ECOLOGY OF THE CITRUS PSYLLA, TRIOZA ERYTREAE (HEMIPTERA: TRIOZIDAE). 1. DAILY ACTIVITIES AND HABITS OF ADULTS*

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ABSTRACT

Key words: Citrus psylla, Trioza erytreae, behaviour, mating, oviposition

Adults of the citrus psylla are positively phototactic and this behaviour will lead them to the tips of branches where they will have the best chance of finding developing young leaves. At any time of the day and night more than 75 % and at times up to 100% of the adult citrus psylla were present on young leaves and young branches. This is one reason why foliar chemical sprays against this pest need only be applied as light cover sprays.

A movement of some of the adults from young growth points to older leaves takes place during the evenings. This may provide them with more protection against low temperatures and cold winds. There are indications of some form of clumping in the distribution of the adult stage.

Uiterskel

EKOLOGIE VAN DIE CITRUSBLADVLOOI, TRIOZA ERYTREAE (HEMIPTERA: TRIOZIDAE). I. DAAGLIKSE AKTIVITEITE EN GEWOONTES VAN VOLWASSENE

Volwassenes van die triozabladvlooi is positief fototakties in die laboratorium. In die veld sal hierdie gedragspatroon hulle na die punte van takke lei waar die kaste om jong ontwikkelende blare in die wyn beide sal wees. Gedurende enige tyd van die dag en van die nag is meer as 75% en soms tot 100% van die volwasse triozabladvlooi aangeraff op jong blare en jong takke. Dit is een rede waarom chemiese bespuitings teen hierdie plaag tot ligtem in vlammebespuitings beperk kan word.

’n Beweging van volwassenes vind saam vanaf jong groeipunte na ouer blare plaas. Dit kan monatlikklik meer bekrampen teen lae temperatuur en koue winde aan hulle bied. Daar is aanduidings van in vorm van verklomping in die verspreiding van die volwasse studium.

INTRODUCTION

The citrus psylla, Trioza erytreae (Del Guercio) (Hemiptera: Triozidae) is of major economic importance as it is the only known vector of the greening disease of citrus in South Africa (McClean & Oberholzer, 1965). Diseased trees produce poor crops of predominantly greened, worthless fruit which fail to ripen and impart an objectionable bitter-salty flavour when processed. The importance of greening in South Africa was emphasised when approximately 100 000 sweet orange trees were rendered commercially unprofitable (Oberholzer, Von Staden & Basson, 1965). Greening disease has caused fruit losses of between 30 and 100% in orchards at White River, Tzaneen, Modderfontein (Rustenburg) and Pretoria. In addition crop losses of 5 to 30% have occurred at Nelspruit, Kiepersol, the Letsitele and Letaba Valleys, the zone bordering the Modderfontein area (Rustenburg), Lydenburg-Orighstad and the Mudun – Pietermaritzburg district (Schwarz, 1967). Consequently farmers from most of these areas were forced to curtail citrus production (Green & Schwarz, 1970).

Information on the habits of this triozid is still incomplete and mostly has been reported perfunctorily. Moran (1967), Catling (1967) and Moran & Buchan (1975) report that the adults are positively phototactic and Catling (1967) refers to the occasional peculiar wriggling of the adult’s body.

This is the first paper in a series on studies conducted on the behaviour of the citrus psylla. The aim of these studies is to extend our knowledge of the biology and behaviour of this triozid and to determine whether this can be used in formulating an improved pest control strategy.

MATERIALS AND METHODS

About 300 sweet orange nursery trees, Citrus sinensis (Linn.), and 10 young False Horsewood trees, Clausena anisata (Willd.) Hook. f. ex Benth., between 200 and 500 mm high were planted in 4 t nursery bags. This enabled the establishment of a field population of the citrus psylla. To ensure favourable conditions for their breeding the trees were placed under large shade-trees at Nelspruit.

Some of the sweet orange nursery trees were regularly replaced with about 100 others containing young flush. The trees became psylla infested from a nearby citrus orchard; this population supplied material used in these studies.

General behaviour

The behaviour of more than 500 adult citrus psylla on citrus nursery trees were studied in the laboratory and under natural field conditions on False Horsewood and citrus trees. Aspects studied included feeding, movement on the tree, mating and oviposition.

Daily activities

At 08h00 on 20 August 1986, 15 citrus nursery trees, each with mature and immature leaves and with 2-10 adult citrus psylla, were taken from the field population. These were placed about 300 m away from the field population and shaded all day long. These trees and the citrus psyllids on them were left undisturbed for 4 hours. After this period feeding, mating and oviposition behaviour as well as movement on the trees were studied and recorded hourly for a 24 h period. Observations were made by using a dim light source. Care was taken not to touch or disturb the trees during the course of the investigation. Temperature and relative humidities were recorded at the same time intervals as mentioned above. Sunshine data were recorded at a nearby weather station.

These observations were repeated over a 48 h period on 24 and 25 November 1986.

The movements of adult psylla on citrus plants were also studied in the laboratory where light intensity was changed at hourly intervals.
Stridulation

Studies were made in the laboratory and field to determine whether adults stridulate or not. Adult citrus psylla were placed individually on seven citrus nursery trees. These were kept in the laboratory to try and detect, by ear, whether the psylla stridulate. Furthermore, adults were liberated into a plastic bag which was inflated and sealed. According to White (1970), the sound of a psyllid stridulating in such a container is magnified and becomes audible several metres away.

RESULTS

General behaviour

Shortly after the wings of the newly moulted adult have expanded, the insect takes up a feeding position for about 2–12 h. From the time that the developmental process has been completed up to about 30 min later, the adult is reluctant to fly and if disturbed, will jump away and usually falls to the ground. In this case, the adult crawls up any object from where it will commence flying at a later stage.

When walking and occasionally also when sitting, the adult often wriggles its body in the following manner. By bending its middle and hind legs on the right and straightening those on the left, the hind part of the adult's body is moved to the right. This process is repeated to the left and then from side to side. This results in a peculiar wriggling of the body. When disturbed, the adult often moves away and down the branch. If the disturbance is severe, it jumps away and flies off. When the temperature is above about 25°C, adults often jump at the slightest provocation. However, on rainy days and during windy conditions, adults do not usually jump when disturbed and can easily be caught with a pinocete, something which is difficult to do during dry and calm periods.

In the laboratory, adults released in a cage are positively phototactic and many move off plants to the sides of the cage facing the light. After a while most of them will return to the plants but others, especially in large cages, die without moving to the plants.

Daily activities

The hourly activities of adult citrus psylla during winter and summer are given in Fig. 1 and 2 respectively. The prevailing temperatures, relative humidities and sunshine data are also included in the figures.

From Fig. 1a and Fig. 2a it can be seen that more than half of the adult citrus psylla are present on young leaves for most of the day and night. If young branches are included, the figure is more than about 75% for most of the day and up to 100% for short periods.

Some of the adult citrus psylla moved away from the very young growth points and young leaves during the early evening, often settling on the main or side veins of older leaves. As a result of this movement the numbers of adults on older leaves increased from about 17h00 in winter (Fig. 1a). There was little movement in summer (Fig. 2a). The opposite happened the following mornings when many of the adults moved back to young growth points and young leaves. This occurred at about 08h00 during winter (Fig. 1a) and at 09h00 during summer (Fig. 2a). The stimulus for the movement away from the very young growth may be the declining light intensity or the decreasing temperatures. However, since the temperature has hardly started to decrease when this movement commences, it is unlikely that temperature triggers the movement. The movement from older leaves back to the young growth points is possibly stimulated by the increasing light intensity (Fig. 1e; Fig. 2e). However, this could not be proven in the laboratory.

During the movements from young growth points to older leaves, adults often move to a leaf where one or more adults are already present. This may happen even though other leaves may be present in the vicinity. These observations indicate that there may be some form of clumped distribution in the adult stage.

On average, more adults were found to be present on leaf veins (45.8%) than on small branches (22.9%), leaf laminae (16.8%) or petioles (14.7%) (Fig. 1b; Fig. 2b).

Adult citrus psylla spend a large portion of a 24 hour day in a feeding position, apparently feeding. During most of the daylight hours more than 60% were in this position during winter (Fig. 1c) and more than 80% during summer (Fig. 2c). During night, the number of adults in a feeding position was often 100% (Fig. 1c; Fig. 2c).

The movement of citrus psylla on, to and from citrus nursery trees during summer and winter is shown in Fig. 3. There was little variation in the numbers of citrus psylla on the nursery trees for most of the day (Fig. 3). The numbers increased between 16h00 and 18h00 during winter and between 18h00 and 19h00 during summer (when new arriving psylla landed on the trees). During summer a gradual decrease in the numbers occurred during night when predators (Hemiptera and spiders) either caught the psylla or drove them from the trees.

Time of mating

During winter, mating was observed to take place from 08h00 to 19h00. However, a mating pair was also observed at 23h00 (Fig. 1d). There was a peak of mating between 13h00 and 15h00. This was during the warmest time of the day when the percentage of adults mating was as high as 25.

During summer mating took place almost at any time of the day and night (Fig. 2d). Two mating peaks occurred, the one just after sunrise when 11.5% mated and the other between 16h00 and 18h00 when 12.1% mated. The first peak occurred when the temperature had just started to rise and at the second the temperature began to drop and the light intensity decreased. Field observation confirmed that mating may occur at any time of the day or night.

Oviposition

Oviposition usually takes place on the tips of shoots on the youngest growth, including young axillary buds. The favourite places for egg laying are along the edges and midribs on the ventral surface of young leaves. They are also often laid on young leaf petioles, twigs and thorns and may occasionally be found on flower petals and on lemon fruit.

Stridulation

No evidence could be found that stridulation occurs and if it exists, it seems to be, at least for the human ear, not audible.
The observations made by Bedfords and Blowers (1967) and others confirm that the citrus nursery trees can only survive with the help of cover sprays. The use of cover sprays can be increased by applying them as a cover spray (8). Observation on the activity of the adult citrus psylla to be able to jump and fly high to the take-off point is important for the control of the pest. On average, the leaf veins (30%), leaf lamina (15%), and other parts of the leaf (55%) are used by the psylla. This is comparable to the study of Wang (1984) on the psylla in citrus. The leaves (43.0%) and branches (23.7%) have the highest percentage of adults on them. A movement of the branches and leaves during the day can affect the activity of the psylla. The data on the percentage of adults engaging in mating is shown in Figure 2d. The percentage of adults in each position is shown in Figure 2c. The percentage of adults on different parts of the citrus tree is shown in Figures 2a, 2b, 2c, 2d, and 2e. The movement of the citrus trees during the day can affect the activity of the psylla and the percentage of adults on different parts of the tree. The temperature and humidity data are shown in Figure 2f. The data on the percentage of adults engaged in feeding is shown in Figure 2c.
DISCUSSION

The observations that adults are positively phototropic, confirm earlier work (Moran, 1967; Catling, 1967; Moran & Buchan, 1975). In the field this behaviour will lead newly hatched adults and those that have recently dispersed to trees to the tips of branches were the change of finding developing young leaves will be greatest. Furthermore, the observations reported here indicate the adult citrus psylla to be almost exclusively confined to young leaves and young branches. It is known that nymphs can only survive on young tender flush (Van der Merwe, 1923; Annecke & Cilliers, 1963; Moran & Blowers, 1967). For these reasons, foliar chemical sprays against this pest need only be applied as light cover sprays. This emphasises the recommendations for the use of light cover sprays against this pest made by Bedford (1975). The cost of the insecticide applied as a light cover spray is half that of a full cover spray (Bedford, 1975) and it therefore represents a substantial saving.

Observations that adult citrus psylla are reluctant to jump and fly off during windy conditions, is similar to the take-off behaviour of various insects. For instance, Haine (1955) found that there was a tendency for the tree-dwelling aphid species not to take off when exposed to comparatively high wind speeds.

On average, more citrus psylla adults were found on leaf veins (45.8%) than on small branches (22.9%), leaf laminae (16.6%) and petioles (14.7%). This is comparable to the findings of Tsai, Hwang & Wang (1984) with the Oriental citrus psylla, Diaphorina citri Kuwayama on Murraya paniculata (L.) Jack. This psyllid occurred mostly on midveins of leaves (43.0%), followed by petioles (30.7%), leaf blades (23.7%) and branches (2.6%).

A movement of some of the adults from young branches and young leaves to mature leaves takes place during the early evening. This movement was more prominent during winter than summer. Older leaves may provide the adults with more protection against low temperatures and cold winds. In practice this movement may also be of some value in control programmes. It may bring the adults into contact with insecticides which had been applied earlier when these leaves were young. Therefore, if chemicals are applied specifically against the citrus psylla as full cover sprays, the older leaves will also be covered with pesticides and a more efficient control may result. However, the higher cost might not be economically justified and this is not recommended.

Chemicals with long residual action applied to control pests such as citrus thrips, Scirtothrips aurantii Faure, and American bollworm, Heliothis armigera (Hübner), will also be of value in reducing the adult psylla population. It is therefore logical to consider the control of the citrus psylla, citrus thrips and American bollworm as an entity, especially during spring, as has been suggested by Van den Berg, De Villiers & Müller (1983). A single contact insecticide can then replace an application of bait for thrips and one or two contact insecticides for psylla and American bollworm larvae. By doing this, some of the sprays could be made more cost-effective.

Our results indicate that if there is new flush present, citrus psylla remain on the same tree for several hours, especially at night. Furthermore, host searching mostly takes place shortly before sunset (Van den Berg & Deacon, 1989). If it is assumed that greening is mainly introduced to and spread in an orchard from nearby citrus orchards, fast acting contact and systemic insecticides that can kill a psylla within a few hours will probably kill it while still on the first tree. It will thus only be able to infect a single tree with greening. It therefore follows that although contact and systemic insecticides may not prevent the spread of greening to an orchard, they may serve to reduce the spread of the disease.

The highest percentage of mating psylla recorded
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during winter was 25.0 % and during summer 12.1 %.
This may be because mating is concentrated over
a shorter period of the day during winter than
summer and because the individual mating periods
will probably be longer during winter.

Our results suggest that adult psylla may be gregarous
at night. As far as could be ascertained, the
citrus psylla does not stridulate as many Psyllidae
do (Heslop-Harrison, 1960; Campbell, 1964; Whane,
1970). Pheromones may play a role in bringing them
together. Samways & Manicom (1983) mention
the possibility of some mutual attraction between
adult citrus psylla. The nocturnal clumping observed
during the present studies, lends support to this possi-
bility. Aggregation of adults was also observed in the
Oriental citrus psylla, D. citri (Whang, 1981). Ag-
grgregation has obvious mate-location value and if
psylla are able to alert one another to predator
attacks it will also have survival value.

Citrus psylla was found to sit in feeding positions
for long periods of the day. This is true for
other psyllids e.g. Clark (1962) found that Cardias-
pina albiextincta Taylor spends much of its time
feeding or resting. This would account for the earlier
observation (Catling, 1973) that the adult citrus
psylla cannot survive longer than 55 h away from
suitable foliage and that the maximum lifespan in
the absence of their host plants was calculated to be 55 h
(Van den Berg & Deacon, 1988). This could pro-
bably be ascribed to desiccation and predation rather
than to starvation. The extended hours of feeding also
explains why systemic insecticides are so effective against
this pest.

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