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DISPERSAL OF THE CITRUS PSYLLA, *TRIOZA ERYTREAE* (HEMIPTERA: TRIOZIDAE), IN THE ABSENCE OF ITS HOST PLANTS

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Abstract

Key words: Citrus psylla, *Trioza erytreae*, dispersal

Dispersal of the citrus psylla was studied by releasing about 25 000 adults in a ploughed land of 3 × 2,5 km and recapturing them with yellow sticky traps. Even in the absence of their host plants, they were able to disperse with the aid of prevailing winds to a distance of at least 1,5 km. More females than males were captured at distances further than 500 m. An estimation of the maximum lifespan of the citrus psylla in the absence of their host plants was calculated to be 85,37 h. This phenomenon can probably be ascribed to desiccation rather than starvation.

Uittreksel

VERSPREIDINGSVERMOË VAN DIE SITRUSBLADVLOOI, TRIOZA ERYTREAE *(HEMIPTERA: TRIOZIDAE), IN DIE AFWESIGHEID VAN SY GASHEERPLANTE*

Verspreidingsvermoë van die sitrusbladvlooi is bestudeer deur ongeveer 25 000 volwassenes in 'n geploegde land van 3 × 2,5 km los te laat en hulle te herversamel met klewerige geel valle. Die volwasse sitrusbladvlooi kan saam met heersende wind versprei tot minstens 1,5 km, selfs in die afwesigheid van hul gasheerplante. Meer wyfies as mannetjies is op afstande van verder as 500 m gevang. Die maksimum lewensduur in die afwesigheid van hul gasheerplante is beraam op 85,37 h. Hierdie verskynsel kan heel moontlik eerder aan uitdroging as uithongering toegeskryf word.

Introduction

The citrus psylla, *Trioza erytreae* (Del Guercio) (Hemiptera: Psylloidea: Triozidae), is the only known vector of the heat sensitive strain of greening of citrus that is present in South Africa (McClean & Oberholzer, 1965; Moll & Martin, 1973). Sections of a tree affected by greening bear abnormal fruit, and eventually severe tree decline takes place. As a result of the greening disease severe crop losses have been experienced in the White River and Plaston areas (Eastern Transvaal), Rustenburg (Western Transvaal) and Tzaneen-Politsi (Northern Transvaal) (Oberholzer, Von Staden & Basson, 1963). Consequently farmers from these areas have been forced to curtail citrus production (Moll, Van Vuuren & Milne, 1980; Van den Berg & Nel, 1981).

Apart from the spread of greening through infected nursery trees, which can be limited by good nursery practices and application of existing legislation, the citrus psylla may be the only long distance transmitting agent of the disease. A sound knowledge of the dispersal of the citrus psylla is therefore of great importance. Conflicting opinions exist over the dispersal ability of this pest. Catling (1973) stated that this psyllid does not appear to possess strong dispersal powers, and later (1978) stated that adults have weak dispersal powers and are not capable of sustained flight. Samways & Manicom (1983) on the contrary, demonstrated that the citrus psylla is indeed an excellent invader and can readily locate isolated areas of flush over several hundred metres.

There is great variation of dispersal ability within the Psylloidea e.g. *Cardiaspina albitextura* Taylor, has limited powers of dispersal and the majority of females oviposit within 91 m of where they originated (Clark, 1962). On the other hand, certain psyllids disperse long distances on air currents, e.g. *Paratrioza cockerelli* (Sulc) which is often collected as a significant component of the aerial plankton (Glick, 1939 in Hodkinson, 1974; Jensen, 1954). In the third case, there is variation in the dispersal ability of different generations of the pear psylla, *Cacopsylla pyricola* (Förster). The summer generations of this species (F1–F3) show very limited flight activity while the hibernating generation (F4) disperses strongly (Swirski, 1954; Wilde, 1962). However, extensive dispersion may also take place (Fye, 1983) if high populations of pear psylla occur when they are in the prehibernating generation (F3). It therefore seems possible that species like *C. pyricola,* which are capable of distant dispersal only do so as a result of shortage of food or egg laying sites.

The aim of this study was to determine the dispersal ability of the citrus psylla in the absence of its host plants. This will give an indication of how far orchards have to be separated before they can be considered isolated. In practice, this may demonstrate the influence of a lack of effective psylla control in one orchard on the influx of psylla in nearby orchards.

Materials and Methods

The research was done near Roedtan on the farm Platdoorns (24° 27′ S 28° 56′ E), where no commercial citrus production occurred within a radius of 20 km. The experiment was laid out in a land, measuring 3 × 2,5 km, which consisted of ploughed black turf soil covered with about 2 % wheat straw of the previous year. Less than about 0,01 % of the soil was covered with newly emerged weeds. The more common species were *Amaranthus spinosus* L., *Datura stramonium* L., *Datura ferox* L., *Ipomoea coscimosperma* Hochst. ex Choisy, *Ipomoea sinensis* (Desr.) Choisy subsp. *blepharosepala* (Hochst. ex A. Rich.) Verdc., *Senecio consanguineus* DC., *Sesamum tripyllum* Welw. ex Aschers. and *Setaria verticillata* (L.) Beauv. An experimental block with 50 m intervals in a 500 × 500 m grid was measured out in the centre of the land with the rows running due north to south and east to west. Around this grid a bigger grid was laid out with 250 m intervals in a block of about 2 × 2 km (Fig. 1). On each intersection of the grid rows an iron pole, in the shape of a T-piece was driven into the ground to provide a horizontal platform at 1 m height. A saturn yellow trap, 210 × 220 mm (Samways, 1984), was clamped in an upwards-facing horizontal position on each of the platforms. These traps were each painted

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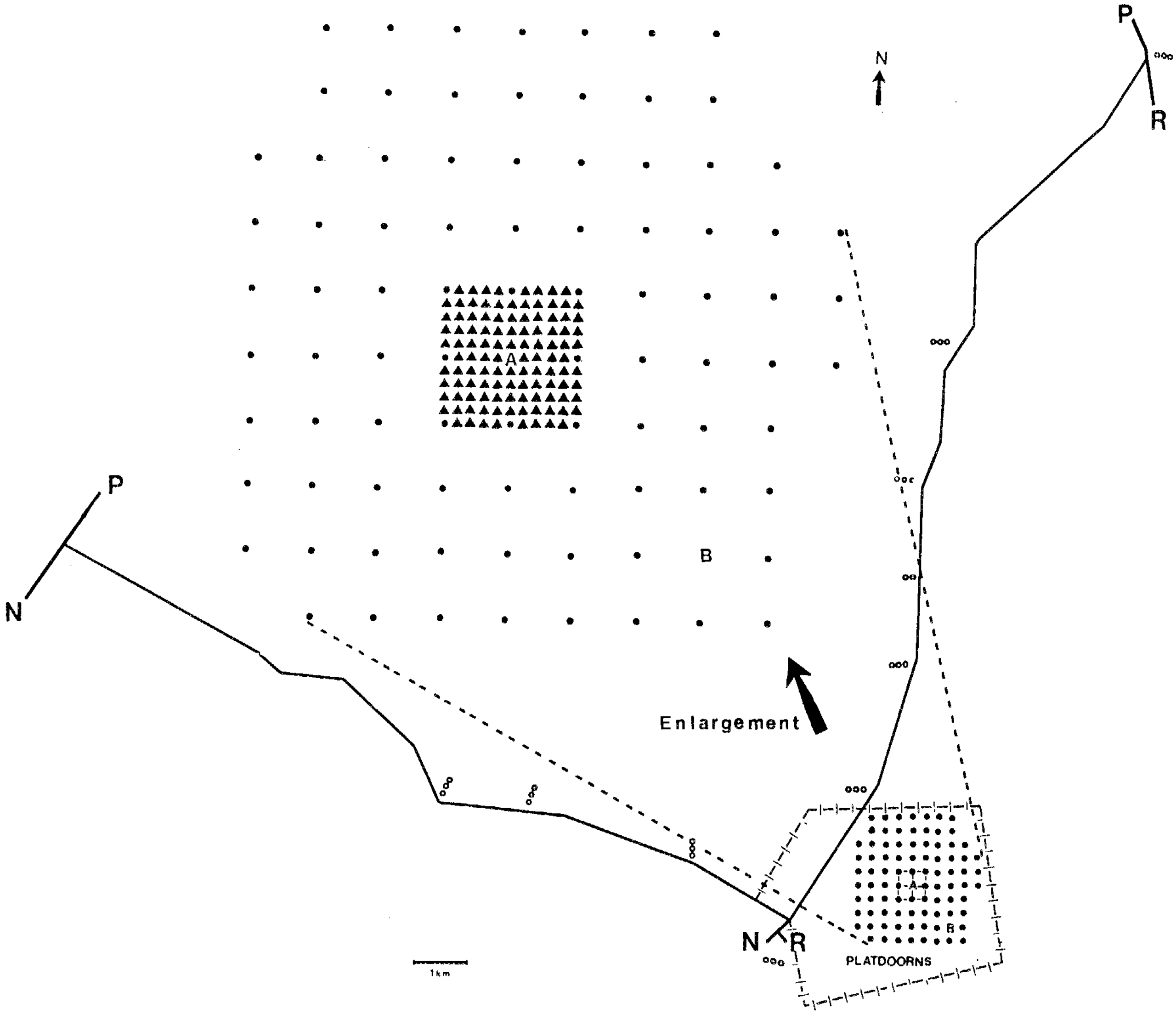

FIG. 1 Positions of release points and traps
A = First release point
B = Second release point
▲ = In operation during first trial
• = In operation during both trials
° = In operation during second trial
Road to: P = Potgietersrus, N = Naboomspruit, R = Roedtan

with clear polybutene adhesive to provide a sticky trapping surface. An anemometer erected at a height of 1,5 m on the outside of the inner grid recorded wind speed and direction during the course of the experiment. An adjacent Stevenson screen contained a thermohygrograph, wet and dry bulb and minimum and maximum thermometers.

Adult citrus psylla were obtained for the study as follows: Citrus branches with leaves infested by final instar nymphs were collected in orchards in the Nelspruit area. These branches were placed in water-saturated oasis floral foam which was kept in plastic containers. Three of these plastic containers with infested branches were then placed on the hardboard floor of a cage (260 × 370 mm and 800 mm high) which enclosed the leaves and branches of a sweet orange nursery tree. The bottom 500 mm of the organdie sides of the cage were darkened with brown paper, while a groove was made in the base of the cage through which the stem of the tree fitted. This was sealed off with brown paper and masking tape. Adult psylla emerged within a few (2–7) days after being collected, moved upwards against the sides of the cage and the stem, and commenced feeding on the tree. A total of six sweet orange nursery trees, 0,8–1 m high, free of greening disease and bearing new flush were each infested in this way. The caged infested trees were transported to the experimental site three days after the nymphs were collected.

Experiment I

Three of the cages were opened at the centre of the inner grid an hour after sunrise on 23 April 1986 to release about 15 000 psylla. The cages were closed and removed after 24 h.

The traps in the inner grid were checked daily for the next three days and the sexes of the trapped psylla were determined microscopically and recorded for every trap. The other traps were checked on the second and third days.

Experiment II

On the third day, after all the psylla had been removed from the traps, the traps of the inner grid were removed with the exception of the eight traps falling in the outer grid. A trap was also erected at the centre of the inner grid where the previous release point was. A second release point was chosen near the south-western corner (Fig. 1). A further 26 traps, in groups of two or three, with intertrap distances of 30 m were erected at locations extending from 2,2 to 15,1 km from the second release point (Fig. 1).

During the afternoon of 26 April, about 10 000 adult citrus psylla were released from the remaining three cages in the same manner as described above. The traps in the grid were checked for citrus psylla after 4 days and then removed. The other 26 traps were only checked for citrus psylla after 7 days and were then removed.

RESULTS

Experiment I

Observations at the release point as well as preliminary counts on some of the traps which were examined 6 h after the time of release indicated that most of the psylla dispersed shortly after being released.

The dispersal of psylla in the small grid and the wind roses for the first day and for the second and third days combined are provided in Fig. 2. From Fig. 2 it is clear that the dispersal of the citrus psylla was mainly in the direction of the wind that prevailed during the first day. Although it seems that a few psylla flew upwind, it is more likely that they would have dispersed during the calm periods of which there were 1 and 2 h during the first and second day respectively. The temperatures and humidities during this trial (Table 1) were moderate and comparable to the long term means recorded for April at Nelspruit (min. 14, 5 °C and 37, 4 % R.H., max. 27,0 °C and 87,1 % R.H.) (Anon., 1987). For this reason the prevailing temperatures and humidities during these trials should not have had a greater effect on dispersal than it would have had in citrus orchards at Nelspruit.

As psylla were also captured on some of the most distant traps in the outer grid (Fig. 3) some of the citrus psylla probably dispersed much further. To calculate this probability, the number of psyllids trapped in the inner grid were compared to those trapped in the outer grid. The length of an arc subtending a given angle increases in direct proportion to the distance from the vertex. Thus it follows that the arc within which a trap is situated is twice the length of that of a trap at half the distance. Therefore, if insects were able to disperse to unlimited distances from a release point, the chances of recapturing them would be inversely proportional to the distance they are situated from the release point. To calculate the probability that the psylla could disperse further, the ratios of psylla collected on traps on the 16 compass bearings from the release point were calculated as explained in Table 2. The psylla would probably not have dispersed further than the furthest traps on the bearings where X = 0 (Table 2) e.g. NNE, NE and ENE. However, the chances are exceptionally good that females dispersed further than 978 m to the WNW and 1 160 m to the NW (1,22:1 and 2,22:1 respectively). The chance of dispersion further than 558 m to the WSW by females is about equal (0,96:1) whereas the chances for females to disperse further than 1 520 m to the N or 1 076 m to the NNW was less than equal i.e. 0,38:1 and 0,66:1 respectively.

The chance that males dispersed further than 1 250 m to the NNW, was 1,06:1, whilst the chances of them dispersing more than 558 m in the WNW direction or 1 250 m in the NW direction was small, i.e. 0,32:1 and 0,53:1 respectively.

Experiment II

No psylla was captured on the traps outside the outer grid. Dispersal of psylla from the second release point is

TABLE 1 Prevailing temperatures and relative humidities during the trials

	Temperature (°C)			Relative humidity at 08h00
	Min	Max	Mean	
Experiment I				
Day 1	15	23	19	73
Day 2	14	26	20	80
Day 3	7,5	23	15,3	57
Experiment II				
Day 1	8	24	16	59
Day 2	10	25	17,5	71
Day 3	9	27	18	65

TABLE 2 Calculations of the dispersal of citrus psylla to traps in the same direction from the release point

Wind direction	ΣA_1B_1		Mean of A_1		ΣA_2B_2		$\frac{\Sigma A_1B_1}{\Sigma A_2B_2}$	
	♀	♂	♀	♂	♀	♂	♀	♂
N	1 520	0	1 520	0	3 695	4 720	0,38	0
NNE	0	0	0	0	1 599	1 003	0	0
NE	0	0	0	0	676	989	0	0
ENE	0	0	0	0	450	0	0	0
E	0	0	0	0	150	50	0	0
ESE	0	0	0	0	0	0	0	0
SE	0	0	0	0	71	71	0	0
SSE	0	0	0	0	319	0	0	0
S	0	0	0	0	200	200	0	0
SSW	0	0	0	0	368	113	0	0
SW	0	0	0	0	2 163	884	0	0
WSW	1 674	0	558	0	1 735	2 187	0,96	0
W	0	0	0	0	1 755	1 405	0	0
WNW	2 935	558	978	558	2 410	1 724	1,22	0,32
NW	6 960	1 250	1 160	1 250	3 134	2 344	2,22	0,53
NNW	2 152	3 750	1 076	1 250	3 280	3 524	0,66	1,06

Where A_1 = Distance of a trap T_1 in the outer grid from release point
B_1 = Number of psylla on trap T_1
A_2 = Distance of a trap T_2 in the inner grid from release point
B_2 = Number of psylla on trap T_2

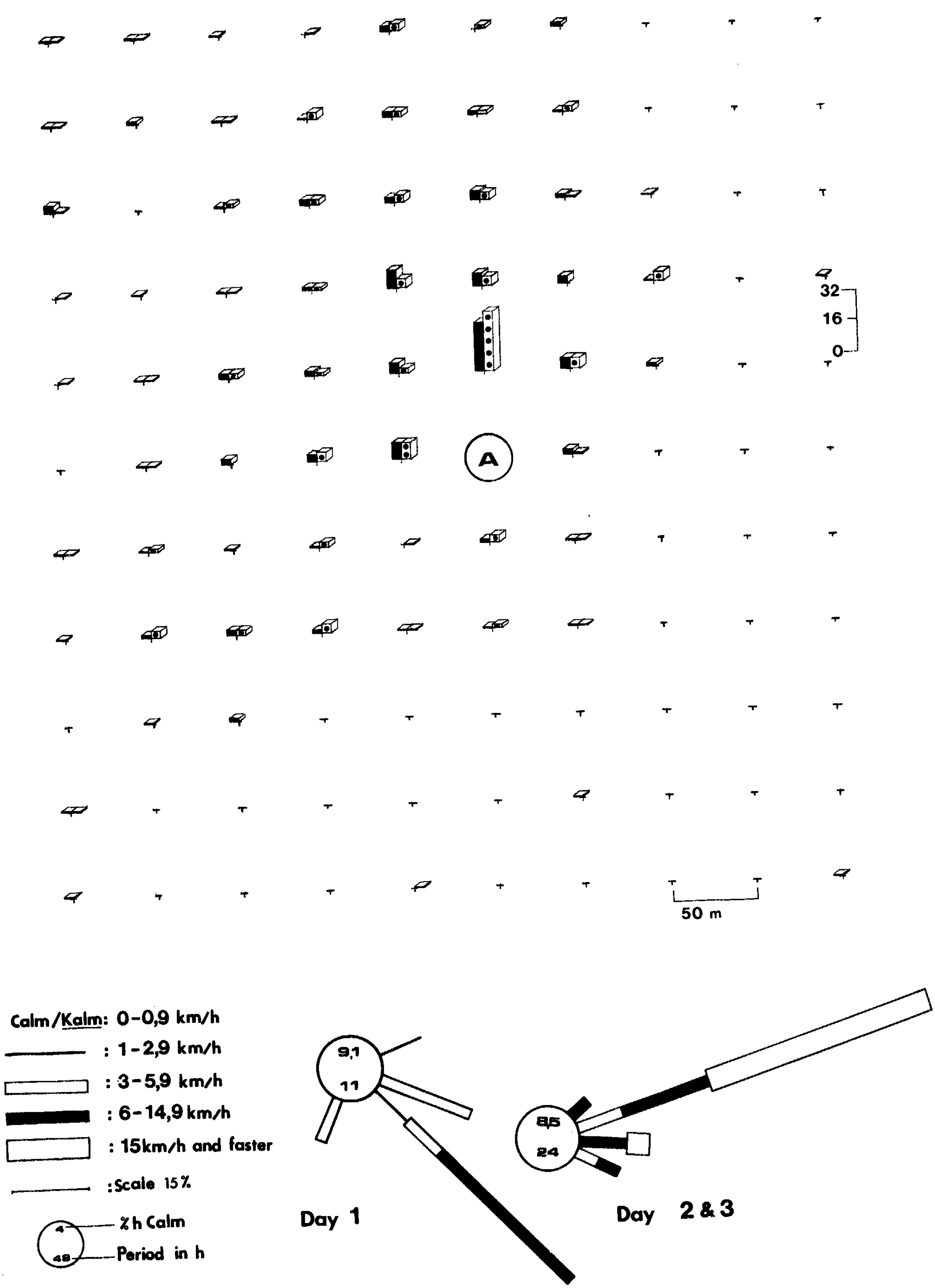

FIG. 2 Dispersal of citrus psylla during the first to third day after release in a grid of 500 × 500 m and the corresponding windroses (Experiment I)
A = Release point
+ = Traps
Females (black columns), males (dotted columns)

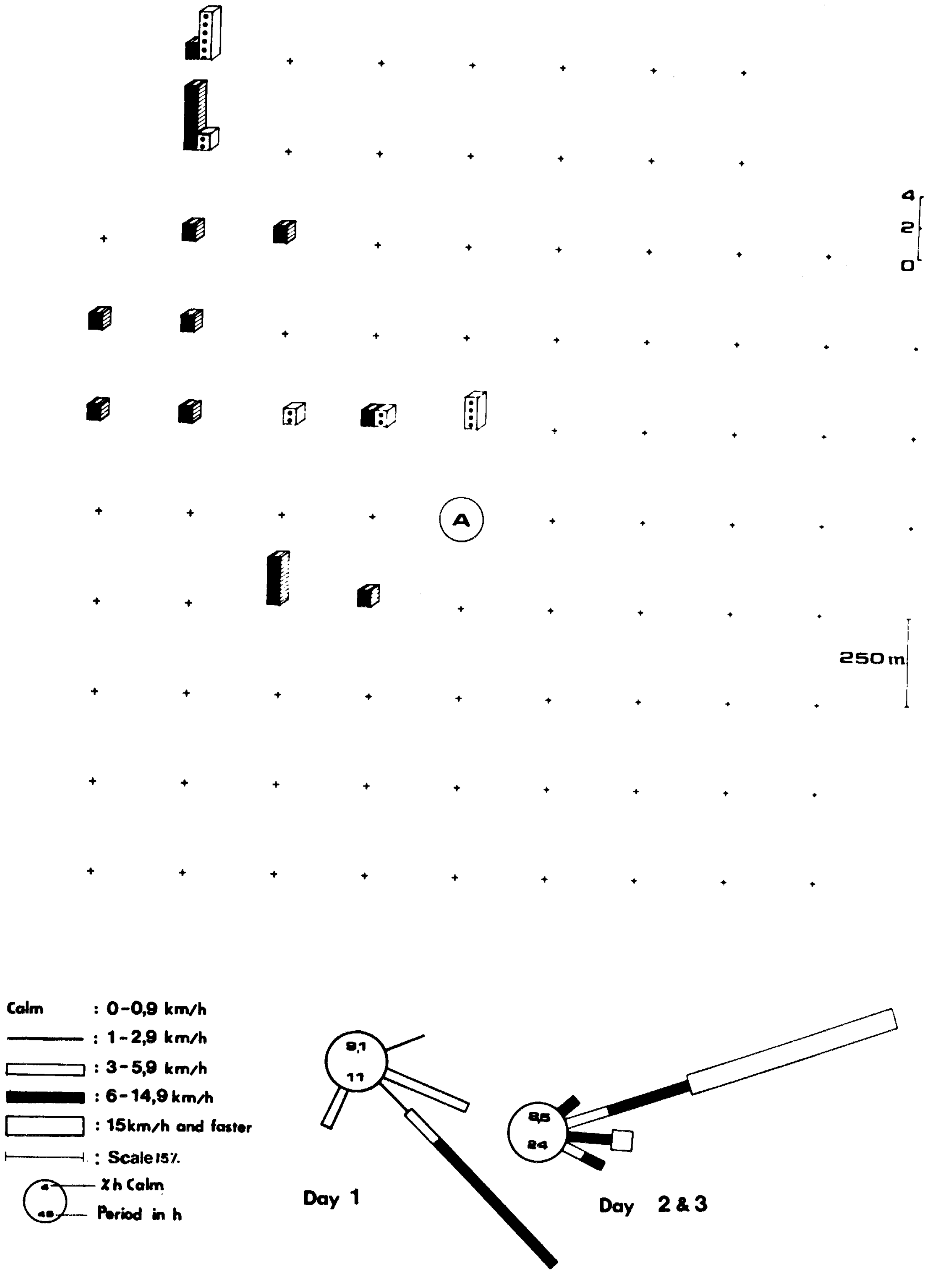

FIG. 3 Dispersal of citrus psylla after release in the outer grid of about 2 × 2 km (Experiment I)
A = Release point
+ = Traps
Females (black colomns), males (dotted columns)

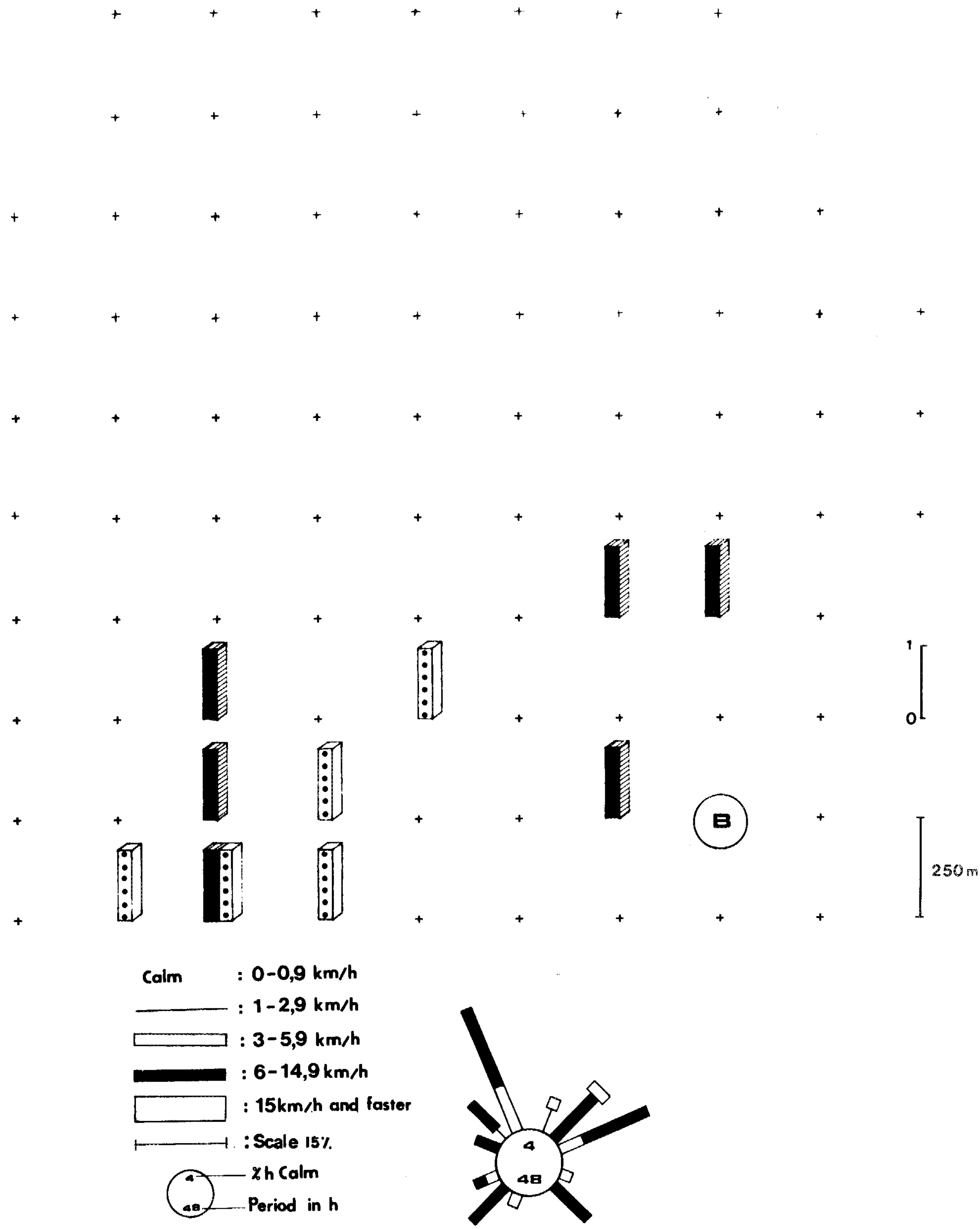

FIG. 4 Dispersal of citrus psylla after release in a grid of about 2 × 2 km (Experiment II) and the corresponding windrose
B = Release point
+ = Traps
Females (black columns), males (dotted columns)

shown in Fig. 4. The furthest dispersal observed was 1 520 m for a male and 1 275 m for a female (Fig. 4).

Distances flown by the different sexes

The dispersal distances achieved by the citrus psylla during both experiments are summarised in Table 3. The ratio of females to males is slightly larger for the cumulative number trapped in the first 300 m (1,1:1) and much larger when all those trapped further than 300 m are combined (1,8:1). Although no statistical difference occurred for the latter (t = 1,058; d.f. 24; assoc. prob. = 0,150), there was a tendency for females to disperse somewhat further than males.

TABLE 3 Distance of dispersal by the sexes of the citrus psylla (both experiments)

Distance in m	Females	Males	Ratio ♀ : ♂
1–100	64	65	0,98:1
101–200	53	43	1,23:1
201–300	38 (T 155)	33 (T 141)	1,15:1 (T1,10:1)
301–400	5	4	1,25:1
401–500	1	0	1 :0
501–600	4	1	4 :1
601–700	0	0	0 :0
701–800	1	1	1 :1
801–900	0	0	0 :0
901–1 000	2	1	2 :1
1 001–1 100	2	1	2 :1
1 101–1 200	1	0	1 :0
1 201–1 300	8	5	1,6 :1
1 301–1 400	0	0	0 :0
1 401–1 500	1	0	1 :0
1 501–1 600	0 (T25)	1 (T14)	0 :1 (T1,79:1)
Total	180	155	1,16:1

The furthest recorded distance observed were almost the same for both sexes, i.e. 1 520 m for males and 1 460 m for females.

Estimate of survival in the absence of host plants

Estimates of the survival of citrus psylla adults were made from the daily catches on the inner traps. These estimates represent the proportion of the population which did not die or migrate during the intervals between samples.

The calculated estimate of survival is 85,37 h ($y = 2{,}4024 - 0{,}0281x$; $F = 113{,}7$: $P = 0{,}0004$). No statistical difference occurred between the estimated life-spans of the sexes (Mann-Whitney U-statistic = 4,0, not significant at $P = 0{,}05$).

Discussion

There were indications that adult citrus psylla, even in the absence of their host plants can disperse with the help of prevailing winds, to a distance of at least 1,5 km. This is not in agreement with observations of Catling (1973, 1978) who found that the citrus psylla does not have strong dispersing abilities. However, the present work supports that of Samways & Manicom (1983) who found that citrus psylla are excellent invaders and that they can readily locate isolated areas of flush over several hundred metres. In practice it means that orchards have to be at least 1,5 km apart before they can be considered isolated. The lack of psylla control in one orchard can therefore have an influence on the population size of this pest on orchards as far as 1,5 km downwind and, also on the spread of greening in those orchards.

The dispersal abilities of various members of the Psylloidea differ considerably. Some species have limited powers of dispersal (Clark, 1962), some disperse over long distances on air currents (Jensen, 1954), and in the case of others the different generations have different dispersal abilities (Swirski, 1954; Wilde, 1962). Even population density could play a role in this regard (Fye, 1983).

It seems possible that the citrus psylla only disperses over long distances when forced to do so. Thus under favourable conditions short distance rather than long distance dispersal can be expected. This would account for the short distance dispersal reported by Catling (1973, 1978). It would also account for dispersal over longer distances to abundant new flush as reported by Samways & Manicom (1983) and the long distance dispersal in the absence of host plants as reported in this study.

A more acceptable explanation is that emigration may be a regular feature of the life cycle of the citrus psylla, as it is of a broom psyllid, *Arytaina spartiophila* (Förster) (Watmough, 1968). If this is the case, emigration will occur even when the population density of adults is low and abundant flush is available.

Although there was a tendency for females to disperse somewhat further than males the difference was not statistically significant. If females do disperse further, it will enable them to infect new and uninfected citrus orchards and rutaceous plants.

The estimate of the maximum lifespan calculated to be 85,37 h in the absence of their host plants agrees favourably with Catling (1973) who stated that adults survived less than 55 h away from suitable foliage. This is also in agreement with the observations of Clark (1962) who found that when deprived of foliage the psyllid, *Cardiaspina albitextura,* cannot survive for more than a few hours in summer or for more than 2–3 days at cooler times of the year. The reason why adult citrus psylla succumb after a few days in the absence of host plants could probably be ascribed to desiccation rather than starvation. The estimated survival (3,56 days) for *T. erytreae* in the absence of their host plants, is considerably less than the 17–50 days longevity observed by Catling (1973) under insectary conditions. If their host plants were present during these trials, their life-span would probably have been extended and they may even have dispersed further than the distances observed during these trials.

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