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Notes on the biology of the South African citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae)

by

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The biology of *Trioza erytreae* (Del Guercio), African vector of citrus greening disease, was studied in the field and in an open insectary. Short notes on the life history are given. The incubation period varied from 6–15 days and nymphal development from 17–43 days, both being strongly correlated with mean temperature. Pre-oviposition was usually 3–7 days and longevity 17–50 days. Sex ratios fluctuated in the field but females were always predominant. Adults mate several times. Under insectary conditions mated females laid 217–1305 eggs whereas unmated females laid fewer eggs which were infertile. Though field observations revealed a small but definite movement of adults away from citrus, *T. erytreae* does not appear to possess strong dispersal powers.

INTRODUCTION

Trioza erytreae (Del Guercio), a gall-forming psyllid indigenous to the Ethiopian region, is the vector of citrus greening disease in southern Africa (McClean & Oberholzer, 1965). This paper describes the results of studies carried out in an open insectary and brief field observations made in citrus groves at Letaba (Northern Transvaal) and Malkerns (Swaziland) from 1965 to 1969. These new data supplement and largely confirm previous accounts on the biology of *T. erytreae* by Van der Merwe (1941), Annecke & Cilliers (1963) and Moran & Blowers (1967) which were based mainly on laboratory and insectary studies.

RESULTS

Life history notes

The life history of *T. erytreae* is typical of a subtropical psyllid species and there is no diapause. It is confined to the Rutaceae and was occasionally observed on *Clausena anisata* (Willd.) Hook. f. ex Benth in both study regions and on one occasion typical leaf galls were seen on *Oricia* sp. in the Northern Transvaal. On citrus, heavy populations cause severe leaf distortion which is sometimes accompanied by mild chlorosis, though normal leaf colour returns once the insects have departed. There is no apparent decline in the attractiveness of foliage due to feeding and no defoliation or dieback occurs as is the case with *Diaphorina citri* Kuw., the Indian citrus psylla (Husain & Nath, 1927).

The final moult usually takes place during the early morning, beginning at first light. Based on 284 females, the pre-oviposition period was 3–5 days in summer

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(mean temperature 24–26°C) and 6–7 days in winter (14–16°C) though in the absence of young growth this period may be extended indefinitely (Catling, 1969). Mating takes place as soon as the teneral adult hardens and occurs at all times of the day. It is initiated, sometimes aggressively, by the male. A mating pair align themselves in parallel both facing in the same direction and remain *in coitu* for about four minutes. In the insectary, two females were observed to mate an average of 2–3 times a day during a six day period while others mated 3–4 times a day. Longevity appeared to be similar for both sexes.

Duration of immature stages

Durations of the immature stages were observed under varying temperature conditions in the field. Extremes of humidity were not found to affect nymphal development though they may influence incubation period. Adults from a laboratory culture of *T. erytreae* were confined on vigorous citrus seedlings in pots, allowed to lay eggs for 24 hours, and the seedlings then placed outside near a set of meteorological thermometers housed in a Stevenson screen. On some occasions it was possible to make *in situ* counts on naturally-occurring colonies of *T. erytreae*. The insects were examined at daily intervals prior to and during hatching and the emergence of adults. The limit of duration was usually fixed on the day on which the maximum number of individuals hatched or emerged as adults. Colonies suffering high mortality were rejected, as were colonies supported on poor quality plant tissue where nymphal development may be prolonged (Catling, 1971). Mean temperature was calculated from daily maximum + daily minimum/2. Incubation period was based on 14 counts involving 4173 normally hatched eggs while nymphal development was followed on 1696 fifth instar nymphs in 12 counts.

Fig. 1 shows that durations were inversely related to mean temperature. Incubation period varied from 6–15 days and nymphal development from 17–43 days. There is an indication that the threshold temperature for nymphal development lies between 10 and 12°C, mean daily temperatures which are rarely recorded in the citrus regions of southern Africa.

In scatter diagrams drawn from selected *in situ* counts there was a trend for the durations of instars I, II, IV and V to be related to mean temperature. Instar III was usually the shortest and its duration was relatively unaffected by temperature. In laboratory studies, Moran & Blowers (1967) found the durations of instars II, III and IV to be of almost equal length.

Sex ratio

Sex ratios in field populations were determined by rearing adults from fifth instar nymphs or by collecting adults off citrus trees. Also, several *in situ* counts were made on citrus seedlings. In the Letaba district, females predominated in the early summer populations of 1966; in October 38,5% of 577 adults and in November 40,6% of 456 adults, were males. From three *in situ* counts, sex ratios varied from 13,7–50,0% males (355 insects examined). Fig. 2 shows that sex ratios were variable in the Malkerns district but that females were always predominant. On two occasions at very low population densities, small colonies of *T. erytreae* were without males at Malkerns in April 1969. In a culture kept at 18–24°C with a 12 hour photoperiod, the proportion of males declined over a 12 month period until no males were produced at all.

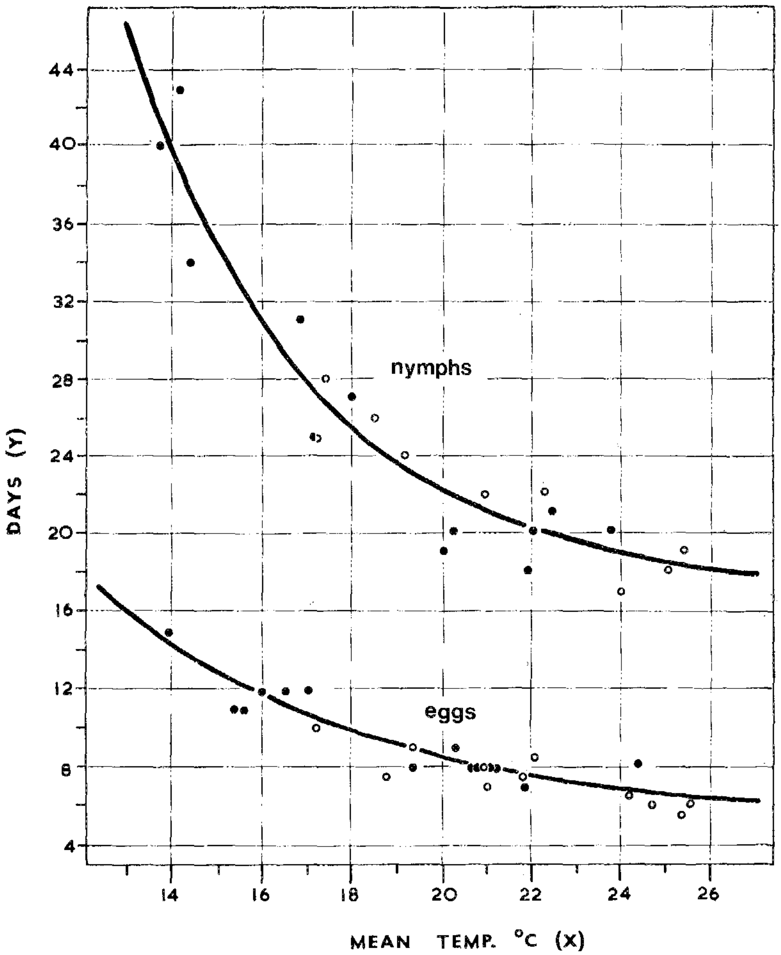

Fig. 1. Incubation period and duration of nymphal development of *Trioza erytreae* against mean temperature, from field studies at Letaba (hollow points) and Malkerns (solid points). Incubation: $Y = 4{,}9763 + 3{,}3443 \times 0{,}8452^{x-20}$, variance accounted for $=$ 86,59% Nymphal development: $Y = 16{,}7974 + 5{,}2726 \times 0{,}7843^{x-20}$, variance accounted for $=$ 91,25%. x-20 was used to reduce computer time.

It appears that males and females develop at about the same rate and have a similar longevity so that sex ratio does not change with the age of the brood as has been reported for *Psylla pyricola* Foerster (Burts & Fischer, 1967). There was no evidence that sex ratio was related to photoperiod, season or flush density, nor could it be correlated with mean temperature, though at Malkerns, the three lowest values for percentage males occurred in the cool months of April, June and August. The pre-

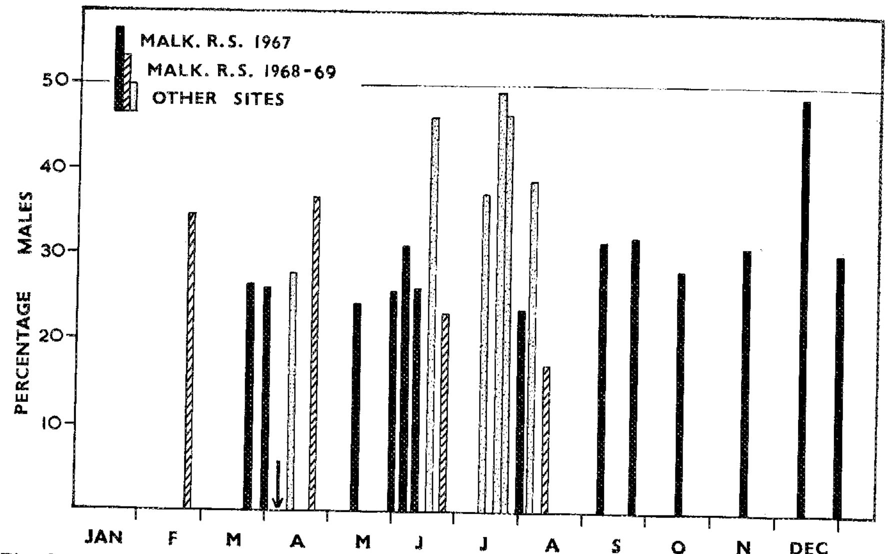

Fig. 2. Sex ratio in field populations of *Trioza erytreae* at Malkerns from 1967 to 1969 (6924 adults examined). Arrow indicates no males present. Malk. R.S. = Malkerns Research Station.

dominance of females, provided they are normally mated, contributes strongly to the fecundity of the species. However, from occasional colonies of infertile eggs recorded at Letaba in 1966 it appears that some females do not find a mate when populations are sparse and adults become widely scattered.

Oviposition

Egg-laying tests and general observations on oviposition were carried out in the insectary at Malkerns. Teneral adults developing from fifth instar nymphs, collected in the field, were carefully transferred to vigorously growing potted citrus seedlings. A single female was confined on each plant, males being introduced according to the nature of the specific test. Despite the use of a fine brush, many of the delicate saltatorial adults were lost or trapped in the lamp chimneys covering the plants. Six series of egg-laying tests were carried out. A daily record was kept of the egg production of individual females in series 1–5, while eggs were counted at weekly intervals in series 6. At weekly intervals, or sooner if all young leaves became densely packed with eggs, females were carefully transferred to new seedlings. An accurate check count was then made on the egg-infested seedlings and where necessary an adjustment applied to the running total of eggs per female. In series 1, females had no access to males. In series 2, fully mature females were supplied with 2–3 males for a three day period, while in series 3–6, females were supplied with 1–2 males constantly.

The results of the egg-laying tests are shown in Table 1. Unlike *P. pyricola*, where Burts & Fischer (1967) found that oviposition rate decreases in the absence of males, there was no significant difference in the total or daily rate of egg production between single or multiple mated *T. erytreae* females. Unmated females produced fewer

TABLE 1. Results of egg-laying tests with *Trioza erytreae* in the insectary at Malkerns, Swaziland, in 1967–68. All females died naturally and lived longer than 14 days. Mean daily egg production excludes pre-oviposition periods.

Series		Unmated	Single early mating	Continuous mating			
Study period		Dec. 6– Jan. 3	Dec. 5– Jan. 3	Dec. 12 –30	Dec. 29– Jan. 24	Jan. 16– Mar. 4	May 21– Jul. 31
Mean temp. °C		23,7	23,7	23,3	25,3	23,4	15,7
Mean RH		69	69	68	69	73	50
No. of females		4	5	3	3	3	6
Mean Longevity in days	Mean range S.E.	19,5 15–28 2,9	25,6 23–28 0,9	17,0 17 0,0	22,3 15–26 3,7	36,3 27–45 5,3	49,5 23–71 6,5
Total egg production	mean range S.E.	216,8 101–437 76,5	828,2 550–1140 98,8	341,7 165–517 103,5	359,7 31–721 203,6	1304,7 1049–1604 164,7	1303,8 266–2542 299,6
Mean daily egg production per female	mean range S.E.	21,1 7–18 2,6	34,7 22–50 4,9	23,6 11–37 7,5	17,3 6–30 6,9	39,6 29–46 5,2	28,7 17–40 3,1
Max. number eggs per day*		76 33	143 100	73 53	64 58	159 106	—

* For the two most productive females

eggs than mated females ($P<0,05$) and their mean daily production was significantly lower than that of single ($P<0,01$) or multiple mated females ($P<0,05$). Eggs produced by unfertilized females were always infertile, whereas under favourable conditions the fertility of eggs laid by normally mated females was usually better than 95%. The egg production obtained in series 5 and 6 was considerably higher than that quoted by Van der Merwe (1941) and Moran & Blowers (1967). It is likely that under the insectary conditions, where test insects were provided with an unlimited supply of nutritious foliage, oviposition rates were higher than would often be realized in the field except during the spring flush cycles.

Eggs may be deposited immediately after mating has ceased and were laid freely at all times of the year. Mated and unmated females start to lay at about the same time and females were found to remain fertile for 11–16 days after removal of males. Despite an irregular daily pattern, maximum egg production occurred towards the middle of the adult lifespan after which there was a gradual decline (fig. 3). Egg-laying ceased a few days before death. Eggs were laid at mean daily temperatures

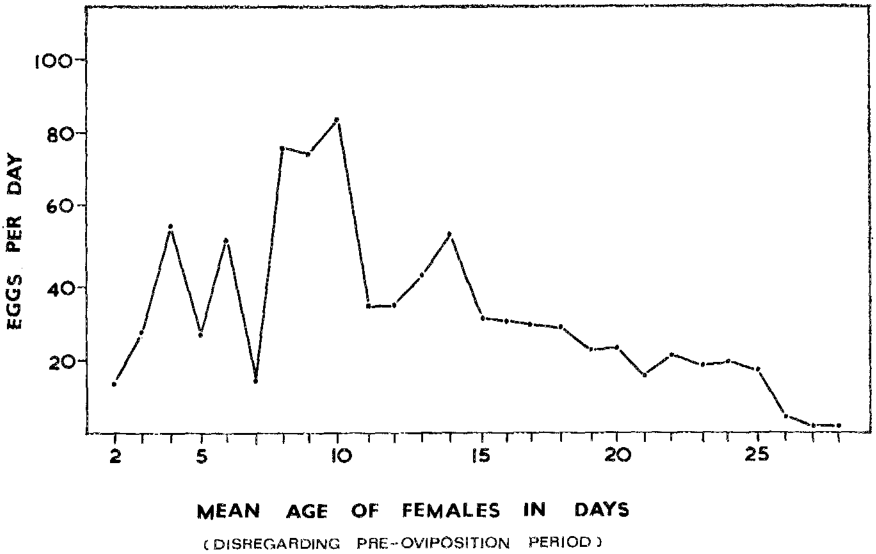

Fig. 3. Mean daily egg production of five *Trioza erytreae* females having a similar adult lifespan, on citrus seedlings in the insectary at Malkerns.

between 14 and 29°C and mean daily relative humidities between 27 and 94%. There was a slight tendency for more eggs to be deposited with a rise in temperature, but the high day to day variation in egg-laying rendered this trend of doubtful significance. According to Bursell (1964), with the fluctuating temperatures experienced in the field, egg production may not follow any simple relationship with mean temperature. Moran & Blowers (1967) reported that oocyte development in *T. erytreae* was inhibited under a daily fluctuating temperature regime with several hours at 32°C. In the insectary at Malkerns, however, no decline in egg-laying was observed during or following periods of up to 10 days of maximum daily temperatures reaching 32°C—including five consecutive days with 3–7 hours above that temperature.

In the winter test series, during which low levels of humidity prevailed, there was an apparent decline in egg production below 50% RH. The mean production of six females for 8–11 day periods declined through 38,2; 31,1; 27,7 and 24,4 eggs per day with a progressive decrease in mean daily RH of 62, 49, 45 and 44%. On analysis however, the regression coefficient was found to be non-significant.

Dispersal

Dispersal was studied in a large grove of three-year-old citrus trees at Letaba under conditions of plentiful young growth and little wind. In mid June 1966, a careful inspection revealed two colonies of *T. erytreae* on a single tree in the centre of the study grove; no other trees were found to be infested. A main data block of 50 trees was then marked out around the infested tree (number 26, fig. 4), these trees being carefully inspected at weekly intervals thereafter. Five inspections carried out between

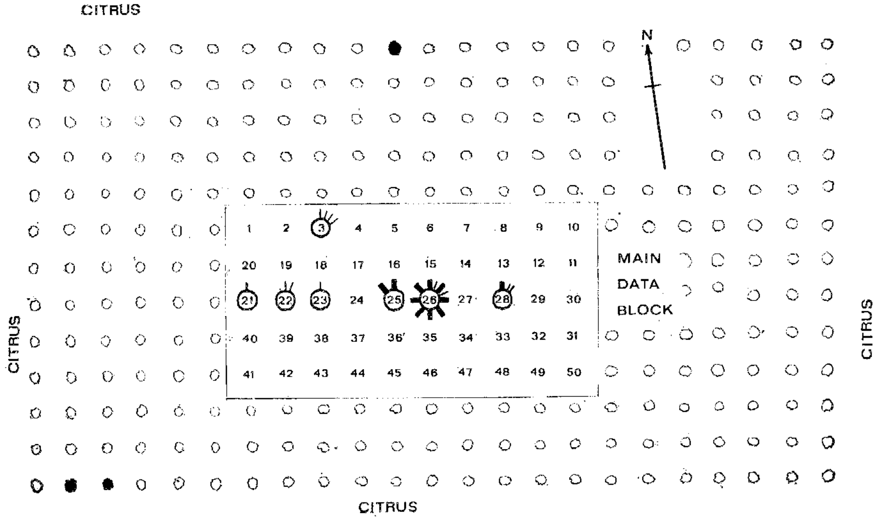

Fig. 4. Presumed dispersal of *Trioza erytreae* adults from a single infested citrus tree (No. 26) at Letaba. Colonies within the main data block are shown by heavy lines (5 colonies) and thin lines (1 colony). Infested trees outside of main data block are shown solid.

July and mid October revealed five colonies outside the main data block. Between July 16 and 18, 105 adults emerged from the two colonies on tree 26. Over the following 2,5 month period 67 colonies were recorded in the main data block, 95% of these were present in the same central row where the trees were only 3,7 m apart and 88% were within an eight metre radius of their presumed origin. In every case the developmental stage of the insects recorded in the main data block indicated their origin to be tree 26.

Studies on flight activity were carried out at Malkerns between November 1968 and December 1969. Three pairs of yellow impact traps, operated continuously, were mounted on a ladder at heights of 1,5, 8,0 and 15,0 m above the ground. The ladder was placed 40 m from a study grove near a large thicket of natural bush containing apparently, no alternate host plants. Two more traps were operated in the thicket. Four specimens of *T. erytreae* were taken by the impact traps on the ladder in the first summer season at a time when a peak of adults was indicated in the study grove. In the following season, six adults were trapped on the ladder impact traps (with fragments of possibly two more specimens) and nine adults were recorded in the thicket. On the ladder impact traps, most individuals were collected on the lower trap facing the grove. Between August and December 1969 when air samples were taken at regular intervals with a Johnson & Taylor enclosed suction trap mounted near the ladder impact traps, five adults were caught. Females were predominant in all traps.

Since the dispersal studies described here were restricted to simple field observations, only tentative conclusions can be drawn. Clearly this aspect warrants further investigation. The studies suggest that *T. erytreae* does not disperse strongly from citrus which has plentiful young growth. No dispersal phase or behavioural response to reach upper air levels was observed though such behaviour could have passed undetected.

Though powerful fliers, the usual flight habit of *T. erytreae* is to circle several times before resettling near the take-off point. Test adults survived less than 55 hours away from suitable foliage and according to Catling (1972), females appear to have limited searching powers for breeding sites. However, trapping studies at Malkerns indicated a definite movement of *T. erytreae* away from citrus at rates similar to that shown by some aphids having effective dispersal and long range migration. Moreover, dispersal from alternate host plants has yet to be considered.

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