Host Plant Factors Influencing Oviposition of the Small Brown Planthopper, *Laodelphax striatellus* FALLÉN, with Special Reference to Oviposition Preference and Fecundity

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INTRODUCTION

The small brown planthopper, *Laodelphax striatellus* FALLÉN, is a vector of the stripe-disease virus which causes severe damage to rice plants in the middle and southern parts of Japan. With the increasing acreage of early seasonal rice culture, rice plants in Hiroshima Pref. have been affected by this virus in large areas since the worst outbreak in 1961. Major infection of the rice plant to the stripe-disease is found to be due to adults of the first generation and often also nymphs of the second generation (SHINKAI 1962, NASU 1963).

Therefore, the ecological characteristics of the first generation adults associated with their migrations and field populations are of great importance because of their primary transmission of stripe-disease virus to susceptible rice plants. It is also observed that the first generation individuals live among various gramineous grasses on spring breeding grounds and that they build up a large population on wheats in particular (KIMURA et al. 1963, MIYAKE 1966). These results observed suggest the possibility that there might be a considerably close relation between host plants and populations on each host in conjunction with their oviposition. Up to the present, however, for this species there has been little information on these problems. In the present paper the effects of various host plants on the oviposition preference and fecundity were studied.

MATERIALS AND METHODS

Oviposition Preference

1. Oviposition on Wheat, Water Foxtail and Annual Bluegrass in the Field.

Field survey on oviposition was conducted on three host plants, i. e. wheat, *Triticum aestivum* L., water foxtail, *Alopecurus aequalis* SOBOL var. *amurensis* OHWI and annual bluegrass, *Poa annua* L., at the fields in Saijo from mid-April to late May of 1963, corresponding to the egg-laying period of the first adult. A field planted to wheat, the variety Yutaka and a fallow field of mixed annual bluegrass and water foxtail growing as wild grasses were used for egg counts. The two fields were approximately 7 a and adjacent to each other. Eggs on each plant were counted at 5-day intervals on 100-270 plants of wheats and grasses selected randomly at five sections in each field.

2. Laboratory Experiments on the Oviposition Preference

The laboratory experiments on the oviposition preference were conducted on the above-mentioned three host species from mid-April to mid-May of 1964 and also on two host species, i. e. water foxtail and rice seedling, *Oryza sativa* L., continuously from April to June to determine whether any shift in preference occurred as the season progressed. Adults used were obtained from the stocks which had been reared under uniform conditions in a saran-screened cage 30 by 30 by 40 cm, i. e. on rice seedlings at a temperature of 25°C and long day condition through successive generations. The test plants were introduced into a glass tube, 4 cm in diameter and 50 or 100 cm long, with two males and two females. Adults were allowed to oviposit during a 5-day period under natural conditions, and then each plant was dissected and eggs were counted.

3. Effect of Nitrogen Fertilizer on the Oviposition Preference.

Another oviposition experiments were conducted in the same methods as described previously on March 6-10 and April 14-20 in 1964. Wheat plants tested were taken from the four wheat fields of the Experiment Station in which various nitrogen levels were supplied. Nitrogen fertilizations in each field were as follows: High-N plot, 1.2kg nitrogen per a in both rice cropping and wheat cropping: Normal-N plot, 0.8kg nitrogen per a in rice cropping and 1.12kg nitrogen per a in wheat cropping: Non-N and Non-Fertilizer plots, no nitrogen or no fertilizers in both croppings. The wheat variety was Norin No. 43 and ammonium sulfate was used as the source of nitrogen. Such fertilizing methods have been practiced over a period of 25 years.

On the other hand, the relative abundance of the small brown planthopper on the above-mentioned 4 wheats was evaluated by sweeping the plants with a 37-cm insect net. Population counts were made at 5-day intervals during the period when the first generation nymphs reached their peak population. Each of the 4 fields was approximately 0.4 a in area.

The 1965 experiments included two host species, i. e. wheat and water foxtail which recieved different nitrogen levels at rates of 0 (Non-N) and 1.35kg of nitrogen per a (High-N). Experiments were carried out at a constant temperature of 20°C on March 15-22 and April 14-19. The experimental methods are just the same as described above.

Effect of Food on Egg Production

Newly hatched nymphs were obtained from the stocks mentioned above. These nymphs were put individually into each small glass tube, 1.5 cm in diameter and 15 cm long, as soon as they hatched, and supplied such food plants as rice seedling, about 10 days old at 25°C, wheat, annual bluegrass and water foxtail, respectively, and reared at a constant temperature of 20°C and long day condition. The adults which emerged from these nymphs on the same dates were paired within 24 hours and reared on the above-mentioned food plants in various combinations as shown in Table 7. Fresh food plants were supplied every other day or every three days in both nymphal and adult rearings. Glass tubes were checked daily for adult mortality and first egg-laying dates and every other day or every three days for eggs.

RESULTS

Oviposition Preference

1. *Oviposition on Wheat, Water Foxtail and Annual Bluegrass in the Fields.*

Data on the field survey which was made to determine the relative effectiveness of some host plants for oviposition by the first adults are shown in Table 1. These results are based on the records of the egg count at the peak period of egg-laying which came in mid-May of 1963.

Table 1. Host preference of the small brown planthopper shown by oviposition on three host species in the fields. 1963 (May).

Host species	Average number of eggs deposited per plant	Per cent of plants deposited
Wheat	18.9	54.3
Water foxtail	6.4	37.0
Annual bluegrass	7.0	20.4

Table 1 showed that there was a significant difference in oviposition between wheat and grasses. Wheat was the most preferred plant for oviposition with significantly more eggs than water foxtail and annual bluegrass. This phenomenon is probably due to the greater attractiveness of wheat to adults and shows that an attractive stage of growth of wheat coincides with the egg-laying period.

2. *Laboratory Experiments on the Oviposition Preference.*

The results of totalling eggs laid on three host plants on the different counting dates during the stage of the first adult are shown in Table 2. Table 3 and Figure 1 show the seasonal changes in oviposition rate on rice seedling and water foxtail.

Table 2. Seasonal host preference of the small brown planthopper shown by oviposition on three host species in the laboratory. Ⅰ. 1964

Dates Oviposition		Number Pairs	Number and per cent of eggs deposited on					
			Wheat		Water foxtail		Annual bluegrass	
			Eggs	Per cent	Eggs	Per cent	Eggs	Per cent
April	15—21	15	92	15.9	369	64.0	116	20.1
April	23—28	11	159	35.4	102	22.7	188	41.9
May	6—11	10	310	53.1	231	39.5	43	7.4
May	14—19	11	284	55.0	205	39.7	27	5.3

Table 3. Seasonal host preference of the small brown planthopper shown by oviposition on two host species in the laboratory. Ⅱ. 1964.

Dates Oviposition		Number Pairs	Number and per cent of eggs deposited on Rice seedling Eggs	Per cent	Water foxtail Eggs	Per cent
April	23—28	12	62	17.6	291	82.4
May	6—11	10	18	13.0	120	87.0
May	14—18	14	42	14.7	243	85.3
May	18—25	14	213	36.3	374	63.7
June	10—17	8	96	76.8	29	23.2

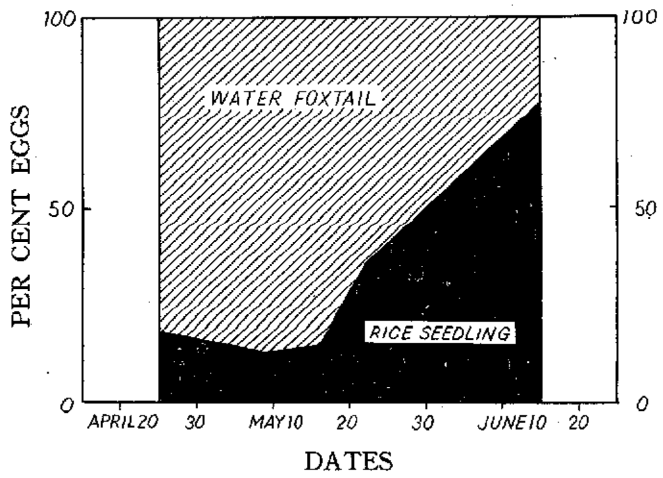

Fig. 1. Seasonal host preference of the small brown planthopper shown by oviposition on two plant species. 1964.

In the seasonal oviposition experiments there was an increase in oviposition on wheat as the season advanced. On the contrary, a decrease in oviposition was found on both annual bluegrass and water foxtail as they matured. In another experiment in which rice seedling and water foxtail were compared, the oviposition on water foxtail had also a similar tendency to decrease toward maturity of host. The growth rate among three host species differed in nature, annual bluegrass was growing rapidly, followed in order by water foxtail and wheat. In comparison between rice seedling and water foxtail, rice seedling was always young, while water foxtail was growing under natural conditions. Thus, an advanced stage of growth may protect the plant from oviposition by adults.

In the main egg-laying period, however, data in Table 2 supported the results of the field experiment in which wheat was preferred significantly for oviposition site over the two grasses.

3. *Effect of Nitrogen Fertilizer on the Oviposition Preference.*

The results on the oviposition experiments for wheat and water foxtail which received different nitrogen levels are shown in Table 4 and 5. On the other hand, the results on the ovipositon experiments mentioned above were evaluated indirectly on the basis of nymphal emergence in the wheat fields by sweeping plants (Table 6).

Table 4. Host preference of the small brown planthopper shown by oviposition on various wheats supplied with different nitrogen levels. I. 1964.

Dates	Number	Number and per cent of eggs deposited on					
		High-N Wheat		Non-N Wheat		Non-Fertilizer Wheat	
Oviposition	Pairs	Eggs	Per cent	Eggs	Per cent	Eggs	Per cent
March, April	32	619	64.7	337	35.3	–	–
April	11	197	81.4	–	–	45	18.6

Table 5. Host preference of the small brown planthopper shown by oviposition on wheat and water foxtail supplied with different nitrogen levels. II. 1965.

Dates	Number	Number and per cent of eggs deposited on							
		High-N Wheat		Non-N Wheat		High-N Water foxtail		Non-N Water foxtail	
Oviposition	Pairs	Eggs	Per cent	Eggs	Per cent	Eggs	Per cent	Eggs	Per cent
March, April	26	566	60.9	364	39.1	–	–	–	–
March, April	21	–	–	–	–	236	61.9	145	38.1
March, April	25	647	72.6	–	–	244	27.4	–	–
March, April	28	–	–	420	67.2	–	–	205	32.8
March	10	173	71.5	–	–	–	–	69	28.5
March	11	–	–	156	52.2	143	47.8	–	–

Table 6. Populations of the small brown planthopper by 50 net-sweeps on various wheats supplied with different nitrogen levels. 1964.

Dates		Number of nymphs and adults on							
		High-N Wheat		Normal-N Wheat		Non-N Wheat		Non-Fertilizer Wheat	
		Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
May	26	678	2	137	0	15	0	35	2
June	1	868	12	571	21	33	2	52	6
June	6	111	8	248	15	24	1	19	6

According to Table 4 and 5, each plant of the wheats and grasses received high nitrogen levels was more attractive than those received low or no nitrogen levels. In comparison between wheat and water foxtail, wheat was significantly preferred regardless of supplying nitrogen fertilizer.

Table 6 indicates that there is a tendency for the populations to increase correspondingly with increasing nitrogen levels. One sample of 50 sweeps of insect net on June 1 yielded 880 individuals from wheat supplied with nitrogen highly, while only 35-58 individuals per 50 sweeps were collected on Non-N wheat or Non-Fertilizer wheat. Thus, significant difference was observed between the nitrogen-fertilized treatments and the non-nitrogen fertilized treatments, with the former exhibiting much higher populations than the latter. Such differences in population are probably due to those in oviposition preference of the preceding adults as shown in Table 4 and 5, and these data were good agreement with the results on the oviposition preference experiments in the laboratory.

Effect of Food on Longevity and Egg Production

Laboratory experiments were conducted to investigate the role of nymphal and adult food. The preovipositional period, longevity and fecundity of the adults reared from 4 different food plants are shown in Table 7 and Figure 2.

Table 7. Effects of different nymphal and adult food plants on longevity and fecundity of the small brown planthopper adult. 1964.

Treatments	Food plants		Dates	Number	Preovipositional period (days)		Longevity (days)				Fecundity			
					Females		Females		Males		Egg masses per female		Eggs per female	
	Nymphal	Adult	paired	Pairs	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
A	Wheat	Wheat	Feb. 5—9	29	3—12	5.9	3—54	32.1	3—39	27.3	1—122	52.8	[illegible]—325	115.4
B	Annual bluegrass	Wheat	Feb. 11—19	38	3—16	7.5	3—57	27.2	3—46	25.4	1—90	43.1	3—219	91.0
C	Water foxtail	Wheat	Feb. 13—18	31	3—13	6.1	4—46	25.6	4—50	22.1	10—102	40.7	6—227	88.0
D	Wheat	Annual bluegrass	Feb. 10—12	22	4—12	6.5	4—50	29.4	5—59	28.1	9—70	31.8	10—177	62.3
E	Annual bluegrass	Annual bluegrass	Feb. 6—12	40	4—16	5.7	2—54	22.7	2—48	20.9	2—81	25.8	4—202	47.6
F	Water foxtail	Water foxtail	Feb. 9—22	27	3—13	7.7	5—51	21.4	5—47	15.6	1—61	22.6	2—120	39.3
G	Rice seedling	Rice seedling	Feb. 19—24	38	3—14	7.7	3—40	26.6	3—27	16.3	2—76	38.1	2—131	69.3

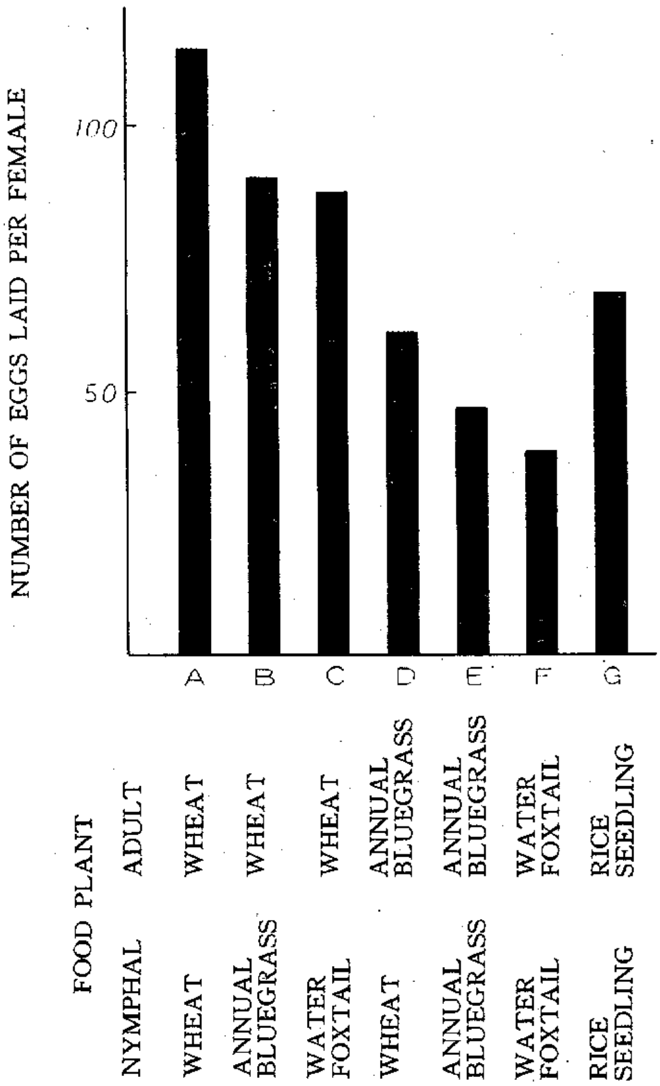

Fig. 2. Effect of different nymphal and adult food plants on egg production of the small brown planthopper adult. 1964.

The water foxtail-reared and rice seedling-reared individuals required the longest preoviposition period, 7.7 days, and the annual bluegrass-reared females the shortest, 5.7 days.

The preoviposition period ranged from 3 to 16 days. The females in all treatments had almost the same preoviposition period, 5.7 to 7.7 days, regardless of the species of food plant during nymphal and adult stages. While food plant during both stages influenced the duration of adult longevity and egg production remarkably. Females lived longer than males in all treatments. The adults reared on wheat exclusively during nymphal and adult stages lived longest (female 32.1 days, male 27.3 days), while those reared on water foxtail had the smallest measurements (female 21.4 days, male 15.6 days). A similar trend was also evident in egg production. Thus, the female lived about 1.5 times as long and laid approximately 3 times as many eggs when they fed wheat exclusively during nymphal and adult stages as when fed water foxtail, giving the poorest results on both longevity and egg production.

In comparisons between nymphal food when reared on the same adult food (Treatment A, B and C or D and E), egg production of the adults resulting from nymphs reared on wheat was much more than that of adults from water foxtail or annual bluegrass. Inversely, when reared on the same nymphal food (A and D, B and E, C and F), adults fed wheat were again more fecund than those fed annual bluegrass or water foxtail. As is seen from Figure 2, wheat was the most favorable host for maximum longevity and fecundity.

DISCUSSION

In the field survey and laboratory experiments on the oviposition preference, it was shown that the fiirst adult of the small brown planthopper had a distinct preference for wheat during the main egg-laying period. Regular changes in the percentage of oviposition on each host were found as the season advanced. These changes are based to a great degree on the host growth, showing seasonal increase in oviposition on wheat or rice seedling on the one hand and seasonal decrease on grasses on the other. In nature, annual bluegrass was growing the most rapidly, followed in order by water foxtail and wheat. Therefore, it may be reasonable to consider that the oviposition rate on each host is so much changed according to the differences in host growth. This tendency was particularly clearly seen in the host plant at generative growth period (Table 2). Thus, it is believed that plant maturity has an internal effect on oviposition preference. As a result, adult migrants are considered to shift to summer hosts including rice plant. MIYAKE & FUJIWARA (1962), in experiments with the white back planthopper, *Sogatella furcifera* HORVÁTH and the brown planthopper, *Nilaparvata lugens* STÅL and MIYAKE (1966) with the small brown planthopper, *Laodelphax Striatellus* FALLÉN, obtained similar results that the growing conditions of host plants were reflected in oviposition. Thus, these findings take the leading role ecologically in induction of migration of the planthoppers, so further experiments on the problem of the dependence of host preference on host plant relations are being carried out.

In addition, the use of nitrogen fertilizer affeccted the preference during oviposition and the clearly-shown increase of eggs laid on host plants received high nitrogen levels was also the general rule in the small brown planthopper as well as in other insects. Furthermore, wheat, as compared with water foxtail, was more preferred host plant for preference during oviposion regardless of the use of nitrogen fertilizer.

Data in Table 6 indicated that increasing levels of nitrogen fertilizer were associated with corresponding increase in the small brown planthopper population, supporting the results of oviposition preference for host plants grown at high levels of nitrogen as shown in Table 4 and 5.

The results described above lead to the conclusion that the growth stage and species of host plant and the use of fertilizer may have been one of factors responsible for the differences in oviposition preference. The seasonal changes of growth of host plant are among the most important ecological factors associated not only with oviposition preference but also with migration.

Table 7 compared the suitability of some host plants for reproduction of the small brown planthopper. Longevity and fecundity were affected by the species of nymphal and adult food plant. Their records showed that food plants during the adult stage were more essential for maximum longevity and egg production than the nymphal food. The rank of the host plant for producing longevity of adults was wheat, annual bluegrass and water foxtail. The average egg production per female was 115.4 on wheat, 47.6 on annual bluegrass and 39.3 on water foxtail. Thus, it was found that wheat had a greater influence on longevity and fecundity than any other host species. It appeared that there was a relationship between the adult longevity and the number of eggs produced. Namely, in general the females that lived the longest produced the greatest number of eggs. Consequently, the effects of nymphal and adult food on the longevity of the adult and on the egg production are apparently related factors.

SUENAG (1963) and MOCHIDA (1964 a, 1964 b) have shown that temperature levels and fluctuations in temperature had a marked influence on the ovipositon rate of the white back planthopper, *Sogatella furcifera* HORVÁTH, and the brown planthopper, *Nilaparvata lugens* STÅL, and that the temperature conditions not only after emergence but also during the nymphal stage affect the oviposition of the brown planthopper remarkably. It is of interest to note that both temperature and host plant factors affect on the oviposition in the same direction.

As stated already, since the small brown planthopper has a wide range of host species during spring season, it is believed that host conditions, as an oviposition site or a food source, have major effects on the occurrence of the planthoppers, depending upon whether or not the host plants are in preferred stage or favorable one. For example, the fact that wheat is the most preferred for oviposition site and also the most favorable for reproduction, gives an account of a large population on wheat in the spring. Therefore, host plant relations other than climatic conditions appear to be important factors in determining the build-up of local population of the small brown planthopper.

The significance of the observed facts is obvious, not only with regard to fundamental problems in planthopper ecology, but also in problems of purely practical nature. We have to take account of these findings when we are forecasting the extent of occurrence of the small brown planthopper. Also in the case of the white back planthopper and the brown planthopper, such as occurred seriously in 1966 and 1967 (TAKAKI 1967, FUJIWARA 1967), the importance of host plant factors on the oviposition must be studied thoroughly.

SUMMARY

The effects of host plant relations on the oviposition preference and reproduction of the small brown planthopper, *Laodelphax striatellus* FALLÉN, were studied under field and laboratory conditions from 1963 to 1965. Wheat, *Triticum aestivum* L., water foxtail, *Alopecurus aequalis* SOBOL var. *amurensis* OHWI, annual bluegrass, *Poa annua* L. and rice seedling, *Oryza sativa* L., were compared.

A comparison of oviposition on different host plants on the different counting dates was made throughout the spring season. In both field and laboratory experiments wheat was preferred over water foxtail and annual bluegrass for oviposition by the adults during the peak period of egg-laying which came in early to mid-May. Data through the season

indicated regularity of oviposition as the season advanced. There were gradual increases in ovipotision on wheat or rice seedling on the one hand and seasonal decreases on grasses on the other. These phenomena are probable due to the differences in growth of host plants

The use of nitrogen fertilizer and host species at the same growing stage also affected preference during oviposition. Wheat and water foxtail received high nitrogen levels were more attractive than those received low or no nitrogen levels. In comparison between wheat and water foxtail, which were both young, wheat was significantly preferred regardless of the use of nitrogen fertilizer. Data on nymphal populations in wheat fields in which various nitrogen levels were supplied showed an increase with each increase in nitrogen level and differences in population between treated and untreated plots were remarkable. These data supported the results of oviposition preference obtaind in the laboratory.

The effects of host plant relations were important in determining the longevity and fecundity of the adult. Food throughout life span of this species influenced longevity and fecundity. Adult food had a greater influence on them than any other factor, including food during the nymphal stage. Of 4 gramineous host plants tested, wheat was the most favorable for maximum longevity and egg production. The rank of the host plants for producing longevity and fecundity was wheat, rice seedling, annual bluegrass and water foxtail. It was concluded that host plant factors other than climatic conditions were important in determining the build-up of the small brown planthopper during the spring and in governing the migration into paddy fields.

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摘　　　　要

寄主条件がヒメトビウンカの産卵寄主選択ならびに産卵能力におよぼす影響

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ヒメトビウンカの春季の主たる寄主であるコムギ，スズメノカタビラ，スズメノテッポウを用いて，その種類，生育時期，窒素質肥料などが成虫の寄主選択ならびに産卵におよぼす影響を調べた。

第1回成虫の産卵最盛期にあたる5月上中旬野外では，コムギへの産卵がスズメノカタビラ，スズメノテッポウにくらべて著しく多かった。この傾向は室内実験でも全く同様であった。4月から6月にわたり，イネ苗とスズメノテッポウに対する産卵を時期的に調べた結果，両寄主への産卵には一定の傾向が認められた。すなわち，スズメノテッポウの生育にしたがって本種への産卵は次第に減少し，6月中旬の熟期には産卵率は約20%に落ちた。生育の異なる冬草間でも，生育の進んだ寄主への産卵は少なく，寄主の生育差が寄主選択を支配する大きな要因と考えられた。窒素質肥料もまた寄主選択に影響し，窒素施用量の多い寄主へ強い選択性を示した。

幼虫，成虫期を通しての飼料のちがいは成虫の生存期間，産卵数にも影響をおよぼし，とくに幼虫時代にくらべ成虫時代の飼料の影響が大であった。供試した寄主4種の中では，コムギが成虫の生存期間また産卵数を最も大ならしめ，次いでイネ苗，スズメノカタビラ，スズメノテッポウの順であった。