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# Egg Mortality of German Cockroaches Exposed to Fenitrothion MC Bait and Hydramethylnon Bait

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**ABSTRACT** **The viability of the oothecae (eggs) of *Blattella germanica* females which were killed by ingesting fenitrothion MC bait and hydramethylnon bait was studied under the high humidity condition (75% RH). In case of the females treated with fenitrothion MC bait, 17 oothecae out of 25 (68%) and 520 eggs out of 807 (64.4%) were hatched during the period of 4-24 days after treatment. In case of the females treated with hydramethylnon bait, 15 oothecae out of 25 (60%) and 499 eggs out of 842 (59.3%) were hatched during the period of 1-28 days after treatment. In the control group (decapitated females), 21 oothecae out of 25 (84%) and 728 eggs out of 835 (87.2%) were hatched during the period of 1-24 days after decapitation, which was significantly different from those of the eggs of the females treated with both fenitrothion MC bait and hydramethylnon bait ($P < 0.05$). Neither the degree of maturity of oothecae, nor detachment/attachment of oothecae from/to female abdomens were correlated to the hatching (viability) of the oothecae.**

**Key words : egg mortality, *Blattella germanica*, fenitrothion MC bait, hydramethylnon bait**

**적 요** 바퀴(*Blattella germanica*)는 난 발육이 완성될 때까지 난협을 복부말단에 달고 다닌다. 최근 널리 사용되고 있는 fenitrothion MC bait와 hydramethylnon bait 섭취 후 죽은 암컷의 난협내 알의 부화율을 75% RH의 높은 습도하에서 관찰하여 다음과 같은 결과를 얻었다. Fenitrothion MC bait을 처리한 군에서는 68%의 난협부화율(17/25)과 64.4%의 알부화율(520/807)을 얻었고, hydramethylnon bait 처리군에서는 60% (15/25) 난협부화율과 59.3% (499/842)의 난부화율을 보였는데 이들간의 통계적 유의성은 없었다. 두부를 제거한 대조군의 경우는 84% (21/25)의 난협부화율과 87.2% (728/835)의 난부화율을 보여 상기 살충제 처리군과는 유의성이 있었다($P < 0.05$). 45% 습도하의 대조군(두부절단)에서는 28%와 36.7%의 난협 및 난부화율을 각각 나타냈고 20% 습도하의 대조군에서는 전혀 부화하지 않았다. 난협의 발육 정도 또는 난협의 어미로 부터의 탈락 여부와 난협 부화율간에는 어떤 연관성도 보이지 않았다.

검색어 : 난 치사율, 바퀴, 후시니트로치온, 히드라메칠론

It was known that insecticides not only kill cockroaches but also affect somehow fecundity of females exposed to chemicals. Hirakoso and Mizutani (1961) exposed German cockroaches to several insecticides of chloralhydrate and organophosphorus compounds by topical application and by injection into females, and found that hatching rates of the oothecae were affected in considerable degree. Yokoyama and Pritchard (1984) indicated that sublethal doses of insecticides had no effect on egg fertility. On the other hand, Abd-Elghafar and Apple (1992) reported that number of oothecae formed and number of offsprings produced in each ootheca increased with increasing sublethal concentrations of chlorpyrifos. Some studies have been done how sublethal doses of insecticides influence on the fecundity of the females, including hatching rate of oothecae, whereas little is known how insecticides affect the fecundity of females when exposed to lethal doses. We observed the mortality rates of oothecae and eggs of *Blattella germanica* when the females ingested fenitrothion MC bait or hydramethylnon bait and were killed.

## MATERIALS AND METHODS

NIH strain of *Blattella germanica* has been reared in large plastic containers in which many cardboard-made tubes are piled for their harborage. One or two harborage tubes were transferred

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into a plastic container with a tight lid, and anesthetized the cockroaches inside the tubes by introducing $CO_2$ gas. The females with oothecae regardless of their maturities were used for the test.

Small disposable petri dishes (3.5 cm in diameter) were used for the test. A round opening (2 cm in diameter), adhered with fine nylon muslin was made in middle of the cover for ventilation. Each of 25 females with ootheca on their abdomen was introduced in each petri dish with the test bait together. After the females were killed by the bait, the oothecae were observed with 24 hour intervals for 30 days. When offsprings were hatched, the oothecae were dissected under a stereo-microscope, and number of the eggs unhatched and number of the offsprings were counted. Two poison baits, fenitrothion MC 2% and hydramethylnon 2% were tested. As a control, 25 healthy females holding ootheca were decapitated and each of headless females holding ootheca was put in each petri dish and observed the fate of the oothecae daily.

All tests were carried out in the insectary in which the temperature was kept 24-25°C, and the relative humidity was adjusted to the desired per cent (75%, 45% and 20% RH) for the successive tests.

## RESULTS

In case of fenitrothion MC treated females under the high humidity condition (75% RH), 17 out of 25 oothecae were hatched, showing 68% of the ootheca hatching rate, and 520 eggs out of 807 were hatched, giving 64.4% of the egg hatching rate. One ootheca was hatched on day 4 after the female died, three on day 5, two on day 6, one on day 11, five on day 12, three on day 13, one each on day 20 and 24. The hatching period was 4-24 days after the female died. Among 17 oothecae hatched, only two oothecae (11.8% of the viable oothecae) gave 100% of the egg hatching rate (Table 1). All the females detached the ootheca from their body as soon as they knockdowned.

In case of hydramethylnon treated females, 15 oothecae out of 25 were hatched showing 60% of the ootheca hatching rate, and total 499 eggs out of 842 were hatched giving 59.3% of the egg hatching rate. Two oothecae hatched on day 1 after treatment, two each on day 2 and 7, one each on day 9, 12, 14 and 21, two on day 23, two on day 25, and one on day 28. The hatching period of oothecae was 1-28 days. Among 15 oothecae hatched, seven oothecae (46.7% of the viable oothecae) showed 100% of the egg hatching rate. Four oothecae were detached, and hatched during the period of two days when the females were alive. All the other oothecae were retained on abdomen after the females died.

**Table 1.** Hatching rate of 25 oothecae when the females of *B. germanica* ingested fenitrothion MC bait, under the high humidity condition (75% RH)

| Days after treatment | No. of oothecae hatched | No. of eggs/ ootheca | No. of eggs hatched | Hatching rate (%) | Ootheca detached/ attached |
|---|---|---|---|---|---|
| 4 | 1 | 26 | 23 | 88.5 | Detached |
| 5 | 3 | 32 | 28 | 87.5 | 〃 |
| | | 41 | 34 | 82.9 | 〃 |
| | | 38 | 36 | 94.7 | 〃 |
| 6 | 2 | 28 | 25 | 89.3 | 〃 |
| | | 37 | 37 | 100 | 〃 |
| 11 | 1 | 28 | 27 | 96.4 | 〃 |
| 12 | 5 | 39 | 33 | 84.6 | 〃 |
| | | 45 | 42 | 93.3 | 〃 |
| | | 17 | 11 | 64.7 | 〃 |
| | | 31 | 30 | 96.8 | 〃 |
| | | 27 | 24 | 88.9 | 〃 |
| 13 | 3 | 47 | 44 | 93.6 | 〃 |
| | | 38 | 35 | 92.1 | 〃 |
| | | 39 | 39 | 100 | 〃 |
| 20 | 1 | 36 | 33 | 91.7 | 〃 |
| 24 | 1 | 34 | 19 | 55.9 | 〃 |
| 30 | | 29 | 0 | 0 | 〃 |
| | | 20 | 0 | 0 | 〃 |
| | | 40 | 0 | 0 | 〃 |
| | | 30 | 0 | 0 | 〃 |
| | | 27 | 0 | 0 | 〃 |
| | | 32 | 0 | 0 | 〃 |
| | | 30 | 0 | 0 | 〃 |
| | | 16 | 0 | 0 | 〃 |
| Total | 17* | 807 | 520 | 64.4 | |

* Hatching rate of the oothecae was 68% (17/25).

In case of decapitated females (control group), hatching rate of eggs were clearly correlated to the degree of humidity. Under the high humidity condition (75% RH), as shown in Table 3, 21 oothecae out of 25 were hatched, giving 84% of the ootheca hatching rate, and total 728 eggs out of 835 were hatched, giving 87.2% of the egg hatching rate. One ootheca was hatched on day 1 after decapitation, one on day 2, four on day 5, one on day 7, two on day 10, seven on day 12, two on day 13, and one each on day 15, 17 and 24. The hatching period was 1-24 days. Among 21 oothecae hatched, 17 oothecae (81.0% of the viable oothecae) gave 100% of the egg hatching rate. When the females were artificially decapitated, 10 oothecae were detached from the females, and 15 oothecae were continuo-

**Table 2.** Hatching rate of 25 oothecae when the females of *B. germanica* ingested hydramethylnon bait, under the high humidity condition (75% RH)

| Days after treatment | No. of oothecae hatched | No. of eggs/ ootheca | No. of eggs/ hatched | Hatching rate (%) | Ootheca detached/ attached |
|---|---|---|---|---|---|
| 1 | 2 | 43 | 40 | 93.0 | Detached* |
| | | 37 | 37 | 100 | 〃 * |
| 2 | 2 | 31 | 31 | 100 | 〃 * |
| | | 40 | 40 | 100 | 〃 * |
| 7 | 2 | 25 | 20 | 80 | Attached |
| | | 31 | 31 | 100 | 〃 |
| 9 | 1 | 21 | 20 | 95.2 | 〃 |
| 12 | 1 | 28 | 28 | 100 | 〃 |
| 14 | 1 | 36 | 36 | 100 | 〃 |
| 21 | 1 | 43 | 40 | 93.0 | 〃 |
| 23 | 2 | 38 | 24 | 63.2 | 〃 |
| | | 48 | 48 | 100 | 〃 |
| 25 | 2 | 45 | 42 | 93.3 | 〃 |
| | | 42 | 25 | 59.5 | 〃 |
| 28 | 1 | 45 | 37 | 82.2 | 〃 |
| 30 | | 40 | 0 | 0 | 〃 |
| | | 31 | 0 | 0 | 〃 |
| | | 35 | 0 | 0 | 〃 |
| | | 26 | 0 | 0 | 〃 |
| | | 19 | 0 | 0 | 〃 |
| | | 27 | 0 | 0 | 〃 |
| | | 26 | 0 | 0 | 〃 |
| | | 36 | 0 | 0 | 〃 |
| | | 29 | 0 | 0 | 〃 |
| | | 20 | 0 | 0 | 〃 |
| Total | 15** | 842 | 499 | 59.3 | |

* The female was alive.
** Hatching rate of the oothecae was 60% (15/25).

**Table 3.** Hatching rate of 25 oothecae when the females of *B. germanica* were decapitated, under the high humidity condition (75% RH)

| Days after decapitated | No. of oothecae hatched | No. of eggs per ootheca | No. of eggs hatched | Hatching rate (%) | Ootheca detached/ attached |
|---|---|---|---|---|---|
| 1 | 1 | 27 | 27 | 100 | Attached |
| 2 | 1 | 38 | 38 | 100 | 〃 |
| 5 | 4 | 37 | 37 | 100 | Detached |
| | | 34 | 34 | 100 | 〃 |
| | | 39 | 39 | 100 | 〃 |
| | | 34 | 34 | 100 | 〃 |
| 7 | 1 | 36 | 36 | 100 | Attached |
| 10 | 2 | 28 | 28 | 100 | 〃 |
| | | 24 | 24 | 100 | Detached |
| 12 | 7 | 37 | 37 | 100 | 〃 |
| | | 40 | 40 | 100 | Attached |
| | | 39 | 39 | 100 | 〃 |
| | | 36 | 36 | 100 | Detached |
| | | 36 | 36 | 100 | 〃 |
| | | 32 | 31 | 96.9 | Attached |
| | | 28 | 26 | 92.9 | 〃 |
| 13 | 2 | 39 | 39 | 100 | Detached |
| | | 27 | 27 | 100 | Attached |
| 15 | 1 | 41 | 39 | 95.1 | Detached |
| 17 | 1 | 44 | 38 | 86.4 | Attached |
| 24 | 1 | 43 | 43 | 100 | Detached |
| 30 | | 8 | 0 | 0 | 〃 |
| | | 22 | 0 | 0 | 〃 |
| | | 35 | 0 | 0 | 〃 |
| | | 31 | 0 | 0 | 〃 |
| Total | 21* | 835 | 728 | 87.2 | |

* Hatching rate of oothecae was 84% (21/25).

usly attached on the abdomen. Detachment/attachment on the head-less body did not influence the viability of the eggs. The oothecae (eggs) of the decapitated females did not hatch at all under the extremely low humidity condition (20% RH). On the other hand, when 45% of the relative humidity was given, eight oothecae out of 25 were hatched, giving 28% of the ootheca hatching rate and 310 eggs out of 844 were hatched, giving 36.7% of the egg hatching rate. Two oothecae each were hatched on day 13, 16 and 20, and one each on day 24 and 30. Four oothecae out of eight hatched (50% of the viable oothecae) gave 100% of the egg hatching rate (Table 4). Average number of eggs was 33.8 per ootheca. Five out of eight viable oothecae detached from the females and all unviable oothecae were kept retained on the females.

## DISCUSSION

Water is essential to the development of eggs. The oothecae of *Blatta orientalis*, *Periplaneta americana* and their related species are resistant to water loss by hardened wall or being covered with water-proofing materials. However, oothecae of *B. germanica* differ from those of the above species. Cornwell (1968) metioned that there was sufficient water in the newly formed ootheca of the German cockroach (62%) to allow development and hatching of eggs when kept at high humities, additional water being supplied by the female. Premature detachment of the ootheca from *B. germanica* female has a marked effect on hatching. Ross (1929) suggested that if 9 days old oothecae were detached, the eggs would hatch when kept moist, but would not do so under any conditions if removed earlier. Roth and Willis (1955) showed that the age of the ootheca at time of separation from the female is not the sole factor which influences hatching; when detached oothecae were kept at low humidity (30–50% RH), eggs fail to hatch unless the oothecae were removed from females on the day prior to hatching when development is almost complete. Our results showed no interrelation between the interval of detachment and viability of

the oothecae as shown in Table 3. When the oothecae were kept at 45% RH, 36.7% of the eggs were hatched as shown in Table 4.

Hirakoso and Mizutani (1961) reported that the hatching rate of the oothecae detached from the *Blattella germanica* females which had been knockdowned by toppical application of insecticides was 24% (24/100 oothecae) to dieldrin, 17% (17/100) to chlordame, 11% (11/100) to diazinon, 16% (16/100) to dichlorvos, 25% (25/100) to dibrom and 42% (42/100) in the untreated (control) group. However their result was not able to compare to our result because they did not mention what relative humidity was kept during the test. So low hatching rate (42%) of the oothecae in their untreated control group would probably resulted from the fact that they tested the hatching rate of ootheca under the low relative humidity condition. Our result showed that the hatching rate of the oothecae was closely correlated to the humidity condition, i.e. 84%, 28% and 0% of oothecal hatching rates (87.2%, 32.8% and 0% of egg hatching rates) were shown under the relative humidity condition of 75%, 45% and 20%, respectively (Table 5). Another reason for their low hatching rates in both the treated and untreated groups is that 13 days of their observation period was too short, because our result showed that the ootheca hatching was occurred even after 28-30 days of the treatment (Table 2 and Table 3).

Harmon and Ross (1987, 1988) reported that exposure to insecticides caused gravid females of *Blattella germanica* to drop their oothecae prematurely, resulting in decreased hatch. However, our results showed that the viability of the oothecae is not related to the maturity of the oothecae formed. The completely and/or the almost completely developed oothecae in which over 40 eggs were formed were hatched on day 5 and on days 12-13 in case of fenitrothion MC bait, on days 1-2 and on days 25-28 in case of hydramethylnon bait and on days 12-17 and on day 24 in case of decapitated females. Inaddition, prematured oothecae in which less than 30 eggs were formed were hatched on days 4-6 and on day 12 in case of fenitrothion MC, on days 7-9 and on day 12 in case of hydramethylnon, and on day 1 and on days 10-13 in case of decapitated females. Not viable oothecae that 100% mortality were shown included both completely and incompletely developed oothecae.

**Table 4.** Hatching rate of 25 oothecae when the females* of *B. germanica* were decapitated, under the low humidity condition (45% RH)

| Days after decapitated | No. of oothecae hatched | No. of eggs per ootheca | No. of eggs hatched | Eggs hatching rate (%) | Ootheca detached/ attached |
|---|---|---|---|---|---|
| 13 | 2 | 48 | 46 | 95.8 | Detached |
| | | 46 | 46 | 100 | 〃 |
| 16 | 2 | 42 | 42 | 100 | 〃 |
| | | 29 | 29 | 100 | 〃 |
| 20 | 2 | 42 | 31 | 73.8 | Attached |
| | | 50 | 50 | 100 | Detached |
| 24 | 1 | 36 | 35 | 97.2 | Attached |
| 30 | 1 | 41 | 31 | 75.6 | 〃 |
| | | 20 | 0 | 0 | 〃 |
| | | 35 | 0 | 0 | 〃 |
| | | 30 | 0 | 0 | 〃 |
| | | 27 | 0 | 0 | 〃 |
| | | 31 | 0 | 0 | 〃 |
| | | 37 | 0 | 0 | 〃 |
| | | 40 | 0 | 0 | 〃 |
| | | 18 | 0 | 0 | 〃 |
| | | 43 | 0 | 0 | 〃 |
| | | 37 | 0 | 0 | 〃 |
| | | 25 | 0 | 0 | 〃 |
| | | 28 | 0 | 0 | 〃 |
| | | 22 | 0 | 0 | 〃 |
| | | 19 | 0 | 0 | 〃 |
| | | 29 | 0 | 0 | 〃 |
| | | 38 | 0 | 0 | 〃 |
| | | 31 | 0 | 0 | 〃 |
| Total | 8** | 844 | 310 | 36.7 | |

* The head-less females were alived until 3-4 days after decapitation.
** Hatching rate of oothecae was 28% (7/25).

**Table 5.** Comparison of the hatching rates of eggs (oothecae) when the females were killed by ingestion of the insecticides (fenitrothion and hydramethylnon) and by decapitation

| Treatment | Humidity condition (% RH) | No. of oothecae tested | No. of oothecae hatched | Ootheca hatching rate | No. of eggs (%) | No. of eggs hatched | Egg hatching rate(%)* |
|---|---|---|---|---|---|---|---|
| Fenitrothion MC | 75 | 25 | 17 | 68 | 807 | 520 | 64.4[a] |
| Hydramethylnon | 75 | 25 | 15 | 60 | 842 | 499 | 59.3[a] |
| Decapitation | 75 | 25 | 21 | 84 | 835 | 728 | 87.2[b] |
| 〃 | 45 | 25 | 8 | 32 | 844 | 310 | 36.7[c] |
| 〃 | 20 | 25 | 0 | 0 | 817 | 0 | 0 |

* Egg hatching rates followed by a different letter are significantly different ($P < 0.05$) by the Duncan's multiple range test.

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