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Ecological studies of asiatic citrus psyllid (*Diaphorina citri* K.) with special reference to its spatial distribution[1]

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Abstract : Experiments on spatial distribution of asiatic citrus psyllid (*Diaphorina citri* Kuwayama) were conducted at Taiwan Agricultural Research Institute from the winter of 1979 to the summer of 1981. Forty 4th or 5th instar nymphs of asiatic citrus psyllids were introduced on 240 pot-raised citrus saplings (*Citrus reticulata* var. *Suenkat*) in greenhouse. The highest mean density observed was 57.1 nymphs per sapling. The relative degree of aggregation (m^*/m) was high during the low population density period when *D. citri* was just introduced into greenhouse, and declined as the population density increased. This figure tended to be stable when the insect has been introduced into greenhouse for more than 2 months. The m^*-m relationship in nymphal and adult populations were expressed as $m^*=3.86+2.83m$, and $m^*=5.86+1.33m$, respectively. Both nymph and adult aggregated to form colonies as distribution units and the units with random inntra-colony distribution distributed contagiously. The colony area ranged from 1 to 4 saplings.

Naturally occurring *D. citri* in field had m^*-m relationship as $m^*=0.73+2.46m$ for nymph and $m^*=0.76+2.23m$ for adult. Both nymph and adult had smaller unit colonies in field than in greenhouse. The distribution of nymph and adult in field had similar aggregation tendency. The colony area in field was approximately 1-2 branches.

The asiatic or oriental citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera : Psyllidae), distributed primarily in tropical and subtropical Asia, has been reported causing serious damage to citrus [7]. The damage results from the growth of sooty mold on psyllid honeydew covered leaves, and transmission of the pathogen that causes greening disease [6]. The psyllid is a very destructive pest and has played an important role in citrus production [4].

This study was initiated to investigate the population buildup in greenhouse, population flunctuation in field, and characteristics of spatical distributions. These informations are valuable for understanding the population of asiatic citrus psyllid and essential for developing sampling plan for its management.

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Materials and Methods

Experiment was conducted at Taiwan Agricultural Research Institute from the winter of 1979 to the summer of 1981. In greenhouse, two hundred and forty 3-year-old citrus saplings (*Citrus reticulata* var. *Suenkat*) of about 50cm high with 3-5 branches were planted individually in pot (dia. 24cm). Pots were arranged in a square-grid pattern of 12 rows and 20 lines in an area of $3.8\times6.3m^2$(Figure 1). Forty 4th or 5th instar psyllid nymphs were evenly introduced on 8 randomly selected plants on 18 December 1979. Observations on the population distribution and buildup were started on 18 January and terminated on 30 June 1980. Number of psyllid were counted twice a week during this period. Temperature and humidity were recorded during the experimental period.

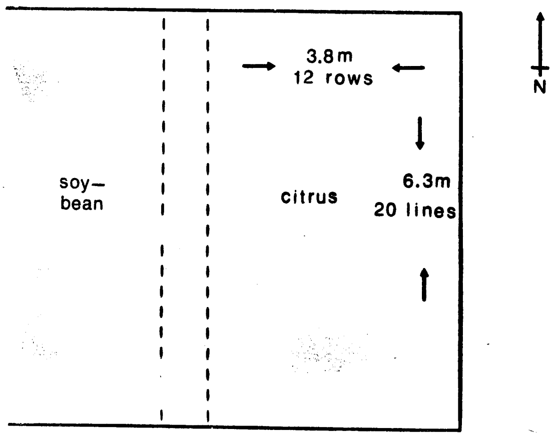


Fig. 1. Diagram of test area in greenhouse.

Field observations were made at 0.5 acre of citrus orchard with 3-year-old saplings of about 180cm high in TARI experimental field. No insecticide was applied in this orchard for at least 3 months prior to the observations as well as throughout the experimental period. The orchard was divided into four blocks, 20 branches were randomly selected over the whole area. Populations of naturally occurring asiatic citrus psyllid were sampled during 1980 and 1981.

Tendency of aggregation of insect population was measured by Lloyd's patchiness, m^*/m, where m^* is the mean crowding and m is the mean density of the species. Mean crowding is defined by Lloyd as the mean number of other individuals per individual per quadrat. It relates to the mean density and the variance (σ^2) of the population in the following way : $m^*=m+(\frac{\sigma^2}{m}-1)$.

Type of dispersion was detected by series and unit-size m^*-m relations. Series m^*-m relation can be expressed by a linear regression equation : $m^*=\alpha+\beta m$, where α and β are the constant characteristics of the distribution of the species concerned. Unit-size m^*-m relation is obtained by successive changes of quadrat size for a single population.

The parameter ρ is given by $\rho=\frac{m_i^*-m^*_{i-1}}{m_i-m_{i-1}}$ where i stands for the ascending order of quadrat size.

Results and Discussion

Figure 2 illustrats the successive population changes of *D. citri* in greenhouse. Figure 2 (A) shows the inoculation sites and the others (B, C, D, E, F) illustrate the situation in the 2nd, 3rd, 4th, 5th and 6th month. The population build up and the agg-

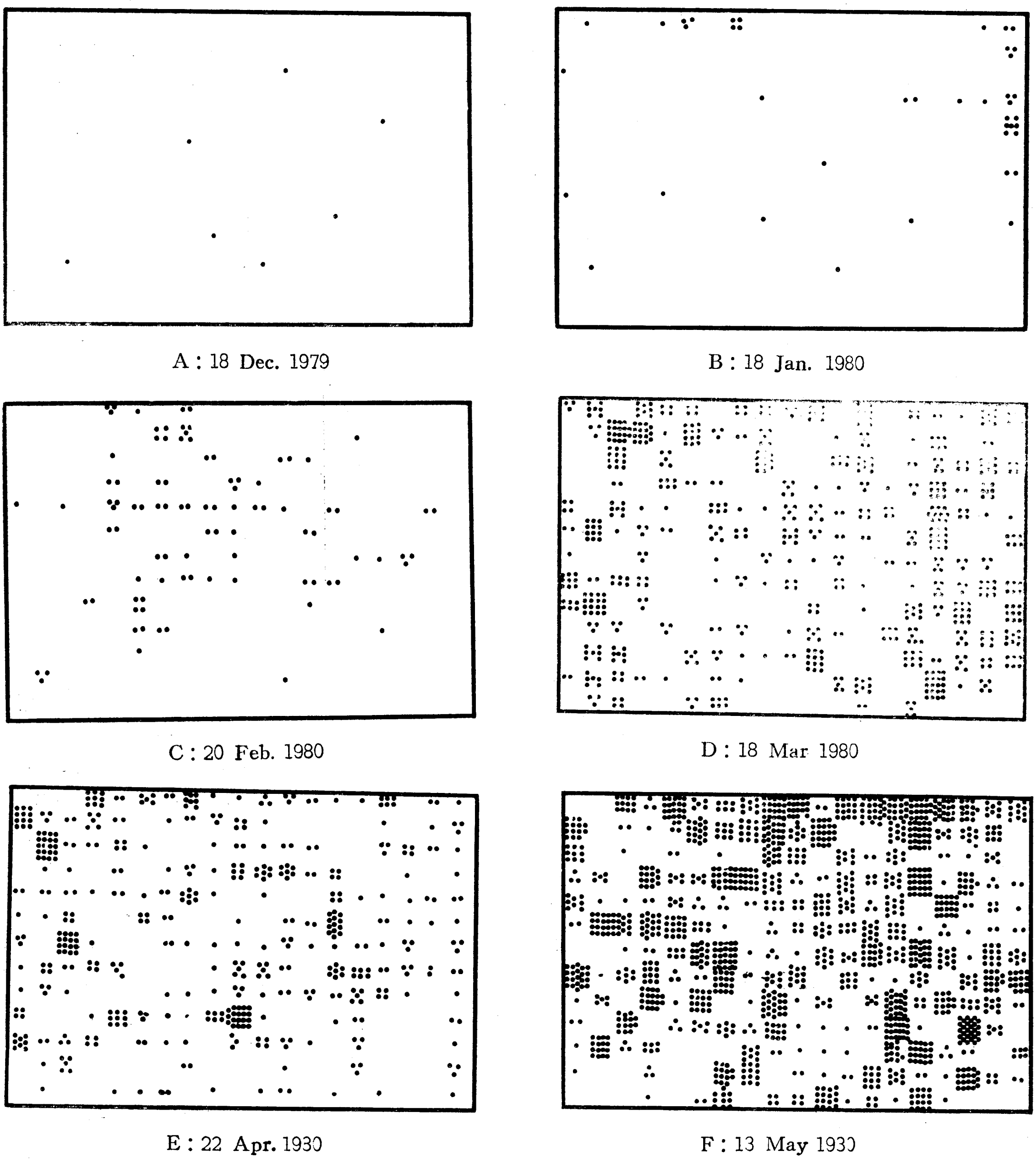


Fig. 2. Successive changes of nymphal dispersion of *D. citri* in greenhouse. Drawings are made based on data on the specified date. Each dot stands for 5 nymphs.

regation pattern changes can be compared in those Figures of that order.

Figure 3 shows the population changes of asiatic citrus psyllid nymph in greenhouse. Following the inoculation, there was a gradual population buildup which first peaked at a density of 15.6 nymphs per plant on 14 March. Thereafter the population declined sharply. The sharp decline following the first peak was due to the gradual dieback of buds caused by the psyllid feeding thereby reducing the food and possibly shade for

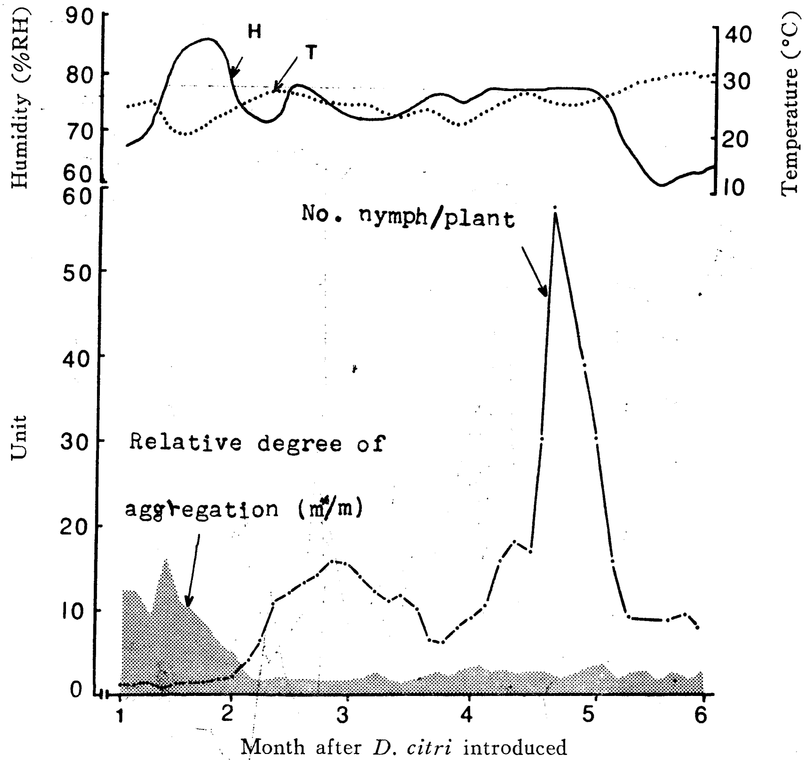


Fig. 3. Population fluctuation and relative degree of aggregation of *D. citri* nymph in greenhouse.

their survival. During the low-population period, citrus plants put out fresh growth, mainly new branches, usually abnormal and brushy type which supplied large amount of food and habitat for the psyllid. With the rapid increase of food and habitat, the number of young psyllid increased almost exponentially to a peak density of 57.1 nymphs per plant during the first week of May. Following the second peak, the density dropped drastically to 8-9 nymphs per plant and stayed around at that level for quite a while. Meanwhile as the result of their feeding most of the young leaves were found seriously damaged. From the observations it was evident that citrus flushing is the main factor influencing the population buildup of the insect in greenhouse. With better plant growth in terms of abundance of new leaves, the insect population would increase and it decreased only when the young leaves were exhausted.

The m*/m value was plotted against sampling date at the bottom of Figure 3. The first value was 12.6 obtained on 18 January. This value increased to 13.4 then declined continuously in the following 6 surveys. The decline of m*/m value terminated at the point of 2.1 when the nymphal density exceeded 6.2 per sapling, i. e., total number of nymph exceeded 1495. The decrease of the m*/m value revealed that the distribution became less contagious along with the growth of population. After this declining period, the m*/m values became stablized suggesting thereby that the aggregation of distribution was not affected by the growth of population any more. In other words, the change of mean density did not influence the degree of aggregation.

Figure 4 shows the series m*-m relationship of nymph and adult asiatic citrus psyllid in greenhouse. The relationships were expressed as m*=3.86+2.83m (r=0.92) for

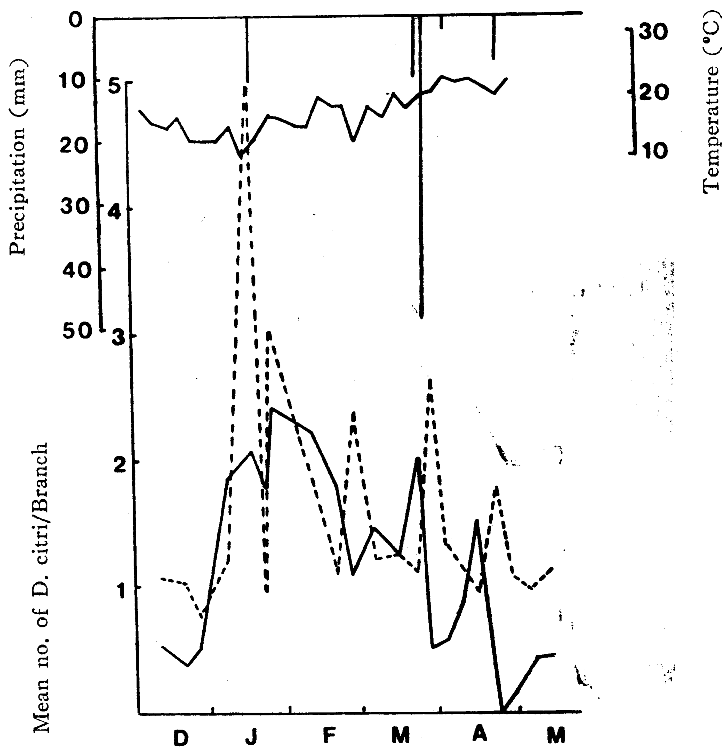


Fig. 4. Population fluctuation of *D. citri* nymph (——) and adult (······) in field.

nymph and m*=5.86+1.33m (r=0.92) for adult. The intercept α, or the index of basic contagion, was lower in the nymphal populations than in the adult populations, i. e., the basic component of the nymphal population was smaller than that of adult. Density contagiousness coeficients, the slope β, expressing the relative degree of aggregation in the distribution of basic components, were larger than 1 in both nymph and adult stages. This indicates the distribution pattern of the basic components of nymphal and adult stages were contagious.

Population density of *D. citri* in natural environment was much lower than that in the greenhouse (Figure 5). The comparatively high densities were only observed during January and February; the time when citrus puts on new leaves. The highest density was 7.5 psyllid per branch on 17 January. Another obvious difference between the field population and the greenhouse population is the frequent fluctuation. The changeble and complicated natural environments made the population of both nymph and adult fluctuated more violently and frequently in the field.

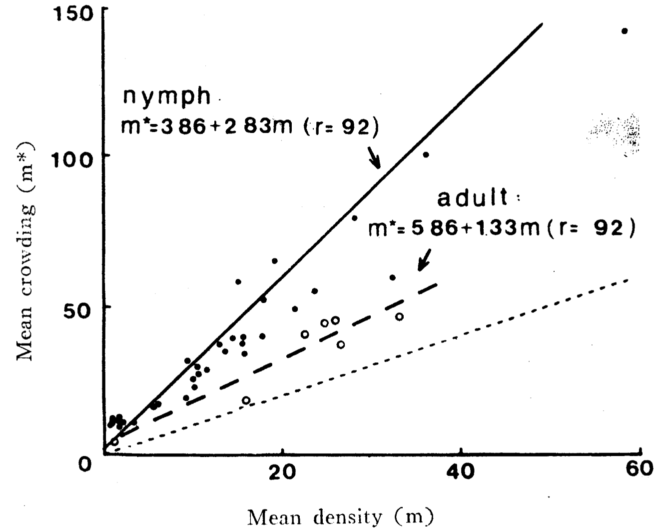


Fig. 5. Series m*-m relationship of *D. citri* populations in greenhouse. ——with dots : nymph, -------with circular : adult, ···expectation from Poisson series.

Figure 6 shows the series m*-m relaionship of nymph and adult asiatic citrus psyllid in field. The relationships are expressed as $m^*=0.73+2.46m$ ($r=0.87$) for nymph and $m^*=0.76+2.23m$ ($r=0.74$) for adult. In both cas(s the intercept α were lower in field than in greenhouse even though the quadrat size sampled were smaller in greenhouse than in field. It indicates the basic components of the psyllid population, no matter at nymph or adult stage, were larger in grenhouse than in field. This might be explained

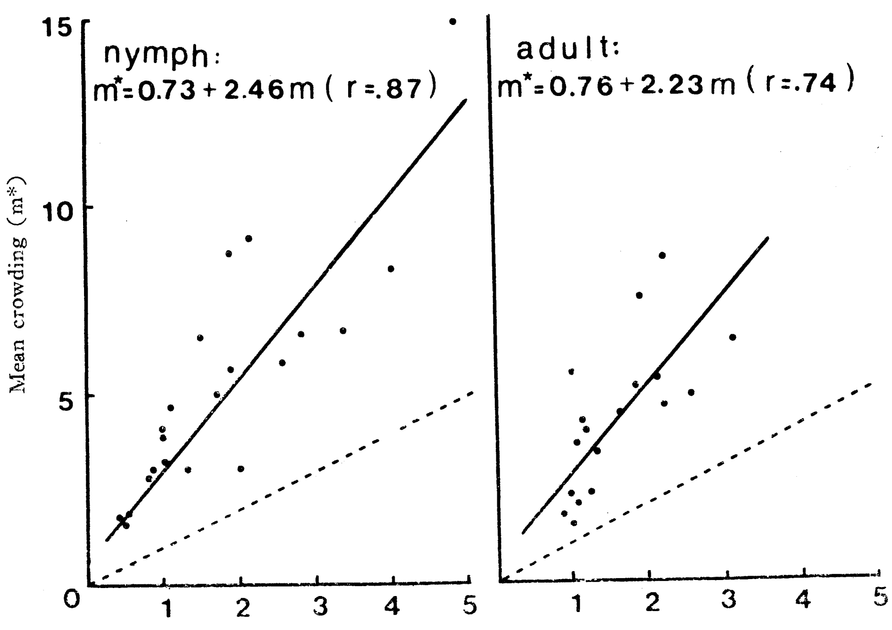


Fig. 6. Series m*-m relationship of *D. citri* populations in field. Dotted line shows the expectation from Poisson series.

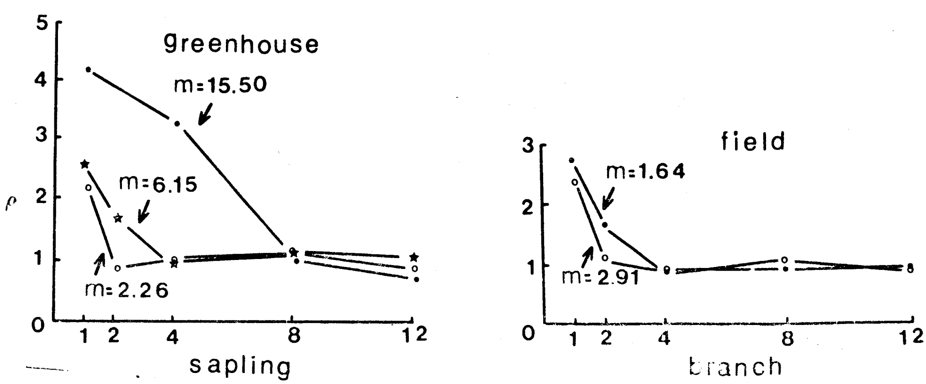
by the larger migration space and higher mortality of this insect in natural environment in the field. β values for populations of both stages in field were fairly close to each other. It seems that the relative degree of contagiousness in field did not vary much with the alternation of the developmental stages. Besides, effect of different environments in greenhouse and in field on the degree of contagiousness were not as significant as that on colony size.

The unit-size relations are shown in Figure 7. It illustrates the change of ρ values with ascending quadrat sizes for asiatic citrus psyllid nymph. It indicated that the nymph aggregated to form colonies with random intra-colony distribution. The colony area ranged from 1 to 4 saplings (1 sapling for 15 populations, 2 saplings for 12 populations, 4 saplings for 2 populations) in greenhouse. Colony area of the nymph in field were from 1 to 2 branches (1 branch for 13 populations and 2 branches for 5 populations).

The aggregation of individuals of naturally existing insects, especially those which lay eggs in clusters, was very common. Ways to observe the characteristics of the aggregated distributions were developed to detect the difference among these popula tions. The m*/m value and the m*-m relationship were used in this report to describe *D. citri* population in greenhouse and in field because they were easy to analyze and supplied abundant basic information.

Difference of distributions of populations in these two environments appeared in their methamethical models. Data of all the samples were tested fo fit negative binomial or poisson distributions. Among the 14 populations in field, 5 populations of nymph and 7 populations of adult were fitted well by negative binomial distribution while none of them could be fitted by the poisson distribution. None of the samples obtained in greenhouse could be fitted by either poisson or negative binomial distribution.

Field population of the asiatic citrus psyllid was influenced by food, habitat, rainfall, temperature, aeration, and other unknown factors. These factors having complicated relationships with each other affect the insect population directly or indirectly. With the irregular environmental conditions, the study of the nature of the psyllid population in



Quadrat size

Fig. 7. Examples of ρ indeces of *D. citri* nymph populations in greenhouse and in field plotted against quadrat size.

field is thus difficult. Greenhouse supplies a quite stable environmont because many factors which influence the insect population in nature did not exist in the greenhouse. The population fluctuation and spatial distribution in greenhouse is considered the characteristic feature of this insect under a simplified condition.

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柑橘木蝨 (*Diaphorina citri* K.) 之生態與空間分布之特性[1]

王 清 玲[2]

中 文 摘 要

本試驗於民國 68 年冬季至 70 年夏季在臺灣省農業試驗所溫室及田間進行，將 40 隻第 4 或第 5 齡木蝨(*Diaphorina citri* Kuwayama)幼蟲放飼於溫室內 240 株盆栽之酸橘(*Citrus reticulata* var. *Suenket*) 苗上，任其繁衍，所得幼蟲最高密度爲每株 57.1 隻。相對聚集度在木蝨剛開始繁衍密度尚低時很高，其後則隨族羣之增長而降低，經 2 個月後趨於穩定。幼蟲與成蟲之 m*-m 關係可分別以 $m^*=3.86+2.83\ m$ 與 $m^*=5.86+1.33\ m$ 表示，幼蟲與成蟲均聚集成羣落以爲分布之單位，單位內之個體爲逢機分布，單位之間爲聚集性之分布。每一單位所占區域約爲 1 ～ 4 苗木。

田間柑橘園內自然發生木蝨之棲羣密度較溫室爲低，且變化較大，其 m*-m 關係式在幼蟲爲：$m^*=0.73+2.46\ m$, 成蟲：$m^*=0.76+2.23\ m$。幼蟲及成蟲分布之單位均較溫室內者爲小，此二時期之個體在田間分布之聚集性相似，分布單位所占之區域約爲 1 ～ 2 分枝。

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