NATURAL ENEMIES OF
HELCOVERPA ARMIGERA IN AFRICA:

– A REVIEW

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PREFACE

This work was prepared as part of research project R4365 funded by the Overseas Development Administration of the British Government, on the natural enemies of Helicoverpa armigera in East Africa. It is hoped that this review will be of value to researchers in African countries, and also in other parts of the world where Helicoverpa spp. and Heliothis spp. are a major problem.

Part of the study was conducted at the C.A.B International Institute of Entomology (CIE) and the British Museum of Natural History (BMNH), both in London. The authors would like to thank K.M. Harris (Director), Z. Bouček, A. Polaszek and A.K. Walker (all CIE), and R.W. Crosskey, I.D. Gauld and T. Huddleston (all BMNH), who have greatly helped in the search of museum material and have made valuable contributions to this work with their taxonomic comments on the parasitoid species presented in Part II of this review.

Thanks are also due to P.J. Guest (Jealotts Hill Research Station, Bracknell, UK), N.J. Mills (CIBC, UK), B.T. Nyambo (Agricultural Research Institute, Ilonga, Tanzania) and P. Rivett (Plant Protection Division, Fernhurst, UK) for providing useful information, and to D.J. Girling (CIBC) and K. Howard (CIE) for their assistance in the literature search. We are grateful to D.J. Greathead (Director, CIBC) for his comments on the manuscript.

Finally, we are much indebted to A.H. Greathead (CIBC, UK) for extensive reading and editing of the manuscript.
ABSTRACT

The natural enemies of Helicoverpa armigera Hübner in Africa are reviewed, using published, unpublished and museum sources. A large variety of natural enemies are represented in almost 300 host records, including 83 parasitoids identified to species and 93 identified only to genus. The taxonomy, distribution, biology, alternative hosts or prey, host-plant associations and secondary natural enemies are detailed for all recorded natural enemies, and the different aspects are summarized and evaluated for the total natural enemy complex. Striking differences are found in the reported parasitoid complexes between East Africa and southern Africa. Methods for sampling natural enemies of H. armigera are discussed, and suggestions are made for accurately estimating parasitism rates for the different types of parasitoids attacking H. armigera.
PART I

1. INTRODUCTION

The bollworm *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae), better known under its previous name *Heliothis armigera*, is a major constraint to food and cash-crop production in Africa, attacking various crops including cotton, legumes, maize, sorghum, sunflower, tobacco and tomato. Damage is frequently localized on the reproductive parts of crops, i.e. those parts which are harvested. Nearly all the detailed studies on the biology and control of this pest have been made in cotton.

Generally, *Helicoverpa armigera* larvae live hidden within the fruiting parts of the plant during most of their development. Thus, large amounts of insecticide are needed if larvae are to ingest a lethal dose during their short period of contact with the foliage between hatching and entering the host-plant. Moreover, *H. armigera* has a strong ability to develop resistance to insecticides (Joyce 1982), and cases of resistance of *H. armigera* to organochlorines and pyrethroids in the field have been reported in several parts of the world (Wilson 1974; Goodyer et al. 1975; Gledhill 1982; Collins 1986). It seems that the impact of parasitoids on *H. armigera* populations in cotton has declined during the last decades with the escalating use of insecticides (Reed 1965; Balla 1982). Currently, more durable and ecologically sound management systems are being studied.

Biological control is a major component of integrated pest management which seeks to maximize the contribution of naturally occurring parasitoids, predators and pathogens to depression of pest populations. Certain characteristics of *H. armigera*, e.g. the migratory ability of the adults and the aggressiveness of the larvae, may make it a difficult target for biological control, however there is a large number of parasitoid species attacking *H. armigera* in Africa. Only limited data exist on the role they play in controlling the pest.

In the past, information on the major parasitoids of *H. armigera* in Africa has been summarized on several occasions (e.g. Henrard 1937; Pearson 1958; Risbec 1960; Greathead 1966; Greathead & Girling 1988). However, this review is an attempt to give a complete picture of all natural enemy records of *H. armigera* from Africa, with comments on their taxonomy, distribution, biology, alternative hosts or prey, host-plant associations and secondary natural enemies, thereby using published, unpublished and museum sources.
2. THE PEST

2.1 TAXONOMY

There has been much confusion about the taxonomy of Heliothidinae (Nye 1982). Traditionally, the taxon armigera Hübner has been placed in the familiar genus Heliothis. However, Hardwick (1965) erected the new genus Helicoverpa to separate armigera and similar species from Heliothis. There have been strong urgings from agricultural scientists to revert to Heliothis armigera because of the enormous literature, and familiarity with this name. However, there is a growing consensus among taxonomists that Helicoverpa and Heliothis are separate genera (e.g. Holloway, Bradley & Carter 1987; Poole 1988) so that we reluctantly use the combination Helicoverpa armigera here.

Four species occur in Africa: Helicoverpa assulta Guenée, H. fletcheri Hardwick, H. peltigera Schiffermüller, and H. armigera. The latter is by far the most economically important species and is the subject of this review. Host records from H. armigera are likely to include misidentifications of the related species above.

2.2 LIFE-HISTORY

2.2.1 Adult

The pre-oviposition period is 1-4 d (=days), the oviposition period 2-5 d, and the post-oviposition period 1-2 d, at 30-33°C (Singh & Singh 1975). Reed (1965) reported a fecundity of 1,200 eggs during the rainy season and 200 eggs during the dry season. With the availability of food, the longevity is 11 d, and the sex ratio 1:1 at 21-27°C (Reed 1965). Adults are strongly attracted to crops with honeydew or nectar and feeding is important for survival. Nocturnal flights and oviposition mostly occur just after dusk (Topper 1987b).

2.2.2 Oviposition

Females oviposit at night. Beeden (1974) found that eggs on cotton were laid uniformly over the field throughout the season. Eggs (0.5 mm in diameter) are laid singly on the leaves or on reproductive parts of the plant. In the vegetative stage of cotton oviposition is low and eggs are mostly laid on the upper surface of the leaves on the top part of the plant. Oviposition usually increases in the reproductive stage of the crop. Favoured oviposition sites are fertile portions, such as tassels of maize or the flower buds of cotton.

2.2.3 Development

Larvae feed externally or internally on different parts of the host plants, preferentially the reproductive portions such as the fruits of tomato, peppers and legumes, inflorescences of sorghum and sunflower, squares of cotton and cobs of maize. After six instars the larvae have completed feeding and bury themselves in the soil to pupate.

At 21-27°C, the duration of instars one to six is 2.8, 2.2, 2.5, 2.4, 3.1 and 5.4 d respectively, the prepupal period is 2.7 d (total larval period: 21 d), and the pupal period 16-18 d (Reed 1965). Towards the dry season, a proportion of the pupal population enter diapause, which lasts 30-170 d (Reed 1965; Roome 1979).
2.3 HOST PLANTS

*Helicoverpa armigera* can feed and breed on a wide variety of host plants, including horticultural and field crops (Pearson 1958). Pigeon pea, beans and maize are more favoured for oviposition than cotton (Pearson 1958; Jayaraj 1982). The former crops were also preferred by feeding larvae. In several cases however, larval weights were higher on cotton than on maize, legumes or sunflower, and it was concluded that cotton was the most suitable crop for development and reproduction of *H. armigera* (Jayaraj 1982).

2.4 PHENOLOGY

Because the adults of *H. armigera* are migratory and have a high reproductive rate, pest populations can invade fields very rapidly. However, the susceptible period of crops to attack by *H. armigera* is usually very short and restricted to the reproductive growth stage, although some crops and weeds are attacked from the seedling stage onwards. The pest oviposits on sorghum during the short period of flowering, so that only one generation can develop per crop (Nyambo 1986). The attractive stage of maize is during silking, for about three weeks. Tomato is most suitable for oviposition during flowering and fruiting. Cotton is attacked from the vegetative stage onwards, but mostly during the flowering stage (Reed 1965). During the season, *H. armigera* populations can move from crop to crop, following the susceptible stages of each crop (Topper 1987a; Balla 1982).

2.5 SAMPLING METHODS

2.5.1 Adults

The most commonly used technique for sampling adults has been the light trap, which catches moths of different ages and physiological conditions. Recently, synthetic pheromone traps have been developed, trapping only sexually mature males. In Tanzania, pheromone trap catches gave relative population estimates that were better correlated with subsequent infestation levels than were light trap catches (Nyambo 1986). However, in order to estimate population size of *H. armigera* in a restricted area, it is necessary to sample the populations of eggs, larvae or pupae, rather than the highly migratory adults.

2.5.2 Eggs

To sample egg populations of *H. armigera* in the field, visual counting is the only available method, which can be conducted on a per plant basis for absolute densities (based on known plant spacings), or on the basis of plant portions that are favoured as oviposition sites, for relative counts. The latter method is generally preferred because most crops have a great amount of foliage during their susceptible stage. The eggs are randomly distributed within a field (Beeden 1974; Haggis 1982). In South Africa, van Hamburg (1981) found egg counts on cotton to be poor estimates of larval densities, and attributed this to variation in egg viability and variation in egg parasitism; he did not consider predation. Reed's (1965) observations on cotton in Tanzania indicated that a poor survival of eggs later in the season may have been due to predation.

2.5.3 Larvae

Larval populations of *H. armigera* can be estimated by visual counts,
sweepnet, D-vac, plantshake or whole plant bag sampling (Kogan & Pitre 1980). In North America, the most commonly used technique on soybean is the plantshake method, using a drop cloth at the base of the plant. This method is reasonably accurate for all larval instars, including the first instars which are often overlooked in visual counts (Stinner, Bradley & van Duyn 1980), but is likely to be less efficient for plants on which the larvae feed internally. The efficiency of different sampling methods will depend on the crop species and crop phenology, and needs to be evaluated for different crop situations.

2.5.4 Pupae

Pupal sampling has been evaluated by Stinner, Bradley & van Duyn (1980). Most suitable methods are soil sifting and soil scraping (removing the top layer of the soil to count pupal tunnels).
3. SAMPLING NATURAL ENEMIES

3.1 PARASITOIDS

The occurrence of parasitoids is generally recorded as a percentage parasitism of the host population. Usually, host stages are collected and reared in the laboratory on plant material or artificial diet, until emergence of parasitoids. Where larval stages of the parasitoid are known, dissection of field collected material may be more efficient and accurate, because the host may die during laboratory rearing before parasitoids emerge. Dissection also permits measurement of superparasitism (multiple parasitism by the same species) and multiparasitism (multiple parasitism by different species).

Assessment of the impact of parasitoids on pest populations can be difficult, because estimates can be greatly hampered by sources of bias and other problems resulting from the characteristics of parasitoid-pest interactions (Marstom 1980; van Driesche 1983). Major problems in determining percent parasitism of H. armigera in the field are discussed below.

(i) Host-age specificity of parasitoids

The species in the extensive parasitoid complex of H. armigera often attack a particular stage of the host and emerge from a different stage of the host. For example, some ichneumonids attack the first host instar and emerge from the second host instar. Tachinids, on the other hand, tend to attack only late host instars. Therefore, percent parasitism should be assessed separately for each major parasitoid species, based on different host instars. Figure 1 shows the host-stage specificity of major parasitoids of H. armigera, extracted from the literature (see Part II).

(ii) Exposure period of susceptible host stages

Apart from the fact that parasitism should be calculated separately for each parasitoid species, host stages must be selected to give the most accurate estimate of parasitism. Sampling of host stages commonly interrupts the exposure period of stages susceptible to certain parasitoids, and thus results in underestimation of parasitism by that particular parasitoid species. Ideally, the host should be sampled after the susceptible period, but prior to the host stage from which the parasitoid(s) emerge. For example, if the parasitoid attacks the first and emerges from the third host instar, the host should be sampled during the second instar. As is clear from Figure 1, only few parasitoids of H. armigera have such an optimal stage for sampling. In some parasitoid species there is an overlap between the host stages attacked and those from which they emerge. Table 1 shows the host instars to be selected for most accurate measurement of the level of parasitism for some major larval parasitoids of H. armigera. Alternatively, one could also include the host stages susceptible to attack, or host stages from which parasitoids emerge, and then correct for underestimates (Marstom 1980). However, methods should be applied consistently. The selection of host instars requires the measurement of head-capsule widths in relation to instars (Hansen, Owens & Huddleston 1981). Head-capsule widths of H. armigera can vary between crops (P.J. Guest pers. comm.); measurements from cotton are presented in Table 2.

(iii) Change in host stage development

Egg parasitoids can prolong the presence of the host stage they attack in the field. For example, H. armigera eggs parasitized by Telenomus spp. (Scelionidae) emerge after a period several times the length of the incubation period of unparasitized eggs. Consequently, field samples of
<table>
<thead>
<tr>
<th>Parasitoid species</th>
<th>EGG</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>PUPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apanteles diparopsidis</td>
<td>I----</td>
<td>----</td>
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<tr>
<td>Apanteles maculitarsis</td>
<td>I++++</td>
<td>xxxxI</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Apanteles ultor-group</td>
<td>I----</td>
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<tr>
<td>Apanteles vitripennis-group</td>
<td>I++++</td>
<td>xxxxI</td>
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<tr>
<td>Brachymeria sp.</td>
<td>I------</td>
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<tr>
<td>Carcelia illota</td>
<td>I----</td>
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<tr>
<td>Cardiochiles nigricollis</td>
<td>I++++</td>
<td>++++</td>
<td>xxxxI</td>
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<tr>
<td>Cardiochiles sp.</td>
<td>I----</td>
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<tr>
<td>Charops sp.</td>
<td>I++++</td>
<td>xxxxI</td>
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<td></td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>I++++</td>
<td>xxxxI</td>
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<tr>
<td>Enicospilus sp.</td>
<td>I----</td>
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<tr>
<td>Euplectrus sp.</td>
<td>I----</td>
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<tr>
<td>Goniophthalmus halli</td>
<td>I++++</td>
<td>++++</td>
<td>++++</td>
<td>xxxxI</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Linnaemya longirostris</td>
<td>I++++</td>
<td>xxxxI</td>
<td></td>
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<tr>
<td>Metopius sp.</td>
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<tr>
<td>Nemoraea capensis</td>
<td>I----</td>
<td>----</td>
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<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>I++++</td>
<td>xxxxI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>I++++</td>
<td>xxxxI</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Pristomerus sp.</td>
<td>I----</td>
<td>----</td>
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<td>----</td>
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<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Pseudogonia rufifrons</td>
<td>I++++</td>
<td>++++</td>
<td>++++</td>
<td>xxxxI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telenomus spp.</td>
<td>I----</td>
<td>----</td>
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</tr>
<tr>
<td>Trichogrammatoidea spp.</td>
<td>I----</td>
<td>----</td>
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</tr>
</tbody>
</table>

**Figure 1.** Host stages of *H. armigera* during which its parasitoids are active. +, indicates host stage attacked; o, indicates optimal stage for sampling; x, indicates host stage from which parasitoids emerge; -, indicates that (i) the parasitoid is present in the host stage, but no information is available on attack or emergence of parasitoid, or (ii) that the parasitoid emerges from the host stage it attacks.
Table 1. Host instars of H. armigera to be selected for most accurate measurement of the level of parasitism by different parasitoid species.

<table>
<thead>
<tr>
<th>Parasitoid</th>
<th>Host instar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apanteles diparopsidis</td>
<td>Early second</td>
</tr>
<tr>
<td>Apanteles maculitarsis</td>
<td>Second</td>
</tr>
<tr>
<td>Cardiochiles sp.</td>
<td>Second</td>
</tr>
<tr>
<td>Charops sp.</td>
<td>Second</td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>First, second</td>
</tr>
<tr>
<td>Gonioptalmus halli</td>
<td>Sixth</td>
</tr>
<tr>
<td>Linnaemya longirostris</td>
<td>Sixth</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>Fifth, early sixth</td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>Fifth, early sixth</td>
</tr>
</tbody>
</table>

Table 2. Mean head-capule width (mm) of H. armigera instars on cotton in Tanzania (n=35) (Source: Reed 1965).

<table>
<thead>
<tr>
<th>Instar</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-capule width</td>
<td>0.25</td>
<td>0.4</td>
<td>0.6</td>
<td>1.0</td>
<td>1.6</td>
<td>2.4</td>
</tr>
</tbody>
</table>

host eggs can overestimate parasitism levels, because for any cohort of eggs laid, unparasitized eggs might have hatched and disappeared from the plant, while their parasitized counterparts remain. Likewise, some larval and pupal parasitoids can retard the development of their host such that unparasitized hosts of the same age may have passed on to the next larval or pupal stage, which might not be sampled. This can also cause overestimation of parasitism, but retardment and the errors it brings are usually not as extreme as with egg parasitoids (Table 3).

A partial solution for this problem (and those posed by (i) and (ii) above) is to place cohorts of a particular life stage into the field for subsequent monitoring. Clearly, this is easier for sessile stages such as eggs and pupae, although larger larvae may be tethered to plants (Weseloh 1974, 1982). This method will also measure other mortalities acting on the exposed stage, such as disappearance of hosts due to predation. Natural placement of hosts in the field is important, and if possible, it might be better to clean plants and mark newly laid cohorts of eggs (Metcalfe & Breniere 1969), or confine pupating larvae under cages in the soil (P.J. Guest, pers. comm.) to ensure natural distribution of the stage exposed.

(iv) Mortality of parasitized hosts
When field mortality is higher for parasitized than for unparasitized hosts, and when hosts are not dissected, the contribution of parasitism to mortality of the host will be underestimated.

Moreover, when parasitized hosts are sampled from the field, they are removed from possible subsequent attack by other parasitoids, hyperparasitoids, predators and diseases. Hence, such sampling may overestimate the contribution to mortality of the particular parasitoid recovered. This problem may also arise with cohort studies (see (iii) above) depending on the time of recollection, and will be more severe when
Table 3. Retardment of host development and change in host appearance due to parasitism by different parasitoid species.

<table>
<thead>
<tr>
<th>Parasitoid</th>
<th>Stage attacked</th>
<th>Retardment of host stage development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apanteles spp.</td>
<td>Larva</td>
<td>+ (1)</td>
</tr>
<tr>
<td>Bracon brevicornis</td>
<td>Larva</td>
<td>+ (1)</td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>Larva</td>
<td>+ (1)</td>
</tr>
<tr>
<td>Euplectrus laphygmae</td>
<td>Larva</td>
<td>+ (1)</td>
</tr>
<tr>
<td>Goniophthalmus halli</td>
<td>Larva</td>
<td>− (2)</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>Larva</td>
<td>− (2)</td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>Larva</td>
<td>− (2)</td>
</tr>
<tr>
<td>Telenomus ullyetti</td>
<td>Egg</td>
<td>+ (3)</td>
</tr>
<tr>
<td>Trichogrammatoida lutea</td>
<td>Egg</td>
<td>+ (3)</td>
</tr>
</tbody>
</table>

(1) Larva becomes inactive and stops feeding  
(2) Larva continues feeding until emergence of parasitoid(s)  
(3) Host is killed during embryonic development, and the egg turns black

Parasitism makes hosts susceptible to other mortalities (e.g. Carroll & Risch 1983). Thus particular attention should be paid to this possible source of sampling error when parasitized hosts are rendered more sluggish than healthy hosts (see Table 3).

3.2 PREDATORS

Plant-inhabiting predator complexes and their impact on Helicoverpa spp. is poorly understood in African agroecosystems. Sampling methods for estimating population sizes and spatial distributions of predators of Helicoverpa and Heliothis spp. have been evaluated in North America, and these methods may be applied for some African cropping systems. Samples may be obtained from standard parts of the plants or from entire plants, depending on the predator species, the crop species and crop phenology.

In general, the simplest and most reliable sampling methods are direct observation, plant shaking and sweepnet sampling. On soybean and cotton, plant shaking is considered the best method for sampling small slowly moving hemipterans, except for Orius spp. (Anthocoridae), whereas sweepnet sampling is more suitable for larger insect predators such as chrysopids and coccinellids (Bechinski & Pedigo 1982; Irwin & Shepard 1980; Goodenough 1986). Wilson & Gutierrez (1980) report that, compared to the immature stages, adult predators on cotton were consistently found higher on the plant, especially on the developing squares. Adults were accurately sampled using a sweepnet. Direct observation is time consuming, but is probably the best method for measuring the activity of predators such as ants. D-vac sampling (Dietrick 1961) is usually least reliable (Gonzalez et al. 1977; Irwin & Shepard 1980). Byerly et al. (1978) report that sweepnet and D-vac sampling were not accurate enough for following population trends of predators of H. armigera and other pests on cotton, when compared to bag sampling of entire plants.

The efficiency of the different sampling methods will however largely depend on the crop species and crop phenology. Furthermore, it should be
noted that some predators, e.g. syrphid and chrysopid larvae, may be more active on plants at night and may therefore be undersampled by day.

In order to relate predator densities to the impact on pest populations, additional experimental methods on predation are needed (Luck, Shepard & Kenmore 1988). The use of exclusion/inclusion field cages is perhaps the most suitable quantitative method for demonstrating the action of predators of Helicoverpa spp. (van den Bosch et al. 1969; Barry, Hatchett & Jackson 1974; Thead, Pitre & Kellogg 1987).

Other little known natural enemies in African agroecosystems are ground dwelling predators. Most important are probably carabids and ants. They attack pupating larvae and pupae of Helicoverpa spp. in the soil, or may forage on plants. A reason why ground predators are generally overlooked is that many are nocturnal. Ground predator populations are probably best sampled using pitfall traps (Muma 1975; Southwood 1978).

3.3 PATHOGENS

As with parasitism levels, the assessment of the level of diseased hosts is biased by various factors.

Pathogens are generally not specific to a certain larval instar. They may attack, and kill, both young and older larvae. However, in Botswana, Daoust (1974) found that mortality of H. armigera by nuclear polyhedrosis virus (NPV) was highest in young larvae, so young instars should preferably be selected for measuring mortality due to NPV.

Larvae collected in the field should be placed directly into sterile diet containers for individual rearing, so as to prevent cross contamination by diseases from field equipment or other larvae. Similarly, because natural food may be contaminated, sterile artificial diet is to be preferred.

McKinley (1971) reported that larvae in the field appeared less susceptible to NPV than those in the laboratory, and attributed this to physical stress. Likewise, larvae collected from the field and reared in the laboratory may suffer higher mortality due to diseases than in the field, i.e. diseases may be effectively dormant in larvae in the field, only becoming active when larvae are subjected to stress, thereby leading to overestimates of field mortality.

Pathogens develop rapidly in hosts, hence, it should be noted that sampling hosts from the field may underestimate generational mortality due to diseases, because healthy hosts, if left in the field, may have subsequently contracted and died of disease before the next life stage.

3.4 POPULATION STUDIES

The effect of parasitoids, predators and pathogens is best studied in the context of their action and interaction, over a pest generation in the field. Methods of life-table analysis, combined with sampling techniques described above, may be used to quantify the contribution of different natural enemies to generational mortality (e.g. Hogg & Nordheim 1983) and, through extension into key-factor analysis, to population change. Design of life-table and key-factor analysis is discussed by Southwood (1978) and Varley, Gradwell & Hassell (1973).

However detailed the studies, samples of natural enemies or estimates of their impact should always be made in combination with quantitative samples of H. armigera population size for the relevant stages. Otherwise, much valuable information on the relationship between natural enemy impact and host population change may be lost.
4. SUMMARY OF THE NATURAL ENEMIES OF H. ARMIGERA

Literature on natural enemies of Helicoverpa spp. from Africa (predominantly Helicoverpa armigera) is very limited as compared with that for North America (Kogan et al. 1978; Johnson, King & Bradley 1986). Most African studies come from southern Africa and East Africa (Table 4). Detailed studies from East Africa are limited to those from Uganda by Coaker (1959), and from Tanzania by Reed (1965) and Nyambo (1986). These studies mostly concern larval parasitoids. In East Africa, hymenopteran larval parasitoids are the most commonly recorded parasitoids, whereas in southern Africa dipterans were more frequently recorded. Egg parasitoid records are common only from southern Africa.

Table 4. Number of records of H. armigera parasitoids from African countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Diptera larval and pupal parasitoids</th>
<th>Hymenoptera egg parasitoids</th>
<th>Hymenoptera parasitoids other than egg parasitoids</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Africa</td>
<td>30</td>
<td>5</td>
<td>55</td>
<td>90</td>
</tr>
<tr>
<td>Kenya</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Tanzania</td>
<td>18</td>
<td>2</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>Uganda</td>
<td>6</td>
<td>3</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>59</td>
<td>26</td>
<td>34</td>
<td>119</td>
</tr>
<tr>
<td>Botswana</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>South Africa</td>
<td>31</td>
<td>17</td>
<td>23</td>
<td>71</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>21</td>
<td>7</td>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>Other</td>
<td>29</td>
<td>4</td>
<td>37</td>
<td>70</td>
</tr>
<tr>
<td>Madagascar</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Senegal</td>
<td>11</td>
<td>1</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Sudan</td>
<td>9</td>
<td>0</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>11</td>
<td>2</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>35</td>
<td>133</td>
<td>289</td>
</tr>
</tbody>
</table>

* Predominantly Tachinidae
** Predominantly Braconidae and Ichneumonidae

4.1 TAXONOMY

In addition to the 83 identified species of natural enemies recorded from H. armigera in Africa, there are 93 records of partially identified natural enemies (Table 5). Some of these are important biological control agents (e.g. Nyambo 1986), and most are found in the Ichneumonidae and in the smaller parasitoid families. Particularly difficult parasitoid genera are Charops and Pristomerus (Ichneumonidae), and Apanteles and Cardiochiles.
The huge genus Pristomerus might have several hundreds of undescribed species in Africa (I.D. Gauld pers. comm.).

Identification of the tachinid genera Exorista, Carcelia, Pales and Palexorista is difficult because species are morphologically very similar (Crosskey 1980, 1984). Furthermore, some of the currently described species in these genera may represent a complex of sibling or semi-sibling species (R.W. Crosskey pers. comm.).

Revision of African parasitoids of H. armigera in the genera Cardiochiles and Palexorista is underway at the BMNH and CIE.

Table 5. Number of species of parasitoids of H. armigera recorded from Africa. I, identified species; II, records not identified to species level.

<table>
<thead>
<tr>
<th>Order</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachinidae</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>Ichneumonidae</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Braconidae</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>93</td>
</tr>
</tbody>
</table>

4.2 ALTERNATIVE HOSTS

Data on alternative hosts of parasitoids of H. armigera should be treated with utmost caution, because misidentifications are frequent. This is best illustrated with Palexorista laxa Curran, an important tachinid parasitoid of H. armigera which has been recorded from many alternative hosts covering several lepidopterous families. However, according to Crosskey (1967), H. armigera is the only proven host of P. laxa. Palexorista is a particularly difficult genus, and several closely related species have been confused under the name P. laxa. The alternative host records may therefore include several Palexorista species which have other host-associations. Such cases have significant consequences for defining host specificity of parasitoids of H. armigera, and thus for implementing biological control.

Furthermore, records alone do not indicate preference of parasitoids. A parasitoid might show a preference for one particular host, and use other species as hosts only to bridge periods of absence of its preferred host. Hence, it may be necessary to identify principal and alternative hosts of parasitoids.

Table 6 is a summary of the host range for a number of parasitoids of H. armigera. Note that partially identified parasitoid species, some of which are very important, cannot be included here.

Within the Tachinidae, the subfamily Tachininae seem to be parasitoids of noctuids. The important subfamily Goniinae has more generalist species, recorded from non-noctuid hosts. Exceptions are Goniophthalmus halli Mesnil, Paradrino halli Curran, and probably also Palexorista laxa, common parasitoids in Africa, which are probably specific parasitoids of H. armigera. Again, records of alternative hosts in such taxonomically difficult groups as Carcelia, Exorista and Pales, must be regarded with caution.

Most braconid parasitoids of H. armigera are polyphagous, with the exception of Cardiochiles spp. Although based on few records for each species, none of the five Cardiochiles spp. has been recorded from a host.
Table 6. Parasitoids of *H. armigera* and their host range in Africa. I, recorded from *H. armigera* only; II, recorded from Noctuidae only; III, recorded from several families of Lepidoptera.

<table>
<thead>
<tr>
<th>Family</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tachinidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subfamily Tachininae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dejeania bombylans (1)</td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Hystricovoria bakeri</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Linnaemya agilis</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linnaemya albigronis</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linnaemya longirostris</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Nemoraea capensis</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nemoraea rubelliana</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Subfamily Goninae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcelia illota (1)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceromya cibdela</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Exorista sorbillans</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exorista xanthaspis</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Gonia bimaculata</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Goniopthalmus halli</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Pales blepharipus</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pales coerulae</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Pales nigronitens</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pales seminitida</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Palexorista idonea</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Palexorista laxa (4)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Paradrino halli (3)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peribaea mitis</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Peribaea orbata</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Pseudogonia rufifrons</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Sturmia convergens</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Thelairosoma angustifrons</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Winthermia dasyops (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Zygobothria ciliata</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Ichneumonidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barylypa rufae (1)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charops ater</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Enicospilus capensis (2)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Metopius discolor (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Netelia opaculus</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netelia testacea</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Braconidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apanteles diparopsidis</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Apanteles maculitarsis</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Apanteles ruficrus</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Bracon brevicornis</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Cardiochiles nigricollis (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Cardiochiles nigromaculatus (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Cardiochiles trimaculatus (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
Table 6 (contd.).

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiochiles variegatus</strong> (1)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chelonus curvimaculatus</strong></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><strong>Chelonus versatilis</strong> (1)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Meteorus laphygmarum</strong></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><strong>Scelionidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Telenomus ullyetti</strong> (2)</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><strong>Eulophidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Euplectrus laphygmae</strong></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Trichogrammatidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trichogrammatoida lutea</strong></td>
<td></td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

(1) Based on few records
(2) Occasionally recorded from Pyralidae
(3) Only once recorded from another Noctuidae (Cetola sp.)
(4) H. armigera is the only proven host (see text)

Other than H. armigera, Cardiochiles nigriceps Viereck, a well-studied species from North America, has shown a high degree of specificity to the host Heliothis virescens Fabricius (Part II).

In scelionid egg parasitoids of the genus Telenomus a combination of several physical cues as well as chemical cues (contact kairomones) leads to host acceptance (Part II), and allows them to select host age and host species; they generally are host specific. Trichogrammatid parasitoids on the other hand are generally less specific, and often attack a range of Lepidoptera host eggs available in a specific habitat.

### 4.3 DISTRIBUTION

Information on geographical distribution of African parasitoids of Helicoverpa armigera is patchy. Parasitoids from the Afrotropical Region recorded from other regions as well are presented in Table 7. It can be seen that the African parasitoid complex is most closely related to that of the Oriental Region.

Within the African continent, striking differences exist between the parasitoid complexes reported from different areas (Table 8). When comparing H. armigera parasitoids from the two best-studied areas, southern Africa (Botswana, South Africa and Zimbabwe) and East Africa (Kenya, Tanzania and Uganda), only three species are important in both areas; these are Palexorista laxa, Paradrino halli and Chelonus curvimaculatus Cameron. All of the other species are important in only one of the areas, although they might be present in both. An example of the latter is Apanteles diparopsidis Lyle, which is an important parasitoid of H. armigera in Tanzania (Nyambo 1986), while in southern Africa it is found only on Diparopsis spp. and Earias spp. (Noctuidae).

When comparing parasitoid guild structures of the two areas (see Table 4) it is apparent that egg parasitoids are important in southern Africa whereas they are rare in East Africa. This may however be attributable to
Table 7. Distribution of widespread parasitoids, recorded from H. armigera in Africa, outside the Afrotropical Region.

<table>
<thead>
<tr>
<th></th>
<th>Oriental Region</th>
<th>Palaearctic Region</th>
<th>Nearctic Region</th>
<th>Neotropical Region</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tachinidae:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcelia illota</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exorista sorbillans</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Exorista xanthaspis</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gonia bimaculata</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Goniophthalmus halli</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Hystricovoria bakeri</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
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<tr>
<td>Peribaea orbata</td>
<td></td>
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<td>+</td>
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<tr>
<td>Pseudogonia rufifrons</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Sturmia convergens</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voria ruralis</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Zygobothria ciliata</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><strong>Ichneumonidae:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enicospilus capensis</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netelia testacea</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><strong>Braconidae:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apanteles ruficrus</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Bracon brevicornis</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Cardiochiles nigromaculatus</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

the lack of attention being paid to egg parasitoids in East Africa. Ichneumonids, on the other hand, are among the principal parasitoids of H. armigera only in East Africa. Similarly, Tachinidae are better represented in the parasitoid complex in southern Africa than in East Africa, while hymenopterous larval parasitoids were the major group in East Africa (Table 4).

4.4 HOST-PLANT ASSOCIATIONS

Host-plant associations of natural enemies of H. armigera have not been studied experimentally in Africa. However, some trends appear from field collections of parasitoids. The most extensive data set in this respect is the work by Nyambo in Tanzania (Nyambo 1986; Nyambo, unpublished). From these data it appears that there is a parasitoid guild, composed of Palexorista laxa, Chelonus curvimaculatus and Apanteles diparopsidis, attacking H. armigera on sorghum, but not to a significant degree on other crops. Consequently, H. armigera on sorghum suffers much higher parasitism levels than on other crops.

By contrast, Cardiochiles spp. seem to be generally associated more with cotton than with other crops. In Tanzania, Cardiochiles spp. were associated with cotton and the weed cleome, and were rare on sorghum and maize (Nyambo 1986). Parsons (1940) reared C. nigricollis Cameron mostly from larvae collected on cotton in South Africa. Moreover, Greathead (1966) found C. trimaculatus Cameron to be the most important parasitoid of H. armigera on cotton in Uganda.
Table 8. Major parasitoids of *H. armigera* in East Africa and southern Africa. (a) indicates the species that are important in East Africa as well as in southern Africa.

<table>
<thead>
<tr>
<th>Parasitoid species</th>
<th>Country** (a)</th>
<th>Crop</th>
<th>* Reported Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>--EAST AFRICA--</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tachinidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcelia illota</td>
<td>T</td>
<td>Cotton</td>
<td>7%</td>
</tr>
<tr>
<td>Gonioptalmus halli</td>
<td>K,T</td>
<td>Cotton</td>
<td>Up to 12%</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>T,U</td>
<td>Mainly sorghum</td>
<td>Up to 42%</td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>T</td>
<td>Various</td>
<td>Common</td>
</tr>
<tr>
<td><strong>Ichneumonidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charops sp.</td>
<td>T</td>
<td>Various</td>
<td>Up to 23%</td>
</tr>
<tr>
<td>Charops sp.</td>
<td>U</td>
<td>Various</td>
<td>Up to 10%</td>
</tr>
<tr>
<td>Enicospilus sp.</td>
<td>U</td>
<td>Mainly cotton</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Braconidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apanteles diparopsidis</td>
<td>T</td>
<td>Sorghum</td>
<td>Up to 26%</td>
</tr>
<tr>
<td>Apanteles ultor-group</td>
<td>U</td>
<td>? Maize/groundnut</td>
<td>Up to 20%</td>
</tr>
<tr>
<td>Apanteles vitripennis-group</td>
<td>T</td>
<td>Various</td>
<td>Common</td>
</tr>
<tr>
<td>Cardiochiles trimaculatus</td>
<td>U</td>
<td>Mainly cotton</td>
<td>8%</td>
</tr>
<tr>
<td>Cardiochiles sp.</td>
<td>T</td>
<td>? Mainly cotton</td>
<td>Up to 18%</td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>T,U</td>
<td>Various</td>
<td>Up to 12%</td>
</tr>
<tr>
<td><strong>--SOUTHERN AFRICA--</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tachinidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linnaemya longirostris</td>
<td>SA</td>
<td>Various</td>
<td>Important</td>
</tr>
<tr>
<td>Gonia bimaculata</td>
<td>SA</td>
<td>Citrus</td>
<td>Important</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>B,SA,Z</td>
<td>Cotton</td>
<td>20-30%</td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>Z</td>
<td>Citrus</td>
<td>Up to 25%</td>
</tr>
<tr>
<td><strong>Braconidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apanteles maculitarsis</td>
<td>SA</td>
<td>Various</td>
<td>Common</td>
</tr>
<tr>
<td>Apanteles nr. aethiopicus</td>
<td>SA</td>
<td>? Peas</td>
<td>Important</td>
</tr>
<tr>
<td>Bracon brevicornis</td>
<td>SA</td>
<td>Antirrhinum</td>
<td>Common</td>
</tr>
<tr>
<td>Cardiochiles nigricollis</td>
<td>B,SA</td>
<td>Mainly cotton</td>
<td>Common</td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>SA</td>
<td>Maize, citrus</td>
<td>Common</td>
</tr>
<tr>
<td><strong>Scelionidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telenomus ullyetti</td>
<td>SA,Z</td>
<td>Various</td>
<td>Up to 70%</td>
</tr>
<tr>
<td><strong>Trichogrammatidae:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichogrammatoidea lutea</td>
<td>SA,Z</td>
<td>Maize, cotton</td>
<td>Up to 60%</td>
</tr>
</tbody>
</table>

* Percent parasitism
** E, Botswana; K, Kenya; SA, South Africa; T, Tanzania; U, Uganda; Z, Zimbabwe

Nyangbo (1986) commonly reared Charops sp. from *H. armigera* on tomato, cleome and chickpea, whereas it was rare in collections from cotton and maize.

In South Africa, Taylor (1934) and Parsons (1940) reported that *H. armigera* was attacked by *Bracon brevicornis* only on antirrhinum plants,
while the pest was present on various host plants.

Citrus in southern Africa seems to have its own parasitoid guild which attacks *H. armigera*, during flowering, early in the season. The tachinids *Gonia bimaculata* Wiedemann (Cuthbertson 1934), *Gonia* sp. (Hall & Ford 1933; Jones 1939) and *Paradrino halli* (Jones 1939) were important parasitoids of *H. armigera* on citrus, but were rare on cotton and food crops, usually grown later in the season (Parsons & Ullyett 1934; Parsons 1940; Jones 1939). It is unclear whether this difference is caused by seasonal occurrence of the parasitoids or host-plant associations.

4.5 SEASONALITY

In tropical Africa, the occurrence of *H. armigera* and its natural enemies is influenced by rainfall. Rainfall in Uganda is relatively uniform throughout the year. Coaker (1959) found that *H. armigera* populations in Uganda remained at relatively stable low levels over four years, which he attributed to a well-balanced parasitoid-host relationship. In western Tanzania on the other hand, *H. armigera* enters diapause to survive the well-defined dry season. Reed (1965) stated that *H. armigera* populations were able to build up rapidly after this period because of the absence of natural enemies, which increased more slowly; later in the season, natural enemies seemed to reduce pest populations. Nyambo’s (1986) work in Tanzania shows that *Palexorista laxa*, *Chelonus curvimaculatus* and *Apanteles diparopsidis* were absent during the dry season, whereas *Charops* sp. and *Cardiochiles* sp. (or spp.) were common throughout the year. During the growing season, the occurrence of *Chelonus curvimaculatus* and *A. diparopsidis* was irregular (Nyambo 1986).

These results suggest that augmentation and other means to encourage natural enemies to build up early in the season, before pest infestation becomes severe, deserve consideration.

4.6 RECOMMENDATIONS

Despite the amount of natural enemy data presented in Part II, our knowledge of the role that predators, parasitoids and pathogens play in regulating *H. armigera* populations in agricultural food and cash crops remains inadequate. Local in-depth studies are needed on the dynamics and natural mortality factors of *H. armigera* populations. Studies on the role of natural enemies should pay special attention to the inadequately studied predators, and try to assess their seasonal occurrence, and impact on *H. armigera* populations. In addition, detailed studies on egg parasitoid populations are needed in East Africa. Experimental studies on host-plant associations of natural enemies may help to identify key natural enemies in different crops, and form the basis for their augmentation or encouragement in integrated pest management programmes.
PART II

5. NATURAL ENEMIES OF H. ARMIGERA IN AFRICA

In this chapter, all parasitoids, predators and pathogens recorded from *Helicoverpa armigera* in Africa are reviewed. Depending on the information available, the following aspects are described for each species.

a. Name in current taxonomy, with synonyms. Author’s names are not parenthesized (Crosskey et al. 1985). Synonyms are limited to those that refer to *H. armigera* records from Africa.

b. Taxonomic comment, including misidentifications and commentary on the reliability of records. Bracketed references refer to taxonomists’ comments as follows:

(1) R.W. Crosskey, pers. comm.
(2) A.K. Walker, pers. comm.
(3) T. Huddleston, pers. comm.
(4) A. Polaszek, pers. comm.
(5) Z. Bouček, pers. comm.

c. Distribution; within the Afrotropical Region by country, other regions by region.

d. Biology; relevant notes on adults, oviposition (including host location/recognition), development, and host stages attacked.

e. Alternative hosts or prey. Host records are not exhaustive; noctuids are given by species (African records only), non-noctuid lepidopterans by family, and non-lepidopterans by order (worldwide records).

f. Host-plant associations.

g. Secondary natural enemies.

h. *H. armigera* records; including country, host plant, occurrence (or percent parasitism or predation) and source. The initials ‘BMNH’ are given for specimens in the British Museum (Natural History) collection.

Families and orders are arranged in accordance with recent classification. Within each family species are listed alphabetically.
5.1 PARASITOIDS

DIPTERA

Bombyliidae

Sp. indet

H. armigera records:
South Africa Maize Important Parsons & Ullyett 1934

Phoridae

Dohrniphora paolii Schmitz

Diploneura paolii Schmitz (Risbec 1960).

Biology: Dubious record as a true parasitoid; might well be a general saprozoic species.

Distribution: Afrotropical Region: Somalia.

H. armigera records:
Somalia - - Risbec 1960

Sarcophagidae

The majority of species of Sarcophaginae are opportunist saprophages depositing their larvae in wounds, corpses and damaged tissues of animals and plants. Most Sarcophaga spp. sensu lato fall into this category but a few, chiefly Neotropical species, have been shown to be obligate parasitoids. Thus, records of Sarcophaga spp. as parasitoids of H. armigera should be treated with caution and careful observation made on the circumstances under which larvae and pupae are fed on by the fly larvae before they are accepted as true parasitoids (Greathead 1963).

Amobia signata Meigen

Pachyophthalmus signatus Meigen (Hall & Ford 1933)

Distribution: Afrotropical Region: southern Africa, West Africa; Nearctic Region; Oriental Region; Palaearctic Region.

Biology: This is possibly a hyperparasitoid.

Alternative hosts: HYMENOPTERA; ORTHOPTERA.

H. armigera records:
Zimbabwe Citrus Common Hall & Ford 1933

Sarcophaga hirtipes Wiedemann

Distribution: Widespread mainland Afrotropical Region; Mediterranean Subregion; Oriental Region.

H. armigera records:
Tanzania - - Robertson 1965

Sarcophaga sp.

H. armigera records:
Somalia Maize - Chiaromonte 1933

Sarcophaga sp.

H. armigera records:
Senegal Maize, millet Rare Bhatnagar 1987
Tachinidae

The biology of Tachinidae is reviewed by Clausen (1940) and Herting (1960).

Subfamily Tachininae

Dejeania bombylans Fabricius

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread from Ethiopia to South Africa, Angola, Sierra Leone, Zaire.

**Alternative hosts:** LEPIDOPTERA Noctuidae: Cucullia terrensis Felder.

**H. armigera records:**
- Tanzania Cotton - Robertson 1965
- Zimbabwe Cotton Abundant Cuthbertson 1934

Hystricovoria bakeri Townsend

**Distribution:** Afrotropical Region: Botswana, Ghana, Kenya, South Africa; Oriental Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae: Xanthodes graellsii Feisthamel; Arctiidae; Lymantriidae; Tortricidae.

**H. armigera records:** Although this species occurs in the Afrotropical Region, host records on H. armigera have been reported only from the Oriental Region (Crosskey 1976).

Genus Linnaemya Robineau-Desvoidy

Limited information exists on the biology of this genus. Strickland (1923) reported that Bonnetia (=Linnaemya) compta Fallen deposits its incubated eggs on the plant, in the vicinity of a host. Eggs hatch immediately and larvae attach to the passing host to bore through its integument. Many parasitoid larvae are actively killed by the host while entering the host’s body, or die inside the host. The parasitoid pupates outside the host.

Linnaemya agilis Curran

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Benin, Kenya, Malawi, Nigeria, South Africa, Tanzania, Uganda, Zaire, Zimbabwe.

**Alternative hosts:** LEPIDOPTERA Noctuidae: Diparopsis castanea Hampson, Earias biplaga Walker, E. insulana Boisdouval.

**H. armigera records:**
- South Africa Cotton - Curran 1934
- Tanzania Cotton - Curran 1934
- Uganda Cotton - Nyiira 1970a
- Uganda - - Coaker 1959

Linnaemya albifrons Smith

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread West Africa to East Africa, north-east Africa & southern Africa, Zaire.

**Alternative hosts:** LEPIDOPTERA Noctuidae: Leucania leucostichca Hampson.

**H. armigera records:**
- South Africa Cotton - Taylor 1932
- Zimbabwe - - Risbec 1960

Linnaemya longirostris Macquart

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread eastern Africa from Sudan and
Ethiopia to South Africa, Zaire.

**Biology:** The larval period of *L. longirostris* is 10-12 d, the pupal period 14-19 d. Occurs mostly during the fifth and sixth larval stages of the host *H. armigera*, and often emerges from the host pupa (Parsons 1940).

**Host-plant associations:** *L. longirostris* occurs on a variety of food crops and wild plant species. It appears from Parsons' (1940) data that *L. longirostris*, together with *Palexorista* sp., is more abundant on maize than on cotton.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Cucullia* sp., *Plusia limbirena* Guenée.

*H. armigera* records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>Tomato</td>
<td>BMNH (Cock Coll 1987)</td>
</tr>
<tr>
<td>Kenya</td>
<td>Cotton</td>
<td>Le Pelley 1959</td>
</tr>
<tr>
<td>Kenya</td>
<td></td>
<td>Rens 1977</td>
</tr>
<tr>
<td>Kenya</td>
<td></td>
<td>van Emden 1960</td>
</tr>
<tr>
<td>South Africa</td>
<td>Various crops</td>
<td>Important</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>Taylor 1932</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>Simmonds 1960</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Cotton</td>
<td>Robertson 1973</td>
</tr>
<tr>
<td>Uganda</td>
<td></td>
<td>Coaker 1959</td>
</tr>
</tbody>
</table>

*Linnæpysia* sp.

*H. armigera* records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zimbabwe</td>
<td>Tobacco</td>
<td>Bünzli &amp; Büttiker 1957</td>
</tr>
</tbody>
</table>

**Nemoraea capensis** Robineau-Desvoidy

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread north-east Africa, East Africa and southern Africa, Nigeria, Zaire.

**Biology:** Occurs in the fifth and sixth instars of *H. armigera* (Parsons 1940).

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Agrotis segetum* Schiffermüller, *Diparopsis castanea*, *Spodoptera exempta* Walker.

*H. armigera* records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>Cotton, sorghum</td>
<td>Rare</td>
</tr>
<tr>
<td>South Africa</td>
<td>Peas, citrus</td>
<td>Rare</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>Simmonds 1960</td>
</tr>
</tbody>
</table>

**Nemoraea rubellana** Villeneuve

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Cameroun, Ethiopia, Kenya, Rwanda, South Africa, Tanzania, Uganda, Zaire, Zimbabwe.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Spodoptera exempta*.

*H. armigera* records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td></td>
<td>Rens 1977</td>
</tr>
</tbody>
</table>

**Paratachina obliqua** Loew

*Paratachina ingens* Brauer & Bergenstamm (Taylor 1932)

**Taxonomic comment:** The record is regarded as reliable (1).

**Distribution:** Afrotropical Region: South Africa.

*H. armigera* records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>Taylor 1932</td>
</tr>
</tbody>
</table>

**SUBFAMILY GONIINAE**

**Carcelia evolans** Wiedemann

**Taxonomic comment:** There is a complex of sibling or semi-sibling species around 'evolans'. The record below is regarded as doubtful (1).

**Distribution:** Afrotropical Region: Ivory Coast, Senegal, Sierra Leone.
Biology: Jacquemard (1969) described the biology of *C. evolans* parasitizing *Diparopsis watersi* Rothschild in Cameroun. The females oviposit on cotton bolls that have been infested with bollworms. The eggs hatch almost immediately. First instars attack and enter the host, and remain inside for about 12 d. The host is killed in its fifth instar, and mature parasitoid larvae leave the dead host to pupate outside. Pupal period: 10 d. *C. evolans* enters diapause simultaneously with the host.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Busseola fusca* Hampson, *Diparopsis* spp.; Lasiocampidae; Papilionidae.

**H. armigera** records:
- Tanzania Cotton Rare Robertson 1973

**Carcelia illota** Curran

**Taxonomic comment:** This is probably a complex of sibling or semi-sibling species (1).

**Distribution:** Afrotropical Region: Nigeria, Tanzania, South Africa; Oriental Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Acontia* sp., *Spodoptera littoralis* Boisduval; Lasiocampidae; Papilionidae.

**H. armigera** records:
- Nigeria - - BMNH (Beeden Coll 1974)
- Tanzania Cotton 7% Robertson 1973
- Tanzania Cotton Low numbers Reed 1965, BMNH
- Tanzania Cotton, - BMNH (Ritchie Coll 1923) pigeon pea

**Carcelia sp.**

**H. armigera** records:
- Senegal - Rare Bhatnagar 1987

**Carcelia sp.**

**H. armigera** records:
- Tchad Cotton - Silvie pers. comm. 1988

**Ceromoca cibdela** Villeneuve

**Actia cibdela** Villeneuve (Cuthbertson 1934)

**Taxonomic comment:** Reliable record (1).

**Distribution:** Afrotropical Region: Mozambique, Nigeria, Tanzania, Zaire.

**Alternative hosts:** LEPIDOPTERA Noctuidae; Sphingidae.

**H. armigera** records:
- South Africa Cotton - Cuthbertson 1934

**Chetogena sp.**

**H. armigera** records:
- Senegal Various crops - Bhatnagar 1987

**?Drino sp.**

**H. armigera** records:
- Uganda Cotton - Nyiira 1970a

**Exorista sorbillans** Wiedemann

**Tricholyga sorbillans** Wiedemann (Taylor 1932)

**Taxonomic comment:** Records must be regarded as suspect (1). Many undescribed species have been confused under *E. sorbillans* (Crosskey 1984).

**Distribution:** Afrotropical Region: Cameroun, Kenya, Malawi, Sierra Leone, Uganda; Mediterranean Subregion; Oriental Region.

**Biology:** Datta & Mukherjee (1978) studied the biology of *Exorista sorbillans* (as *Tricholyga sorbillans*) on *Bombyx mori* Linnaeus (Lep.: Bombycidae).
Oviposition: Macrotype eggs are laid on the host, mostly on intersegmental regions, with an average of 2 eggs per host.

Development: Eggs hatch within 2-3 d, larvae enter the host and feed inside for 5-6 d. The third instar emerges from the host to pupate outside. Egg+larval period: 8-12 d; pupal period: 10 d.

Alternative hosts: LEPIDOPTERA Lasiocampidae; Limacodidae; Lymantriidae; Noctuidae; Papilionidae; Psychidae; Saturniidae; HYMENOPTERA.

H. armigera records:
South Africa Cotton - Taylor 1932

Exorista xanthaspis Wiedemann

Exorista fallax Melgen (Lazarevic 1971)

Taxonomic comment: Records are regarded as reliable (1).

Distribution: Afrotropical Region: widespread (incl. Madagascar, Seychelles, Socotra); Oriental Region; Palaeartic Region.

Biology: Achan et al. (1968) described the life-history of this parasitoid, under its synonym E. fallax, parasitizing H. armigera.

Adult: Mating occurs soon after emergence. The pre-oviposition period is 7-10 d.

Oviposition: Females attack the late instars of the host. Eggs are attached to the host near its head region, and hatch after 3-8 d. The parasitoids emerge from the host after 7-10 d (Herting 1960).

Alternative hosts: LEPIDOPTERA Noctuidae: Agrotis segetum, Earias sp., Plusia orichalcea Fabricius, Serrodes partita Fabricius, Spodoptera exempta, S. exigua Hübner, Xanthodes intersepta Gueneé; Arctiidae; Lasiocampidae; Lymantriidae; Pieridae; Pyralidae; Sphingidae.

B. armigera records:
South Africa Cotton Rare Bhatnagar 1987
Sudan Cotton - Lazarévic 1971

Gonia bimaculata Wiedemann

Taxonomic comment: Records are regarded as reliable (1).

Distribution: Afrotropical Region: widespread (excl. West Africa); Oriental Region; Palaeartic Region.

Biology: Gonia spp. oviposit microtype eggs on the plant, to be ingested by late instar host larvae.

Alternative hosts: LEPIDOPTERA Noctuidae: Agrotis segetum, Apopestes limbata Staudinger; Arctiidae.

H. armigera records:
Somalia Maize - Chiaromonte 1933
South Africa Cotton Rare Parsons 1940
South Africa Cotton 2% Parsons & Ullyett 1934
South Africa Cotton - Simmonds 1960
South Africa Citrus Important Cuthbertson 1934

Goniophthalmus halli Mesnil

Taxonomic comment: All records below are regarded as reliable (1).

Distribution: Afrotropical Region: Botswana, Kenya, Namibia, Sudan, Tanzania, West Africa, Zimbabwe; Oriental Region.

Biology: Patel & Singh (1972) described the biology of G. halli parasitizing H. armigera.

Adults: Mating occurs generally on the day of emergence. Pre-oviposition period: 5-7 d. Fecundity: 5,000 eggs per female.
Oviposition: Numerous microtype eggs (0.18x0.1 mm) are attached to the host plant, near the edges of feeding spots of the target host, in order to be ingested together with the plant material.

Development: Eggs hatch in the host gut and the parasitoid larvae inhabit the haemolymph until they reach the third instar; they then attack other organs. Mortality of parasitoid eggs or larvae is generally high (Muck 1985). Parasitized hosts are not easily distinguishable from unparasitized and will continue feeding. Although several larvae can be found per host, no more than one parasitoid will eventually emerge, due to strong intraspecific competition. The parasitoid usually pupates within the host pupa, but sometimes the parasitoid larva leaves the host pupa to pupate outside.

Egg+larval period: variable, 9-17 d; pupal period: 8-16 d (27°C). In Tanzania this species has been reported to diapause for 130 d within its host pupa during the dry season (Reed 1965).

Host stages: The fourth, fifth or sixth instars of H. armigera are attacked. The adult parasitoid usually emerges from the host pupa.

Alternative hosts: No records from Africa. G. halli is regarded as a parasitoid specific on H. armigera. Out of 19 host records of this parasitoid worldwide only 2 are records of hosts (Lepidoptera) other than H. armigera.

H. armigera records:
- Botswana Cotton 0.1% Roome 1971a, BMNH
- Cape Verde - - Mück 1985
- Kenya Cotton - BMNH (Rens Coll 1970)
- Kenya - - Dewhurst unpubl. 1985
- Senegal Maize, millet Up to 2% Bhatnagar 1987
- Sudan - - BMNH (Wood Coll 1933)
- Tanzania Cotton Up to 12% Reed 1965, BMNH
- Tanzania Cotton Rare Robertson 1973
- Tchad Cotton - Silvie pers. comm. 1988
- Zimbabwe - - Mesnil 1956
- Zimbabwe Citrus - BMNH (Jones Coll 1938)
- Zimbabwe - - BMNH (Hall Coll 1929)

Pales blepharipus Brauer & Bergenstamm

Phorocera blepharipus Brauer & Bergenstamm (Taylor 1932)

Taxonomic comment: The specific name must be regarded as doubtful (1).

Distribution: Afrotropical Region: South Africa, Zaire.

Alternative hosts: LEPIDOPTERA Noctuidae: Anomis auragoides Guenee, Cucullia terrensia, Plusia sp., Spodoptera exempta, Xanthodes graellsi; Lasiocampidae; Lymantriidae; Pyralidae; Saturniidae; Sphingidae.

H. armigera records:
- South Africa Cotton Rare Cuthbertson & Munro 1941
- South Africa Cotton - Taylor 1932

Pales coerules Jaennicke

Taxonomic comment: The specific name must be regarded as doubtful (1).

Distribution: Afrotropical Region: north-east Africa to southern Africa; Oriental Region.

Alternative hosts: LEPIDOPTERA Noctuidae: Spodoptera littoralis; Hesperiidae; Lasiocampidae; Lycaenidae; Lymantriidae; Papilionidae.

H. armigera records:
- South Africa Various crops Rare Parsons 1940
- Zimbabwe Citrus - BMNH (Jones Coll 1938)

Pales nigronitens Villeneuve

Taxonomic comment: The specific name must be regarded as doubtful (1).

Parsons (1940) recorded P. nigronitens as well as P. pavida Meigen, but according to Cuthbertson & Munro (1941) they were both P. nigronitens.

Distribution: Afrotropical Region: South Africa, Zaire.
**Biology:** Occurs in the second to the sixth instar of *H. armigera* and emerges from its pupa. Development egg-adult: 29-40 d (Parsons 1940).

**Alternative hosts:** LEPIDOPTERA Limacodidae.

**H. armigera** records:
- South Africa: Citrus, Rare Parsons 1940 vegetables

**Palexorista seminitida** Villeneuve

*Taxonomic comment:* The specific name must be regarded as doubtful (1).

*Distribution:* Afrotropical Region: Malawi, Nigeria, Zaire.

*Alternative hosts:* LEPIDOPTERA Lasiocampidae; Thaumetopoeidae.

**H. armigera** records:
- Zimbabwe: Malvaceae - Cuthbertson & Munro 1941
  (from ?H. armigera)

**Palexorista idonea** Brauer & Bergenstamm

*Sturmia partitor* Curran (Cuthbertson 1939).

*Taxonomic comment:* The specific name below must be regarded as suspect (1).

*Distribution:* Afrotropical Region: Mozambique, South Africa.

*Alternative hosts:* LEPIDOPTERA Lasiocampidae.

**H. armigera** records:
- Zimbabwe: Cotton - Cuthbertson 1939

**Palexorista imberbis** Wiedemann

*Taxonomic comment:* Records from Africa must be regarded as suspect.

Despite many records in literature, there is no evidence that 'imberbis' occurs in the Afrotropical Region (1). All BMNH specimens from Africa, that were recorded as 'imberbis', are *Palexorista laxa*.

*Distribution:* Djibouti, Egypt, Israel.

*Alternative hosts:* LEPIDOPTERA Noctuidae: *Spodoptera exigua, S. littoralis, Xylina exoleta* Linnaeus; Lasiocampidae.

**H. armigera** records:
- Sudan: Cotton V. important Tunstall 1958
- Sudan: Cotton Important Lazarévíc 1971
- Tchad: Cotton - Silvie pers. comm. 1988
- Uganda: Cotton Rare Greathead 1966

**Palexorista laxa** Curran

*Sturmia laxa* Curran (Taylor 1932; Cuthbertson & Munro 1941)

*Taxonomic comment:* This is probably a complex of sibling or semi-sibling species (1), and is currently being studied at the BMNH. In current taxonomy, *P. laxa* has been misidentified as *Sturmia (=Palexorista) inconspicua* Meigen (Jones 1939) and Drino (=*Palexorista*) imberbis (Reed 1965; Robertson 1973), neither occurring in the Afrotropical Region. *H. armigera* records are reliable for specimens present in the BMNH collection only; other records must be regarded as doubtful.

*Distribution:* Afrotropical Region: Botswana, Malawi, Senegal, South Africa, Sudan, Tanzania, Uganda, Zimbabwe; Oriental Region.

**Biology:** Jackson *et al.* (1976) described the biology of *P. ?laxa* parasitizing *Helicoverpa zea* Boddie.

Adults: Mating occurs soon after emergence. Pre-oviposition period: 6.9 d (25°C), 4.6 d (30°C); oviposition period: 24.5 d (25°C), 17.5 d (30°C). Oviposition: Female attaches the incubated, macrotype eggs to the host body from a position standing beside the host.

Development: Eggs hatch immediately after oviposition and the emerging larvae enter the host. During development of the parasitoid larvae the host feeds normally, until the larvae emerge. Depending on the size of the host, one to seven parasitoid larvae emerge per host; they pupate outside.

Egg + larval period: 6.0 d (25°C), 4.6 d (30°C); pupal period: 9.4 d (25°C), 6.7 d (30°C) (Jackson *et al.* 1976), 12 d (Reed 1965).
Host stages: Mostly, fourth to sixth instars are attacked. The parasitoid emerges from the sixth instar or from the prepupa.

**Alternative hosts:** LEPIDOPTERA Noctuidae: Anomis auragoides, Busseola fusca, Leucania leucosticha, L. loreyi Duponchel, Lycophotia olivestata Hampson, Spodoptera exempta, S. exigua, Tarache nitidula Fabricius, Xanthodes graellsi; Arctiidae; Lasiocampidae; Pyralidae; Sphingidae.

According to Crosskey (1967) *H. armigera* is the only proven host of *P. laxa*. In this respect, the above alternative host records must be regarded as suspect. Gerling & Rotary (1973) demonstrated that *P. laxa* failed to develop in the noctuid *Spodoptera littoralis*. The parasitoids died at an early stage, together with their hosts. In the Sudan, Tunstall (1958) reported that *P. flaxa*, an important parasitoid of *H. armigera*, did not parasitize *Diparopsis watersi* to any extent.

**Host-plant associations:** Data from Tanzania reveal a strong association of *P. laxa* with sorghum, compared with maize, cotton or cleome (Nyambo 1986). It was observed that *H. armigera* on sorghum feeds in a more exposed position than on other crops. This phenomenon might explain the differences in parasitism levels. See also *Palexorista* sp. below.

**H. armigera records:**

Botswana Sorghum - BMNH (Roome Coll 1970)
Botswana - 14.5% Roome 1971a
Mali - BMNH (Doumbia Coll 1978)
Senegal - Risbec 1960
Senegal Sorghum Rare Bhatnagar 1987
South Africa Cotton - Cuthbertson & Munro 1941
South Africa Cotton - Taylor 1932
Sudan - BMNH (Wood Coll 1933)
Tanzania Cotton Up to 25% Reed 1965, BMNH
Tanzania Various crops Up to 42% Nyambo 1966, BMNH
Tanzania Cotton 14% Robertson 1973, BMNH
Tanzania - BMNH (Ritchie Coll 1923)
Tanzania - BMNH (Disney Coll 1949)
Uganda - BMNH (Mubbin Coll 1939)
Zaire - Risbec 1960
Zimbabwe - BMNH (Gatuma Coll 1969)
Zimbabwe - Jones 1939, BMNH

**Palexorista quadrizonula Thomson**

*Distribution:* Afrotropical Region: widespread (incl. São Tome, Seychelles).

**H. armigera records:**

Senegal Various crops Up to 10% Bhatnagar 1987

**Palexorista sp. nr. inconspicua Meigen**

**H. armigera records:**

Somalia Maize - Chiaromonte 1933

**Palexorista sp. nr. laxa Curran**

**H. armigera records:**

Botswana Abutilon - BMNH (Ingram Coll 1968)
(from *Heliothis* sp.)

**Palexorista sp.**

*Taxonomic comment:* Misidentified as *Sturmia* (=*Palexorista*) *inconspicua*, which is not Afrotropical (1). This might well be *P. laxa*.

**Biology:** Larval period: 10-14 d; pupal period: 8-17 d. Occurs mainly in the fifth and sixth instars of *H. armigera* (Parsons 1940).

**Host-plant associations:** In South Africa, higher parasitism by this species was observed on maize than on cotton. This might have been a density response; densities were higher on maize (Parsons & Ullyett 1934; Parsons 1940).
**H. armigera** records:
- South Africa: Various crops. V. important. Parsons 1940
- South Africa: Cotton. Simmonds 1960
- South Africa: Cotton. 20-30%. Parsons & Ullyett 1934
- South Africa: Maize. Important. Parsons & Ullyett 1934
- Sudan: - - Balla 1982

**Palexorista sp.**

**H. armigera** records:
- Senegal: Various crops. Rare. Bhatnagar 1987

**Paradrino halli** Curran
- Drino halli Curran (Robertson 1973)
- Sturmia halli Curran (1939)
- Sturmia rhodesiensis Jones (1939)

**Taxonomic comment:** This is a distinctive species; records are therefore regarded as reliable (1).

**Distribution:** Afrotropical Region: Botswana, Tanzania, Uganda, Zimbabwe.

**Biology:** Jones (1939) studied the biology of *P. halli* as the most important parasitoid of *H. armigera* on citrus in Zimbabwe.

- Adult: Males can copulate directly after emergence, females only after 3 d. Pre-oviposition period is 7 d. Longevity: 12-33 d for females, 6-22 d for males; without food longevity is 5 d shorter for both sexes.
- Oviposition: The adult female alights on the host to oviposit; oviposition occurs very quickly to prevent defence by the host. The ovipositor is short. Fully incubated macrotype eggs (0.7x0.23 mm) are attached to the integument of the host. The number of eggs per host varies with the abundance of hosts, most commonly 1-3 eggs are laid per host.
- Development: Within 15 min after oviposition eggs hatch and the first instars enter the host by boring through the integument. The parasitoid larvae enter the host’s fat bodies and create a hole for respiration in one of the tracheae; they place their spiracles in the opening. A funnel of wound tissue is formed around the parasitoid. Fully grown parasitoid larvae emerge from the host to pupate outside. When emerging from the host pupal stage they do so from between the segments of the pupa; this species bores no hole in the host pupa. In Tanzania, usually one parasitoid emerged per host (Robertson 1973). Egg+larval period: 16-20 d; pupal period: 7-16 d (Robertson 1973).
- Host stages: The mostly attacked of *H. armigera* is the fourth. Parasitoid larvae emerge from the sixth instar or pupa of the host.

**Host-plant associations:** Parasitism is rather low on different crops. Jones (1939) however found high levels of parasitism on citrus during spring, much higher than on maize or vegetable crops later in the season. This could be attributable to a seasonal rather than a host plant effect.

**Alternative hosts:** LEPIDOPTERA Noctuidae: occasionally *Busseola fusca* and *Cetola* sp.; no other record. This species is regarded as a specialist parasitoid of *H. armigera*.

**H. armigera** records:
- Botswana: Various crops. Rare. Roome 1971a
- Tanzania: Cotton. Rare. Robertson 1973
- Zimbabwe: Citrus. Up to 25%. Jones 1939, BMNH
- Zimbabwe: Various crops. Up to 5%. Jones 1939
- Zimbabwe: Cotton. - Bünzli & Büttiker 1957
- Zimbabwe: - - Curran 1939

**Peribaea mitis** Curran

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Kenya, South Africa, Sudan.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Spodoptera exigua*; Geometridae.
**H. armigera records:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Host</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan</td>
<td>Clover</td>
<td>BMNH (Johnston Coll 1927)</td>
</tr>
<tr>
<td>Sudan</td>
<td></td>
<td>BMNH (Bedford Coll 1929)</td>
</tr>
</tbody>
</table>

**Peribaea orbata** Wiedemann

*Actia aegyptia* Villeneuve (Ismael & Swailem 1975)

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: East Africa & southern Africa, Congo basin, West Africa to north-east Africa; Oriental Region.

**Biology:** This parasitoid attacks mostly the second or third instar of the host *Spodoptera littoralis*. Pupal period: 7-10 d (Hegazi, Hammad & El-Minshawy 1977).

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Spodoptera exempta*, *S. exigua*, *S. littoralis*.

**H. armigera records:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
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<tbody>
<tr>
<td>Egypt</td>
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</tr>
</tbody>
</table>

**Plagiomima rufolateralis** Crosskey

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Botswana, Namibia.

**H. armigera records:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>Carnations,</td>
</tr>
<tr>
<td></td>
<td>sunflower (from Heliothis sp.)</td>
</tr>
</tbody>
</table>

**Pseudogonia rufifrons** Wiedemann

*Gonia ritchiei* Cuthbertson & Munro (1941)

*Isomera cinerascens* Rondani (Lazarevic 1971)

*Pseudogonia cinerascens* Rondani (Parsons 1940; Simmonds 1960)

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread (incl. Cape Verde Islands, Socotra); Oriental Region; Palaearctic Region.

**Biology:** The biology of *P. rufifrons*, under its synonym *Gonia cinerascens*, has been extensively studied on the host *Galleria mellonella* Linnaeus (Lep.: Pyralidae) by Campadelli and others in Italy. Mating occurs on the day of emergence. Pre-oviposition period: 16 d at 24°C. Longevity: 22 d for females, 15 d for males at 24°C (Campadelli & Baronio 1979). Fecundity: several thousands of eggs (Gardenghi & Mellini 1980).

**Oviposition:** Numerous microtype eggs are attached to the leaves to be ingested by the host together with the plant material. Development: Eggs hatch in the fore- or mid-gut; hatching is mainly induced by digestive enzymes of the host (Mellini & Campadelli 1979). The first instar develops within the abdominal muscles of the host. Ecdysteroid hormones of the host act directly on parasitoid development (Barinio & Sehnal 1980). The second instar moves to the space between the old larval skin and the developing pupa. The mature third instar pupates inside the cocoon of the host. No more than one parasitoid will emerge per host, due to intraspecific competition. Pupal period: 10 d (27°C). Total development period: 30-37 d (Parsons 1940).

**Host stages:** Most commonly, fourth to sixth instars of *H. armigera* are attacked. The adult parasitoid emerges from the host pupa (Parsons 1940).

**Host-plant associations:** Parsons (1940) found *P. rufifrons* more frequently on *H. armigera* on peas, than on other crops.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Leucania loreyi*, *Spodoptera exempta*, *S. exigua*.

**H. armigera records:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Host</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Maize</td>
<td>Up to 14% Bhatnagar 1987</td>
</tr>
<tr>
<td>South Africa</td>
<td>Various crops</td>
<td>Rare Parsons 1940</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>- Simmonds 1960</td>
</tr>
</tbody>
</table>
South Africa  Citrus  -  Cuthbertson & Munro 1941
(from ?H. armigera)
Sudan  Cotton, beans  -  Lazarévíc 1971

**Sturmia convergens** Wiedemann

*Sturmia flavohalterata* Bischof (Milner 1967)

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Ethiopia, Kenya, Malawi, Nigeria, Sierra Leone, South Africa, Tanzania, Zambia, Zimbabwe; Oriental Region.

**Biology:** The female deposits microtype eggs in the vicinity of the host, mostly on the underside of the leaves. First instar larvae find and enter the host. Mature larvae leave the host pupae and pupate in the soil (Herting 1960).

**Alternative hosts:** LEPIDOPTERA Danaidae; Nymphalidae.

**H. armigera records:**
- Tanzania  Striga  -  Milner 1967

?**Stur**mia sp.

**Taxonomic comment:** This might well be *Palexorista* sp.

**H. armigera records:**
- Zimbabwe  Citrus  V. important  Hall & Ford 1933

**Thelairosoma angustifrons** Villeneuve

**Taxonomic comment:** Records must be regarded as doubtful (1).

**Distribution:** Afrotropical Region: Malawi, Nigeria, South Africa, Tanzania, Uganda, Zaire.

**Alternative hosts:** LEPIDOPTERA Bombycidae; Sphingidae.

**H. armigera records:**
- Zimbabwe  Cotton  -  Pearson 1958

**Voria capensis** Villeneuve

**Taxonomic comment:** The record below is regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread eastern Africa from Kenya to South Africa, Ghana, Nigeria.

**H. armigera records:**
- South Africa  -  -  Cuthbertson & Munro 1941

**Voria ruralis** Fallen

**Taxonomic comment:** This species is very near to *V. capensis*.

**Distribution:** Afrotropical Region: from Kenya to South Africa; Nearctic Region; Neotropical Region; Oriental Region; Palaearctic Region.

**Biology:** This cosmopolitan species has been studied extensively as a parasitoid of the noctuid *Trichoplusia ni* Hübner in North America. Adults: Mating occurs soon after emergence. Pre-oviposition period: 9 d; oviposition period: 14 d (Brubaker 1968). Fecundity: 60 eggs per female (Elsey & Rabb 1970). Longevity: 28 d for females, 20 d for males (Grant & Shepard 1983).

Oviposition: Fully incubated eggs are laid on the host and hatch immediately.

Development: First instar larvae bore into the host body and settle in the muscle fibre. After a few days, the parasitoid larvae create a hole for respiration in the integument of the host and place their abdominal spiracles in the opening (Elsey & Rabb 1970). The parasitoids pupate inside the host larva or pupa. This species is gregarious, with an average of 2.2 pupae emerging per *T. ni* host. Egg+larval period: 7-9 d; pupal period: 7-8 d (27°C) (Grant & Shepard 1983); see also Jackson, Butler & Bryan (1969).

Host stages: Late host instars are preferred for oviposition. Adult parasitoids emerge from the host larval or pupal stage.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Plusia chalcites* Esper, *P. limbirena*, *P. orichalcea*. Worldwide, *V. ruralis* is mainly a parasitoid.
of Noctuidae.

**H. armigera** records: Although this species occurs in the Afrotropical Region, host records on *H. armigera* have been reported only from the Oriental Region.

**Winthemia dasypus** Wiedemann

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, South Africa, Tanzania, Uganda, Zaire; South Yemen.

**Biology:** It has been recorded that Winthemia species have a short pre-oviposition period (2-3 d). They inject their eggs in the host larva or attach the eggs to the host integument. Eggs hatch in about one week. The larval period is very short (Clausen 1940).

**H. armigera** records:

- South Africa Cotton Cuthbertson & Munro 1941

**Eygobothria ciliata** van der Wulp

**Sturmia munroi** Curran (Cuthbertson 1934; Jones 1939)

**Taxonomic comment:** Records are regarded as reliable (1).

**Distribution:** Afrotropical Region: widespread mainland; Oriental Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Diparopsis castanea*, *Spodoptera exigua*; Geometridae; Lasiocampidae; Psychidae; Sphingidae.

**H. armigera** records:

- South Africa Citrus Cuthbertson 1934
- Zimbabwe Citrus Rare Jones 1939

**HYMENOPTERA**

**Ichneumonidae**

**Barylypa humeralis** Brauns

**Distribution:** Palaearctic Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae.

**H. armigera** records:

- Egypt Predom. Tomato Up to 16% Megahed et al. 1977

**Barylypa rufa** Holmgren

**Distribution:** Palaearctic Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae.

**H. armigera** records:

- Egypt - Common Ismael & Swailem 1975

**Campoplex xanthostoma** Gravenhorst

**Distribution:** Palaearctic Region.

**Alternative hosts:** LEPIDOPTERA Gelechiidae; Noctuidae; Pyralidae.

**H. armigera** records:

- Egypt - Rare Megahed et al. 1977

**Genus Charops** Holmgren

The African fauna in this genus is still largely undescribed. Likewise, very limited information exists on the biology of *Charops* spp. Duodu & Lawson (1983) studied *C. diversipes* Roman on the nymphalid host *Acraea terpsicore* Linnaeus. *Charops* spp. generally attack exceptionally young host larvae (mostly first instars), although a *Charops* sp. has been reported to attack the third instar of *Orgyia mixta* Snellen (Lymantriidae) more than the first or second instar (Migunda 1970). The development of *C. diversipes*, from egg to adult, is 13-17 d. The mature
larva emerges from the host larva and starts spinning a cocoon. The cocoon remains on the plant during pupation. Pupae of Charops spp. are commonly hyperparasitized by Brachymeria spp. (Chalcididae). The records below might include many different species.

**Charops aster Szepigeti**

**Taxonomic comment:** Records are regarded as reliable (2).

**Distribution:** Afrotropical Region: Madagascar, Mozambique, Nigeria.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Spodoptera littoralis*; Nymphalidae.

**H. armigera records:**
- Mozambique - - BMNH (Umbeluzi Coll 1982)

**Charops sp.**

**H. armigera records:**
- Tanzania Legumes Common Reed 1965

**Charops sp.**

**Biology:** This species is common year-round in Tanzania. The parasitoid larva emerges from the third or fourth instar of the host (Nyambo 1986).

**Host-plant associations:** Common on tomato, cleome and chickpea; rare on cotton and maize (Nyambo 1986).

**H. armigera records:**
- Tanzania Various crops Up to 23% Nyambo 1986

**Charops sp.**

**H. armigera records:**
- Tanzania Cotton 2.1% Robertson 1973

**Charops sp.**

**H. armigera records:**
- Tanzania Pigeon pea - BMNH (Disney Coll 1949)

**Charops sp.**

**H. armigera records:**
- Tanzania Striga - Milner 1967

**Charops sp.**

**H. armigera records:**
- Uganda Various crops 10% Coaker 1959

**Charops sp.**

**H. armigera records:**
- Uganda Cotton - Nyiira 1970a

**Charops sp.**

**H. armigera records:**
- Botswana Cotton, cleome - Roome 1975a

**Charops sp.**

**H. armigera records:**
- Chad Cotton - Silvie pers. comm. 1988

**Charops spp.**

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Plusia orichalcea*.

**H. armigera records:**
- South Africa Cotton, tomato V. rare Parsons 1940
Charops sp.
H. armigera records:
- Nigeria - - BMNH (Beeden Coll 1974)

Charops sp.
H. armigera records:
- Senegal Sorghum, Rare Bhatnagar 1987 acanthospermum

Diadegma sp.
Angitia sp. (Parsons 1940)

Taxonomic comment: Probably many undescribed species in Africa (2).
Biology: Larval period: 7-11 d; pupal period: 12-15 d. Attacks mostly the third host instar (Parsons 1940).

H. armigera records:
- South Africa Peas, maize Rare Parsons 1940

Genus Enicosipilus Stephens

Moutia & Courtois (1952) report that Enicosipilus sp. has a pre­oviposition period of 8-10 d and a fecundity of 8-14 eggs per female. The female deposits one egg in the body cavity of the host, and the egg hatches after 2 d. The larva develops in the haemolymph of the host. When fully grown, it emerges from the host and spins a cocoon on the plant. Oviposition is probably most frequent in the third and fourth instars of the host. In general, Enicosipilus spp. are parasitoids of Noctuidae; many are thought to be host specific. Some species are adapted to dry conditions, e.g. E. capensis Thunberg, is known as a dry season parasitoid of noctuids in India (Gauld & Mitchell 1978).

Enicosipilus capensis Thunberg

Distribution: Afrotropical Region: throughout (incl. Madagascar); Oriental Region.
Alternative hosts: LEPIDOPTERA Noctuidae: Sesamia sp., Spodoptera exempta, many other Noctuidae; occasionally Pyralidae.

H. armigera records: Although this species occurs throughout Africa, host records on H. armigera have been reported only from the Oriental Region.

Enicosipilus sp.
H. armigera records:
- Uganda Cotton 11% Coaker 1959

Enicosipilus sp.
H. armigera records:
- Tanzania Cotton Rare Robertson 1973

Metopius discolor Tosquinet

Distribution: Afrotropical Region: South Africa, Tanzania.
Biology: Endoparasitoid. Attacks late host instars. Egg-adult period: 32-39 d (Parsons 1940). Metopius spp. are the only ichneumonids that emerge from the host pupal stage.

Alternative hosts: No records.

H. armigera records:
- South Africa Various crops Rare Parsons 1940
- South Africa Cotton - Taylor 1932
- South Africa Cotton - Simmonds 1960
- Tanzania Cotton Rare Reed 1965

Netelia sp. capensis Holmgren

Biology: Netelia spp. oviposit one black egg with a hard shell on the host. Usually full-grown host larvae (fifth and sixth) are attacked. The host
is killed before it pupates.

_H. armigera_ records:
Uganda - Rare Coaker 1959

**Netelia opacula** Schrank
**Taxonomic comment:** Specific name must be regarded as doubtful (2).
**Distribution:** Afrotropical Region: Ethiopia, Kenya, South Africa, Uganda; Palaearctic Region.
**Alternative hosts:** LEPIDOPTERA Noctuidae: records from Palaearctic Region only.

_H. armigera_ records:
Kenya - - Le Pelley 1959

**Netelia testacea** Gravenhorst
**Taxonomic comment:** Record below is regarded as reliable (2).
**Distribution:** Afrotropical Region: Zimbabwe; Palaearctic Region.
**Alternative hosts:** LEPIDOPTERA Noctuidae, records from outside the Afrotropical Region only; Arctiidae; Lasiocampidae; Notodontidae; Sphingidae.

_H. armigera_ records:
Zimbabwe - - BMNH (Gatooma Coll 1969)

_Netelia sp._

_H. armigera_ records:
Kenya Tomato - BMNH (Cock Coll 1987)

_Netelia sp._

_H. armigera_ records:
Tanzania Cotton Up to 3% Reed 1965

_Netelia sp._

_H. armigera_ records:
Tanzania Various crops Rare Nyambo 1986

_Netelia sp._

_H. armigera_ records:
Tanzania Cotton Rare Robertson 1973

_Netelia sp._

_H. armigera_ records:
Uganda Cotton - Nyiira 1970a

**Pristomerus sp. nr. fumipennis** Wilkinson
**_H. armigera_ records:**
Uganda - Rare Coaker 1959

**Pristomerus sp.**
**Taxonomic comment:** Many undescribed _Pristomerus_ spp. in Africa.
**Biology:** Solitary endoparasitoid. Occurs mainly in second and third host instars. Larval period: 7-9 d; pupal period: 9-11 d (Parsons 1940). The fully grown larva spins a cocoon near the host remains.

_H. armigera_ records:
South Africa Various crops Rare Parsons 1940

**Pristomerus sp.**

_H. armigera_ records:
Tanzania Cotton Rare Reed 1965

**Pristomerus sp.**

_H. armigera_ records:
Tanzania Various crops Rare Nyambo 1986
Pristomerus sp.
H. armigera records:
Botswana Various crops - Roome 1975a

Pristomerus sp.
H. armigera records:
South Africa Cotton - Simmonds 1960

Pristomerus sp.
H. armigera records:
Senegal Sorghum - Bhatnagar 1987

Braconidae

Aleiodes sp.
Taxonomic comment: Recorded as Rogas sp.; the genus Rogas was later transferred to Aleiodes.
H. armigera records:
Uganda Cotton - Nyiira 1970a

Aleiodes sp.
H. armigera records:
Senegal Various crops Up to 7% Bhatnagar 1987

Genus Apanteles Förster
Taxonomic comment: This huge genus was classified in species-groups by Nixon (1965), and has been reclassified by Mason (1981) in a number of new genera. Because Mason’s reclassification is based only on American species, excluding species from all other parts of the world, it is not generally accepted. We therefore use Nixon’s classification.

Biology: Species in this genus are larval, in some cases egg-larval, endoparasitoids of Lepidoptera. Mature larvae emerge from the host and pupate in cocoons alongside the host remains. Some species emerge from very young host larvae, some from the host’s final instar. Species are either solitary or gregarious (Le Masurier 1987). Although some species attack a wide variety of host species of different lepidopterous families, most are restricted to a small number of closely related hosts.

Apanteles diparopsidis Lyle
Taxonomic comment: The record below is regarded as reliable (2).
Distribution: Afrotropical Region: Malawi, Rwanda, South Africa, Sudan, Tanzania, Uganda, West Africa, Zaire.
Biology: Attacks the first and emerges from the second instar of H. armigera. Pupal period: 5-8 d (Nyambo 1986).
Host-plant associations: Common on sorghum, rare on cotton (Nyambo 1986).
Alternative hosts: Mainly known as a parasitoid of Diparopsis and Earias spp.; LEPIDOPTERA Noctuidae: Diparopsis castanea, D. watersi, Earias biplaga, E. insulana; Gelechiidae; Lyonetiidae; Pyralidae.
H. armigera records:
Tanzania Various crops Up to 26% Nyambo 1986

Apanteles maculitarsis Cameron
Taxonomic comment: The records below are regarded as doubtful (2).
Distribution: Afrotropical Region: Kenya, Malawi, Senegal, South Africa.
Biology: Larval period: 8-10 d; pupal period: 6-8 d. Mostly, it attacks the first instar and emerges from the third instar of H. armigera (Parsons 1940).
Alternative hosts: LEPIDOPTERA Noctuidae: Spodoptera exempta; Lasiocampidae;
Saturniidae.

Host-plant associations: Most frequent on peas (Parsons 1940).

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host Type</th>
<th>Record Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Various crops</td>
<td>Common Parsons 1940</td>
</tr>
<tr>
<td>South Africa</td>
<td>Various crops</td>
<td>- de Saeger 1944</td>
</tr>
</tbody>
</table>

Apanteles ruficrus Haliday

Taxonomic comment: Recognizable species; records are regarded as reliable (2).

Distribution: Afrotropical Region: Cameroun, Madagascar, Senegal, Somalia, South Africa, Sudan, Uganda; Oriental Region; Palaearctic Region; introduced in North America and New Zealand.


Mating occurs directly after emergence. There is no pre-oviposition period, because eggs are fully developed upon emergence. Fecundity: 220 eggs per female. Longevity of female: 6.3 d (26°C). Sex ratio 2:1, in favour of males.

Oviposition: The female deposits a large number of eggs per host, just under the host integument. During the next 5 d the eggs swell up from 0.13x0.04 mm to 0.56x0.25 mm, and hatch. The larvae feed within the host during their development. The host gradually becomes inactive and stops feeding. The fully grown third instar parasitoids leave the host almost simultaneously and start spinning their white cocoons alongside the host remains. Hafez reported that about 60 parasitoids emerge per Agrotis host. Egg+larval period: 11-18 d; pupal period: 3-6 d (28°C) (McCutcheon, Salley & Turnipseed 1983).

Alternative hosts: LEPIDOPTERA Noctuidae: Agrotis ipsilon, Euxoa spinifera Hübner, Leucania loreyi, Plusia circumflexa Linnaeus, P. gamma Linnaeus, Sesamia cretica Lederer, Spodoptera exempta, S. exigua, S. littoralis; Arctiidae; Geometridae; Hesperiidae; Lycaenidae; Lymantriidae; Nymphalidae; Pyralidae; Yponomeutidae.

Secondary natural enemies: A pteromalid has been recorded from A. ruficrus cocoons in Egypt (Hafez 1947).

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Host Type</th>
<th>Record Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>-</td>
<td>Common Ismail &amp; Swailen 1975</td>
</tr>
<tr>
<td>Egypt</td>
<td>-</td>
<td>Rare Megahed et al. 1977</td>
</tr>
<tr>
<td>Senegal</td>
<td>-</td>
<td>- Risbec 1950</td>
</tr>
<tr>
<td>Somalia</td>
<td>Maize</td>
<td>- de Saeger 1944</td>
</tr>
<tr>
<td>Sudan</td>
<td>Cotton</td>
<td>- Greathead 1966</td>
</tr>
</tbody>
</table>

Apanteles sesamiae Cameron

Taxonomic comment: Distinct species; records are regarded as reliable (2).

Distribution: Afrotropical Region: Cameroun, Kenya, Malawi, Mozambique, Senegal, South Africa, Sudan, Uganda, Zaire.

Biology: Ulyett (1935) described the biology of A. sesamiae parasitizing Busseola fusca.

Adult: Mating occurs shortly after emergence. Longevity: 3-4 d.

Development: Egg+larval period: 14-21 d; pupal period: 5-7 d (26°C, 80%RH). High humidity seems to be essential for development. Commonly, 60-100 larvae emerge per host larva.

Host stages: Mature parasitoid larvae emerge from the fifth or sixth instar of the host.

Alternative hosts: Known mainly as a stemborer parasitoid; LEPIDOPTERA Noctuidae: Busseola fusca, Sesamia spp.; Pyralidae. The stout body and short appendages suggest the adaptation of this species to parasitize stemborers (see Ulyett 1935).

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Record Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zaire</td>
<td>- de Saeger 1944</td>
</tr>
</tbody>
</table>

(from Heliothis sp.)
Apanteles sp. nr. aesthiopicus (ultr-group of Nixon (1965))
Biology: Occurs in the first to the third host instar of H. armigera.
Larval period: 7-10 d; pupal period: 6-8 d (Parsons 1940).
Host-plant associations: Frequent on peas (Parsons 1940).
H. armigera records:
South Africa Peas Important Parsons 1940

Apanteles sp. ultr-group of Nixon (1965)
H. armigera records:
Uganda Various crops Up to 20% Coaker 1959

Apanteles sp. vitripennis-group of Nixon (1965)
Biology: This species attacks the first instar of the host (Nyambo, unpublished). A. vitripennis is a solitary species (Le Masurier 1987).
H. armigera records:
Tanzania Various crops Common Nyambo 1986

Apanteles sp.
H. armigera records:
Uganda Cotton - Nyiira 1970a

Apanteles sp.
H. armigera records:
Kenya Pigeon pea - BMNH (KARI Coll 1985)

Apanteles sp.
H. armigera records:
Botswana Sorghum, sunflower - Roome 1975a

Apanteles sp.
H. armigera records:
Somalia Cotton - Russo 1940

Apanteles sp.
H. armigera records:
Tchad Cotton - Silvie pers. comm. 1988

Apanteles sp.
H. armigera records:
Egypt Various plants Up to 27% Megahed et al. 1977

Apanteles sp.
H. armigera records:
Madagascar Cotton Important Vaissayre 1977

Ascogaster ?cava de Saeger
Distribution: Afrotropical Region: Zaire.
H. armigera records:
Uganda - Rare Coaker 1959

Bracon brevicornis Wesmael
Microbracon brevicornis Wesmael (in all references below)
Taxonomic comment: Bracon brevicornis is now thought to be a synonym of B. hebetor Say (2).
Distribution: Afrotropical Region: South Africa, Sudan, West Africa; Nearctic Region; Neotropical Region; Oriental Region; Palaearctic Region.
Biology: Gregarious larval ectoparasitoid. Taylor (1932) described the biology of B. brevicornis parasitizing H. armigera in South Africa.
Adult: Pre-oviposition period less than a day. Fecundity: 200 eggs per

Host feeding by adult females has been recorded.

Oviposition: The host is paralysed and 3-8 eggs, depending on the size of the host, are deposited on the integument. Eggs hatch after 1.5-2 d.

Development: Larvae develop outside the host. Mature larvae spin a cocoon and pupate alongside the host remains. Larval period: 4-5 d; pupal period: 6-8 d.

Alternative hosts: Wide host range; LEPIDOPTERA Noctuidae: Busseola fusca, Diparopsis watersi, Earias insulana, Leucania sp., Spodoptera exempta, S. exigua; Gelechiidae; Pieridae; Pyralidae; Stenomidae; Tortricidae; COLEOPTERA.

Host-plant associations: In South Africa, B. brevicornis was found associated almost exclusively with H. armigera on Antirrhinum majus, a garden plant, while H. armigera was present on various crops (Taylor 1932; Parsons 1940).

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Percentage</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>Various plants</td>
<td>Up to 17%</td>
<td>Megahed et al. 1977</td>
</tr>
<tr>
<td>South Africa</td>
<td>Exclusively</td>
<td>-</td>
<td>Taylor 1932</td>
</tr>
<tr>
<td></td>
<td>on antirrhinum</td>
<td>-</td>
<td>Simmonds 1960</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cotton</td>
<td>-</td>
<td>Ullyett 1933</td>
</tr>
<tr>
<td>South Africa</td>
<td>Maize</td>
<td>10%</td>
<td>Parsons 1940</td>
</tr>
<tr>
<td>South Africa</td>
<td>Various crops</td>
<td>Rare</td>
<td>Parsons 1940</td>
</tr>
<tr>
<td>South Africa</td>
<td>Antirrhinum</td>
<td>V. common</td>
<td>Pettey 1948</td>
</tr>
<tr>
<td>South Africa</td>
<td>Lucerne,</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td></td>
<td>antirrhinum</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Tchad</td>
<td>Cotton</td>
<td>-</td>
<td>Silvie pers. comm. 1988</td>
</tr>
</tbody>
</table>

**Bracon hebetor Say**

**Taxonomic comment:** Bracon brevicornis is now thought to be a synonym of B. hebetor (2).

**Distribution:** Afrotropical Region; Neotropical Region; Oriental Region; Palaearctic Region.

**Alternative hosts:** Wide host range; LEPIDOPTERA Blastoblasidae; Gelechiidae; Hesperiidae; Lycaenidae; Noctuidae; Oecophoridae; Pyralidae; Stenomidae; Tineidae; Yponomeutidae; HYMENOPTERA.

**H. armigera records:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Status</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Maize, millet</td>
<td>Rare</td>
<td>Bhatnagar 1987</td>
</tr>
</tbody>
</table>

**Bracon kirkpatricki Wilkinson**

**Microbracon kirkpatricki** Wilkinson (Balla 1982)

**Distribution:** Afrotropical Region: Congo, Egypt, Ivory Coast, Malawi, Senegal, Somalia, Sudan; Oriental Region; introduced in North America in 1969.

**Biology:** Engroff & Watson (1975) described the biology of B. kirkpatricki parasitizing Pectinophora gossypiella Saunders (Gelechiidae).

**Alternative hosts:** LEPIDOPTERA. Mainly known as a parasitoid of Pectinophora gossypiella (Gelechiidae); Pyralidae.

**H. armigera records:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Status</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan</td>
<td>-</td>
<td>-</td>
<td>Balla 1982</td>
</tr>
</tbody>
</table>

**Bracon sp.**

**H. armigera records:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Status</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>Cotton</td>
<td>-</td>
<td>Le Pelley 1959</td>
</tr>
</tbody>
</table>

**Bracon sp.**

**H. armigera records:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Status</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Millet</td>
<td>Rare</td>
<td>Bhatnagar 1987</td>
</tr>
</tbody>
</table>

**Braunsia sp.**

**H. armigera records:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>Status</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>Cotton</td>
<td>-</td>
<td>Le Pelley 1959</td>
</tr>
</tbody>
</table>
Genus Cardiochiles Nees

Taxonomic comment: There are several undescribed species in Africa. Species from the Sahelian Subregion have recently been revised (Huddleston & Walker in press). Revision for tropical Africa is underway.

Biology: Cardiochiles spp. are solitary endoparasitoids of Lepidoptera. They usually attack their host during early host instars and emerge from the fourth, fifth or sixth instar, depending on the parasitoid species. The North American Cardiochiles nigriceps is the best studied species in this genus, and is regarded as a highly specific parasitoid of Heliothis virescens. It has been shown that the females locate their host by close range chemoreception. They examine areas contaminated with mandibular gland secretions of H. virescens (Vinson 1968; Vinson & Lewis 1965; Vinson et al. 1975). The active chemical compounds are specific to H. virescens; the parasitoid will show a weaker response to frass of the closely related Helicoverpa zea (Vinson et al. 1975). The latter is an unsuitable host for C. nigriceps, because it will encapsulate the parasitoid egg (Lynn & Vinson 1977). C. nigriceps deposits one egg per host larva. Oviposition temporarily paralyses the host. The egg hatches within 1.5-2 d, and the new larva develops and remains inside the host until the host enters the soil to pupate (Danks, Rabb & Southern 1979). When the larva emerges from the host it feeds externally on the host remains, and starts spinning a cocoon to pupate in the ground (Lewis & Vinson 1968). Compare also Singh & Parshad (1970) for the biology of Cardiochiles hymeniae Fisher & Parshad.

Although there is no evidence that the African Cardiochiles spp., which parasitize H. armigera, are host specific, none of the species presented below has been found on a host other than H. armigera.

It has been reported that C. nigriceps is associated with tobacco plants (Vinson 1975; Martin et al. 1981). In Tanzania, Cardiochiles spp. seem to be associated with cotton more than other crops (Nyambo 1986).

Cardiochiles nigricollis Cameron

Taxonomic comment: Records are regarded as reliable (2).

Distribution: Afrotropical Region: Botswana, South Africa, Zaire.

Biology: Larval period: 10-13 d; pupal period: 9-12 d. Mainly, second and third instars of H. armigera are attacked (Parsons 1940).

Host-plant associations: In South Africa, C. nigricollis was mostly found in cotton-bred hosts (Parsons 1940).

H. armigera records:

Botswana Cotton, maize, - Roome 1975a
cleome
South Africa Predom. cotton Common Parsons 1940
South Africa Cotton, maize - de Saeger 1948

Cardiochiles nigromaculatus Cameron

Taxonomic comment: Reliable records (2).

Distribution: Afrotropical Region: Malawi, South Africa, Uganda, Zaire; Oriental Region.

H. armigera records:

Tanzania - - Reed 1965, BMNH
Uganda Cotton - Nyiira 1970a

Cardiochiles trimaculatus Cameron

Taxonomic comment: Records are regarded as reliable (2).

Distribution: Afrotropical Region: Equatorial Guinea, South Africa, Tanzania, Uganda, Zaire.

Biology: According to Greathead (1966), C. trimaculatus was the most important parasitoid of H. armigera on cotton in Uganda.

H. armigera records:

Tanzania Cotton Rare Robertson 1973
Uganda Various crops 8% Coaker 1959
Cardiochiles sp. nr. *trimaculatus* Cameron  
**Taxonomic comment:** These are two separate species.  
**Host-plant associations:** These species seem to be associated with cotton and cleome; they are rare on sorghum (Nyambo 1986).  

**H. armigera records:**  
Uganda *Cotton* Important Greathead 1966

Cardiochiles sp.  
**Taxonomic comment:** These are two separate species.  

Cardiochiles variegatus Szepligeti  
**Taxonomic comment:** Reliable records (2).  
**Distribution:** Afrotropical Region: Gambia, Niger, Nigeria, Senegal, Tanzania, Zaire.  

**H. armigera records:**  
Nigeria *Maize, millet, acanthospermum* Maize, millet, acanthospermum Bhatnagar 1987, BMNH

Cardiochiles sp.  
**Taxonomic comment:** These are two separate species.  

Chelonus bifoveolatus Szepligeti  
**Taxonomic comment:** Record below is regarded as reliable (2).  
**Distribution:** Afrotropical Region: Tanzania, Zaire.  

**H. armigera records:**  
Tanzania - Robertson 1970

Chelonus curvimaculatus Cameron  
**Taxonomic comment:** Probably a complex of species. In current taxonomy records are regarded as reliable (2).  
**Distribution:** Afrotropical Region: Madagascar, Mauritius, Somalia, South Africa, Sudan, Tanzania, Uganda, Zaire, Zimbabwe.  

**Biology:** Solitary egg-larval parasitoid. Broodyrk (1969) described the biology of *C. curvimaculatus*.  
Adult: Copulation occurs soon after emergence. No pre-oviposition period. The fecundity is high (520 eggs per female at 26.5°C). Longevity: 8.2 d for females, 6.4 d for males at 26.5°C; longevity at 32°C is only 1.5 d for both sexes.  
Oviposition: Females attack the host in its egg stage. They deposit one egg (0.2x0.05 mm) per host, and do not distinguish between parasitized and unparasitized host eggs. Also, freshly laid eggs are attacked to the same extent as are older eggs. In young host eggs the parasitoid deposits its egg in the yolk, in older host eggs the parasitoid oviposits directly into the haemocoel of the host embryo. Adult females of *Chelonus* sp. nr. *curvimaculatus* respond to kairomones of their host; the kairomones are emitted by the scales the moths leave at oviposition sites (Chiri & Legner 1982).  
Development: Eggs hatch after 1-1.5 d (26.5°C). Larvae emerging in the yolk of the host egg will soon enter the haemocoel of the embryo.
Parasitized larvae of *H. armigera* are arrested in their third larval instar and start spinning their cocoon; spinning normally takes place in the host's sixth instar. The parasitoid larva consumes the host and pupates outside. According to Nyambo (1986) parasitoid larvae emerge from the second or third instar of the host. Broodryk demonstrated that *C. curvimaculatus* adjusts its development period to the host species. Consequently, this parasitoid can synchronize its life-cycle with that of different host species. On *H. armigera* the egg-to-adult period is 29 d (26.5°C) (Broodryk 1969). Larval period: 8–10 d; pupal period: 9–12 d (Parsons 1940). Also, diapause synchronization has been reported from *C. curvimaculatus* (Broodryk 1969).

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Celama squalida* Staudinger, *Earias insulana*; Gelechiidae; Pyralidae; COLEOPTERA. Broodryk (1969) reports that *Spodoptera littoralis* encapsulated the larva of *C. curvimaculatus* in 78% of the cases, whereas *H. armigera* did not encapsulate the parasitoid.

**H. armigera records:**
- Madagascar: Cotton, Important, Vaissayre 1977
- South Africa: Maize, Common, Parsons 1940
- South Africa: Citrus, Frinsloo 1984
- Tanzania: Various crops, Up to 12%, Nyambo 1986
- Uganda: Rare, Coaker 1959

**Chelonus pilosulus** Szepligeti
**Taxonomic comment:** Probably correct identification in current taxonomy (2).
**Distribution:** Afrotopical Region: Sudan, Tanzania.

**H. armigera records:**
- Sudan: Cotton, Lazarévic 1971

**Chelonus versatilis** Wilkinson
- *Chelonella versatilis* Wilkinson (1932)
- *Microchelonus versatilis* Wilkinson (Robertson 1970)
**Taxonomic comment:** Probably correct identification in current taxonomy (2).
**Distribution:** Afrotopical Region: Botswana, Sudan, Tanzania; Mediterranean Subregion.

**Biology:** Adults emerge from the third or fourth instar of *H. armigera*.

**Alternative hosts:** LEPIDOPTERA Gelechiidae: *Pectinophora gossypiella*; Pyralidae.

**H. armigera records:**
- Botswana: 0.6%, Roome 1971a
- Sudan: Cotton, Wilkinson 1932
- Tanzania: Various crops, Robertson 1970

**Chelonus sp.**

**H. armigera records:**
- South Africa: Cotton, Simmonds 1960

**Chelonus sp.**

**H. armigera records:**
- Zimbabwe: Citrus, V. rare, Hall & Ford 1933

**Disophrys lutea** Brullé
**Taxonomic comment:** Record is regarded as reliable (2).
**Distribution:** Afrotopical Region: widespread; Palaearctic Region.

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Spodoptera exempta*.

**H. armigera records:**
- Senegal: Sorghum, Rare, Bhatnagar 1987

**Disophrys nigricornis** Brullé
**Taxonomic comment:** Record must be regarded as doubtful (3).
**Distribution:** Afrotopical Region: Senegal, Tanzania, Zaire.
**H. armigera** records:
- Senegal - - Risbec 1950

**Disophrys** sp.
Taxonomic comment: Record must be regarded as doubtful (3).

**H. armigera** records:
- Sudan Cotton, beans - Lazarévic 1971

**Meteorus clytes** Nixon
Taxonomic comment: Record is regarded as reliable (3).
Distribution: Afrotropical Region: South Africa, Tanzania.
Alternative hosts: No records.

**H. armigera** records:
- Tanzania Groundnut - BMNH (Disney Coll 1952)

**Meteorus laphygmarum** Brues
Taxonomic comment: All the records below are regarded as reliable (3).
Alternative hosts: LEPIDOPTERA Noctuidae: *Earias biplaga*, *Spodoptera exigua*.

**H. armigera** records:
- Madagascar - - Brenière 1965
- Nigeria - - BMNH (Beeden Coll 1974)
- Sudan - - BMNH (Bedford Coll 1927)
- Tanzania Cotton Rare Robertson 1973
- Tchad Cotton - Silvie pers. comm. 1988
- Uganda - Rare Coaker 1959

**Meteorus** sp.

**H. armigera** records:
- Tanzania Cotton Rare Reed 1965
- Tanzania Various crops Rare Nyambo 1986

**Meteorus** sp.

**H. armigera** records:
- Botswana - - Roome 1975a

**Meteorus** sp.

**H. armigera** records:
- Senegal - - BMNH
(from *Heliothis* sp.)

**Meteorus** sp.

**H. armigera** records:
- Tchad Cotton - Silvie pers. comm. 1988

**Microp1itis sufiventris** Kokujev

**H. armigera** records:
- Egypt Various plants Up to 50% Megahed et al. 1977

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**Ceraphronidae**

**Genus Ceraphron** Jurine
Gregarious endoparasitoids. Most species are recorded in the literature as hyperparasitoids, especially through *Apanteles* spp. on Lepidoptera. Chaudhary & Chand (1973) described the biology of *C. fijiensis* Ferriere
from India. Newly formed cocoons or mature Apanteles larvae which had emerged from the phytophagous host, were attacked. Larval period: 7-8 d; pupal period: 8-9 d at 30°C.

Ceraphron sp.

H. armigera records:
Uganda - Rare Coaker 1959

?Ceraphron sp.

H. armigera records:
Uganda - - Nyiira 1970a

Scelionidae

Platytenomus busseolae Gahan

Taxonomic comment: This is probably a misidentification (4).
Distribution: Afrotropical Region: Nigeria, Tanzania.
Alternative hosts: LEPIDOPTERA Noctuidae: Busseola fusca, Sesamia sp.; Pyralidae.

H. armigera records:
Uganda Cotton - Coaker 1959

Telenomus ullyetti Nixon

Phanurus ullyetti Nixon (Parsons & Ullyett 1936)

Taxonomic comment: The records below are regarded as reliable (4). Parsons & Ullyett (1934) recorded Phanurus sp., which was later considered to be P. ullyetti (Parsons & Ullyett 1936), a synonym of T. ullyetti.
Distribution: Afrotropical Region: Cameroun, South Africa, Tanzania, Zimbabwe.

Biology: Jones (1937) described the biology of this species parasitizing H. armigera.

Adults: Mating occurs immediately after emergence. No pre-oviposition period. Fecundity: 30-90 eggs per female. Sex ratio: 7:3, in favour of females. Arrhenotokous. Longevity: 18 d for females, 14 d for males (22°C); non-oviposition extends the female life-span.

Oviposition: Eggs are deposited in the yolk of young host eggs (1 egg per host). Females can distinguish between parasitized and unparasitized hosts. Detailed studies on the related Telenomus heliothidis Ashmead, a parasitoid of Helicoverpa zea in North America, have revealed that several physical cues as well as chemical cues (contact kairomones) are involved in recognizing and accepting the host egg (Strand & Vinson 1982, 1983).

Development: The parasitoid remains for a comparatively long period passively as a first instar in the yolk of the host egg. There is evidence that the female of T. heliothidis injects an arrestment factor in the host egg at oviposition. Consequently, the host ceases development (Strand et al. 1986).
The second instar attacks the host embryo. If the embryo has grown beyond a certain size, the parasitoid larva will not be able to attack, and starves. Egg-adult period: 25 d at 19.4°C or 14 d at 26°C.

Alternative hosts: LEPIDOPTERA Pyralidae: Chilo sp., Scirpophaga sp.
Host-plant associations: Parsons (1940) observed higher egg parasitism levels, mainly by T. ullyetti, on tomato, and to a lesser extent on cucumber and marrow, than on legumes. He attributed this to the distribution of host eggs which are aggregated near the flowers on the former crops.

H. armigera records:
South Africa Cotton Up to 70% Parsons 1940
Genus *Brachymeria* Westwood in Stephens

Little is known about this genus in the Afrotropical Region. *Brachymeria* spp. are pupal parasitoids, many species attack the pupae of beneficial hymenopterans.

**Brachymeria botteqi** Masi

*Taxonomic comment: Record below must be regarded as suspect (5).*

**H. armigera** records:

- Zimbabwe Tobacco Rare Bünzli & Büttiker 1957

**Brachymeria cowani** Kirkby

*Taxonomic comment: Record below must be regarded as suspect (5).*

**H. armigera** records:

- Tanzania Cotton Rare Reed 1965

**Brachymeria** sp.

*Biography: Recorded as a secondary parasitoid.*

**H. armigera** records:

- Uganda - - Coaker 1959

**Brachymeria** sp.

**H. armigera** records:

- Tanzania Cotton Rare Robertson 1973

**Hyperchalcidioidea soudanensis** Steffan

*Distribution: Afrotropical Region: Cameroun, Kenya, Nigeria, Sudan, Uganda.*

*Biography: Pupal ectoparasitoid.*

*Alternative hosts: LEPIDOPTERA Noctuidae: Busseola fusca; Psychidae; Pyralidae.*

**H. armigera** records:

- Sudan - - Balla 1982
Eurytomidae

**Eurytoma sp.**

**Biology:** Hyperparasitoid of *Apanteles* sp.

**H. armiger** records:

- **Uganda**
  - Coaker 1959

**Eurytoma spp.**

**Biology:** Hyperparasitoid of *Apanteles* sp.

**H. armiger** records:

- **Zimbabwe** Tobacco
  - Rare
  - Bünzli & Büttiker 1957

Eulophidae

**Euplectrus laphygmae** Ferrière

**Distribution:** Afrotropical Region: Ethiopia, Kenya, Malawi, Senegal, South Africa, Sudan, Tanzania, Uganda, Zimbabwe.

**Biology:** Neser (1973) studied *E. sp. nr. laphygmae* parasitizing the noctuid *Plusia acuta* Walker. Gerling & Limon (1976) described the biology of *E. laphygmae* parasitizing *Spodoptera littoralis*.

- **Adult:** Males emerge before females. Most females are arrhenotokous. Sex ratio is about 1:1 (Gerling & Limon 1976). Longevity: 45 d for females, 29 d for males (26°C). Fecundity: 165 eggs per female (Gerling & Limon 1976). Host feeding by adult females has been recorded.
- **Oviposition:** Females briefly paralyse the host during oviposition and attach their eggs (0.2x0.1 mm) to the host integument, mostly to the first three abdominal segments. Females can discriminate between host species and host instars. The number of eggs deposited per host depends on the host size. Eggs hatch after 1-2 d (Neser 1973).
- **Development:** The first instar larvae start feeding while still contained in the eggshell. The host stops feeding within 2 d after emergence of the parasitoid larvae and its body gradually collapses during the next 3 d. The entire parasitoid development takes place at the oviposition site. When mature, the larvae move underneath the dead host and spin their cocoons. Larval period: 3-5 d; total development (egg-adult): 7.5-9 d (30°C) (Neser 1973); compare also Parsons (1940). 3-5 larvae develop per *Spodoptera littoralis* host (Hegazi, Hammad & El-Minshawy 1977).
- **Host stages:** According to Neser (1973) the first and sixth instars of *Plusia* are rejected for oviposition. Gerling & Limon (1976) found that only the first four instars of *Spodoptera littoralis* were attacked. *E. laphygmae* oviposited normally on *H. armigera*, but failed to complete development on this host.

**Secondary natural enemies:** Multiparasitism by *E. laphygmae* and the endoparasitoids *Microplitis* sp., *Meteorus laphygrum* and *Copidosoma* sp. was found on *Plusia acuta* (Neser 1973).

**Alternative hosts:** LEPIDOPTERA Noctuidae: *Achaena catella* Guenée, *Anomis leona*, *Plusia gamma*, *P. orichalcea*, *Spodoptera exempta*, *S. exigua*; Arctiidae; Geometridae; Pyralidae.

**H. armiger** records:

- **Senegal**
  - Risbec 1960
- **Sudan**
  - Ferrière 1941
- **(from Heliothis sp.)**
  - BMNH Coll 1976
- **Tanzania**
  - Robertson 1970

47
**Euplectrus sp.**

*H. armigera* records:
- South Africa Peas - Parsons 1940

**Euplectrus sp.**

*H. armigera* records:
- Chad Cotton - Silvie pers. comm. 1988

**Euplectrus sp.**

*H. armigera* records:
- Uganda Cotton - Nyiira 1970a

**Pediobius furvus** Gahan


*H. armigera* records:
- Sudan - - Balla (1982)

**Pediobius mediopunctatus** Waterston

*Distribution*: Afrotropical Region: Ivory Coast, Senegal.

*Biology*: Often recorded as a hyperparasitoid.

*Alternative hosts*: *Lepidoptera* Noctuidae: *Anomis* leona (hyper), *Eublemma gayneri* Rothschild, *Spodoptera littoralis* (hyper); Arctiidae; Hesperiidae; Lycaenidae; *Hymenoptera*.

*H. armigera* records:
- Senegal - - Risbec 1960

**Elsidinae**

**Elsamus johnstoni** Ferrière

*Distribution*: Afrotropical Region: Sudan, Uganda, Zimbabwe; Oriental Region.


*Alternative hosts*: Mainly recorded from *Earias* spp. (Noctuidae) and *Pectinophora gossypiella* (Gelechiidae). Facultative hyperparasitoid.

*H. armigera* records:
- Sudan - - Balla 1982

**Encyrtidae**

**Copidosoma sp.**

*Biology*: Gregarious egg-larval parasitoid. El-Heneidy & Abbas (1983) described the biology of this particular *Copidosoma* sp. Adults: Mating occurs within a few hours of emergence. Sex ratio: 3:2, in favour of females. Longevity: 3-6 d (25°C). Development: Eggs are deposited in the host egg. *Copidosoma* sp. has a
polyembryonic mode of reproduction. The parasitoids develop inside the host larva, pupate, and emerge as adults from the sixth instar of H. armigera. 20-600 adults emerge per host. Diapause of the parasitoid, in its prepupal stage, occurs inside the host remains.

Host-plant associations: El-Heneidy & Abbas (1983) report that this species was found only on weeds, not on cotton or tomato, and attributed this to the seasonal occurrence of the parasitoid.

**H. armigera records:**

- **Egypt**: Various plants, Rare. *Megahed et al.* 1977
- **Copidosoma sp.**
- **H. armigera records:**
  - **Senegal**: Various crops, -. *Bhatnagar* 1987
- **Copidosoma sp.**
- **H. armigera records:**
  - **Egypt**: Common. *Ismael & Swailem* 1975 (from Heliothis sp.)

**Mymaridae**

**Sp. indet**

**H. armigera records:**

- **Zimbabwe**: -, Rare. *Jones* 1937

**Trichogrammatidae**

**Trichogramma pretiosum Riley**

Distribution: Introduced and established in South Africa in 1975; Nearctic Region.

**Alternative hosts:** LEPIDOPTERA Geometridae; Pyralidae; Tortricidae; NEUROPTERA.

**H. armigera records:**

- **South Africa**: Cotton, Rare. *van Hamburg* 1981

**Trichogramma sp. nr. evanescens Westwood**

**H. armigera records:**

- **Madagascar**: Cotton, Important. *Vaissayre* 1977

**Trichogramma sp.**

**H. armigera records:**

- **Tanzania**: Cotton, Up to 5%. *Reed* 1965

**Trichogramma sp.**

**H. armigera records:**

- **Uganda**: Cotton, -. *Coaker* 1959

**Trichogramma sp.**

**H. armigera records:**

- **Uganda**: Cotton, -. *Nyiira* 1970a

**Trichogramma spp.**

**H. armigera records:**

- **Botswana**: Various crops, -. *Roome* 1975a
**Trichogramma sp.**

**H. armigera records:**

South Africa - - Taylor 1932

**Trichogramma sp.**

**H. armigera records:**

South Africa Rare Jones 1937

**Trichogrammatoidea lutea Girault**

**Trichogramma lutea Girault**

**Taxonomic comment:** The records below are regarded as reliable (4).

**Distribution:** Afrotropical Region: Cape Verde, South Africa, Zaire, Zambia, Zimbabwe.

**Biology:** Jones (1937) studied the biology of *T. lutea* parasitizing *H. armigera*.

Adults: Mating occurs soon after emergence. Mated females are fertilized for life, males can mate many times. No pre-oviposition period. Fecundity: 32 eggs per female; 0-15 eggs are laid per day. Longevity: 2-9 d (26°C). Arrhenotokous.

Oviposition: Females oviposit 1-5 eggs into the host egg. Eggs are often superparasitized, in which case they yield no offspring (Mück 1985). Eggs are deposited in the central yolk of the host egg and are often enclosed by the embryo during its development.

Development: Parasitoid eggs swell up, and hatch after one day. The first instar feeds on the yolk, the second instar starts feeding on the organs of the host embryo. Development of the host is arrested. *T. lutea* is less restricted to young host eggs than is *Telenomus ullyetti*. One to four adults (mostly 2) emerge per host. If more than one progeny of mated females develop per host, usually only one is male (Kfir 1982).

Egg-adult period: 19 d at 19.4°C or 9 d at 26°C.

**Alternative hosts:** *LEPIDOPTERA* Noctuidae: Anomis leona Schaus, Dinaropsis castanea, Earias biplaga; Pyralidae; Tortricidae.

**H. armigera records:**

Cape Verde - - Mück 1985

South Africa Cotton Up to 60% Parsons 1940

South Africa Citrus - Frinsloo 1984

South Africa Cotton - Taylor 1932

South Africa Cotton Up to 19% van Hamburg 1981

South Africa Cotton Up to 17% Parsons & Ullyett 1934

South Africa Maize 41% Parsons & Ullyett 1936

South Africa Cotton Up to 50% Parsons & Ullyett 1936

Zambia Maize, cotton Important Bebbington & Allen 1935

Zimbabwe Cotton Up to 50% Peat 1935

Zimbabwe Cotton Up to 48% Jones 1937

Zimbabwe Maize Up to 75% Jones 1937

Zimbabwe Citrus <1% Jones 1936, 1937

**Trichogrammatoides sp.**

**H. armigera records:**

Senegal Acanthospermum Up to 17% Bhatnagar 1987

Maize Up to 27%

Sorghum Up to 32%

Tomato Up to 80%
Bethylidae

Goniozus sp.

H. armigera records:
Senegal    Maize, millet    -    Bhatnagar 1987
5.2 PREDATORS AND PATHOGENS

HEMIPTERA

Anthocoridae

Genus Orius Wolff, J.F.

Taxonomic comment: Little is known about Afrotropical Orius species (Gauri 1980). It is doubtful whether the African species recorded as O. insidiosus Say is the same as the Nearctic species.

Biology: Orius spp. have been extensively studied in North America (Ryerson & Stone 1979). Mating can occur directly after molting from the last nymphal stage. In O. tristicolor White, the pre-oviposition period is 2-3 d, the oviposition period 22 d, the fecundity 130 eggs per female (25°C) (Askari & Stern 1972) and the longevity 15 d (Iglinsky & Rainwater 1950). Eggs (0.42x0.4 mm) are deposited in the plant tissue, sometimes in clusters, and hatch after 3-5 d (25.5°C). The five nymphal stages of O. tristicolor will develop in 14.4 d at 25.5°C or 8.4 d at 33°C (Askari & Stern 1972). In small laboratory containers at 27°C, O. insidiosus consumed 0.7 eggs, or 4.4 first instar larvae, of Heliothis spp. per day per predator (Lingren, Ridgway & Jones 1968).

Alternative food: Orius spp. feed on a wide variety of arthropod prey (Marshall 1930); they are in particular important predators of spider mites, thrips and noctuid pests. Besides arthropods they also feed on plant tissues, such as pollen (Salas-Aguilar & Ehler 1977), and a coincidence in population build-up of O. insidiosus and the period of pollen-shed has been reported from maize (Dicke & Jarvis 1962) and soybean (Isenhour & Yeargan 1981). Alternative food may also be provided as floral or extrafloral nectaries. Trelease (1879) suggested that extrafloral nectaries of cotton can provide an alternative food source during the absence of insect prey. Although O. tristicolor has been observed feeding on extrafloral nectaries (van den Bosch & Hagen 1966) populations did not increase until their insect prey became abundant (Yokoyama 1978).

Host-plant associations: Orius insidiosus occurs on many wild plant species (Barber 1936). In North America it has been shown that O. insidiosus was more abundant in soybean fields with grass and mixed weeds, than in weed-free or broadleaf-weed soybean habitats (Shelton & Edwards 1983); it was suggested that predators are likely to be attracted to weedy habitats as a result of alternative food sources and favourable microclimatic conditions.

Orius albidipennis Rauter

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Status</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>-</td>
<td>Megahed et al. 1977</td>
</tr>
</tbody>
</table>

Orius ?Insidiosus Say

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Status</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Cotton, maize</td>
<td>40%</td>
</tr>
<tr>
<td>Uganda</td>
<td>Cotton</td>
<td>Important</td>
</tr>
</tbody>
</table>

Orius laevigatus Fieb.

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Status</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>-</td>
<td>Megahed et al. 1977</td>
</tr>
</tbody>
</table>

Orius sp. nr. insidiosus Say

H. armigera records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Status</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Cotton, maize</td>
<td>40%</td>
</tr>
</tbody>
</table>
Orius sp.

**H. armigera** records:
- Zimbabwe Cotton V. important Peat 1935

Orius sp.

**H. armigera** records:
- South Africa Cotton - Parsons 1940

Orius sp.

**H. armigera** records:
- Senegal Maize, millet - Bhatnagar 1987

Orius spp.

**H. armigera** records:
- Egypt - - Ismael & Swailem 1975

Reduviidae

**Coranus papillosus** Thunberg

**H. armigera** records:
- South Africa Cotton - Taylor 1932

**Ectomocoris fenestratus** Klug

**H. armigera** records:
- Senegal Various crops Rare Bhatnagar 1987

**Rhinocoris albopunctatus** Stål

**Distribution:** Afrotropical Region: Cameroun, South Africa, Uganda.

**Biology:** Nyiira (1970b) studied the biology of this species in Uganda.

**Oviposition:** Brown eggs (1.5x0.5 mm) are deposited in a cluster (5-250 eggs per cluster) on the foliage or stems, mostly on the underside of leaves. Eggs are brooded by the male parent. Nymphs hatch after 5-15 d (21-28°C). Nymphal development (5 stages) takes 54-92 d (21-28°C). Nyiira reports that adults consumed 1-3 **H. armigera** larvae per day in the laboratory.

**Alternative prey:** Rhinocoris spp. are polyphagous. Nyiira reported their feeding on *Earias* spp. (Noctuidae) and several Coleoptera, Hemiptera and Hymenoptera species, among which beneficial insects including Orius sp. (Anthocoridae), nymphs of Rhinocoris sp. (Reduviidae) and ants.

**Secondary natural enemies:** In Uganda, Odhiambo (1959) found that the related *Rhinocoris albopilosus* Signoret, despite parental care, suffered 10-20% egg parasitism by two *Hadronotus* species (Hym.: Scelionidae).

**H. armigera** records:
- South Africa Cotton - Taylor 1932
- Uganda Cotton - Nyiira 1970b

**Rhinocoris segmentarius** Stål

**H. armigera** records:
- South Africa Cotton - Taylor 1932
- Uganda Cotton - Nyiira 1970a

**Cosmolestes pictus** Klug

**H. armigera** records:
- Uganda Cotton - Nyiira 1970a
Pentatomidae

Glypsus conspicuus Westwood


Biology: Reed (1965) reported that G. conspicuus attacked the eggs and all larval stages of H. armigera.

H. armigera records:
- South Africa Cotton - Taylor 1932
- Tanzania Cotton Regular Reed 1965

Macrorhaphis acuta Dallas

Macrorhaphis spurcata Walker (Nyiira 1970b)
Microrhaphis spurcata Walker (Taylor 1932)

Biology: Reed (1965) reported that M. acuta attacked the eggs and all larval stages of H. armigera.

Distribution: Afrotropical Region: Malawi, South Africa, Uganda.

H. armigera records:
- South Africa Cotton - Taylor 1932
- Tanzania Cotton Common Reed 1965
- Uganda Cotton - Nyiira 1970a

THYSANOPTERA

Scolothrips sexmaculatus Pergande

Distribution: Afrotropical Region: Nearctic Region; Neotropical Region; Oriental Region; Palearctic Region.

Biology: Adults are bisexual. Low capacity of increase; fecundity: 4-5 eggs per female; longevity: 7-14 d (Bailey 1939). The eggs are inserted in the plant tissue and hatch after 6-10 d. Egg+nymphal period: 17-37 d (Lewis 1973).

Alternative prey: S. sexmaculatus is known as a mite predator; it can become cannibalistic when crowded (Bailey 1939).

H. armigera records:
- Egypt - - Ismael & Swailem 1975

NEUROPTERA

Chrysopidae

Chrysopidae are known for their predacious habits during the larval stages and have been recorded feeding on a wide variety of arthropods, including many agricultural pests. It has been demonstrated that larvae of Chrysoperla carnea Stephens respond to kairomones in the scales of Helicoverpa zea moths (Lewis et al. 1977; Nordlund et al. 1977); moths leave scales at their oviposition sites. Adult chrysopids are nocturnal and feed on soft plant parts. In cotton, extrafloral nectaries encourage population build-up of C. carnea (Schuster, Lukefahr & Maxwell 1976). Chrysopids, especially C. carnea, are commonly mass-reared and released against various insect pests, including Helicoverpa spp. (Hassan 1974).

Chrysopa congrua Walker

Distribution: Afrotropical Region: Tanzania, Zimbabwe.


Oviposition period: 35 d. Fecundity: 177 eggs per female. Longevity of
adults: 50 d (25°C). In the laboratory, the number of *H. armigera* eggs consumed during larval development was 20 during the first instar, 55 during the second instar and 219 during the third instar. Development period egg: 4 d; larva 11.9 d; pupa: 8.9 d (25°C), when fed on *H. armigera* eggs.

**Alternative prey:** In the laboratory, a wide variety of prey is consumed (Brettell 1982).

**H. armigera** records:

**Chrysopa pudica Navas**

**Biology:** Brettell (1982) described the biology of *C. pudica*.

**Alternative prey:** In the laboratory, a wide variety of prey is consumed (Brettell 1982).

**H. armigera** records:
- Tanzania: Cotton, Common. Reed 1965

**Chrysopa sp.**

**Biology:** Feeds on eggs and larvae of *H. armigera*. In the laboratory, predator larvae consumed up to 14 eggs per day and were able successfully to attack third instars (Reed 1965).

**H. armigera** records:
- South Africa: Cotton. Pearson 1958

**Chrysopa sp.**

**H. armigera** records:
- South Africa: Cotton. Parsons 1940

**Chrysopa sp.**

**H. armigera** records:
- Uganda: Cotton. Nyiira 1970a

**Chrysoperla carnea Stephens**

**Chrysopa carnea** Stephens (Ismael & Swailem 1975; Balla 1982)

**Distribution:** Mediterranean Subregion; Nearctic Region; Neotropical Region; Oriental Region; Palaearctic Region.

**Biology:** Adult: Pre-oviposition period 9 d. Longevity 36 d. Fecundity 39 eggs per female at 27.4°C, when fed on *H. armigera* (Awadallah, Abou-Zeid & Tawfik 1975). Incubation period egg: 3 d; larval period: 10 d; pupal period 6.7 d (27-30°C), when fed on *H. armigera*. Predation: daily consumption of the third instar of the predator is 26 eggs or 90 first instars of *H. armigera* (El-Dakroury et al. 1977). *C. carnea* responds to kairomones emitted by *Helicoverpa armigera* (Nordlund et al. 1977).

**Alternative prey:** A wide variety of prey is consumed.

**H. armigera** records:
- Egypt: - Ismael & Swailem 1975
- Egypt: - Megahed et al. 1977
- Sudan: - Balla 1982

**Mallada boninensis** Okamoto

**Chrysopa boninensis** Okamoto (Brettell 1979)

**Distribution:** Afrotropical Region: Cape Verde, Guinea, Kenya, Mozambique, South Africa, Tanzania, Zaire, Zimbabwe; Oriental Region.

**Biology:** Brettell (1979) described the biology of *M. boninensis*.
Longevity of adults: 25 d (25°C). In the laboratory, the number of *H. armigera* eggs consumed during development was 20 during the first instar, 40 during the second instar and 240 during the third instar. Larvae of this species carry debris of dead prey on their back. Development period, egg: 3.7 d; larva 10.6 d; pupa: 9.5 d (25°C), when fed on *H. armigera* eggs. Lee & Shih (1983) describe the biology and predation of this predator from China.

**Alternative prey:** In the laboratory, a wide variety of prey is consumed (Brettell 1979).

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Prey Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zimbabwe</td>
<td>Cotton</td>
<td>Common Brettell 1979</td>
</tr>
</tbody>
</table>

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**COLEOPTERA**

**Carabidae**

**Genus Chlaenius Bonelli**

African *Chlaenius* spp. feed on a variety of arthropods (Larochelle 1974). Adults of this carabid genus are ground-dwelling and nocturnal. Eggs are laid singly in the soil (David, Banerji & Kalra 1973). Larvae move up and down the plants in search of prey and feed on first to third instars of noctuids (Katiyar et al. 1976). According to Chen & Chen (1982), larvae of *C. bioculatus* Chaudoir consume about 30 young lepidopterous larvae during their development.

**Chlaenius boisduvali** Dejean

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Prey Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Various crops</td>
<td>Bhatnagar 1987</td>
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</tbody>
</table>

**Chlaenius dusaultii** Dufour

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Prey Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Various crops</td>
<td>Bhatnagar 1987</td>
</tr>
</tbody>
</table>

**Graphipterus obsoletus** Olivier

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Prey Type</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Various crops</td>
<td>Bhatnagar 1987</td>
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</table>

**Pheropsophus sp. nr. lafertei** Arrow

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>Prey Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>Various crops</td>
<td>Bhatnagar 1987</td>
</tr>
</tbody>
</table>

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**Staphilinidae**

**Paederus alfieri** Koch

**H. armigera** records:

<table>
<thead>
<tr>
<th>Location</th>
<th>-</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>-</td>
<td>Megahed et al. 1977</td>
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**Coccinellidae**

**Coccinella undecimpunctata** Linnaeus

**Biology:** Ibrahim (1955) described the biology of *C. undecimpunctata*. 

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DIPTERA

Asilidae

Asilid larvae are well known as predators of egg-pods of locusts in the soil (Greathead 1963).

Promachus sp.

Polistes sp.

Biology: Adults collect prey larvae and fly them to their nest, and feed them to their offspring.

Eumenidae

Delta sp.

Biology: Adults collect H. armigera larvae and fly them to their nest, and feed them to their offspring.

Eumenes maxillosus De Geer

Sphecidae

The majority of sphecids are predators. Their biology and behaviour is reviewed by Bohart & Menke (1976).

Ammophila sp.

Biology: Adults collect H. armigera larvae and fly them to their nest, and feed them to their offspring.
Formicidae

The ant fauna in tropical agroecosystems is usually well developed, and ants have been shown to play a significant role in the control of insect pests (e.g. Leston 1973). Although research has mainly been concentrated on tree crops (Leston 1973; Room 1975), it is believed that ants are also important control agents of insect pests in annual cropping systems, because ant faunas can develop very rapidly (Carroll & Risch 1983). The ant fauna and its impact in African annual cropping systems is still poorly understood. Some observations in South Africa indicate that Dorylus sp., a ground-dwelling species, has a great impact on populations of *H. armigera* pupae in the soil (P.J. Guest pers. comm.). On the other hand, ants have been reported to carry away parasitized *H. armigera* larvae (Taylor 1932). The ecology of foraging by ants is reviewed by Carroll & Janzen (1973).

**Myrmica sp.**

<table>
<thead>
<tr>
<th><em>H. armigera</em> records:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania Cotton Common Reed 1965</td>
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</tbody>
</table>

**Pheidole megacephala Fabricius**

<table>
<thead>
<tr>
<th><em>H. armigera</em> records:</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa - Steyn 1955</td>
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</table>

**Pheidole sp.**

<table>
<thead>
<tr>
<th><em>H. armigera</em> records:</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa Maize, cotton V. important Parsons &amp; Ulyett 1934</td>
</tr>
<tr>
<td>Tanzania Cotton Common Reed 1965</td>
</tr>
<tr>
<td>Uganda Cotton - Nyiira 1970a</td>
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</table>

**Sp. indet.**

<table>
<thead>
<tr>
<th><em>H. armigera</em> records:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana - Common Roome 1975a</td>
</tr>
</tbody>
</table>

**NEMATODA**

**Mermithidae**

**Hexameritis sp.**

**Biology:** In India, Achan et al. (1968) found that *Hexameritis*-infested larvae of *Helicoverpa armigera* turned green and subsequently yellow in colour before they stopped feeding. After 4-5 d the nematodes emerged from the host.

<table>
<thead>
<tr>
<th><em>H. armigera</em> records:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal Groundnut, acanthospermum Up to 2% Bhatnagar 1987</td>
</tr>
</tbody>
</table>
Nuclear Polyhedrosis Virus (NPV)

**Biology:** Diseased larvae are yellow and eventually turn brown-black. First and second instars of *H. armigera* are most susceptible to NPV (Ripper & George 1965; Daoust 1974); mortality occurs shortly after infestation, while larvae are still in a young stage (Whitlock 1974). North American strains of this biocontrol agent have been introduced and applied as a biological insecticide against *H. armigera* in Africa (Angelini & Labonne 1970; McKinley 1971; Roome 1971b, 1975b).

**H. armigera records:**
- Botswana: Sorghum, up to 61% mortality, Roome 1971a,b
- Senegal: Various crops, Bhatnagar 1987
- Sudan: Various crops, Bergold & Ripper 1957
- Tanzania: Various crops, very important, Nyambo 1986
- Tanzania: (unpublished)
- Uganda: Cotton, Coaker 1958
- Zimbabwe: (unpublished)

Bacteria

**Biology:** Probably only young larvae are susceptible to bacterial disease. Mortality occurs at later instars, often when larvae are fully grown (Nyambo 1986).

**H. armigera records:**
- Tanzania: Various crops, very important, Nyambo 1986

Fungi

*Nomuraea rileyi* (Farlow) Samson

**Biology:** In the laboratory, Mohamed, Sikorowski & Bell (1977) found that first and second instars and of *H. zea* were less susceptible to infection by the fungus than were third to fifth instars. This fungus has been reviewed by Ignoffo (1981). In general, the occurrence of fungi in the field is irregular and unpredictable, mainly determined by weather conditions (rainfall).

**Alternative hosts:** LEPIDOPTERA: species from various families; some Coleoptera.

**H. armigera records:**
- Tanzania: (unpublished)
- Sp. indet.: Tanzania, rare, Reed 1965


Bosch, R. van den; Hagen, K.S. (1966) Predacious and parasitic arthropods in
California cotton fields. California Agricultural Experiment Station Bulletin 820, 32 pp.


Chiaromonte, A. (1933) Considerazioni entomologiche sulla coltura delle cereali nella Somalia Italiana. l'Agricoltura Coloniale 27, 484-487.


Gerling, D.; Rotary, N. (1973) Hypersensitivity, resulting from host-unsuitability, as exemplified by two parasite species attacking Spodoptera littoralis (Lep.: Noctuidae). Entomophaga 18, 391-396.


Nixon, G.E.J. (1943) A synopsis of the African species of Meteorus (Hym.:
Braconidae). Bulletin of Entomological Research 34, 53-64.


Pettey, F.W. (1948) The biological control of prickly pears in South Africa. Science Bulletin of the Department of Agriculture, South Africa 271, 1-


Roome, R.E. (1975b) Field trials with a nuclear polyhedrosis virus and Bacillus thuringiensis against larvae of Heliothis armigera (Hb.) (Lepidoptera: Noctuidae) on sorghum and cotton in Botswana. Bulletin of Entomological Research 65, 507-514.


Heliothis virescens. Physiological Entomology 7, 83-90.


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<td>Formicidae</td>
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<td>Trichogrammatidae</td>
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<td>Vespidae</td>
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</table>
LIST OF NATURAL ENEMY SPECIES

acuta, Macrorhapis (Pentatomidae)
agilis, Linnaeuma (Tachinidae, Tachininae)
albidipennis, Orius (Anthocoridae)
albifrons, Linnaeuma (Tachinidae, Tachininae)
albopunctatus, Rhinocoris (Reduviidae)
Aleides sp. (Braconidae)
alferii, Paederus (Staphilinidae)
Amorphila sp. (Sphecidae)
Amobia signata (Sarcophagidae)
angustifrons, Thelairosoma (Tachinidae, Goniinae)
Apanteles diparopsidis (Braconidae)
Apanteles maculitarsis (Braconidae)
Apanteles ruficrus (Braconidae)
Apanteles sesamiae (Braconidae)
Ascogaster cava (Braconidae)
ater, Charops (Ichneumonidae)
bakeri, Hystricovoria (Tachinidae, Tachininae)
Barylypa rufa (Ichneumonidae)
bifoveolatus, Chelonus (Braconidae)
bimaculata, Gonia (Tachinidae, Goniinae)
blepharipus, Pales (Tachinidae, Goniinae)
boisduvali, Chlaenius (Carabidae)
Bombylans, Dejeania (Tachinidae, Tachininae)
boniensis, Mallada (Chrysopidae)
bottegi, Brachymera (Chalcididae)
Brachymera bottegi (Chalcididae)
Brachymera cowani (Chalcididae)
Bracon brevicornis (Braconidae)
Bracon hebetor (Braconidae)
Bracon kirkpatricki (Braconidae)
Braunsia sp. (Braconidae)
brevicornis, Bracon (Braconidae)
busseolae, Flatytenonomus (Scelionidae)
capensis, Enicospilus (Ichneumonidae)
Campoplex xanthostoma (Ichneumonidae)
capensis, Nemorae (Tachinidae, Tachininae)
capensis, Netelia (Ichneumonidae)
capensis, Voria (Tachinidae, Goniinae)
Carcelia evolans (Tachinidae, Goniinae)
Carcelia illota (Tachinidae, Goniinae)
Cardiochiles nigricollis (Braconidae)
Cardiochiles nigromaculatus (Braconidae)
Cardiochiles trimaculatus (Braconidae)
Cardiochiles variegatus (Braconidae)
carnea, Chrysoperla (Chrysopidae)
Ceraphron sp. (Ceraphronidae)
Ceromya cibdela (Tachinidae, Goniinae)
Charops ater (Ichneumonidae)
Chelonus bifoveolatus (Braconidae)
Chelonus curvimanus (Braconidae)
Chelonus pilosulus (Braconidae)
Chelonus versatilis (Braconidae)
Chetogena sp. (Tachinidae, Goniinae)
Chlaenius boisduvali (Carabidae)
Chlaenius dusaultii (Carabidae)
Chlorion sp. (Sphecidae)
Chrysopa congrua (Chrysopidae)
Chrysopa pudica (Chrysopidae)
Chrysoperla carnea (Chrysopidae)
cibdela, Ceromya (Tachinidae, Goniinae)
ciliata, Zygobothria (Tachinidae, Goniinae)
clytes, Meteorus (Braconidae)
Coccinella undecimpunctata (Coccinellidae)
coerulea, Pales (Tachinidae, Goniinae)
congrua, Chrysopidae (Chrysopidae)
conspicuus, Glypsus (Pentatomidae)
convergens, Sturmia (Tachinidae, Goniinae)
Copidosoma sp. (Encyrtidae)
Coranus papillosus (Reduviidae)
Cosmolestes pictus (Reduviidae)
cowani, Brachymeria (Chalcididae)
curvimaculatus, Chelonus (Braconidae)
dasyops, Winthemia (Tachinidae, Goniinae)
Dejeania bombylans (Tachinidae, Tachininae)
Delta sp. (Eumenidae)
Diadegma sp. (Ichneumonidae)
diparopsidis, Apanteles (Braconidae)
discolor, Metopius (Ichneumonidae)
Disophysys lutea (Braconidae)
Disophysys nigricornis (Braconidae)
Dohrniphora paollii (Phoridae)
Drino sp. (Tachinidae, Goniinae)
dusaultii, Chlaenius (Carabidae)
ectomocoris fenestratus (Reduviidae)
Elasmus johnstoni (Elasmidae)
Enicospilus capensis (Ichneumonidae)
evolans, Carcelia (Tachinidae, Goniinae)
Eumenes maxillosus (Eumenidae)
Euplectrus laphygmae (Eulophidae)
Eurytoma sp. (Eurytomidae)
Exorista sorbillans (Tachinidae, Goniinae)
Exorista xanthaspis (Tachinidae, Goniinae)
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halli, Paradrino (Tachinidae, Goniinae)
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idonea, Palexorista (Tachinidae, Goniinae)
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illoa, Carcelia (Tachinidae, Goniinae)
johnstoni, Elasmus (Elasmidae)
kirkpatricki, Bracon (Braconidae)
laevigatus, Orius (Anthocoridae)
laphygmae, Euplectrus (Eulophidae)
laphygarum, Meteorus (Braconidae)
laxa, Palexorista (Tachinidae, Goniinae)
Linnaemya agilis (Tachinidae, Tachininae)
Linnaemya albilabris (Tachinidae, Tachininae)
Linnaemya longirostris (Tachinidae, Tachininae)
longirostris, Linnaemya (Tachinidae, Tachininae)
lutea, Disophrys (Braconidae)
lutea, Trichogrammatoidea (Trichogrammatidae)
Macrorhaphis acuta (Pentatomidae)
maculitarsis, Apanteles (Braconidae)
Mallada boninensis (Chrysopidae)
maxillosus, Eumenes (Eumenidae)
mediopunctatus, Pediobius (Eulophidae)
megacephala, Pheidole (Formicidae)
Meteorus clytes (Braconidae)
Meteorus laphygmarum (Braconidae)
Metopius discolor (Ichneumonidae)
Micropilis sufviventris (Braconidae)
mitis, Peribaea (Tachinidae, Goniinae)
Myrmicaria sp. (Formicidae)
Nemoraea capensis (Tachinidae, Tachininae)
Nemoraea rubellana (Tachinidae, Tachininae)
Netelia capensis (Ichneumonidae)
Netelia opacula (Ichneumonidae)
Netelia testacea (Ichneumonidae)
nigricollis, Cardiochiles (Braconidae)
nigricornis, Disophrys (Braconidae)
nigromaculatus, Cardiochiles (Braconidae)
nigronitens, Pales (Tachinidae, Goniinae)
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obliqua, Paratachina (Tachinidae, Tachininae)
obsolatus, Graphipterus (Carabidae)
opacula, Netelia (Ichneumonidae)
orbata, Peribaea (Tachinidae, Goniinae)
Orius albidipennis (Anthocoridae)
Orius insidiosus (Anthocoridae)
Orius laevigatus (Anthocoridae)
Pales blepharipus (Tachinidae, Goniinae)
Paederus alfieri (Staphilinidae)
Pales coerulea (Tachinidae, Goniinae)
Pales nigronitens (Tachinidae, Goniinae)
Pales seminitida (Tachinidae, Goniinae)
Palexorista idonea (Tachinidae, Goniinae)
Palexorista imberbis (Tachinidae, Goniinae)
Palexorista laxa (Tachinidae, Goniinae)
Palexorista quadrizonula (Tachinidae, Goniinae)
paolii, Dohrniphora (Phoridae)
pariporus, Coranus (Reduviidae)
Paradrino halli (Tachinidae, Goniinae)
Paratachina obliqua (Tachinidae, Tachininae)
Fediobius furvus (Eulophidae)
Fediobius mediopunctatus (Eulophidae)
Peribaea mitis (Tachinidae, Goniinae)
Peribaea orbata (Tachinidae, Goniinae)
Pheidole megacephala (Formicidae)
Pheropsophus sp. (Carabidae)
pictus, Cosmolestes (Reduviidae)
pilosulus, Chelonus (Braconidae)
Plagiomima rufolateralis (Tachinidae, Goniinae)
Platyctelenomus busseolae (Scelionidae)
Polistes sp. (Vespidae)
pretiosum, Trichogramma (Trichogrammatidae)
Pristomerus sp. (Ichneumonidae)
Promachus sp. (Asilidae)
Pseudogonia rufifrons (Tachinidae, Goniinae)
pudica, Chrysopa (Chrysopidae)
quadrimornula, Palexorista (Tachinidae, Goniinae)

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Rhinocoris segmentarius (Reduviidae)
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ruficrus, Apanteles (Braconidae)
rufifrons, Pseudogonia (Tachinidae, Goniinae)
rufolateralis, Plagiomima (Tachinidae, Goniinae)
ruralis, Voria (Tachinidae, Goniinae)
Sarcophaga hirtipes (Sarcophagidae)
Scymnus sp. (Coccinellidae)
Scolothrips sexmaculatus (Thysanoptera)
segmentarius, Rhinocoris (Reduviidae)
seminitida, Pales (Tachinidae, Goniinae)
semaiae, Apanteles (Braconidae)
sexmaculatus, Scolothrips (Thysanoptera)
signata, Amobia (Sarcophagidae)
sorbillans, Exorista (Tachinidae, Goniinae)
soudanensis, Hyperchalcidia (Chalcididae)
Sturmia convergens (Tachinidae, Goniinae)
sufiventris, Microplitis (Braconidae)
Telenomus ullyetti (Scelionidae)
testacea, Netelia (Ichneumonidae)
Thelairosoma angustifrons (Tachinidae, Goniinae)
Trichogramma pretiosum (Trichogrammatidae)
Trichogrammatoides lutea (Trichogrammatidae)
trimaculatus, Cardiochiles (Braconidae)
undecimpunctata, Coccinelia (Coccinellidae)
ullyetti, Telenomus (Scelionidae)
variegatus, Cardiochiles (Braconidae)
versatilis, Chelonus (Braconidae)
Voria capensis (Tachinidae, Goniinae)
Voria ruralis (Tachinidae, Goniinae)
Winthemia dasyops (Tachinidae, Goniinae)
xanthaspis, Exorista (Tachinidae, Goniinae)
xanthostoma, Campoplex (Ichneumonidae)
Zygobothria ciliata (Tachinidae, Goniinae)
ANNEX 2

ALTERNATIVE NOCTUID HOSTS OF *H. ARMIGERA* PARASITOIDS

Achaea catella Guenee
Agrotis segetum Schiffermuller
Agrotis ipsilon Rottenburg
Anomis auragooides Guenee
Anomis leona Schaus
Apopestes limbata Staudinger
Busseola fusca Hampson
Celama squalida Staudinger
Cucullia terrensis Felder
Diparopsis castanea Hampson
Diparopsis watersi Rothschild
Earias biplaga Walker
Earias insulana Boisduval
Eublemma gayneri Rothschild
Euxoa spinifera Hubner
Leucania leucostiga Hampson
Leucania loreyi Duponchel
Lycophotia oliveata Hampson
Plusia chalcites Esper
Plusia circumflexa Linnaeus
Plusia gamma Linnaeus
Plusia limbirena Guenee
Plusia orichalcea Fabricius
Serrodes partita Fabricius
Sesamia cretica Lederer
Spodoptera exempta Walker
Spodoptera exigua Hubner
Spodoptera littoralis Boisduval
Tarache nitidula Fabricius
Xanthodes graellsii Feisthamel
Xanthodes intersepta Guenee
Xylina exoleta Linnaeus
**ANNEX 3**

**RECORDED HOST PLANTS REFERRED TO IN THE CATALOGUE**

List of Latin names are arranged alphabetically.

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Family</th>
<th>Common name</th>
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<td>Abutilon sp.</td>
<td>Malvaceae</td>
<td>Abutilon</td>
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<td>Acanthospermum hispidum</td>
<td>Compositae</td>
<td>Acanthospermum</td>
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<tr>
<td>Antirrhinum majus</td>
<td>Scrophulariaceae</td>
<td>Antirrhinum</td>
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<td>Arachis hypogaea</td>
<td>Leguminosae</td>
<td>Groundnut</td>
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<td>Cajanus cajan</td>
<td>Leguminosae</td>
<td>Pigeon pea</td>
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<td>Dianthus caryophyllus</td>
<td>Caryophyllaceae</td>
<td>Carnation</td>
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<td>Citrus spp.</td>
<td>Rutaceae</td>
<td>Citrus</td>
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<td>Cleome spp.</td>
<td>Capparidaceae</td>
<td>Cleome, spider flower</td>
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<td>Gramineae</td>
<td>Finger millet</td>
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<tr>
<td>Gossypium herbaceae</td>
<td>Malvaceae</td>
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<tr>
<td>Helianthus annuus</td>
<td>Compositae</td>
<td>Sunflower</td>
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<td>Solanaceae</td>
<td>Tomato</td>
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<td>Leguminosae</td>
<td>Lucerne</td>
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<td>Solanaceae</td>
<td>Tobacco</td>
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<td>Gramineae</td>
<td>Bulrush millet</td>
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<td>Leguminosae</td>
<td>Bean</td>
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<td>Pisum sativum</td>
<td>Leguminosae</td>
<td>Pea</td>
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<td>Sorghum bicolor</td>
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<td>Sorghum</td>
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<td>Striga spp.</td>
<td>Scrophulariaceae</td>
<td>Striga</td>
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<td>Trifolium spp.</td>
<td>Leguminosae</td>
<td>Clover</td>
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<tr>
<td>Zea mays</td>
<td>Gramineae</td>
<td>Maize</td>
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## ANNEX 4

### Checklist of H. armigera Parasitoids Recorded from East Africa (Kenya, Tanzania, Uganda)

<table>
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<th>Parasitoid species</th>
<th>Country</th>
<th>Crop</th>
<th>Occurrence</th>
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<tr>
<td>Aleiodes sp.</td>
<td>U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Apanteles diparopsidis</td>
<td>T</td>
<td>Various</td>
<td>Up to 26%</td>
</tr>
<tr>
<td>Apanteles sp. vitripennis-group</td>
<td>T</td>
<td>Various</td>
<td>Common</td>
</tr>
<tr>
<td>Apanteles sp. ultor-group</td>
<td>U</td>
<td>Various</td>
<td>Up to 20%</td>
</tr>
<tr>
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<td>U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Apanteles sp.</td>
<td>K</td>
<td>Pigeon pea</td>
<td>-</td>
</tr>
<tr>
<td>Ascogaster ?cava</td>
<td>U</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>Brachymeria ?cowani</td>
<td>T</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>Brachymeria sp.</td>
<td>U</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bracan sp.</td>
<td>T</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Braunsia sp.</td>
<td>T</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Carcelia illota</td>
<td>T</td>
<td>Cotton</td>
<td>Low numbers</td>
</tr>
<tr>
<td>Cardiochiles nigromaculatus</td>
<td>T,U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Cardiochiles trimaculatus</td>
<td>U</td>
<td>Mainly cotton</td>
<td>8%</td>
</tr>
<tr>
<td>Cardiochiles spp.</td>
<td>T,U</td>
<td>Various</td>
<td>Up to 18%</td>
</tr>
<tr>
<td>Ceraphron sp.</td>
<td>U</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>?Ceraphron sp.</td>
<td>T</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Charops sp.</td>
<td>T</td>
<td>Various</td>
<td>Up to 23%</td>
</tr>
<tr>
<td>Charops sp.</td>
<td>U</td>
<td>Various</td>
<td>10%</td>
</tr>
<tr>
<td>Chelonus bifoveolatus</td>
<td>T</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Chelonus curvimaculatus</td>
<td>T,U</td>
<td>Various</td>
<td>Up to 11%</td>
</tr>
<tr>
<td>Chelonus versatilis</td>
<td>T</td>
<td>Various</td>
<td>-</td>
</tr>
<tr>
<td>Dejeania bombylana</td>
<td>T</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>?Drino sp.</td>
<td>U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Enicospilus ?communis</td>
<td>U</td>
<td>Mainly cotton</td>
<td>11%</td>
</tr>
<tr>
<td>Enicospilus sp.</td>
<td>T</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>?Euplectrus laphygmae</td>
<td>T</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>?Euplectrus sp.</td>
<td>U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Eurytoma sp.</td>
<td>U</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Goniophthalmus halli</td>
<td>K,T</td>
<td>Cotton</td>
<td>Up to 12%</td>
</tr>
<tr>
<td>Linnaemya agilis</td>
<td>T,U</td>
<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Linnaemya longirostris</td>
<td>K,T,U</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>Meteorus clytes</td>
<td>T</td>
<td>Groundnut</td>
<td>-</td>
</tr>
<tr>
<td>Meteorus laphygmarum</td>
<td>T,U</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>Meteorus sp.</td>
<td>U</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>Metopius discolor</td>
<td>T</td>
<td>Cotton</td>
<td>Rare</td>
</tr>
<tr>
<td>Nemoraea rubellana</td>
<td>K</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Netelia ?capensis</td>
<td>U</td>
<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>Netelia opacula</td>
<td>K</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Netelia spp.</td>
<td>K,T,U</td>
<td>Various</td>
<td>Rare</td>
</tr>
<tr>
<td>Palexorista laxa</td>
<td>T,U</td>
<td>Various</td>
<td>Up to 42%</td>
</tr>
<tr>
<td>Paradrino halli</td>
<td>T</td>
<td>Various</td>
<td>Common</td>
</tr>
<tr>
<td>Pristomerus spp.</td>
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<td>-</td>
<td>Rare</td>
</tr>
<tr>
<td>Sarcophaga hirtipes</td>
<td>T</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sarcophaga sp.</td>
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<td>Cotton</td>
<td>-</td>
</tr>
<tr>
<td>Sturmia convergens</td>
<td>T</td>
<td>Striga</td>
<td>-</td>
</tr>
<tr>
<td>Telenomus ullyetti</td>
<td>T</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>?Trichogramma sp.</td>
<td>T</td>
<td>Cotton</td>
<td>Up to 5%</td>
</tr>
<tr>
<td>?Trichogramma sp.</td>
<td>U</td>
<td>-</td>
<td>-</td>
</tr>
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</table>