

Assessment of key factors responsible for the pest status of the bean flower thrips *Megalurothrips sjostedti* (Thysanoptera: Thripidae) in West Africa

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Abstract

Megalurothrips sjostedti (Trybom) is an important pest of cowpea (*Vigna unguiculata*) in West Africa. Three key factors assumed to be responsible for its pest status are analysed, the survival on alternative host-plants during the dry season, the inefficient biotic mortality factors regulating population growth, and the effect of larval feeding on the development of cowpea flower buds. Extensive surveys indicate clearly that *M. sjostedti* survives the dry season on a wide range of alternative hosts all belonging to the Leguminosae, where it can feed and reproduce. Different antagonists were observed attacking eggs and larvae of *M. sjostedti*; their impact, however, is low and cannot prevent pest outbreaks. Two undescribed *Megaphragma* spp., and one *Oligosita* sp., all trichogrammatid egg parasitoids, were recorded for the first time. The anthocorid *Orius* sp. was the most important larval predator. No hymenopterous parasitoids could be reared from larvae collected on cowpea and three major alternative hosts, whereas a low percentage of the larvae collected from the flowers of *Tephrosia candida*, an exotic shrub native to India, were parasitized by the eulophid *Ceranisus menes* (Walker), also recorded for the first time in Africa. The feeding activity of six larvae of *Megalurothrips sjostedti* during five days induced the shedding of all flower buds of a cowpea inflorescence. The results of the analysis shed new light on the *M. sjostedti* pest problem, and the ways to solve it. The lack of efficient antagonists, particularly larval parasitoids known from closely related south-east Asian *Megalurothrips* spp., and the high damage threshold, indicate that *M. sjostedti* is a potential target for biological control. However, further studies are needed to investigate the migration of *M. sjostedti* adults to and from alternative host-plants, in order to reinforce the action of biocontrol with cultural practices.

Introduction

The bean flower thrips, *Megalurothrips sjostedti* (Trybom) (Thysanoptera Thripidae), is considered the first major pest attacking the reproductive structures of cowpea (*Vigna unguiculata*) during plant development (Okwakpam, 1967; Taylor, 1969; Nyiira, 1971, 1973). Early feeding damage on developing flower buds can cause their shedding, leading to complete crop failure in

the case of high thrips population levels (Singh & Taylor, 1978; Wien & Rösingh, 1980; Singh *et al.*, 1990).

Recorded on the African continent for the first time in 1905 (Trybom, 1908), *M. sjostedti* was first identified as a pest in East Africa (Faure, 1960). Although Taylor (1965) suggested that *M. sjostedti* was the possible cause of 'distortion, malformation, and discoloration of floral parts' of cowpea, the reports of its damage in West Africa, the most important cowpea growing region world-wide, seemed to be controversial for almost a decade. Okwakpam (1967) indicated that heavy flower shedding could be caused by thrips, but the results of

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Booker (1965) and Van Halteren (1971) did not support this hypothesis. Although more recent studies (Agyen-Sampong, 1978; Singh & Taylor, 1978; Ezueh, 1981; Singh *et al.*, 1990) emphasized the importance of *M. sjostedti* as a major pest, no attempt has been made yet to investigate the cause of this seemingly increasing significance.

Several factors are likely to have a strong influence on the pest status of *M. sjostedti*. Three among them are considered important enough to warrant this investigation. First, the colonization rates of the cowpea fields depend on the occurrence of alternative host-plants which sustain the population of *M. sjostedti* during the off-season. Second, the densities of *M. sjostedti* interacting with fruiting structures are controlled by biological factors whose identity is not yet known. Third, the amount of damage is determined by the infestation patterns of the crop at the time of flower bud development.

The actual knowledge on these factors is summarized as follows.

During the dry season in southern Nigeria (November to March), Taylor (1974) observed both immature stages and adults on the Fabaceae *Cajanus cajan* and *Centrosema pubescens*, showing that *M. sjostedti* could survive the dry season in the absence of cowpeas, reproducing on these host-plants. Unfortunately, no information is available either for other ecological zones (e.g. the dry savannah zone, where the dry season is more important), or for other possible host-plants.

Many predators and parasitoids species are known to attack thrips (Ananthakrishnan, 1973; Lewis, 1973). However, the only antagonists of *M. sjostedti* reported in literature are the two anthocorid bugs, *Orius amnesius* Ghauri, and *Orius albidipennis* (Reuter) (Ghauri, 1980), and an unidentified entomopathogenic fungus, probably belonging to the genus *Entomophthora* (Salifu, 1986). In view of the high number of thrips antagonists found elsewhere, this spectrum is small and clearly needs further investigation. The two *Orius* species can be identified by a careful study of the male genitalia (Ghauri, 1980), which is very time consuming and not applicable for field studies. For this reason, the two species are not separated and are referred to as *Orius* sp. in this paper.

Salifu (1986) associated different densities of *M. sjostedti* with yield loss per raceme. However, since adults were used for the infestation, oviposition and subsequent larval feeding on the flower buds could not be excluded, rendering impossible the numerical evaluation of the density dependency of the damage.

The purpose of this paper is to improve the knowledge on the importance of the above factors on the pest status of *M. sjostedti*. Therefore, the study focuses on plant inhabiting life stages, i.e., eggs, larvae and adults (see Lewis, 1973).

Materials and methods

Qualitative investigation on the host range

The presence of *M. sjostedti* on various potential host-plants was monitored by direct observation and the use of emergence cages in which the hatching larvae were caught. Due to the high variability of the host-plants in terms of size and flowering phenology, no attempt was

made to quantify population densities. Nevertheless, based on their relative abundance in a given area, their flowering period, and the level of the thrips population at peak flowering, infested plants could be assigned to classes of low, medium, and high importance as host-plants. Voucher specimens of leaves and flowers of the alternative host-plants were collected and identified with the key provided by Hutchison & Dalziel (1958).

The investigation started in August 1988 and was carried out over a period of two years in Benin. During the first year, emphasis was given to two regions in the Department of Mono (Tchi-Ahomadégbé and Zouzouvou), and to the Biological Control Center for Africa of the International Institute of Tropical Agriculture, (referred to hereafter as 'the Center'), in Abomey-Calavi, where, in addition to the wild growing host-plants, fields of *C. cajan* and demonstration plots of various tropical Leguminosae were examined. In the second year, three regions of the Zou Department (Sehoué, Djoho and Savalou) were added to the survey sites of the first year. The host-plants were sampled weekly during the cowpea growing season, and every two weeks during the dry season.

To investigate how far north *M. sjostedti* could survive the long dry season (from December to April), a country-wide survey was undertaken on 19 February 1990, covering 1780 km in one week.

Biotic mortality factors affecting the field population

Assessment of predation

Eggs. A direct quantitative assessment of the egg mortality was precluded by the fact that the eggs of *M. sjostedti* are laid into the plant tissue of leaf petioles, peduncles, and calyces, and only a small percentage of them can be observed visually (Lewis, 1973; Rösingh, 1980). Between 10-20 cowpea inflorescences were collected weekly and carefully inspected under a binocular microscope in the laboratory to detect the presence of possible predators. The samples were taken in two unsprayed fields planted on 13 September 1988, and on 12 May 1989, at the Center in Abomey-Calavi. The sowing was done manually with three cowpea seeds per hole at a spacing of 0.25×0.75 m. The seedlings were thinned to one plant per hole two weeks after germination. The variety under study was 'Kpodjiguégué', a local cultivar which is slightly photosensitive, has an indeterminate and semi-erect growth habit, and is harvested after 70-75 days. (see Tamò & Baumgärtner, 1993).

Larvae. In the same fields, predators suspected of attacking *M. sjostedti* larvae were monitored by careful in-field inspections of inflorescences. They were subsequently brought to the laboratory where their ability to feed on thrips larvae was tested by isolating both organisms in the same PVC box ($2.2 \times 2.2 \times 1.8$ cm). Moreover, the weekly catches of the D-Vac sampler (Southwood, 1978) used to monitor the dynamics of *M. sjostedti* (Tamò, 1991) were inspected for possible predators, in particular *Orius* sp. No attempt was made to identify predators of pupal or adult stages.

Table 1. Assessment of the parasitization rate of *Megalurothrips sjostedti* eggs by the trichogrammatid *Megaphragma* spp. for different localities, on different host plants and during different periods.

Locality	Plant	Period	Number of plant organs	Number of viable eggs	Number (%) of eggs parasitized
Zouzouvou	cowpea	14/7 – 14/9/89	2190	1411	493 (25.89)
Tchi-Ahomadegbe	cowpea	14/7 – 14/9/89	2475	1329	584 (30.53)
Djoho/Tannouwo	cowpea	14/11 – 12/12/89	1418	1246	513 (29.16)
Djoho/Tannouwo	<i>Cajanus cajan</i>	14/11 – 19/12/89	160	54	13 (19.40)
Djoho/Tannouwo	<i>Centrosema pubescens</i>	14/11 – 19/12/89	185	37	33 (47.14)
Sehoué/Agon	<i>Pueraria phaseoloides</i>	12/12/89 – 14/02/90	227	492	562 (53.32)
Center	cowpea	11/10 – 2/12/88	2329	4694	32 (0.68)
Center	cowpea	6/6 – 3/8/89	1230	869	4 (0.46)
Center	cowpea	10/10 – 21/12/89	5467	3565	61 (1.68)

Assessment of parasitism

Eggs. Since no direct visual observations of parasitoids could be undertaken, plant parts likely to contain eggs of *M. sjostedti* were collected weekly both from cowpea fields and from alternative host-plants at different locations (table 1) and put into emergence cages described as follows. A bottomless PVC cylinder (11 cm length, 6.5 cm diameter) with a tightly closing cover was placed upside-down, and a PVC funnel (8 cm length, 6.5 cm diameter) was glued onto it. The parasitoids were attracted by the light shining through the transparent collecting tube (3.2 cm length, 1.2 cm diameter) placed on top of the funnel, while the newly hatched thrips larvae were induced to crawl into it by their negative geotactic behaviour (Lewis, 1973). The collecting tubes were checked one week after installation, and the parasitoids and *M. sjostedti* larvae were counted under a binocular microscope.

To confirm that the trichogrammatids collected were unequivocally egg parasitoids attacking *M. sjostedti*, an additional experiment was carried out in the greenhouse on cowpea plants (local variety 'Kpodjiguégué') growing on 'cowpea trees', a modification of the 'cassava tree' (Haug & Megevand, in press).

The 'tree' consists of a PVC bag (150 cm length, 12 cm diameter) filled with rock wool and fixed on a tubular support mounted on a circular platform. A nutrient solution (Luwasa®) was supplied automatically and allowed to percolate through the bag. Ten days old cowpea seedlings were planted in small holes cut into the bag, at densities varying from 16 to 32 plants per 'tree'.

Eight infestation cages, big enough to allow the development of the reproductive structures (fig. 1), were tied upon single inflorescences and infested with 10 *M. sjostedti* females captured in the field. After five days, the females were removed, and 10 suspected egg parasitoids were released in the same infestation cages; 10 days later, the cages were removed, and the inflorescences cut from the plant and put into emergence cages. The emergence of parasitoids was monitored every two weeks.

Larvae. Twice a week, first and second instar larvae were collected from two cowpea fields (variety 'Kpodjiguégué') planted at the Center on 7 May 1990, and on 13 September 1990, respectively, and from three major alternative host-plants flowering during the 1990-91 dry season in the Southern Zou Department, *C. cajan*, *C. pubescens*, and *Pueraria phaseoloides*. In addition, following the discovery of a

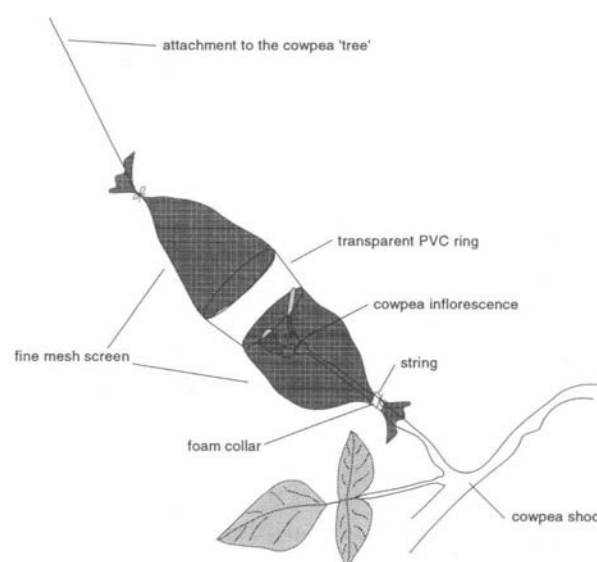


Fig. 1. Infestation cage used for the parasitization test of *Megaphragma* spp.

high population of *M. sjostedti* breeding on *Tephrosia candida*, a shrub native to India (Hutchison & Dalziel, 1958), larvae were collected during the main flowering period (August-October) in 1990 and 1991. Larvae were brought to the laboratory and reared at 25°C in small transparent PVC rearing boxes (2.2×2.2×1.8 cm). Daily, peduncles of cowpea grown in the greenhouse were cut into pieces of 1 cm length, and offered as food. The rearing boxes with the larvae were inspected twice a week for the presence of parasitoids and of entomopathogenic fungi.

Experimental evaluation of bud shedding induced by larval feeding

The experiment was carried out in the greenhouse on cowpea plants (local variety 'Kpodjiguégué') growing on 'cowpea trees' described above.

Flexible PVC pipe (1.5 cm length, 0.8 cm diameter) was cut lengthwise and used to encase the individual stems of the test inflorescences, and sealed with Parafilm®. The upper part of the pipe was left open, and the so formed collar filled with water, in order to

isolate the larvae on the single inflorescences. All the plant parts above the inflorescence were subsequently removed. A drop of vegetable oil was added to the water surface to prevent evaporation.

When the two first visible flower buds started to swell (Ojehomon, 1968), the inflorescences were infested with 0, 1, 2, 6, and 10 first instar larvae of *M. sjostedti*. To obtain the larvae, six to eight females were put into transparent polyacryl tubes (6 cm length, 2.2 cm diameter) which had one end sealed with fine mesh cloth (100 µm), and the other end closed by a tight fitting cap. Pollen of cowpea flowers was offered as food. The oviposition substrate consisted of the upper 5 cm of a fresh cowpea peduncle. The eggs were incubated at 30°C.

The experiment was replicated 10 times. After five days, the number of both viable and damaged, or shed flower buds, as well as the number of living thrips larvae observed on the inflorescence, was counted.

This study was designed merely for the quantification of the pest density-damage relationship on the base of one inflorescence, and it does not represent field conditions.

Results and discussion

Qualitative investigation on the host range

Table 2 lists all the plants where both *M. sjostedti* adults were observed in the flowers, and first instar larvae were recovered in the emergence cages at the

Table 2. Alternative host plants of *Megalurothrips sjostedti* in Benin [m=Mimosaceae, c=Caesalpinaceae, f=Fabaceae; - = not present; • = low, •• = medium, ••• = high importance]

Plant	Family	Abundance in		Flowering during		Thrips level
		southern Benin	northern Benin	rainy season	dry season	
<i>Albizia chevalieri</i>	m	•	••	-	•••	•
<i>Albizia lebbek</i>	m	•	••	-	•••	•
<i>Albizia zygia</i>	m	•	••	-	•••	•
<i>Berlinia grandiflora</i>	c	••	•	•	••	•••
<i>Caesalpinia pulcherrima</i>	c	••	•	•	••	•
<i>Cajanus cajan</i>	f	••	••	•	•••	•••
<i>Calliandra portoricensis</i>	m	•	••	•	••	•
<i>Calopogonium mucunoides</i>	f	••	•	••	•	••
<i>Cassia hirsuta</i>	c	••	•	•	••	•
<i>Cassia mimosoides</i>	c	••	•	•	••	•
<i>Cassia sieberiana</i>	c	•	••	•	••	•
<i>Cassia sophora</i>	c	•	••	•	••	•
<i>Cassia tora</i>	c	••	•	•	••	••
<i>Centrosema pubescens</i>	f	•••	-	•	•••	••
<i>Clitoria ternatea</i>	f	••	•	•	••	••
<i>Crotalaria goreensis</i>	f	••	•	•	••	•
<i>Crotalaria macrocalix</i>	f	••	•	••	•	•••
<i>Crotalaria mucronata</i>	f	••	•	••	•	•••
<i>Delonix regia</i>	c	••	•	•	••	•
<i>Desmodium salicifolium</i>	f	••	•	••	•	•
<i>Desmodium tortuosus</i>	f	••	•	••	•	•
<i>Desmodium velutinum</i>	f	••	•	••	•	•
<i>Dichrostachys cinerea</i>	m	•	••	•	••	•
<i>Dolichos lablab</i>	f	••	•	•	••	•
<i>Eriosema glomeratum</i>	f	••	•	•••	-	••
<i>Eriosema psoraleoides</i>	f	••	•	•••	-	••
<i>Indigofera dendroides</i>	f	••	•	••	•	••
<i>Indigofera hirsuta</i>	f	••	•	••	•	••
<i>Indigofera spicata</i>	f	••	•	••	•	•
<i>Indigofera tinctoria</i>	f	••	•	••	•	•
<i>Lens esculenta</i>	f	••	•	••	•	••
<i>Lonchocarpus cyanescens</i>	f	••	•	•	••	•••
<i>Lonchocarpus sericeus</i>	f	••	•	•	••	••
<i>Millettia thonningii</i>	f	•	••	•	••	•••
<i>Psophocarpus palustris</i>	f	••	-	••	•	•••
<i>Psophocarpus tetragonolobus</i>	f	••	-	••	•	•••
<i>Pterocarpus erinacaeus</i>	f	•	••	•	•••	••
<i>Pterocarpus santalinoides</i>	f	•	•••	•	•••	•••
<i>Pueraria phaseoloides</i>	f	•••	-	•	•••	•••
<i>Sesbania rostrata</i>	f	••	•	••	•	••
<i>Tephrosia bracteolata</i>	f	••	•	•	••	••
<i>Tephrosia candida</i>	f	•••	-	•	••	•••
<i>Tephrosia elegans</i>	f	••	•	•	••	••
<i>Tephrosia linearis</i>	f	••	•	•	••	•••
<i>Tephrosia purpurea</i>	f	••	•	•	••	••
<i>Vigna campestris</i>	f	••	•	•	••	••

same time. With the limited resources available, it was not possible to strive after an exhaustive list. However, the observations allowed us to identify major alternative host-plants during the dry season, which permit the survival of the pest. Two major agro-ecological zones were defined for this purpose, characterized by either bimodal rainfall (the 'south') or monomodal rainfall (the 'north'). In the south, the major host-plants during the dry season were mostly annual or biannual plants such as *P. phaseoloides*, *C. cajan*, *C. pubescens*, and the *Tephrosia* complex. In the north, *M. sjostedti* was found exclusively on savannah trees growing in humid areas, such as *Pterocarpus erinacaeus* and *Millettia thonningii*, and further north mostly on trees growing along water flows, such as the omnipresent *Pterocarpus santalinoides*, where very high breeding populations of *M. sjostedti* were observed. In both zones, however, enough alternative host-plant species occurred in such densities as to sustain a high *M. sjostedti* population in the off-season.

Biotic mortality factors affecting the field population

Predators

Eggs. A phytoseiid mite, identified as *Iphiseius* sp. (Mr D. Gnanvossou, IITA-BCCA, Cotonou, pers. comm.), was observed attacking the few eggs which were not completely embedded in plant tissue. The same behaviour was recorded for young nymphs of *Orius* sp. Considering the small number of eggs that can be attacked by these two predators, their importance as biological control agents ranks very low.

Larvae. Among the arthropods observed on cowpea inflorescences, very few were found to attack *M. sjostedti*. Anthocorid bugs, *Orius* sp., were the most encountered predators (88% of the observed organisms), followed by the staphylinid beetle *Paederus sabaeus* Erichson (9%), while larvae of various coccinellids, mostly *Cheilomenes sulphurea* (Olivier), accounted for 3% only.

The temporal dynamics of *Orius* sp. is shown in fig. 2 for the fields located at the Center. To facilitate comparison with the abundance of *M. sjostedti*, the average found in the different fields was used, and presented on a log₁₀ scale. The visual comparison of the thrips infestation patterns and *Orius* sp. presence suggests that there is no density dependence between the two population trends. While the peak population level for *M. sjostedti* in the second season (fig. 2B,D) was higher than in the first season (fig. 2A,C) by roughly tenfold, the *Orius* sp. population trend remained about the same in both seasons. The reasons why *Orius* sp. does not respond to the high thrips densities of the second growing season are not completely understood. On heavily infested second season fields, it has been observed to be prevalent on border plants. This behaviour suggests either that *M. sjostedti* is not the preferred prey of *Orius* sp., or that the cowpea plant is not its preferred oviposition and dispersal site. The first hypothesis is strengthened by the fact that *Orius* sp. has been observed feeding on the common blossom thrips, *Frankliniella shultzei* (Trybom), which is present on cowpea plants only if the *M. sjostedti* population is low, but disappears from the field with increasing *M. sjostedti* population pressure, presumably due to competition. However, more detailed studies, e.g. electrophoretic gut contents

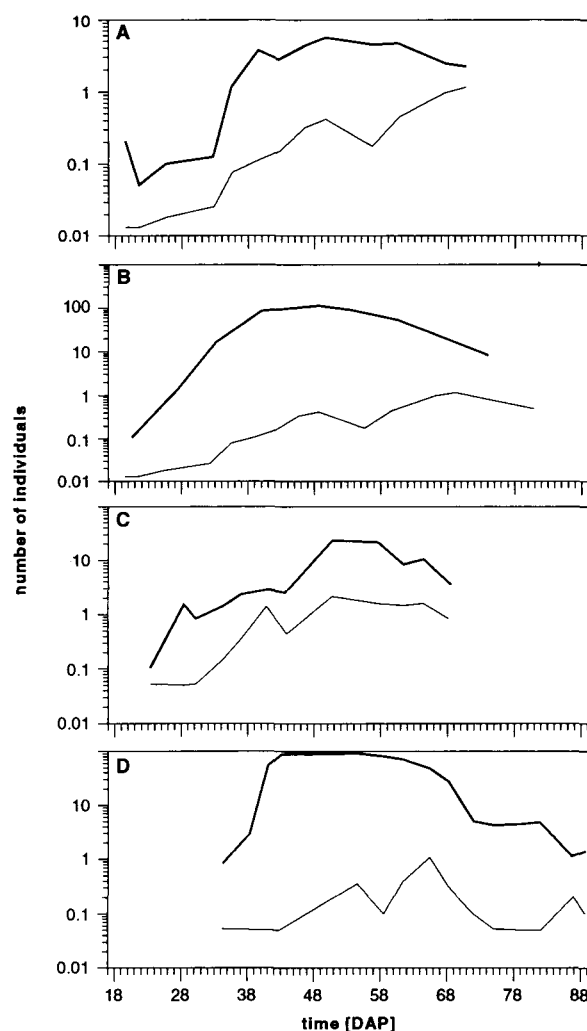


Fig. 2. Abundance pattern of adult individuals of *Orius* sp. (—) and of *Megalurothrips sjostedti* (---) at the Center in Abomey-Calavi, for fields planted during the 1st (A) and the 2nd (B) cropping season in 1989, and during the 1st (C) and the 2nd (D) cropping season in 1990. The data points are obtained as the average of four fields. (DAP: days after planting).

analysis and olfactometric studies, are needed to evaluate prey preferences of *Orius* sp.

In the literature, the only quantitative assessment of the presence of *Orius* sp. is given for Nigeria by Rosingh (1980). *Orius* sp. was found in cowpea flowers feeding on both larvae and adults of *M. sjostedti*, but in a very low number (0.05 - 0.08 *Orius* sp. versus 33 - 45 *M. sjostedti* per flower). However, differences in the sampling methodology did not allow a comparison of the results.

The abundance pattern of *Orius tristicolor* (White), a predator of *Frankliniella occidentalis* (Pergande), has been studied in California by Letourneau & Altieri (1983). This study showed significant higher colonization rates of *O. tristicolor* in polycultures than in monocultures, presumably due to the greater attractiveness of the mixed-cropping habitat. This aspect has not been investigated yet for the cowpea - *M. sjostedti* - *Orius* sp. system in West Africa, but preliminary observations in traditional

cowpea-cereals fields indicated that, as in cowpea monocultures, *Orius* sp. was present on border plants only.

Parasitoids

Eggs. Hymenopterous parasitoids belonging to the trichogrammatid genera *Megaphragma* and *Oligosita* were recovered for the first time from eggs of *M. sjostedti*. *Megaphragma* spp., of which two different undescribed species have been identified (Dr A. Polaszek, International Institute of Entomology, London, pers. comm.), were more abundant, accounting for more than 98% of the specimens caught in the emergence cages.

The experiment with the infestation cages confirmed that both trichogrammatids can parasitize *Megalurothrips sjostedti*, though with different success. While a total of 17 adult *Megaphragma* spp. was found in the cages inoculated with this parasitoid, only one specimen of *Oligosita* sp. could be found using the same methodology. *Oligosita* sp. is mainly an egg parasitoid of Coleoptera and Hemiptera (Clausen, 1972), and is believed to be a facultative parasitoid of thrips. In view of its rare occurrence, more emphasis was given to the study of *Megaphragma* spp.

The comparison of both first instar larvae of *M. sjostedti* and adult *Megaphragma* spp. obtained from the emergence cages (table 1) for various host-plants permits a crude estimation of the parasitism by *Megaphragma* spp. On cowpea, the parasitism level at the Center has been generally very low, while parasitism of nearly 30% was obtained both in the Mono Department and in the Southern Zou Department.

The highest rate of parasitism was recorded on the wild alternative hosts *Pueraria phaseoloides* and *Centrosema pubescens*. The case of *P. phaseoloides* is particularly interesting, because this plant has been introduced from south-east Asia to the African continent as a cover crop (Hutchison & Dalziel, 1958). As opposed to the oviposition sites on cowpea plants, susceptible to wilt or drop (leaf petioles and reproductive structures), the eggs of *M. sjostedti* are embedded in the stem of *P. phaseoloides*, which stays alive until the whole plant dies. This should allow a higher survival rate of the *Megaphragma* spp. larvae developing inside *Megalurothrips sjostedti* eggs, and, consequently, a higher parasitism rate.

Parasitism rates of 3-51% have been recorded for *Megaphragma mymaripenne* Timberlake attacking eggs of *Heliiothrips haemorrhoidalis* (Bouché) in California (Hessein & McMurtry, 1988). However, because of their microscopic size, very little is known about their biology, such as the mean developmental time of 41.4 days from egg to adult, and some behavioural observations on oviposition and emergence from the host (McMurtry, 1961; Hessein & McMurtry, 1988).

Larvae. From over 5000 larvae collected on cowpea and three major alternative host-plants, six were attacked by an entomopathogenic fungus, presumably *Verticillium* sp. (Dr A. Paraíso, IITA-BCCA, Cotonou, pers. comm.), whereas none were found parasitized by Hymenoptera. A different situation was encountered on *Tephrosia candida*: from the 237 larvae reared in 1990, three were parasitized, but the parasitoids died before completing their development. In 1991, 583 larvae were reared, 17 were parasitized, and nine adult parasitoids emerged.

They were identified as *Ceranisus menes* (Walker) (Eulophidae), recorded for the first time in Africa. This identification, however, is tentative, and may be revised in the future, because there are no keys to species outside of Europe, and the group is badly in need of revision (Dr J. LaSalle, International Institute of Entomology, London, pers. comm.).

On the one hand, it is known from the literature that larvae of closely related species such as *Megalurothrips usitatus* (Bagnall) occurring in south-east Asia are parasitized by different species of *Ceranisus*, such as *C. femoratus* (Gahan), *C. vincatus* (Gahan) (Gahan, 1932; Fullaway & Dobrosky, 1934), and *C. menes* (Walker) (Chang, 1990). This could be a plausible reason why these thrips are not considered important pests there (Kalshoven & Van Der Vecht, 1950; Litsinger *et al.*, 1978; Singh *et al.*, 1990). On the other hand, it is noteworthy that in West Africa the newly recorded *C. menes* attacks *M. sjostedti* on the seldom encountered exotic *T. candida*, but it has never been recorded on cowpea, native to this area. Moreover, there are indications that the parasitism rates are low, and nearly half of the parasitoids cannot develop successfully inside the larvae of *M. sjostedti*. All this suggests that the parasitoid is more likely to be associated with other thrips rather than with *M. sjostedti*, and that it is probably more attracted by *T. candida* than by native plants.

Although *M. sjostedti* was recorded on the African continent more than 80 years ago (Trybom, 1908), the above findings do not exclude its possible foreign origin. This hypothesis is further strengthened by the fact that *M. sjostedti* is morphologically very close to *M. typicus* (Bagnall), a rather seldom collected species (Palmer, 1987). Moreover, *M. sjostedti* is the only species of this genus occurring outside its major area of distribution, and at the same time the only one which is an important agricultural pest (Palmer, 1987). It seems, therefore, crucial to test the south-east Asian parasitoids, and particularly those found associated with *M. typicus*, against *M. sjostedti* on cowpea, in order to assess their potential as possible biological control candidates.

In addition, entomopathogens attacking *M. sjostedti* and their use as possible control agents need further investigation.

Experimental evaluation of bud shedding induced by larval feeding

The influence of the different larval densities on the survivorship of flower buds is presented in table 3. The relative survival rate for flower buds remains stable for density 1 and 2, but drops dramatically at a density of six larvae per inflorescence. With 10 larvae per inflorescence, no flower bud survived, and the survival rate of the larvae dropped to 0.61, indicating that the carrying capacity of the inflorescence was exceeded. Consequently, it can be assumed that six larvae feeding on a cowpea inflorescence during five days (6 thrips × 5 days = 30 thrips-days) cause the shedding of all flower buds. In practice, the number of 30 thrips-days, and consequently the capacity for damage compensation may appear high. Nevertheless, this threshold is often reached or exceeded according to observations made during this study. The

Table 3. Influence of different densities of first instar larvae of *Megalurothrips sjostedti* on the survivorship of flower buds of cowpea in the greenhouse, and their survival after 5 days.

Infestation density	Buds per inflorescence	Viable buds after 5 days	Buds survival rate	Relative buds survival rate	Viable <i>M. sjostedti</i> larvae after 5 days	Survival rate of larvae
0	5.2 (± 0.6)	3.5 (± 1.2)	0.67	1	-	-
1	5.7 (± 1.3)	3.6 (± 1.1)	0.63	0.94	0.8 (± 0.4)	0.8
2	5.4 (± 0.9)	3.2 (± 0.4)	0.59	0.88	1.7 (± 0.5)	0.85
6	5.7 (± 0.8)	0.1 (± 0.3)	0.02	0.03	5.2 (± 0.8)	0.87
10	6.2 (± 0.9)	0 (± 0)	0	0	6.1 (± 1.5)	0.61

effect of the damage on cowpea yield formation is investigated by Tamò *et al.* (in press) using computer simulation studies.

Salifu (1986) infested cages containing a single cowpea inflorescence with different densities of *M. sjostedti* adults, aiming to show differences between a resistant and a susceptible variety. During the experimental period exceeding the duration of the egg stage, the adults might have laid eggs, and consequently the hatching larvae might also have contributed to the shedding of flower buds. Since the density-dependency was not considered by the study, the results cannot be compared quantitatively.

Conclusions

The analysis presented in this paper is the first attempt to understand some of the causes of the pest status of *M. sjostedti*. The results indicate explicitly that outbreaks of this pest occur because first, the thrips can breed on a wide range of alternative hosts throughout the agro-ecological zones where cowpea is cultivated, surviving unfavourable periods in this way (e.g., dry season); second, there are no antagonists that can effectively reduce the field population; and third, individual cowpea inflorescences can compensate for thrips damage only as long as the number of thrips larvae does not exceed six during five consecutive days. In practice, however, this threshold is often exceeded.

The effort of focusing on the causes of a pest problem, rather than on the treatment of the symptoms (e.g., by the use of pesticides), has yielded information which is important for the development of comprehensive pest management strategies. First, the lack of efficient natural enemies, combined with the high damage threshold, makes *M. sjostedti* a suitable target for biological control. Secondly, *M. sjostedti* has been found on a wide range of Leguminosae host-plants across the major agro-ecological zones where cowpea is cultivated. This knowledge is a prerequisite for investigating the colonization of cowpea fields, in order to design habitat management strategies which are, for example, based on the use of mixed-cropping systems or the establishment of trap crops. The investigation of the migrational aspects of the population dynamics of *M. sjostedti*, however, requires information on both the dispersal of the adults, and the factors influencing the preference for the different host-plants, which are aspects, at present, still unknown.

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References

- Agyen-Sampong, M. (1978) Pests of cowpea and their control in Ghana. pp. 85–92 in Singh, S.R., Van Emden, H.F. & Taylor, T.A. (Eds) *Pests of grain legumes: ecology and control*. London, Academic Press.
- Ananthakrishnan, T.N. (1973) *Thrips: biology and control*. 120 pp. Delhi MacMillan.
- Booker, R.H. (1965) Pests of cowpea and their control in northern Nigeria. *Bulletin of Entomological Research* **55**, 663–672.
- Chang, N.T. (1990) *Ceranisus menes* (Walker) (Eulophidae: Hymenoptera), a new parasite of bean flower thrips, *Megalurothrips usitatus* (Bagnall) (Thripidae: Thysanoptera). *Plant Protection Bulletin* **32**, 237–238.
- Clausen, C.P. (1972) *Entomophagous insects*. 688 pp. New York, Hafner Publishing Company.
- Ezueh, M.I. (1981) Nature and significance of preflowering damage by thrips to cowpea. *Entomologia Experimentalis et Applicata* **29**, 305–312.
- Faure, J.C. (1960) Thysanoptera of Africa, 3: *Taeniothrips sjostedti* (Trybom), 1908. *Journal of the Entomological Society of South Africa* **23**, 34–44.
- Fullaway, D.T. & Dobrosky, I.D. (1934) A new *Thripoctenus* parasite from the Philippines. *Proceedings of the 5th Pacific Scientific Congress Canada 1933* **5**, 3439–3444.
- Gahan, A.B. (1932) Miscellaneous descriptions and notes on parasitic Hymenoptera. *Annals of the Entomological Society of America* **25**, 736–757.
- Ghauri, M.S.K. (1980) Notes on Anthocoridae (Heteroptera) with description of two new species of economic importance from Africa. *Bulletin of Entomological Research* **70**, 287–291.
- Haug, T. & Megevand, B. (in press) A new rearing unit for the mass-production of cassava mealybugs, green mites, and

- their natural enemies. *Proceedings of the 2nd International Conference of Tropical Entomology, ICIPE, Nairobi, Kenya, July 31- August 4, 1989*.
- Hessein, N.A. & McMurtry, J.A.** (1988) Observations on *Mega-phragma mymaripenne* (Hymenoptera: Trichogrammatidae), an egg parasite of *Heliothrips haemorrhoidalis* Bouché (Thysanoptera: Thripidae). *Pan Pacific Entomologist* **64**, 250–254.
- Hutchison, L.D. & Dalziel, M.D.** (1958) *Flora of west tropical Africa*. Vol. I, Part II. pp. 292–828. London and Tonbridge, The Whitefriars Press Ltd.
- Kalshoven, L.G.E. & Van Der Vecht, J.** (1950) *De plagen van de culturgewassen in Indonesië*. 512 pp. Van Hoeve, La Haye.
- Letourneau, D.K. & Altieri, M.A.** (1983) Abundance patterns of a predator, *Orius tristicolor* (Hemiptera: Anthororidae) and its prey *Frankliniella occidentalis* (Thysanoptera: Thripidae): habitat, attraction in polyculture versus monoculture. *Environmental Entomology* **12**, 1464–1469.
- Lewis, T.** (1973) *Thrips: their biology, ecology, and economic importance*. 349 pp. London, Academic Press.
- Litsinger, J.A., Quirino, C.B., Lumaban, M.D. & Bandong, J.P.** (1978) Grain legume pest complex in rice-based cropping systems at three locations in the Philippines. pp. 309–320 in **Singh, S.R., Van Emden, H.F. & Taylor, T.A.** (Eds) *Pests of grain legumes: ecology and control*. London, Academic Press.
- McMurtry, J.A.** (1961) Current research on biological control of avocado insect and mite pests. *Yearbooks of the California Avocado Society* **45**, 104–106.
- Nyiira, Z.M.** (1971) The status of insect pests on cowpea, *Vigna unguiculata* (L.) Walp. in Uganda and their control. *PANS* **17**, 194–197.
- Nyiira, Z.M.** (1973) Pest status of thrips and lepidopterous species on vegetables in Uganda. *East African Agricultural Forestry Journal* **39**, 131–135.
- Ojehomon, O.O.** (1968) The development of the inflorescence and extra-floral nectaries of *Vigna unguiculata* (L.) Walp. *Journal of the West African Science Association* **13**, 93–111.
- Okwakpam, B.A.** (1967) Three species of thrips in cowpea flowers in the dry season at Badeggi, Nigeria. *Nigerian Entomologist Magazine* **3**, 45–46.
- Palmer, J.M.** (1987) *Megalurothrips* in the flowers of tropical legumes: a morphometric study. pp. 480–495 in **Holman, J., Pelikan, J., Dixon, A.G.F. & Weismann, L.** (Eds) *Population structure, genetics and taxonomy of aphids and Thysanoptera*. The Hague, SPB Academic Publishing.
- Rösingh, C.** (1980) *Untersuchungen über die Resistenz der Kuhherbse, Vigna unguiculata (L.) Walp., gegen Megalurothrips sjostedti (Trybom) (Thysanoptera: Thripidae)*. PhD thesis, University of Hohenheim, Germany.
- Salifu, A.B.** (1986) *Studies on aspects of the biology of the flower thrips, Megalurothrips sjostedti (Trybom) with particular reference to resistance in host cowpea, Vigna unguiculata (L.) Walp.* PhD thesis, Wye College, University of London, England.
- Singh, S.R. & Taylor, T.A.** (1978) Pests of grain legumes and their control in Nigeria. pp. 99–111 in **Singh, S.R., Van Emden, H.F. & Taylor, T.A.** (Eds) *Pests of grain legumes: ecology and control*. London, Academic Press.
- Singh, S.R., Jackai, L.E.N., Dos Santos, J.H.R. & Adalla, C.B.** (1990) Insect pests of cowpea. pp. 43–89 in **Singh, S.R.** (Ed.) *Insect pests of tropical food legumes*. Chichester, John Wiley & Sons.
- Southwood, T.R.E.** (1978) *Ecological methods*. 2nd edn., 524 pp. London, Chapman & Hall.
- Tamò, M.** (1991) *The interactions between the cowpea (Vigna unguiculata Walp.) and the bean flower thrips (Megalurothrips sjostedti Trybom) in Rep. of Benin*. Ph.D. Thesis no. 9455, Swiss Federal Institute of Technology, Zurich, Switzerland.
- Tamò, M. & Baumgärtner, J.** (1993) Analysis of the cowpea (*Vigna unguiculata* Walp.) monocropping system in West Africa: I. A demographic model for carbon acquisition and allocation in cowpea. *Ecological Modelling* **65**, 95–121.
- Tamò, M., Baumgärtner, J. & Gutierrez, A.P.** (in press) Analysis of the cowpea (*Vigna unguiculata* Walp.) monocropping system in West Africa: II. Modelling the interactions between cowpea and the bean flower thrips *Megalurothrips sjostedti* (Trybom). *Ecological Modelling*.
- Taylor, T.A.** (1965) Observations on the bionomics of *Laspeyresia ptychora* Meyr. (Lepidoptera: Eucosmidae) infesting cowpea in Nigeria. *Bulletin of Entomological Research* **55**, 761–773.
- Taylor, T.A.** (1969) On the population dynamics and flight activity of *Taeniothrips sjostedti* (Trybom) (Thysanoptera: Thripidae) on cowpea. *Bulletin of the Entomological Society of Nigeria* **2**, 60–71.
- Taylor, T.A.** (1974) On the population dynamics of *Taeniothrips sjostedti* (Trybom) (Thysanoptera: Thripidae) on cowpea and an alternate host, *Centrosema pubescens* Benth., in Nigeria. *Revue de Zoologie Africaine* **88**, 689–702.
- Trybom, F.** (1908) Physapoda. in **Sjöstedt, Y.** (Ed.) *Wissenschaftliche Ergebnisse einer Schwedischen Zoologischen Expedition nach dem Kilimandjaro, dem Meru, und den umgebenden Ma-saisteppeen Deutsch-Ostafrika, 1905-1906* **3**, 1–22.
- Van Halteren, P.** (1971) Insect pests of cowpea, *Vigna unguiculata* (L.) Walp. in the Accra plains. *Ghana Journal of Agricultural Science* **4**, 121–123.
- Wien, H.C. & Rösingh, C.** (1980) Ethylene evolution by thrips-infested cowpea provides a basis for thrips resistance screening with ethephon sprays. *Nature, London* **283**, 192–194.

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