a distinct response to either attractant. No reports have been noted on insects such as the jackfruit fly which is responsive to more than 2 attractants. Among fruit flies which show responsive behavior to the attractants, the number of species belonging to the subgenus *Strumeta* is the largest, with 9 and 8 species demonstrating responsiveness to methyl eugenol and cue-lure, respectively. This fact indicates that there is very little correlation between the taxonomical position of insect species of the genus *Dacus* and the kind of attractant(s) to which they exhibit a response. In other words, taxonomical classification based upon kinds of effective attractants, is impossible in *Dacus* fruit flies. Considering the case of the jackfruit fly which is responsive to the 2 attractants, it might

generally be said that the mechanism of attraction in insects seemed to be complicated.

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Mortality Factors Affecting Overwintering in Pupae of the Pear Leaf Miner,

Bucculatrix pyrivorella K.

(Lepidoptera : Lyonetiidae)¹

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In Chiba Prefecture, successive outbreaks of the pear leaf miner have occurred during the last several years. This insect is known to repeat 4 generations per year, thus the curve of adult emergence obtained from light trap data (6 watt, black light) shows 4 peaks which appear in late April, late June, early August and early September, respectively. Pupae of the 4th generation overwinter on the bark of trunks and branches of pear trees. Furthermore, population density of the 4th generation is generally the highest in comparison to other generations.

Although the economic importance of this insect has increased greatly in recent years, our knowledge regarding the ecology of this insect is far from satisfactory. In this paper, we examined those factors which cause mortality of overwintering pupae as a first step towards discernment of the ecology of this insect.

In September 1972, 100 specimens of trunks and branches of pear trees in Yachiyo City were selected, wrapped with thick paper (about 15 cm in length $\times$ about 25 cm in width); insects contained therein pupated on the paper in a similar manner as they would on the bark of trees. In February 1973, pupae overwintering in this condition were brought into the laboratory and kept under semi-field conditions: i.e., temperature, humidity and light were not controlled, but the insects were protected from rain. On May 9, 1973, the number of pupal shells and pupae which were killed by various mortality factors, such as predators, parasites, fungal diseases and unknown factors, were examined. The number killed by predators was estimated by counting the remnants of pupae attached onto the artificial substratum.

Monthly changes in mortality caused by various factors were examined from November 1973 to May 1974 in Ichihara and Yachiyo City by direct counting of pupae on the trees. This counting was carried out once or twice per month.

In order to investigate the local difference in mortalities caused by various factors, 7 orchards were chosen from 5 localities in Chiba Prefecture, and the mortality at these orchards was also examined in May 1974.

Fig. 1 shows the relationship between mortality and the number of pupae per 1000 cm² of paper substratum. As shown in this figure, the total

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Fig. 1. Percentage of mortality caused by various mortality factors in relation to number of pupae per 1000 cm². Circles indicate the observed percentages of mortality, and the average is shown by lines. Arrows indicate the dots plotted lower portion than actual.

percentage of mortality did not display an increasing tendency as a function of an increase in pupal density. This relationship did not change when total mortality was divided into any one of several mortality factors, such as fungus diseases, predation, parasitic infection and unknown factors.

OHGUSHI (1968) has reported that in the arrow-head scale, *Unaspis yanonensis* K., survival rate tended to increase with an increase of the overwintering population density. Although such a tendency was not observed in the present experiment, it is very interesting that a high population density did not cause a sharp increase of mortality. In other words, it can be said that within the range of population densities examined, a high population density during the overwintering period does not always bring about an unfavorable effect on the population.

Table 1 shows the mortalities of overwintering

pupae at 5 localities in Chiba Prefecture in 1974. As shown in Table 1, pupal mortality was mainly due to predators and fungus diseases, the former being of greater consequence. In the laboratory, it was ascertained that *Chilocorus kuwanae* S. attacked pupae, however, this was not observed in the field. Since some pupae were observed to have been attacked by spiders in the field, it is suspected that they probably also come under the attack of other predators.

The fungus diseases were attributed to be the second important cause of pupal mortality. Mortality caused by parasites and unknown factors was rather small in comparison with the 2 above-mentioned factors. Although some wasps were found to be parasitic, determination of their species has not yet been completed. KANAI (1972) reported *Elachertus* sp. to be a parasite of this insect. Other mortality factors indicated as "unknown

Table 1. DIFFERENCE IN PUPAL MORTALITY (%) CAUSED BY VARIOUS FACTORS OBSERVED IN 5 LOCALITIES IN 1974

Mortality factors	Locality							
	A	B ₁	B ₂	C	D	E ₁	E ₂	Avg.
Fungus diseases	12.4	1.2	2.5	12.8	9.8	3.9	21.5	9.2
Predators	27.4	43.2	33.5	13.6	29.0	45.9	18.5	30.2
Parasites	5.8	6.4	2.0	3.2	1.4	0.3	5.5	3.5
Unknown factors	2.3	2.4	1.5	2.4	4.9	0.8	5.5	2.8
Total	47.9	53.2	39.5	32.0	45.1	50.9	51.0	45.7
No. of examined	1000	250	200	250	1000	1200	200	585.7

A: Murakami, Yachiyo City.

B₁, B₂: Nanatsugi, Shiroy Town.

C: Ōno, Ichikawa City.

D: Yanagihara, Ichihara City.

E₁, E₂: Machida, Ichihara City.

factors" in the table were not traced in detail in this experiment. However, it is suspected that pupae of this group were already affected by some physiological defects.

From the foregoing results, it can be said that local difference in the action of mortality factors is not conspicuous. OHGUSHI and NISHINO (1966) reported that mortality of *U. yanonensis* during the winter ranged from 84% to 99%. In the case of the pear leaf miner, however, total mortality was only 46%. As compared with other insects, this represents a very low mortality.

Fig. 2 shows monthly changes in the percentage of mortality caused by different factors. The percentage of mortality caused by fungus diseases did not show a great seasonal change. Larvae of the 4th generation usually pupate during the period from the end of September to October. Fungus infection seems to occur during this pupation period or immediately thereafter, since transmission such infections did not occur at a later time. The percentage of mortality caused by predation showed an increase from late autumn to spring of the next year, and the spring increase was very sharp. In the graph, the percentage of mortality was obtained by counting the number of remnant pupae killed by predators during the overwintering period, thus this figure gives the percentage of an accumulated mortality during that period. Therefore, a gradual increase in mortality during the period from the start of examination to March seems to suggest the occurrence of predation at about the same rate. On the other hand, the sharp increase of mortality in

Fig. 2. Monthly change in the percentage of mortality caused by 3 factors in Ichihara City (left) and Yachiyo City (right).

the spring indicates a sharp increase in the number of predators at this time. Some birds, such as the house sparrow, are probably important predator during winter, but this factor has not yet been examined in the field. In spring the important enemies are the predacious insects, such as the ladybug and some spiders. The emergence of parasites from pupae of the pear leaf miner occurred twice in both spring and autumn, but the

numbers which emerged in spring was larger.

In short, it can be said that the monthly change of mortality during the overwintering period is most strongly influenced by the intensity of predation.

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