1. GEOGRAPHICAL DISTRIBUTION OF PHYSIOLOGICALLY VARIED POPULATIONS IN THE RICE STEM BORER, *CHILO SUPPRESSALIS*, IN JAPAN

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Introduction

The rice stem borer, *Chilo suppressalis* Walker, which is distributed throughout Japan with the exception of some part of Hokkaido, is considered to be essentially polyvoltine, because it can be reared successively for several generations a year under suitable conditions, for example, at 25°C. However, in various localities, the pattern of the moth appearance is not necessarily simple, namely in some cooler places it appears only once a year, whereas sometimes it comes out thrice a year in some western

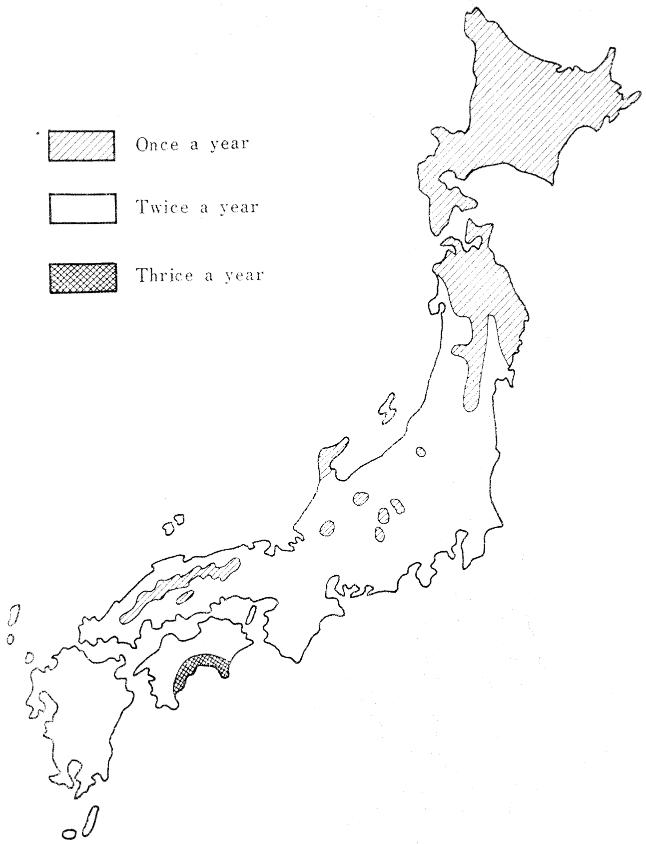

Fig. 1. Trend of annual moth-appearance in Japan.

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parts of Japan. Therefore, from the practical point of view, it is of most importance to understand the nature of various populations in the rice stem borer, and further, if possible, to clarify the factors which control the occurrence of the borer.

The number of generations of the rice stem borer in Japan

As indicated in Fig. 1 and 2, the number of generations of the rice stem borer, which has been obtained from light traps set up throughout Japan, seems to be complicated, because of the genetical factors, climates, differences in the rice growing practices and so on. Nevertheless, we can distinguish some major inner factors which affect the pattern of life cycle of the borer.

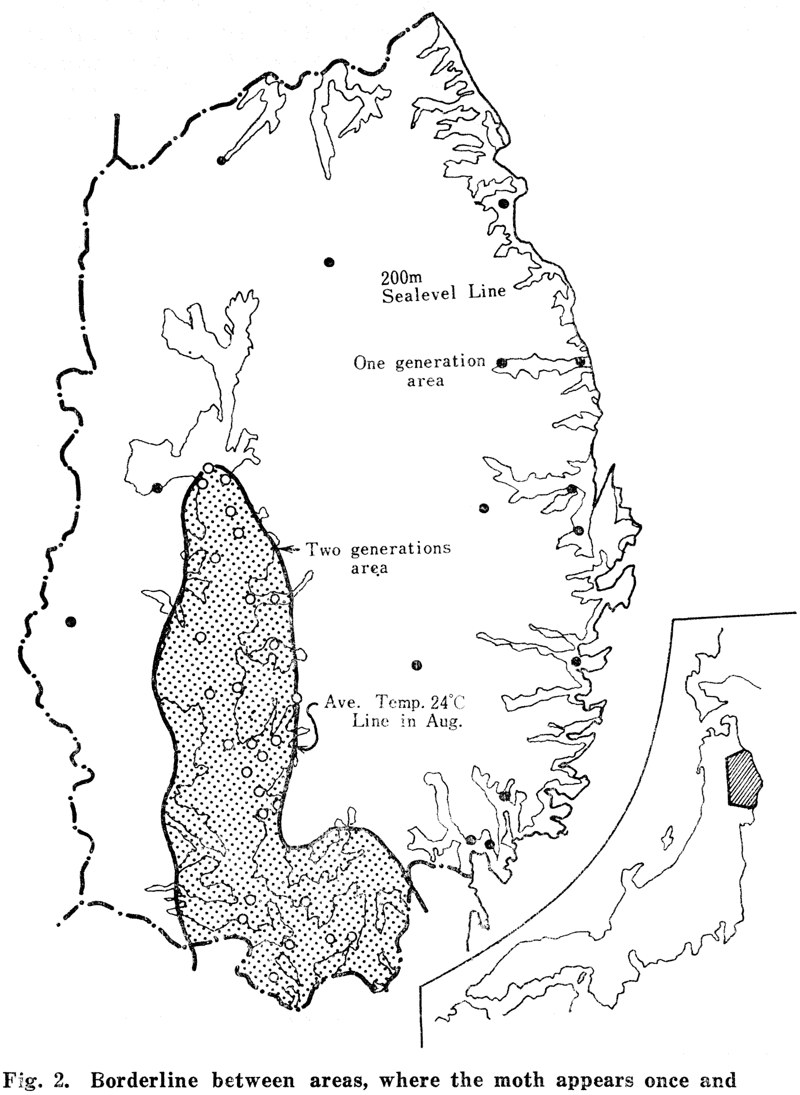

Fig. 2. Borderline between areas, where the moth appears once and twice a year.

Ecotypes in the rice stem borer

Since around 1955, so called "incubation method" which has been designed to forecast the time of the rice stem borer moth, has generally been applied at major observatory station in Japan, and now we feel, we have reached the stage where the whole figure, at least concerning the physiological differentiation of various populations in the rice stem borer in Japan, can be shown.

As early as 1951 Fukaya pointed out that there were two distinct groups of different nature in this borer. The first group is distributed in areas facing the Sea of Japan, and has a comparatively short life cycle than that of the second group, which is distributed in the western part of Japan. Thus, the former has been named Shonai ecotype and the latter the Saigoku ecotype.

The diapause of the rice stem borer belonging to the Shonai ecotype is so slight that when it is subjected to a temperature of about 25°C in winter (December) pupation normally follows after about 18 days, while the larva of the Saigoku ecotype fails to pupate within 60 days.

The relationship between the period before pupation in day and the time of the incubation at 27°C in hibernating borers belonging to these ecotypes can be shown in Fig. 3.

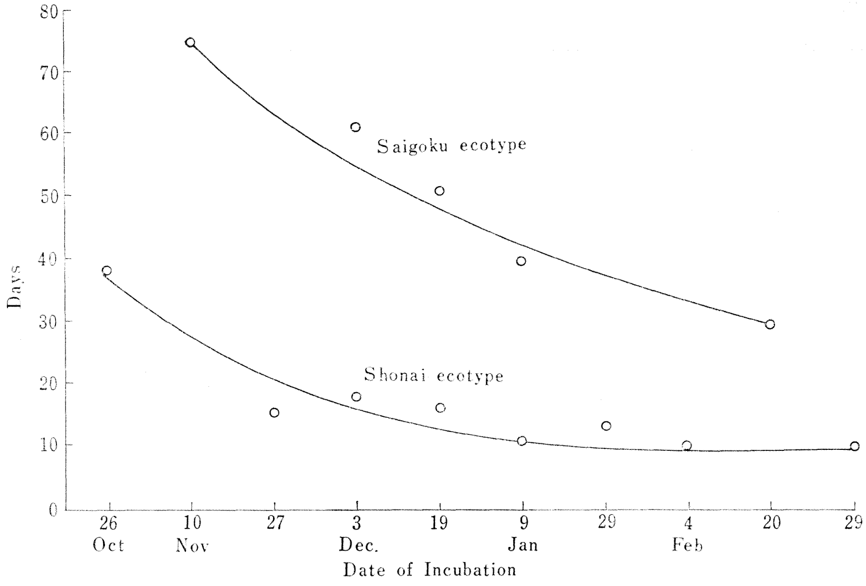

Fig. 3. Periods in days before pupation at 27°C.
(Fukaya & Mitsuhashi, 1961)

Table 1 shows the difference in the larval period at various temperatures among larvae originated from three different localities.

The difference in pupal period is also distinct in different populations, as shown in Table 2.

Moreover, it was demonstrated that there was a difference in susceptibility to photoperiod in both ecotypes. Namely, according to Inoue and Kamano (1957), if the rice stem borer belonging to the Saigoku ecotype is exposed during the larval period

Table 1. Larval period in different populations.

Temperature	Locality (Ecotype)	No. of Indiv.	Larval period (days)	
			Experimental	Theoretical
20.5°C	Yamagata (Shonai Ecotype)	63	36	35.4
	Saitama (Intermediate)	95	57	59.5
	Fukuoka (Saigoku Ecotype)	113	60	66.7
24.0°C	Yamagata	79	26	26.5
	Saitama	?	37	35.9
	Fukuoka	65	42	37.8
29.5°C	Yamagata	70	19	18.9
	Saitama	85	22	22.1
	Fukuoka	110	22	22.5

(Kamano, unpublished)

Table 2. Pupal period in different populations.

Temperature	Locality (Ecotype)	Sex	No. of Indiv.	Pupal period (day)	
				Experimental	Theoretical
20°C	Yamagata (Shonai ecotype)	M	11	17.1±1.2	16.72
		F	17	15.8±0.8	15.31
	Tokushima (Saigoku ecotype)	M	24	18.0±0.9	17.18
		F	19	17.6±1.7	16.42
25°C	Yamagata	M	9	9.7±0.6	10.07
		F	12	9.0±0.5	9.41
	Tokushima	M	24	10.3±0.5	10.78
		F	22	9.6±0.6	10.37
30°C	Yamagata	M	9	7.3±0.7	7.20
		F	11	6.9±0.3	6.79
	Tokushima	M	22	8.0±0.4	7.86
		F	15	7.8±0.2	7.58

(Kamano, unpublished)

to a short day length, which may be ranged from about 8–14 hr. it necessarily enters diapause in the final instar, while a long day from 14.5 to 16 hr. prevents it. In the Shonai ecotype, however, critical day length is observed at 14.5–15 hr. It is certain that this difference is due to the adaptation to a seasonal fluctuation of day length within the area of its distribution.

Fig. 4 shows the implication in the photosensitivity of the rice stem borer of the different two ecotypes.

Based upon these evidences and data obtained from the forecasting work carried out for the past 15 years, the distribution map of the ecotypes has been drawn up as indicated in Fig. 5.

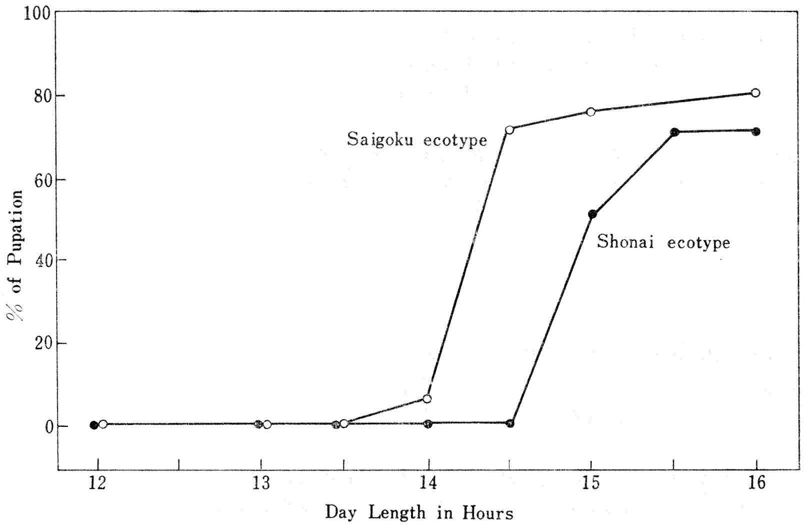

Fig. 4. Photo-sensitivity of different ecotypes.
(Inoue & Kamano, 1957)

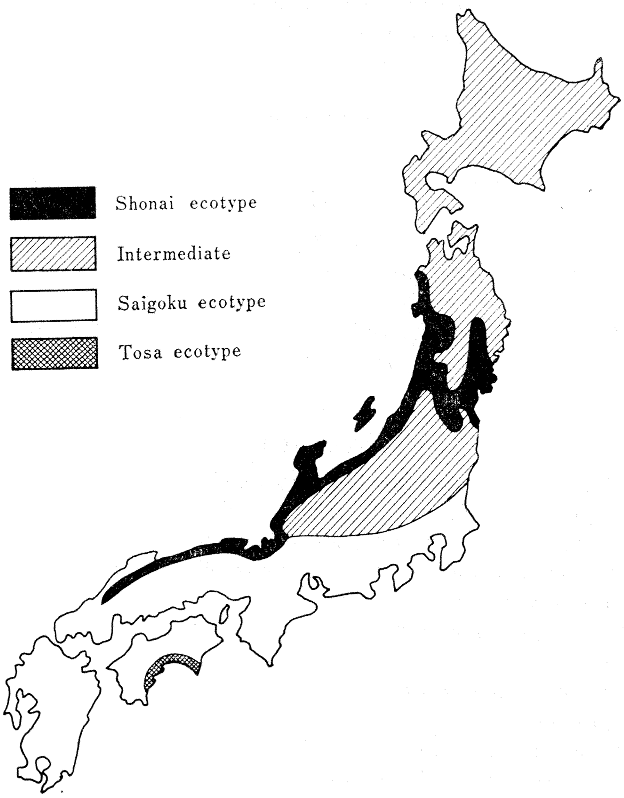

Fig. 5. Geographical distribution of ecotypes.

From time to time, some univoltine populations have been reported from the northern parts of Japan, however, up to present, the real univoltinism in the rice stem borer, which seems to be genetically defined, has been known from a few localities. The univoltine rice stem borer enters diapause even under the condition of long day photoperiod.

As mentioned before, there occurrs the rice stem borer having one generation a year. For example it appears once a year in Hokkaido or some part of Chugoku district. However, almost all rice stem borers collected from these areas proved poly-voltine in nature. Therefore, it may be reasonable to assume the univoltinism shown in these areas is appearance being due to shortage of temperature required for growth of the borer.

Diapause and environmental conditions

It is certain that the incidence of diapause in the second generation is markedly influenced by the timing of the light-sensitive larval stage in relation to the critical date. According to Kishino (1970), there seems to be a high correlation between the grade of latitude and the length of day, which is concerned in the incidence of diapause. Namely, the lower the latitude the shorter the critical day length required for the induction of diapause. However, more detailed experiments should be carried out in each ecotype to make sure of this phenomenon.

The diapause intensity of the rice stem borer is considered to have conclusive effect on the time of moth appearance after the hibernation. It is, without doubt, influenced by various environmental factors such as the time of rice transplanting or harvesting, environmental temperature of hibernating period, precipitation in early spring and so on.

Conclusion

The pattern of the occurrence of prevalence of the rice stem borer is apparently complicated. However, the phenomena can be analysed by some biological procedures as mentioned before.

In conclusion, the physiologically varied population should be primarily recognized as the difference in ecotypes developed in the rice stem borer. Secondarily, the pattern of the appearance of this insect seems to be largely influenced by the time of the onset of larval diapause, which is related to the grade of latitude. Other major environmental factors, are not necessarily essential in physiological differentiation of the rice stem borer in Japan.

Discussion

T. Saito: What is the relationship between the ecotypes you showed in figure 5 of your paper?

M. Fukaya: Firstly there is a difference in the general outer appearance and secondly there are fluctuation and variation in ecotype. This may be due to some environmental factors.

K. Kiritani: How population ecotypes of *Chilo suppressalis* are related in South-East Asia?

M. Fukaya: Various populations are mixed and it is difficult to differentiate ecotypes.

K. Kiritani: As we go towards the south of Japan how these ecotypes change?

M. Fukaya: I do not know. It is difficult to follow.

M.T. Ouye: Have you crossed extreme ecotypes?

M. Fukaya: Yes I tried. F_1 generation seems to have the maternal characters but in F_2 generation this maternal charcter does not occur.

Ku-Sheng Kung: What causes the diapause in *Chilo suppressalis?*

M. Fukaya: The diapause is caused due to juvenile hormone located in the corpora alata of the insect.

Ku-Sheng Kung: Is there any definite border line between the ecotypes?

M. Fukaya: We can not fix a definite border line for different ecotypes as this may fluctuate year to year.

J. S. Hyun: How many generations are there fore Saigoku ecotype?

M. Fukaya: Saigoku type appears twice a year and the three ecotypes are genetically different from each other.