powders in the presence of sesame oil. The knockdown data showed that all the treatments were highly effective in 7 days and after 14 days the powders of amla, ginger and turmeric were significantly superior over control, halda and kachura. But at the end of 21 days amla showed superiority over the other treatments by bringing about 76.5 per cent knockdown. The mortality data indicated that amla, ginger, turmeric and kachura were equally effective in 7 days and there was no significant difference between turmeric and kachura, kachura and control and between control and halda. At the end of 14 days amla and ginger were significantly superior over others. The amla powder showed upto 30.9 per cent mortality and was significantly superior to ginger and turmeric at the end of the test period.

Thus it was observed that ginger as an oleoresin and as a powder with sesame oil when incorporated with pyrethrins has helped in enhancing the residual toxicity. The amla powder with or without sesame oil was found superior in prolonging the tenacity of pyrethrins. Though turmeric as an oleoresin or powder did not show much effect on pyrethrins activity, it brought about stability of residues in the presence of sesame oil to a certain extent. The soluble fractions of the powders might have been responsible for the stability of pyrethrins. Besides, this effect could also be due to the finer particles which might have retained the molecules of pyrethrins without exposing them completely for quick decomposition.

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Efficacy of Insecticides against Lyctus Powder-Post Beetle, *Lyctus brunneus* (Steph.). Takaaki Ito, Yoko Funaki and Chuji Hirose (Research Department, Pesticides Division, Sumitomo Chemical Co. Ltd., 4-2-1 Takatsukasa, Takarazuka, Hyogo 665, Japan) Received May 11, 1976. *Botyu-Kagaku*, 41, ○, 1976.

24. 数種殺虫剤のヒラタキクイムシ，*Lyctus brunneus* (Steph.)，に対する効力 伊藤高明，舩木容子，広瀬忠爾（住友化学工業株式会社生物科学研究所農薬事業部研究部） 51. 5. 11 受理

ヒラタキクイムシ幼虫に対するパーメスリン，フェニトロチオン，クロールデンの殺虫効果を，(1) 薬剤をラワン，メランチ類の板上に塗布後，幼虫を接触させる，(2) 薬剤を人工飼料中に混合後，幼虫に摂食させる，の2方法を用いて調べた．板上での接触試験ではパーメスリンが最も高い殺虫効果を有し，効力発現速度も最も速いことが認められた．薬剤処理人工飼料の摂食試験では，パーメスリンの本幼虫に対する食毒作用はフェニトロチオンに比較すると劣ることが認められた．クロールデンは両試験のいずれにおいても3薬剤中最も低い効力を示した．

一方薬剤処理後，3カ月を経過したラワン，メランチ類の辺材に，ヒラタキクイムシ成虫を放飼することによって被害防止効果を調べた．3薬剤とも，0.1%液処理区では全く被害は認められなかった．しかし0.01%処理区においてはフェニトロチオン，クロールデンの処理辺材の一部に被害が認められたのに対し，パーメスリン処理辺材では全く被害が認められなかった．

以上の結果から本害虫に対して，パーメスリンが3薬剤中最も高い防除効果を有するものと考えられた．

Lyctus powder-post beetle, *Lyctus brunneus* (Steph.), attacks the sapwoods of hardwood products, and causes extensive damage of the internal part of the woods. The female adults of the beetle lay eggs in the vessels of the woods and the new hatched larvae burrow along the

grain of the wood, producing the galleries filled with powder-dust. As they grow up, the new adults cut a way through the surface and push out the powder through the holes. At this time, the damage caused by the beetle may be recognized. Therefore, preventive treatment is necessary for control of the beetle.

On the other hand, the hardwoods imported from Southeast Asia to Japan, generally called woods of lauan, meranti groups, are comparatively inexpensive and hard, but due to the attacks of the beetle, the woods are not generally used for "structual timber". If the woods can be protected from the beetle, utility value of the woods will be extensively increased. It is well known that hardwood products can be protected from attacks of wood-boring beetles for several years by treatment with DDT, dieldrin, lindane, BHC and chlordane[1-5]. However, there are only few available informations[6-8] concerning efficacy of other insecticides against attacks of those beetles. Ito *et al.*[8] reported that the insecticidal activity of permethrin persisted for a long period on woods of lauan, meranti groups, and the insecticide showed high efficacy against the larvae of lyctus powder-post beetle by topical application. They also suggested usage of permethrin as a protectant for the woods of lauan, meranti groups for control of the beetle.

This paper describes insecticidal activities of permethrin, fenitrothion and chlordane against the larvae of lyctus powder-post beetle. Moreover, preventive efficacy of the insecticides is described.

Materials and Methods

Insect: Lyctus powder-post beetles were reared with the artificial diet in the chamber at 25°C and 70% in relative humidity under dark conditions. The preparative method for the artificial diet was mentioned in detail in our previous paper[8].

Chemicals: The insecticides used were permenthrin (purity 92.4%), fenitrothion (purity 97.3%) and chlordane (Commercial product obtained from Velsicol Co. Ltd.). Each of the emulsifiable concentrates (EC) of the insecticides was prepared so as to contain 10% active ingredient, 20% emulsifier (Sorpol SM 100P, Toho Chem. Co. Ltd.) and 70% xylene (W/W).

Efficacy of the insecticides on the wood plates: Each of the EC as mentioned above was diluted with water to give concentration of 0.1 or 1% with respect to the active ingredient. Each of the diluted solutions was applied to surface of woods plates of lauan, meranti groups (10×10×2cm) at the rate of 100 ml/m^2, and then the treated plates were allowed to dry for 24 hrs under room conditions. Ten larvae of the beetle were released on each of the plates and mortality of the larvae was counted by binoculors at appropriate time intervals. In addition, efficacy of the insecticides in shorter exposure was examined. Ten larvae were placed on each of the plates for 1 hr, and thereafter transferred to untreated plate. Mortality was counted as mentioned above. The mature larvae were used for test and average weight of the larvae was about 4 mg. All the treatment were replicated three times.

Efficacy of the insecticides in artificial diet: An appropriate amount of the emultion of an insecticide was added to the diet and throughly mixed. The diet was then pressed to prepare sticks 10 cm in lengh, 5 cm in width and 2 cm in thickness, and dried for 48 hrs at 50°C. Since the larvae could not bore into the diet by themselves, ten holes (about 3 mm in diameter) were made in each of the diet sticks, and one larva was put into each of the holes with its head inward. The hole was filled again with the powder-diet produced by making the holes, and the diet sticks were stored at 25°C and 70% in relative humidity. After 7 days, it was checked whether or not the larvae could burrow in the diet. When movement of the larvae from the initial place was observed, it was judged as burrowing larva. Mortality was also counted. All the treatments were replicated three times.

Preventive test: It is well known that the starch in wood tissues is more abundant in the part of sapwood than in that of heartwood. In a preliminary test, it was confirmed that the larvae could fully develop in the sapwood of the wood of lauan, meranti groups which had the starch at the level of 2.7% (W/W), and the moisture content was about 15% as measured with the

wood moisture meter (Kett Elect. Lab. type: M-SA). The starch content was measured by McCready's method[9], using the saw-dusts produced by cross-cutting as the sample for the determination.

The sapwoods of the woods were cut to provide sticks 5×2 cm in cross-section and 15cm in length. The long axis was paralell to the grain of the wood. The blocks which had at least 3% content of starch were chosen for the test. The cross-sections of all of the blocks were sealed with the paint for the purpose of eliminating penetration of the insecticides through those portions. The blocks were immersed for 30 sec. in the diluted solution containing each of the insecticides at the rate of 0.01 or 0.1% (W/W). Treatment with water only, or the same compositions as the protectants except for the active ingredient was taken as control check.

The test blocks were stored for 3 months after treatment under the room conditions and transferred into the chamber at 25°C and 70% in relative humidity 1 week before use. Then, two pairs of male and female adults, which were a few days after emergence, were released to each of the test blocks placed in polyethylene cups (20 cm in height, 9 cm in diameter). A paper disc for foothold for the adults was placed at the bottom of each cup. Moisture content of the wood was not measured. After about 70 days, the test blocks were cut into small pieces with a knife in order to observe the internal damage and the number of the larvae in the blocks. All the treatment were replicated three times.

Results and Discussion

The results concerning efficacy of the insecticides on the wood plates are shown in Tables 1 and 2. From Table 1, it is obvious that per-

Table 1. Mortality of the larvae of lyctus powder-post beetle released on the woods of lauan, meranti groups treated with the insecticides (continuous exposure).

Insecticides	Dose applied (%)	Mortality (%) and exposure days			
		1	2	5	18
Permethrin	0.1	100*	100	100	100
	1	100	100	100	100
Fenitrothion	0.1	6.7	40.0	100	100
	1	100	100	100	100
Chlordane	0.1	0	0	3.3	60.0
	1	0	0	26.7	100
Control	—	0	0	3.3	30.0

* Value involved dead and moribud larvae

Table 2. Mortality of the larvae of lyctus powder-post beetle released on the woods of lauan, meranti groups treated with the insecticides (1 hr exposure).

Insecticides	Dose applied (%)	Mortality (%) and days after exposure		
		1	2	5
Permethrin	1	46.7*	46.7	46.7
Fenitrothion	1	3.3	16.7	30.0
Chlordane	1	3.3	10.0	13.3
Control	—	0	0	10.0

* Value involved dead and moribud larvae

menthrin showed the highest efficacy against the larvae of the beetle on the wood plates among the three insecticides. However, chlordane at 0.1% killed only 60.0% of the larvae during 18 day-exposure and showed the lowest efficacy among the three insecticides. Further observation of efficacy of chlordane was not conducted for over 18 days, due to a high mortality of the control groups.

Table 2 shows that permethrin could kill 46.7% of the larvae by as short as 1 hr exposure, and thereafter any increaee of mortality was not observed, while mortality of the larvae increased from 3.3 to 30.0% with treatment of fenitrothion during the same period. This results suggest rapid action of permethrin in comparison with fenitrothoin. In fact, Tsuda *et al*[10] also indicated more rapid action of permethrin against some sanitary insects than that of fenitrothion.

Table 3 shows efficacy of the insecticides in the artificial diet. It was demonstrated that treatment with fenitrothion resulted in high mortality after considerable burrowing by the larvae. For example, burrowing-rate of 66.7% was observed in treatment with 500 ppm and mortality of the larvae was over 90%. In contrast, permethrin at 500 ppm killed all of the larvae without burrow, but many of the larvae burrowed and survived in the diet at 50 ppm. It is presumed that an insecticide added to a diet acted as a contact toxicant and stomach poison. Then, rapid contact toxicity of permethrin was suggested from Table 2, and the insecticide at 500 ppm killed all of the larvae without burrow, but not at 50 ppm. This suggests that high mortality of the larvae without burrow in treatment with permethrin at 500 ppm is due mainly to contact toxicity, and the activity of the insecticide as a stomach poison is lower than that of fenitrothion. Then, chlordane even at 500 ppm did not prevent many of the larvae from burrowing and allowed them to survive, and the insecticide showed the lowest efficacy among the three insecticides.

On the other hand, Table 4 shows the results with the preventive test. All of the blocks treated with the same compositions as the protectants except for the active ingredient or water only were severely infested by the beetle. Treatment with permethrin at 0.01 and 0.1%, fenitrothion at 0.1% and chlordane at 0.1% could protect the blocks from the beetle, but one of three blocks treated with fenitrothion or chlordane at 0.01% was attacked by the beetle. It was also observed that release of adults of the beetle to the blocks treated with permethrin at 0.1% resulted in rapid knock-down within a few hours, but not with fenitrothion and chlordane.

Table 3. Efficacy of the insecticides in the artificial diet against the larvae of lyctus powder-post beetle.

Insecticides	Dose applied (ppm)	% of burrowing-larvae	mortality (%)
Permethrin	5	100	6.7
	50	76.7	20.0
	500	0	100
Fenitrothion	5	96.7	13.3
	50	86.7	63.3
	500	66.7	96.7
Chlordane	5	100	6.7
	50	100	3.3
	500	73.3	16.7
Control 1*	—	93.3	3.3
Control 2**	—	96.7	3.3

* The same compositions as protectants except for active ingredient (500 ppm)
** Water only

Table 4. Preventive efficacy of the insecticides, which were applied to the sapwoods of lauan, meranti groups 3 months ago, against attacks of lyctus powder-post beetle.

Insecticides	Dose applied (%)	No. of test blocks	No. of damaged blocks	Total no.* of larvae
Permethrin	0.1	3	0	0
	0.01	3	0	0
Fenitrothion	0.1	3	0	0
	0.01	3	1	7
Chlordane	0.1	3	0	0
	0.01	3	1	19
Control 1**	—	3	3	194
Control 2***	—	3	3	136

* Total number in three replications
** The same compositions as protectants except for active ingredient
*** Water only

High efficacy of permethrin of 0.1% may be due to rapid knock-down without oviposition. Therefore, the insecticide seems to have two actions, namely knock-down effect against the adults and kill effect against layed eggs or hatched larvae. Preventive efficacy of chlordane against attacks of the beetle was shown to be as much as that of fenitrothion. However, tables 1, 2 and 3 showed lower efficacy of chlordane agianst the larvae than that of fenitrothion. High preventive efficacy of chlordane shown in Table 4 is very interesting.

Chlordane has been commonly used as a protectant of woods from beetles in Japan. However, efficacy of permethrin was shown to be higher in all the experiments than that of chlordane. Therefore, this paper suggests usefulness of permethrin as a promising protectant of woods for control of the beetle.

Summary

This paper described insecticidal activities of permethrin, fenitrothion and chlordane against the larvae of lyctus powder-post beetle on woods of lauan, meranti groups and in artificial diet. Preventive efficacy of the insecticides against attacks of the beetle was also described.

Permethrin showed rapid action and highest efficacy against the larvae of the beetle on the woods among the three insecticides. However, activity of permethrin as a stomach poison was more or less lower than that of fenitrothion. Contact and stomach toxicities of chlordane were the lowest among the three insecticides.

Permethrin showed the highest preventive efficacy against attacks of the beetle among the three insecticides, and treatment at 0.01% could protect sapwoods of the woods for the experimental period, 3 months.

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