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環動昆

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Effective Insecticidal Fly Bait, Musca Red®, for the House Fly, *Musca domestica* L. (DIPTERA)

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ハエ用ベイト剤に混用した場合イエバエの性フェロモン(Z)-9-トリコセンのハエに対する誘引活性は剤型が顆粒の時にのみ発現し、粉状ではほとんど認められなかった。また、(Z)-9-トリコセンの誘引活性は顆粒中の濃度に依存していた。顆粒に含まれる着色料の種類とその濃度もベイト剤の誘引活性に影響を与えた。ピレスロイド系殺虫剤のd-T80-レスメトリンを有効成分とし、誘引基材として(Z)-9-トリコセンと着色剤を含むハエ用ベイト剤、ムスカレッドはイエバエに対して忌避性を示さず速効的な活性を有していた。ムスカレッドは鶏舎と豚舎で行なった野外試験でもイエバエに対して顕著な防除効果を示した。

The house fly sex pheromone, (Z)-9-tricosene, in fly bait attracted the insect only when the fly bait was in the form of granules. The attractiveness of the pheromone depended on its concentration in the granules. The kind of coloring matter and its concentration in the granules also affected the attractive properties of the bait. A fly bait, commercially known as Musca-Red®, containing a pyrethroid insecticide (d-T80-resmethrin), (Z)-9-tricosene, and coloring matter No. 11 had rapid effects without repelling house flies. Musca-Red was effective in controlling house flies in fields, poultry houses, and pigpens.

Key Words: Fly bait, (Z)-9-tricosene, d-T80-resmethrin, *Musca domestica*

Introduction

The development of widespread resistance in house flies to most insecticides (organophosphates, pyrethroids, and carbamates) is a serious problem. New and efficient methods for fly control that will not give rise to resistance are needed. (Z)-9-tricosene, the house fly sex pheromone, was isolated and identified in 1971 (CARLSON *et al.*, 1971). The pheromone traps male flies exposed to the pheromone in olfactometers (CARLSON *et al.*, 1973) and both mating and homosexual behaviour are increased by the pheromone (ADAMS and HOLT, 1987). This sex pheromone will be of practical use in the future. First, details of how the sex pheromone acts as an attractant when it is added to fly baits must be established. This study was done to explore the relationship between the formulation of fly bait and the attractiveness of (Z)-9-tricosene, and also the relationship between the color of the bait and the attractiveness. We produced a fly bait, Musca-Red®, that contained resmethrin as the insecticidal ingredient. This paper reports the effects of Musca-Red on house flies in the

laboratory and in field tests.

Materials and Methods

The standard fly bait was compounded of powdery sugar as a feeding attractant and methomyl as the insecticidal ingredient. We evaluated the attractiveness of the fly bait by counting the unmber of dead flies, because most of the flies attracted died in the petri dish containing the bait.

In test 1, two powdery fly baits were use; one was the standard fly bait and the other contained (Z)-9-trocosene at the concentration of 0.05%. The composition of the fly bait used in test 2 was the same as that used in test 1, but the bait was formed into granules. The mean diameter of the granules was 3 mm. Test 3 was done to check the relationship of the form of the fly bait to the attractiveness of (Z)-9-tricosene. Two formulations, granular and powdered, with the same components, sugar, methomyl, and (Z)-9-tricosene, were compared with each other for efficacy.

These three preference tests took place in a test room for free flying (3×4×2.7 m) at 25℃ with fluorescent light. In the test, an unspecified large number of flies (Dai-3-Yumenoshima strain) were kept in the test room and most batches of flies consisted of approximately equal numbers of males and females. In each test, petri dishes (15 cm in diameter, 2.5 cm deep) containing 20 g of each fly bait were placed 30 cm from each other on the floor of the test room.

The number of dead flies in each petri dish was counted every 20-30 minutes and at that time, the petri dishes were replaced in the same position.

To identify the relationship between the attractiveness of (Z)-9-tricosene and its concentration in fly baits, bait containing different concentrations of the pheromone were formed into granules. In this test, petri dishes, each containing 20g of granules at a certain concentration, were arranged 30 cm from each other in concentric circle on the floor of the test room.

To identify the color preference of house flies, 13 kinds of yellowish coloring matter were selected and mixed into the fly bait granules at the concentration of 1 %. Petri dishes, each containing 20 g of one sample, were arranged 30 cm from each other in concentric circles. The color preference tests were done both in the flying test room under fluorescent light and in a greenhouse (1.5×2.5×2 m) under solar light. The attractiveness of fly bait containing coloring matter No. 11 at the concentrations of 0.08 %, 0.16 %, 0.5 %, and 1.3 % was also tested by this methods.

To evaluate the insecticidal effects of Musuca-Red (resmethrin, 0.5 %; (Z)-9-tricosene, 0.0275 %; coloured by No.11), a basic test was done in the laboratory. One grain of Musca-Red was placed in a plastic case (11 cm in diameter and 6 cm deep) in which one fly was confined. The feeding time of the fly on the grain and the time between the fly is leaving the grain until knockdown were observed.

Field tests were done in a poultry house (400 m^2) with cages in layers and having a wet-pit manure system in Osaka and in a pigpen (3,700

Table 1 Feeding tests with Musca-Red

Sex	Feeding time (Sec)	Knockdown (Min)
♂	1	2.47
♂	2	2.83
♂	7	2.05
♀	3	1.52
♀	1	1.27
♀	1	1.05
♀	5	1.43
♀	11	1.53
♀	5	2.58
Mean	4	1.63

m^2) in Tokushima, Japan. Musca-Red granules were scattered at the rate of 1-2 g per square meter of ground. Efficacy was evaluated based on the number of flies before and after treatment.

Results and Discussion

The results of test 1-3 showed that the sex pheromone of the house fly was attractive only when the fly bait was in formed of granules. In test 1, with a powder formulation, the number of flies dying in the petri dishes containing the fly bait with and without (Z)-9-tricosene were not very different. This is, (Z)-9-tricosene in the fly bait was not attractive to flies when the fly bait was powdered (Fig. 1). In test 2, with a granular formulation, the number of flies dying in the petri dishes containing the fly bait with (Z)-9-tricosene was about 6 times that when the fly bait was without the pheromone. The difference between tests 1 and 2 was only the bait formulation. In test 3, many flies were attracted to and died in the petri dish containing the granular bait. Only a few flies died in the petri dish containing the powdery bait, which contained the same concentration of (Z)-9-tricosene as the granular bait.

We could not identify in detail the relationship between the attractiveness of (Z)-9-tricosene and its concentration when in ordinary test systems such as pheromone traps or fly-paper-strip methods. In limited field trials, about twice as many flies landed on a grid treated with 100 μg of (Z)-9-tricosene as on an untreated grid (CARLSON *et al.*, 1971). However, attractiveness of (Z)-9-tricosene in our fly bait depended on its concentration when the fly bait was in granular form (Fig. 2).

The mating strike of male house flies can be elicited by the visual stimuli of static or moving black objects. Thus, (Z)-9-tricosene seemed to be attractive when the pheromone source was

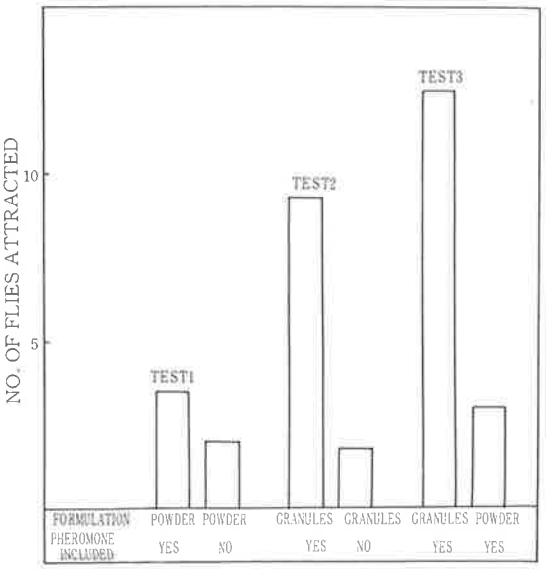

Fig. 1 Pheromonal activity of (Z)-9-tricosene in fly bait in different forms.

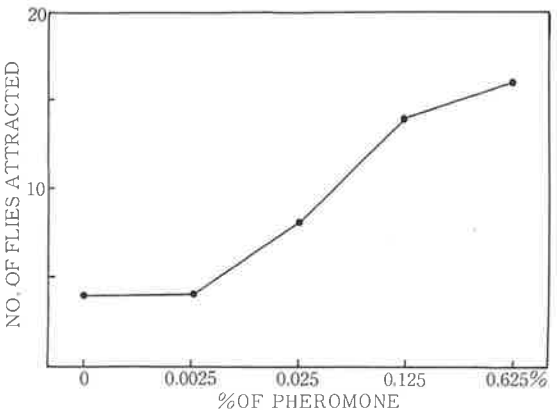

Fig. 2 Relationship between attractiveness and the concentration of (Z)-9-tricosene in granules.

contained in granules, which may be a stranger visual stimulus than powders.

Color perception of the house fly has been discussed by WATERHOUSE (1948) and HECHT (1963). The test results shown in Fig. 3 suggest that the color of the granules was an important factor in the attractiveness of the fly bait. Fly baits colored with No. 4, No. 11, or No. 12 were more attractive than the other yellowish baits. Of these three coloring matters, No. 11 was most attractive to the house fly under both

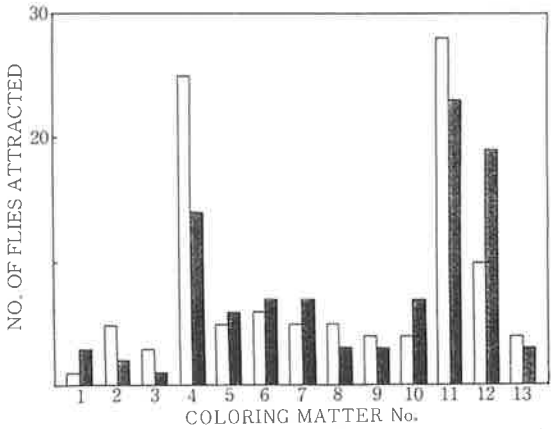

Fig. 3 Attractiveness of fly-bait granules with different coloring matter under different light conditions. ☐ under fluorescent light, ■ under solar light.

fluorescent and solar light.

The concentration of the coloring matter in the granules also affected the attractiveness of the fly bait (Fig. 4). Under fluorescent light, house flies preferred darker baits to lighter ones, and the dose-dependent effect of No. 11 was clear. Under solar light, however, a relationship between the concentration of coloring matter and attractiveness was not seen. Thus, light intensity or wavelength is important in the reactions of house flies to fly baits. The amount of coloring matter in a fly bait must be decided depending on the light conditions of practical situations.

Musca-Red is a new kind of fly bait designed based these test results. The insecticidal ingredient of Musca-Red is pyrethroid, resmethrin. In general, pyrethroids are no longer used as the insecticidal ingredient of a fly bait, because they act repidly through contact toxicity and strongly repel flies. However, we found out that resmethrin could be used in this fly bait without being repellent. Flies fed on Musca-Red for only a few seconds, and were knocked down within 3 minutes of feeding Table 1. The mean feeding time was 4 seconds and it took only 1.63 minute, on the average, from leaving the Musca-Red to knockdown. None of the knocked-down flies revived. The relationship between the feeding period on Musca-Red and the time required for knockdown was not clear. From these test results, Musca-Red seemed to be a rapidly effective fly bait.

In field tests, the number of flies in pigpen treated with Musca-Red at the rate of 1-2g/m^2 decreased to less than 10 % of the original number in 1-2 hours after treatment started (Fig. 5). From field observations, Musca-Red showed no evidence of repellency toward house flies. In a poultry house scattered with 1.9 g of Musca-Red, the density of the house flies

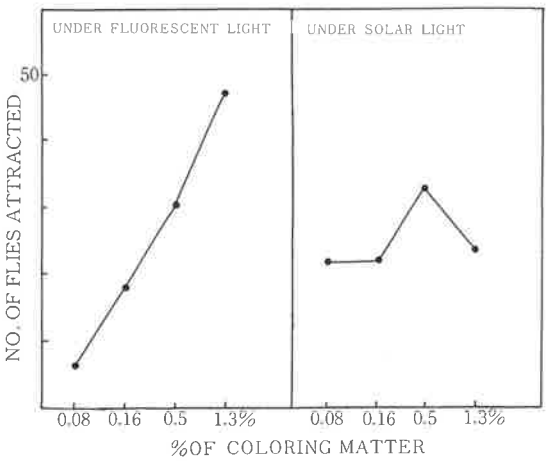

Fig. 4 Relationship between attractiveness and the concentration of coloring matter, No. 11, in the granules.

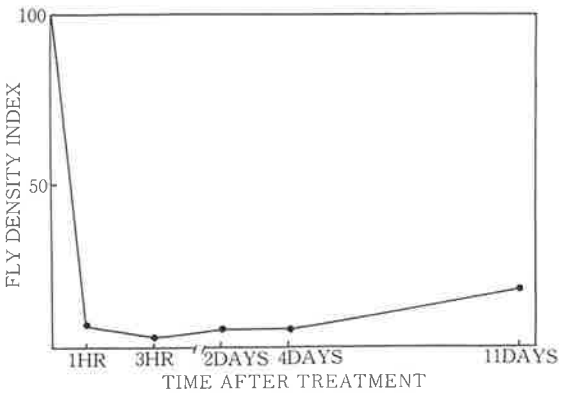

Fig. 5 Effect of Musca-Red on the house-fly population in a pigpen.

decreased to less than 5 % of that before treatment, and this low density continued to the end of the test, until day 9 after treatment started (Fig. 6).

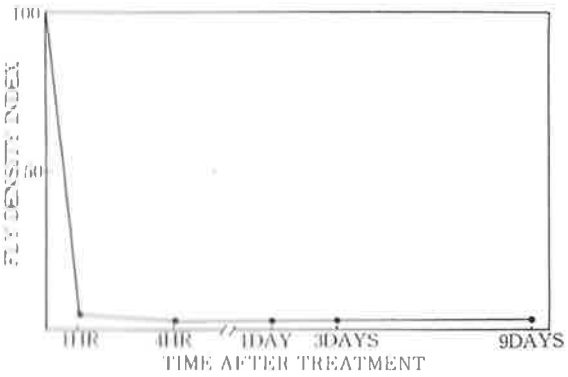

Fig. 6 Effect of Musca-Red on the house-fly population in a poultry house.

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Distribution of the Immature Stages of the Cat Flea, *Ctenocephalides felis* (BOUCHE) in a Household Environment

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家屋内環境におけるネコノミ *Ctenocephalides felis* (BOUCHE) の未熟期個体群の分布

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ネコノミ *C. felis* の卵、幼虫脱皮殻の分布を家屋内環境において調べた。卵と脱皮殻の分布は、調査した2つの部屋のカーペットについて見ると、集中的であった。脱皮殻から推定される未熟期個体群の空間分布は、それぞれの部屋で飼われている犬の習性の影響を受けるようであった。卵は、犬が規則的に寝起きしていると報告された場所の近くに集中していた。幼虫の脱皮殻の採集調査から、1令幼虫はふ化場所からそれほど移動しないことが分かった。カーペット上での分布調査によると、2令幼虫は1令幼虫よりもわずかながら移動しがちであった。

The distribution of eggs and larval cast skins of the cat flea, *Ctenocephalides felis* (BOUCHE) were investigated in a household environment. Eggs and exuviae were found to be dispersed in a contiguous manner on carpeting of the two rooms examined. The spatial distribution of the immature stages (as indicated by the exuviae) was influenced by the habits of a dog within each room. Eggs were concentrated in or approximate to the areas in which the dog reportedly slept on a regular basis. Collections of larval exuviae indicated that first-instar larvae did not move far from the location of eclosion. Second-instar larvae exhibited slightly more movement than first-instar larvae, as indicated by their distribution in the carpet.

Key Words: Flea, *Ctenocephalides*, Spatial distribution, House

Introduction

The life stages of the cat flea, *Ctenocephalides felis* (BOUCHE), are located in two different habitats. Adults are found primarily on dogs and cats; eggs and larvae are usually located in carpeting or crevices in flooring. OSBRINK *et al.* (1986) reported that larger populations of adult fleas were found in rooms in which host animals spent the most time, than in rooms in which they spent little time. However, there is little information on the distribution of the immature stages in household environments, although control strategies for indoor cat flea are directed primarily at the immature stages.

The objectives of the research presented here were to determine the spatial distribution of flea larvae and eggs in household carpeting, and to

assess the effects of biotic and abiotic factors on the distribution patterns.

Materials and Methods

Study Site

In July 1986 a 167 m^2 residence in Christiansburg, VA USA was selected for study, based on a history of moderate to severe cat flea infestations for the previous 3 years. A single dog, *Canis familiaris* L., (ca. 12 kg) has been the only pet inhabiting the house for more than 3 years. Two rooms within the house, the family room(4.1 × 4.1 m)and bedroom(3.2 × 2.9 m)were selected as study sites, based on frequency of visitation by the dog. The cleaning routine for the rooms consisted of bimonthly vacuuming. There was little or no history of insecticide use in the rooms. The location of all articles within the rooms including furniture, doors, windows, plants, and any semi-permanent or permanent articles which were located on the floors were recorded (Figs. 1 and 2). Family members were questioned about behavior patterns of the pet within the two rooms.

Sampling

The numbers of samples were 84 in the family room and 56 in the bedroom. The rooms were emptied of all furniture and articles. The carpeted floor was delineated into 40.6 × 40.6 cm sample units, and boundaries marked with chalk. Each sample unit was vacuumed for 1 min using a 4.0 amp beater-bar vacuum cleaner (Eureka: model 1425). A clean tight-weave muslin bag was affixed to the effluent tube of the vacuum cleaner to collect extracted material of each sample.

Carpet debris from the muslin bags was placed into a 230 micron sieve and gently shaken to separate fine particles from the larger debris in the sample. The portion of the sample unable to pass through the mesh was examined with a dissecting microscope. Immature stages of the cat flea including eggs (hatched and unhatched), and first-and second-instar larval exuviae were counted and recorded for each sample. Debris that passed through the 230 micron sieve was analyzed for 10 samples to ensure that eggs or larval exuviae did not escape detection. Larval exuviae were used as an index

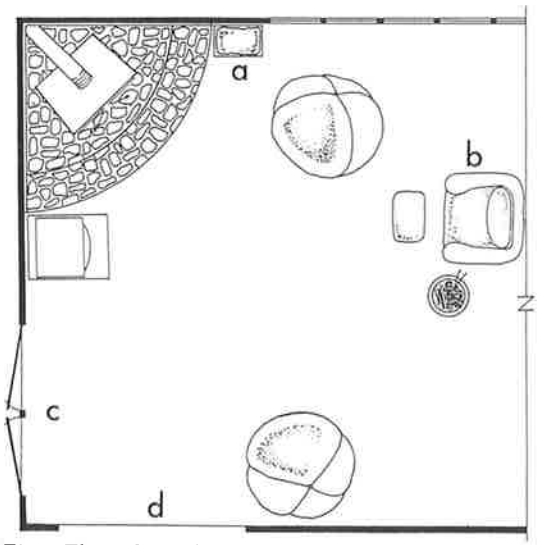

Fig.1 Floorplan of family-room examined: a: pet dog's sleeping area; b: chair; c: doorway to outside; d: doorway to kitchen.

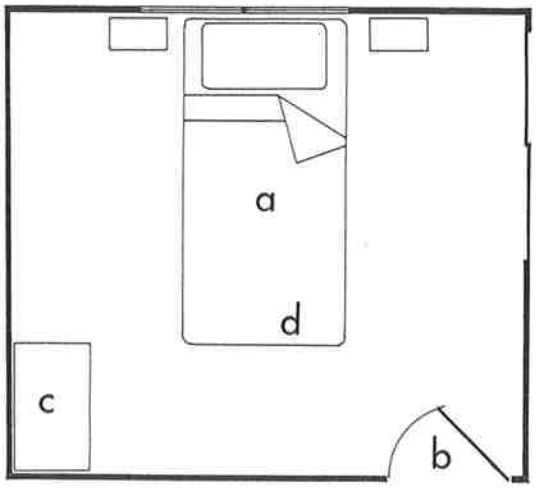

Fig.2 Floorplan of bedroom examined: a: bed; b: doorway; c: dresser; d: location of bed where pet dog slept.

of flea larvae presence. First-and second-instar flea larvae were distinguished on the basis of size of the cast skin and head capsule. Hatched eggs were distinguished from unhatched eggs by presence of a split chorion. The recovery of this sampling method was 59% ± 3%(mean ± SEM) for eggs, and 27% ±7% for larvae(in place of exuviae).

Data Analysis

Sample data for each developmental stage and remnant of life stages taken from the two different rooms were plotted with surfaceII, a computer graphics program (SAMPSON, 1978).

Results and Discussion

Cat flea eggs and larval exuviae showed clumped distribution patrern, with high standard deviation to mean ratios, in both of the two rooms examined (Table 1). Eggs and larval exuviae were more numerous in areas where the pet slept or frequented regularly. Large numbers of hatched eggs were detected near the pet's bed, the doorways to the kitchen, and around the chair in the family-room (Fig. 3), and around and beneath the bed in the bedroom (Fig. 4). In the bedroom, carpet on only one side of the bed contained many hatched eggs. Number of unhatched eggs was largest in the location that hatched eggs were most abundant. Locations containing many larval exuviae also contained many hatched eggs (correlation cofficient: 0.92).

The majority of unhatched eggs in the family room were located in areas of frequent pedestrian and pet traffic. The frequent traffic might cause egg mortality. The distribution of flea eggs may be associated with habits of the pet. The residents reported that the dog would

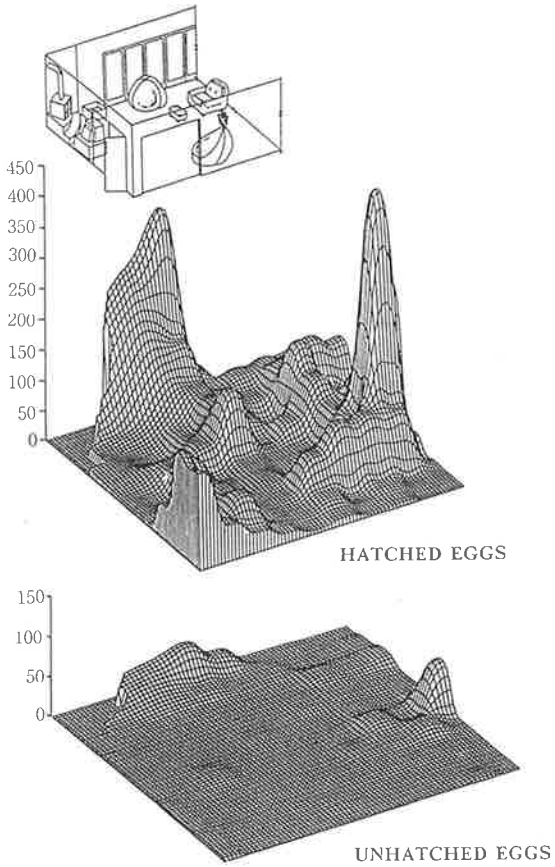

Fig.3 Transect surface plot of the number of hatched and unhatched eggs of cat flea in a family-room.

Table 1 Population parameters of cat flea immatures examined in two rooms

Rool (Sample size)	Stage	Mean	Range	Standard deviation (S.D.)	S.D. to mean ratio
Family-room (n=84)	Hatched egg	51.7	0~431	67.8	1.31
	Larval exuviae	4.29	0~70	9.88	2.30
Bedroom (n=56)	Hatched egg	59.7	1~516	94.3	1.58
	Larval exuviae	20.60	0~175	32.30	1.57

Larval exuviae: total number of exuviae of 1st and 2nd instar larvae

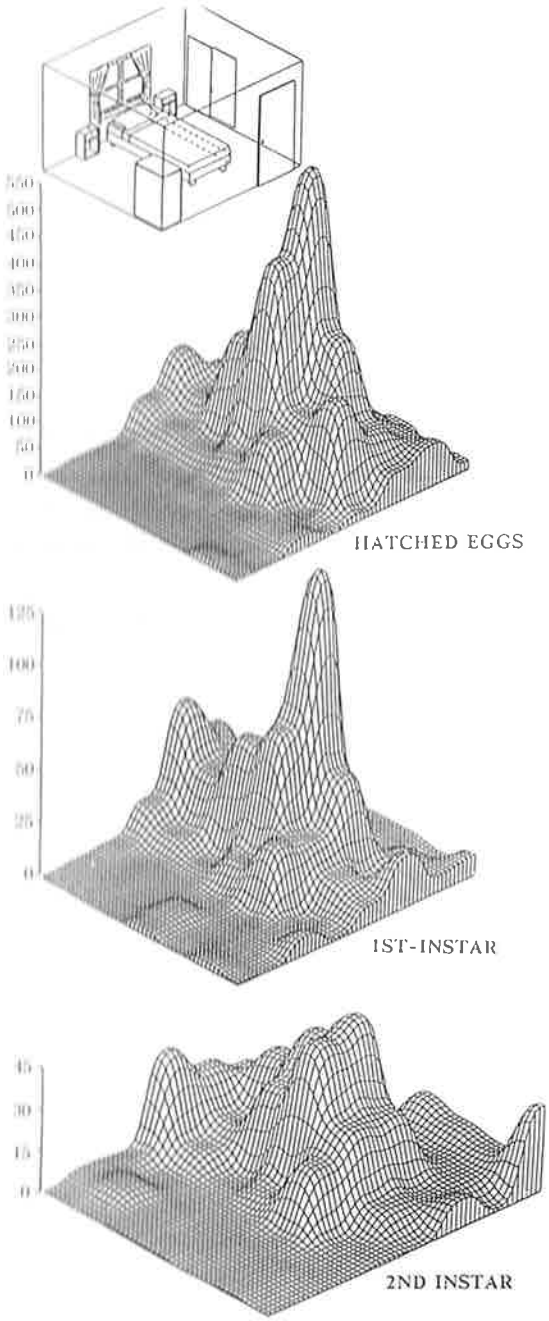

Fig. 4 Transect surface plot of the number of hatched eggs, 1st instar larval exuviae and 2nd instar larval exuviae of cat flea in a bedroom.

sometimes crawl beneath the bed, but usually slept upon the end of the bed close to the door. The largest number (516) of eggs per sample unit was recorded on the carpet where the dog would land after jumping off the end of the bed. The force of impact when the dog reached the floor (after jumping) could have dislodged flea eggs laid in the hair of the dog. A daily routine of the pet sleeping on the bed and jumping off would have resulted in the eggs and dried-blood (from adult fleas feeding)accumulating at this location. The location of the doorway in reference to the bed perhaps explains why large number of hatched eggs were collected on either side of the bed. The dog would move off the bed in the direction of the doorway, which would result in a majority of eggs to be deposited on one side of the bed (Fig. 4).

The coincidence of number of larval exuviae with that of hatched eggs suggests that larvae do not move far from the site of hatching. Host blood or blood components are essential to the larval diet of the cat flea (BRUCE, 1948 ; STRENGER, 1973). The supply of these essential foods is realized by the fact that both eggs and adult flea feces (composed of partially undigested blood) drop from the pet at the same time. RUST and REIERSON (1985) concluded that survival of flea larvae is limited to areas frequented by the host (and with the necessary environmental conditions). Our results support this conclusion.

Few larval exuviae were recovered in the carpet at the doorways to the kitchen, or to the outdoors from the family-room. However, many hatched and unhatched eggs were recorded from these areas. This may indicate that areas exposed to pedestrian traffic are not conducive to successful larval development.

Second-instar exuviae were collected from the area in the bedroom directly against the wall behind the door, although this area had few

first-instar exuviae (Fig. 4). This discrepancy could be due to moving of the second-instar larvae to the areas behind the door.

Conclusion

The spatial distribution patterns of eggs and larval exuviae of the cat flea in specific rooms appeared to be highly contiguous. The deposition and location of hatched eggs, unhatched eggs and first-instar larval exuviae were apparently dependent on the habits of the pet in each room. First-inster larvae did not seem to move far from the location of hatching. Frequent traffic of pedestrian and/or pet seemed to increase the proportion of unhatched eggs to hatched eggs, but decrease the number of second-instar larvae.

Acknowledgements

We thank the residents for the use of their house as a study site. We also appreciate the financial support of the National Pest Control Association and the Virginia Pest Control Association.

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Insecticidal Activity of a Synthetic Pyrethroid, Empenthrin

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合成ピレスロイド・エンペントリンの殺虫特性 千保 聡・川田 均・伊藤高明・安部八洲男（住友化学工業㈱宝塚総合研究所農業科学研究所）

合成ピレスロイドのエンペントリンは常温での揮散性が高いという特性より衣料防虫剤として用いられている。エンペントリンのイエバエ・カ・ゴキブリに対する基礎的な殺虫効果は，*d*-アレスリンおよびピレトリンと比較すると，これらと同等かあるいは劣るものの，油剤・エアゾール・線香などの製剤での殺虫効果は優れ，特にイエバエに対して優れた殺虫効果が示された。また，イエバエ・アカイエカに対する常温揮散による殺虫効果が認められた。従って，エンペントリンは油剤やエアゾールなどの通常の殺虫剤としての用途の他に，蚊取り線香や常温揮散剤などの殺虫成分としても使用できる可能性が示唆された。

The insecticidal activities of empenthrin against house flies, mosquitoes, and German cockroaches were examined by several bioassay methods. In an oil formulation, the killing activity of empenthrin was superior to that of *d*-allethrin and pyrethrins, but its knockdown effect was inferior to that of the other chemicals. In a coil formulation, the knockdown and killing activities of empenthrin against the house fly were superior to those of these other chemicals. In additon, the vapor of empenthrin had high killing and knockdown activities against house flies and mosquitoes.

Key Words: *Musca domestica, Culex pipiens pallens, Blattela germanica,* Empenthrin, Efficacy

Introduction

The chemical structures of natural pyrethrins were reported by LAFORGE and HALLER in 1936. Since then, a number of studies on analogues of chrysanthemic acid esters have been done, and many synthetic pyrethroids such as allethrin (SCHECHTER *et al.*, 1949), tetramethrin (KATO *et al.*, 1964), resmethrin (ERRIOTT *et al.*, 1967), and *d*-phenothrin (OKUNO *et al.*, 1976) were developed. Empenthrin (KITAMURA, 1980; HIRANO *et al.*, 1983) acts in vapor form on insects that infest fabrics (TSUDA *et al.*, 1982). Here, we report the knockdown and killing activities of empenthrin against several insect pests.

Materials and Methods

Test Insects

The test insects were reared at 27±1℃, 60±5% RH, and a 16L-8D photoperiod.

(1) House fly, *Musca domestica* L., CSMA strain
(2) Mosquito, *Culex pipiens pallens* COQUILLETT, Gose strain
(3) German cockroach, *Blattella germanica* L., a

strain with normal susceptibility to insecticides.

Chemicals

The following chemicals were used. Empenthrin: (*RS*)-1-ethynyl-2-methylpent-2-enyl-(1*R*)-*cis, trans*-chrysanthemate (Vaporthrin®, purity 95.2%). Its physical and chemical properties are described in Table 1.

d-Allethrin: (*RS*) -3-allyl-2-methyl-4-oxocyclopent-2-enyl-(1*R*) -*cis, trans* -chrysanthemate (Pynamin® Forte, purity 92.0%)

Pyrethrins: 18.8% pyrethrin extract supplied by Dainippon Jotyugiku Co., Ltd. (Cockthrin®).

d-Phenothrin: 3-phenoxybenzyl-(1*R*)-*cis, trans*-chrysanthemate (Sumithrin®, purity 92.1%).

Test Methods

(1) Topical application method

A drop of an acetone solution of the test chemical was topically applied onto an insect (0.5 l or 0.3 l on the dorsal prothorax of female house flies and mosquitoes, respectively, and 1.0 μl on the dorsal metathorax of cockroaches). Five replications were made, and mortality was observed 24 hours (for house flies and mosquitoes) or 72 hours (for cockroaches) after application. The LD_{50} value (dose required to cause mortality in 50% of the test insects) was caliculated by the graphic method (FINNEY, 1971).

Table 1 Physical and chemical properties of empenthrin

Item	Outline of properties
1. Chemical name	*RS* -1-Ethynyl-2-methylpent-2-enyl 1*R* -*cis, trans*-chrysanthemate
2. Formula	$C_{18}H_{26}O_2$
3. Molecular weight	274.4
4. Appearance	Slightly yellowish transparent liquid
5. Specific gravity	d_{20}^{20} 0.927
6. Melting point	Below −20℃
7. Viscosity	32.2 cP at
8. Solubility	Miscible with almost all of aromatic or aliphatic hydrocarbons, chlorinated aliphatic hydrocarbons chlorinated hydrocarbons, and other organic solvents. Hardly soluble in water 2 to 3 ppm at 25
9. Stability	Stable under storage conditions for technical-grade empenthrin. Stable in most organic solvents. Unstable in alcohols and in water. Relatively unstable under photoirradiation.
10. Vapor Pressure	1.62 10^{-3}mm Hg at 30

(2) Glass chamber method with an oil formulation

The assay with an oil formulation was done as described by OKUNO *et al.*, 1969. A group of 20 adult house flies or 10 male and 10 female adult mosquitoes were released into the test chamber (70×70×70㎝). The test chemical dissolved in kerosene (Nisseki Fog Solvent, Nippon Oil Co., Ltd.) was sprayed into the chamber at the rate of 0.7 ml per chamber. Starting immediately after the spraying, the number of knocked-down insects was counted for the next 10 minutes. Then, all of the insects were collected and transferred into a recovery cup containing food and cotton wet with water, and kept for 24 hours to observe the mortality. Five replications were made. The KT_{50} value (time required to cause 50% knockdown) was caliculated by Finney's graphic method.

(3) Glass chamber method with a coil formulation

The experiment with a coil formulation was done as described by TSUDA *et al.* (1972). A mosquito coil with no active ingredients was cut into 0.5 g pieces, each of which was impregnated uniformly with 0.35 ml of an acetone solution of a test chemical. All of one piece of the impregnated coil was burned in a glass chamber (70×70×70㎝). Thereafter, a group of 20 adult house flies, 10 male and 10 female, or 20 female adult mosquitoes were released into the chamber, and the number of knocked-down insects was counted for the next 20 min. All of

the insects were collected and transferred into a recovery cup containing food and cotton wet with water, and kept for 24 hours to observe the mortality. Five replications were made. The KT_{50} value was calculated by Finney's graphic method.

(4) Test of volatile effect

One milliliter of an acetone solution of a test chemical was applied on a glass plate (20×20cm). After the acetone evaporated, the plate was put on the center of the floor of a glass chamber (70×70×70cm). One hour later, the plate was removed and 20 adult house flies, 10 male and 10 female, or 20 female adult mosquitoes were released into the chamber. The number of knocked down insects was counted for the next 60 minutes, and the mortality was observed after 24 hours. Four replications were made. The KT_{50} value was calculated by Finney's graphic method.

(5) Aerosol test method for flying insects.

The experiment with an aerosol was done following the CSMA standards (1971). A group of 100 adult house flies, 50 male and 50 female or 50 female adult mosquitoes were released into a chamber (1.8×1.8×1.8m). The test aerosol (recipe below) was sprayed into the chamber at the rate of 0.65±0.1 g per chamber. The number of knock-down insects was counted for the next 15 minutes. All of insects were transferred into a plastic cup with food and cotton wet with water, and kept for 24 hours to observe the mortality. Five replications were made. The KT_{50} value was calculated by Finney's graphic method.

Test aerosol recipe:	(ml)
Active ingredient	a given amount
Deodorized kerosene (Isopar M: Esso Standard)	up to 135.0
Dimethyl ether	75.0
Liquefied petroleum gas (Pressure: 3.5kg/cm² at 20℃)	90.0
Total	300.0 ml

Results and Discussion

(1) Insecticidal activity of empenthrin

Table 2 shows the killing activity of empenthrin against the three insect species by topical application method. The activity of empenthrin against the house fly was inferior to that of *d*-allethrin and almost the same as that of pyrethrins. Against the mosquito, the LD_{50} value of empenthrin was twice as that of *d*-allethrin, and four times that of pyrethrins. The activity of empenthrin against the German cockroach was inferior to that of pyrethrins and almost the same as that of *d*-allethrin. Thus, empenthrin had higher insecticidal activity against house flies than against the other insects tested.

(2) Efficacy of oil formulation

Tabel 3 shows the knockdown and killing activities of empenthrin in an oil formulation against the house fly and mosquito. The mortality with empenthrin was slightly higher than that with *d*-allethrin or pyrethrins, the

Table 2 LD_{50} values of empenthrin, *d*-allethrin, and pyrethrins

Chemicals	LD_{50} (μg/insect)		
	House fly	Mosquito	Cockroach
Empenthrin	0.31 (94)	0.10 (25)	1.39 (35)
d-Allethrin	0.22 (132)	0.05 (50)	1.36 (35)
Pyrethrins	0.29 (100)	0.025 (100)	0.48 (100)

( ) : Relative efficacy (Pyrethrins=100)

Table 3 Efficacy of oil formulation against the house fly and mosquito, measured by the glass chamber method

Chemicals	Conc. (%W/W)	KT_{50} (min)-%Mortality*	
		House fly	Mosquito
Empenthrin	0.1	8.0-100	>10-100
	0.2	5.5-100	7.4-100
d-Allethrin	0.05	4.7- 65	6.4- 90
	0.1	2.8- 91	4.5- 94
Pyrethrins	0.05	6.1- 39	8.0-100
	0.1	2.9- 48	6.1- 99

*%Mortality : at 24hr.

knockdown activity of empenthrin was lower than that of those chemicals. The killing activity of empenthrin against the house fly and mosquito seemed to be enhanced by the oil formulation.

(3) Efficacy of coil formulation

Table 4 shows the knockdown and kiling activities of empenthrin in a coil formulation. Against the mosquito, the knockdown activity of empenthrin tended to be higher than that of pyrethrins but lower than that of *d*-allethrin. Empenthrin at the concentration of 0.8 % gave fairly high mortality. Against the house fly, the knockdown and killing activities of empenthrin were much superior to those of *d*-allethrin and pyrethrins. These results suggest that empenthrin might be useful against house flies in a coil formulation.

(4) Efficacy of vapor form

Table 5 compares the insecticidal efficacy of empenthrin vapor, *d*-allethrin vapor, and a vapor of the pyrethrins. Empenthrin had high knockdown and killing activites against tha house fly, and relatively high knockdown activity against the mosquito. The activity of empenthrin against the housefly was higher than that of *d*-allethrin and pyrethrins. Relatively high vapor pressure, a characteristic of empenthrin, may have contributed to the relatively high activity. The results suggest that empenthrin might be useful as a volatile formulation at room temperature.

(5) Efficacy of aerosol formulations against flying insects

Several mixtures of empenthrin and *d*-phenothrin were tested against house flies and mosquitoes. Figure 1 shows the relationship between the ratio at which empenthrin and *d*-phenothrin was mixed and their knockdown activities against the house fly and mosquito. Against the house fly, activity decreased almost linearly with increases in the proportion of *d*-phenothrin. Against the mosquito, the activity was almost constant in the range of ratios of empenthrin to *d*-phenothrin of 100/0 to 50/50, thereafter sharply decreasing. Figure 2 shows the killing activity of mixtures of empenthrin and *d*-phenothrin. Against both kinds of insects, the killing activity was increased by an increase in the amount of *d*-phenothrin in the range of 75/25 to 0/100.

Thus, knockdown and killing activities of mixtures of empenthrin and *d*-phenothrin were affected by the proportion of the mixture. It is, therefore, possible to select a suitable ratio for satisfactory activity. For example, the mixture of 0.75% empenthrin and 0.25% *d*-phenothrin have quick knockdown effect and a strong killing activity against both the house fly and the mosquito.

Table 4 Efficacy of coil formulation against the house fly and mosquito, measured by the glass chamber method

Chemicals	Conc. (%W/W)	KT_{50} (min)—%Mortality*	
		House fly	Mosquito
Empenthrin	0.2	10.7- 63	11.4-10
	0.4	5.2- 85	7.8-16
	0.8	4.2-100	4.2-56
d-Allethrin	0.2	19.9- 9	7.0- 0
	0.4	16.5- 8	5.2- 1
	0.8	12.6- 14	3.7- 1
Pyrethrins	0.2	>20- 14	12.1- 3
	0.4	>20- 30	10.4- 4
	0.8	>20- 36	8.4- 4

*%Mortality : at 24hr

Table 5 Effect of pyrethroids in vapor form against the house fly and mosquito

Chemicals	Conc. (mg/m²)	KT_{50} (min)—%Mortality*	
		House fly	Mosquito
Empenthrin	62.5	15.5-65	46.8-5
	125.0	15.5-60	36.9-5
d-Allethrin	125.0	>60- 2	>60-2
	250.0	>60- 5	>60-2
Pyrethrins	125.0	>60- 0	———
	250.0	>60- 2	>60-2

*%Mortality : at 24hr.

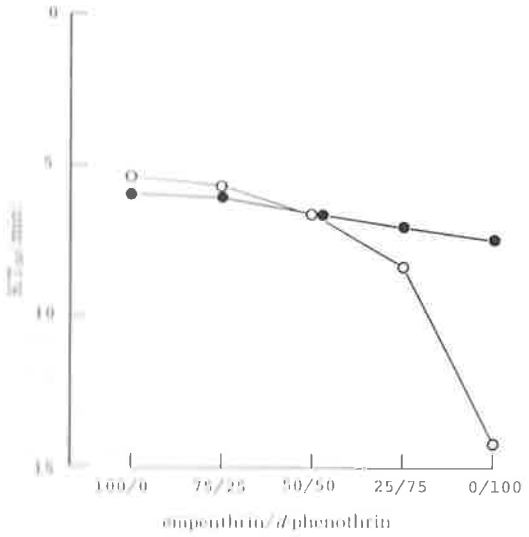

Fig. 1 Relationship between the ratio of empenthrin to *d*-phenothrin in a mixture and the knockdown activity of an oil-based aerosol containing 1.0 % active ingredients. ○:mosquitoes, ●:house flies.

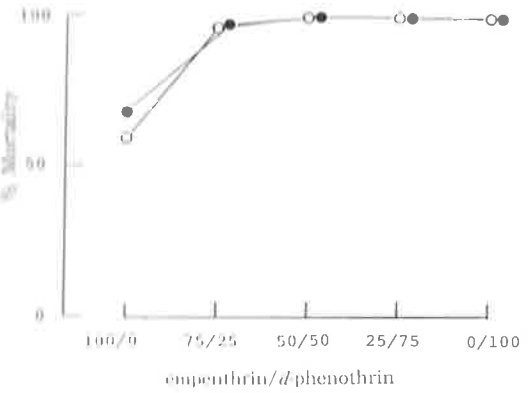

Fig. 2 Relationship between the ratio of empenthrin to *d*-phenothrin in a mixture and mortality of an oil-based aerosol containing 1.0 % active ingredients. ○:mosquitoes, ●:house flies.

This study showed that the killing activity of empenthrin against the house fly is strong and that its vapor is insecticidal. Empenthrin might be of practical use in the form of an aerosol, oil, fly coil, and fly strip. Aerosol formulations need both quick knockdown and strong killing activities. However, because of economical and toxicological considerations, the two requirements are seldom satisfied by any one chemical, because few compounds have both activities, and a high concentration would be necessary to obtain satisfactory activity. From these reasons, the combination of a knockdown agent with a synergist or a killing agent has been generally used in practical aerosol formulations. A mixture of empenthrin and *d*-phenothrin might be practical for house fly mosquito control.

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フェニトロチオンマイクロカプセルのゴキブリ駆除用食毒剤への応用*

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Application of Microencapsulated Fenitrothion to Bait Formulation for Cockroach Control. Tsutomu KANZAKI, Akio INOMOTO, Hiroshi OHGAMI and Yoshio KATSUDA (Research Laboratory, Dainihon Jochugiku Co. Ltd., Toyonaka, Osaka 561, Japan) *Jpn. J. Environ. Entomol. Zool.* **3**：81-86 (1991)

Fenitrothion and microencapsulated fenitrothion (fenitrothion MC) were tested in new bait formulations containing boric acid. In the basic efficacy tests, bait formulations, incorporating boric acid alone from 15% to 35%, were all slow acting. In contrast, the combination baits containing 15% boric acid plus 5% fenitrothion MC (1% as fenitrothion) were fast-acting against cockroaches, and this rapid activity was superior to those of single active ingredient formulations of 1% fenitrothion or 5% fenitrothion MC. The combination gave satisfactory kills and also reduced the cockroach population for a long time in field tests.

Key Words: Microcapsule, Fenitrothion, Boric acid, *Blattella germanica*, *Periplaneta americana*

ホウ酸製剤に速効性を付与したゴキブリ駆除用食毒剤を開発する目的で，フェニトロチオンあるいはフェニトロチオンマイクロカプセル（フェニトロチオンMC）の適用を検討した。致死効果試験では，ホウ酸の配合率が15～35%の製剤は効力の発現にほとんど差がなく，いずれも遅効性であったのに対し，ホウ酸15%とフェニトロチオンMC5%（フェニトロチオンとして1%）の混合製剤は，フェニトロチオン1%あるいはフェニトロチオンMC5%製剤に比べ速効性が増強された。実地試験においては，ゴキブリの生息密度を確実に低下させ，高い駆除効果と残効性を示した。

緒　言

ゴキブリ駆除用食毒剤に使用される主な有効成分としては，フェニトロチオン，ホウ酸およびヒドラメチルノンがある。

ゴキブリに対するフェニトロチオンの作用は，アセチルコリンエステラーゼ阻害であり，ホウ酸の作用は明確ではないが，摂食により最終的にゴキブリが脱水症状を起こし確実に死に至ると考えられている（深見，1990）。また，ヒドラメチルノンは，ゴキブリが摂食すると酸素吸収量が徐々に低下し死に至ることから，呼吸酵素系の阻害剤と考えられている（HOLLIGSHAUS，1987）。

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