Host preference of the pea leaf miner, *Phytomyza atricornis* MG. in relation to the leguminous plants

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Summary The pea leaf miner does severe damage to various agricultural crops in Japan. A series of tests was done to determine if the leguminous host plants: pea, broad bean and common vetch, influenced the feeding and egg-laying habits, and if larval populations varied with varieties of the pea. *Pisium sativum* (pea) received significantly greatest number of feeding and egg-laying punctures. Varieties of the pea tested did not vary in susceptibility to the leaf miner infestations as measured by larval counts.

The pea or chrysanthemum leaf miner, *Phytomyza atricornis* Meigen, is a cosmopolitan polyphagous species. In Japan the larvae of this species mine the leaves of sixty-five plant species, and a severe attack has been discussed in the previous papers on the bionomics of this species on the pea in spring than on other hosts. The female fly has a peculiar habit of making punctures usually along the margin on the under side of leaf and sucking the exuding sap from the parenchyma cells. When the leaf miner occurs, economic losses may be incurred due primarily to the mining of the larvae within the leaf tissue, and secondarily, to the feeding and oviposition punctures of the females. Speculation concerning a possible influence of specific leguminous types on the habits of this fly led to an investigation of the feeding and egg-laying habits on three leguminous plants and four varieties of the pea. The results of a 2-year study on the host preference of the pea leaf miner conducted at the Experimental Farm of the Kyoto Prefectural University are presented in this paper.

Materials and Procedures

CAGE STUDIES:- The mining larvae of the second generation of the pea leaf miner were collected in the pea field at the end of April. The pupae were kept at 100% RH and room temperature. After the emergence, the flies were lapped with honey for a day.

Three plant species, belonging to the family Leguminosae, were selected for the host plant preference tests of the flies because each of them represents wide range of growth characteristics and plant appearance. They were: *Pisium sativum* L. (var. Furansu-Kinusaya), *Vicia fava* L. (var. Nagasaya) and *V. sativa* L., respectively the pea, broad bean and common vetch. The pea and broad bean tested were grown from the seeds in pots (30cm in diameter) under wire-screened house conditions except for the field transplants of common vetch.

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Three planting schedules employed in the host plant preference tests of flies were: Experiment 1 with individual plant species per pot, experiment 2 with all three species per pot, and replicated three or four, and ten times respectively in 1964. Experiment 3 was conducted under combinations of two different plant species and replicated three times in 1966. In the beginning of experiments some leaves of the host plants were taken off to equal approximately in the area of leaf surface between the host plants. Each pot was covered with 50x 65 cm cylindrical saran-screened cage. No attempt was made to control the temperature and humidity during these studies.

Twenty couples of flies in the first two experiments and five or ten couples of flies in the third experiment were introduced from the bottom of cage, which was then tied. It was so difficult to distinguish the egg-laying punctures from the feeding ones in the field that the number of hatched larvae was recorded after ten days of the introduction of flies. The numbers of feeding and egg-laying punctures per $10cm^2$ in area of leaf surface were calculated by means of average number of punctures per plant and total leaf areas of each plant species.

FIELD STUDY: - A test was started in spring, 1966 to determine if the larval populations varied with the varieties of pea: Usui-Endo, Hakuryu-Endo, Oranda-Kinusaya and Furansu-Kinusaya. The experiment was conducted in the pea field arranged in a single-row beds spaced 50cm apart, and arranged in a randomized complete block design with five replications. No chemical control was used at any time on any of the plots.

The leaf miner population was sampled at intervals of ten days beginning prior to the initial infestation and counting until the plants had withered naturally. Number of larvae was obtained by collecting one hundred leaflets at random from near the top, middle, and bottom of the foliage in each generation, from the center plants of each plot (405 plants per treatment), and dividing by the number of observations made.

Results and Discussion

CAGE STUDIES: - Data on the numbers of feeding and egg-laying punctures

Table 1. Feeding and egg-laying punctures of the pea leaf miner on three different host plant species

Experiment	Host plant	Feeding punctures		Egg punctures	
		$\bar{x}$[1]	±s	$\bar{x}$	±s
1	*Pisium sativum*	45.083a[2]	4.721	2.943a	1.083
	Vicia sativa	27.831b	3.998	0.852b	0.309
	V. fava	13.436c	7.999	0.044c	0.048
2	*Pisium sativum*	31.211a	17.593	3.534a	1.085
	Vicia sativa	13.633b	6.276	0.071bc	0.003
	V. fava	6.014c	6.705	0.028c	0.032

1) $\bar{x}$ and ±s show the mean of number per $10cm^2$ of leaf surface and standard deviation respectively.
2) Any two numbers in the same column followed by the same letter are not significantly different as determined by t-test at the 5% level.

per 10cm² of leaf area in the first two experiments are shown in Table 1.

The numbers of both punctures were greatest on the leaves of pea, intermediate on common vetch, and least on broad bean. The proportionate abundance of feeding and egg-laying punctures in experiment 1 and of feeding punctures in experiment 2 on the different host plant species showed significant differences. The significantly little number of feeding punctures in *Vicia fava* is suggestive of responses to chemicals that are insusceptible to the famale fly by taste of a peculiar habit, although neither the material nor behavior basis for such characteristics has been satisfactorily demonstrated. In experiment 2, multiple feeding and egg-laying punctures were also more common on the leaves of pea than on those of common vetch and broad bean. However, the numbers of egg punctures on the common vetch and broad bean were not significantly different.

The number of egg-laying punctures on the leaves of *Pisium sativum* showed a significant correlation with the number of feeding punctures in experiment 2 (r=0.67*), but not on the common vetch (r=0.41) and broad bean (r=0.59).

The data for experiment 3 are presented in Table 2. There were significant differences in ratios of both punctures in the pea and each two of *Vicia* species, but not significantly different when *Vicia* species were planted altogether.

Table 2. Feeding and egg-laying punctures of the pea leaf miner on leaves of two different hosts

Host plant	Number of couple of flies	Feeding punctures		Egg punctures	
		$\bar{x}$	±s	$\bar{x}$	±s
Pisium sativum	5	18.301a	3.233	1.667a	0.566
Vicia sativa		0.570b	0.599	0.060b	0.011
Pisium sativum	5	14.043a	3.753	2.001a	0.495
Vicia fava		2.745b	2.217	0.005b	0.002
P. sativum	10	38.281a	14.770	10.874a	4.222
V. fava		5.007b	3.619	0.213b	0.052
Vicia sativa	5	5.616a	2.789	0.323a	0.227
V. fava		3.510a	1.324	0.043a	0.047
V. sativa	10	20.380a	5.632	1.657a	1.147
V. fava		11.535a	2.402	0.381a	0.355

A considerable difference between the degree of egg-laying punctures of the pea leaf miner is apparent in the results of the first two experiments and experiment 3. It seems reasonable that there may have been a difference in levels of chance for oviposition. The percent egg-puncture was apparently variable by the three different host plant species, ranging from 22.1% in pea to 0.2% in broad bean in the experiment 3, while in experiment 1 from 6.1% in pea to 3.3% in broad bean, and in experiment 2 from 10.2% in the former to 4.6% in the latter. It was significantly lower from the broad bean by a combination of pea with that.

The female flies deposited more eggs on the leaves of pea in experiment 2 than 1, while on the leaves of common vetch and broad bean were adverse. The egg-laying punctures on the leaves of each host plant between the experiments 1 and 2 were not significantly different (Table 3). The only significant difference in number of egg-laying punctures on the leaves of common vetch was computed at the 10% level ($t_{0.1}=1.782$). This data shows that the relative susceptibility of flies did not change for oviposition significantly to the pea. However, the numbers of feeding and egg-laying punctures on the leaves of common vetch by combination of the experiments 1 and 3 were highly significant. The conclusion drawn from these experiments was that the flies of the pea leaf miner deposited significantly greater number of eggs on the leaves of *Pisium sativum* than on that of *Vicia sativa* and *V. fava.*

Table 3. Results of t-test for discrepancy of numbers of feeding and egg-laying punctures in each host between the experiments

Experiments	Host plant	df	Feeding punctures t	Egg punctures t
	Pisium sativum	11	0.548	0.522
1 - 2	*Vicia sativa*	12	0.328	2.158
	V. fava	12	0.313	0.514
	Pisium sativum	4	5.868**	1.911
1 - 3	*Vicia sativa*	5	7.956**	4.058**
	V. fava	5	1.981	0.026

** Significant at the 1% level.

FIELD STUDY: - The leaf miners were active throughout most of the pea growing season. The first generation oviposition began in late March, 1966 and continued to early April. The total numbers of larvae mined on one hundred leaflets of each of the four varieties and total mortalities in each generation are shown in Fig. 1.

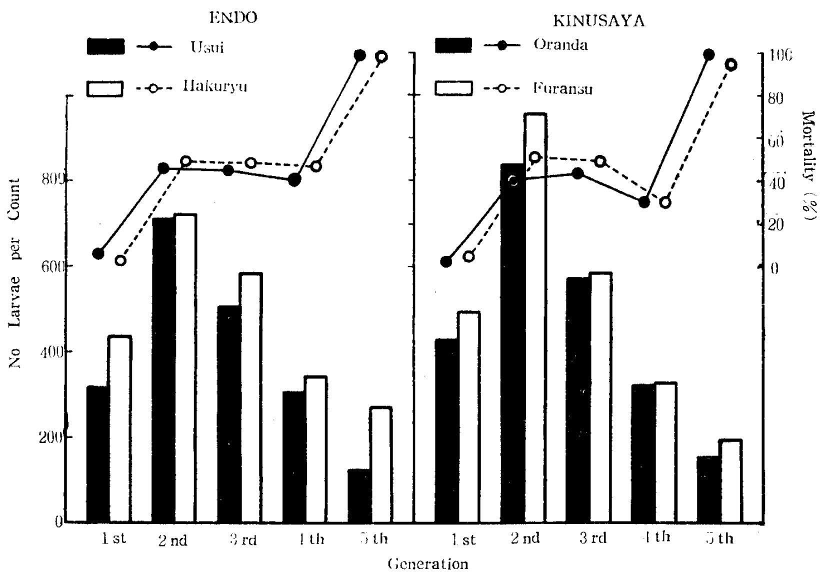

Fig. 1. Numbers of larvae and total mortalities of each of 4 pea varieties in successive generations.

The increase in abundance of larvae occurred in the second generation in each variety, and from then a population decreased gradually as the season progressed. During the five generations of the pea leaf miner in spring, the number of larvae mined the leaves of pea showed no significant differences between any two varieties. The differences of number of eggs on the different varieties were long ago shown to be correlated with the differences of growth vigor or habits in each variety against the rice leaf miner (Kato et al. 1948) and the wheat linear leaf miner (Sasakawa 1954). It seems probable in view of these results that a combination of materials will be needed for an analysis on the pea leaf miner.

Contrasted with the leaf miner larvae, the mortality had two definite peaks, one in the second generation except for the case of Oranda-Kinusaya and another in the fifth. There was a tendency for the larval death to increase in the mature stage until the fourth generation, but a fairly high mortality of the fifth generation occurred in young stage as shown in the black wheat leaf miner (Nishijima et al. 1963).

Population studies of the melon leaf miner by Hills & Taylor (1951), Michelbacher et al. (1951) and Oatman (1959), and of the black wheat leaf miner indicate that the main factor controlling the population of these leaf miners is the hymenopterous parasites under natural field conditions. From the observation of the pea leaf miner it became also evident that a parasite (Eulophidae) was more successful in host population regulation. It has already been shown that the host population levels are not determined by the per cent of parasitization, but rather by the rate of increase of parasitization with increasing host density. Also, the population of a parasite in the pea leaf miner does not clearly indicate an efficacy in host population regulation because it is effected ralatively by a secondary parasite in the later generations. On the other hand, the intraspecific competition may influence the decline in numbers of the leaf miner population after it has reached very high as found in the melon leaf miner (Oatman 1959-'60). It will be discussed later on the host-parasite complex of the pea leaf miner by the data based upon long years of laboratory and field experiments.

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摘　要　ナモグリバエはわが国において栽培作物を含む65種類の植物の葉内を潜孔加害するが，マメ科寄主植物のうち，エンドウ，ソラマメおよびカラスノエンドウならびにエンドウとキヌサヤの4品種に対する成虫の産卵選好性を調査した．

1）エンドウに対する産卵選好性が最も大きい．すなわち，雌成虫による傷痕数については，寄主植物1種単植および3種混植の場合95%信頼度においてエンドウ＞カラスノエンドウ＞ソラマメとなり，2種混植の場合はエンドウ＞カラスノエンドウ＝ソラマメとなる．また，ふ化幼虫数については，単植の場合のみ95%信頼度においてエンドウ＞カラスノエンドウ＞ソラマメとなり，混植の場合にはエンドウ＞カラスノエンドウ＝ソラマメとなる．

2）ウスイおよび白竜エンドウ，オランダおよびフランスキヌサヤの4品種間に寄生幼虫数の有意差は認められない．ナモグリバエ幼虫個体数はいずれの品種でも第2世代に激増した後は減少傾向をたどるが，幼虫死亡率は同世代以降ややよこばい状態がつづき，第5世代で著しく高率となる．

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