7. ECOLOGY OF RICE BORERS IN TAIWAN

Y. I. CHU*

Four species of rice borers, *Chilo auricilius* (Dudgeon), *Sesamia inferens* Walker, *Tryporyza incertulas* Walker, and *Chilo suppressalis* Walker are recorded from Taiwan. For the identification of those species, voluminous papers have been compiled (Kapur 1964, Yano 1968 etc.). Among them, the first species, *C. auricilius* is recorded only by Iishima (1936) and Sonan (1942) in Tainan district. Since then, numerous surveys were conducted by many workers, while the re-discovery of the borer failed till today. According to the above authors, the ecology of this borer in Taiwan is described as follow: having four generations in Tainan district, overwintering as mature larvae, the adult of the first generation emerged in the middle of March. The larvae hatched later than 29th September and developed to the overwintering individuals.

According to the data by Iishima, in Tainan district, among the 510 of collected borers from the damaged paddy straw, 236 were *Chilo auricilius* (ca. 46%), 148 were *Chilo suppressalis* (ca. 29%), 28 were *Tryporyza incertulas* (ca. 5%), and 98 were *Sesamia inferens* (ca. 20%). In the investigation made by Sonan (1942), 18 of borers from 100 paddy stubs were *Chilo auricilius*. While in his another investigation, he collected very few of *Chilo auricilius*, and the majority of the collected individuals was *Tryporyza incertulas*.

Those data not only suggest the occurrence of *C. auricilius* in Taiwan about 35 years ago. But Iishima's data also suggest the interesting fact that indicates the high percentage of occurrence of *Chilo suppressalis* in those period. Because as mentioned later, *Chilo suppressalis* is generally considered as a negligible insect pest before 1960 in Taiwan.

As mentioned already, relating to the *Chilo auricilius*, we have the data of distribution and occurrence 30 years ago, and no further information was available on this borer in Taiwan, so far.

The second species, pink stem borer (*Sesamia inferens* Walker) is also known as one of the five important sugarcane borers, *Scirpophaga nivella* Fabricius, *Eucosma schistaceana* Snellen, *Proceras venosata* (Walker), *Chilotraea infuscatella* (Snellen) and *Sesamia inferens* Walker, and is said to be dominant on autumn paddy sugarcane. Due to the cultivation of paddy sugarcane, the borer is comparatively dominant in the central and southern districts, while in the northern districts it is rather a sporadic insect pest. While in the autumn in 1969, the rice borers outbroke at Chiang tsu tui (Taipei district). Then, according to the author's scrutinized investigation on the damaged field in winter season, among 10,000 examined rice stubbles, there was about 80 per cent of stems damaged. And in the number of 2685 of hibernating borers collected, there were 1532 individuals (about 65%) which were pink stem borer and the other was rice stem borer (*C. suppressalis*). But in general, the pink stem borer is not so prevalent in the northern district. The ecological studies of this borer is also made by many workers especially as the pest of sugarcane in Taiwan (Yanagihara 1934, Yamasaki 1937, Lai and Huang 1953, etc.). It has 5–6 generations in Taiwan, that is an important sugarcane insect pest espeically on the paddy sugarcane. The borer oviposit on the inside surface of the leave sheath of the sugarcane. Egg

* College of Agriculture, National Taiwan University, Taipei, Republic of China.

stage is 5–6 days in summer. The hatched larvae, at first, injure on the inside surface of the leaf sheath. The second instar larvae begin to disperse. Generally, it has 5 instars. The larval and pupal stages last 20–30 days, and 8–10 days in summer, respectively. The adult is abundant from June to July, and November to the next March. Although the life history on the rice plant is not studied well, it is said that the borer is more abundant on the second rice crop.

The paddy borer, *Tryporyza incertulas* Walker, was formerly known as the most notorious and destructive rice insect pest in Taiwan. While since 1952 when organophosphate insecticides, especially parathion, EPN and Diazinone, were extensively used for the control of this pest, the damage of this borer was suddenly decreased and in the following 5–6 years, the paddy borer was exactly diminished to the minor pest of paddy plant in Taiwan. Nowadays, the occurrence of paddy borer is almost restricted to the Henchung, Chiaochou, and Lotung areas (first two in the southern, and the last one in the northeastern districts). The population of the borer is still showing a decreasing tendency year by year, although recently we have an outbreak of this borer at Fengshan in 1968. But the rice borer problem in Taiwan do not extinguish by the diminition of the paddy borer. The new trouble is raised by the increase of rice stem borer (*C. suppressalis*) and *S. inferens*, especially the former species was prevalently land-wide and becomes the most destructive borer in Taiwan since 1961.

Anyway, the paddy borer is one of the well studied insect pests in Taiwan and voluminous papers are published on this pest (Shiraki 1917, Shibata 1932, Tao and Tang 1960, Tao 1966, etc.). According to those authors' works, it is clear that the borer has 4, 5 and 6 generations in northern, central and southern districts, respectively. The adult emergence period in the island is as follow:

Table 1. The emergence period of paddy borer (*Tryporyza incertulas* Walker) in Taiwan.

	Generation					
	1st	2nd	3rd	4th	5th	6th
Taipei (Northern D.)	Mar. B.	June B.	July B.	Sept. B.		
Taichung (Central D.)	Feb. M.	Apr. E.	June E.	Aug. E.	Sept. E.	
Fengshan (Southern D.)	Jan. M.	Apr. M.	June E.	July M.	Aug. E.	Oct. M.

B: Beginning, M: Middle, E: End.

The outbreak season of the moth is May to October, April to October, and March to October, in northern, central, and southern districts, respectively. While the peak of the population rather appeared in September to October in all districts. Both egg and pupal stages last about 7 days. The larval stage is 60, 30, and 150 days, in spring, summer, and winter seasons, respectively.

The last species, *Chilo suppressalis*, is the most important rice borer in the present status. It was formly known as a negligible insect pest in paddy field at least before 1960. While since 1958, its population began to increase gradually, and overcome *Tryporyza incertulas* after few years. This may be just an unexpected coincidence that, the increase in population of *Chilo suppressalis* begins 2–3 years after the extension of japonica type varieties as the second crops. Accordingly in Taiwan, the borer susceptible varieties, namely japonica type, are only cultivated as the first crop

because of the prevalence of paddy borer in the autumn season. And the second crop is restricted to the cutivation of indica type before 1957. While since 1952, as the extensive use of the organo-phosphate insecticide, parathion for the paddy borer control, the population of the paddy borer is successfully depressed by successive 5–6 year insecticidial applications. Therefore, the japonica type paddy plant is permitted to be planted in the autumn season. Additionally, the increment of the population of *Chilo suppressalis* begins from Chiayi district where the japonica type varieties firstly cultivated in the autumn season.

Although we do not have any available experimental data to make some correlation between the population increment of *Chilo suppressalis* and the cultivation of the japonica type varieties in the autumn. It seems to give us some suggestion to solve this problem.

By the way, the pattern of emergence of those two borers are somewhat different. For example, in winter or earlier spring, *Chilo suppressalis* emerged precedingly to paddy borer about 1–2 weeks in Tainan district, and 2–3 weeks in Chiayi district. The data in the northern district are not available. This fact means in Taiwan, generally the territories of the paddy borer is preoccupied by the *Chilo suppressalis* at the emergence stage of the larvae of the first generation. And it is of course that means the prefered condition for the existence of *Chilo suppressalis* at the starting point in years under the natural condition. Further more such difference of emergence period between those two borers indicates the unavailability of one control schedule for the control of both species. Therefore, chemical control measure focused on the paddy borer is not only scarcely effective to the rice stem borer but also has the possibility to promote the population increment to the rice stem borer, by the extinguishment of their competitor and natural enemies.

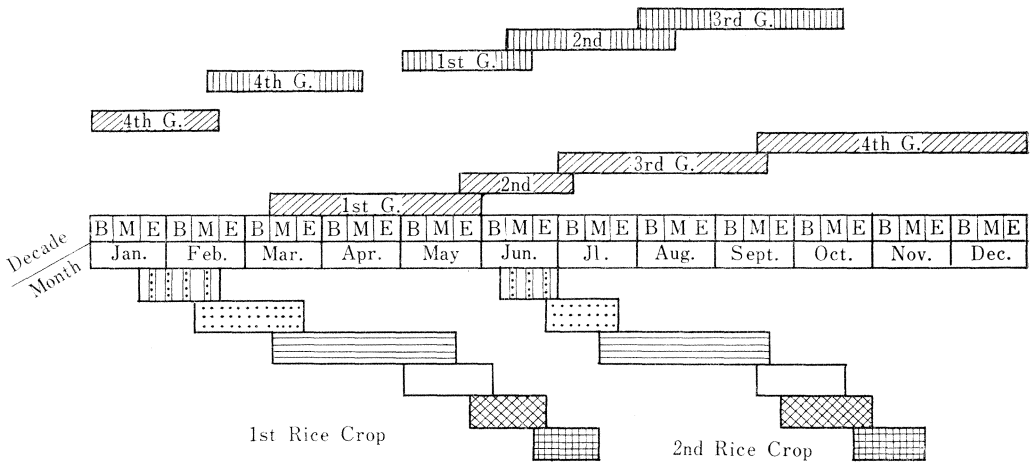

Fig. 1. In northern district.

Note:

- Adult stage of rice stem borer
- Larval stage of rice stem borer
- Seeding stage of rice plant
- Transplanting stage of rice plant
- Tillering stage of rice plant
- Spike formation stage of rice plant
- Heading stage of rice plant
- Maturing stage of rice plant

The food habits are seems to be another unnegligible factor. As the paddy borer is monophagous insect, its host plant is strictly restricted to paddy plant, therefore, their habitat is also confined to the paddy field. While rice stem borer has wide host plant range and numerous host plants are listed from Taiwan. This fact also means the habitat of rice stem borer is distributed not only to paddy field but also to sugarcane field, water oat, and other plant fields. Therefore, when the insecticidal application is concentrated in the paddy field, it is apparent that paddy borer would receive much more serious damage than rice stem borer. Furthermore, the extensive use of nitrogen fertilizer to the rice plant which also began since about 1957, would has some influence to change the pattern of predominancy of the rice borers in the paddy field, while no experimental indorsement is conducted on this discussion.

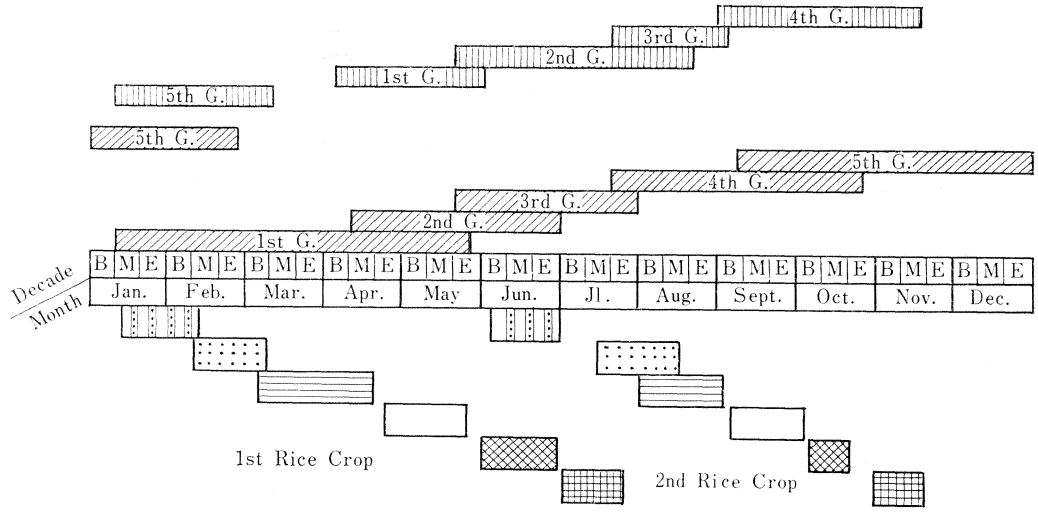

Fig. 2. In central district.

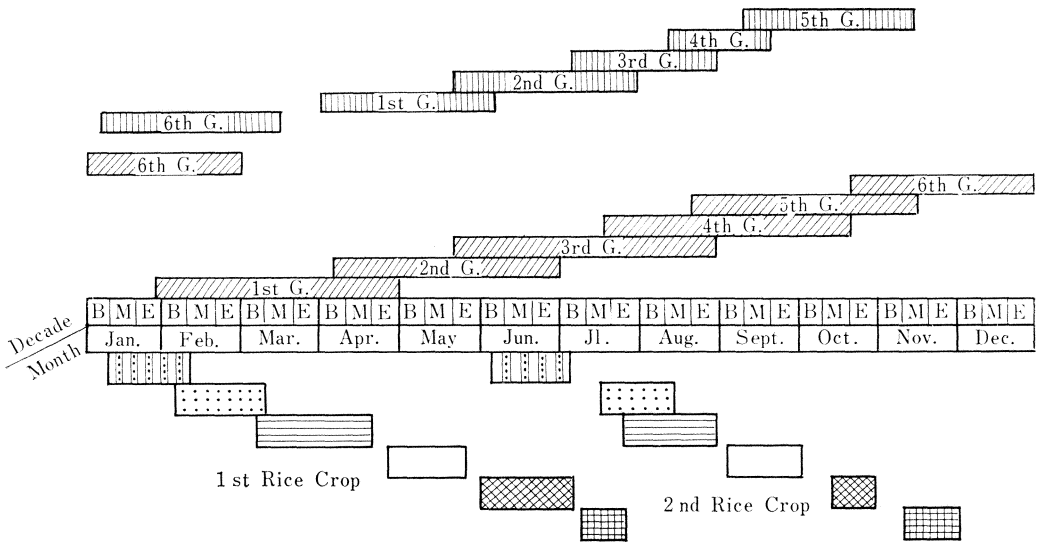

Fig. 3. In southern district.

Anyway, the first outbreak of *Chilo suppressalis* occurred in the spring in 1963, namely on the first paddy crop, owing to the cold and few rainfall climate in central and southern districts. It is said that the damage caused by the borer is summed up to 30–80%. This is, of course, the first record of the outbreak of *Chilo suppressalis* in Taiwan.

Chilo suppressalis has 4, 5 and 6 generations in northern, central, and southern districts, respectively, as *Tryporyza incertulas* does. The occurrence of adult of *Chilo suppressalis* is given in Figs. 1–3.

The ecology of the borer is comparatively well investigated in Chiayi and Taichung districts by Tao and Ho, respectively (Tao and Tang 1960, Tao 1965, 1966. Ho 1963, 1970). The life history of the borer in both districts are summarized by Tao (1965) as follow (Table 2):

Table 2. The life history of the rice stem borer in Chiayi and Taichung districts. (days)

Generation	Chiayi				Taichung			
	egg stage	larval stage	pupal stage	Total	egg stage	larval stage	pupal stage	Total
1st	9.8	50.6	7.9	68.3	10	55	7	72
2nd	7.7	43.0	7.7	59.2	4	46	7	57
3rd	7	25.2	6.9	39.1	4	44	6.5	54.5
4th	5	—	—	43.4	5	41	7	53
5th	—	—	—	53.0	6	—	—	—

Also, the larval stage and adult stage from 1964 to 1966 under the laboratory and field conditions, are given by Ho and Lis (1970) (Table 3 and 4).

Table 3. The duration of larval stage of rice stem boror in Taichung district.

Generation	1964	1965	1966
1st	17 Feb. – 30 May	1 Feb. – 27 May	19 Jan. – 28 May
2nd	23 Apr. – 9 July	17 Apr. – 2 Aug.	28 Apr. – 27 July
3rd	23 May – 16 Aug.	7 June – 29 Aug.	6 June – 29 Aug.
4th	21 July – 13 Oct.	20 July – 28 Oct.	23 July – 18 Oct.
5th	23 Sept. – 2 Mar.	21 Sept. – 24 Feb.	8 Sept. – 6 Mar.

Table 4. The emergence period of rice stem borer moth in Taichung district.

Generation	1964	1965	1966
1st	19 Jan. – 2 Mar.	20 Jan. – 19 Mar.	7 Jan. – 5 Mar.
2nd	15 Apr. – 31 May	10 Apr. – 1 June	19 Apr. – 4 June
3rd	2 June – 4 Aug.	1 June – 12 Aug.	29 May – 5 Aug.
4th	26 July – 25 Aug.	12 July – 3 Sept.	14 July – 2 Sept.
5th	1 Sept. – 26 Oct.	12 Sept. – 7 Nov.	20 Aug. – 27 Oct.

The ecology and emergence of the rice stem borer in Taichung district may be briefly summarized as follows:

The first generation moth emerges in February, it falls in the nursery and transplantation period of the first rice crop. In this generation, generally larval stage lasts from February to the end of May and rice grows transplanting period to the tillering stage. In the earlier stage, the damaged plant is characterized with the yellow leaf sheath and in the later stage with the decayed tip leaf.

In the second generation, the moth emerges from the young ear forming stage to ear-ripening stage, namely from end of April to the beginning of June. Generally, in this generation the flight of the moth to light trap has not studied well, Ho and Liu (1970) attributed to the densed paddy plant in this season and it makes the decrease of the attractive efficiency to the light. The symptom of damaged rice plants is characterized with decayed heart and white head. The pupal stage of this generation generally falls in the ripening stage of the rice crop.

The moth of the third generation begins to appear from the middle of June. While, in this period, almost first crop, except late ripening varieties, has already harvested. Therefore, majority of emerged moth can not find suitable ovipositional host plant. And this becomes the reason of low density of borer in the following generation as well as in the second paddy crop. As the shortage of paddy plant, the emerged moth seeks out alternative host plants, and oviposition is sometimes concentrated in the autumn paddy sugarcane or water oat (*Zizania aquatica*).

It is generally said that the moth of the fourth generation emerged from water oat or sugarcane. The moth of this generation emerged from middle of July to beginning of August, this time falls in the hottest season in Taiwan. Then the paddy crop is in the nursery period to transplanting period of the second crop. As, in this season, the eggs deposited on the young paddy plant, the survivality of the hatched larvae is not so high. In addition to it, the water temperature of the paddy field in this season is very high. Accordingly the daily highest water temperature from 20th July to 10th August always shows above 35°C, and under such condition, larval mortality always over 50%. While after the middle of August, the daily highest water temperature becomes lower than 32°C and larval mortality also goes down to 4.16–21.8% (Chang 1968). And such high water temperature undoubtedly becomes one of the depressing factor of the borer population in the mid-summer and following season.

The fifth emergence of the moth began in the end of September and continued till November. As the emergence period spells so long that the curve of the moth emergence often has two peaks. The rice plant in this season falls in the earforming stage. The damage by the borer is not significant in this generation. The mature larvae overwinter in the rice stubbles and water oat.

Discussion

K. Kiritani, Japan (Comment): I realized that application of a granular type of insecticide is now prevailing in Southeast Asia as well as Japan. In this respect I'd like to emphasize the fact that application of BHC granule against the stemborer kills natural enemies such as spiders through food chain; water→rice plant→leaf hoppers→spiders. Application of BHC granule at a commercial rate does not affect leaf hoppers which contain BHC in their body but this amount is lethal to spiders when they feed on them. Therefore, it is not always right to say that the granule type is always safe to natural enemies as compared with other types of formulations.

Besides insecticide application, I'd like to emphasize that the spreading of early planted rice in southern Japan caused the reduction of *Tryporyza*. Because this change in cultivating system deprived such monophagous pest like *Tryporyza* of the essenetial

food.

In this symposium, I am deeply impressed by the fact that *Tryporyza* was replaced by *Chilo* in every country in Southeast Asia including southern Japan. In Japan we have no chance to study the interspecific relationship any more, so that I'd like to recommend to focus our study on this point in the countries where both species still coexist.

M. D. Pathak, IRRI: Have insecticides been used equally intensively in Henchung, Chiaochou, Lotung areas, and areas where *T. incertulas* is still most prevalent?

Answer: Yes, we can not find any difference on the intensity of insecticidal application between those areas and the area where *Tryporyza incertulas* diminished.

D. B. Reddy, FAO (Comment): Water temperature in paddy fields is reported to influence the natural mortality of the rice stemborer when it is above 35°C. This observation should be investigated more intensively because of the practice of raising more than one crop per year in many parts and even introduction of the third crop. This would involve growing rice under controlled irrigation conditions, particularly during summer or hot season. The high temperature of water may also affect the diapause and survival capacity of different species, particularly, of larval stages. The high temperature of field water may have some influence on the biotic factors operating or influencing the rice stem borer populations.

References

1. Butler, A. G. (1880): On the second collection of Lepidoptera made in Formosa by H. E. Hobson, Esq. Proc. Zool. Soc. London 1880: 566–691.
2. Chang, C. S. (1968): The effect of water temperature of paddy field in the population of rice stem borer (*Chilo suppressalis* Walker). (In Chinese); Plant Protec. Bull. Taiwan 10(1): 59–65.
3. Ho, H. S. (1963): Ecological observation of rice stem borer in the Taichung area and experiment on its control. (In Chinese); Plant Protect. Bull. Taiwan 5(3): 289–94.
4. Ho, H. S. & Liu, T. H. (1970): Studies on the ecology of rice stem borer in Taichung district (*Chilo suppressalis* Walker). (In Chinese); Taiwan Agr. Quat. 6(1): 1–26.
5. Kapur, A. P. (1964): Taxonomy of the rice stem borer. The major insect pests of the rice plant.—Proceedings of a symposium at the International Rice Research Institute, September, 1964. John Hopkins Press. pp. 3–43.
6. Iishima, K. (1936): An unrecorded rice borer from Taiwan (*Diatraea auricilia* Dudgeon) (In Japanese); Ōyō-Dobutsugaku-Zasshi 1: 131–132.
7. Lai, C. & Huang, S. L. (1953): Purple stem borer and paddy sugarcane. (In Chinese); Bull. Taiwan Sugar 12(7): 1–6.
8. Shibata, K. (1932): Experimental studies on the influence of low temperature upon the development of paddy-borer, *Schoenobius incertulas* Wlk. I. J. Soc. Trop. Agric., 4: 504–516.
9. Shiraki, T. (1917): The paddy borer, *Schoenobius incertulas* Walker. Agr. Expt. Sta. Formosa, Spec. Rep. No. 15: 256 pp.
10. Sonan, J. (1942): On *Diatraea auricilia* Dudgeon, a insect pest on paddy. (In Japanese). Taiwan Agr. Maz. 38: 578–583.
11. Tao, C. H. & Tang, C. C. (1960): Study on the ecology of the paddy borer and timing of insecticide application in Taiwan. (In Chinese); Plant Protec. Bull. Taiwan 2(3): 75–82.
12. Tao, C. H. (1965): Insect pest on paddy. (In Chinese); Mem. 60th Aniversary of Dr. Gideon Liu. pp. 285-302.

13. Tao, C. H. (1966): Some notes on the paddy borer and rice stem borer in Taiwan. (In Chinese); Sci. Agr. 14(9–10): 273–288.
14. Yamasaki, T. (1937): On the injury and damaged of pink borer. I. (In Japanese); Ōyō-Dobutsugaku-Zasshi 9(5): 213–227.
15. Yanagihara, M. (1934): Pink borer, an important pest on the paddy sugarcane in Taichu district. (In Japanese); Bull. Sugarcane Res. Taiwan, 12(1–2): 1–53.
16. Yano, K. (1968): Key to the rice stem borers from Asia (Lepidoptera). Mushi 42(7): 81–87.