

Comparative Population Dynamics of Green Leafhoppers in Paddy Fields of the Tropics and Temperate Regions

I Nyoman WIDIARTA*, Yoshito SUZUKI**, Kenji FUJISAKI* and Fusao NAKASUJI*

* Faculty of Agriculture, Okayama University (Tsushima, Okayama, 700 Japan)

** Directorate of Food Crop Protection (Pasar Minggu, Jakarta, Indonesia)

Abstract

The population dynamics in paddy fields of green leafhoppers, *Nephotettix* spp. well recognized as vectors of tungro and dwarf diseases, were compared between the tropical and temperate regions. A FARMCOP suction catcher was employed to survey the population density.

Nephotettix virescens and *N. cincticeps* were dominant species in paddy fields in Indonesia and Japan, respectively. The population growth pattern and the level of peak density differed between the two species, although the reproductive capacity was similar to each other. The density of populations in the tropical paddy fields generally increased to the maximal level in the second generation after the invasion of adults into newly transplanted paddy fields and decreased thereafter. On the other hand, in the temperate paddy fields, the density reached the highest peak in the third generation. The level of peak density of the temperate population was 10 to 100 times as high as that of the tropical one. Factors affecting the difference in population growth pattern and abundance were analyzed.

Discipline: Insect pest

Additional key words: dispersal, *Nephotettix cincticeps*, *N. virescens*, peak density, population growth pattern

Introduction

The green leafhoppers (GLH), *Nephotettix cincticeps*, *N. virescens* and *N. nigropictus*, which are closely related sibling species exhibiting similar biotic performances¹⁵⁾, are well known as the major insect pests of rice in Asia²⁰⁾ that function as vectors of rice dwarf (RDV) and tungro (RTV). The distribution of *Nephotettix cincticeps* is restricted primarily to the temperate region, while the other two species distribute to wide areas extending from sub-tropical

to tropical regions. *Nephotettix virescens* has recently outnumbered *N. nigropictus* in most paddy fields in Indonesia^{6,13,14)}. For convenience, *N. cincticeps* is abbreviated as NC and *N. virescens* as NV hereafter.

The population growth of NV in rice fields in Indonesia was affected by the rice transplanting pattern¹⁸⁾. The variation of population growth pattern of NV was greater than that of NC in the temperate region^{3,18)}. Hokyo et al. (1977)⁶⁾ have suggested that the population density of NV in Indonesia is lower than that of NC in Japan. It should be noticed however that their conclusion was based

Part of this study is the contribution from the Indonesia-Japan Joint Program on Food Crop Protection (ATA-162), which was cooperatively undertaken by the Japan International Cooperation Agency, Japan, and the Directorate of Food Crop Protection, Ministry of Agriculture, Indonesia, during the period 1980 to 1992.

** Present address: Department of Recalcitrant Disease and Pest Management, Kyushu National Agricultural Experiment Station (Nishigoshi, Kumamoto, 861-11 Japan)

on the census data obtained through simple methods, including visual countings and sweepings. In order to get more precise information, the GLH density and its natural enemies were surveyed with a FARM-COP suction catcher²⁾ both in Indonesia and Japan. The census methods in Indonesia and Japan were reported by Widiarta et al. (1990)¹⁸⁾ and Widiarta et al. (1991)¹⁹⁾, respectively. The present paper attempts to compare the population dynamics between NV and NC to identify the factors causing differences in population growth pattern and population density level between the two GLHs.

Population dynamics in paddy fields

1) Population in fallow fields

In Okayama, diapausing nymphs of NC survive the winter in the fallow fields after the harvest of rice plants until next spring. The nymphal diapause is induced by the shortening of day length in the fall¹⁰⁾. After overwintering, NC spends one more generation on foxtail grass, *Alopecurus aequalis* Sobol, which grows in fallow paddy fields. The survival rates of nymphs of the first generation on foxtail grass are lower than those of the following generations on rice plants¹⁹⁾. The low survival rates of NC on foxtail grass provide a limited density of immigrant adults into rice fields. On the other hand, in tropical paddy fields, NV lives on the stubbles,

levees and seedbeds during the fallow period between the two rice cropping seasons^{1,3)}.

2) Population growth in rice fields

The NV populations in the tropical paddy fields show various patterns of growth. Those variations were classified into three groups on the basis of increase patterns after the invasion of adults (G0) as follows: (1) the population density increases to the peak level in the second generation (G2) (Fig. 1b); (2) the population density reaches its maximal level in the next generation (G1) (Fig. 1c); and (3) no increase takes place with the population density (Fig. 1d). Table 1 shows frequencies of the patterns observed in Indonesia. In the wet season, the pattern 1 was observed in 2 out of 3 sets of investigations in the synchronous transplanting areas, although the pattern 3 was predominant in the dry season. The pattern 2 was observed mainly in the asynchronous transplanting areas. It was generally recognized that the NV population increased during the early stage of rice growth in Indonesia and its reproductive rate was low in the later stage. However, the population density of NC in paddy fields in Japan increased gradually for the period of two generations since the invasion of G0 into paddy fields, reaching the highest level at G2 (Fig. 1a). The population growth of NC was named pattern 0. The pattern 0 was observed in all of the 3 sets of

Table 1. Frequencies of population growth patterns in paddy fields in Indonesia and Okayama, Japan

Pattern of population growth ^{a)}	Frequencies of population growth patterns			
	Indonesia			Okayama, Japan
	Synchronous ^{b)}		Asynchronous	
DS	WS			
0	0	0	0	3
1	0	2	0	0
2	1	1	11	0
3	2	0	4	0
Number of observations	3	3	15	3

a): Pattern 0; the population increased for two generations since the invasion of adults with a high peak density: Pattern 1; the population increased for two generations since the invasion of adults but with a low peak density: Pattern 2; the population attained a peak density in the next generation after the invasion of adults: Pattern 3; the population density does not increase since the invasion of adults.

b): DS; Dry season crop, WS; Wet season crop.

Sources: Widiarta et al. (1990)¹⁸⁾, Widiarta et al. (1991)¹⁹⁾ and Widiarta (unpublished).

investigations in Okayama (Table 1). The population growth pattern of NC was similar to the pattern 1 of NV in Indonesia, although the increase rate from G1 to G2 was much higher and the density in G2 was higher in NC than in NV. It is noticeable that the density in the peak generation of NC was 10 to 100 times higher than that of NV (Fig. 1).

Factors affecting differences in the population dynamics

1) Reproductive ability

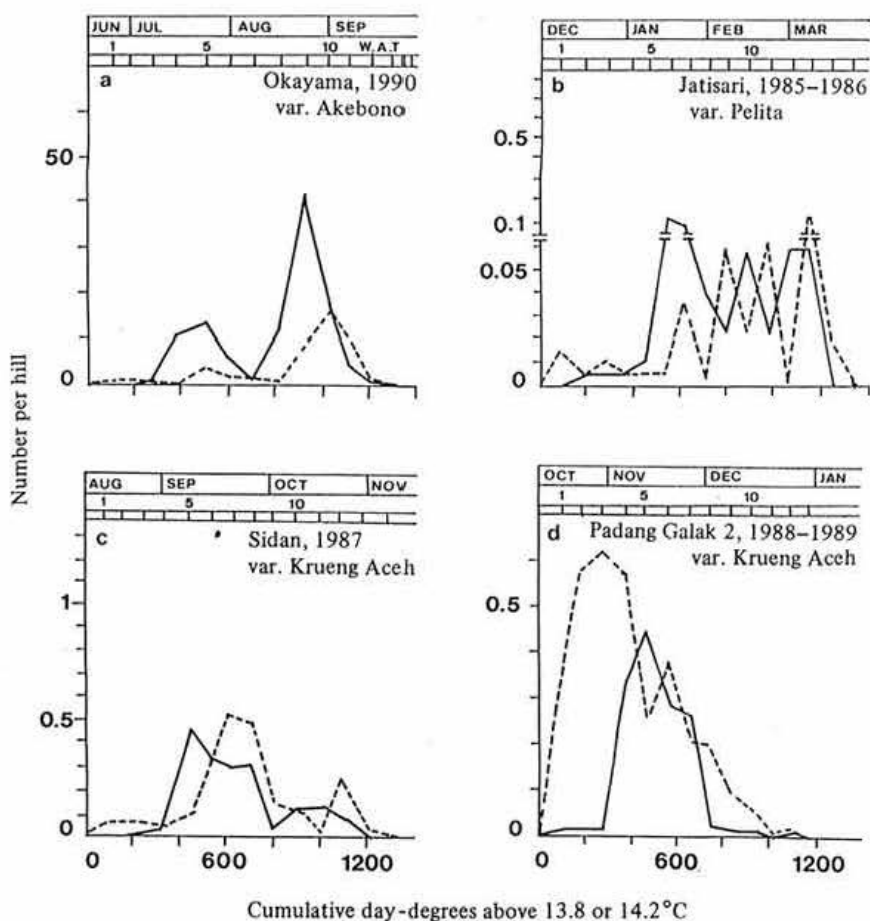


Fig. 1. Population growth patterns of GLH in Indonesia and Japan

—: Large nymphs (4–5th); - - -: Adults.

Calendar dates and sampling intervals in weeks after transplanting (WAT) are shown in the top of each figure.

The values of 13.8 and 14.2°C refer to the developmental threshold for *N. virescens* and *N. cincticeps*, respectively.

Sources: Widiarta et al. (1990)¹⁸⁾, Widiarta et al. (1991)¹⁹⁾ and Widiarta (unpublished).

A comparative study on the various bionomic and demographic parameters among *Nephotettix* spp. was intensively conducted by Valle et al.¹⁵⁻¹⁷⁾. The results of their studies show that there was no fundamental difference between NC and NV in their bionomic and demographic performances on seedlings of japonica rice variety, Nipponbare (Table 2). However, the equilibrium density of NV was slightly larger at high temperature and smaller at intermediate temperature than that of NC. Thus, the difference in bionomics between NV and NC does not explain the variations observed in population growth of GLH

Table 2. Bionomic and demographic parameters of *N. cincticeps* (NC) and *N. virescens* (NV) on japonica rice, Nipponbare

Temperature (°C)		20		25		27		30	
Species		NC	NV	NC	NV	NC	NV	NC	NV
Bionomic parameters									
Incubation period (days)		17.4	18.2	8.3	9.4	7.9	8.9	7.2	7.4
Nymphal dev. period (days) M		40.4	40.9	16.9	18.4	15.1	16.9	14.0	14.4
F		42.9	42.3	17.8	19.1	15.9	17.0	15.3	15.3
Longevity (days) M		23.2	24.0	15.6	22.7	14.8	18.3	14.4	15.5
F		23.6	25.2	16.8	21.7	16.1	19.4	15.9	17.2
Pre-oviposition period (days)		9.8	9.8	5.3	5.4	4.7	5.0	4.3	4.3
Fecundity (No. eggs/female)		79.4	67.9	140.2	165.6	166.6	221.5	168.9	241.2
Demographic parameters									
Net reproductive rate (R_0)		103.7	116.3	135.5	143.3	99.5	138.7	100.1	138.2
Generation time (G)		58.1	57.2	28.2	32.4	25.8	29.5	25.3	25.4
Intrinsic rate of increase (r_m)		0.08	0.08	0.17	0.16	0.18	0.17	0.18	0.19
Carrying capacity (K)				1429	1185 ^{a)}	1506	1256	1374	1580

a): At 24°C

Sources: Valle et al. (1986)^{15,16} and Valle et al. (1987)¹⁷.

between the tropical and temperate areas. NC and NV populations were reproduced on a japonica variety, Akebono and on two indica varieties, IR-8 and IR-22 for two generations in field cages. Both NC and NV finally reached almost the same level of population densities on japonica rice (Fig. 2), while indica rice was less suited to NC. The NC population could increase only in the early stage of IR-8 but not on IR-22. These results are consistent with those reported by Kishino (1976)¹¹, and Liu and Takahashi (1990)¹². The NV populations both on IR-8 and IR-22 finally reached the same level of high density as on Akebono. The above facts show that NV is not inferior to NC in reproductive ability. *Nephotettix virescens* has a high ability to reproduce on indica rice just as in the case of NC on japonica rice, providing that there are no natural enemies and no possibilities of dispersal.

2) Natural enemies and a possible competitor

Natural enemies could be one of the important factors which reduce the population density of GLH in paddy fields⁷⁻⁹. The densities of natural enemies, such as lycosid and other spiders, veliid bugs, *Microvelia* spp. and mirid bugs, *Cyrtorhinus lividipennis*, in paddy fields of the tropical and temperate regions are shown in Fig. 3. The spiders and *Microvelia* densities in G0 generation were higher in Jatisari than in Bali and Okayama. In G1 and G2

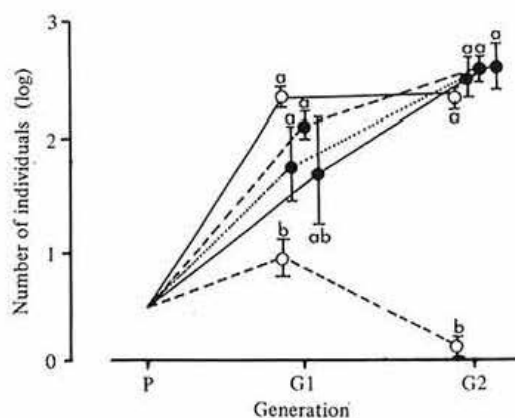


Fig. 2. Population growth of NV and NC on indica and japonica planted in pots in the field cages

● : NV, ○ : NC.

Cultivars: --- : indica IR-8,

..... : indica IR-22,

— : japonica Akebono.

Means with the same letter in the same generation are not significantly different at $P=0.05$ (Duncan's multiple range test).

Source: Widiarta and Ikeda (unpublished).

generations their densities were the lowest in Bali and not different between Jatisari and Okayama. The densities of *C. lividipennis* were extremely low in Okayama. The numerical response of spiders to the

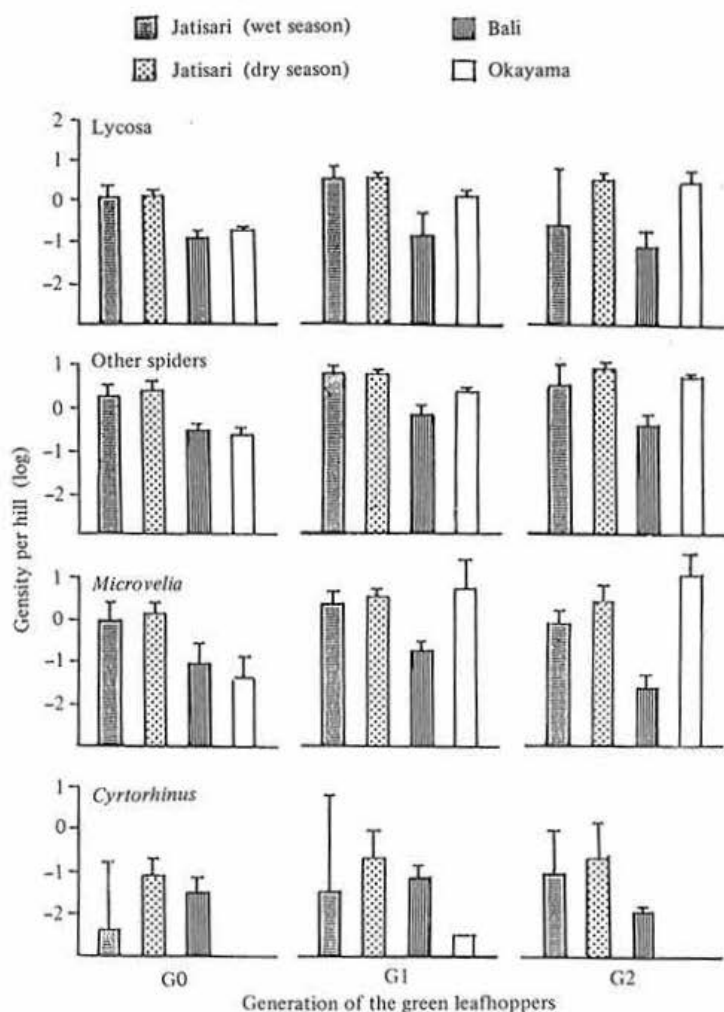


Fig. 3. Densities of major predators in each generation of GLH in tropical and temperate paddy fields
Sources: Widiarta et al. (1990)¹⁸ and Widiarta (unpublished).

density of GLH in G1 in Indonesia is shown in Fig. 4. It is observed that spiders scarcely responded to the increase of GLH density. This suggests that the spiders are not highly effective in controlling the GLH density in Indonesia. Percentage of egg parasitism on G1 was not significantly different between tropical and temperate paddy fields (Widiarta, unpublished). Effects of nymphal parasitism on the GLH density were not important in both the tropical (Widiarta, unpublished) and temperate areas⁸). Therefore, natural enemies do not help explain the difference observed in the peak density

of GLH between the tropical and temperate paddy fields.

The brown planthopper (BPH), *Nilaparvata lugens* and GLH occupy a similar niche in paddy fields, implying that BPH might be a possible competitor which reduces reproduction of GLH. The population density of BPH in each generation of GLH is shown in Fig. 5. The BPH densities in Okayama were the lowest in G0 generation but increased to the level as high as those in Jatisari in the later stage of rice growth. The densities of BPH varied to some extent in G0 between the tropical and temperate

paddy fields. However, such a difference is not large enough to explain the difference in population dynamics of GLH between the tropical and temperate paddy fields.

3) Dispersal of adults

A possible factor which might cause the aforementioned difference is the variation in the dispersal activity of adults. The relationships between the

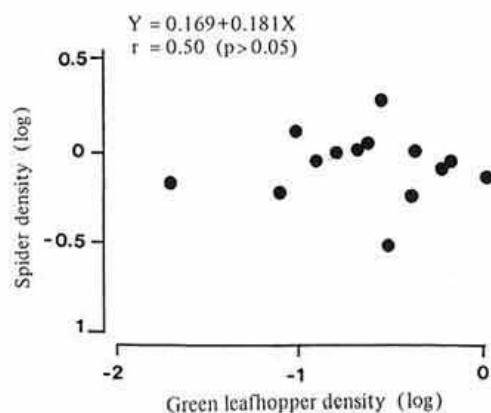


Fig. 4. Responses of spiders to the density of NV in asynchronous fields in Padang Galak and Sidan, Bali

number of emerged adults per hill and the percentage of adults that disappeared before ovarial-maturation at G1 are presented in Fig. 6. The disappearance rates of adults tended to increase with the increment in the density of emerged adults in both the tropical and temperate paddy fields. It seems therefore that the disappearance of adults might have been caused mainly by dispersal, since effects of natural environments were rather minor. The regression coefficient of relationships between the disappearance of adults and the density of emerged adults was larger in Bali than in Okayama ($P < 0.05$, t -test). This suggests that NV in the tropical areas has a higher dispersal propensity than NC in Okayama. The preliminary experiment in the field cages also suggested that dispersal activity of NV is higher than that of NC (Widiarta and Ikeda, unpublished).

4) Residential period and number of eggs laid

The residential period (estimated longevity) and number of eggs laid by a G1 female were estimated with the method proposed by Hokyo and Kiritani⁵⁾, assuming the same period for ovarial pre-maturation of female adults in the G1 generation in Indonesia and Japan (Table 3). The residential period of G1 was shorter in Bali than in Okayama. A short

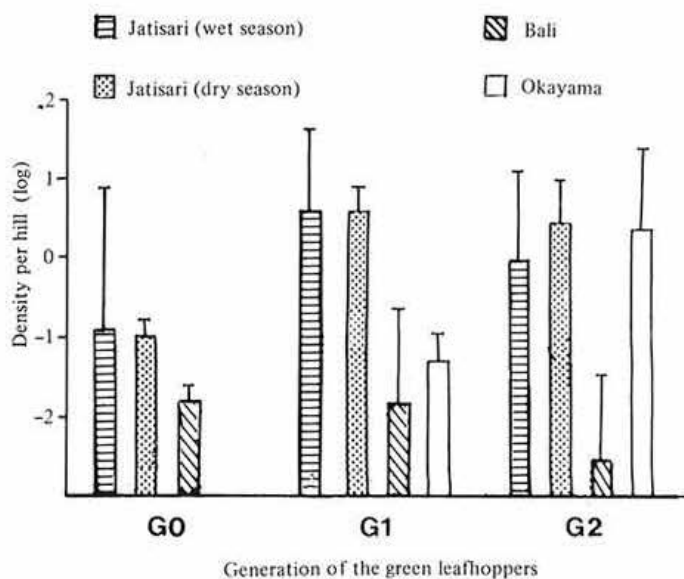


Fig. 5. Densities of a possible competitor, the brown planthopper, in each generation of GLH in Japan and Indonesia

residential period is caused partially by their active dispersal as mentioned earlier. There is a close correlation between the longevity of adults and the number of eggs laid for many planthopper species in the laboratory⁴⁾. Few eggs were laid in the later stage of rice in tropical areas, especially in paddy fields asynchronously transplanted. The number of eggs laid by females of G1 population was 10 times larger in Okayama than in Bali.

Conclusion

The population dynamics of NV in the tropical paddy fields was different from that of NC in the temperate paddy fields in terms of population growth pattern and level of peak density. The population

growth pattern of NV showed a greater variation than that of NC. The maximal densities of NC were much higher than those of NV.

The difference in the population dynamics between NV and NC could not be explained by the variations in such factors as bionomic and demographic parameters, reproductive abilities, densities of predators and the BPH as a possible competitor. The dispersal propensity of NV was higher than that of NC, thereby NV had a shorter residential period, laying fewer numbers of eggs in the later stage of rice growth. Therefore, it may be concluded that the difference in the dispersal activity of adults caused the variations observed in the pattern of population fluctuations and the densities between tropical and temperate paddy fields.

Table 3. Residential period and number of eggs laid by a G1 female of the green leafhoppers population in Padang Galak and Sidan, Indonesia and Okayama, Japan

Population	Residential period ^{b)} (days)	Number of eggs laid
<i>N. virescens</i>		
Sidan		
SDN (August, 1987) ^{a)}	6.2	13.6
SDN (January, 1988)	2.9	1.8
Padang Galak		
PGB (July, 1988)	2.2	- ^{c)}
PGA (September, 1988)	1.5	-
PGA2 (October, 1988)	3.6	8.2
PGA (November, 1988)	-	-
PGB (December, 1988)	6.6	-
PGA (February, 1989)	2.0	-
PGA3 (February, 1989)	2.5	-
PGA (March, 1989)	2.0	5.5
PGA1 (April, 1989)	2.1	-
PGB (June, 1989)	8.3	4.0
PGA (October, 1989)	4.3	-
Mean	3.7	6.6
<i>N. cincticeps</i>		
Okayama		
OKY (June, 1988)	7.9	130.5
OKY (June, 1989)	3.0	14.5
OKY (June, 1990)	4.9	63.5
Mean	5.3	69.3

a): Transplanting time.

b): Estimated after the method proposed by Hokyō and Kiritani (1967)⁵⁾.

c): Data not available.

Sources: Widiarta et al. (1991)¹⁹⁾ and Widiarta (unpublished).

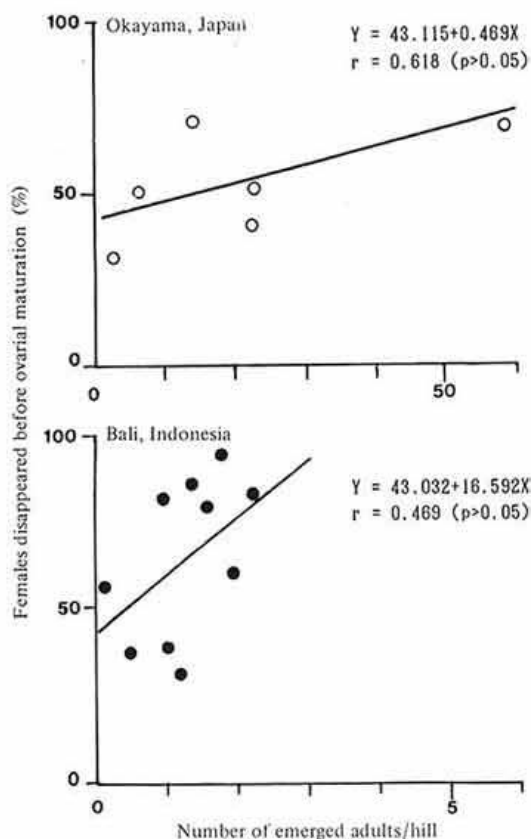


Fig. 6. Relationships between density of emerged adults and percentage of females which disappeared before ovulation-maturation

Data taken in asynchronously transplanted fields in Padang Galak and Sidan, Bali (●) and in Okayama (○).

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(Received for publication, Aug. 23, 1991)