On Oviposition in the Brown Planthopper, *Nilaparvata lugens* (STÅL) (Hom., Auchenorrhyncha)

II. The Number of Eggs in an Egg Group, Especially in Relation to the Fecundity

By Osamu MOCHIDA

Kyûshû National Agricultural Experiment Station, Chikugo-shi, Fukuoka-ken, Japan

INTRODUCTION

It is said that the number of eggs in an egg group in both species of the brown planthopper (*Nilaparvata lugens* (STÅL)) and the white-back planthopper (*Sogatella furcifera* (HORVÁTH)) varies according to environmental conditions, state of the oviposition plants, physiological status of females, etc. SUENAGA (1963) stated that the size of egg groups laid in rice seedlings is related to the fecundity in both species.

The present paper is a record of observations on the size of egg groups laid in rice plants under some environmental conditions, and it is considered whether or not the fecundity of populations could be shown by examining the size of egg groups laid by them.

MATERIAL AND METHODS

Fourth and fifth instar nymphs were collected from the paddy fields in summer and autumn. They corresponded to the third and fourth generation, respectively. The newly-emerged females obtained from these nymphs were reared individually in test tubes on rice seedlings in the fourth ~seventh leaf stage or on leaf blades of rice plants which grew in the field. A paddy rice variety, Nôrin No. 18 was used as host plant, except one shown in Table 1. Test insects were kept in incubators regulated constantly at an 8-hour photoperiod or in a weather-instrument shelter made of frosted glass at natural photoperiods. The present work was carried out at the Kyûshû National Agricultural Experiment Station from 1960 to 1962.

OBSERVATIONS

The size of egg groups laid in the tissue of rice plants in the field

Females of the brown planthopper deposit their eggs in groups in the tissue of

Table 1. The size of egg groups deposited in 20 stems of rice plants in the paddy field at the harvest time in 1962. Rice variety; Kinmaze.

Oviposition site		No. egg groups deposited	No. eggs in an egg group mean (min.–max.)		No. eggs deposited total	(%)
Blades	upper surface	176	14.5	(2–62)	2558	(86.8)
	under surface	44	7.7	(1–28)	341	(11.6)
	total	220	13.1		2899	
Sheaths		6	7.8	(5–13)	47	(1.6)
Total		226	13.0	(1–62)	2946	(100)

(Received for publication, January 6, 1964)

leaf sheaths and blades, in like manner as females of many other delphacids as shown by HASSAN (1939), NASU & SUENAGA (1956), etc. The eggs deposited regularly in a row overlap each other in the slit made by a female and are sheltered with a hardened covering secreted by her. It is said that the deposition site changes by the physiological state of females, growing stage of rice plants, and other environmental conditions. A common deposition site of the brown planthopper is lower part of the stem or green sheath. On the fully grown-up plants, however, the eggs are frequently found in the upper part of the stem and in the midrib of the upper surface of higher blades.

It is said that the number of eggs in an egg group varies according to the deposition site, growing stage of oviposition plants, state of females, and so on. However, there are few published data which explicate these phenomena. Therefore, the investigation was carried out about a sample of rice plants collected in the fields at the harvest time in 1962. The results, given in Table 1, showed clearly that both the number of the egg groups and the

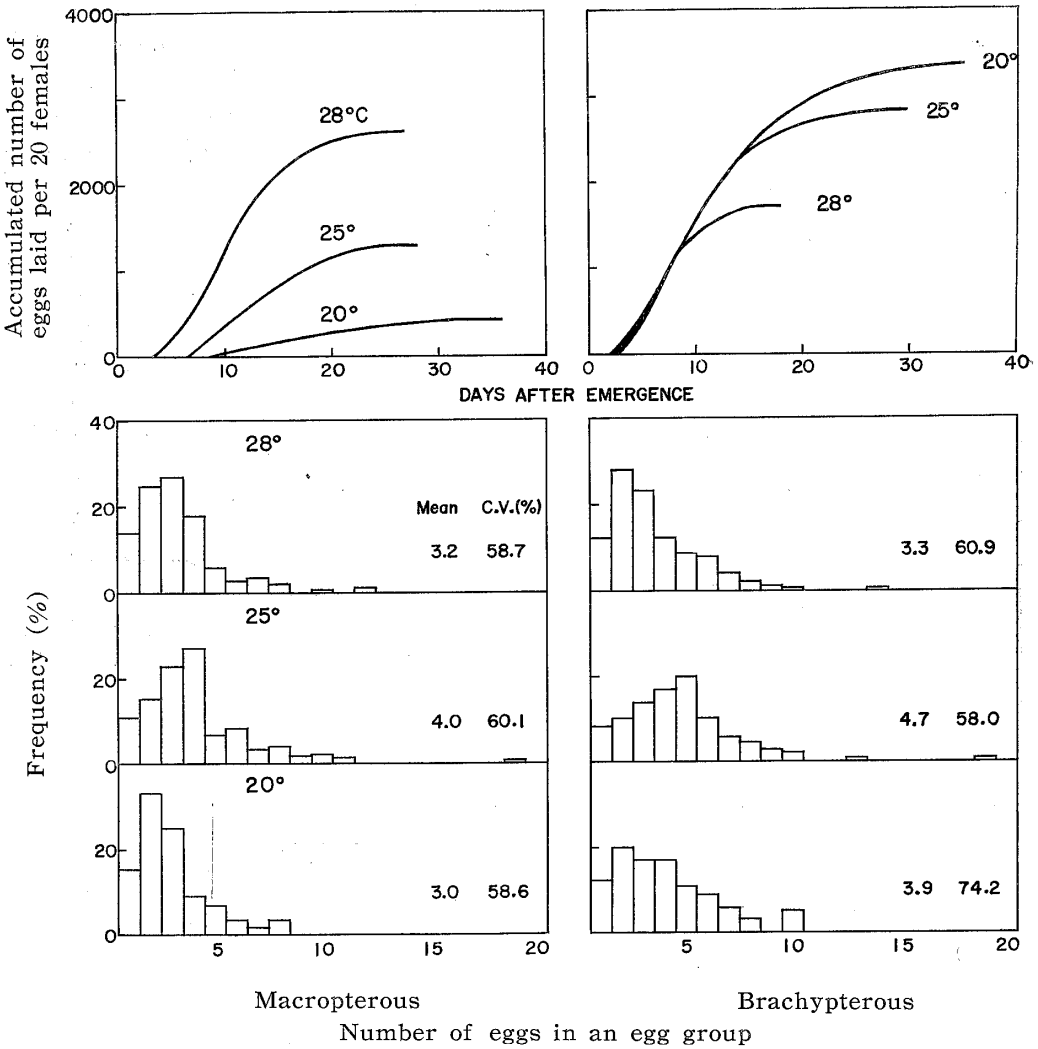

Fig 1. Relationship between fecundity and distribution pattern for the size of egg groups laid under constant temperature conditions of 20~28°C. A total of 497 egg groups in macropterous females and that of 600 egg groups in brachypterous ones were examined, respectively. Host plant; rice seedlings. Light; an 8-hour photoperiod per day.

number of eggs in an egg group deposited in blades were more numerous than those in sheaths. In this case, the distribution pattern for the size of egg groups was very skew.

The size of egg groups laid in rice seedlings at constant temperatures

Both macropterous and brachypterous females in the third generation in 1960 were used for this experiment.

Effect of temperatures on the fecundity and size of egg groups: The relationship between the fecundity and the distribution pattern for the size of egg groups was illustrated in Fig. 1. The fecundity was remarkably influenced by temperatures. However, the distribution patterns for the size of egg groups did not change according to the fecundities in each wing form.

A comparison of the distribution patterns for the size of egg groups laid, at the early oviposition period and at the late oviposition

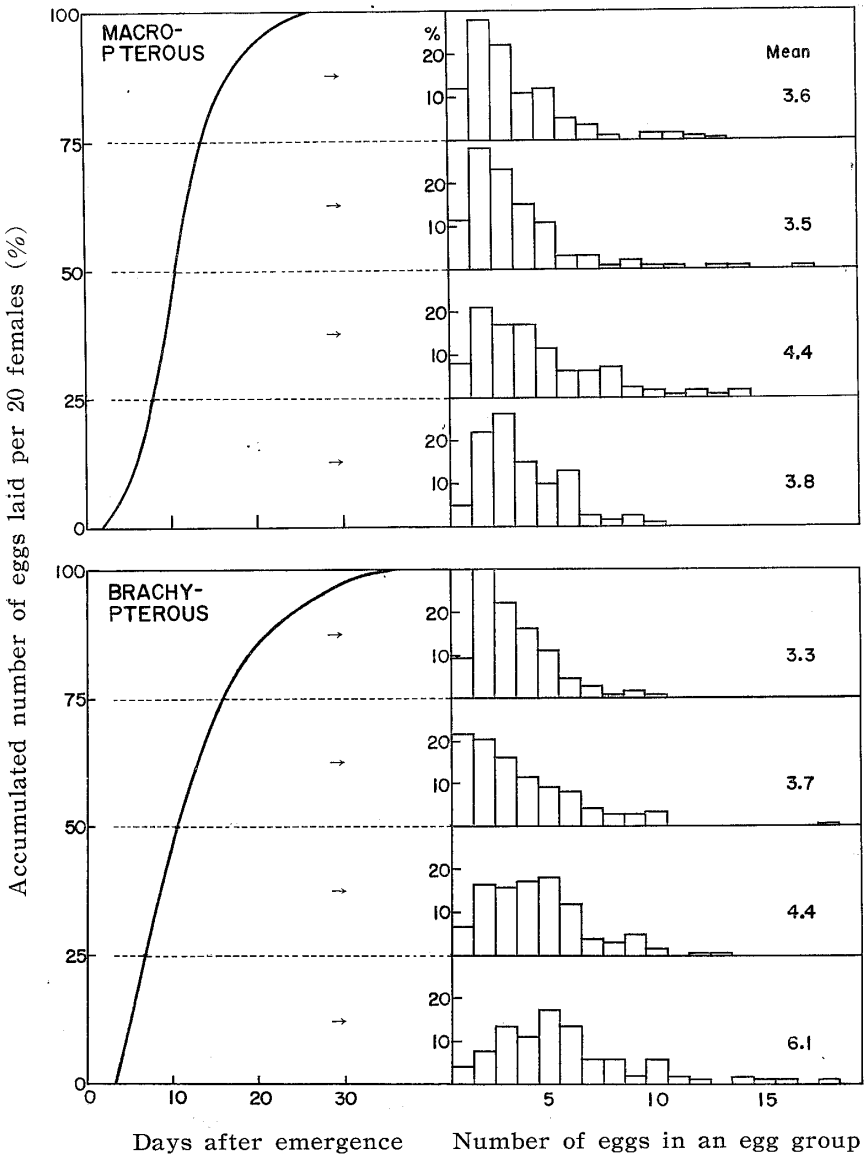

Fig. 2. Accumulated oviposition curve of population and successive changes in the distribution pattern for the size of egg groups. A total of 748 egg groups in macropterous females and that of 497 egg groups in brachypterous ones were examined, respectively. Host plant; rice seedlings. Light; an 8-hour photoperiod per day. For further explanation, see text.

period: The successive change in the distribution patterns for the size of egg groups was examined in two cases of macropterous females at 28°C and brachypterous ones at 20°C, respectively, where the females in both wing forms deposited the most eggs as shown in Fig. 1. The oviposition curve was divided for convenience into four parts in relative value of the accumulated number of eggs laid per 20 females; the first, second, third, and fourth successive 25 per cent. Then, the distribution patterns for the size of egg groups were compared among these parts. The results were given in Fig. 2. It was shown that there were no clear differences in the mean size of egg groups among four successive periods in the macropterous females. However, the size of egg groups in the brachypterous tended to decrease as time went on.

A comparison of the size of egg groups between prolific and infertile females: The four individuals that laid a large number of eggs and four ones that laid a small number of eggs were sampled out of 48 macropterous females in the third generation reared at 28°C. The mean numbers of eggs deposited per female in these two groups were 508.7 (595, 520, 507, and 484) and 203.0 (243, 211, 187, and 171), respectively. Similarly, two groups which consisted of four brachypterous females reared at 20°C were chosen out. The mean numbers of eggs were 321.0 (427, 397, 258, and 202) and 144.5 (199, 183, 146, and 50), respectively. The distribution patterns for the size of egg groups were compared among these two groups in each wing form. The results were given in Fig. 3. There were no clear relationships between the fecundity and the size of egg groups.

Relationship between the fecundity of population and the size of egg groups: The size of egg groups deposited by females in the third generation was compared with that in the fourth generation. The rearing conditions after emergence were the same in both generations; for macropterous at 28°C and for brachypterous at 20°C, respectively. The results, given in Fig. 4, showed apparently that the size of egg groups did

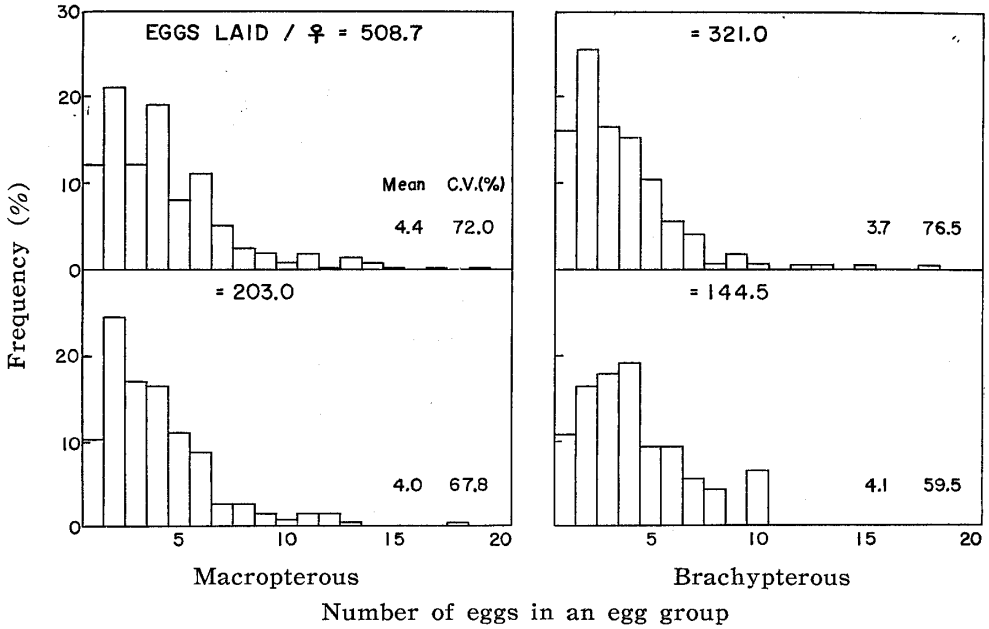

Fig. 3. Comparison of the distribution pattern for the size of egg groups between prolific females (upper) and infertile ones (lower). A total of 357 egg groups in macropterous females at 28°C and that of 197 egg groups in brachypterous ones at 20°C were examined, respectively. Host plant; rice seedlings. Light; an 8-hour photoperiod per day.

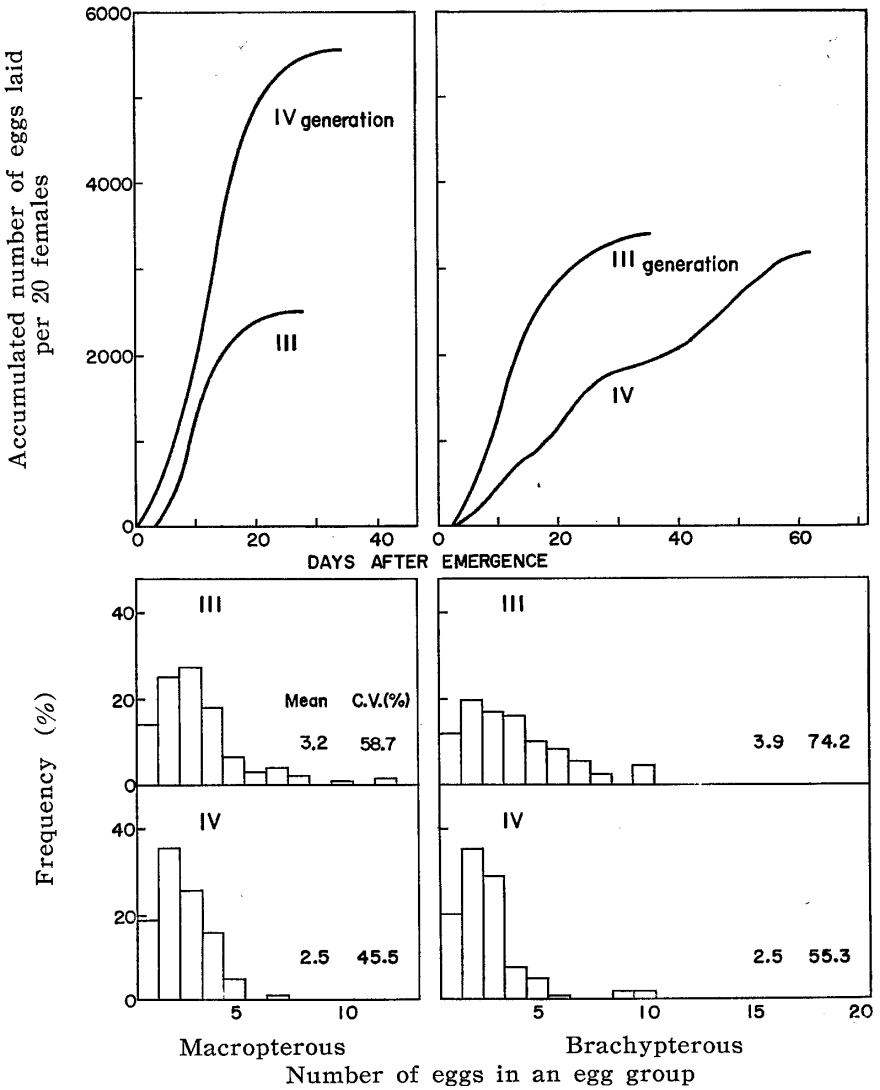

Fig. 4. Relationship between the fecundity of population and distribution pattern for the size of egg groups laid. All of the macropterous females and brachypterous ones were reared at 28°C and 20°C after emergence, respectively. A total of 400 egg groups was examined in each form, respectively. Host plant; rice seedlings. Light; an 8-hour photoperiod per day.

not change in response to the differences in the fecundities.

The size of egg groups laid in leaf blades of rice plants at natural temperatures and natural photoperiods

Females in both the third and fourth generations in 1961 were used for the experiment. The number of eggs deposited during the life span was counted, and the obtained distribution patterns for the size of egg groups were shown in Fig. 5. There were no clear differences in the distribution patterns between these two generations in each wing form, and no apparent relationship between the fecundity and the size of egg groups in both forms. On the other hand, the size of egg groups during the four successive periods (the first, second, third, and fourth 25 per cent shown in Fig. 2) in all the cases tended to decrease simply on an average as follows:

Mean size of egg groups in the macropterous form in the 3rd generation (late Aug.—mid Sept.) ;

6.7→6.5→5.6→5.3

Mean size of egg groups in the macropterous form in the 4th generation (late Sept.—early Nov.) ;

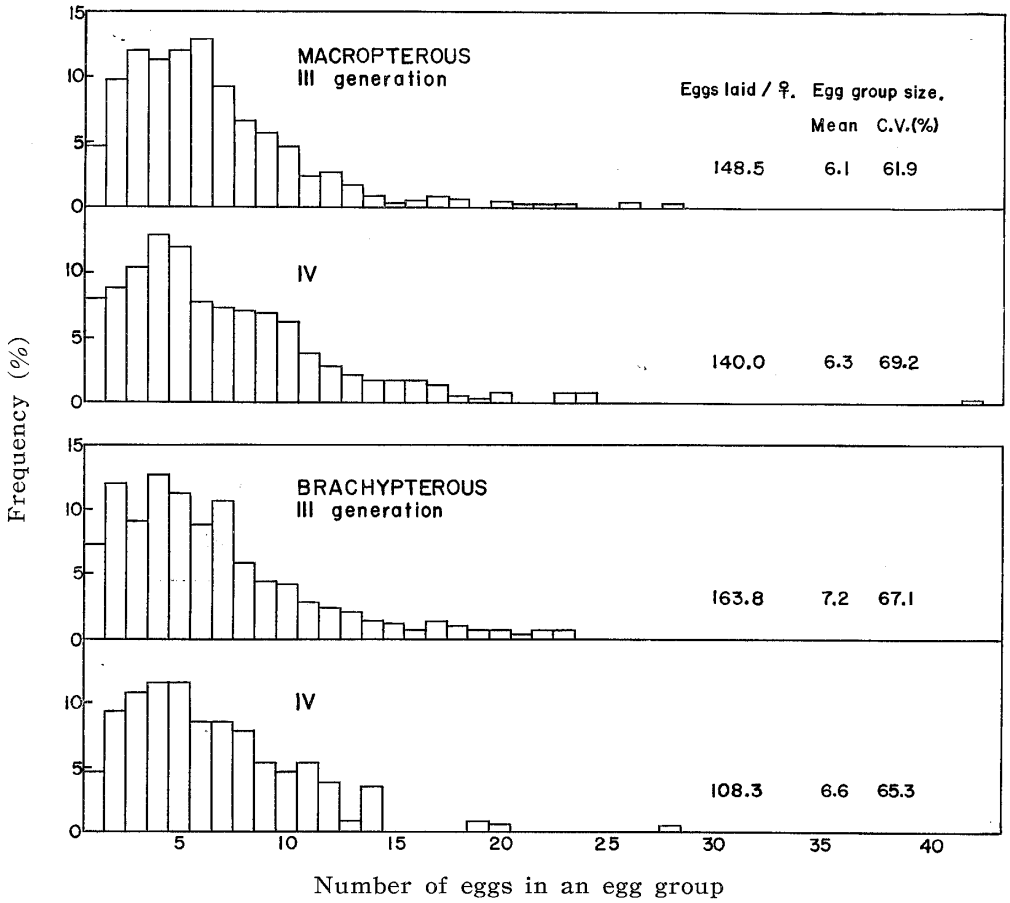

Fig. 5. Distribution pattern for the size of egg groups laid in leaf blades of rice plants at natural temperatures. A total of 1187 egg groups in macropterous females and that of 417 egg groups in brachypterous ones were examined, respectively. Light; natural photoperiods.

6.1→7.0→7.8→4.4

Mean size of egg groups in the brachypterous form in the 3rd generation (late Aug.—mid Sept.);

7.9→7.6→7.4→5.7

Mean size of egg groups in the brachypterous form in the 4th generation (late Sept.—mid Oct.);

7.4→6.6→6.6→5.1

The distribution patterns for the size of egg groups were very skew in all the cases, as given clearly in Fig. 5.

A comparison of the sizes of egg groups laid in rice seedlings and in leaf blades of rice plants in the ripening period

The macropterous females in the fourth generation in 1961 were used as the material for experiment at natural temperatures. The results, given in Fig. 6, showed apparently that the distribution patterns

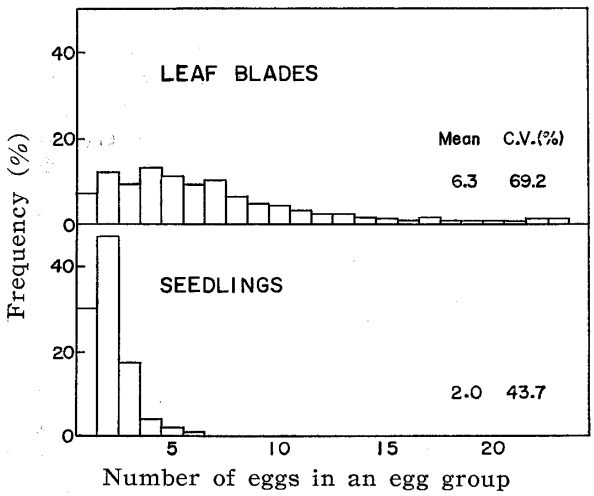

Fig. 6. Comparison between the size of egg groups laid in leaf blades of rice plants in the ripening period and that in rice seedlings. A total of 486 egg groups laid in blades and that of 711 egg groups in seedlings were examined, respectively. Light; natural photoperiods.

for the size of egg groups in these populations were different each other, and that the size of egg groups in seedlings was markedly smaller than that in blades. The mean size of egg groups in seedlings did not change for each of the four successive periods (late Sept.—early Nov.), though that in blades tended to diminish simply as mentioned in the preceding paragraph:

Mean size of egg groups in seedlings;
1.8→1.9→2.0→2.3

Mean size of egg groups in leaf blades;
6.1→7.0→7.8→4.4

DISCUSSION

It is recognized in several insects that the size of egg masses is important for survival rate (YAMAZAKI & HATAI, 1960; LYONS, 1962; MORIMOTO & SATO, 1962; CAMPBELL, 1963) and is influenced by the physiological states of insects (NORRIS, 1950). Likewise, it is known in many phytophagous insects that the oviposition site and the size of egg masses change as their host plants grow.

In Auchenorrhyncha-Homoptera, WEAVER and KING (1954) stated that the type of oviposition site in *Philaenus leucophthalmus* (L.) influences the number of eggs per egg group and also the total number of eggs laid. RAATIKAINEN (1960) reported that both the number and the size of egg groups in *Calligypona sordidula* (S.) depend on the hardness of the stem tissue of oat and are smaller if the tissue is stronger. Similar phenomena are described briefly with some other species (MURATA & HIRANO, 1929 a, b; RAATIKAINEN & TINNILÄ, 1959).

As for the size of egg groups in the brown planthopper, many workers have dealed with results on adults reared on rice seedlings in Japan. That is, the number of eggs in an egg group varies usually from 1 to 10 with a mode of 1 or 2 (ANDO, unpublished; ESAKI & SAMESHIMA, 1939; SUENAGA & NAKATSUKA, 1958; SUENAGA, 1963).

In the present investigation, it was shown that the size of egg groups deposited in the tissue of leaf blades of grown-up rice plants was remarkably larger than that in seedlings. In leaf blades, the size of egg groups tended to decrease as rice plants grew older. However, the size of egg groups in seedlings was not changeable from the early oviposition period to the late, under both constant environmental conditions and natural temperature ones. These indicate that the size of egg groups is affected by the state of the oviposition plant (not only directly by the hardness of the tissue in oviposition sites and the size of rice plants, but also indirectly by the nutritive value to the insect), but little influenced by temperature. It was also observed that the size of egg groups laid in seedlings was usually almost constant, without regard to the differences in fecundity of populations or individuals. The range of variation in the size of egg groups in seedlings was narrower (1—19) than that in leaf blades (1—42). These suggest that there are few chances to indicate the fecundity or the physiological state of females by examining the number of eggs in an egg group, as far as seedlings are used as oviposition plant. However, the size of egg groups laid in the tissue of larger rice plants in the field may be useful as an indicator of the fecundity of them. Further experiments on this point are needed, and a statistical analysis on fitting some mathematical frequency series to the observed ones for the size of egg groups will be conducted comparatively among this and some other species.

SUMMARY

1. The distribution pattern for the size of egg groups laid in leaf blades and sheaths of rice plants was generally very skew, but that in rice seedlings was not so skew.

2. The number of eggs in an egg group deposited in rice seedlings was smaller than that in the blades and sheaths.

3. There were little differences in the size of egg groups between macropterous

and brachypterous females.

4. Though fecundity was remarkably influenced by temperature, the size of egg groups was not affected as far as seedlings were used for oviposition plant.

5. It may be difficult to know the fecundity of individuals by examining the number of eggs in an egg group deposited in rice seedlings.

ACKNOWLEDGEMENTS

It is with great pleasure that the author records his gratitude to Dr. H. Suenaga, Mr. M. Yoshimeki, and Mr. E. Kuno for their advice and criticism given throughout this work.

REFERENCES

Andô, N. (unpublished) cited from Suenaga & Nakatsuka (1958).
Campbell, R. W. (1963) Canad. Ent. **95** : 465～474.
Esaki, T. and T. Sameshima (1939) Report on the leafhoppers injurious to the rice plant and their natural enemies. No. 10, 1～74.
Hassan, A. I. (1939) Trans. Ent. Soc. London **89** : 345～384.
Lyons, L. A. (1962) Canad. Ent. **94** : 49～58.
Morimoto, N. and Y. Sato (1962) Japanese Jour. Appl. Ent. Zool. **6** : 190～195.
Murata, T. and I. Hirano (1929 a) Byochu-Gai Zasshi **16** : 518～528.
Murata, T. and I. Hirano (1929 b) Ibid. **16** : 597～611.
Nasu, S. and H. Suenaga (1956) Nôrinsyô Byôgaityû Hasseiyosatu Siryô **56** : 4～29.
Norris, M. J. (1950) Anti-Locust Bull. **6** : 1～50.
Raatikainen, M. (1960) Ann. Ent. Fenn. **26** : 229～242.
Raatikainen, M. and A. Tinnilä (1959) Valt. maatal. koetoim. julk. **178** : 101～109.
Suenaga, H. (1963) Bull. Kyushu Agr. Expt. Sta. **8** : 1～152.
Suenaga, H. and K. Nakatsuka (1958) Byôgaityû Hasseiyosatu Tokubetu Hôkoku No. 1, 453 pp.
Weaver, C. R. and D. R. King (1954) Ohio Agr. Expt. Sta. Res. Bull. **741** : 1～99.
Yamazaki, S. and N. Hatai (1960) Bull. Nat. Inst. Agr. Sci. **C-11** : 1～36.

摘　　要

トビイロウンカの産卵について

第2報　卵塊卵粒数と産卵能力との関係

持　田　　作
農林省九州農業試験場

本種の卵は植物の組織中に縦に1列に卵塊をなして産下される。幼苗に産下された1卵塊当りの卵粒数は1～19であった。これに対し生育した稲の葉身に産下された場合は1～42であって，その卵塊の大きさの分布は正規型よりはひずみを示した。卵塊の大きさは翅型によって著しく相違することはなかった。幼苗を与えた場合，産卵数は飼育温度によって非常に変化するが，卵塊の大きさは変化しなかった。従って産卵植物として従来一般に供試されてきた幼苗を使用する限りでは，卵塊の大きさから個体群の産卵能力を判断することは困難であるように考えられる。1卵塊当りの卵粒数（x－1）の分布の理論的な分布型へのあてはめについては別に検討する予定である。