STUDIES ON TWO IMPORTANT APHELINID PARASITES OF THE COTTON WHITE FLY BEMISIA TABACI (GENT.) WITH REFERENCE TO THEIR INFLUENCE ON THE HOST POPULATION.

Huberta Naseya Wani
B.Sc. Hon. (Agric.) Khartoum

A thesis presented to the University of Khartoum in partial fulfilment of the requirements for the degree of M.Sc. (Agric.)

Faculty of Agriculture,
Sharm el-Shaikh, Khartoum. 1969.
Very tiny hymenopterous parasites of the cotton whitefly, *Bemisia tabaci* (Genn.). Their morphological features (mainly external features of the adults) biological and ecological behaviour were for a long time not known in the Giza conditions (Egypt). Their influence on the whitefly was not experimentally ascertained. This work has however attempted to throw some light upon all these aspects.

Their life span was found to be short, fecundity low and were also found ineffective as control agents of the host, *Bemisia tabaci*.

Various reasons were discussed for the ineffectiveness of these parasites in controlling the whitefly. Among the factors discussed were physical and cultural limitations and also the effect of insecticidal sprays. DDT was found to harm the parasites the more, especially the immature stages (larvae).
CONTENTS

ACKNOWLEDGEMENTS

INTRODUCTION

LITERATURE REVIEW

1. Economic importance of Bemisia tabaci (Genn.) 3
2. Life history and control of Bemisia tabaci (Genn.) 4
3. Life History of the Aphelinid parasitizing the whitefly 5
   3.1 Encarsia spp.
   3.2 Prosopistria spp.
   3.3 Parasolaspis spp.
4. Role of the Aphelinid in controlling the whiteflies 10

MATERIALS AND METHODS

1. Parasite and host cultures 13
2. Morphological studies 13
3. Biological studies 14
4. Ecological studies 17
5. Methods of assessing the parasitism of Bemisia tabaci under natural conditions 18
6. Experiments on the effect of conventional insecticides on the parasites 19
RESULTS AND FINDINGS

Morphological studies

1. Encarsia utsu & Masaki
   1.1 Size
   1.2 Colour
   1.3 Antenna
   1.4 Wings
   1.5 Legs
   1.6 Ovipositor

2. Eutrocarus mundus Harcot (female)
   2.1 Size
   2.2 Colour
   2.3 Antenna
   2.4 Wings
   2.5 Legs
   2.6 Ovipositor

3. Eutrocarus mundus Harcot (female)
   3.1 Size
   3.2 Colour
   3.3 Antenna
   3.4 Wings
3.5 Legs
3.6 Aedeagus

4. Key to the morphological differentiation of Encarsia lutea and Eretmocerus mundus

BIOLOGICAL AND ECOLOGICAL STUDIES

1. Developmental history
2. Life cycle
3. Host stages susceptible to parasitism
4. Mating
5. Oviposition
6. Emergence
7. Feeding
8. Longevity and fecundity
9. Population and relative occurrence of Encarsia lutea and Eretmocerus mundus
   9.1 The population during the growing season (November - March)
   9.2 Relative sex ratio of Encarsia lutea and Eretmocerus mundus on cotton and 'lubia'
   9.3 The parasite population during the dead-season
10. Host-parasite relationship
10.1 The relative population of the cotton whitefly, *Bemisia tabaci* on four cotton varieties

10.2 Extent of parasitism

10.3 Number of parasitized insects (larvae and pupae) at different levels of the host plant (cotton) in the field

10.4 Seasonal fluctuation of the whiteflies and their extent of parasitism on 'lubia'

10.5 The effect of some conventional insecticides on the parasites

10.5.1 Laboratory results

10.5.2 Field results

DISCUSSION

SUMMARY

REFERENCES

APPENDIX I

APPENDIX II
ACKNOWLEDGEMENTS

The practical side of this work was carried out in the Agricultural Research Corporation, Entomology Section, Medani, under the supervision of Dr. Omeen Ibrahim Ganeel (Entomologist) to whom the writer is indebted for his sincere help and advice. Thanks are also due to my University Supervisor, Dr. El Imam El Khidir, Senior Lecturer, Department of Crop Protection whose joint effort with Dr. Omeen Ibrahim Ganeel helped in orderly presentation of this work.

I wish to express my indebtedness to my Co-Supervisor, Dr. T.V. Venkataraman, Reader in Entomology, for his valuable and helpful suggestions during the course of this study.

The help of Dr. Ferriere of Centre de Identification des Insects entomophages, Geneva, Suise and of the British Museum (Natural History) is also greatly acknowledged for identifying the parasite species.

Thanks are due to the Photographic Unit of the Faculty of Agriculture, especially to Sayed Fathalla Abdel Haleen and Sayed Mohamed Ganoel Ahmed in carrying out the photographic work.

The Director of the Agricultural Research Corporation Dr. Hussein Idris and the Head of the Entomology Section of the Corporation, Sayed Hussein Mohamed Hassan are greatly thanked for initiating this work and for providing the facilities for its accomplishment.
thesis.
INTRODUCTION

In the Sudan Gezira and other parts of the country the cotton whitefly, \textit{Bemisia tabaci} (Gennadius), (Homoptera : Aleyrodidae), has become a pest of leading economic importance because of its complex damage, cited in the following pages, is not only limited to cotton but is extended to other economic crops too. The danger this insect poses was realized since the thirties and measures to control it were initiated from the fifties onwards by some leading workers amongst whom were Amaden (1954), Joyce (1955), Marcos (1957/58), Lema (1960), Proctor (1961) and Ganeel (1964/65). The nature of the control method was, and still is, chemical.

Besides therefore, the general fear of what subsequent results the continuous use of the insecticides might inflict on the insect and other forms of life in the long run, the need was felt to explore new avenues to combat the whitefly. Hence, the study of its parasites, \textit{Braconia lutea} Masi and \textit{Eretmocerus suneus} Marcoz, (Hymenoptera : Aphelinidae) its most outstanding natural enemies in the Gezira.

As a preliminary approach, studies were therefore conducted on the morphology, biology, extent of natural parasites in the field and influence of some conventional insecticides on the two parasites. It is these aspects that the following study aims to cast some light upon.
In the following pages, the results of this study are presented. The observations have been carried out both in the laboratory and in the field in the Gezira Agricultural Research Corporation, Medani, during the seasons 1966/67 and 1967/68.

It is hoped that this work will create interest, which will perhaps initiate amongst workers in the country, spirit to study the biocides of the indigenous biotic agents which in return might offer assistance to the current methods of insect pest control in the Sudan.
LITERATURE REVIEW

1. Economic importance of Bemisia tabaci (Genn.)

*Bemisia tabaci*, the cotton whitefly, has been known to inflict manifold and complex damage to the cotton crop in India, the Sudan and in other parts of the world.

Hussain (1931) and Hussain and Trehan (1933), quoting Milne (1922), Robert (1929) and Brought (1931) reported the great losses suffered by the 'Punjab-American' varieties of cotton for five years in India. Stunted growth, yellowing and reddening of the leaves, premature defoliation, softness of young bolls, bad opening and poorly developed lint and seed were the symptoms observed. There was, however, a great controversy over the causes of these losses. Later it was established that the whitefly was the main cause (Mira and Lambo 1929).

Laird and Dickson (1959) in U.S.A. stated that leaffromple virus was transmitted from cotton to cotton by the adult of the whitefly, *Bemisia tabaci*, the immature forms being unable to acquire the virus.

In the Sudan the whitefly has equally been destructive. In the twenties, whiteflies were reported to cause 'salt' i.e., honeydew secretion on cotton leaves (Bedford 1921). Kirkpatrick
(1930), Massey and Andrews (1932) observed that the whitefly was the vector of the virus responsible for cotton leaf curl. This later on was confirmed by Nour and Nour (1964). Yassin and Nour (1965) have found that the same insect transmits the tomato leaf curl virus. Coeland (1933/34) and No Dervid (1952/53) remarked that heavy infestation of cotton by this pest caused shedding. Pollard (1953), agreeing with Bedford (1921) held that the hossy-dew found on the cotton leaves was caused by the whitefly which according to Fowler (1956) was responsible for lowering the leaf nitrogen of the plant. Asad Abdin (1959/62), in pot experiments, and Nammad (1965) in large field cages concluded that the whitefly infestation reduced both yield and cotton quality. Inters three report of 1968 of cotton stickiness, stressed the importance of the whitefly together with the cotton aphia as the causal agent of stickiness in the Sudan cotton due to the 'amal' it produces, and Gamel's (1969) Symposium paper presented in the Agricultural Conference in Kedani, gives a detailed record of the various deleterious effects of the whitefly on the cotton crop in the Gezira.

2. Life history and control of *Bemisia tabaci* (Genn.)

The life history of *Bemisia tabaci* has been investigated
by several workers, especially so in India, (Kusain and Prehan 1933) and the Sudan.

In the Sudan, Cowland (1937/38), Bedford (1935/36) and Norman et al (1953/54) were among the early workers who had studied the life history of the whitefly in the Gezira. Recent workers include Khalifa and Ahmed Khidir (1964) in Shambat and Gameel (1964/65) in the Gezira. Results found agreed that the developmental stages of the insect constituted of eggs, larvae, pupae and adults and that during summer the life-cycle was short, (15-23 days) and long in winter, (21-42 days). Longevity of the female was found to range between 2-38 days during which time a large number of eggs could be deposited. Gameel (1964/65) listed about 150 host plants of this insect and outlined its seasonal fluctuation.

The control measure of this pest in the Sudan is mainly chemical, (Gameel 1964/65). Biological methods of control have not been investigated, but in other countries where Zaninia tabaci and other aleyrodes are a menace, a substantial record of the Aphelinid parasites has been made (Thompson 1944). The list of the parasites is presented in Appendix (1).

3. Life history of the Aphelinids parasitizing the whitefly.

Work on Encarsia lutea Kari and Braconocerus mundus Nsect
by various workers in different countries under various conditions. Speyer (1927 and 1930), Hussain and Trehan (1933) and Burnett (1958) were amongst the earliest workers who studied the morphology and bionomics of some of the Encarsia spp. More recent workers include Timofelva (1963) Halveski (1964), Oanecal (1965), Dymart (1966) and Sering (1966).

Speyer (1927) and Halveski (1964) observed that Encarsia formosa (Gahan) was tiny in size and yellowish in colour. It reproduced parthenogenetically, mainly females and rarely males. Fecundity at high temperature was estimated at 50 eggs per female, but less at low temperature. The egg, 0.08 mm. long and 0.03 mm. wide, hatched in four days to larva which moulted three times in 14 days into pupa. From the pupa it took 10 days for the adult to emerge. Life-cycle was estimated to be 28 days and the female parasite could be kept ovipositing for about 9 days.

The same workers also suggested that Encarsia formosa probably hibernates within the whitefly scale as a pupa or
adult because of the bitter winter conditions. It was also observed to continuously breed with an artificial heat which suggested that it might be a tropical insect without a hibernating period.

Balveski (1964), in Bulgaria, studying the life-cycle of Encarsia formosa on Trialeurodes vaporariorum (Westwood) at 25-28°C. and 75-80% R.H., found the following information: the egg took 4-6 days to hatch, the larva 10-16 days to pupate and the pupa 4-6 days to change into adult. He found that the total life-cycle was 16-28 days, fecundity of the parasite was 60-80 eggs per female, mostly laid in the second and subsequent instars of the host. According to him the first host instar was also attacked. Reproduction was observed to be parthenogenetic.

In Moscow, Timofelva (1963) found that the life cycle of Encarsia formosa took 20-30 days to complete and fecundity was 60-70 eggs, mostly laid in the third instar larvae of the host.

Garling (1966) in U.S.A. found that Encarsia pergandiella (Howard) reproduced parthenogenetically, its fecundity was 48-5 eggs at 75 ± 4°F. during 70% of its life span. Life cycle was 13-14 days for males and 15 days for females, eggs hatched in four days into larva which moulted three times. Fertilized eggs
*Abbilocera* (Holdway) found that the fourth instar of the whitefly was preferred for oviposition though the other host instars were also used. He found the life cycle of the parasite to be 10-25 days. He also studied *Encarsia pergandiella*, studied by Garling (1966) and found similar results which confirmed those already found by Garling.

In the Punjab (India) Hussein and Trehan (1955) found the life cycle of an *Encarsia* sp. in August lasted only 6-7 days within the cotton whitefly nymph. Eggs were deposited within the body of the host and the adult parasite emerged out of the pupal skin by cutting circular holes. Ganesan (1965) found that the life cycle of the parasite ranged from 21-29 days at 27-32°C.

3.2 *Prosopaltella* spp.

Subba Rao *et al.* (1966) found the life cycle of *Prosopaltella perniciosissima* (Toser), a parasite of San Jose Scale in India and
Pakistan, at 80°F. and 50% R.H., lasting 25-30 days, longevity of the adult parasites was 8-12 days and rarely 15 days. Gianbore (1965) in Italy and Neuffer (1964) in Germany found the longevity to be 20-21 days in July-August and 50-60 days in Autumn overwintering in the egg stage within a first instar of the host nymph.

3.3 Eretmocerus spp.

Investigations by Sweetman (1936) on Eretmocerus seriosus (Silv.) and Dysart (1966) on Eretmocerus haldemani (Howard) showed that the parasites have the following features: tiny and yellowish; reproduced sexually; mating being affected soon after emergence of adults; proceeded by oviposition soon afterwards; eggs were deposited between leaf and ventral surface of the whitefly nymph, hatching into first instar which moulted into second while still outside the nymph. In its third instar, the larva pierced the whitefly pupa where it completed development into an adult.

The adult ate out a circular hole at the antero-dorsal region of the pupa for escape. From egg to adult it was said to last 28 days, fecundity was estimated at 200 eggs per female, only one larva entered the nymph the rest were observed to die outside the nymph. No super-parasitism was observed as with Encarsia spp.
was very pessimistic. He observed that the effect of these parasites was slightly felt only in the winter months of November to February, bulk of whitefly death was mainly due to physical factors.

El Khidir (1960) in Shambat, (Sudan) observed that host plants of the whiteflies play an important role in attracting the parasites. He found that on Hibiscus esculentus, a hairy host plant of the whitefly, percent parasitization of the whitefly by Encarsia, Eretmocerus and Prospaltella was 25.5% while on the other non-hairy host plants e.g. Delisches lablab, Cucumis melo and Cucurbita pepo, percent parasitization was very much lower. Gemeel (1965) in Medani found about 40% parasitization on cotton.

In Punjab (India) Husein and Zrehan (1973) noted that in nature mortality of Bemisia pensylvanica, synonymous to Bemisia tabaci, due to Encarsia sp. was very negligible in June, increasing only to about 23.6% in September.
Anascasia formosa was shown in Britain to control effectively Trialeurodes vaporariorum the greenhouse whitefly (Speyer 1930). In Canada, Barnett (1926) in his model of host parasite interaction, estimated that Anascasia formosa was about 50% efficient in controlling Trialeurodes vaporariorum.

In Australia, Wilson (1960), controlled effectively the same pest on greenhouse tomatoes with Anascasia formosa, and Timofelva (1963) in Morocco was able to induce 100% parasitism of Trialeurodes vaporariorum with the same parasite, introduced from Canada.

Salvovski (1964) in Bulgaria, found that 90-95% of Trialeurodes vaporariorum larvae were controlled on vegetables by Anascasia formosa and when Hydrogen Cyanide was used it killed only the adult parasites but not the immature stages of the parasites.

Eretmocerus and Prospaltella spp. have also been used to control some of the aleyrodids. Wheatley (1954) in Kenya remarked that Eretmocerus sericus (Silv.) successfully controlled the citrus whitefly, Aequorocarthus voglumi (Ashby) at Matuga, Ukunda, Gazi and Ktsapa stations where insecticides had not been used for two years.
Smith et al. (1964) mentioned the successful control of the same citrus whitefly in Mexico by three species of Aphelinidae, two of which were Prosopaltella clypeus (Silv.) and Prosopaltella opulenta (Silv.) after an unsuccessful attempt to control the pest with insecticides. According to the same worker, though Bretmocerus serius was introduced, it was not very effective except in areas of persistent high relative humidity. Prosopaltella clypeus was found most effective under humid conditions, too, but less so in areas of long dry periods. Prosopaltella opulenta was found better because of its wide climatic range adaptability.

In Burma, Ceylon, Siam, Malaya and other countries records of parasitism by Bretmocerus serius and Prosopaltella sp. had been noted to reach 54-69%, while in U.S.A, Bretmocerus heldemani (Kow.) had been observed to control effectively the citrus whitefly, Aleurocanthus samari (Quaint.). In the Middle East, the same parasite together with Prosopaltella lutea (Haloi) were noted to have completely suppressed the citrus blackfly, Aleurocanthus woglumi (Thompson 1944).

Sivart (1966) in U.S.A. found that Bretmocerus heldemani and an Encarsia sp. could attack the whitefly, Trialeurodes abutilones (Haloi.) up to the level of 23 and 53% respectively.
cotton, 

Gossypium spp. and 'Lubia' Dolichos lablab (L.) on which the host insect 

Bemisia tabaci (Genn.) was bred. These crops were grown on the experimental farms and the greenhouse and the parasite specimens were collected, in situ, on leaves or by means of an aspirator for the experiment.

2. Morphological studies.

For morphological studies mainly external features of the adults which were identified by Dr. Ferriere of Centre de identification des Insects entomophages, Geneva, Switzerland, as 

Bacicia luteus Kasi and 

Brevicorpus mundus Marcet and confirmed by the authorities of the British Museum (Natural History), the parasite materials collected were cleared in "Swan medium" in square dishes for 10-20 minutes, then mounted on slides after staining with either safranin blue or fuchsine acid. The method of description used by Spyer (1927) and Garling (1966) to describe the morphological features of 

Bacicia formosa and 

Bacicia pergandigia, was followed in describing these parasites as the original descriptions by Kasi and Marcet were not available.
Measurements were taken using a stage micrometer and all dimensions are in millimetres, each constituting an average of ten measurements.

Drawings were made with the aid of a Camera lucida.

3. Biological studies

To study the biology of the parasites, leaves of potted cotton plants of 30–65 days old, in situ, were used to breed the host insect. Five healthy leaves from each pot were selected for infestation with 10–20 adult whiteflies trapped in breeding microcages (average size 1.0" x 0.5"). The whiteflies were confined in these microcages for egg laying (Fig.1). The eggs were left undisturbed to hatch inside the microcages and develop into, first, second, third, fourth and pupal instars, by estimating the developmental period for each stage. In this way healthy whitefly instars of different stages were obtained for the experiment.

For the study of the life cycle, the third and fourth instars of the host insect were exposed to the adult parasites for about two days (maximum preovipositional period). The parasitized host instars were observed daily, in situ, under a binocular microscope to follow the life cycle and the developmental history of the parasites.
Fig. 1. Microcage used for breeding whiteflies and their parasites.
Healthy whitefly instars were also used to follow the life cycle of the host insect under the same conditions of laboratory temperature and humidity (23-27°C and 20-30% R.H.).

For the host instar preference, a number of the different host insect stages (first, second, third, fourth and pupal instars already bred for the experiment) were also exposed to the parasites. The parasitized stages at the end of the experiment were noted and percent parasitism calculated.

The mating process of the parasites was investigated after confining several pairs of freshly emerged adult parasites under a watch-glass (1.5" diam.) on leaves in petri-dishes. Observations were conducted under a binocular microscope.

Oviposition was also studied under a binocular microscope by exposing 24-hour old parasites onto healthy whitefly instars on cotton leaves in a petri-dish. The experiment was mainly conducted in the morning hours between 0600 and 0700 hours (G.M.T.) as at this time the parasites kept overnight were less active and could be easily confined.

For fecundity studies two methods were followed. In the first method the abdomen of the parasite females were dissected on curved slides containing 0.9% saline solution and the number of eggs was recorded. The fecundity was also ascertained by
confining freshly copulated parasite females on whitefly nymphs in microcages. The host nymphs were dissected with very fine needles for the eggs of parasites which were also recorded.

Emergence of the adult parasites from the host puparium were also studied. Cotton and 'lubia' leaves containing the parasitized host pupae were collected from the greenhouse and the experimental farm. The pupae of the parasites were about 7-10 days and nearly of the same number. They were contained in petri-dishes in which moist filter papers were placed. Observations were carried out at a two-hour interval using a binocular microscope and the number of the adult parasites emerging each time was recorded.

For longevity studies, freshly emerged adult parasites were introduced into vials (1" x 3") using aspirators. Some vials were supplied with glucose soaked cotton lints, (a substitute for the honey-dew secretion on which the adult parasites were seen feeding) suspended on pieces of thread from the muslin covered ends of the vials to serve as food for the parasites. The other vials were not supplied with food, but the open ends were covered with muslin cloth to provide for aerations. The vials were separated into Eretmocerus vials with food and those without. The same treatment was applied to the E. acrea vials.
All the vials were then transferred to a pot containing moist soil to provide favourable relative humidity.

4. Ecological studies

The population of the two parasites was studied in the field and the investigations were carried out on the following crops: cotton, and 'Jubia'.

Materials used for collecting the parasites were mostly aspirators and petri-dishes. Parasites were collected from 100 plants (5 leaves each) and transferred to the petri-dishes containing 10% alcohol solution where the population was counted. Sampling was conducted during the growing season from August to March.

Survey during the dead-season (April, May and June), to find out where and at what stage of their developmental history, the parasites spend the dead-season, was also conducted along the Blue Nile River at Medani (Sudan) where gardens planted with various vegetable crops were available. Okra, Hibiscus esculentus (L.) and egg-plant Solanum melongena (L.) were selected as the standard crops out of those given in Appendix (II) as these were available in almost all the gardens inspected. Leaf samples (100 leaves) of each of the two crops were examined, in situ, and another sample, (20 leaves) picked at random was brought for
laboratory inspection of the parasite immature stages. Sampling was conducted three times each month at an interval of 10 days and six gardens were inspected.

5. Methods of assessing the parasitism of Benisia tabaci under natural conditions.

The extent of parasitism was determined by using the method of Gowland (1933/34) for counting the number of whitefly instars within a central standardized area of each of a hundred leaves, randomly, collected from the field.

The materials from which the leaves were collected were the cotton varieties Bar XII, Albar (hairy and bushy), Acala and Bar 14/25. These were sown on two and a half faddans on 15 August. Two months later at an interval of 10 days, 100 leaves of each cotton variety were collected into nylon bags (6" x 12") for laboratory determination of the whitefly population and degree of parasitism.

A circular area of 1.5" diam. on the centre of each leaf, measured out by a watch-glass of the same diameter was taken as the standard area for inspection under the binocular microscope. Points noted in the count were, first, the total population of the whitefly instars within the 1.5" diam. area. Second, the total population of the host instars parasitized (i.e., larvae
The distribution of parasites on the cotton plant was also investigated. This was done by using the method of Schuur (1955/56) of collecting samples of leaves from top, middle and bottom positions of the plant. These leaves were later examined in the laboratory.


For the effect of some conventional insecticides on the parasites, tests were conducted in the laboratory and in the field.

In the laboratory the materials used were potted cotton plants, variety Bar XLI (30-45 days old). The host insect and the parasites were bred on these plants in exactly the same way as those used earlier for the study of the biology of the parasites. Some parasite larvae were left undisturbed to develop into the pupal stage, in situ, while the other larvae of parasites were treated with the insecticides DDT.
Bidrin and anthio, using a spraygon quality sprayer (No. 32 greenhouse hand sprayer). The equivalents of the conventional doses, similar to those applied in the field treatment (Gazira) were used in the laboratory tests, 1.00 lb (a.i.) per fed. DOT, 0.40 lb (a.i.) per fed. Bidrin and 0.30 lb (a.i.) per fed. Anthio.

The larvae of the parasites which were left to develop to pupae were later treated with the same insecticides in the laboratory.

For the field tests, the cotton variety Bar XII sown on two faddans was sprayed in November with similar doses of the same insecticides using a Knapack sprayer. Host insect and parasite count (Cowland 1933/34) to determine the effect of the insecticides was conducted 7 and 21 days after spray,
The description following applies to the female species (Figs. 2-6) as no males were detected throughout the study period and also as the original description of this species by Mali was not available the following description is based on personal observation.

1.1 Size

Very tiny, 0.360 mm, long from anterior head region to tip of abdomen (Fig.6).

1.2 Colour

Generally yellowish and shiny when viewed against the sunlight. The compound eyes are dark brown in colour, cover a good portion of the head. Three, triangularly arranged ocelli, are present at the dorsal portion of the head, pinkish red in colour.

Thorax is dark yellow, but the abdomen is light yellowish.
1.3 **Antennae (Fig. 2)**

It is elevated, dark yellowish and impregnated with minute hairs with 5 sensilla on segments 4-8. The antenna is 0.367 mm. long and 8-segmented, resting on a stalk. Average dimensions of the segments from proximal to distal end of the antenna are: 0.084, 0.034, 0.039, 0.038, 0.041, 0.038, 0.041 and 0.046 mm. respectively.

1.4 **Wings (Fig. 3)**

These are hyaline and membranous covered uniformly with short hairs on the disc, and fringed at the margin with longer and stouter ones. Venation is greatly reduced. The fore-wing is broader than the hind-wing, is 0.688 mm. long and 0.173 mm. wide at the broadest region. The hind-wing narrow, is 0.375 mm. long and 0.038 mm. wide at the broadest region.

1.5 **Legs (Fig. 4-a)**

Have the tibia and tarsus covered with hairs. Tarsus is 5-segmented. The first segment is twice longer than the rest which are subequal. Tarsal spur present and strigil with soft pad ending.

1.6 **Ovipositor (Fig. 5)**

It is 0.200 mm. long, protruding distinctly behind the tip.
Figs. 2-4. *Encarsia lutea* (Female)

2. **Antenna**

3. **Wings and coupling mechanism:**
   (a) Fore-wing
   (b) Hind-wing
   (c) Coupling apparatus

4. **Legs (tibia and tarsus only)**
   (a) for *Encarsia lutea*
   (b) same for *Prozus mundus*
Figs. 5-6. *Eucaridia lattea* (Female)

5. Ovipositor
6. Adult
of the abdomen and is enclosed in a sheath at the posterior tip of which are 5 hairs, three on each side of the projecting ovipositor. The sheath and ovipositor rest in abdominal ventral grooves. The abdomen which is 5-6 segmented, bears a pair of fibrilles at its tip on each side of the ovipositor.

2. *Brachapedus sundus* Härct (Female)

Females and males (Figs. 7-10) of this species were present throughout the study course. These parasites were first observed by Härct (1931) in Italy and Spain parasitizing an aleyrod on eggplant, *Solanum melongena* (L).

2.1 Sine

The female (Fig. 10) is very small 0.423 mm. long from the anterior region of the head to the tip of the abdomen.

2.2 Colour

Yellowish-red throughout the body. The head, 0.100 mm. wide, bears a pair of prominently brown compound eyes. Ocelli, three in number, and pinkish red in colour are distinctly present.

2.3 Antenna (Fig. 7a)

It is composed of 5 segments. The entire antenna rests on a stalk. Total length is 0.165 mm. and is impregnated with 3-5 stout sensilla. The ring-joints two in number and subequal,
are 0.015 mm. long each. The second-segment (from the proximal end) is 0.060 mm. long and the first, resting on a stalk, is about 0.105 mm. long.

2.4 Wings

Similar in features to those of Encarsia lutea (Fig. 3). The fore-wing is 0.435 mm. long. The hind-wing is 0.413 mm. The coupling apparatus are similar to those of Encarsia lutea, too.

2.5 Legs

As in Fig. 4 b, tibia and tarsus are hairy but not as much as those of Encarsia lutea. Tarsus is 4-segmented and the first tarsal segment is longer than the rest. Tarsal spur is present and the strigil pad-like.

2.6 Opispositor (Fig. 3)

Like that of Encarsia lutea, it protrudes behind the tip of the abdomen. It resembles that of Encarsia lutea in most of its features except that at the end of its enclosing sheath there are no hair like structures.

3. Pseudoceras mundus Marcet (Male)

The male Pseudoceras mundus is very identical to the female
is most morphological features except the antenna and aedeagus.

3.1 Size

The size is small 0.464 mm. long. The head which is about 0.183 mm. wide is mostly covered with the dark brown compound eyes. Three ocelli are also present, pinkish-red in colour.

3.2 Colour

Generally yellowish throughout the body.

3.3 Antenna (Fig. 7b)

Unlike that of the female, antenna of the male is composed of 3-segments and a stalk on which the whole antenna rests. Total length is 0.480 mm.; the flagellum heavily impregnated with sensillae is 0.330 mm. long. The pedicel i.e. the mid-segment is about 0.030 mm. long and the scape which is connected to the stalk is 0.120 mm. long.

3.4 Wings

Similar to those of the female (Fig. 3).

3.5 Legs

Similar to those of the female too (Fig. 8a).

3.6 Aedeagus (Fig. 9)

It is 0.140 mm. long, unsheathed and protrudes beyond the tip of the abdomen.
4. Key to the morphological differentiation of *Encarsia lutea* and *Eretmocerus mundus*.

1. (a) Tiny body, generally yellowish in colour and shiny, antenna 2-segmented .................. 2(a)
   (b) Tiny body, generally yellowish in colour and shiny, antenna with 3 or 5 segments ........... 2(b)

2. (a) Tibia and tarsus very hairy with five tarsal segments ...................................... 3(a)
   (b) Tibia and tarsus not very hairy and four tarsal segments only .................................. 3(b)

3. (a) Tip of the ovipositor sheath bears six hairs, three on each side of the protruding ovipositor ......................... 4(a)
   (b) Tip of the ovipositor sheath does not bear any hairs on each side of the protruding ovipositor .................................................. 4(b)

4. (a) *Encarsia lutea* Meisi
   (b) *Eretmocerus mundus* Marshet
1. Developmental History (Figs. 17-19)

The eggs of *Lecanida lutea* and *Lecanidae punctata* (Fig. 11) are light yellowish in colour, oval-shaped in case of *L. lutea* and pear-shaped in that of *L. punctata*. They hatch into larvae which could not be easily differentiated except at the pupal stage.

The larva, once hatched from the egg in about 3-4 days, develops very fast within the nymph of the host insect. It feeds by sucking the host internal fluid and content, rapidly assuming the shape of a horse-shoe, (Fig. 12). The gut, a blind-sac, is easily visible through the transparent cuticle. It can be noted that the body of the parasite larva is broader anteriorly than posteriorly. In the final larval stage, 8-12 days from egg deposition, 13 segments and about 8-9 pairs of spiracles could easily be seen. These are located on the third to the tenth segments of the parasite larva, (Fig. 13). At about the same stage of development, the blind gut opens its sac through the small slit to release the feces. The larva moves forward until its head reaches the anterior wall of the host puparium. It then bends the tail of its body anteriorly to the left until the small area comes into contact with the left wall of the host puparium.
The process may last 3-4 hours. The larva then becomes a pre-pupa, light yellowish in colour, (Fig. 14). In this stage no external appendages are visible, but 1-2 days later the colour changes becoming a very black pupa in case of *N. lutea* and light brown in that of *N. mundus*. The *Protopoccercus* pupa is not enclosed in a sheath, (Fig. 15) in this way it differs from that of *Encarsia* which is enclosed in a membranous sheath (Fig. 16).

The *Encarsia* pupa like that of *Protopoccercus* develops compound eyes (dark brown) 2 days after the pre-pupal stage. In another 2 days the antennae, legs and mouthparts show clearly and in another 2-3 days the antennae, show very clear segmentation and the other appendages, e.g. wings show full development with hairs at their margins and discos, (Figs. 17 and 18). The pupae of both *Protopoccercus* and *Encarsia*, when developed into adult parasites, could easily be seen under the binocular microscope in motion within the host puparium orientating to cut a circular hole for exit at the antero-dorsal region of the puparium, (Fig. 19). One parasite emerges from each host insect.

2. Life cycle

The duration of the developing stages of the whitefly parasites *Protopoccercus mundus* and *Encarsia lutea* are presented in Table 1, but that of their host *Bemisia tabaci* is only mentioned in the text below.
Figs. 11-14. Immature stages of the parasites

11. Eggs:
   (a) Eggs of *Encarsia lutea*
   (b) Eggs of *Encarsia suspensa*

12. Parasitized host-larva showing:
   (a) Gut of the parasite larva
   (b) Larva of the parasite (horse-shoe shaped)
   (c) Host puparium

13. Parasite larva in final stage

14. Parasitized host-larva showing:
   (a) Parasite prepupa
   (b) Feces released by the parasite larva.
Figs. 15-16. Pupae of the parasites.

15. Pupa of Arotmolcerus mundus (male)
   (a) Host-puparium
   (b) Arotmolcerus pupa

16. (a) Pupa of Ancarzia lutea (female)
    inside the host puparium
    (enclosed in a membranous sheath).
17. Host puparium with the parasite pupa orientated upside down
   (this is a rare case)

18. Fully developed *Encarsia* pupa with very clear segmentation of antennae.

19. Empty host-puparium from which *Encarsia lutea* adult parasite has emerged showing:
    (a) Exit hole (roughly circular in shape).
    (b) Cast skin of the parasite.
Table I. Duration of the immature stages (in days) of the whitefly parasites.

<table>
<thead>
<tr>
<th>Stage of development</th>
<th><em>Eretmopera acutus</em></th>
<th><em>Encarsia lutea</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Egg to full grown larva</td>
<td>8-16</td>
<td>8.9±0.8</td>
</tr>
<tr>
<td>Prepupa to pupa</td>
<td>1-2</td>
<td>1.0±0.5</td>
</tr>
<tr>
<td>Pupa to adult</td>
<td>7-9</td>
<td>7.8±0.6</td>
</tr>
<tr>
<td>Total life cycle</td>
<td>16-21</td>
<td>18.0±3.3</td>
</tr>
</tbody>
</table>
For *E. mundus* it was found that the mean developmental period from egg to full grown larva was 8.9±0.8 days and the range was 8-10 days. The prepupa to pupa developed in 1-2 days, the mean period was found to be 12.0±0.5 days. The pupal stage took 7-9 days to develop into an adult, the mean period being 7.8±0.8 days. The total mean life cycle was found to be 18.0±3.3 days and the range 16-21 days.

As for *E. lutea* from egg to full grown larva 10.7±0.8 days was found to be the mean period and the range 10-12 days. The prepupa lasted 1.4±0.5 days, range being 1-2 days and the pupa developed into adult in 6.8±0.8 days with 6-8 days range. The total mean life cycle was therefore found to be 18.9±1.4 days with 17-21 days as the range.

As for the host, *Bemisia tabaci* the mean period from egg laying to emergence was 26.9±2.7 days, the range being 24-30 days (December-January).

3. Host stages susceptible to parasitism.

Table II, indicates that the first and second instar in the experiment were not parasitized by either *Baculocerus mundus* or *Encarsia lutea*. In this case, as the Table shows, parasitism was 0.0%. The same case also occurred with the pupae.
<table>
<thead>
<tr>
<th>Parasite species</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
<th>8th</th>
<th>9th</th>
<th>10th</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of host insects</td>
<td>100</td>
<td>180</td>
<td>170</td>
<td>190</td>
<td>120</td>
<td>110</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>% Parasitised</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Host insects</td>
<td>100</td>
<td>180</td>
<td>170</td>
<td>190</td>
<td>120</td>
<td>110</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>% Parasitised</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
As for the third and fourth instars, it can be noted that parasitization was effected. There was 10.0% parasitism by *Eretmocerus mundus* and 16.0% by *Encarsia lutea*. The parasites in both cases were left to develop to adults, the duration of which, at most, was 21.0 days for each parasite species.

4. Mating

No mating took place among the *Encarsia lutea* adults individuals. As for *Eretmocerus mundus* the mating process was observed to take place 1-2 hours after the adult emergence in the morning. The male before mounting the female was seen to approach her from in front, head to head, playing about with its antennae by rubbing them with those of the female. When the female posed still, the male gradually moved to its rear and quickly mounted it. Only one mounting was affected and the male was soon repulsed when it tried to go for a second mount. The female sometimes moved away but in other times was left to clean itself by rubbing its membranous wings with its hind-legs, while at the same time tapping before it very actively with the antennae.

5. Oviposition

The parasites, especially, *Encarsia lutea*, 24 hours after emergence, was seen cleaning a spot on the third and fourth instar which it was often seen to prefer. The antennae were
the body held erect while rocking up and down at a fairly high rate. Antennae were kept actively in motion pointing downwards. After a brief period of 75 seconds, the ovipositor was retracted and cleaned with the hind-legs. Table III shows time in seconds (using a stopwatch) taken by *A. lutea* and *A. mundus* while ovipositing. Parasitized hosts were mostly avoided.

6. Emergence

Emergence of *Acarus lutea* and *Acronegma mundus* from the whitely puparium, was observed to take place through a circular hole, mostly made at the antero-dorsal part of the host puparium. The parasites were seen to exit out an exit hole, (Fig. 19) while lying dorso-ventrally within the puparium. The antennae, one after the other, were then stretched out through the hole, and the body, curving like a comma, was subsequently pulled out. The wings are unfolded and stretched by the hind-legs. The fresh parasite then moves away from the empty puparium, vigorously feel- ing before it with the antennae. The process on the whole could last 30 minutes, on the average.
Table III. Time (in seconds) taken by *E. lutens* and *E. mundus* to oviposit in each host.

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Host Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td><em>E. lutens</em></td>
<td>75.00 95.00 70.00 85.00 65.00 70.00 80.00 66.00</td>
</tr>
<tr>
<td><em>E. mundus</em></td>
<td>91.00 73.00 75.00 65.00 87.00 69.00 70.00 75.00</td>
</tr>
</tbody>
</table>
Encarsia and Neotrombicula adults were observed to feed on the honey-dew produced by the whiteflies and also on the internal fluid of host instar, which comes out through a puncture made by the ovipositor.

When feeding on the internal fluid of the host instar, the parasite was seen to approach the whitefly instar by the antennae. After tapping the instar, the parasite was observed to turn round and move backwards towards the instar which was then pierced several times with the ovipositor on the dorsum. The piercing process was seen to last 3-5 minutes. When the internal fluid of the host started to ooze the parasite was seen to make another turn and to approach the instar head foremost. Then it was seen to suck the fluid that had come out. The process was seen repeated on several whitefly instars.

2. Longevity and fecundity.

Table IV shows that under the prevailing laboratory conditions 23-27°C. and 20-30% R.H., longevity of the parasites was very short, even when fed. It can be observed that starved
<table>
<thead>
<tr>
<th>Species</th>
<th>E. mundus</th>
<th>E. lutea</th>
<th>E. tabaci</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longevity without food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.08-1.00</td>
<td>0.30-0.60</td>
<td>2.0-4.0</td>
</tr>
<tr>
<td>Mean</td>
<td>0.54</td>
<td>0.55</td>
<td>3.0</td>
</tr>
<tr>
<td>Longevity with food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>3.00-5.00</td>
<td>1.60-4.00</td>
<td>15.0-20.0</td>
</tr>
<tr>
<td>Mean</td>
<td>4.00</td>
<td>3.50</td>
<td>17.5</td>
</tr>
<tr>
<td>Fecundity/female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>8-25</td>
<td>10.0-15.0</td>
<td>9.0-20.7</td>
</tr>
<tr>
<td>Mean</td>
<td>16.5</td>
<td>12.5</td>
<td>10.8</td>
</tr>
</tbody>
</table>
H. mundus lived only 0.54 days on the average, with 0.0-1.60 days as the range. Starved H. lutea lived for 0.56 days on the average. The range was 0.5 to 0.6 days.

Fed parasites lived longer than the starved ones. Their respective longevity together with their host B. tabaci is shown in the Table. The host was confined on cotton leaves.

The respective fecundity of fed species are also shown in the Table. As can be seen, maximum egg production capacity was 8-25 eggs for H. mundus, 10-15 for B. lutea, but B. tabaci produced from 9 to 207 eggs.

It is clear from these results that fecundity in Bemisia tabaci is much higher than that of its parasites.


9.1 The population during the growing season (November-March)

On cotton, as Fig. 21 shows, the joint parasite population rose gradually from 15 November until 30 January, when the highest population peak was reached, 100 parasites per 500 leaves, (five leaves from each plant). Thereafter the population started to drop continuously until 20 parasites only could be collected by 15 March.
On 'lubia', the population started to build up about 15 December, reaching its highest level on about 15 February, i.e. 110 parasites per 500 leaves. The population then began to drop throughout the other half of February till March.

It can be noted in the Figure, that the parasite population on cotton began to drop from its peak, 20 January, at a time when that on 'lubia' was starting to build up, and it can also be seen that between February and March there was a general decrease in the parasite population in both cotton and 'lubia', but the decrease on the former was severer than on the latter. For instance on 15 February, on 'lubia', while 110 parasites were collected only 70 were found on cotton and at the end of February, while there were 100 parasites collected from 'lubia', only 50 were collected from cotton. Despite, the probability that age and tenderness of leaves of the crops might have invariably influenced the parasite population as the crops were sown at different dates (15 August for cotton and 15 October for 'lubia'), the largest parasite population on both crops was found during December, January, and February, the winter months. It might mean, therefore, that among other factors, the weather, especially temperature, could have influenced the ultimate population of the parasites.
Fig. 21. Occurrence of adult parasites on cotton and 'lubia' (November to March 1967/68).
9.2 Relative sex ratio of *Encarsia lutea* and *Brazopogon mundus* on cotton and 'Lucia'.

Table V indicates the sex ratio of the two parasites. It can be observed that all the *E. lutea* collected from cotton and 'Lucia' during the experimental period, January-March, were females. Males were not found.

For *B. mundus*, both females and males were available, but the former were more numerous than the latter.

In this parasite collection, the presence of only one sex of *E. lutea* (females), could be taken to confirm the observation by some leading workers that the adult individuals of the genus *Encarsia* mostly reproduce parthenogenetically.

9.3 The parasite population during the dead-season.

Results of the investigation during the dead-season, April-June, are shown on the histogram (Fig. 22) which indicates that all the developmental stages of the two parasites, *E. lutea* and *B. mundus* were available throughout the dead-season.

Concerning the relative prevalence, the histogram shows that, in April, out of the total population sampled, 43% comprised the larvae of *E. lutea* plus *B. mundus*, 57% pupae of *B. mundus* and less than 1% pupae of *E. lutea*. Of the population of the adult
Table V. Relative sex ratio of *Euscelis lutescens* and *Prostocerus mundus* (1967/68)

<table>
<thead>
<tr>
<th>Host plant</th>
<th>Date of Sampling</th>
<th><em>Euscelis lutescens</em> (Macd.)</th>
<th></th>
<th></th>
<th><em>Prostocerus mundus</em> (Macd.)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
</tr>
<tr>
<td>Cotton</td>
<td>10 January</td>
<td>942</td>
<td>-</td>
<td>942</td>
<td>680</td>
<td>130</td>
<td>810</td>
</tr>
<tr>
<td></td>
<td>20 January</td>
<td>710</td>
<td>-</td>
<td>710</td>
<td>800</td>
<td>100</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>30 January</td>
<td>355</td>
<td>-</td>
<td>355</td>
<td>290</td>
<td>10</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>10 February</td>
<td>200</td>
<td>-</td>
<td>200</td>
<td>320</td>
<td>40</td>
<td>360</td>
</tr>
<tr>
<td>'Lubia'</td>
<td>20 January</td>
<td>365</td>
<td>-</td>
<td>365</td>
<td>440</td>
<td>100</td>
<td>540</td>
</tr>
<tr>
<td></td>
<td>10 February</td>
<td>110</td>
<td>-</td>
<td>110</td>
<td>850</td>
<td>200</td>
<td>1050</td>
</tr>
<tr>
<td></td>
<td>20 February</td>
<td>245</td>
<td>-</td>
<td>245</td>
<td>350</td>
<td>50</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>10 March</td>
<td>123</td>
<td>-</td>
<td>123</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>
parasites collected in the same month (April), 60% were \( P. \) mundus and 40% \( P. \) lutescens.

In May 40% of the population sampled comprised of larvae of \( P. \) mundus plus \( P. \) lutescens, 30% were pupae of \( P. \) mundus and 20% pupae of \( P. \) lutescens. Strong winds during this month (May) could not allow collection of substantial numbers of adult parasites.

In June, 50% of the immature stages (i.e., larvae + pupae) of the parasites was composed of \( P. \) lutescens pupae, 30% were pupae of \( P. \) mundus and the rest 20% constituted larvae of both parasites. The adults composed mostly of \( P. \) mundus and very few \( P. \) lutescens.

The histogram clearly shows therefore, that there is no specific stage in which the parasites spend the dead-season. All stages of development were available at different levels.


10.1 The relative population of the cotton whitefly \( Bemisia tabaci \) on four cotton varieties.

The population (immature stages of the cotton whitefly) was estimated by using the method of Cowland (1933/34) for counting the number of whitefly instars within a central standardized area of each of a hundred leaves. The same method was also used
to estimate the degree of parasitism by the parasites.

The whitefly count (Fig. 23) shows that there is a peak in whitefly population in all the cotton varieties during the period 30 October and 30 November. After 30 November whitefly population dropped in all the varieties until finally it dwindled to insignificant level towards end of January.

Albar bore the greatest number of whiteflies, over 135 nymphs per standard area (disc of 1.5 inches diameter averaged for 100 leaves) and the least was Bar XLI with less than 50 nymphs per standard area. The varieties Acala and Bar 14/25 had quite a substantial whitefly infestation though not as much as Albar.

It should be noted that unlike the other varieties of cotton, Albar is bushy and hairy. These factors might have helped in creating a favourable microclimate for the whitefly multiplication.

10.2 Extent of parasitism.

Considering the extent of parasitism on the same varieties (Fig. 24) two peaks could be seen. The first between 30 October and 20 November and the second between mid-December and 20 November.

In the second peak, Albar and Bar 14/25 had the highest
percent parasitism 17% and 18% each. Acala had only 10% at the end of January and Bar XLI, 12% on 10 February, the former reaching its peak before the latter.

Towards the end of February, the rate of parasitism began to decline in all the cotton varieties except Albar (a long maturing variety with fresh leaves which could still attract the parasites and its host, the whitefly).

When the findings of Fig. 24 (disregarding the rise in parasitism in the cotton variety Bar 14/25 in the first peak), are compared with those of the whitefly population (Fig. 25), it can be noticed that Fig. 24 gives a typical parasitic trend of action whereby the highest rate of parasitism (second peak) coincides with the fall of the host population. Varley (1957) considers this as a typical delayed action of a density-dependent factor, whereby each dependent factor exercised control of the size of the other population.

10.3 Number of parasitized insects (larvae and pupae) at different levels of the host plant (cotton) in the field.

This was done by using the method of Schuur (1955/56) of collecting samples of leaves from three different positions of the host plant; top, middle and bottom.
Fig. 23. The relative population of the whiteflies on four cotton varieties (October to January 1966/67).

+ BTD = Standardized leaf area of 1.5" diameter averaged for 100 leaves.
pupa of the host insect is the top leaves. (See experimental results of the host stages susceptible to parasitism, Table II.)

In the bottom leaves where mostly pupae of the host are found, (Khalifa and El Khidir 1964) extent of parasitism is generally less than in the middle leaves.

78. Seasonal fluctuation of the whitefly and their extent of parasitism on 'Rubia'.

Fig. 25 shows the result of the study. In the Figure, it can be noted that the whitefly population rose steadily till a peak on 30 January after which there was a drop. The decline in the whitefly population continued till 15 March, probably due to aging of the host plant.

The pattern of parasitization showed close resemblance to that of the whitefly fluctuation. Parasitization was highest between 15 January and end of February, after the population of the host insect, the whitefly, had started to drop. This could be considered to be an example of a typical delayed density dependent action (Varley 1967). Parasitization reached a magnitude of
Table VI. Percentage of parasitised insects (Larvae and pupae) at different levels of the host plant (cotton) in the field.

<table>
<thead>
<tr>
<th>Leaf position</th>
<th>Bar XLI</th>
<th>Bar 14/25</th>
<th>Acuna</th>
<th>Albar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-leaves</td>
<td>0.60</td>
<td>0.00</td>
<td>0.94</td>
<td>2.50</td>
</tr>
<tr>
<td>Middle-leaves</td>
<td>8.72</td>
<td>12.30</td>
<td>11.06</td>
<td>9.70</td>
</tr>
<tr>
<td>Bottom-leaves</td>
<td>8.48</td>
<td>6.16</td>
<td>14.40</td>
<td>8.50</td>
</tr>
</tbody>
</table>
55-66%. Thereafter there was a steady and gradual drop to 40% on 15 March, to 20% on 30 March and to less than 5% on 15 April, as the host plants grew older and consequently the host insect rorer.

10.3 The effect of some conventional insecticides on the parasites.

10.3.1 Laboratory results.

The laboratory results (Table VII) showed that out of 220 parasite larvae and 230 pupae treated with Hidrin, 18.2% of the parasite larvae and 60.3% of the pupae were able to develop into adults. The Anthio treated specimens resulted in 14.2% of the 140 parasite larvae emerging as adults and 80.6% of the 250 pupae.

In the DDT treatment, 100 larvae and 470 pupae of the parasites were sprayed in situ, with hand sprayer. Whereas 95.7% of the pupae developed into adult parasites after spray, the DDT killed all the larvae of the parasites.

It is very clear that the DDT affected the parasite larvae more than the pupae. This might be due to the reason that the larvae of the parasites act as active feeders and could probably have taken in the DDT during feeding. The pupae of the parasites especially Hemaria are normally enclosed in sheaths (Fig.17) within the host puparium, and moreover are not active
Table VII. Effect of insecticides on the immature stages of *H. mundus* and *H. lutea* treatment conducted in November 1967 in the laboratory.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Parasites treated</th>
<th>Adult parasites emerged</th>
<th>% emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Stages</td>
<td></td>
</tr>
<tr>
<td>Bidrin</td>
<td>220</td>
<td>Larva</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>230</td>
<td>Pupa</td>
<td>140</td>
</tr>
<tr>
<td>Anthio</td>
<td>140</td>
<td>Larva</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>Pupa</td>
<td>200</td>
</tr>
<tr>
<td>DD2</td>
<td>100</td>
<td>Larva</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>470</td>
<td>Pupa</td>
<td>450</td>
</tr>
<tr>
<td>Control</td>
<td>125</td>
<td>Larva</td>
<td>113</td>
</tr>
</tbody>
</table>
feeders. For this reason they might probably have survived the
effect of the insecticide.

10.5.2 Field results.

The field results (Table VIII) showed that, 7 days after
spray, parasitism ranged between 17 and 23% in all the treat-
ments. The control-treatment, though expected to show a high
magnitude of parasitisation than the rest, had only 18.5%.

Twenty-one days after spray there was no substantial in-
crease in the rate of parasitism in all the treatments. The
DDT-treated plots showed 15.3% parasitism on the average. The
Anthic and Bidrin plots showed 20 and 23.2% respectively.
Table VIII. Effect of insecticides treatments on whitefly parasitism in the field.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent parasitism after spray</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 days</td>
</tr>
<tr>
<td>DDT</td>
<td>23.0%</td>
</tr>
<tr>
<td>Anthio</td>
<td>17.0%</td>
</tr>
<tr>
<td>Bidrin</td>
<td>23.1%</td>
</tr>
<tr>
<td>Control</td>
<td>18.5%</td>
</tr>
</tbody>
</table>
The cotton whitefly parasites, Encarsia lutea Nesi and Hyposoterus mundus Marcast (Hymenoptera: Aphelinidae) are very tiny insects, 0.358 and 0.483 mm. long respectively. They are yellowish in colour and shiny, always found together and mostly on the lower epidermis of the leaves. They are difficult to be seen with the naked eye, except at very close range and when many together. The smallness and delicacy of these parasites demand great care and patience for their study. Speyer (1927) and other early workers experienced the same problem.

*Encarsia lutea*, synonymous to *Prosopisteles lutea*, (Stoner et al 1965), unlike *Hyposoterus mundus*, reproduces parthenogenetically. Speyster (1927, 1930), Belavski (1964), Garling (1966) and Dynart (1966) observed a similar phenomenon with *Encarsia formosa* (Gahan), *Encarsia pergandiella* (Howard) and *Encarsia quisintensi* (Power) in Britain, Bulgaria and U.S.A. respectively. The same authors found the life cycle of *Encarsia formosa* to last from 18-20 days at 25-26°C, and 75-85% R.H. In Moscow, Timofeysa (1963) found similar results, 20-30 days with the same parasite and the fecundity never exceeded 60-70 eggs per female at a life span of about 9 days. These findings almost
resemble those found in this work for the species Encarsia lutea. Seventeen to twenty-one days was the duration of the life cycle, and under the same conditions as that of its host the whitefly, Menispa tabaci was found to be 24–30 days. Like its host whose developmental period is influenced by weather conditions (Khalifa and El Khidir 1964), the cold and dry conditions of the winter in which the experiments were conducted might probably have played a part in prolonging the life cycle of the parasites.

Garling (1964) found superparasitism with Encarsia pergandiella (the same family and genus as Encarsia lutea), but the result of dissecting several hundred hosts of Encarsia lutea, in this work, indicated the presence of only one egg in each host. It could mean, therefore, that Encarsia lutea, might not be a superparasite, an advantage most desirable in parasites, but the drawback is its short life span coupled with its very low fecundity which was found to range from 10–15 eggs per female. It should be noted that the whitefly female lays an average of about 100 eggs (much more numerous than those of Encarsia lutea) during 15–20 days of its life span.

Heteracerus mundus, unlike Encarsia lutea reproduces sexually. The life cycle under similar condition of experi-
his work, "Biological control of insects" observed that *Eretmocerus sericeus* laid its eggs outside the host between the leaf surface and the host where they hatched into first instars which later entered the host by piercing. In this work, *Eretmocerus mundus* did not lay the eggs outside the host, an observation which probably suggests that the eggs might have been deposited inside the host.

The life span of *Eretmocerus mundus* was found to be very short (3-5 days). Fecundity was found to be low too, 3-25 eggs per female. Mamal (1965) found similar results under identical conditions.

Preference of the host stages by these parasites was studied. The results indicate that both parasites preferred to parasitize the third and fourth instars rather than the first, second and pupal instars (Table II). The parasites rejected parasitized whitely nymph. Darling (1966) found that mating *Encarsia formosa* females were able to parasitize all whitefly nymphal instars of the greenhouse whitelyfly, *Aleyrodes vexatorius*.
(Houtwood), but preference was shown for instars two and three. Speyer (1927), Timofelva (1953), Balveski (1964) and Dystart (1965) observed a similar phenomenon.

The fact that the third and fourth instars are preferred for oviposition is probably the reason that has contributed to a comparatively higher rate of parasitism in the middle leaves of the cotton plants (Table VI), where the third and fourth whitefly instars are mostly abundant (Khalifa and El Khtidir 1964). The attack of these stages could be regarded as a checkpoint for the whitefly, constituting a breaking point in its life history.

Mention was made earlier that the two parasites were always found together on the crops examined, further field investigation showed that although this was the case, no one particular species was dominant over the other. In addition it was found that the parasites do not hibernate during the dead-season, all the stages were available (Fig.22). Balveski (1964) observed in Bulgaria that Encarsia formosa an allied species of Encarsia lubec, hibernates as a pupa or adult within the whitefly scale in winter. This might have arisen because of difference in weather conditions.

Concerning the influence of the parasites on the whitefly population in the field, the results of investigation on unsprayed field (Fig.24) were deplorable. Parasitisation of the
host, Bacisina tabaci, never exceeded 20% and although two peaks were observed (most prominent occurring between 10 January and 20 February) they were not striking. January and February were the winter months when the parasites were most abundant. The investigation on 'lubia' crop (Fig. 25) also revealed the effective influence of the parasites in about the same time (January to February) during which period parasitism reached a magnitude of 55-50%. Growth in the 'lubia' crop was dense and together with the good weather conditions then, might have created favourable microclimate for the increase in the parasite activity.

Though January and February were the months during which an appreciable degree of parasitism was attained on both cotton and 'lubia', economically it serves very little purpose for the former crop, because the control occurs too late in the season when the whiteflies (highest population usually occurs between October and November, Fig. 23) would have already inflicted heavy damage. Cowland (1933/34) once remarked that the effect of these parasites was very slight and only felt in the winter months (December – February). The remark is confirmed in this work.

While it is difficult to pin-point a specific cause for the ineffectiveness of Bacisina lutea and Aphidocerus mundus to
control the cotton whitefly in the Giza, a number of factors could be suspected. These include, amongst others, physical, cultural and chemical factors.

Physically, the weather conditions in the Sudan Giza, very very much with seasons — very hot summers and cold dry winters. These considerable fluctuations in weather conditions are fatal to the host insect *Bemisia tabaci* without which the parasite cannot live.

As for the cultural effect, the very methods of crop rotation, phytosanitation, imposition of a dead-season and many others, aimed at reducing the insect pests, probably have the same effect on the parasites, being insects themselves. Similarly, the insecticidal sprays are most probably fatal to the parasites just as much as they are to the other insect pests. Balveski (1964) in Bulgaria, observed this effect on the adult parasites when he applied Hydrogen Cyanide on vegetable gardens to control *Trialeurodes vaporariorum* (Westwood), and Wheatley (1964) in Kenya, used *Brevicoryne brassicae* (Sulv.) successfully to control the citrus whitefly, *Aleyrodes volucre* (Ashby) when the orchards were not treated chemically for two years.

Insecticidal tests conducted on immature stages (larvae and pupae) of the two parasites in the laboratory revealed the
fatal effect of the chemicals on the parasites (Table VII). Judging from the % emergence, the larvae were greatly killed, especially by DDT. As for the field treatments (Table VIII), the results were such that it was difficult to draw conclusive remarks, although in the DDT treatment, 21 days after spray, there was again less parasites (15%). The use of DDT in the Gesira against jassids once caused resurgence of the whiteflies (Van der Leen 1961). The possibility that the insecticidal sprays applied in the field might have killed some adult parasites, as the sprays were conducted between 0400 hours and 0800 hours (G.M.T.), a time interval during which maximum emergence of the adult parasites occurs (Fig.20) could not be overlooked. But still, when the results of the control-treatments are compared with the insecticide-treatments (Table VIII), one fact remains clear, i.e. with or without the chemical treatments these parasites are not effective enough to suppress the whiteflies - 23% being the maximum level of parasites in this case (Table VIII) and about 30% in the unsprayed field (Fig.24), are not good enough. However, these low figures might be of importance if in the future an integrated control programme using the less harmful parasite insecticides is resolved to.
SUMMARY

1. Encarsia lutea Masi and Encarsia mundus Masi, both Aphelinidae, are very tiny yellowish hymenopterous primary endoparasites of the cotton whitefly, Bemisia tabaci nymphs. Size is about 0.368 and 0.423 mm, respectively. The morphological features (mainly the adult external features) are discussed and illustrated diagramatically. The main differences are pointed out in the key on page 26.

2. Only females of E. lutea were found during this investigation, and they reproduce parthenogenetically. Both sexes of E. mundus were found. Sexual reproduction was the normal mode among them.

3. Their longevity during the period of study was found to be very short and fecundity very low compared with that of their host.

4. Both parasites preferred the third and fourth instars of the whitefly for oviposition in which development to adults occurs.

5. The life cycle of both parasites was found to range between 16-21 days, a period almost equal to that of the host, (24-30 days).
6. The two parasites were always associated with each other in the lower surface of the leaf, and were found not to hibernate.

7. The efficacy of the parasites to parasitize the whitefly under natural condition was found to be very low, attributed most probably to intrinsic and other factors. Twenty percent was the maximum level reached on cotton and was found to occur too late in the season, (December), when harm was already inflicted on the cotton by the whitefly which appeared abundantly between October and November. Hence, the parasites were thought to serve little control purpose, economically.

8. The insecticides DDT, Anthio, and Bixrin were found to kill the parasite larvae more than the pupas, and of the three insecticides, DDT was found to be the most harmful to the parasites.
Annual Report of the Agricultural Research Division,
Entomology Section, Sudan.

Annual Report of the Agricultural Research Division,
Entomology Section, Sudan.


Sudan Government Welfare Tropical Research Laboratory,


(1969). The effects of the whitefly, Nezizia tabaci (Genn.) on cotton.
(Symposium paper delivered between 6th. and 9th. Jan. 1969, in the Agricultural Conference Medani, Sudan.)

Canad. Ent. 98 : 704-724.


Indian J. agric. Sci. 3 : 701-752.


Annual Report of the Agricultural Research Division, Entomology Section, Sudan.


NORMAN, N.R. et al. (1953/54). Biology, status and control of the cotton whitefly.
Annual Report of the Agricultural Research Division, Entomology Section, Sudan.

NOIR, M.A. & NOIR, J.J. (1964). Identification, transmission and host range of the leaf curl virus attacks infecting cotton in the Sudan.


(1930). Biological control of the greenhouse whitefly.


Indian J. ent. 28: 299-303.

SWEETMAN, H.L. (1936). The Biological Control of Insects.


Bellville Ont. Canada - the Imperial Parasite Service.

THOMELVA, T.V. (1963). Encarsia a parasite of the greenhouse whitefly, Trialeurodes vaporariorum (Westwood) - Moscow.

Zeichen. Rept. 8: 6.
J. Exp. Appl. 4: 47-53.


Commonwealth Agricultural Bureaux Faraham Royal, Bucks, England.


* References seen as abstracts only.
** Reference read only.
### APPENDIX I

**List of Parasites Recognized on Bemisia Tabaci and its Allied Species**

**Europe and Asia**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-Insect</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Prosopeltella</em> sp.</td>
<td><em>Dialeurodes citri</em> (Ashm.)</td>
<td>India and Indo-China</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Trialeurodes inaequalis</em> (Gouv.)</td>
<td>France</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Acerococcus voglii</em> (Ashby)</td>
<td>Ceylon and Samatra</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Acleurodes ricini</em> (Hirst)</td>
<td>India</td>
</tr>
<tr>
<td><em>Prosopeltella strauss</em> (Silv.)</td>
<td><em>Bemisia giffardi</em> (Kotin)</td>
<td>Malaysia</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Dialeurodes anginana</em> (Mask.)</td>
<td>Batch E. Indies</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Asterochiton</em> sp.</td>
<td>&quot;</td>
</tr>
<tr>
<td>Parasite</td>
<td>Europe and Asia</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td><em>Drepanosiphum striatum</em> (Sick)</td>
<td>Aleurodes sp.</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>Necrasovia rhodii</td>
<td></td>
</tr>
<tr>
<td><em>P. slypealis</em> (Silv.)</td>
<td>Aleurocanthus spinosus (Kuw.)</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td><em>P. ishii</em> (Silv.)</td>
<td>A. incertus (Silv.)</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td><em>P. citrifolii</em> (Silv.)</td>
<td>A. spiniferus (Quaint)</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td><em>P. soliennis</em> (Kuw.)</td>
<td>A. subrotundus (Silv.)</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td><em>P. paratrenza</em> (Silv.)</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td><em>P. arnate</em> (Silv.)</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>Parasite</td>
<td>Host-insect</td>
<td>Locality</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Prospaltella opulenta (Silv.)</td>
<td>Aleurocanthus incertus (Silv.)</td>
<td>Philippines</td>
</tr>
<tr>
<td>P. smithi (Silv.)</td>
<td>A. Voglinsi (Ashby)</td>
<td>China, Japan and Ceylon</td>
</tr>
<tr>
<td>P. divergens (Silv.)</td>
<td>&quot;</td>
<td>India, Java,马来亚, Sumatra and Singapore</td>
</tr>
<tr>
<td>P. lutea (Hasi)</td>
<td>&quot;</td>
<td>Middle-East</td>
</tr>
<tr>
<td>Encarsia sp.</td>
<td>Bauhinia gossypifera (M. &amp; L.)</td>
<td>China</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>Punjab (India)</td>
</tr>
<tr>
<td>Encarsia formosa (Gahan)</td>
<td>Diaspyropodes chittendeni (Laing)</td>
<td>England</td>
</tr>
<tr>
<td>Parasite</td>
<td>Host-insect</td>
<td>Locality</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><em>Euxarxis formosa</em> (Gahan)</td>
<td><em>T. vaporariorum</em> (Westw)</td>
<td>Britain and Germany</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>Bulgaria</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>U.S.S.R. (Moscow)</td>
</tr>
<tr>
<td><em>E. partenopea</em> (Masai)</td>
<td>&quot;</td>
<td>Britain</td>
</tr>
<tr>
<td><em>E. persiquena</em> (Silv.)</td>
<td><em>Aleyrodes brassicae</em> (Walk)</td>
<td>England</td>
</tr>
<tr>
<td><em>E. mercati</em> (Silv.)</td>
<td><em>Aleurocybotes astiferus</em> (Quaint)</td>
<td>Philippines</td>
</tr>
<tr>
<td><em>E. tricolor</em> (Forst.)</td>
<td><em>Aleurcanthus voglini</em> (Ashby)</td>
<td>India, Philippines, Malaysia, Netherlands</td>
</tr>
<tr>
<td><em>E. nipponica</em> (Silv.)</td>
<td><em>Aleurcanthus spiniferus</em> (Quaint)</td>
<td>Japan</td>
</tr>
</tbody>
</table>
### APPENDIX I (Contd.)

**Europe and Asia**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-insect</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Breinocerus serice</em> (Sili.)</td>
<td><em>Aleoecanthus vogloni</em> (Ashby)</td>
<td>Burma, Ceylon and Malay.</td>
</tr>
<tr>
<td><em>E. diversitillata</em> (Sili.)</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td><em>E. sagittum</em> (Naccot)</td>
<td><em>Aleoecides sp.</em></td>
<td>Italy and Spain</td>
</tr>
</tbody>
</table>

**South and North America and the West Indies.**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-insect</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Prospallicia sp.</em></td>
<td><em>P. floridensis</em> (Quaint)</td>
<td>U.S.A. (Florida)</td>
</tr>
<tr>
<td><em>P. citrella</em> (Hov)</td>
<td><em>P. vaporarium</em> (Weste)</td>
<td>Chile</td>
</tr>
<tr>
<td><em>P. transvaga</em> (Timb)</td>
<td><em>P. vaporarium</em> (Weste)</td>
<td>Hawaii</td>
</tr>
<tr>
<td><em>P. aleurodes</em> (Gour.)</td>
<td><em>Aleurodes sp.</em></td>
<td>Trinidad</td>
</tr>
<tr>
<td><em>P. alliata</em> (Gash.)</td>
<td>&quot;</td>
<td>Porto Rico</td>
</tr>
<tr>
<td>Parasite</td>
<td>Host-insect</td>
<td>Locality</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td><em>E. braziliensis</em> (Hemp.)</td>
<td>Aleurothrixus sp.</td>
<td>Haiti</td>
</tr>
<tr>
<td><em>E. clypealis</em> (Silv.)</td>
<td>Aleurocanthus wolgumi (Aeshy)</td>
<td>Mexico</td>
</tr>
<tr>
<td>Encarsia sp.</td>
<td>T. vaporariorum (Wesw.)</td>
<td>Hawaii</td>
</tr>
<tr>
<td>&quot;</td>
<td>Aleurodiscus cardini (Bick.)</td>
<td>Cuba</td>
</tr>
<tr>
<td>&quot;</td>
<td>A. minimus (Quaint)</td>
<td>Porto Rico</td>
</tr>
<tr>
<td>Encarsia pergandiae (Hows.)</td>
<td>T. abutilonis (Hade)</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>&quot;</td>
<td>T. vaporariorum (Wesw.)</td>
<td>&quot;</td>
</tr>
<tr>
<td>E. territoria (Gahan)</td>
<td>T. floridensis (Quaint)</td>
<td>&quot;</td>
</tr>
<tr>
<td>E. forscom (Gahan)</td>
<td>T. vaporariorum (Wesw.)</td>
<td>Canada and B.S.A.</td>
</tr>
<tr>
<td>E. laiaela (Hows.)</td>
<td>&quot;</td>
<td>Chile</td>
</tr>
<tr>
<td>E. vericolor (Sir)</td>
<td>&quot;</td>
<td>Hawaii</td>
</tr>
</tbody>
</table>
### APPENDIX I (Contd.)

South and North America and the West Indies.

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-insect</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. catheriniae</em> (Dob.)</td>
<td><em>Aleostratus sp.</em></td>
<td>Haiti</td>
</tr>
<tr>
<td><em>E. haitiensis</em> (Dob.)</td>
<td><em>Aloispritus floccosus</em> (Nash.)</td>
<td>&quot;</td>
</tr>
<tr>
<td><em>E. cubensis</em> (Gahan)</td>
<td><em>A. howardi</em> (Quaint.)</td>
<td>Cuba</td>
</tr>
<tr>
<td><em>E. portoricensis</em> (Hov.)</td>
<td>&quot;</td>
<td>Santo Domingo</td>
</tr>
<tr>
<td><em>E. aegypti</em> (Hedl.)</td>
<td><em>Trialeurodes merrilli</em> ( Briton)</td>
<td>U.S.A.</td>
</tr>
<tr>
<td><em>E. mexicana</em> (Hov.)</td>
<td><em>T. vaporariorum</em> (Westw.)</td>
<td>Chile</td>
</tr>
<tr>
<td><em>E. mexicana</em> (Hov.)</td>
<td>&quot;</td>
<td>Argentina</td>
</tr>
<tr>
<td><em>E. mexicana</em> (Hov.)</td>
<td><em>Trialeurodes sp.</em></td>
<td>Haiti</td>
</tr>
<tr>
<td><em>E. illinoiensis</em> (Des.)</td>
<td><em>Aleostratus sp.</em></td>
<td>U.S.A.</td>
</tr>
<tr>
<td><em>E. paulistus</em> (Hemp.)</td>
<td><em>Aloispritus floccosus</em> (Nash.)</td>
<td>Haiti</td>
</tr>
<tr>
<td><em>E. portoricensis</em> (Hov.)</td>
<td>&quot;</td>
<td>Porto Rico</td>
</tr>
</tbody>
</table>
### APPENDIX I (Contd.)

**Parasite** | **Host-insect** | **Loc**
---|---|---
**E. haldemani** (How.) | **A. howardi** (Quaint.) | U.S. |
" | **T. suratolens** (Hold.) | " |

**Africa**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-insect</th>
<th>Loc</th>
</tr>
</thead>
</table>
**Prospaltella sp.** | **Bosisia gossypipera** (H. & L.) | Sud |
" | **Trialeurodes savignyi** (Corb.) | S. |
" | **Aleuridius sp.** | " |
**Prospaltella sublutea** (Silv.) | **Bosisia sp.** | Soc |
**P. magniclavus** (Dir.) | **Trialeurodes bokhimi** (Q. & R.) | Br. |
**Encarsia sp.** | **Bosisia gossypipera** (H. & L.) | Sud |
**Encarsia elegans** (Masi) | **Aleuridius niloticus** (Friesner & Hosny) | Egy |
<table>
<thead>
<tr>
<th>Parasite</th>
<th>Host-Insect</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freticularus sp.</td>
<td>Malenezia after (Priesner &amp; Hosny)</td>
<td>Egypt</td>
</tr>
<tr>
<td>&quot;</td>
<td>Aeurolochoa pilotis (Priesner &amp; Hosny)</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>Aeurolochoa citri (Priesner &amp; Hosny)</td>
<td>&quot;</td>
</tr>
<tr>
<td>E. diversiciliatus (Silv.)</td>
<td>B. gosomipera (M. &amp; L.)</td>
<td>Sudan</td>
</tr>
<tr>
<td>E. merius (Silv.)</td>
<td>Aeurocanthus wolusi (Ashby)</td>
<td>Kenya</td>
</tr>
<tr>
<td>Australia and New Zealand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosptella tristis (Schut)</td>
<td>Neomansellia borgii</td>
<td>Australia</td>
</tr>
<tr>
<td>Lacerta fornasca (Gahan,)</td>
<td>T. vaporariorum (Westw.)</td>
<td>New Zealand and Tasmania</td>
</tr>
<tr>
<td>Scientific name</td>
<td>English name</td>
<td>Arabic name</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Cucumis sativus (L)</td>
<td>Cucumber</td>
<td>Khiyar</td>
</tr>
<tr>
<td>Ceratocapsus elitorius (L)</td>
<td>Jew's mallow</td>
<td>Molukhiya</td>
</tr>
<tr>
<td>Capsicum frutescens (L)</td>
<td>Chilli pepper</td>
<td>Shatta</td>
</tr>
<tr>
<td>Cucurbita maxima (Duch.)</td>
<td>Pumpkin</td>
<td>Darna</td>
</tr>
<tr>
<td>Hibiscus occultus (L)</td>
<td>Okra or Lady's fingers</td>
<td>Bannia</td>
</tr>
<tr>
<td>Ipomoea batatas (L)</td>
<td>Sweet potatoes</td>
<td>Bambooy</td>
</tr>
<tr>
<td>Lycopersicon esculentum (Mill)</td>
<td>Tomato</td>
<td>Tamatia</td>
</tr>
<tr>
<td>Lablab vulgaris (Savi)</td>
<td>Bonavist bean</td>
<td>Lubia, af.</td>
</tr>
<tr>
<td>Medicago sativa (L)</td>
<td>Lacerne (alfalfa)</td>
<td>Berzeem</td>
</tr>
<tr>
<td>Phaseolus vulgaris (L)</td>
<td>Haricot bean</td>
<td>Tamulia</td>
</tr>
<tr>
<td>Scientific name</td>
<td>English name</td>
<td>Arabic name</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Portulaca oleracea (L)</td>
<td>Purslane</td>
<td>Higla</td>
</tr>
<tr>
<td>Beta vulgaris sativa (L)</td>
<td>Egyptian reddish</td>
<td>Fugil</td>
</tr>
<tr>
<td>Solanum melongena (L)</td>
<td>Egg-plant</td>
<td>Hadigan</td>
</tr>
<tr>
<td>Vigna unguiculata (Waip)</td>
<td>Cow pea</td>
<td>Lubia hilo</td>
</tr>
</tbody>
</table>