations of *Sesamia fusca* [*Busseola fusca*].

023

Mally, C.W. 1920. The maize stalk borer, *Busseola fusca*, Fuller. Bulletin, Department of Agriculture, Union of South Africa 3: 111 pp.

Available information on *Busseola fusca* is recorded. The pest has 2-3 generations. Natural enemies are not effective. Cultural methods suitable to local conditions are effective against the pest.

024

Matthee, J.J. (ed.) 1974. Pests of graminaceous crops in South Africa. Entomology Memoir, Department of Agricultural Technical Services, Republic of South Africa 40: 26 pp. 79 ref.

Distribution, severity of damage, bionomics, and control measures of *Busseola fusca* are reviewed. Future lines of research are outlined.

025

Morstatt, H. 1913. [List of noxious insects.] Liste schadlicher insekten. (In De.) Pflanze 9(6): 288-296.

Busseola fusca is included in the list of insect pests of East Africa.

026

Moyal, P. 1988. [The borers of maize in the savannah area of Ivory Coast. Morphological, biological and ecological data. Control trials and plant-insect relations.] Les foreurs du maïs en zone des savanes en Côte-d'Ivoire. Données morphologiques, biologiques, écologiques. Essais de lutte et relation plante-insecte. (In Fr.) Paris, France: ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer). Ph.D. thesis, Université de Paris, Paris, France.

Distribution, biology, ecology, and control of 5 maize borers including *Busseola fusca* were studied during 1982-83. *B. fusca* was effectively controlled by deltamethrin at 15 g a.i./ha applied 20 and 40 days after plant emergence.

027

N'Doye, M. 1977. Synthesis of some results achieved about millet and sorghum boring insects [including *Busseola fusca*] in Senegal. Presented at the Working Meeting on Grass Boring Insects, Nov 1977, Bouaké, Ivory Coast. (In Fr.) 9 pp. 3 ref.

028

Reddy, K.V.S. 1984. Sorghum stem borers. Annual Report, International Centre of Insect Physiology and Ecology 1983:18.

Infestation of *Busseola fusca* started during 8th week after planting at Mbita Point, Kenya, and during 5th week in farmers' fields. Several parasites and predators were recorded on stem borers including *B. fusca*. Sorghum lines resistant to stem borers were identified.

029

Reddy, K.V.S. 1989. Sorghum stem borers in eastern Africa. (Summary(s) in Fr.) Page(s) 33-40 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 45 ref.

Literature on the distribution, biology, ecology, yield losses, and control measures of stem borers including *Busseola fusca* is reviewed.

030

Reddy, K.V.S., and Omolo, E.O. 1985. Sorghum insect pest situation in eastern Africa. Page(s) 31-36 in Proceedings of the International Sorghum Entomology Workshop, 15-21 Jul 1984, College Station, Texas, USA. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 19 ref.

Distribution, crop losses, and control measures of sorghum pests (including *Busseola fusca*) in eastern Africa are reviewed. *B. fusca* is reported from Burundi, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

031

Saunders, A.R. 1930. The maize stalk-borer (*Busseola fusca*, Fuller). Page(s) 188-195 in Maize in South Africa. South African Agricultural Series vol. 7. South Africa: Central News Agency Ltd.

Distribution, description, life cycle, severity of damage, and control of *Busseola fusca* are discussed.

032

Sithole, S.Z. 1989. Maize insect pests in Zimbabwe. (Summary(s) in Es, Fr.) Page(s) 286-288 in Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects, 9-14 Mar 1987, Mexico. Mexico: Centro Internacional de Mejoramiento de Maíz y Trigo. 5 ref. [Es summary: p. 313; Fr summary: pp. 326-327].

Distribution, severity of damage, and control measures of maize insect pests including *Busseola fusca*, are discussed. Chemical control was achieved by using endosulfan 1 per cent dust or trichlorfon 2.5 per cent G. Carbofuran 10 per cent G at planting time and carbaryl 85 w.p. were also used by commercial farmers. Development and

utilization of maize genotypes resistant to stem borers is suggested.

033

Sithole, S.Z. 1989. Sorghum stem borers in southern Africa. (Summary(s) in Fr.) Page(s) 41-47 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 26 ref.

Literature on the distribution, biology, and control measures of *Busseola fusca* is reviewed.

034

Smith, J.G. 1965. Stem borers of maize [including *Busseola fusca*]. Ghana Farmer 9(2): 49-51.

035

Swaine, G. 1964. The African maize borer [*Busseola fusca*]. Agricultural and Veterinary Chemicals 5(5): 147.

036

Taylor, D.E. 1982. Entomology notes. The maize stalk-borer. Zimbabwe Agricultural Journal 79(4): 119.

Notes are provided on the identification, host plants, severity of damage, biology, and control of *Busseola fusca* in Zimbabwe.

037

Usua, E.J. 1977. *Busseola fusca* (Full.). Page(s) 468-470 in Diseases, pests and weeds in tropical crops (Kranz, J., Schmutterer, H., and Koch, W., eds.). Berlin, Federal Republic of Germany: Verlag Paul Parey.

Distribution, host plants, damage symptoms, economic importance, morphology, life cycle and ecology, natural enemies, and control measures of *Busseola fusca* are briefly discussed.

038

van Eijnatten, C.L.M. 1965. Towards the improvement of maize in Nigeria. (Summary(s) in Nl.) Mededelingen van de Landbouwhoogeschool te Wageningen 65(pt.3): 120 pp.

Bionomics, severity of damage, and control of *Busseola fusca* are given.

039

van Rensburg, G.D.J., and Drinkwater, T.W. 1987. The maize stalk borer. Farming in South Africa D.3: 7 pp.

The life cycle and seasonal incidence of *Busseola fusca* in South Africa are outlined. It attacks both

maize and sorghum and causes an annual crop loss of 10 per cent. Methods for its control are described.

040

Walker, P.T. 1957. The progress of stalk borer control in East Africa. Miscellaneous Report, Colonial Pesticide Research, Tanganyika 191: 7 pp. 11 ref.

Research on various aspects (survey and systematics, bionomics and life cycle, laboratory work with insecticides, field trials, sampling, infestation, and yield) of stem borers including *Busseola fusca* is reviewed.

041

Walker, P.T., and Hodson, M.J. 1976. Developments in maize stem-borer control in East Africa, including the use of insecticide granules. Annals of Applied Biology 84:111-114. 21 ref.

Literature on life cycle, nature of damage, and control measures of *Busseola fusca* are reviewed. Attack of 1st generation pest was favored by rainfall over 10 mm in Jan.-Feb. and 2nd generation later by heavy rains. Granules containing endosulfan and tetrachlorvinphos were effective in controlling the pest.

042

Whellan, J.A. 1956. Some recent observations on maize pests. Page(s) 45-47 in Proceedings of the second Annual Conference of the Professional Officers of the Department of Research and Specialist Services, 19-20 Mar 1956, Salisbury, Southern Rhodesia. Salisbury, Southern Rhodesia: Federal Ministry of Agriculture. 4 ref.

A new species of *Busseola* was observed on *Penisetum purpureum* in southern Rhodesia. Moths of this species were darker and winter diapause was easily terminated by higher temperature and humidity. Life cycle and control measures of *B. fusca* are described.

043

Zampalegre, A. 1979. [Aspects of the biology and damage of *Busseola fusca* on sorghum.] Elements de biologie et degats de *Busseola fusca* sur sorgho. (In Fr.) Diplome d'Ingenieur du Developpement Rural, Universite de Ouagadougou, Ouagadougou, Upper Volta. 52 pp.

Studies were conducted on the biology, life cycle, and seasonal fluctuation of *Busseola fusca*, and the severity of damage and crop losses in Burkina Faso. Yield losses as high as 42.88 per cent were

reported. Cultural practices such as destruction of crop residue or its incorporation in the soil, and natural enemies are suggested for the control of the pest.

Descriptions (Taxonomy)

044

Bowden, J. 1956. New species of African stem-boring Agrotidae (Lepidoptera). Bulletin of Entomological Research 47(3): 415-428. 2 ref.

Adults of 3 new genera and 6 new species are described. *Busseola quadrata* and *B. segeta* resemble a rufous-ochraceous form of *B. fusca*, and *B. phaia* the infusate form.

045

Hampson, Sir G.F. 1902. *Sesamia fusca*, n.sp. Annals of the South African Museum 2: 296.

Taxonomic description of *Sesamia fusca* [*Busseola fusca*] and the distinguishing characteristics from three other members of the genus *Sesamia* are given.

046

Tarns, W.H.T., and Bowden, J. 1953. A revision of the African species of *Sesamia* Guenee and related genera (Agrotidae-Lepidoptera). Bulletin of Entomological Research 43(4): 645-678. 28 ref.

Six genera and 29 species were revised and a new genus *Speia* is erected for *Phalaena vuteria* Stoll. *Busseola* was also included in the revision.

047

Usua, E.J. 1969. Description of the larvae of *Busseola fusca* Fuller and *Manga basilinea* Bowden (Lepidoptera: Noctuidae). Bulletin of the Entomological Society of Nigeria 2(1): 77-81. 6 ref.

048

Usua, E.J. 1987. Descriptions of the larvae and pupae of some important lepidopterous stem-borers of cereals. Occasional Publication no.29. Samaru, Zaria, Nigeria: Entomological Society of Nigeria. 21 ref.

Busseola fusca is one of the 8 stem borers described. The common name, host plants, world distribution, and the characteristics distinguishing male from female pupae, for each species, are given. Simple keys based on the morphological features, and on chaetotaxy in the case of larvae, are provided for identification of the borers.

049

van Rensburg, G.D.J. 1987. Stalk borer in maize—identification chart. Farming in South Africa D.1:1 p.

Key features for identifying *Busseola fusca*, *Sesamia calamistis*, and *Chilo partellus* based on egg, larval and adult morphology, distribution in South Africa, and host range are tabulated.

Biology, Ecology, Pest Status, and Crop Loss Assessment

050

Anonymous. 1927. Miscellaneous entomological notes. Farming in South Africa 1(1): 10.

Busseola fusca was not found in the Transvaal during Jan. 1926.

051

Anonymous. 1930. Reports received from the Experiment Stations. Progress Reports from Experiment Stations, Empire Cotton Growing Corporation 1930: 71-72.

Busseola fusca was highly destructive in Natal, South Africa. No grain could be produced from sorghum grown near native-grown maize and sorghum, though in other locations good crops were harvested.

052

Anonymous. 1944. Progress reports from experiment stations, season 1942-1943. Progress Reports from Experiment Stations, Empire Cotton Growing Corporation 1942-43:181 pp.

Busseola fusca larvae were observed on sorghum stems.

053

Anonymous. 1946. Annual report 1946. Report, Department of Agriculture, Kenya 1945: 125 pp.

Busseola fusca damage to maize in the Trans Nzoia and Vasin Gishu districts of Kenya is reported.

054

Anonymous. 1968. Outbreaks and new records. FAO Plant Protection Bulletin 16(4): 71-74. 2 ref.

Busseola fusca infestation on maize in Somalia is reported.

055

Aders, W.M. 1913. Entomology in relation to agriculture. Report, Medical and Sanitary Divisions, Zanzibar 1913: 84-93.

Larvae and pupae of *Busseola fusca* were found in the main stalk of millet in Zanzibar.

056

Adesiyun, A.A. 1979. Stem borer outbreak on sorghum and maize in 1978. *NOMA* 2(1): 5-7.

In 1978, early onset of rains resulted in a shortening of the unfavorable dry season. Pest mortality was therefore reduced. Coupled with early sowing of maize and sorghum, and synchronization with peak oviposition of *Busseola fusca*, a severe outbreak was recorded.

057

Adesiyun, A.A. 1983. Studies on some effects of relative humidity, food and light in termination of larval diapause in *Busseola fusca* (Lepidoptera: Noctuidae). *Nigerian Journal of Entomology* 4(1-2): 88-93.

Larval diapause in *Busseola fusca* was influenced by the cumulative effects of time and one of, or all the factors tested. Low relative humidity, darkness, and absence of food retarded diapause development. The time required for diapause development and pupation decreased as the dry season progressed.

058

Adesiyun, A.A. (In press.) Influence of sorghum and millet diets on the survival, development and oviposition of the stem borer, *Busseola fusca* (Fuller). *Nigerian Journal of Entomology* ? : ?.

Larval and pupal mortality of *Busseola fusca* was higher on millet (85 per cent and 26.7 per cent, resp.) than on sorghum (39 per cent and 6.5 per cent, resp.). *B. fusca* fed on millet was smaller, weighed less, laid fewer eggs, and had longer pre-oviposition periods.

059

Adeyemi, S.A.O. 1969. The survival of stem borer population in maize stubble. *Bulletin of the Entomological Society of Nigeria* 2(1): 16-22. 8 ref. *Busseola fusca* emerged from maize stubble during studies at Moor Plantation, Ibadan, Nigeria in 1964-68. Stubble left after the early-season harvest had an average of 27 borers/100 stalks and that of the late-season harvest 15/100 stalks.

060

Alawode, DA 1985. 1984 annual report. Millet pathology. Samaru, Zaria, Nigeria: IAR (Institute for Agricultural Research)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). p. 2. (Limited distribution.)

All entries in the millet pathology trials at Nigeria showed 100 per cent borer (*Sesamia calamistis* and *Busseola fusca*) infestation.

061

Allan, W. 1930. Insect pests and plant diseases of economic importance during the year [1929]. Report, Department of Agriculture, Northern Rhodesia 1929: 36-44.

Maize in northern Rhodesia was attacked by *Busseola fusca*.

062

Allan, W. 1931. Insect pests and plant diseases of economic importance during the year [1930]. Report, Department of Agriculture, Northern Rhodesia 1930: 21-24.

Young maize was severely damaged by *Busseola fusca* in northern Rhodesia. The pest did not attack farms on which crop residues were regularly destroyed.

063

Anderson, T.J. 1927. Annual report of the Entomologist. Report, Department of Agriculture, Kenya 1926:135-147.

Busseola fusca is widely distributed and constantly present in Kenya because of the continuous presence of volunteer maize.

064

Anderson, T.J. 1932. Entomological Section, annual report, 1931. Report, Department of Agriculture, Kenya 1931: 99-117.

Busseola fusca infestation on maize stalks increased up to 60 per cent during the year 1931 in Kenya (according to H. Wilkinson's report).

065

Ayuk-Takem, J.A., Chheda, H.R., and Ekebil, J.P. 1982. Problems and potentials of maize research and production in Cameroon (*Zea mays* L.). (Summary(s) in Fr.) *Revue Science et Technique* 2(4): 5-16. 18 ref.

Busseola fusca was one of the common pests on maize in Cameroon.

066

Ballard, E. 1914. A list of the more important insect pests of crops in the Nyasaland Protectorate. *Bulletin of Entomological Research* 4(4): 347-351.

Busseola fusca caused severe losses by boring into maize and millet stems.

067

Barrow, M.R. 1989. Screening and breeding for resistance to *Busseola fusca* Page(s) 184-191 in *Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects*, 9-14 Mar 1987, Mexico. Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo. 16 ref. [Es summary: pp. 308-309; Fr summary: pp. 321-322].

Biology of *Busseola fusca*, and methods of maintaining a regular supply of 1st instar larvae, artificial infestation, damage evaluation, development and utilization of resistance involving population and inbred development, and measuring the effectiveness of resistance are described. Three resistance factors (the 1st that kills the early instar larvae, the 2nd that repels larvae, and, the 3rd that retards larval development) and their role in integrated pest management are described.

068

Beevor, P.S., Hall, D.R., and Nesbitt, B J. 1983. Pheromones and other recent developments in biochemical pest management. Page(s) 163-171 in *Chemistry and world food supplies: the new frontiers, CHEMRAWN II: papers presented at the International Conference on Chemistry and World Food Supplies*, 6-10 Dec 1982, Manila, Philippines (Shemilt, L.W., ed.). Oxford, UK: Pergamon Press.

Busseola fusca on maize was monitored by the use of pheromones in Zimbabwe.

069

Blair, B.W. 1971. Recent research on the maize stalk-borer *Busseola fusca* (Fuller): influence on control methods. *Rhodesia Agricultural Journal* 68(6): 111-112. 8 ref.

The occurrence, biology, and severity of damage of *Busseola fusca* on maize in Africa are reviewed with special reference to Rhodesia. The possibility of using a sex pheromone for the control of the pest is discussed.

070

Blair, B.W., and Read, J.S. 1969. A preliminary report on the sex pheromone of the maize stalk-borer *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). *Rhodesian Journal of Agricultural Research* 7(1): 55-59. 11 ref.

A sex pheromone in virgin females of *Busseola fusca* was identified as an unsaturated acetate

ester. Morphology and histology of the sex pheromone gland are described.

071

Bonzi, S.M. 1982. [*Chilo diffusilineus* J. de Joannis (Lepidoptera Pyralidae), a cereal stem borer in irrigated and rainfed crops in Upper Volta [Burkina Faso].] *Chilo diffusilineus* J. de Joannis (Lepidoptera Pyralidae) borer des tiges de cereales irriguees et pluviales en Haute-Volta. (In Fr. Summary(s) in En, Es.) *Agronomie Tropicale* 37(2): 207-209. 5 ref.

Busseola fusca caused 96.3 per cent infestation on sorghum, 6.9 per cent on maize, and 2.1 per cent on pearl millet.

072

Bonzi, S.M. 1982. Note on sorghum insect pests in Upper Volta. Page(s) 747 in *Sorghum in the eighties: proceedings of the International Symposium on Sorghum*, 2-7 Nov 1981, ICRISAT Center, India. Vol.2. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Abstract.)

Busseola fusca was one of the most common insect pests on sorghum in Upper Volta [Burkina Faso].

073

Bonzi, S.M., Doumbia, Y.O., Selvaraj, C.J., and Konate, A. 1986. Pest problems on sorghum in the Sahel. Page(s) 108-118 in *Proceedings of an International Seminar of the CILSS Project on Integrated Pest Management*, 6-13 Dec 1984, Niamey, Niger. Ouagadougou, Burkina Faso: CILSS (Comite Permanent Inter-etats de Lutte Contre la Secheresse dans le Sahel).

Severity of damage and biology of *Busseola fusca* are briefly discussed.

074

Bosque-Perez, N.A., and Mareck, J.H. 1990. Distribution and species composition of lepidopterous maize borers in southern Nigeria. *Bulletin of Entomological Research* 80: 363-368. 22 ref.

Borers at 6 locations in southern Nigeria were studied during the second planting season (Aug.-Nov.). *Busseola fusca* was found at Idah and Alabata, and constituted a small proportion (2 to 29 per cent) of the population.

075

Botchey, M.A. 1985. Population patterns of stem borers on maize. Annual Report, International Centre of Insect Physiology and Ecology 1984: 6-7.

Busseola fusca appeared in very low numbers on maize at Nairobi, Kenya showing peaks of less than 0.17 larvae and pupae per plant.

076

Bowden, J. 1976. Stem-borer ecology and strategy for control. *Annals of Applied Biology* 84(1): 107-111. 2 ref.

The co-evolution of tropical stem borers (including *Busseola fusca*) with their graminaceous hosts is traced. Crop damage and response are linked to the adaptation of the host plants.

077

Breniere, J. 1970. [Entomological research carried out in French-speaking West Africa in the fields of sorghum and millet.] *Recherches entomologiques effectuees en Afrique de l'Ouest francophone en matiere de sorgho et de mil.* (In Fr.) *African Soils/Sols Africains* 15(1-3): 85-91. [Also in En on pp. 93-99]

Busseola fusca was reported as one of the stem borers of sorghum in West Africa.

078

Chikonda, M.M., and Mkamanga, G.Y. 1988. Sorghum and millet entomology in Malawi. Page(s) 63-68 in *Proceedings of the fourth Regional Workshop on Sorghum and Millets for Southern Africa, 21-24 Sep 1987, Matopos, Zimbabwe.* Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Incidence of *Busseola fusca* on pearl millet in Malawi is reported.

079

Chorley, J.K. 1946. Report of the Division of Entomology for the year ending 31st Dec 1945. *Rhodesia Agricultural Journal* 43: 547-562. [Also issued as: Bulletin, Ministry of Agriculture [Southern Rhodesia] no. 1377.]

Maize planted in Salisbury, Southern Rhodesia, in January 1945 was severely damaged by *Busseola fusca*,

080

CIE (CAB International Institute of Entomology). 1988. *Busseola fusca* (Fuller). Distribution Maps of Pests, Series A (Agricultural) 499: 2 pp.

World distribution of *Busseola fusca*, together with supporting references is given. The map

shows Angola, Benin, Burkina Faso, Burundi, Cameroon, Chad, Ethiopia, Gabon, Ghana, Guinea, Cote d'Ivoire, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, and Zimbabwe as the countries affected by *B. fusca*.

081

Cletus, A.T. 1989. Maize pest problems in Cameroon: the present and future role of host plant resistance. (Summary(s) in Es, Fr.) Page(s) 289-290 in *Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects, 9-14 Mar 1987, Mexico.* Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo. [Es summary: p. 314; Fr summary: p. 327]

Busseola fusca is recorded in the high rainfall, lowland area of Cameroon.

082

Doumbia, Y.O. 1980. [Entomology of sorghum and millet.] *Entomologie du mil - sorgho.* (In Fr.) Page(s) 3-4 in *Cellule de la defense des cultures resultats de la campagne 1979.* Document no.6. Bamako, Mali: Section de Recherches sus les Cultures Vivrieres et Oleagineuses.

Busseola fusca was observed on sorghum in Masantola, Sotuba, and Kogoni regions of Mali.

083

Esele, J.P.E. 1986. Crop protection aspects of sorghum in Uganda. Page(s) 244-258 in *Sorghum and millet improvement in eastern Africa: proceedings of the fifth Regional Workshop, 5-12 Jul 1986, Bujumbura, Burundi.* Nairobi, Kenya: SAFGRAD (Semi-Arid Food Grain Research and Development)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern Africa Regional Program. 3 ref.

Severity of damage of stalk borers is described. Screening trials for *Chilo* sp. and *Busseola* sp. resistance, are mentioned.

084

Evans, A.C. 1951. Entomological research in the Overseas Food Corporation (Tanganyika). *Annals of Applied Biology* 38: 526-529.

Severe infestation of sorghum by *Busseola fusca* occurred during 1947-49 in the experimental farm at Kongwa and affected large-scale planting

which was only possible in 1949-50 when infestation was less severe.

085

Fuller, C. 1901. First report of the Government Entomologist. Report, Department of Agriculture, Natal 1899-1900: 45-48.

Life cycle and distribution of *Sesamia fusca* [*Busseola fusca*] are given.

086

Gebre-Amlak, A. 1985. Survey of lepidopterous stem borers attacking maize and sorghum in Ethiopia. Ethiopian Journal of Agricultural Sciences 7(1): 15-26. 7 ref.

Busseola fusca was one of the 3 stem borers recorded. The pest was dominant at higher altitudes (1160 to 2500 m) and cooler areas. Of 6 parasitoids recorded, *Apanteles sesamiae* was the most widespread. *Diaperasticus erythrocephala* was noticed for the first time preying upon *B. fusca* larva at Welega, Ethiopia.

087

Gebre-Amlak, A. 1988. Development of maize stalk borer, *Busseola fusca* (Fuller) in wild host plants in Ethiopia. (Summary(s) in De.) Journal of Applied Entomology 106(4): 390-395. 8 ref.

Pennisetum purpureum and *Sorghum verticilliflorum* (thick stemmed), and *Saccharum officinarum* and *Sorghum verticilliflorum* (thin stemmed) were identified as the major and minor alternative hosts for *Busseola fusca*, respectively.

088

Gebre-Amlak, A. 1988. Ecology and management of maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in southern Ethiopia. Ph.D. thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden. 106 pp. 36 ref.

Distribution, biology, sources of infestation, and cultural control of *Busseola fusca* were studied. The impact of wild and cultivated host plants, treatment of crop residues, and planting dates were assessed in the context of non-pesticide management techniques.

089

Gebre-Amlak, A. 1989. Phenology and fecundity of maize stalk borer *Busseola fusca* (Fuller) in Awassa, southern Ethiopia. Insect Science and its Application 10(2): 131-137. 20 ref.

Three generations of *Busseola fusca* per year were observed on maize. Pupation of diapause larvae

was observed in Apr. Fecundity and longevity of the 1st generation female moths from non-diapause larvae were more than those from diapause generation. Peak oviposition period was between the 2nd and 5th nights after moth emergence.

090

Gebre-Amlak, A. 1989. Termination of diapause in the maize stalk borer, *Busseola fusca* (Fuller) (Lep., Noctuidae), in Awassa, southern Ethiopia. Journal of Applied Entomology 107(2): 160-165. 15 ref.

Busseola fusca pupated from 17-26 Apr. in the field. A cumulative rainfall of about 80 mm or above from Mar. was necessary to induce pupation.

091

Gebre-Amlak, A. 1990. Lepidopterous stem borers attacking maize and sorghum and their management in Ethiopia. Page(s) 262-268 in Cereals of the semi-arid tropics: proceedings of a Regional Seminar, 12-16 Sep 1989, Garoua, Cameroon. Stockholm, Sweden: International Foundation for Science.

Busseola fusca was one of the three borers observed. The pest was dominant at higher altitudes (1160-2500 m) and in cooler areas. Diapausing larvae were found in residues of different lengths, but longer stalks contained more larvae. Placing infested maize horizontally for 4 weeks or sorghum stalks for 2 weeks was effective in reducing *B. fusca* larvae. Early planting of maize in Apr. is suggested to increase yields without using insecticides against the pest.

092

Girling, D.J. 1978. The distribution and biology of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) and its relationship to other stem-borers in Uganda. Bulletin of Entomological Research 68(3): 471-488. 22 ref.

Field populations of 4 stem borers including *Busseola fusca* were studied during 1971-72. Although the four species attacked the same host plants (maize, sorghum, and sugarcane), they occupied different ecological niches. *Eldana saccharina* was predominant on mature plants while *B. fusca* preferred 3-month-old plants.

093

Hargreaves, E. 1929. Report on the Entomological Section. Section I. Report, Department of Land and Forests, Sierra Leone 1928: 20-22.

Busseola fusca was found in the stalks of maize in Sierra Leone.

094

Hargreaves, H. 1924. Annual report of the Government Entomologist. Report, Department of Agriculture, Uganda 1922: 29-32.

Incidence of *Busseola fusca* on maize was reported for the first time in Uganda in 1922.

095

Hargreaves, H. 1927. Annual report of the Government Entomologist. Report, Department of Agriculture, Uganda 1926: 24-27.

Infestation of *Busseola fusca* on maize in Uganda is reported.

096

Hargreaves, H. 1928. Annual report of the Government Entomologist. Report, Department of Agriculture, Uganda 1927: 11 pp.

Busseola fusca caused considerable damage to maize in Uganda.

097

Hargreaves, H. 1932. Annual report of the Government Entomologist. Report, Department of Agriculture, Uganda 1931 (pt.2): 43-47.

The egg, larval, pupal, and preoviposition periods of *Busseola fusca* on maize lasted 10, 68-74, 14-16, and 3-5 days, respectively. A maximum of 249 eggs were laid in 5 days. Infestation was scarce on the Oct.-Dec. crop in Uganda.

098

Harris, K.M. 1957. Cereal stem borers, northern region of Nigeria. Report on the Agricultural Department, Nigeria 1955-56: ?.

Busseola fusca was one of the second most abundant of 4 spp. of stem borers recorded in northern Nigeria on sorghum, maize, and rice. *Busseola fusca* was predominant in Zaria and Kano. There was a significant positive correlation between the number of stems bored and the yield.

099

Harris, K.M. 1964. Annual variations of dry-season populations of larvae of *Busseola fusca* (Fuller) in northern Nigeria. Bulletin of Entomological Research 54(4): 643-647.

Busseola fusca larvae survived the 5-6 rainless months in diapause in crop residues. Larval mortality was low between Jan. and Mar. Date and location of sampling did not influence larval populations significantly.

100

Harris, K.M. 1989. Bioecology of sorghum stem borers. Page(s) 63-71 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRI-SAT Center, India. Patancheru, A.R 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 51 ref.

Literature on the distribution, biology, and ecology of *Busseola fusca* is reviewed.

101

Harris, W.V. 1944. Annual report of the Entomologist for the year 1943. Report, Department of Agriculture, Tanganyika Territory 1943: 5 pp.

Busseola fusca infestation on maize and sorghum in Tanganyika territory is reported.

102

Hassanali, A. 1989. Synopsis of the Unit's [Chemistry and Biochemistry Research Unit] major accomplishments. Annual Report, International Centre of Insect Physiology and Ecology 1988: 61-62.

Isolation and characterization of the protein associated with diapause in *Busseola fusca* larvae is reported.

103

Heenop, H.C. 1960. Maize stalk borer [*Busseola fusca*] and army worm: investigations indicate rainfall influences development. Farming in South Africa 36(4): 27-29.

104

Ho, D.T., and Reddy, K.V.S. 1983. Monitoring of lepidopterous stem-borer population by pheromone and light traps. Insect Science and its Application 4(1-2): 19-23. 22 ref.

Busseola fusca was the least attracted among the 5 species of stem borers tested in the pheromone and light trap studies in sorghum and maize fields in western Kenya during 1981-82.

105

IAPSC (Interafrican Phytosanitary Council). 1985. *Busseola fusca* (Fuller). Distribution Maps of Major Crop Pests and Diseases in Africa 193: 2 pp. [Text also in Fr.]

The map shows Angola, Benin, Cameroon, Ethiopia, Ghana, Cote d'Ivoire, Kenya, Lesotho, Malawi, Nigeria, Rwanda, Sierra Leone, Somalia, Tanzania, Togo, Uganda, Zaire, Zambia, and Zimbabwe as the countries affected by *Busseola fusca*.

106

IAR (Institute for Agricultural Research). 1983. Annual report of the Institute for Agricultural Research, Ahmadu Bello University 1981-82 (year ending 31st March 1982). Samara, Zaria, Nigeria: IAR. 74 pp.

Research on the severity of damage and control of *Busseola fusca* on sorghum in Nigeria is reviewed.

107

ICIPE (International Centre of Insect Physiology and Ecology). 1983. Maize borer, *Busseola fusca* Annual Report, International Centre of Insect Physiology and Ecology 1982: 31.

A brief report of rearing *Busseola fusca* on artificial diet is given. Duration of larval development using artificial diet and stems is compared.

108

ICIPE (International Centre of Insect Physiology and Ecology). 1983. Sorghum and maize stem borers. Annual Report, International Centre of Insect Physiology and Ecology 1982: 21.

Distribution, alternative host plants, parasites, and predators of stem borers including *Busseola fusca* are discussed. List of sorghum lines resistant to both *Chilo partellus* and *B. fusca* is given.

109

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1984. Stem borer (*Busseola fusca*). Annual Report, International Crops Research Institute for the Semi-Arid Tropics 1983: 52-53.

In Nigeria, damage by *Busseola fusca* on sorghum was estimated by visual rating system. The rating in the upper half of the stalk provided the highest correlation. Time of infestation and grain weight per head were highly correlated. Boot formation and flowering were critical periods. Yield reductions were lower with late infestations.

110

Ingram, W.R. 1970. Pests of cereals. Page(s) 227-228 in *Agriculture in Uganda* (Jameson, J.D., ed.). London, UK: Oxford University Press.

Busseola fusca is reported as one of the most common stem borers attacking cereals and sugarcane in Uganda.

111

IRA (Institut de la Recherche Agronomique). 1985? Maize entomology. Page(s) 99-111 in *National Cereals Research and Extension Pro-*

ject. NCRE. Annual report 1984. Yaounde, Cameroon: IRA.

In Cameroon, *Busseola fusca* accounted for 98.1, 0, and 24 per cent of the maize borers at Yaounde, Bertoua, and Ekona, resp., during the first season, and 69, 23.4, and 41.3 per cent resp., during the second season. *B. fusca* infestation at vegetative, flowering, and post flowering stages was 58.4, 26.5, and 15.1 per cent respectively.

112

IRAT (Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres). 1986. [Entomological sampling in maize plots (stem-borers).] Sondages entomologiques dans les parcelles de maïs (foreurs des tiges). (In Fr.) Montpellier, France: IRAT. 2 pp.

Methods involving measurement of infestation levels and estimation of yield losses are presented for assessing the damage caused by *Busseola fusca* on maize.

113

Isa, A.L. 1968. Somalia: note on insect pests of maize. *FAO Plant Protection Bulletin* 16(4): 73-74. 2 ref.

In Somalia, *Busseola fusca* infestation ranged from 20-60 per cent in Nov. 1965. Infestation was more in the lower Juba than in the Chebelli Valley.

114

Jack, R.W. 1917. The maize stalk borer (*Calamistes fusca*, Hmps.). *Rhodesia Agricultural Journal* 14(6): 707-717.

Life cycle and cultural control of *Calamistes fusca* [*Busseola fusca*] are discussed. Second brood larvae that bored into the stalks of maize and kaffir corn [sorghum] hibernated as far down as the roots.

115

Jack, R.W. 1931. Report of the Chief Entomologist for the year 1930. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1930: 65-73.

Approximately 85 per cent of *Busseola fusca* larvae on maize in southern Rhodesia hibernated in the stalks above the ground level. Maize planted early was not helpful as a trap crop because of delayed rains and germination.

116

Jack, R.W. 1940. Report of the Division of Entomology for the year ending 31st December, 1939.

Report of the Secretary, Department of Agriculture, Southern Rhodesia 1939: 35 pp.

Busseola fusca damaged maize severely during Apr. and May. Early sown maize was badly attacked in Dec. in some areas in southern Rhodesia.

117

Jordan, F.J. 1966. Report on an investigation into the presence and prevalence of rice stem borers and their parasites in Sierra Leone, 1964-1965. Rokupr, Sierra Leone: West African Rice Research Station. 49 pp.

Busseola fusca was reared to maturity on rice in Sierra Leone [as quoted in Grist and Lever 1969, p. 124].

118

KARI (Kenya Agricultural Research Institute). 1982? Entomology and biological control. Page(s) 75-86 in Kenya Agricultural Research Institute. Record of research. Annual report 1981. Nairobi, Kenya: KARI. 11 ref.

Research on the ecology and control of *Busseola fusca* is reported along with other pests of maize in Kenya.

119

Kaufmann, T. 1983. Behavioral biology, feeding habits, and ecology of three species of maize stem-borers: *Eldana saccharina* (Lepidoptera: Pyralidae), *Sesamia calamistis* and *Busseola fusca* (Noctuidae) in Ibadan, Nigeria, West Africa. Journal of the Georgia Entomological Society 18(2): 259-272. 14 ref.

Peak populations of *Busseola fusca* on maize occurred from Jun. to Oct. Full-grown larvae entered diapause from Nov.-Dec. to Apr.-May and adults emerged after 5-6 months. Parthenogenesis was observed for the first time.

120

Kaufmann, T. 1983. Observations on the host plant adaptation of *Busseola fusca* (Lepidoptera: Noctuidae) in Nigeria. Proceedings of the Entomological Society of Washington 85(2): 321-326. 5 ref.

Sorghum diets of *Busseola fusca* produced high mortality, unbalanced sex ratio, and sterility. Adaptation to different diets resulted in genetic differences.

121

Kfir, R. 1988. Hibernation by the lepidopteran stalk borers, *Busseola fusca* and *Chilo partellus*

on grain sorghum. Entomologia Experimentalis et Applicata 48(1): 31-36.

Busseola fusca infested more than 90 per cent of sorghum (cultivar SSK-52) in the dry season of 1986 (Apr.-Oct.) at Delmas and Brits, Transvaal, South Africa. About 82 per cent of *B. fusca* hibernated as 6th instar larvae and 16 per cent as 5th instar larvae. Pupal period lasted for 3 weeks during Oct.-Nov. Some parasites (*Apanteles sesamiae*, *Chelonus curvimaculatus*, *Chelonus* sp., *Pristomerus* sp., *Bracon* sp., and *Iphiaulax* sp.) and predators (*Pheidole megacephala* and *Dorylus helvolus*) are reported.

122

Kfir, R. 1989. Stalkborer hibernation on grain sorghum. Bulletin of the Plant Protection Research Institute (South Africa) 15: 8.

More than 90 per cent of sorghum plants were infested by *Busseola fusca* and *Chilo partellus* in the Transvaal. Infestation dropped gradually as winter progressed. Parasitism was higher on *B. fusca* when compared to that of *C. partellus*. Some parasites and predators are reported.

123

Lamborn, W.A. 1914. The agricultural pests of the southern provinces, Nigeria. Bulletin of Entomological Research 5(3): 197-214.

Busseola fusca infested maize in Nigeria.

124

Leuschner, K. 1988. Cereal entomology in the SADCC region. Page(s) 273-280 in Proceedings of the fourth Regional Workshop on Sorghum and Millets for Southern Africa, 21-24 Sep 1987, Matopos, Zimbabwe. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Incidence of *Busseola fusca* on sorghum at research stations in Makoka, Malawi; Gairo, Tanzania; and Matopos, Henderson, Panmure, and Aisleby, Zimbabwe is reported.

125

Leuschner, K. 1990. Sorghum and millet entomology in the SADCC region 1988/89. Page(s) 105-117 in Proceedings of the sixth Regional Workshop on Sorghum and Millets for Southern Africa, 18-22 Sep 1989, Bulawayo, Zimbabwe. Bulawayo, Zimbabwe: SADCC (Southern African

Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Infestation of finger millet by *Busseola fusca* at Matopos, Zimbabwe and use of thiodan for its control are reported.

126

Libby, J.L. 1968. A maize insect field study. Nigerian Entomologists' Magazine 1(5): 91-94. 8 ref.

Maize crop planted late in Aug. 1965 at Ife in western Nigeria was severely infested by *Busseola fusca* 9 weeks after sowing.

127

Lounsbury, C.P. 1925. Report of the Division of Entomology 1924-25. Journal of the Department of Agriculture, Union of South Africa 11(6): 577-586.

Busseola fusca infested South African broom corn [sorghum] more heavily than those imported from South America and Europe.

128

MacFarlane, J. 1983. Entomology research report 1982. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/SAFGRAD (Semi-Arid Food Grain Research and Development)/OAU (Organization of African Unity)/STRC (Scientific Technical Research Commission). 61 pp. (Limited distribution.)

Busseola fusca infestation, percentage of internodes bored, stem tunnelling, number of borers per plant, varieties showing high and low borer infestations, grain weight per head and 1000 grain weight, in various trials in Nigeria are reported.

129

MacFarlane, J. 1984. ICRISAT/SAFGRAD-Nigeria sorghum entomology-1983. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/SAFGRAD (Semi-Arid Food Grain Research and Development). 6 pp. (Limited distribution.)

High correlation was observed between time of infestation by *Busseola fusca* and sorghum grain yield. Boot formation and flowering were the most critical periods. There was no relationship between time of infestation and stem borer damage,

and extent of damage and grain yield. A method of visual estimation of stem borer damage is described.

130

MacFarlane, J.H. 1990. Damage assessment and yield losses in sorghum due to the stem borer *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in northern Nigeria. Tropical Pest Management 36(2): 131-137. 22 ref.

Relationship between different methods of assessing damage by *Busseola fusca* and grain weight per head in various sorghum cultivars is discussed. Visual damage rating system and nodes bored gave the best relationship. Sorghum infested before boot formation suffered greater yield losses.

131

Macharia, M. 1989. Yield losses in maize due to *B. fusca* [*Busseola fusca*] and its survival in crop residues. Annual Report, International Centre of Insect Physiology and Ecology 1988: 5.

Yield loss caused by *Busseola fusca* larvae was more during early growth stages than at later stages at Njoro, Kenya. Per cent grain yield loss was proportional to the number of borer larvae. Crop residue disposal practices - cut stumps, partial burning, deep ploughing, and harrowing reduced 64, 65, 67, and 89 per cent of live larvae, and 14, 17, 91, and 97 per cent of pupae, respectively.

132

Mally, C.W. 1920. Some zoological factors in the economic development of South Africa. South African Journal of Science 17(1): 64-75.

Busseola fusca infestation on maize in South Africa resulted in a loss of 540,000 sterling pounds in 1919.

133

Mally, C.W. 1920. The maize stalk borer, *Busseola fusca*, Fuller. Bulletin, Department of Agriculture, Union of South Africa 3: 111 pp.

Available information on *Busseola fusca* is recorded. The pest has 2-3 generations. Natural enemies are not effective. Cultural methods suitable to local conditions are effective against the pest.

134

Masina, G.T. 1990. Cereal insect pests in Swaziland. Page(s) 245-252 in Cereals of the semi-arid tropics: proceedings of a Regional Seminar, 12-16

Sep 1989, Garoua, Cameroon. Stockholm, Sweden: International Foundation for Science.

Busseola fusca was the second most important stem borer accounting for 19 per cent infestation in Swaziland. It was present in all the regions except the Lowveld.

135

Mason, C. 1916. Report of the Government Entomologist. Report, Department of Agriculture, Nyasaland 1916:19-22.

Absence of *Busseola fusca* was marked in Nyasaland in 1916.

136

Mchowa, J.W. 1990. The effect of planting date on the incidence of the stalk borers, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in two varieties of sorghum. Page(s) 154-159 in Proceedings of the sixth Regional Workshop on Sorghum and Millets for Southern Africa, 18-22 Sep 1989, Bulawayo, Zimbabwe. Bulawayo, Zimbabwe: SADCC (Southern African Development Co-ordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Larval incidence and population density of *Busseola fusca* and *Chilo partellus* in 2 sorghum varieties (Serena and ZSV1) planted at 4 planting dates (D1, D2, D3, and D4) at 14 day intervals starting from 9th Dec, were assessed during 1987-88 in Malawi. *B. fusca* infestation was higher on Serena in D1 and D4, and on ZSV1 in D2 and D3. *B. fusca* was less abundant than *C. partellus*.

137

Megenasa, T. 1982. Insect pests of sorghum in Ethiopia. Page(s) 54-64 in Sorghum improvement in eastern Africa: proceedings of the Regional Workshop, 17-21 Oct 1982, Nazreth and Debre Zeit, Ethiopia (Gebrekidan, B., ed.). Nazreth, Ethiopia: Ethiopian Sorghum Improvement Project.

Movement of *Busseola fusca* larvae into the base of the sorghum head resulted in undersized heads and 15 per cent grain loss.

138

Mlambo, S.S. 1983. The status of cereal stem-borer and legume pod-borer research in Zim-

babwe. Insect Science and its Application 4(1-2): 221-222.10 ref.

Ecology and control of cereal stem borers including *Busseola fusca* in Zimbabwe are reviewed. Migration is an important parameter in the proliferation of the pest.

139

Moore, W. 1913. The maize stalk borer (*Sesamia fusca*, Hamp.) and its control. Agricultural Journal of the Union of South Africa 5(3): 419-428.

Life cycle of *Sesamia fusca* [*Busseola fusca*] is described. Trap cropping and winter ploughing are suggested for controlling the pest. However, trap cropping is not suitable for the cooler parts of South Africa where maize is planted early to avoid frosts.

140

Morstatt, H. 1920. [The pests and diseases of sorghum in East Africa.] Die schadlinge und krankheiten der sorghumhirse (Mtama) in Ostafrika. (In De.) Arbeiten aus der Biologischen Bundesanstalt für Land- u. Forstwirtschaft 10(3): 243-268.

Busseola sorghicida, Thureau [*Busseola fusca*] was identified as a pest of sorghum in East Africa.

141

Moyal, P., and Tran, M. 1989. [Morphological study of the pre-imaginal instars of lepidopterous borers of maize in the savannah area of Ivory Coast.] Etude morphologique des stades pre-imaginaux des lepidopteres foreurs du mais en zone des savanes de cote-d'Ivoire. (In Fr. Summary(s) in En, Fr.) Annales de la Societe Entomologique de France (N.S.) 25(4): 461-472. 20 ref.

Chaetotaxy of cob and stem borers of maize including *Busseola fusca* is studied. Characters for distinction between species are given.

142

Nesbitt, B.F., Beever, P.S., Cork, A., Hall, D.R., Lester, R., Blair, B.W., and Tannock, J. 1980. Identification of the female sex pheromone of the maize stalk borer *Busseola fusca*: a preliminary report. Tropical Pest Management 26(3): 327.

The three isomeric components, (Z)-11-, (E)-11-, and (Z)-9-tetradecenyl acetates produced by *Busseola fusca* were synthesized and tested in traps for field attractancy. The components in their natural ratio (10:2:2) were highly attractive to male

B. fusca. Individual compounds and binary mixtures were not attractive.

143

Nesbitt, B.F., Beevor, P.S., Hall, D.R., Lester, R., Davies, J.C., and Reddy, K.V.S. 1979. Components of the sex pheromone of the female spotted stalk borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae): identification and preliminary field trials. *Journal of Chemical Ecology* 5(1): 153-163.

The components of a pheromone released by *Busseola fusca* females are identified as (Z)-11- and (E)-11-tetradecenyl acetates.

144

Njau, M.A. 1989. Endocrinology of development in the last larval instar of *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1988: 5-6.

Juvenile hormone titre was low in non-diapausing larvae but higher during diapause in *Busseola fusca*. Moulting hormone titres in diapausing larvae were generally lower.

145

Nwanze, K.F. 1981. Annual report 1980. Entomology. Ouagadougou, Upper Volta: International Crops Research Institute for the Semi-Arid Tropics, Upper Volta Cooperative Program. 39 pp. (Limited distribution.)

Busseola fusca was observed in Upper Volta [Burkina Faso] in the region below latitude 11 deg 30'N, where the annual rainfall exceeds 900 mm, restricting the pest to the southern region. It was not found in Kamboinse. In northern Nigeria, the pest was observed at Kano and Dutsin-Ma. At Samaru, Nigeria, *B. fusca* accounted for 98 per cent of the borer larvae on sorghum. At Farako-Ba, Upper Volta, it accounted for 38.9 per cent, and did not show any distinct generations.

146

Nwanze, K.F. 1982. Insect pests of sorghum in West Africa. Page(s) 743 in *Sorghum in the eighties: proceedings of the International Symposium on Sorghum*, 2-7 Nov 1981, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Abstract.)

Severe infestations of *Busseola fusca* occurred in Nigeria as far north as 12 deg 6' latitude, being most severe at Samaru and Funtua. In Burkina Faso, *B. fusca* infestations occurred below lati-

tude 11 deg 30'N where annual rainfall exceeded 900 mm. The late crop was most severely infested.

147

Nwanze, K.F. 1985. Sorghum insect pests in West Africa. (Summary(s) in Fr.) Page(s) 37-43 in *Proceedings of the International Sorghum Entomology Workshop*, 15-21 Jul 1984, College Station, Texas, USA. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 15 ref.

Incidence, severity of damage, distribution, and seasonal abundance of the major insect pests of sorghum including *Busseola fusca* are discussed. *B. fusca* accounted for 98 per cent of borer larvae in Samaru, Nigeria and less than 40 per cent at Farako-Ba (Bobo-Dioulasso), Burkina Faso. Only two generations of the pest were observed at Farako-Ba.

148

Nwanze, K.F. 1988. Distribution and seasonal incidence of some major insect pests of sorghum in Burkina Faso. (Summary(s) in Fr.) *Insect Science and its Application* 9(3): 313-321. 14 ref. *Busseola fusca* was predominant in the south of latitude 12 deg N.

149

Nwanze, K.F. (No date.) Stem-borers of cereals in Sahelian West Africa: relative importance and control. Page(s) 115-123 in *Biological control of pests: its potential in West Africa: proceedings of an International Conference*, 9-13 Feb 1981, Dakar, Senegal. Dakar, Senegal: US Agency for International Development Regional Food Crop Protection Project. [Also issued in Fr.: Pages 108-115 in *Lutte biologique contre les ravageurs et ses possibilites en Afrique de l'Ouest: compte rendu du Seminaire qui a eu lieu*, 9-13 Fev 1981, Dakar, Senegal.]

Busseola fusca was observed on maize and sorghum in Upper Volta [Burkina Faso] in the region below latitude 11 deg 30'N, with an annual rainfall greater than 900 mm. It was also found in Kano and Dutsin-Ma, northern Nigeria. In the Sahel, population of *B. fusca* was lesser than that of *Acigona ignefusalis* [*Coniesta ignefusalis*]. Sorghum leaves were severely damaged by *B. fusca* in northern Nigeria in 1980, Various cultural measures, use of resistant varieties, and release of biological agents, are reviewed in the context of integrated pest management.

150

Nyambo, B.T. 1990. Monitoring insect pest populations in relation to crop phenology in the ICIPE-ECA project area. Annual Report, International Centre of Insect Physiology and Ecology 1989: 7. Adult populations of *Busseola fusca* and *Chilo partellus* were monitored by trapping, using synthetic pheromone or 1-day-old virgin females, on maize at 5 sites in Kenya, during the 1989 short rains. Weekly moth catches varied significantly between sites. Infestation was very low between 2-10 WAE. No relationships could be established between trap catches, percentage plant damage, and leaf damage ratings.

151

Nye, I.W.B. 1960. The insect pests of graminaceous crops in East Africa. Report of a survey carried out between March 1956 and April 1958. Colonial Research Studies no.31. London, UK: Her Majesty's Stationery Office. 51 pp.

Biology and control measures of insect pests including *Busseola fusca* in Kenya, Uganda, and Tanganyika on maize and sorghum; *B. phaia phaia* in northern Rhodesia and Tanganyika on *Pennisetum purpureum* and *B. p. segeta* in Uganda and Tanganyika on *P. purpureum* and *Panicum maximum* are reported. *B. sorghicida* Thureau is a synonym of *B. fusca*.

152

Ochieng, R.S. 1980. Preliminary observations on maize and sorghum infestation by various species of stem borers under the Mbita Point field conditions. Annual Report, International Centre of Insect Physiology and Ecology 1979:18-19.

Infestation levels and distribution of stem borers including *Busseola fusca* are given.

153

Ochieng, R.S. 1988. Rearing target insects and their natural enemies. Annual Report, International Centre of Insect Physiology and Ecology 1987: 20-21.

Composition of a diet (B2) for *Busseola fusca* is given. Development of the borer on diet B2 was good but the 4th generation was infertile.

154

Ogunwolu, E.O., Nwosu, K., and Ogunyebi, S.O. 1981. Stem borer damage in maize as affected by host plant density. Journal of Agricultural Science (UK) 96: 695-697.11 ref.

In Nigeria, late crop of maize was heavily infested by stem borers including *Busseola fusca* in 1978 at Amakama, resulting in 84.4 per cent plant stand depletion. Association between plant density and stem borer feeding damage was not significant. More larvae were observed in maize plots with plant spacings of 100 x 15 and 100 x 10 cm than in other treatments. At Ibadan, *B. fusca* was predominant and plant density was negatively correlated with stand loss. At both places borer population was highest on 3-week-old plants.

155

Ogwaro, K. 1982. Intensity levels of stem borers in maize and sorghum and the effect on yield under different intercropping patterns. Insect Science and its Application 4(1-2): 33-37.13 ref.

A single *Busseola fusca* larva could reduce the yield of the stems by 28 per cent of mean dry cob weight. Maize was infested more during the vegetative stages and sorghum towards maturity. Infestation was more in pure stands of sorghum.

156

Okuda, T. 1988. Effect of artificial wetting and rainfall on the larval diapause of a stem borer, *Busseola fusca* in western Kenya. (Summary(s) in Fr.) Entomologia Experimentalis et Applicata 48(3): 263-267.16 ref.

Diapausing larvae of *Busseola fusca* collected from the field during the short rainy season pupated following artificial wetting in the laboratory. Conditions of continuous moisture during the long rainy season play a significant role in the termination of diapause.

157

Okuda, T. 1988. Factors governing diapause termination in *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1987: 6.

Early phase of diapause in *Busseola fusca* was not sensitive to any of the factors tested, but late diapause larvae pupated after artificial wetting. Continuous exposure to water for 7-9 days was required for highest level of pupation. Pupation was also accelerated by chilling late diapause larvae at -10 deg C for 5 minutes.

158

Okuda, T. 1989. Aggressive characteristics of diapausing larvae of a stem borer, *Busseola fusca* Fuller (Lepidoptera, Noctuidae) in artificially

crowded conditions. Applied Entomology and Zoology 24(2): 238-239.11 ref.

159

Okuda, T. 1990. Significance of water contact as a factor terminating larval diapause in a stem borer, *Busseola fusca* Entomologia Experimenta et Applicata 57(2): 151-155.16 ref.

Neither feeding the larvae of *Busseola fusca* on fresh sorghum stems nor allowing them to drink water stimulated a break in the larval diapause. Diapause larvae transferred to artificial wet conditions pupated without increase in fresh weight. Water contact was more significant than water uptake in terminating larval diapause.

160

Onyango, F.O. 1990. Rearing the maize stem-borer, *Busseola fusca*, on an artificial diet. Annual Report, International Centre of Insect Physiology and Ecology 1989:19.

Five successive insectary generations of *Busseola fusca* were successfully reared on an artificial diet. Larval diapause was minimum.

161

Osir, E.O., Labongo, L.V., and Unnithan, G.C. 1989. A high molecular weight diapause-associated protein from the stem-borer *Busseola fusca*: purification and properties. Archives of Insect Biochemistry and Physiology 11(3): 173-187. 31 ref.

Busseola diapause protein (BDP) was purified from the haemolymph of diapausing larvae of *Busseola fusca*, by a combination of density gradient ultra-centrifugation, gel permeation, and affinity chromatography. Composition of this protein is given.

162

Osir, E.O., Unnithan, G.C., and Labongo, L.V. 1989. The diapause phenomenon in the stem-borer *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1988: 64-66.

Identification and purification of diapause protein in *Busseola fusca* (BDP); physical, chemical, and immunological properties of BDP, and its *de novo* synthesis in the fat body tissue of diapausing insects are described.

163

Peacock, A.D. 1913. Entomological pests and problems of southern Nigeria. Bulletin of Entomological Research 4(3): 191-220.

Infestation of *Calamistis fusca* [*Busseola fusca*] on maize is reported.

164

Pickett, J.A., and Schooley, D.A. 1989. External review report of the chemistry and biochemistry research unit, January 9-13 1989; I.R.R.E.A. report. Nairobi, Kenya: International Centre of Insect Physiology and Ecology. 9 pp.

A protein was isolated from diapausing larvae of *Busseola fusca*. It was an excellent marker for predicting diapause induced by JH or semi-chemicals in ageing stems of the host plant.

165

PPRI (Plant Protection Research Institute). 1979. Report, Plant Protection Research Institute, Zimbabwe 1979: 4-51.

As part of plant protection research activities in Zimbabwe, an investigation showed that the sex pheromone of *Busseola fusca* is identified as Cis-9-tetradecenyl acetate.

166

Prentice, A.N. 1944. Progress reports from experiment stations, season 1942-1943. Progress Reports from Experiment Stations, Empire Cotton Growing Corporation 1942-43:118-119.

Busseola fusca larvae were observed in sorghum stems in Shinyanga, Tanzania.

167

Reddy, K.V.S. 1983. Studies on the stem-borer complex of sorghum in Kenya. Insect Science and its Application 4(1-2): 3-10. 20 ref.

Distribution of stem borers of sorghum and maize in Kenya is reported. *Busseola fusca* was dominant at Kissi with 61 per cent infestation. Sources of sorghum resistance to *B. fusca* were identified. Carbofuran (1 kg a.i./ha) was very effective in controlling the pest when evaluated 11 weeks after planting.

168

Reddy, K.V.S. 1987. Incidence of sorghum/maize stem borers and crop losses. Annual Report, International Centre of Insect Physiology and Ecology 1986: 3-4.

A peak density of *Busseola fusca* (21.6 larvae per 10 plants) was observed at 7 WAE on sorghum at Ungoye, Kenya. The density declined to 10.6 larvae/pupae per 10 plants at the time of harvest. On maize, infestation started at 6 WAE and reached a peak (1.4 larvae/pupae per 10 plants) at 11 WAE.

At harvest the borer population was negligible and only 4 per cent of the plants were damaged.

169

Reddy, K.V.S. 1988. Assessment of on-farm yield losses in sorghum due to insect pests. (Summary(s) in Fr.) *Insect Science and its Application* 9(6): 679-685. 36 ref.

Methods of assessing and quantifying on-farm yield losses caused by sorghum pests including *Busseola fusca* are discussed.

170

Reddy, K.V.S. 1988. Incidence of target insect pests and crop losses caused by them. Annual Report, International Centre of Insect Physiology and Ecology 1987: 4-5.

Incidence of stem borers in sorghum and maize at Mbita Point Field Station (MPFS) and Ungoye in Kenya is reported. At MPFS, incidence of *Busseola fusca* on sorghum and maize was 1.2 and 0.25 larvae/pupae per 10 plants, resp., and at Ungoye, the incidence was 4.0 and 0.93, respectively.

171

Reddy, K.V.S., and Unnithan, G.C. 1985. Alternative host plants of stem borers. Annual report, International Centre of Insect Physiology and Ecology 1984: 7.

In Kenya, *Busseola fusca* was observed on *Hyparrhenia rufa*, *Pennisetum macrourum*, *Phragmites mauritianus*, *Sorghum arundinaceum*, and *S. verticilliflorum*, at Mbita Point and nearby fields.

172

Reddy, K.V.S., and Unnithan, G.C. 1985. Population patterns of stem borers on sorghum. Annual Report, International Centre of Insect Physiology and Ecology 1984: 6.

At Mbita Point Field Station, Nairobi, Kenya, infestation of *Busseola fusca* was up to 95 per cent and started at 5 weeks after emergence (WAE). At Rusinga Island, infestation was 79-100 per cent and started at 6 WAE. Number of larvae per stem at Rusinga Island ranged from 2.4 to 5.7.

173

Ritchie, A.H. 1927. Entomological report, 1925-26. Report, Department of Agriculture, Tanganyika Territory 1925-26: 33-36.

Busseola fusca infestation on maize in Tanganyika territory is reported.

174

Ritchie, A.H. 1935. Report of the Entomologist, 1934. Report, Department of Agriculture, Tanganyika Territory 1934: 73-83. Late planted maize was severely attacked by *Busseola fusca* in Tanganyika.

175

Scheltes, P. 1978. Ecological and physiological aspects of aestivation-diapause in the larvae of two pyralid stalk borers of maize in Kenya. Wageningen, Netherlands: PUDOC (Centre for Agricultural Publishing and Documentation). 110 pp. *Busseola fusca* is also discussed along with *Diatraea grandiosella* and *Ostrinia nubilalis*.

176

Schmutterer, H. 1971. Contribution to the knowledge of the crop pest fauna in Ethiopia. (Summary(s) in De.) *Zeitschrift für Angewandte Entomologie* 67(4): 371-389. 6 ref.

Cereals in central and eastern Ethiopia were attacked by *Busseola fusca*.

177

Sithole, S.Z. 1989. Distribution of lepidopterous stem borers of sorghum in Zimbabwe. Page(s) 195-203 in *Proceedings of the fifth Regional Workshop on Sorghum and Millets for Southern Africa*, 21-23 Sep 1988, Maseru, Lesotho. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program. 10 ref.

Relative abundance of *Busseola fusca* in high, middle and lowveld was 78.67, 17.32, and 21.12 per cent, resp. during 1986/87, and 79.8, 5.32, and 15.61 per cent, resp. during 1987/88. *B. fusca* favored high elevations, high rainfall, and high relative humidity.

178

Sithole, S.Z., de Milliano, W.A., Kaula, G., Motalaote, B., Mtisi, E., Kunene, S., and Lepheana, F.T.M. 1987. The insect pest situation in sorghum at research stations in SADCC countries during the 1985/86 cropping season. Page(s) 375-381 in *Proceedings of the third Regional Workshop on Sorghum and Millets for Southern Africa*, 6-10 Oct 1986, Lusaka, Zambia. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-

Arid Tropics) Sorghum and Millet Improvement Program. 4 ref.

Busseola fusca was observed in Zimbabwe, Botswana, Lesotho, and Swaziland in the 1985-86 cropping season. Stem borers caused 20 per cent damage by late Mar. 1986. Distribution of pest species was influenced by environmental factors such as temperature, humidity, and altitude.

179

Sithole, S.Z., and Maramba, P. 1986. The status of diseases and pests of sorghum and millets in Zimbabwe. Page(s) 161-171 in Proceedings of the second Regional Workshop on Sorghum and Millets for Southern Africa, 23-27 Sep 1985, Gaborone, Botswana. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program,

Stem borers (including *Busseola fusca*) were the most serious pests of sorghum in the communal areas of Zimbabwe during Jan. - Mar. 1985.

180

Smee, C. 1927. Report of the Entomologist. Report, Department of Agriculture, Nyasaland 1926:13-20.

Busseola fusca was found on maize and millet stalks in Nyasaland.

181

Smee, C. 1944. Report of the Entomologist, 1943. Report, Department of Agriculture, Nyasaland 1943:11pp.

Busseola fusca was injurious at altitudes above 4000 ft. in Nyasaland.

182

Smithers, C.N. 1960. Moisture and pupation in *Busseola fusca* (Hmps.) (Lepid.: Noctuidae). Journal of the Entomological Society of Southern Africa 23(1): 225-227. 3 ref.

Overwintering larvae of *Busseola fusca* on maize collected in southern Rhodesia during Aug. 1958, were given various water treatments. Pupation began after 10-20 days, but proceeded much faster in stems that had been initially water-soaked than in dry stems or in stems dipped once in water.

183

Smithers, C.N. 1960. Some recent observations on *Busseola fusca* (Fuller) (Lep., Noctuidae) in

southern Rhodesia. Bulletin of Entomological Research 50(4): 809-819. 7 ref.

Life history, seasonal cycle, and feeding habits of *Busseola fusca* are discussed. The pest had two generations in the year, and a majority of 2nd generation larvae entered diapause. Diapause was induced by larval feeding on drying food.

184

Swaine, G. 1957. The maize and sorghum stalk borer, *Busseola fusca* (Fuller), in peasant agriculture in Tanganyika territory. Bulletin of Entomological Research 48(4): 711-722. 9 ref.

Life cycle, larval diapause, and control of *Busseola fusca* are discussed. The pest had two generations on the main crops of sorghum and maize and a 3rd on sorghum tillers. Diapause was terminated by contact with water. Cob yield increased when treated with DDT.

185

Tchekmenev, S.Yu. 1981. The effect of the maize stalk borer, *Busseola fusca* (Fuller) on the growth, percentage of broken panicles, and yield of maize. Beitrage zur Tropischen Landwirtschaft und Veterinarmedizin 19(1): 91-95.

In studies in Ethiopia during 1977-78, maize at 10-12 leaf stage was manually infested with 1-5 first instar larvae of *Busseola fusca* (collected from sorghum) per plant. Plant height was reduced 2-3 times when infested with 4-5 larvae. One larva per plant increased the number of plants with broken panicles by 8.6 per cent. Increasing larval infestation per plant caused 6.6 g (15.2 per cent) loss of grain yield.

186

Unnithan, G.C. 1985. Development and reproduction of *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1984: 7.

Busseola fusca showed high fecundity with an average of 636 eggs per female on sucrose solution and 677 eggs on distilled water. Mating within few hours after eclosion reduced longevity and preoviposition period, and increased fecundity, while delayed mating resulted in reduced fertility and fecundity.

187

Unnithan, G.C. 1987. Development and reproductive biology of the maize stem-borer *Busseola fusca* Fuller (Lepid., Noctuidae). (Summary(s) in

De.) Journal of Applied Entomology 104(2): 172-179.12 ref.

The mean duration of postembryonic development was 40.8 days. Facultative diapause in *Busseola fusca* can be prevented if the larvae are fed on young sorghum plants. Male and female lifespan averaged 8.7 and 6.9 days, respectively. The overall mean fecundity and egg fertility were 723 eggs/female and 84 per cent, respectively. The maximum number of eggs laid by a single female was 1790.

188

Unnithan, G.C. 1989. Communication disruption in *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1988: 7.

Male-female communication in *Busseola fusca* was disrupted in fields permeated with synthetic pheromone at Rusinga Island and Mbita, Kenya.

189

Unnithan, G.C., and Paye, S.O.1990. Factors involved in mating, longevity, fecundity and egg fertility in the maize stem-borer, *Busseola fusca* (Fuller) (Lep., Noctuidae). Journal of Applied Entomology 109(3): 295-301.

Delayed mating prolonged longevity and pre-oviposition period but reduced oviposition period, fecundity and egg fertility. Highest fecundity (822 eggs) and egg fertility (94 per cent) were obtained when the females were mated on the night of eclosion. *Busseola fusca* males showed multiple mating ability indicating the inefficiency of mass trapping of males in suppressing pest population. Delayed mating achieved by permeating the field with synthetic pheromone may result in the production of less viable eggs and can be used as a control strategy.

190

Unnithan, G.C., and Reddy, K.V.S. 1989. Incidence, diapause and carry over of the cereal stem borers on Rusinga Island, Kenya. Tropical Pest Management 35(4): 414-419. 24 ref.

Busseola fusca was the predominant stem borer on sorghum. *Chilo partellus* occurred only in small numbers. *B. fusca* survived the off-season (Jul./Aug.-Feb./Mar.) as diapausing larvae in crop residues and *C. partellus* as active population. Infestation of newly planted crop was attributed to diapausing population of *B. fusca*. Stubble destruction is recommended for its control.

191

Unnithan, G.C., and Saxena, K.N. 1985. Trapping and pheromone biology of *B. fusca* [*Busseola fusca*] and *C. partellus* [*Chilo partellus*]. Annual Report, International Centre of Insect Physiology and Ecology 1984: 9.

Busseola fusca virgin females were more than 2 times as efficient as synthetic pheromone in attracting males. Mated females and blank water traps did not attract any males.

192

Unnithan, G.C., and Saxena, K.N. 1988. Pheromonal trapping and monitoring of the stem borers *C. partellus* [*Chilo partellus*] and *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1987: 5-6.

Traps with a single virgin female of *Busseola fusca* attracted more males than those with 1 and 5 mg synthetic pheromone for the first 10 days, while the catches were similar for the subsequent 15 days. A dosage of 5 mg was more effective than 1 or 2 mg of synthetic pheromone. Male populations of *B. fusca* showed a major peak at about 12 weeks after crop emergence and a minor peak 7-8 weeks later.

193

USADA (Union of South Africa, Department of Agriculture). 1913. Report of the Department of Agriculture, Union of South Africa, 1st Jan. 1912 to 31st Mar. 1913. Report, Department of Agriculture, Union of South Africa 1912-13: ? pp.

Damage due to *Sesamia fusca* [*Busseola fusca*] on maize in South Africa is reported.

194

USADA (Union of South Africa, Department of Agriculture). 1922. Departmental activities: entomology. Journal of the Department of Agriculture, Union of South Africa 4(2): 114-117.

Severity of *Busseola fusca* infestation during Dec. in South Africa is reported.

195

Usua, E.J. 1966. Stem borers of maize in western Nigeria with particular reference to *B. fusca* [*Busseola fusca*] and *Sesamia* spp. (Lepidoptera: Noctuidae). M.Sc. thesis, University of Ibadan, Ibadan, Nigeria. 169 pp.

Relative abundance ratio of *Busseola fusca* to *Sesamia calamistis* and other stem borers was 7:1:1.

196

Usua, E.J. 1967. Observations on diapausing larvae of *Busseola fusca* Journal of Economic Entomology 60(5): 1466-1467. 5 ref.

Adults of *Busseola fusca* reared on maize from non-diapausing larvae in Nigeria laid more eggs than those reared from diapausing larvae. The mortality of diapausing larvae in maize stems that had been cut and left lying on the ground was about 8 times as great as that of larvae in standing stems.

197

Usua, E.J. 1968. Effect of varying populations of *Busseola fusca* larvae on the growth and yield of maize. Journal of Economic Entomology 61(2): 375-376. 6 ref.

When maize plants (18-24 inches tall) were artificially infested with 1-5 newly hatched *Busseola fusca* larvae in Ibadan, Nigeria in 1964, the rate of plant growth decreased and the number of deadhearts increased; 1-2 larvae per plant reduced the yield by 25 per cent.

198

Usua, E.J. 1968. Role of food and water in the onset of diapause in *Busseola fusca* (Fuller) (Lep., Agrotidae). Entomologist's Monthly Magazine 104(1247-49): 105-107. 5 ref.

Laboratory trials in Nigeria in Aug. 1964 and Jul. 1965, showed that diapause in *Busseola fusca* is genetically controlled and that the influence of food and water is less marked.

199

Usua, E.J. 1968. Temperature and relative humidity effects on the development of the immature stages of the maize stemborers, *Busseola fusca* and *Sesamia calamistis* Journal of Economic Entomology 61(4): 1091-1093. 5 ref.

Incubation period for *Busseola fusca* eggs decreased with increasing temperature. Larvae developed well at room temperatures between 81.4 and 85 deg F, and went into a quiescent period at 73.6 deg F with apparently no sizeable development. A temperature of 90 deg F was lethal to *B. fusca* larvae.

200

Usua, E.J. 1968. The biology and ecology of *Busseola fusca* and *Sesamia* species in south-western Nigeria. 1. Distribution and population studies. Journal of Economic Entomology 61(3): 830-833.

Distribution of maize stem borers throughout south-western Nigeria during Nov.-Dec. 1964 is presented. *Busseola fusca* was more abundant in humid lowland rainforest zones. Eggs were laid within 30 inches of the maize whorl. Four larval generations were observed.

201

Usua, E.J. 1969. Description of the larvae of *Sesamia penniseti* Bowden and *S. botanephaga* Tarns and Bowden (Lepidoptera: Noctuidae). Bulletin of the Entomological Society of Nigeria 2(1): 72-76. 7 ref.

Maize and sugarcane were infested by *Busseola fusca* in Nigeria.

202

Usua, E.J. 1970. Diapause in the maize stem-borer. Journal of Economic Entomology 63(5): 1605-1610. 14 ref.

Studies conducted in Nigeria in 1965-66 showed that *Busseola fusca* larvae entered diapause in both fresh and dry maize but were pigmented only in fresh stems. During diapause, feeding was reduced by 82 per cent. Presence of water in the field favored adult emergence.

203

Usua, E.J. 1970. Some notes on maize stem-borers in Nigeria. Journal of Economic Entomology 63(3): 776-778. 7 ref.

Emergence of *Busseola fusca* adults was influenced by the onset of darkness and not by temperature or relative humidity. The average number of eggs laid per female was 445. Fecundity was reduced by 50 per cent in unmated females.

204

Usua, E.J. 1973. Induction of diapause in the maize stemborer, *Busseola fusca* Entomologia Experimentalis et Applicata 16(3): 322-328. 15 ref.

Diapause in *Busseola fusca* was induced by feeding on mature maize stems with low water, low protein, and high carbohydrate contents. Temperature and photoperiod did not influence diapause.

205

Usua, E.J. 1974. Observations on the physiology of diapause and non-diapause larvae of *Busseola fusca* (Fuller) (Lep., Noctuidae). Bulletin of Entomological Research 63(3): 513-518. 17 ref.

Respiration rate, thermal death point, weight loss, and life span of diapause and non-diapause

larvae of *Busseola fusca* were compared. Efficient water conservation enabled diapause larvae to survive adverse conditions.

206

Usua, E.J. (In press.) Distribution of stemborers of maize in the eastern states of Nigeria. Nigerian Journal of Pure and Applied Sciences ? : ?. 8 ref.

Busseola fusca was restricted to the drier derived savanna zone forest in the northern border of eastern states. Of 52 borers collected in the mangrove forest, 135 in fresh-water forest, 402 in rain forest and 343 in derived savanna, 53.8, 46.6, 52.4, and 45.4 per cent, resp. were *Sesamia calamistis* and only 0, 0, 16.6, and 40.2 per cent, resp., were *B. fusca*.

207

van den Merwe, C.P. 1937. Insects attacking sugarcane. Science Bulletin, Department of Agriculture, Union of South Africa 171: 8 pp. 7 ref.

Busseola fusca infested sugarcane occasionally. The damage was not serious as the mature plants were hard to penetrate.

208

van Rensburg, J.B.J. 1981. [The epidemiology of *Busseola fusca*: a study of insect-host-plant relationships.] Die plaagstatus van *Busseola fusca* (Fuller): 'n studie van plaag-tot-gewasverhouding. (In Af.) Ph.D. thesis, University of Stellenbosch, Stellenbosch, South Africa. 213 pp.

209

van Rensburg, J.B.J. 1988. Plant population and cultivar effects on yield losses caused by the maize stalk borer, *Busseola fusca* (Lepidoptera: Noctuidae). South African Journal of Plant and Soil 5(4): 215-218. 6 ref.

Rates of dispersal, larval survival, and number of damaged plants increased with increased plant population. High yielding, long duration maize cultivars suffered more severe yield losses due to *Busseola fusca*.

210

van Rensburg, J.B.J., Giliomee, J.H., and Walters, M.C. 1988. Aspects of the injuriousness of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Bulletin of Entomological Research 78(1): 101-110.15 ref.

Yields were significantly reduced when maize plants were infested by *Busseola fusca* during the post-tasselling period, in South Africa. The num-

ber of larvae per plant was a weak estimator of expected yield losses.

211

van Rensburg, J.B.J., and Pringle, K.L. 1989. A sequential sampling technique for surveys of eggs laid by the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa 52(2): 223-228.11 ref.

Oviposition by *Busseola fusca* in sampling units of 20 adjoining maize plants per plant row was determined over the key period of 3-6 weeks after crop emergence. A clumped spatial pattern of oviposition was indicated by a significant fit of the negative binomial distribution to the data (exponent $k=1,6632$). A sequential sampling technique that reduces the time and effort spent to conduct egg surveys was developed.

212

van Rensburg, J.B.J., van Rensburg, G.D.J., Giliomee, J.H., and Walters, M.C. 1987. The influence of rainfall on the seasonal abundance and flight activity of the maize stalk borer, *Busseola fusca* in South Africa. (Summary(s) in Af.) South African Journal of Plant and Soil 4(4): 183-187.14 ref.

The relationship between the seasonal abundance of *Busseola fusca* and rainfall is indirect and survival of moths is determined by the direct influence of humidity. It is implied that infestations will be more serious during years with favorable rains.

213

van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1985. Geographical variation in the seasonal moth flight activity of the maize stalk borer, *Busseola fusca* (Fuller), in South Africa. South African Journal of Plant and Soil 2(3): 123-126.

Seasonal abundance of *Busseola fusca* moths was monitored by Robinson light traps. Climatic factors influenced the time and magnitude of the three seasonal moth flights. Time of planting determined the severity and time of occurrence of larval infestations.

214

van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1987. Ecology of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noc-

tuidae). Bulletin of Entomological Research 77(2): 255-269. 30 ref.

Studies in South Africa showed that planting date influenced *Busseola fusca* populations. The pest preferred 3-to 5-week-old plants for oviposition. With the emergence of tassel, larvae migrated to adjacent plants. Number of damaged plants increased without any increase in larval population.

215

van Rensburg, J.B.J., Walters, M.C., and Gilimoe, J.H. 1988. Response of maize to levels and times of infestation by *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa 51(2): 283-291.

Maize plants were artificially infested with egg batches of *Busseola fusca* at different times after crop emergence. Regression equations of yield loss on percentage plants with eggs varied over different seasons, which was attributed to hybrid differences and variation in climate. Yield losses were negatively dependent on the time of infestation, since losses were less pronounced with oviposition occurring after 5-6 weeks after crop emergence. Ear damage was most severe with oviposition 5-7 weeks after crop emergence.

216

van Rensburg, J.B.J., Walters, M.C., and Gilimoe, J.H. 1988. The comparative abundance and in-season distribution of larval infestations of *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) on maize. Journal of the Entomological Society of Southern Africa 51(1): 138-140. 4 ref.

Busseola fusca larvae were first observed on maize 4 weeks after plant emergence in South Africa. Maximum numbers of larvae were present during the 8th week. Infestation was lowest in Nov. plantings.

217

van Rensburg, J.B.J., Walters, M.C., and Gilimoe, J.H. 1989. Selective oviposition by the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa 52(1): 105-108. 5 ref.

Selective oviposition by *Busseola fusca* was investigated using two maize hybrids of different phe-

notypical characteristics (SA33 and SR52). More and larger egg batches were obtained from the hybrid (SR52) with thicker stalks.

218

Walker, P.T. 1960. The distribution and sampling of maize plants infested with the stalk borer, *Busseola fusca* Fuller in Tanganyika. Report, Great Britain Colonial Pesticides Research Unit, CPRU/Porton 173: 8 pp.

219

Walker, P.T. 1960. The relation between infestation by the stalk borer *Busseola fusca*, and yield of maize in East Africa. Annals of Applied Biology 48(4): 780-786. 17 ref.

The relation between maize yield and infestation by *Busseola fusca* in Tanganyika was rectilinear. Grain yield increased by 35 lb/acre for every 1 per cent decrease in infestation for the higher yield group and by 17 lb for the lower yield group. Economics of control by insecticides and the accuracy of methods of sampling infestations are also discussed.

220

Walker, P.T. 1963. The relation between height of maize and attack by maize stem borer, *Busseola fusca* in Tanganyika. Report, Great Britain Tropical Pesticides Research Unit, TPRU/Porton 257: 3 pp.

221

Walker, P.T. 1965. The distribution of loss of yield in maize and of infestations of maize stem borer, *Busseola fusca* (Noctuidae) in East Africa. (Summary(s) in De, Fr, Nl.) International Symposium on Phytopharmacy and Phytiatry 17: 1577-1587. 4 ref.

A mathematical relationship was developed for the interaction between influence of sowing times, levels and frequencies of infestation by *Busseola fusca*, and crop loss of maize in western Tanganyika [Tanzania].

222

Walker, P.T. 1981. The relation between infestation by lepidopterous stem borers and yield in maize: methods and results. (Summary(s) in Fr, Ru.) Bulletin, Organisation Europeenne et Mediterraneenne pour la Protection des Plantes 11(2): 101-106. 33 ref.

Methods used to assess *Busseola fusca* damage are reviewed.

223

Walker, P.T. 1983. Management of maize pests. Page(s) 232-246 in *Pest and vector management in the tropics* (Youdeowel, A., and Service, M.W., eds.). London, UK: Longman.

A critical rainfall of more than 10 mm resulted in diapause termination of *Busseola fusca*.

224

Walker, P.T. 1983. The assessment of crop losses in cereals. *Insect Science and its Application* 4(1-2): 97-104.

Crop losses due to cereal pests including *Busseola fusca* are studied. Methods of loss assessment and surveys of crop losses are reviewed.

225

Walter-Echols, G., Agounke, D., and Akpaloo, Y. 1983. Importance of cassava, cowpea and maize pests in Togo, West Africa. Page(s) 103 in *Proceedings, 10th International Congress of Plant Protection, 20-25 Nov 1983, Brighton, UK Vol.1.* Croydon, UK: British Crop Protection Council.

Busseola fusca was one of the principal pests on maize in Togo.

226

Walters, M.C., Drinkwater, T.W., van Rensburg, J.B.J., and Boshoff, L. 1980. The maize stalk-borer. *Farming in South Africa* D.3:1-8.

Busseola fusca did not migrate to long distances.

227

WAMRU (West African Maize Research Unit). 1957. Entomology report. Report, West African Maize Research Unit (Nigeria) 1954: 30.

Busseola fusca damage to maize in Ghana is presented in a map prepared by J. Bowden and W.R. Stanton.

228

Wheatley, P.E. 1961. The insect pests of agriculture in the Coast Province of Kenya. 5. Maize and sorghum. *East African Agricultural and Forestry Journal* 27(2): 105-107.

Busseola fusca infested maize and sorghum in Teita Hills, Kenya.

229

Whitney, W.K. 1970. Observations on maize insects at the International Institute of Tropical Agriculture (IITA) Ibadan. *Bulletin of the Entomological Society of Nigeria* 2 (2): 146-155. 47 ref.

Busseola fusca larvae accounted for 44.6 per cent of the total larval population in the month of Aug. in 1970 and were controlled by carbaryl and malathion.

230

Young, W.R., and Teetes, G.L. 1977. Sorghum entomology. *Annual Review of Entomology* 22: 193-218.177 ref.

Distribution, pest status, severity of damage, and economic importance of various sorghum pests (including *Busseola fusca*) are given.

Pest Management (General)

231

Breniere, J. 1971. [The problem of lepidopterous borers of Graminaeae in West Africa.] Les problemes des lepidopteres foreurs des graminees en Afrique de l'Ouest. (In Fr. Summary(s) in En.) *Annales de Zoologie, Ecologie Animale* 3(3): 287-296. 40 ref.

Busseola fusca was found on sorghum and maize. Problems faced in the control of stem borers are discussed.

232

du Plessis, C. 1936. The maize stalk-borer. *Farming in South Africa* Reprint no.14: 2 pp.

Busseola fusca caused 10 per cent damage to maize in South Africa. Destruction of infested plants, delayed planting, top dressing trap crops with derrisol, winter and early-spring ploughing, and stump removal controlled *B. fusca*. Trap crops in narrow strips and light traps were not effective.

233

Heenop, C.H. 1963. Controlling the maize stalk borer (*Busseola fusca*): a new approach. *Farming in South Africa* 39(6): 6-8.

234

IAR (Institute for Agricultural Research). 1983. Annual report of the Institute for Agricultural Research, Ahmadu Bello University 1981-82 (year ending 31st March 1982). Samaru, Zaria, Nigeria: IAR. 74 pp.

Research on the severity of damage and control of *Busseola fusca* on sorghum in Nigeria is reviewed.

235

Ingram, W.R. 1960. Experiments on the control of stalk borers [including *Busseola fusca*] on sor-

ghum in Uganda. East African Agricultural Journal 25(3): 184-187.

236

KARI (Kenya Agricultural Research Institute). 1982? Entomology and biological control. Page(s) 75-86 in Kenya Agricultural Research Institute. Record of research. Annual report 1981. Nairobi, Kenya: KARI. 11 ref.

Research on the ecology and control of *Busseola fusca* is reported along with other pests of maize in Kenya.

237

Lounsbury, C.P. 1918. Division of Entomology, annual report 1917-18. Report, Department of Agriculture, Union of South Africa 1917-18: 87-107. It is reported that continued attention has been given to the problem of combating the maize stalk borer, *Busseola fusca*.

238

Mlambo, S.S. 1983. The status of cereal stem-borer and legume pod-borer research in Zimbabwe. Insect Science and its Application 4(1-2): 221-222. 10 ref.

Ecology and control of cereal stem borers including *Busseola fusca* in Zimbabwe are reviewed. Migration is an important parameter in the proliferation of the pest.

239

Nwanze, K.F., and Mueller, R.A.E. 1989. Management options for sorghum stem borers for farmers in the semi-arid tropics. (Summary(s) in Fr.) Page(s) 105-113 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 47 ref.

Literature on control measures and integrated pest management of sorghum stem borers including *Busseola fusca* is reviewed. The impracticability and non adoption of most of the recommended control measures by farmers are stressed. A farming systems perspective and farmer-oriented research approach to stem borer management are suggested.

240

Nye, I.W.B. 1960. The insect pests of graminaceous crops in East Africa. Report of a survey carried out between March 1956 and April 1958. Colonial Research Studies no.31. London, UK: Her Majesty's Stationery Office. 51 pp.

Biology and control measures of insect pests including *Busseola fusca* in Kenya, Uganda, and Tanganyika on maize and sorghum; *B. phaia phaia* in northern Rhodesia and Tanganyika on *Pennisetum purpureum* and *B. p. segeta* in Uganda and Tanganyika on *P. purpureum* and *Panicum maximum* are reported. *B. sorghicida* Thunberg is a synonym of *B. fusca*.

241

PPRI (Plant Protection Research Institute). 1978. Annual report 1975-76. Report, Plant Protection Research Institute, South Africa 1978: 71-149. 4 ref.

Research on the biology and control of *Busseola fusca* in South Africa is reviewed.

242

Tadesse, A. 1986. Major insect problems on sorghum in Ethiopia and strategies for their control. Page(s) 216-238 in Sorghum and millet improvement in eastern Africa: proceedings of the fifth Regional Workshop, 5-12 Jul 1986, Nairobi, Kenya. Nairobi, Kenya: SAFGRAD (Semi-Arid Food Grain Research and Development)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern Africa Regional Program. 26 ref.

Distribution and control measures of *Busseola fusca* are discussed. Cultural control (removal of trash and stubbles, destruction of alternate hosts, horizontal laying of stalks, cutting the stalks close to ground, and early sowing), biological control by *Telenomus busseolae*, *Eupelmus* sp., *Procerochasmias nigromaculatus* and *Apanteles sesamiae*, and chemical control by furadan, sumicidin, deltamethrin, and endosulfan are recommended.

243

Taylor, W.E. 1973. Pest control for increased productivity. Sierra Leone Agricultural Journal 2(1): 54-59. 15 ref

Notes on the control of insect pests including *Busseola fusca* on maize, in Sierra Leone are given.

244

Walker, P.T. 1960. A survey of the use of maize stalk borer (*Busseola fusca*) control methods in East Africa. East African Agricultural Journal 25(3): 165-168.

Cultural Control

245

Anonymous. 1926. Control of maize-stalk borer. Farming in South Africa 1(3): 91.

Damage to maize by *Busseola fusca* in the high veldt region of the Transvaal was greater than 10 per cent. In Potchefstroom, 85 per cent in Jul. and 50 per cent in Aug. of the maize stalks were attacked resp. by about 1,400 and 1,075 larvae per acre. The stumps of the young, cut down maize were covered with earth to control *B. fusca* infestation.

246

Abu, J.F. 1986. Biology and control of the insect pests of sorghum in the southern Guinea savanna zone of Nigeria. Samaru, Zaria, Nigeria: Institute for Agricultural Research. 23 pp.

Early planting lowered *Busseola fusca* infestation.

247

Adenuga, A.O. 1977. Comparative methods and the economics of control of stem borers (Lepidoptera: Noctuidae and Pyralididae) on local maize, *Zea mays* Page(s) 52-53 in Nigerian Society for Plant Protection: NSPP 7th Annual Conference proceedings. Nigeria: Nigerian Society for Plant Protection.

In investigations on the control of stem borers (including *Busseola fusca*) on maize in Nigeria, carbaryl as a wettable powder was the best of 3 insecticides tested in sprays. The economic gain from applying carbaryl on late maize was about 4 times that for early maize. Cultural control by removing stalks and stubble after each harvest did not reduce stem borer populations.

248

Adesiyun, A.A. 1983. Some effects of intercropping of sorghum, millet and maize on infestation by lepidopterous stalk-borers, particularly *Busseola fusca* Insect Science and its Application 4(4): 387-391. 18 ref.

Among the sole crops, *Busseola fusca* infestation was highest on sorghum followed by maize and millet. Due to the inability of *B. fusca* to utilize pearl millet effectively for oviposition, intercropping sorghum with millet in alternate stands within the same row minimized borer infestation.

249

Adesiyun, A.A., and Ajayi, O. 1980. Control of the sorghum stem borer, *Busseola fusca*, by par-

tial burning of the stalks. Tropical Pest Management 26(2): 113-117.

In Nigeria, partial burning of stalks (to cure them for firewood) immediately after grain harvest killed 95 per cent of the larvae of *Busseola fusca* without any damage to the stalks.

250

Aikins, J.S. 1957. Dry season investigation of the stem borers, northern region (Ghana). Ghana Farmer 1:190-191.

Busseola fusca survived the dry spell on volunteer plants in Ghana. Destruction of grasses, stubble, and sorghum stems left after harvest is recommended for stem borer control.

251

Allan, W. 1931. Insect pests and plant diseases of economic importance during the year [1930]. Report, Department of Agriculture, Northern Rhodesia 1930: 21-24.

Young maize was severely damaged by *Busseola fusca* in northern Rhodesia. The pest did not attack farms on which crop residues were regularly destroyed.

252

Amoako-Atta, B., and Omolo, E.O. 1983. Yield losses caused by the stem- /pod-borer complex within maize-cowpea-sorghum intercropping systems in Kenya. Insect Science and its Application 4(1-2): 39-46. 15 ref.

Maize with cowpea and sorghum at a land equivalent ratio (LER) of 1.5 and sorghum with cowpea at 1.3 LER are identified as the best cropping patterns for the control of stem borers including *Busseola fusca*.

253

Amoako-Atta, B., Omolo, E.O., and Kidega, E.K. 1983. Influence of maize, cowpea and sorghum intercropping systems on stem- /pod-borer infestations. Insect Science and its Application 4(1-2): 47-57. 29 ref.

An improved method of sampling stem and pod borers within an intercropping system is discussed. The frequency of occurrence of *Busseola fusca* was not influenced by cropping patterns.

254

Anderson, T.J. 1931. Annual report of the Senior Entomologist, 1930. Report, Department of Agriculture, Kenya 1930:190-205.

Seventy per cent of maize planted between Oct. 1929 and Feb. 1930 was infested by *Busseola fusca* in Kenya. Planting maize between 15th Feb. and 31st May, destruction of maize stalks and volunteer maize and top dressing with derrisol (1:600) were recommended.

255

Dissemond, A. 1987. The influence of mixed crops of sorghum, maize and *Vigna* on the incidence of pests, diseases and weeds in Kenya. (In De. Summary(s) in En.) Dissertation, Rheinsche Friedrich-Wilhelms-Universitat, Bonn, Federal Republic of Germany. 211 pp.

Surveys carried out at Mbita Point in the semi-arid South Nyanza district of Kenya during 1983-85 are reported. *Busseola fusca* is one of the pests studied.

256

Dissemond, A., and Hindorf, H. 1990. Influence of sorghum/maize/cowpea intercropping in the insect situation at Mbita/Kenya. *Journal of Applied Entomology* 109(2): 144-150. 14 ref.

Intercropping of cereals with cowpea reduced the population of *Busseola fusca* and other stem borers.

257

Dissemond, A., and Weltzien, H.C. 1986. Influence of sorghum and cowpea intercropping on plant pests in a semi-arid area of Kenya. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* 51(3a): 1147-1155. 10 ref.

Intercropping of sorghum did not affect *Busseola fusca* infestation significantly.

258

Elemo, K.A., and Ajayi, O. 1989. Effects of nitrogen on stem borer damage in sorghum/millet mixture. *Insect Science and its Application* 10(5): 601-605. 10 ref.

Grain yield and stem borer (*Acigona ignefusalis* [*Coniesta ignefusalis*] and *Busseola fusca*) infestation were not significantly influenced by the rate and time of nitrogen application in a sorghum/millet mixture in Nigeria during 1984-85. *B. fusca* damage was severe on sorghum in 1984. Borer damage was more severe in the mixture than in the sole crop. Yield of sole sorghum was 5 times that of the mixture in 1984 and two and a half times in 1985.

259

Gebre-Amlak, A. 1988. Ecology and management of maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in southern Ethiopia. Ph.D. thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden. 106 pp. 36 ref. Distribution, biology, sources of infestation, and cultural control of *Busseola fusca* were studied. The impact of wild and cultivated host plants, treatment of crop residues, and planting dates were assessed in the context of non-pesticide management techniques.

260

Gebre-Amlak, A. 1988. Survival of maize stalk borer, *Busseola fusca* (Fuller), in crop residues in Ethiopia. *Crop Protection* 7(3): 183-185. 7 ref. Placing infested maize and sorghum stalks horizontally for 4 and 2 weeks resp., reduced carry over populations of *Busseola fusca* while those stored upright in stacks contained the highest number of live larvae.

261

Gebre-Amlak, A. 1990. Lepidopterous stem borers attacking maize and sorghum and their management in Ethiopia. Page(s) 262-268 in *Cereals of the semi-arid tropics: proceedings of a Regional Seminar, 12-16 Sep 1989, Garoua, Cameroon*. Stockholm, Sweden: International Foundation for Science.

Busseola fusca was one of the three borers observed. The pest was dominant at higher altitudes (1160-2500 m) and in cooler areas. Diapausing larvae were found in residues of different lengths, but longer stalks contained more larvae. Placing infested maize horizontally for 4 weeks or sorghum stalks for 2 weeks was effective in reducing *B. fusca* larvae. Early planting of maize in Apr. is suggested to increase yields without using insecticides against the pest.

262

Gebre-Amlak, A., Sigvald, R., and Pettersson, J. 1989. The relationship between sowing date, infestation and damage by the maize stalkborer, *Busseola fusca* (Noctuidae), on maize in Awassa, Ethiopia. *Tropical Pest Management* 35(2): 143-145.

Infestation of late sown maize by second generation *Busseola fusca* larvae was higher (22.5-100 per cent), when compared to that of early sown maize attacked by first generation larvae (0-22.6 per cent).

263

Ingram, W.R., Irving, N.S., and Roome, R.E. 1973. A handbook on the control of agricultural pests in Botswana. Gaborone, Botswana: Government Printer.

Burning of cereal residues immediately after harvest was recommended in Botswana to control stem borers including *Busseola fusca*.

264

Jack, R.W. 1917. The maize stalk borer (*Calamistes fusca*, Hmps.). Rhodesia Agricultural Journal 14(6): 707-717.

Life cycle and cultural control of *Calamistes fusca* [*Busseola fusca*] are discussed. Second brood larvae that bored into the stalks of maize and kaffir corn [sorghum] hibernated as far down as the roots.

265

Jack, R.W. 1918. A note on the maize stalk borer. Rhodesia Agricultural Journal 15(5): 449-450.

Busseola fusca moths emerged from soil in a crippled condition when the stalks were buried at a depth of 2 inches. When buried at 4-6 inches, all moths died in the soil without reaching the surface. Deep burial of maize stalks along the furrows during Nov. and Dec. is recommended.

266

Jack, R.W. 1922. Notes on the maize stalk borer or 'top worm'. Rhodesia Agricultural Journal 19(1): 87-88.

Infestation of *Busseola fusca* was severe due to late planting and weather conditions. Early planting of a number of rows of maize or kaffir corn [sorghum] as a trap crop and planting between 4th and 24th Dec. in Salisbury, Rhodesia [Zimbabwe] are recommended.

267

Jack, R.W. 1928. Trap cropping against maize pests. Rhodesia Agricultural Journal 25(11): 1228-1231.

Planting four rows of maize 300 yards apart or around the field in smaller areas in Nov., and destroying them along with volunteer maize plants by 15th Dec. is recommended to control *Busseola fusca*.

268

Jack, R.W. 1929. Report of the Chief Entomologist for the year 1928. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1928: 39-46.

Busseola fusca moths did not emerge from maize stalks buried below two inches. Top dressing with derris powder gave good control without scorching the plants.

269

Jack, R.W. 1930. Report of the Chief Entomologist for the year ending 31st December 1929. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1929: 45-52.

Maize planted early as a trap crop for *Busseola fusca* was 100 per cent infested and the infestation of the main crop was negligible in southern Rhodesia.

270

Jack, R.W. 1931. Report of the Chief Entomologist for the year 1930. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1930:65-73.

Approximately 85 per cent of *Busseola fusca* larvae on maize in southern Rhodesia hibernated in the stalks above the ground level. Maize planted early was not helpful as a trap crop because of delayed rains and germination.

271

Kfir, R. 1989. Prospects of biological and cultural control of lepidopteran stalk borers in summer grain crops in South Africa. Proceedings of the Congress of the Entomological Society of Southern Africa 7: 79.

Parasitoids (*Trichogramma chilonis*, *T. ostrinia*, *Apanteles flavipes*, *Allorhogas pyralophagus*, *Mallochia pyralidis*, *Paratheresia claripalpis*, *Xanthopimpla stemmator*, and *Tetrastichus ayyari*) of stem borers including *Busseola fusca* were released in infested maize and sorghum fields. Only a few recoveries were made.

272

Kfir, R. 1990. Prospects for cultural control of the stalk borers, *Chilo partellus* (Swinhoe) and *Busseola fusca* (Fuller), in summer grain crops in South Africa. Journal of the Entomological Society of Southern Africa 53(1): 41-47. 20 ref.

Slashing maize and sorghum plants in the Transvaal destroyed 70 per cent of stem borers including *Busseola fusca*. Ploughing and discing the plant residues after slashing destroyed a further 24 per cent of the pest population on sorghum and 19 per cent on maize.

273

Lawani, S.M. 1982. A review of the effects of various agronomic practices on cereal stem borer populations. *Tropical Pest Management* 28(3): 266-276. 71 ref.

Literature on the effects of field sanitation, tillage and mulching, time of planting, multiple and intensive cropping, rotations, spacing, intercropping, use of fertilizers, and irrigation on stem borers including *Busseola fusca* is reviewed.

274

Lounsbury, C.P. 1918. Division of Entomology, annual report, 1916-17. Report, Department of Agriculture, Union of South Africa 1916-17: 93-105.

Uprooting and raking of maize stumps is helpful in controlling *Busseola fusca*. Mechanical appliances were developed for this purpose.

275

Macharia, M. 1989. Yield losses in maize due to *B. fusca* [*Busseola fusca*] and its survival in crop residues. Annual Report, International Centre of Insect Physiology and Ecology 1988: 5.

Yield loss caused by *Busseola fusca* larvae was more during early growth stages than at later stages at Njoro, Kenya. Per cent grain yield loss was proportional to the number of borer larvae. Crop residue disposal practices - cut stumps, partial burning, deep ploughing, and harrowing reduced 64, 65, 67, and 89 per cent of live larvae, and 14, 17, 91, and 97 per cent of pupae, respectively

276

Mason, C. 1915. Report of the Entomologist for the year ending 31st March 1915. Report, Department of Agriculture, Nyasaland 1915:16 pp.

Topping of young maize leaves when the damage was noticed controlled *Busseola fusca*,

277

Moore, W. 1913. The maize stalk borer (*Sesamia fusca*, Hamp.) and its control. *Agricultural Journal of the Union of South Africa* 5(3): 419-428.

Life cycle of *Sesamia fusca* [*Busseola fusca*] is described. Trap cropping and winter ploughing are suggested for controlling the pest. However, trap cropping is not suitable for the cooler parts of South Africa where maize is planted early to avoid frosts.

278

Musick, G.J., and Petty, H.B. 1973. Insect control in conservation tillage systems. Page(s) 120-125 in *Conservation tillage: proceedings of a National Conference*, Ankeny, Iowa, USA. Ankeny, Iowa, USA: Soil Conservation Society of America.

No-tillage tended to increase incidence of *Busseola fusca* in maize.

279

Naude, T.J. 1940. Work on the control of insect pests. Annual report of the Division of Entomology. *Farming in South Africa* 87: 4 pp.

Delayed planting of maize to avoid *Busseola fusca* infestation is recommended.

280

Ogwaro, K. 1982. Intensity levels of stemborers in maize and sorghum and the effect on yield under different intercropping patterns. *Insect Science and its Application* 4(1-2): 33-37.13 ref.

A single *Busseola fusca* larva could reduce the yield of the stems by 28 per cent of mean dry cob weight. Maize was infested more during the vegetative stages and sorghum towards maturity. Infestation was more in pure stands of sorghum.

281

Omolo, E.O.1984. Intercropping and pest management. Annual Report, International Centre of Insect Physiology and Ecology 1983: 20.

Infestation by pests including *Busseola fusca* in different maize/sorghum/cowpea combinations at 3 locations in Kenya is reported.

282

Omolo, E.O.1986. Stem-borer incidence in sorghum intercropped with maize and cowpea tested in Kenya. Page(s) 367-378 in *Sorghum and millet improvement in eastern Africa: proceedings of the fourth Regional Workshop*, 22-26 Jul 1985, Soroti, Uganda. Nairobi, Kenya: SAFGRAD (Semi-Arid Food Grain Research and Development/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern Africa Regional Program. 10 ref.

Sorghum in monoculture, and sorghum intercropped with maize suffered more damage due to *Busseola fusca* than sorghum intercropped with cowpea, or a combination of sorghum, cowpea, and maize.

283

Omolo, E.O., and Reddy, K.V.S. 1985. Effects of different sorghum-based cropping systems on insect pests in Kenya. (Summary(s) in Fr.) Page(s) 395-401 in Proceedings of the International Sorghum Entomology Workshop, 15-21 Jul 1984, College Station, Texas, USA. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 7 ref.

Infestation by stem borers including *Busseola fusca* was more in monocultures of sorghum or maize than in a sorghum-maize intercrop. Stem borer build-up was slower at Rongo than at Mbita Point Field Station and Ogonjo.

284

Parsons, F.S. 1929. Report on the work of the Cotton Experiment Station, Candover, Magut, Natal, for the season 1927-1928. Progress Reports from Experiment Stations, Empire Cotton Growing Corporation 1927-28: 55-89. 5 ref.

Early sown sorghum was severely infested by *Busseola fusca*. A carbolic sheep dip (kerol) at 1:350 dilution gave good control when ratooned plants were infested.

285

Rao, N.G.P. (No date.) Host plant resistance to sorghum stem borer. Page(s) SB32-SB48 in Sorghum breeding research report 1981 and 1982. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/OAU (Organization of African Unity)/SAFGRAD (Semi-Arid Food Grain Research and Development)/IAR (Institute for Agricultural Research). (Limited distribution.)

Percentage of deadhearts, leaf injury, and tunnelling caused by *Busseola fusca* on sorghum entries at Samaru, Nigeria, are presented. There was no relationship between deadheart percentage and leaf injury. Tunnelling was heavy. Infestation was more under nitrogen fertilization and low plant density. Varieties SPV 315308d SPV 245 performed well in most of the trials.

286

Reddy, K.V.S., and Masyanga, B.S.K. 1988. Effects of different proportions of sorghum/cowpea intercrop rows on crop borer incidence. Annual Report, International Centre of Insect Physiology and Ecology 1987: 6-7.

Busseola fusca infestation started 10 weeks after emergence (WAE) in all the treatments involving

sorghum. Number of pupae per sample increased from 1.48 at 10 WAE to 3.04 at 16 WAE. Alternating 2 rows of sorghum with 2 rows of cowpea reduced *B. fusca* damage by 20 per cent compared to the monocrop of sorghum.

287

Shetty, S.V.R. 1984. ICRISAT/SAFGRAD-Nigeria agronomy—1983. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/SAFGRAD (Semi-Arid Food Grain Research and Development). 13 pp. (Limited distribution.)

Incidence of *Busseola fusca* was observed in a genotype and crop density, and genotype and rate of fertilizer study. Higher fertility plots showed greater damage by stem borer, while crop density levels did not show any significant trend.

288

Sithole, S.Z. 1987. The effect of date of planting on shootfly and stem borer infestations on sorghum. Page(s) 174-183 in Proceedings of the third Regional Workshop on Sorghum and Millets for Southern Africa, 6-10 Oct 1986, Lusaka, Zambia. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program. 16 ref.

Infestation of stem borers including *Busseola fusca* was highest (32 per cent) in mid-Mar. and lowest (16 per cent) in late-Jan. in Zimbabwe. The early-sown crop yielded 4.69 t/ha while the late-sown crop yielded 0.56 t/ha. Yield losses for 2nd, 3rd, and 4th planting dates were 49, 83, and 88 per cent, respectively.

289

Verma, A.N., and Singh, S.P. 1989. Cultural control of sorghum stem borers. (Summary(s) in Fr.) Page(s) 81-87 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 57 ref.

Literature on the role of cultural practices such as time of sowing, crop rotation, tillage, plant spacing, water management, fertilizer management, removal of deadhearts, field sanitation, removal of alternate host plants, mulching, and intercropping in the management of sorghum stem borers including *Busseola fusca*, is reviewed.

290

Wahl, R.O.1916. Notes on some common insect pests of the vegetable garden. Bulletin, Union of South Africa Department of Agriculture 14:19-24. *Busseola fusca* is controlled by destroying maize plants after removing the cobs. Suggests that plants should not be allowed to remain through the winter.

291

Wahl, R.O.1926. The maize-stalk borer (*Busseola fusca*, Fuller). Farming in South Africa 1(8): 279-282.

Destruction of maize stalks before Oct. using the crop for fodder and silage, removing the stumps by oxen-drawn barbed wire or railway metal, top cutting, trap cropping, crop rotation, and use of insecticides (derrisol and kymac) are recommended for controlling *Busseola fusca*.

292

Wahl, R.O.1930. The maize stalk borer. Farming in South Africa 5(53): 205-206.

Trap cropping with maize or sorghum in strips or in the form of small plots is recommended for the control of *Busseola fusca*. Methods of destroying the stubbles are suggested.

293

Walters, M.C. 1975. Evolution in tillage techniques and impact on entomological research, with special reference to the maize stalkborer, *Busseola fusca* (Fuller). Page(s) 235-244 in Proceedings of the first Congress of the Entomological Society of Southern Africa, 1974, Stellenbosch, South Africa (Durr, H.J.R., Giliomee, J.H., and Nesor, S., eds.). Pretoria, South Africa: Entomological Society of Southern Africa. 22 ref.

Role of conventional tillage in controlling *Busseola fusca* through the destruction of overwintering populations is emphasized.

294

Wilkinson, H. 1931. The control of cut worm. Bulletin, Department of Agriculture, Kenya 12: 5 pp.

In Kenya, planting maize in Apr. and harvesting in Nov. helped in controlling *Busseola fusca*, besides controlling cutworm.

Plant Resistance

295

Adenuga, A.O., and Fasina, A.S. 1987. Screening of maize varieties for resistance to stem

borers - *Busseola fusca* (Fuller), *Sesamia calamistis* (Hamps) and others (Lepidoptera-Noctuidae). Nigerian Journal of Agronomy 2(2): 33-39. 9 ref.

Maize cultivars were evaluated for resistance to stem borers by visual assessment method. Relative abundance ratio of *Busseola fusca*, *Sesamia calamistis*, and others was 8:1:0 and 7:2:1 in early and late seasons, respectively. Emergence of *B. fusca* adults was low in the late season. Hybrids and early maturing open-pollinating cultivars were more resistant than yellow seeded hybrids.

296

Barrow, M.R. 1985. The effect of different maize genotypes on the maize stalk-borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), feeding in whorl tissue. Journal of the Entomological Society of Southern Africa 48(1): 113-119.11 ref.

Two resistance factors to *Busseola fusca* were observed in maize - a short lived but effective factor in the whorl tissue that either killed or repelled early-instar larvae; the second which was operative for most of the larval period and retarded larval development.

297

Barrow, M.R. 1987. The effect of first generation maize stalkborer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), on yield of different maize genotypes. Journal of the Entomological Society of Southern Africa 50(2): 291-298.

Yield potential of genotypes varied significantly under *Busseola fusca* attack. Yield reductions ranged from 38 per cent in the least susceptible inbreds to 100 per cent in the most susceptible.

298

Barrow, M.R. 1989. Screening and breeding for resistance to *Busseola fusca* Page(s) 184-191 in Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects, 9-14 Mar 1987, Mexico. Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo. 16 ref. [Es summary: pp. 308-309; Fr summary: pp. 321-322].

Biology of *Busseola fusca*, and methods of maintaining a regular supply of 1st instar larvae, artificial infestation, damage evaluation, development and utilization of resistance involving population and inbred development, and measuring the effectiveness of resistance are

described. Three resistance factors (the 1st that kills the early instar larvae, the 2nd that repels larvae, and, the 3rd that retards larval development) and their role in integrated pest management are described.

299

Barry, B.D. 1980. Where are we, and where are we going with insect resistance in sorghum? African Journal of Plant Protection 2(2): 149-159. 6 ref. [Text also in Fr. En.text: pp. 149453; Fr.text: pp. 155-159].

Rating systems were developed for host-plant resistance programmes for sorghum pests including *Busseola fusca*. Three hundred and six sorghum lines were tentatively selected from about 4000 lines for possible resistance to *B. fusca* in Nigeria in 1973.

300

Daramola, A.M. 1985. Field evaluation of the resistance of nine maize cultivars to stem borer infestation in south western Nigeria. Nigerian Journal of Science 20: 28-30.

Infestation of *Busseola fusca* and *Sesamia calamistis* ranged from 25-36 per cent in 9 cultivars tested at Ikenne and Ilora, Nigeria. None of them was resistant.

301

Esele, J.P.E. 1986. Crop protection aspects of sorghum in Uganda. Page(s) 244-258 in Sorghum and millet improvement in eastern Africa: proceedings of the fifth Regional Workshop, 5-12 Jul 1986, Bujumbura, Burundi. Nairobi, Kenya: SAFGRAD (Semi-Arid Food Grain Research and Development)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern Africa Regional Program. 3 ref.

Severity of damage of stalk borers is described. Screening trials for *Chilo* sp. and *Busseola* sp. resistance, are mentioned.

302

Gebrekidan, B. 1981. Ethiopian Sorghum Improvement Project progress report no.9. Nazareth, Ethiopia: Addis Ababa University, and Institute of Agricultural Research.

Nearly 6000 indigenous lines were evaluated for *Busseola fusca* resistance under natural infestation and only 1 per cent tolerant lines were identified.

303

Gebrekidan, B. 1985. Breeding sorghum for resistance to insects in eastern Africa. (Summary(s) in Fr.) Insect Science and its Application 6(3): 351-357. 41 ref.

Sources and mechanisms of resistance, screening techniques, and breeding for resistance to stem borers including *Busseola fusca* are discussed.

304

Guthrie, W.D. 1989. Breeding for insect resistance in maize. Plant Breeding Reviews 6: 209-243.

Breeding for resistance to 15 major insect pests of maize including *Busseola fusca* are discussed. The value of biotechnology in breeding for insect pest resistance is considered.

305

House, L.R., and Obilana, A.B. 1987. Development of varieties for small farming conditions: sorghum. Page(s) 450-452 in Improving food crop production on small farms in Africa: FAO/SIDA Seminar on Increased Food Production through Low-cost Food Crops Technology, 2-17 Mar 1987, Harare, Zimbabwe. Rome, Italy: FAO.

Resistance to stem borers (*Busseola fusca* and *Chilo partellus*) as one of the traits to be taken into consideration in developing improved sorghum varieties is emphasized.

306

ICRISAT (International Centre of Insect Physiology and Ecology), 1983. Sorghum and maize stem borers. Annual Report, International Centre of Insect Physiology and Ecology 1982: 21.

Distribution, alternative host plants, parasites, and predators of stem borers including *Busseola fusca* are discussed. List of sorghum lines resistant to both *Chilo partellus* and *B. fusca* is given.

307

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1983. Stem borer (*Chilo partellus*). Annual Report, International Crops Research Institute for the Semi-Arid Tropics 1982: 22-23.

Three entries from International Sorghum Stem Borers Nursery (ISSBN), identified as tolerant to *Chilo partellus* in India performed well against *Busseola fusca* at Samaru, Nigeria.

308

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1984. ICRI-

SAT/SAFGRAD/IAR cooperative sorghum improvement research at Nigeria. Progress report 19804983. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/SAFGRAD (Semi-Arid Food Grain Research and Development). 54 pp. (Limited distribution.)

Varietal differences relating to seedling deadhearts and stem tunnelling caused by *Busseola fusca* on sorghum under different nitrogen levels, crop densities, and planting dates are presented. Stem borer infestation, percentage of internodes bored, stem tunnelling, and number of borers per plant and entries having lowest and highest infestations in various trials are reported.

309

IITA (International Institute of Tropical Agriculture). 1982. Annual report for 1981. Annual Report, International Institute of Tropical Agriculture 1981: 87-90.

Breeding maize for resistance to *Busseola fusca* in Nigeria is described.

310

Kishore, P. 1989. Chemical control of stem borers. Page(s) 73-79 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 55 ref.

Stem borers of maize and sorghum including *Busseola fusca* are effectively controlled by leaf whorl placement of granular or dust applications of endosulfan, phenthoate, quinalphos, carbaryl, malathion, and fenvalerate. Integration of endosulfan with host plant resistance is discussed.

311

Kuhn, H.C. 1978. Selection for resistance against the maize stalk-borer (*Busseola fusca*). Technical Communication of the Department of Agricultural and Technical Services of the Republic of South Africa 152: 84-86.

312

Kundu, G.G. 1985. Evaluation of maize cultivars for resistance to stem borer. Indian Journal of Entomology 47(3): 325-327. 5 ref.

Twenty maize cultivars were evaluated for resistance to stem borers including *Busseola fusca*. Four cultivars, Afgoi Composite White, Audinle Local, Antigua-FAW Resistant, and POOL 15 were least susceptible.

313

MacFarlane, J. 1983. Entomology research report 1982. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/SAFGRAD (Semi-Arid Food Grain Research and Development)/OAU (Organization of African Unity)/STRC (Scientific Technical Research Commission). 61 pp. (Limited distribution.)

Busseola fusca infestation, percentage of internodes bored, stem tunnelling, number of borers per plant, varieties showing high and low borer infestations, grain weight per head and 1000 grain weight, in various trials in Nigeria are reported.

314

Pathak, R.S., and Olela, J.C. 1983. Genetics of host plant resistance in food crops with special reference to sorghum stem-borers. Insect Science and its Application 4(1-2): 127-134. 52 ref.

A 6 X 6 diallel cross indicated polygenic inheritance of resistance to sorghum stem borers including *Busseola fusca*. Resistance to primary damage (deadhearts) was governed by both additive and non-additive genes while secondary damage (stem tunnelling) was governed mainly by additive gene action.

315

Rao, N.G.P. (No date.) Host plant resistance to sorghum stem borer. Page(s) SB32-SB48 in Sorghum breeding research report 1981 and 1982. Samaru, Zaria, Nigeria: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)/OAU (Organization of African Unity)/SAFGRAD (Semi-Arid Food Grain Research and Development)/IAR (Institute for Agricultural Research). (Limited distribution.)

Percentage of deadhearts, leaf injury, and tunnelling caused by *Busseola fusca* on sorghum entries at Samaru, Nigeria, are presented. There was no relationship between deadheart percentage and leaf injury. Tunnelling was heavy. Infestation was more under nitrogen fertilization and low plant density. Varieties SPV 315308d SPV 245 performed well in most of the trials.

316

Reddy, K.V.S. 1985. Relative susceptibility and resistance of some sorghum lines to stem-borers in western Kenya. (Summary(s) in Fr.) Insect Science and its Application 6(3): 401-404. 8 ref.

Results of screening for resistance to 4 spp. of stem borers including *Busseola fusca* in western Kenya are reported. It was observed that while *Chilo partellus* was a regular and dominant sp. at ICIPE's [International Centre of Insect Physiology and Ecology] research station at Mbita Point, *B. fusca* was predominant in farmers' fields.

317

Sapin, P. 1985. [Resistance to diseases and insects [*Busseola fusca*, Burkina Faso].] Resistance aux maladies et aux insectes. (In Fr.) Page(s) 39-40 in *Le sorgho au Burkina Faso et son amelioration par l'IRAT, synthese des travaux 1961-1981. Memoires et Travaux de l'IRAT no.11.* Nogent-sur-Marne, France: Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres.

318

Sithole, S.Z., and Mtisi, E. 1987. Research activities in relation to sorghum/protection in Zimbabwe: 1985/86 cropping season. Page(s) 165-173 in *Proceedings of the third Regional Workshop on Sorghum and Millets for Southern Africa, 6-10 Oct 1986, Lusaka, Zambia .* Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program. 2 ref.

Of 25 sorghum germplasm lines that were screened for resistance to diseases and insect pests, several lines were highly resistant to stem borers including *Busseola fusca*.

319

Smith, M.E., Mihm, J.A., and Jewell, D.C. 1989. Breeding for multiple resistance to temperate, subtropical, and tropical maize insects at CIMMYT. Page(s) 222-234 in *Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects, 9-14 Mar 1987, Mexico.* Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo. 30 ref. [Es summary: p. 310; Fr summary: p. 323J.

Breeding decisions made and methodologies used in developing multiple borer resistance involving 8 species of borers including *Busseola fusca* are described. Available information on the inheritance and mechanisms of resistance, results of international testing and evaluation of resistance, breeding methodologies and results of com-

plementary studies that may influence the breeding process is given.

320

van Rensburg, G.D.J. 1983. Breeding for maize borer resistance: progress and prospects [*Busseola fusca*, South Africa]. Technical Communication, Department of Agriculture, South Africa 182: 62-63.

321

van Rensburg, J.B.J., and Malan, C. 1990. Resistance of maize genotypes to the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). *Journal of the Entomological Society of Southern Africa* 53(1): 49-55.

Fifteen maize genotypes were evaluated for resistance to *Busseola fusca*. Three Mississippi inbred lines (Mp705, Mp706, and Mp707) exhibited pronounced antibiosis to larvae of *B. fusca*. An inbred line with a high content of the antibiotic chemical DIMBOA (GT112R) showed limited resistance to *B. fusca*. Inbred lines previously resistant to *B. fusca* exhibited intermediary resistance, while previously observed differences in resistance of local commercial maize hybrids to *B. fusca* was confirmed. Utilization of larval antibiosis and nonpreference by moths in maize breeding programmes is recommended.

322

Walters, M.C. 1974. Mechanisms of resistance to insects and application to maize stalk borer. *Proceedings of the 1st South African Maize Breeding Symposium, Potchefstroom.* Technical Communication, Department of Agricultural and Technical Services, South Africa 132: 83-87.11 ref.

Various stages in the infestation process and different stimuli influencing insect response during the course of the establishment of the pest on a host plant are discussed with special reference to *Busseola fusca*. Attempts to introduce resistance factors in maize are briefly reviewed.

Biological Control and Natural Enemies

323

Akerman, C. 1932. On the carnivorous habits of the long-horned grasshopper, *Clonia vittata* Thunberg. *Annals of the Natal Museum* 7(1): 143-144.

The predacious grasshopper, *Clonia vittata*, Thunb., occurs in Natal in the long grass and

weeds at the edge of maize fields, and its chief food is the larvae, pupae, and adults of *Busseola fusca*.

324

Betbeder-Matibet, M. 1989. Biological control of sorghum stem borers. (Summary(s) in Fr.) Page(s) 89-93 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 15 ref.

Biological control of sorghum stem borers including *Busseola fusca* are reviewed. Thirty parasites were recorded on *B. fusca*.

325

Bordat, P.D., Breniere, J., and Coquard, J. 1977. [African grass borers: parasitism and rearing methods.] Foreurs de graminees Africaines: parasitisme et techniques d'elevege. (In Fr.) Agronomie Tropicale 32(4): 391-399. 26 ref.

Tetrastichus atriclavus was found on *Busseola fusca* in Nigeria.

326

Brownbridge, M. 1990. Evaluation of *Bacillus thuringiensis* for the control of cereal stem borers. Page(s) 145 in Proceedings and abstracts, V International Colloquium on Invertebrate Pathology and Microbial Control, 20-24 Aug 1990, Adelaide, Australia. Glen Osmond, Australia: Department of Entomology.

Aqueous and granular preparations of *Bacillus thuringiensis* protected sorghum from damage by *Chilo partellus* and *Busseola fusca* in field trials conducted in Kenya.

327

Brownbridge, M. 1990. Further evaluation of *B. thuringiensis* [*Bacillus thuringiensis*] for the control of lepidopteran pests. Annual Report, International Centre of Insect Physiology and Ecology 1989:14-15.

Busseola fusca was very susceptible to *Bacillus thuringiensis*. Mortality of 80-100 per cent was obtained with fifth instar larvae on stems dipped in *Bacillus thuringiensis*.

328

Curran, C.H. 1939. African Tachinidae-II. American Museum Novitates 1022: 5 pp.

The tachinids described include *Sturmia halli*, sp. n., bred from larvae and pupae of *Heliothis*

armigera, Hb. (obsoleta, F.) [*Helicoverpa armigera*] and *Rhodesina parasitica*, gen. et sp. n., 'parasitic on *B? fusca*' [*?Busseola fusca*, Fuller], both in southern Rhodesia.

329

Cuthbertson, A. 1936. Biological notes on some Diptera of southern Rhodesia. Occasional Papers of the Rhodesia Museum 5: 46-63.

The tachinid, *Zenillia evolans* [*Carcelia evolans*] is a parasite of the overwintering brood of *Busseola fusca*. *Z. evolans* was parasitized by *Perilampus maurus*, Wlk.

330

Fergusson, N.D.M. 1983. A review of the genus *Platytenomus* Dodd (Hym., Proctotrupeoidea). Entomologist's Monthly Magazine 119*: 199-206.

Biology, distribution, and taxonomy of *Platytenomus* sp. (including *P. busseolae* on *Busseola fusca*) are described.

331

Gebre-Amlak, A. 1985. Survey of lepidopterous stem borers attacking maize and sorghum in Ethiopia. Ethiopian Journal of Agricultural Sciences 7(1): 15-26. 7 ref.

Busseola fusca was one of the 3 stem borers recorded. The pest was dominant at higher altitudes (1160 to 2500 m) and cooler areas. Of 6 parasitoids recorded, *Apanteles sesamiae* was the most widespread. *Diaperasticus erythrocephala* was noticed for the first time preying upon *B. fusca* larva at Welega, Ethiopia.

332

Girling, D.J. 1977. *Parasierola* sp. (Hym., Bethyridae), a parasite of *Eldana saccharina* Wlk. (Lep., Pyralidae). Entomologist's Monthly Magazine 113(1360-63): 211-212.

The parasitic bethyrid, *Parasierola* sp., a known parasite of *Eldana saccharina* in Uganda, did not accept *Busseola fusca* as a host.

333

Guang, L.Q., and Ogedah, K. 1990. Biology of *Trichogramma* sp. nr. *mwanzai* Annual Report, International Centre of Insect Physiology and Ecology 1989:18.

Trichogramma sp. nr. *mwanzai* failed to parasitize *Busseola fusca* eggs under natural conditions in western Kenya. Parasitization was observed when the eggs were artificially exposed.

334

Hill, D.S. 1975. Cereal stem borers (especially *Chilo partellus* (Swinh.), *Chilo orichalcociliella* (Strand) (Pyralidae) and *Busseola fusca* (Fuller) (Noctuidae). Page(s) 37-41 in *Agricultural insect pests of the tropics and their control*. Cambridge, UK: Cambridge University Press.

Research on biological control of stem borers (including *Busseola fusca*) in East Africa is reviewed.

335

ICIPE (International Centre of Insect Physiology and Ecology). 1983. Sorghum and maize stem borers. Annual Report, International Centre of Insect Physiology and Ecology 1982: 21.

Distribution, alternative host plants, parasites, and predators of stem borers including *Busseola fusca* are discussed. List of sorghum lines resistant to both *Chilo partellus* and *B. fusca* is given.

336

Ingram, W.R. 1983. Biological control of gramineous stem-borers and legume pod-borers. *Insect Science and its Application* 4(1-2): 205-209.

Releases of exotic parasites against *Busseola fusca* in East Africa were not successful.

337

Kfir, R. 1987. Hibernation by the borers *Busseola fusca* and *Chilo partellus* in grain sorghum in the Transvaal. *Proceedings of the Congress of the Entomological Society of Southern Africa* 6: 42-43.

About 85 per cent of *Busseola fusca* larvae hibernated as 6th instar larvae inside dry sorghum stalks. About 65 per cent of the larvae were in the lower 3rd and 30 per cent in the middle 3rd of the stalk. Predation by the ant *Pheidole megacephala* and parasitism by *Cotesia sesamiae* [*Apanteles sesamiae*], *Bracon* sp., *Chelonus* sp., and *Iphiaulax* sp. were observed. Pupal period lasted for 3 weeks during Oct.-Nov.

338

Kfir, R. 1988. Hibernation by the lepidopteran stalk borers, *Busseola fusca* and *Chilo partellus* on grain sorghum. *Entomologia Experimentalis et Applicata* 48(1): 31-36.

Busseola fusca infested more than 90 per cent of sorghum (cultivar SSK-52) in the dry season of 1986 (Apr.-Oct.) at Delmas and Brits, Transvaal, South Africa. About 82 per cent of *B. fusca* hibernated as 6th instar larvae and 16 per cent as 5th instar larvae. Pupal period lasted for 3 weeks

during Oct.-Nov. Some parasites (*Apanteles sesamiae*, *Chelonus curvimaculatus*, *Chelonus* sp., *Pristomerus* sp., *Bracon* sp., and *Iphiaulax* sp.) and predators (*Pheidole megacephala* and *Dorylus helvolus*) are reported.

339

Kfir, R. 1989. Biological control of stalk borers. *Bulletin of the Plant Protection Research Institute (South Africa)* 16:5.

Busseola fusca was the only stem borer present at Cedara, Natal. Mass releases of *Xanthopimpla stemmator*, *Tetrastichus ayyari*, and *Trichogramma chilonis* were made. *X. stemmator* and *T. ayyari* were recovered near their release sites.

340

Kfir, R. 1989. Prospects of biological and cultural control of lepidopteran stalk borers in summer grain crops in South Africa. *Proceedings of the Congress of the Entomological Society of Southern Africa* 7: 79.

Parasitoids (*Trichogramma chilonis*, *T. ostrinia*, *Apanteles flavipes*, *Allorhogas pyralophagus*, *Mallochya pyralidis*, *Paratheresia claripalpis*, *Xanthopimpla stemmator*, and *Tetrastichus ayyari*) of stem borers including *Busseola fusca* were released in infested maize and sorghum fields. Only a few recoveries were made.

341

Kfir, R. 1989. Stalkborer hibernation on grain sorghum. *Bulletin of the Plant Protection Research Institute (South Africa)* 15: 8.

More than 90 per cent of sorghum plants were infested by *Busseola fusca* and *Chilo partellus* in the Transvaal. Infestation dropped gradually as winter progressed. Parasitism was higher on *B. fusca* when compared to that of *C. partellus*. Some parasites and predators are reported.

342

Kfir, R. (In press.) Alternative, non-chemical control methods for the stalk borers *Chilo partellus* (Swinhoe) and *Busseola fusca* (Fuller) in summer grain crops in South Africa. *Technical Communication, Department of Agriculture and Water Supply, Republic of South Africa* ? : ?.

Egg, larval, and pupal parasitoids were released in large numbers in South Africa to control *Busseola fusca*. *Xanthopimpla stemmator* and *Tetrastichus howardi* were recovered in the vicinity of the release sites.

343

Maafo, I.K.A. 1975. Laboratory mass rearing of exotic *Tetrastichus* spp. for the control of maize and sugarcane stem borers in Ghana. (Summary(s) in Fr.) Ghana Journal of Agricultural Science 8(2): 89-93. 6 ref.

The exotic parasites, *Tetrastichus inferens* Yoshimoto, *T. Israeli* Mani & Kurian, and *T. ayyari* Rohw. showed high fecundity and helped in controlling stem borers including *Busseola fusca*.

344

Maniania, N.K. 1990. Evaluation of fungal pathogens for the control of stem-borers. Annual Report, International Centre of Insect Physiology and Ecology 1989:15-16.

The strains of *Metarhizium anisopliae* and one strain of *Beauveria bassiana* were tested for pathogenicity against larvae of *Chilo partellus* and *Busseola fusca*. The fungi were virulent to both pests.

345

Maniania, N.K. 1990. Pathogenicity of entomogenous fungi (Hyphomycetes) to larvae of the stem-borers, *Chilo partellus* Swinhoe and *Busseola fusca* Fuller. Page(s) 152 in Proceedings and abstracts, Fifth International Colloquium on Invertebrate Pathology and Microbial Control, 20-24 Aug 1990, Adelaide, Australia. Glen Osmond, Australia: University of Adelaide, Department of Entomology.

Bioassays with several strains of hyphomycetes, 2nd-instar larvae of *Chilo partellus* and 5th- to 6th-instar larvae of *Busseola fusca* are summarized. *Beauveria bassiana* and *Metarhizium anisopliae* were pathogenic to both species, *B. bassiana* isolate ICIPE 4, and *M. anisopliae* isolates ICIPE 18 and ICIPE 30 being the most effective.

346

Milner, J.E.D. 1967. Final report on a survey of the parasites of graminaceous stem-borers in East Africa. Kawanda, Uganda: Commonwealth Institute of Biological Control, East African Station. 159 pp.

Information on the occurrence, ecology, natural enemies, and distribution of the stem borers including *Busseola fusca* is reviewed. Introduction of *Sturmiopsis parasitica* into several new areas of Uganda and Kenya is recommended for the

control of *B. fusca*. Suggestions for further work are given.

347

Mohyuddin, A.I. 1971. Comparative biology and ecology of *Apanteles flavipes* (Cam.) and *A. sesamiae* Cam. as parasites of graminaceous borers. Bulletin of Entomological Research 61: 33-39.

In a test for the suitability of East African graminaceous stem borers as hosts of *Apanteles flavipes* and *Apanteles sesamiae*, *Busseola fusca* was a preferred host second to *Chilo partellus*.

348

Mohyuddin, A.I. 1972. Distribution, biology and ecology of *Dentichasmias busseolae* Heinr. (Hym., Ichneumonidae), a pupal parasite of graminaceous stem-borers (Lep. Pyralidae). Bulletin of Entomological Research 62(2): 161-168. 8 ref.

Busseola fusca was accepted for oviposition by *Dentichasmias busseolae* when placed in the pupation tunnels of *Chilo partellus*, but was not parasitized in the field in Ethiopia.

349

Mohyuddin, A.I., and Greathead, D.J. 1970. An annotated list of the parasites of graminaceous stem borers in East Africa, with a discussion of their potential in biological control. (Summary(s) in Fr.) Entomophaga 15(3): 241-274.

Based on surveys of parasites of lepidopterous stem borers, the introduction of *Hyperchalcidia soudanensis* Steffan, a pupal parasite of *Busseola fusca* present in northern Uganda, and northern and eastern Kenya, into Central Tanzania; and a larval parasite of *B. fusca* from southern Tanzania into northern Uganda and northern Kenya is recommended.

350

Nagaraja, H. 1971. Morphological differences between *Apanteles chilonis* (Munakata) and *A. sesamiae* Cameron (Hym.: Braconidae), parasites on graminaceous moth borers. Technical Bulletin of the Commonwealth Institute of Biological Control 14: 59-61.1 ref.

Reports experiments in India with *Apanteles sesamiae* which parasitizes *Busseola fusca* and *Sesamia* sp. in Africa.

351

Odindo, M.O., Otieno, WA, and Oloo, G.W. (In press.) Infection and mortality of the cereal stem borer *Chilo partellus* Swinhoe, *Busseola fu-*

sea Fuller, *Sesamia calamistis* Hampson, and *Eldana saccharina* Walker on sorghum. Discovery and Innovation ? : ?.

Streptococcus, *Monococcus*, *Rhizopus*, *Fusarium*, and *Nosema* spp. were recovered from stem borers including *Busseola fusca* on sorghum. Incidence of disease in larvae increased gradually from plant emergence to plant maturity.

352

Odindo, M.O., Otieno, W.A., Oloo, G.W., Kilori, J., and Odhiambo, R.C. 1989. Prevalence of microorganisms in field-sampled borers on sorghum, maize, and cowpea in western Kenya. Insect Science and its Application 10(2): 225-228.14 ref.

Bacillus cells, monococci, fungal spores, conidia, hyphal bodies, granulosis virus, polyhedral inclusion bodies, rhabditids, and microsporidia were isolated from larval cadavers of *Busseola fusca*.

353

Ogwang, J. 1990. The host range of *Nosema* sp. in some lepidopteran stem-borers. Annual Report, International Centre of Insect Physiology and Ecology 1989:13-14.

Chilo partellus and *Eldana saccharina* were susceptible and *Busseola fusca* was resistant to *Nosema* infection in laboratory and field studies conducted at Mbita Point Field Station, Kenya.

354

Oloo, G.W. 1985. Parasitoid studies on cereal stem borers in monocrop and intercrop systems. Annual Report, International Centre of Insect Physiology and Ecology 1984:16.

In Kenya, a new parasitoid on *Busseola fusca* eggs was recorded at Gingo. *Apanteles sesamiae* was common on larvae in the Lake Basin region. Predominance of the pupal parasitoids, *Dentichasmias busseolae* and *Pediobius furvus* in field populations of *B. fusca* at Mbita Point on maize and sorghum monocrops was confirmed.

355

Otieno, W.A. 1987. Seasonal incidence of a fungus (*Beauveria* sp.) in *B. fusca* [*Busseola fusca*] and *C. partellus* [*Chilo partellus*] in sorghum agro-ecosystems. Annual Report, International Centre of Insect Physiology and Ecology 1986:15. Evidence of a local isolate of the fungus, *Beauveria* sp. as the causal agent of mortality of *Busseola fusca* on farmers' fields is given.

356

Otieno, W.A., and Odindo, M.O. 1984. Incidence of pathogens. Annual Report, International Centre of Insect Physiology and Ecology 1983: 22-23.

Incidence of pathogens of stem borers including *Busseola fusca* is reported. Stem borer mortality was low and bacteria appeared to be the most common mortality factor.

357

Quicke, D.L.J. 1983. Some new host records for genera and species of Braconinae (Hym., Braconidae) including economically important species. Entomologist's Monthly Magazine 119(1424-27): 91-93. 7 ref.

Twelve new host records for Braconinae are reported including *Merinotus* sp. on *Busseola fusca* in Nigeria.

358

Ritchie, A.H. 1932. Report of the Entomologist, 1931. Report, Department of Agriculture, Tanganyika Territory 1931: 83-86.

Busseola fusca attacking maize was parasitized by *Chasmias glaucopterus*.

359

Scheibelreiter, G.K. 1980. Sugarcane stem borers (Lep.: Noctuidae and Pyralidae) in Ghana. (Summary(s) in De.) Zeitschrift fur Angewandte Entomologie 89(1): 87-99.12 ref.

Biological control of sugarcane stem borers including *Busseola fusca* is discussed.

360

Skoroszewski, R.W., and van Hamburg, H. 1987. The release of *Apanteles flavipes* (Cameron) (Hymenoptera: Braconidae) against stalk-borers of maize and grain-sorghum in South Africa. Journal of the Entomological Society of Southern Africa 50(1): 249-255.19 ref.

Apanteles flavipes was temporarily established on *Chilo partellus* and *Busseola fusca*, but could not be recovered after the winter.

361

Uillyett, G.C. 1935. Notes on *Apanteles sesamiae*, Cam., a parasite of the maize stalk-borer (*Busseola fusca*, Fuller) in South Africa. Bulletin of Entomological Research 26(2): 253-262.4 ref.

Apanteles sesamiae, the main parasite of *Busseola fusca* in the eastern Transvaal, infested 2.9 and

59.1 per cent of borer larvae in the months of Feb. and Mar., respectively. Its life cycle and a study on its introduction into Canada are described.

362

van Rensburg, J.B.J., Walters, M.C., and Giliomee, J.H. 1988. Mortality in natural populations of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) in South Africa. (Summary(s) in Af.) *Phytophylactica* 20(1): 17-19. 5 ref.

Of 9 parasitoids *Apanteles sesamiae* was the most important mortality factor of *Busseola fusca*. Mortality was related to both planting date and plant age as parasitism by *A. sesamiae* was considerably higher in later plantings than in earlier plantings.

363

Wilkinson, D.S. 1932. A revision of the Ethiopian species of the genus *Apanteles* (Hym. Bracon.). *Transactions of the Entomological Society of London* 80(2): 301-344.

Of several species of the genus *Apanteles* on hosts of economic importance, *A. sesamiae*, Cam., was bred from *Sesamia fusca* [*Busseola fusca*], in Cape Colony, Uganda, and Kenya. A list of the hosts and an index to the Ethiopian species of *Apanteles* are given.

Chemical Control

364

Anonymous. 1927. Entomological notes, no.36. *Farming in South Africa* 1927: 3 pp.

Scorching of maize plants by insecticides did not affect yields. A sheep dip containing derris diluted at the rate of 1:200 is reported to be quite safe to control *Busseola fusca*.

365

Anonymous. 1927. Top-dressing maize against stalk-borer [*Busseola fusca*]. Unexpected damage with derrisol. *Farming in South Africa* 1(10): 392. Severe phytotoxicity to maize was reported following the use of derrisol for controlling *Busseola fusca*.

366

Anonymous. 1961. Stem borer control at Nchenachena. Report, Department of Agriculture, Nyasaland 1959-60(pt2): 26.

Four dusting treatments of DDT with and without nitrogen were tested for the control of *Buss-*

eola fusca on maize in Malawi. There was no response to nitrogen and all dusting treatments were equally effective in increasing yields. Single application of 5 lb of 5 per cent DDT dust is recommended for short term yield increase, and for long term control over wider areas a second application a fortnight later is suggested.

367

Adenuga, A.O.1977. Comparative methods and the economics of control of stem borers (Lepidoptera: Noctuidae and Pyralididae) on local maize, *Zea mays* Page(s) 52-53 in *Nigerian Society for Plant Protection: NSPP 7th Annual Conference proceedings*. Nigeria: Nigerian Society for Plant Protection.

In investigations on the control of stem borers (including *Busseola fusca*) on maize in Nigeria, carbaryl as a wettable powder was the best of 3 insecticides tested in sprays. The economic gain from applying carbaryl on late maize was about 4 times that for early maize. Cultural control by removing stalks and stubble after each harvest did not reduce stem borer populations.

368

Adesiyun, A.A. 1986. Control of the stem borer, *Busseola fusca*, on sorghum with granular insecticides. *Samaru Journal of Agricultural Research* 4(1-2): 35-43.

Two granular insecticides, trichlorfon 5G and endosulfan 5G resulted in high mortality (60-100 per cent) of *Busseola fusca* larvae in Samaru, Nigeria. Due to the short active life of insecticides and the long oviposition period of the insect, up to three applications of the insecticides were required. A device for applying insecticide granules to the whorl is described.

369

Adeyemi, S.A.O., Donnelly, J., and Odetoyinbo, J.A. 1972. Studies on chemical control of the stem-borers of maize. *Nigerian Agricultural Journal* 3(2): 61-66.10 ref.

Two applications of 1.5 lb carbaryl/acre, either as an 85 per cent wettable powder in 20 gallons of water or as a 5 per cent dust effectively controlled *Busseola fusca* on early and late sown maize at Ibadan, Nigeria during 1962-65. The insecticides tested reduced infestation and stand loss, especially in late maize, but did not increase grain yield.

370

Ajayi, O. 1987. Insecticidal control of the sorghum stem borer. Page(s) 35-38 in *Cereals Research Programme. Cropping Scheme report, 1987.* Samaru, Zaria, Nigeria: Institute for Agricultural Research.

Granules of carbofuran, applied into the planting hole at planting, followed by a side dressing 6 weeks later, controlled *Busseola fusca* larvae which entered the stem at the base.

371

Anderson, T.J. 1931. Annual report of the Senior Entomologist, 1930. Report, Department of Agriculture, Kenya 1930:190-205.

Seventy per cent of maize planted between Oct. 1929 and Feb. 1930 was infested by *Busseola fusca* in Kenya. Planting maize between 15th Feb. and 31st May, destruction of maize stalks and volunteer maize and top dressing with derrisol (1:600) were recommended.

372

Arnold, H.C. 1928. Top dressing of maize against stalk borer. Rhodesia Agricultural Journal 25(2): 162-165.

Some emergency measures to control *Busseola fusca* are suggested. Removing the top leaves (up to one-third of plant height) of 5-6 weeks old plants is recommended. In older plants proportionately smaller portion is cut off and the plant is treated with some diluted carbolic dip or an insecticidal dust.

373

Barry, B.D., and Andrews, D. 1971. A sprayer for control of *Busseola fusca* in the whorl of sorghum. Journal of Economic Entomology 67(2): 310-311. 3 ref.

Usefulness of a 500 ml pistol-grip hand sprayer was evaluated using carbaryl in Nigeria. The sprayer facilitated delivery of accurate dosages to each whorl. It was not convenient to control 3rd generation of *Busseola fusca* as the plants were taller.

374

Bowden, J. 1956. Maize stem borer control extension dusting trials first and second seasons, 1954. New Gold Coast Farmer 1(1-2): 23-26, 59-61.

Two applications of 5 per cent DDT at 14 and 28 days after sowing at rates of 16 and 20 lb/acre, resp., reduced plant mortality and increased

yields in trials conducted to control *Busseola fusca* and *Sesamia botanephaga* at the Gold Coast, Ghana.

375

Chorley, J.K. 1932. Report of the Chief Entomologist for the year ended 31st December 1931: agricultural. Rhodesia Agricultural Journal 29(7): 522-524.

Derrisol killed 91 per cent of *Busseola fusca* larvae in a trap crop of maize. In further tests, the average infestation was 16 and 97 per cent in treated and untreated crops, respectively.

376

Coaker, T.H. 1956. An experiment on stem borer control on maize. East African Agricultural and Forestry Journal 21(4): 220-221. 2 ref.

DDT at 20 lb/acre was applied thrice at fortnightly intervals to control *Busseola fusca* in Uganda during 1953-56. Grain yield did not differ significantly in treated and untreated plots suggesting that considerable stem damage does not necessarily affect cob development.

377

Daramola, A.M. 1985. Comparative effectiveness of carbofuran and carbaryl in the control of maize stem borer. Nigerian Journal of Plant Protection 9: 54-59. 12 ref.

Both insecticides significantly reduced borer (*Busseola fusca*, *Sesamia calamistis*, and *Eldana saccharina*) infestation during late season. Carbofuran was superior to carbaryl in reducing infestation and increasing grain yield. Infestation was lower when carbofuran was applied as seed dressing than when applied as side dressing 7 days after germination.

378

Drinkwater, T.W. 1979. The application of systemic insecticides to the soil for the control of the maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), and of *Cicadulina mbila* (Naude) (Hemiptera: Cicadellidae), the vector of maize streak virus. (Summary(s) in Af, Fr.) Phytophylactica 11(1): 5-11. 9 ref.

Carbofuran applied to the planting furrow at 0.1-0.3 g/m gave better control of *Busseola fusca* than comparable rates of methoposfolan and aldicarb in South Africa during 1974-76.

379

Egwuatu, R.I., and Ita, C.B. 1982. Some effects of single and split applications of carbofuran on

the incidence of and damage by *Locris maculata*, *Busseola fusca* and *Sesamia calamistis* on maize. (Summary(s) in Es, Fr.) Tropical Pest Management 28(3): 277-283.17 ref.

A single dose of carbofuran at 1.5 kg/ha applied as granules in the planting hole of maize in Nigeria reduced the incidence of *Busseola fusca*.

380

Gebre-Amlak, A. 1982. Effects of frequencies of insecticide application on maize stalk borer *Busseola fusca* (Fuller) control. Ethiopian Journal of Agricultural Sciences 4(1): 55-59.

DDT, endosulfan, and carbaryl, each applied twice at 10 days intervals, reduced *Busseola fusca* infestation by 82.50, 71.50, and 64.25 per cent respectively. Two applications of DDT was more effective than 3 applications of the other two insecticides.

381

Gebre-Amlak, A., and Megenasa, T. 1982. The effects of time of insecticide application on maize stalk borer (*Busseola fusca*) control. Ethiopian Journal of Agricultural Sciences 4(2): 67-73.

Application of insecticides (DDT, endosulfan, and carbaryl) at 4 and 6 weeks after plant emergence gave better control of *Busseola fusca* than with treatments at 2 and 8 weeks.

382

Haines, G.C. 1933. Top-dressing maize [by derrisol] for the control of stalk-borer [in South Africa]. Farming in South Africa Reprint no.64: 2 pp.

Application of derrisol to maize tops for the control of *Busseola fusca* in South Africa is described.

383

Hall, D.R., Beevor, P.S., Cork, A., Lester, R., Nesbitt, B.F., Nyirenda, G.K.C., Nota Phiri, D.D., Blair, B.W., and Tannock, J. 1981. The female sex pheromone of the maize stalk-borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae): identification and initial field trials. Zimbabwe Journal of Agricultural Research 19(1): 111-122.18 ref.

A female sex pheromone of *Busseola fusca* comprising (Z)-11-, (E)-11-, and (Z)-9 tetradecenyl acetates was identified by electroantennography and gas chromatographic analysis. Use of synthetic baits containing all the three acetates in 10:2:2 ratio gave good results in Malawi and Zimbabwe.

384

Jack, R.W. 1919. Maize culture on red soil: value of poisoned bait as an aid to good stands. Rhodesia Agricultural Journal 16(2): 107-112.

Poisoned bait was not found to be effective against *Busseola fusca*.

385

Jack, R.W. 1929. Report of the Chief Entomologist for the year 1928. Report of the Secretary, Department of Agriculture, Southern Rhodesia 1928: 39-46.

Busseola fusca moths did not emerge from maize stalks buried below two inches. Top dressing with derris powder gave good control without scorching the plants.

386

Jotwani, M.G. 1983. Chemical control of cereal stem-borers. Insect Science and its Application 4(1-2): 185-189. 31 ref.

Information on the chemical control of stem borers including *Busseola fusca* on sorghum and maize is reviewed.

387

Kishore, P. 1989. Chemical control of stem borers. Page(s) 73-79 in International Workshop on Sorghum Stem Borers, 17-20 Nov 1987, ICRI-SAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 55 ref.

Stem borers of maize and sorghum including *Busseola fusca* are effectively controlled by leaf whorl placement of granular or dust applications of endosulfan, phenthoate, quinalphos, carbaryl, malathion, and fenvalerate. Integration of endosulfan with host plant resistance is discussed.

388

Leuschner, K. 1990. Sorghum and millet entomology in the SADCC region 1988/89. Page(s) 105-117 in Proceedings of the sixth Regional Workshop on Sorghum and Millets for Southern Africa, 18-22 Sep 1989, Bulawayo, Zimbabwe. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Infestation of finger millet by *Busseola fusca* at Matopos, Zimbabwe and use of thiodan for its control are reported.

389

Leyenaar, P., and Hunter, R.B. 1977. Effect of stem borer damage on maize yield in the coastal savanna zone of Ghana. (Summary(s) in Fr.) Ghana Journal of Agricultural Science 10(1): 67-70. 4 ref.

Maize yield was reduced considerably in both the seasons of 1975 by stem borers including *Busseola fusca*. Application of a granular formulation of carbofuran (furadan) to the seed at sowing at 0.170 g a.i./hill and to the plant whorl at 0.085 g a.i./plant 6 weeks later resulted in an increase in yield of more than 170 per cent.

390

Matthee, J.J., and Oberholzer, J.J. 1959. Maize stalk borer very partial to kaffir-corn. Farming in South Africa 34(10): 36.

Sorghum stems, ear stalks, and seed set were severely affected by 2nd generation larvae of *Busseola fusca* in Feb. Chemical control of these larvae was not effective as they bored directly into the stems. Control of the 1st generation larvae on maize during Nov.-Dec. by treating the calyx with DDT was suggested to prevent the infestation on sorghum by the 2nd generation larvae.

391

Parsons, F.S. 1929. Report on the work of the Cotton Experiment Station, Candover, Magut, Natal, for the season 1927-1928. Progress Reports from Experiment Stations, Empire Cotton Growing Corporation 1927-28: 55-89. 5 ref.

Early sown sorghum was severely infested by *Busseola fusca*. A carbolic sheep dip (kerol) at 1:350 dilution gave good control when ratooned plants were infested.

392

Reddy, K.V.S. 1983. Studies on the stem-borer complex of sorghum in Kenya. Insect Science and its Application 4(1-2): 3-10. 20 ref.

Distribution of stem borers of sorghum and maize in Kenya is reported. *Busseola fusca* was dominant at Kissi with 61 per cent infestation. Sources of sorghum resistance to *B. fusca* were identified. Carbofuran (1 kg a.i./ha) was very effective in controlling the pest when evaluated 11 weeks after planting.

393

Ripley, L.B. 1926. Top-dressing of maize against maize stalk-borer. Results of tests. Farming in South Africa 1(5): 153-154.

Derrisol at a strength of 1:150 and sodium fluosilicate dust were helpful in controlling *Busseola fusca*, followed by carbolic sheep dips, disinfectants and a sheep dip containing derris (1:100). Calcium cyanide was toxic to plants and lead arsenate increased larval infestation.

394

Ripley, L.B. 1928. Top-dressing maize against stalk-borer. Farming in South Africa 10: 5 pp.

A dip containing derris and a carbolic dip diluted at 1:250 and 1:350 resp., applied against *Busseola fusca* combined high killing power and low scorching property.

395

Ripley, L.B., and Hepburn, G.A. 1928. Top-dressing maize against stalk-borer. Farming in South Africa 6(66): 222.

Pulvex (ground derris root) powder at a rate of one teaspoonful per plant and kymac (a sheep dip containing derris) liquid diluted at about 1:250, and powder diluted at 1:450 gave satisfactory control of *Busseola fusca*. Cryolite diluted with water (1:600) was as effective as kymac at 1:300, but was highly phytotoxic.

396

Ripley, L.B., and Hepburn, G.A. 1929. Stalk-borer in maize. Effect of top-dressing. Farming in South Africa Reprint no.59:4 pp.

Kymac (sheep dip with derris at a strength of 1:250), and water suspensions of cryolite (1:600) and pulvex (1:540) were helpful in controlling *Busseola fusca*. Pulvex was non-toxic to plants while cryolite and kymac caused mild scorching.

397

Ripley, L.B., and Hepburn, G.A. 1934. Adhesives for cryolite suspensions. Science Bulletin, Department of Agriculture, South Africa 122:12 pp.

Cryolite was effective in controlling *Busseola fusca*. Of 31 materials examined for their adhesiveness, linseed oil (at 0.348 cc/gm of synthetic cryolite) gave maximum adhesiveness and suspensibility followed by tung oil and boiled fish oil. Treacle, sodium resinate, caesinate, and skim milk reduced adhesiveness.

398

Sagnia, S.B. 1983. Possible integrated pest management tools for the effective control of cereal stem-borers in Gambia. Insect Science and its Applications 4(1-2): 217-219. 5 ref.

Malathion 50 EC at 1.5 kg a.i./ha, basudin 10 G at 2.0 kg a.i./ha, and basudin 60 EC at 1.2 kg a.i./ha, effectively controlled cereal stem borers including *Busseola fusca*. Integrated methods of control are discussed.

399

Sithole, S.Z. 1988. The effect of protecting sorghum at different growth stages on stemborer infestation and yield. Page(s) 201-208 in Proceedings of the fourth Regional Workshop on Sorghum and Millets for Southern Africa, 21-24 Sep 1987, Matopos, Zimbabwe. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program.

Pesticide application during the early stages of plant development was more effective in controlling stem borers including *Busseola fusca* on sorghum in Zimbabwe. Stem borer incidence was higher on the cultivar Segalane than on Red Swazi.

400

Sithole, S.Z., and Makombe, G. 1989. Economic analysis for the application of dipterex 2.5 per cent granules to control stemborers attacking sorghum in the communal areas of Zimbabwe. Page(s) 204-211 in Proceedings of the fifth Regional Workshop on Sorghum and Millets for Southern Africa, 21-23 Sep 1988, Maseru, Lesotho. Bulawayo, Zimbabwe: SADCC (Southern African Development Coordination Conference)/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum and Millet Improvement Program. 8 ref.

Two sorghum cultivars, Segalane and Red Swazi were treated with dipterex 25 per cent granules for the control of stem borers including *Busseola fusca*. With a minimum rate of return of 60 per cent acceptable to farmers in the communal areas, application of dipterex gave acceptable returns only to Segalane.

401

Swaine, G. 1957. The maize and sorghum stalk borer, *Busseola fusca* (Fuller), in peasant agriculture in Tanganyika territory. Bulletin of Entomological Research 48(4): 711-722.9 ref.

Life cycle, larval diapause, and control of *Busseola fusca* are discussed. The pest had two gener-

ations on the main crops of sorghum and maize and a 3rd on sorghum tillers. Diapause was terminated by contact with water. Cob yield increased when treated with DDT.

402

Udagawa, T. 1987. Ethofenprox (Trebon), a novel insecticide without rice brown plant hopper resurgence. 2. Efficacy to rice and other crop pests. Page(s) 63 in Abstracts, International Congress of Plant Protection, 5-9 Oct 1987, Manila, Philippines. Manila, Philippines: International Congress of Plant Protection.

Ethofenprox at 0.1-0.2 kg ai/ha controlled *Busseola*, *Sesamia*, *Spodoptera*, and aphids on maize.

403

USADA (Union of South Africa, Department of Agriculture). 1922. Departmental activities: entomology. Journal of the Department of Agriculture, Union of South Africa 4(4): 300-304.

Treating *Busseola fusca* infested maize plants with 'Little's Fluid Sheep Dip' diluted with water (1100), applied at one teaspoonful for an 18-inch plant is recommended.

404

USADA (Union of South Africa, Department of Agriculture). 1923. Departmental activities: entomology. Journal of the Department of Agriculture, Union of South Africa 6(3): 199-201.

In the Transvaal, *Busseola fusca* was controlled by pouring a small cupful of hycol solution (one tablespoonful to one gallon of water) into the tops of each maize plant when about two feet high.

405

van Rensburg, G.D.J., and Giliomee, J.H. 1989. Comparative efficacy of pre- and post-emergence application of insecticides for simultaneous control of the maize leafhopper, *Cicadulina mbila*, and the stalk borers, *Busseola fusca* and *Chilo partellus*, on maize. (Summary(s) in Af.) Phytomythologica 21: 399-402.11 ref.

Seed dressing with carbosulfan controlled leaf hoppers but did not control *Busseola fusca* and *Chilo partellus*. Carbofuran granules applied to the planting furrow at rates of 15 g and 20 g a.i./100 m row length provided simultaneous control of leafhopper and stem borers.

406

van Rensburg, G.D.J., and Malan, E.M. 1982. Control of sorghum pests and phytotoxic effect of

carbofuran on five hybrids of grain sorghum. (Summary(s) in Af.) *Phytophylactica* 14(4): 159-163.17 ref.

Application of 10 per cent carbofuran granules at 1.5-2.5 kg a.i./ha to sorghum in South Africa reduced *Busseola fusca* infestation, but was phytotoxic especially in soils with low clay content and during drought stress.

407

van Rensburg, J.B.J. 1988. Efficacy of cloethocarb for control of *Busseola fusca*, *Cicadulina* spp. and nematodes in maize. *Applied Plant Science* 2(2): 63-67.10 ref.

Cloethocarb at a rate of 20 g a.i./100 m controlled *Busseola fusca*. Differences in formulations (granular formulations based on sand, clay, calcium carbonate, and maize meal carriers) did not influence efficacy.

408

van Rensburg, J.B.J., and Walters, M.C. 1978. The efficacy of systemic insecticides applied to the soil for the control of *Cicadulina mbila* (Naude) (Hem: Cicadellidae), the vector of maize streak disease, and the maize stalk borer *Busseola fusca* (Fuller) (Lep: Noctuidae). (Summary(s) in Af, Fr.) *Phytophylactica* 10(2): 49-52.11 ref.

Carbofuran granules applied to the planting furrow at 20 g a.i./100 m row length resulted in better yields when compared to ethoprophos (ethylprop), thiofanox, disulfoton, terbufos, and mephosfolan, in trials conducted to control *Busseola fusca* in South Africa in 1977.

409

van Rensburg, J.B.J., Walters, M.C., and Stemmet, G.P. 1978. A preliminary study on the application of carbofuran granules to the soil for the control of grain sorghum pests. (Summary(s) in Af, Fr.) *Phytophylactica* 10(1): 28-30. 9 ref.

Carbofuran granules (10 per cent) applied to the plant furrow at 10, 20, and 30 g a.i./100 m row length resulted in reduction of infestation by *Busseola fusca*.

410

Wahl, R.O. 1926. The maize-stalk borer (*Busseola fusca*, Fuller). *Farming in South Africa* 1(8): 279-282.

Destruction of maize stalks before Oct. using the crop for fodder and silage, removing the stumps by oxen-drawn barbed wire or railway metal, top

cutting, trap cropping, crop rotation, and use of insecticides (derrisol and kymac) are recommended for controlling *Busseola fusca*.

411

Walker, P.T. 1959. Further insecticide trials on the maize stalk borer (*Busseola fusca*) in Tanganyika, 1957. Report, Great Britain Colonial Pesticides Research Unit, CPRU/Porton 161: 10 pp.

412

Walker, P.T. 1960. Insecticide studies on the maize stalk borer, *Busseola fusca* (Fuller), in East Africa. *Bulletin of Entomological Research* 51(2): 321-351.

Endrin was effective against *Busseola fusca* when applied as 2 per cent dust or 0.03-0.4 per cent emulsion spray. Yield increased up to 2.6 times over the control. A method of testing pesticide residues by exposing 1st instar larvae to direct contact with residues is described.

413

Walker, P.T. 1960. The characteristics of a commercial hand operated granule distributor, the Cook 'Granula,' modified for rows of maize [for controlling insect pests including *Busseola fusca*]. Report, Great Britain Colonial Pesticides Research Unit, CPRU/Porton 176:4 pp.

414

Walker, P.T. 1960. The relation between infestation by the stalk borer *Busseola fusca*, and yield of maize in East Africa. *Annals of Applied Biology* 48(4): 780-786.17 ref.

The relation between maize yield and infestation by *Busseola fusca* in Tanganyika was rectilinear. Grain yield increased by 35 lb/acre for every 1 per cent decrease in infestation for the higher yield group and by 17 lb for the lower yield group. Economics of control by insecticides and the accuracy of methods of sampling infestations are also discussed.

415

Walker, P.T., and Selway, M. 1960. The retention on maize of granules, as used for the insecticidal control of stalk borers. Report, Great Britain Colonial Pesticides Research Unit, CPRU/Porton 178: 7 pp.

Attaclay, attapulgit is used for the control of *Busseola fusca*.

416

Walters, M.C., and Drinkwater, T.W. 1975. Preliminary studies on the application of systemic insecticides to the soil for the control of the maize stalk borer, *Busseola fusca* (Fuller) (Lep.: Noctuidae). (Summary(s) in Af, Fr.) *Phytophylactica* 7(4): 121-123. 4 ref.

Carbofuran 10 per cent granules at 1 kg a.i./ha was very effective in controlling *Busseola fusca* when evaluated 11 weeks after planting at Potchefstroom, South Africa in 1975. The other granules tested were phorate, aldicarb, and disulfoton. Phorate treatment reduced plant density.

417

Warui, C.M., Kuria, J.N., and Kamau, G.M. 1986. Pyrethrum formulations in the control of maize stalkborers *Chilo partellus* Swinh, *C. orichalcociliellus* Strand (Pyralidae), *Sesamia calamistis* Hmps and *Busseola fusca* Fuller (Noctuidae) in Kenya. *Pyrethrum Post* 16(2): 43-47.14 ref.

Pyrethrum marc impregnated with pyrethrins was as effective as dipterex [trichlorfon], one of the insecticides generally recommended in Kenya to control *Busseola fusca*.

418

Weaving, A.J.S. 1964. A preliminary assessment of the effectiveness of pyrethrum against the stalk borer *Busseola fusca* (Fuller) in the field in Kenya. *Bulletin of Entomological Research* 55(3): 565-572. 5 ref.

Pyrethrum dust (0.2 per cent), synergized with 5 parts piperonyl butoxide, applied to maize at 20 lb/acre was as effective as 5 per cent DDT dust applied at the same rate. Both insecticides reduced the infestation of *Busseola fusca* by 50 per cent and the number of damaged cobs by 40 per cent.

419

Whitney, W.K. 1970. Observations on maize insects at the International Institute of Tropical Agriculture (IITA) Ibadan. *Bulletin of the Entomological Society of Nigeria* 2 (2): 146-155.47 ref.

Busseola fusca larvae accounted for 44.6 per cent of the total larval population in the month of Aug. in 1970 and were controlled by carbaryl and malathion.

420

Wilkinson, H. 1936. Report of the Entomological Section. Report, Department of Agriculture, Kenya 1935: 60-70.

Stalk borer regulations were brought into operation when *Busseola fusca* infestation on maize was noticed in western Kenya. Maize planted between Feb. and Mar. was more heavily infested. Larvae found on the outer leaves of *Pennisetum purpureum* died eventually. Derrisol controlled the pest effectively.

Legislative Control

421

Anderson, T.J. 1928. Annual report of the Entomologist, 1927. Report, Department of Agriculture, Kenya 1927: 208-219.

A campaign to restrict maize planting to the period 15th Feb.-10th Jun. 1928 for controlling *Busseola fusca* in Kenya is reported.

422

Anderson, T.J. 1929. Control of maize stalk borers. Bulletin, Department of Agriculture, Kenya 7F: 5 pp.

Busseola fusca caused 85 per cent damage to maize and millet in Kenya. A campaign advocating compulsory notification of the presence of borers, destruction of old maize stalks and volunteer maize, planting dates, and appointment of inspectors is reported.

423

Wilkinson, H. 1929. Annual report of the Entomologist, 1928. Report, Department of Agriculture, Kenya 1928:172-186.

Describes campaign against *Busseola fusca* on maize and the success achieved leading to temporary revocation of regulations in the campaign.

424

Wilkinson, H. 1936. Report of the Entomological Section. Report, Department of Agriculture, Kenya 1935: 60-70.

Stalk borer regulations were brought into operation when *Busseola fusca* infestation on maize was noticed in western Kenya. Maize planted between Feb. and Mar. was more heavily infested. Larvae found on the outer leaves of *Pennisetum purpureum* died eventually. Derrisol controlled the pest effectively.

425

Wilkinson, H. 1939. Entomological Section. Annual report. Report, Department of Agriculture, Kenya 2: 86-101.

Destruction of infested maize by 7th Feb. in two districts of Rift Valley Province, Kenya was ordered under the Diseases of Plants Prevention (Amendment) Rules, 1936 to control *Busseola fusca*. Planting maize before 15th Feb. 1937 or between 31st May 1937 and 15th Feb. 1938 was not allowed.

Other Control Methods

426

Beevor, P.S., Hall, D.R., and Nesbitt, B.F. 1983. Pheromones and other recent developments in biochemical pest management. Page(s) 163-171 in Chemistry and world food supplies: the new frontiers, CHEMRAWN II: papers presented at the International Conference on Chemistry and World Food Supplies, 6-10 Dec 1982, Manila, Philippines (Shemilt, L.W., ed.). Oxford, UK: Pergamon Press.

Busseola fusca on maize was monitored by the use of pheromones in Zimbabwe.

427

Blair, B.W. 1971. Recent research on the maize stalk-borer *Busseola fusca* (Fuller): influence on control methods. Rhodesia Agricultural Journal 68(6): 111-112. 8 ref.

The occurrence, biology, and severity of damage of *Busseola fusca* on maize in Africa are reviewed with special reference to Rhodesia. The possibility of using a sex pheromone for the control of the pest is discussed.

428

Blair, B.W., and Read, J.S. 1969. A preliminary report on the sex pheromone of the maize stalk-borer *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Rhodesian Journal of Agricultural Research 7(1): 55-59. 11 ref.

A sex pheromone in virgin females of *Busseola fusca* was identified as an unsaturated acetate ester. Morphology and histology of the sex pheromone gland are described.

429

Campion, D.G. 1983. Pheromones for the control of insect pests [including *Busseola fusca*] in deve-

loping countries. Page(s) 192-206 in Regional Symposium on Integrated Pest Control for Cotton in the Near East, 5-9 Sep 1983, Adana, Turkey. Adana, Turkey: FAO.

430

Campion, D.G., and Nesbitt, B.F. 1983. The utilisation of sex pheromones for the control of stem-borers. Insect Science and its Application 4(1-2): 191-197. 63 ref.

Research on the identification of the sex pheromones of lepidopterous stem borers including *Busseola fusca* and the use of pheromones in crop protection is reviewed. Pheromone components of various stem borers are listed.

431

Ho, D.T., and Reddy, K.V.S. 1983. Monitoring of lepidopterous stem-borer population by pheromone and light traps. Insect Science and its Application 4(1-2): 19-23. 22 ref.

Busseola fusca was the least attracted among the 5 species of stem borers tested in the pheromone and light trap studies in sorghum and maize fields in western Kenya during 1981-82.

432

Nesbitt, B.F., Beevor, P.S., Cork, A., Hall, D.R., Lester, R., Blair, B.W., and Tannock, J. 1980. Identification of the female sex pheromone of the maize stalk borer *Busseola fusca*: a preliminary report. Tropical Pest Management 26(3): 327.

The three isomeric components, (Z)-11-, (E)-11-, and (Z)-9-tetradecenyl acetates produced by *Busseola fusca* were synthesized and tested in traps for field attractancy. The components in their natural ratio (10:2:2) were highly attractive to male *B. fusca*. Individual compounds and binary mixtures were not attractive.

433

Nesbitt, B.F., Beevor, P.S., Hall, D.R., Lester, R., Davies, J.C., and Reddy, K.V.S. 1979. Components of the sex pheromone of the female spotted stalk borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae): identification and preliminary field trials. Journal of Chemical Ecology 5(1): 153-163.

The components of a pheromone released by *Busseola fusca* females are identified as (Z)-11-, and (E)-11-tetradecenyl acetates.

434

Nyambo, B.T. 1990. Monitoring insect pest populations in relation to crop phenology in the ICIPE-ECA project area. Annual Report, International Centre of Insect Physiology and Ecology 1989: 7. Adult populations of *Busseola fusca* and *Chilo partellus* were monitored by trapping, using synthetic pheromone or 1-day-old virgin females, on maize at 5 sites in Kenya, during the 1989 short rains. Weekly moth catches varied significantly between sites. Infestation was very low between 2-10 WAE. No relationships could be established between trap catches, percentage plant damage, and leaf damage ratings.

435

PPRI (Plant Protection Research Institute). 1979. Report, Plant Protection Research Institute, Zimbabwe 1979:4-51.

As part of plant protection research activities in Zimbabwe, an investigation showed that the sex pheromone of *Busseola fusca* is identified as Cis-9-tetradecenyl acetate.

436

Revington, J., van Rensburg, J.B.J., Burghardt, G., and Knauf, W. 1984. Preliminary field trials with a pheromone based monitoring system for the maize stalkborer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa 47(1): 107-113. 9 ref.

Trapping rates of *Busseola fusca* increased with higher concentrations of release inhibitor in a pheromone baited delta trap system in South Africa. Higher loading gave higher trapping rates. Correlations between the light trap catches and oviposition on maize plants 5 weeks after emergence were +0.96 for the cultivar SR52 and +0.99 for A220.

437

Unnithan, G.C. 1989. Communication disruption in *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1988: 7.

Male-female communication in *Busseola fusca* was disrupted in fields permeated with synthetic pheromone at Rusinga Island and Mbita, Kenya.

438

Unnithan, G.C., and Paye, S.O. 1990. Factors involved in mating, longevity, fecundity and egg fertility in the maize stem-borer, *Busseola fusca*

(Fuller) (Lep., Noctuidae). Journal of Applied Entomology 109(3): 295-301.

Delayed mating prolonged longevity and pre-oviposition period but reduced oviposition period, fecundity and egg fertility. Highest fecundity (822 eggs) and egg fertility (94 per cent) were obtained when the females were mated on the night of eclosion. *Busseola fusca* males showed multiple mating ability indicating the inefficiency of mass trapping of males in suppressing pest population. Delayed mating achieved by permeating the field with synthetic pheromone may result in the production of less viable eggs and can be used as a control strategy.

439

Unnithan, G.C., and Saxena, K.N. 1985. Trapping and pheromone biology of *B. fusca* [*Busseola fusca*] and *C. partellus* [*Chilo partellus*]. Annual Report, International Centre of Insect Physiology and Ecology 1984: 9.

Busseola fusca virgin females were more than 2 times as efficient as synthetic pheromone in attracting males. Mated females and blank water traps did not attract any males.

440

Unnithan, G.C., and Saxena, K.N. 1988. Pheromonal trapping and monitoring of the stem borers *C. partellus* [*Chilo partellus*] and *B. fusca* [*Busseola fusca*]. Annual Report, International Centre of Insect Physiology and Ecology 1987: 5-6.

Traps with a single virgin female of *Busseola fusca* attracted more males than those with 1 and 5 mg synthetic pheromone for the first 10 days, while the catches were similar for the subsequent 15 days. A dosage of 5 mg was more effective than 1 or 2 mg of synthetic pheromone. Male populations of *B. fusca* showed a major peak at about 12 weeks after crop emergence and a minor peak 7-8 weeks later.

Integrated Pest Management

441

Barrow, M.R. 1989. Screening and breeding for resistance to *Busseola fusca* Page(s) 184-191 in Toward insect resistant maize for the third world: proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects, 9-14 Mar 1987, Mexico.

Mexico: Centro Internacional de Mejoramiento de Maiz y Trigo. 16 ref. [Es summary: pp. 308-309; Fr summary: pp. 321-322].

Biology of *Busseola fusca*, and methods of maintaining a regular supply of 1st instar larvae, artificial infestation, damage evaluation, development and utilization of resistance involving population and inbred development, and measuring the effectiveness of resistance are described. Three resistance factors (the 1st that kills the early instar larvae, the 2nd that repels larvae, and, the 3rd that retards larval development) and their role in integrated pest management are described.

442

Betbeder-Matibet, M. 1986. Principles of integrated pest management against stem borers [including *Busseola fusca*] of tropical cereals and sugarcane in Africa, Madagascar and Mascareignes. (In Fr. Summary(s) in En.) *Revue de Zoologie Africaine* 100: 97-104.

443

Nwanze, K.F. (No date.) Stem-borers of cereals in Sahelian West Africa: relative importance and control. Page(s) 115-123 in *Biological control of pests: its potential in West Africa: proceedings of an International Conference, 9-13 Feb 1981, Dakar, Senegal.* Dakar, Senegal: US Agency for International Development Regional Food Crop Protection Project. [Also issued in Fr.: Pages 108-115 in *Lutte biologique contre les ravageurs et ses possibilites en Afrique de l'Ouest: compte rendu du Seminaire qui a eu lieu, 9-13 Fev 1981, Dakar, Senegal.*]

Busseola fusca was observed on maize and sorghum in Upper Volta [Burkina Faso] in the region below latitude 11 deg 30'N, with an annual rainfall greater than 900 mm. It was also found in Kano and Dutsin-Ma, northern Nigeria. In the Sahel, population of *B. fusca* was lesser than that of *Acigona ignefusalis* [*Coniesta ignefusalis*]. Sorghum leaves were severely damaged by *B. fusca* in northern Nigeria in 1980. Various cultural measures, use of resistant varieties, and release of biological agents, are reviewed in the context of integrated pest management.

444

Nwanze, K.F., and Mueller, R.A.E. 1989. Management options for sorghum stem borers for farmers in the semi-arid tropics. (Summary(s) in Fr.) Page(s) 105-113 in *International Workshop on*

Sorghum Stem Borers, 17-20 Nov 1987, ICRISAT Center, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 47 ref.

Literature on control measures and integrated pest management of sorghum stem borers including *Busseola fusca* is reviewed. The impracticality and non adoption of most of the recommended control measures by farmers are stressed. A farming systems perspective and farmer-oriented research approach to stem borer management are suggested.

445

Reddy, K.V.S. 1985. Integrated approach to the control of sorghum stem borers. (Summary(s) in Fr.) Page(s) 205-215 in *Proceedings of the International Sorghum Entomology Workshop, 15-21 Jul 1984, College Station, Texas, USA.* Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 58 ref.

The distribution and importance of 27 lepidopterous stem borers of sorghum including *Busseola fusca* are reviewed, and existing control practices are discussed with a view to developing an integrated approach.

446

Sagnia, S.B. 1983. Possible integrated pest management tools for the effective control of cereal stem-borers in Gambia. *Insect Science and its Applications* 4(1-2): 217-219. 5 ref.

Malathion 50 EC at 1.5 kg a.i./ha, basudin 10 G at 2.0 kg a.i./ha, and basudin 60 EC at 1.2 kg a.i./ha, effectively controlled cereal stem borers including *Busseola fusca*. Integrated methods of control are discussed.

447

Saxena, K.N., Reddy, K.V.S., Omolo, E.O., Pala-Okeyo, A., and Ngode, L. 1989. Integrated pest management: pilot trials. Annual Report, International Centre of Insect Physiology and Ecology 1988: 20-21.

Studies involving farmers at two locations in Kenya using several components for IPM (intercropping, adjustment of planting time, crop residue disposal, and plant resistance to insect pests) reduced damage to sorghum by stem borers including *Busseola fusca*.

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