# THE INSECT GROWTH REGULATOR, TRIFLUMURON (OMS–2015) AGAINST *AEDES AEGYPTI* IN JAKARTA, INDONESIA

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## ABSTRAK

Uji laboratorium dan lapangan dengan IGR Triflumuron (OMS–2015) terhadap larva nyamuk *Aedes aegypti* telah dilakukan di Jakarta. Uji laboratorium dilakukan dengan 6 variasi dosis, yaitu 0,004; 0,011; 0,034; 0,10; 0,33 dan 1,0 ppm Triflumuron terhadap perkembangan larva nyamuk *Ae. aegypti* di dalam tempayan. Dari uji laboratorium dapat diketahui bahwa Triflumuron dengan dosis 0,004 ppm dapat menekan perkembangan pupa untuk menjadi dewasa dalam waktu 2 minggu, sedangkan dosis 0,10 ppm menekan padat populasi nyamuk *Ae. aegypti* selama 4 minggu dan dosis 1,0 ppm menekan padat populasi nyamuk *Ae. aegypti* selama 8 minggu. Uji lapangan dengan menggunakan Triflumuron di daerah pelabuhan Tanjung Priok, Jakarta, seluas 27 hektar dengan dua kali perlakuan, dengan dosis 0,042 dan 0,075 ppm, terjadi penurunan populasi nyamuk *Ae. aegypti* dewasa dan indeks pupa menjadi 0 dalam 4 hari setelah perlakuan. Penurunan populasi nyamuk *Ae. aegypti* dewasa terlihat setelah 2 minggu sesudah perlakuan dengan tidak berhasilnya larva/pupa menjadi nyamuk dewasa.


## INTRODUCTION

Insect Growth Regulators (IGRs) have considerable potential for use in mosquito control as they often suppress adult production at rates comparable to conventional insecticides and usually with less environmental impact. Furthermore, unlike some of the pathogens proposed for mosquito control, the IGR tends to give residual action.

At dosage rates higher than necessary for mosquito control Triflumuron has shown some adverse effect on *Cyclops* sp. and a few aquatic insects[1], but recovery was within a few days to 2–3 weeks. In the domestic water containers, habitat of *Aedes aegypti*, the modes of action of the IGR show no hazard to fish or other vertebrates. Also, very low dosage rates of this compound were effective against *Ae. aegypti* in the laboratory, giving an LC50 of 5.17 ppb[2]. In Jakarta Aminah et al. (1981)[3] have tested several formulations of two IGRs against *Ae. aegypti* in water containers simulating domestic use and showed that at one ppm a.i. methoprene gave control for eight weeks, and the concentration of diflubenzuron remained effective for 12–18 weeks. A field trial by ten Houten et al. (1980)[4] with one ppm a.i. methoprene applied to *Ae. aegypti* sources in Tanjung Priok, Jakarta, showed emergence rates and overall adult populations were markedly reduced for one month.

In this present study we tested the IGR, triflumuron* at a wide range of dosage rates in water jars simulating domestic use to determine a basic dosage rate necessary for substantial initial kill and the relationship between dosage and


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* 1–(2 chlorobenzoyl) 3–(4–trifluoro–methoxyphenal) company designation, SIR–8514 WHO designation, OMS–2015.

duration of effect. A field trial with the same IGR was carried out to determine its applicability in domestic water under actual usage.

## METHODS AND MATERIALS

### Simulated Domestic Water Use

Quadruplicate earthenware jars with 30 litres of water were screaned to prevent unwanted natural ovipositioning. Ten first instar colony *Ae. aegypti* larvae were introduced into each jar three times a week, or 120 larvae weekly for each dosage tested. Ten to fifteen litres of water were removed and replaced three times weekly. Care was taken to prevent accidental removal of larvae. Larval mortalities were taken as the difference between the number of first instars introduced and the number of live pupae removed. Daily laboratory observations were made of pupal mortality and successful and unsuccessful adult emergence. Three full series of tests were run at progressively higher dosage rates, ranging from 0.004 to 1.0 ppm a.i.

### Field Trial

*Area.* A test area of 27 ha was selected for treatment in the port area of Jakarta, Tanjung Priok. It consists mostly of low income families living closely together. Well water in Tanjung Priok is brackish, and piped water is poorly distributed, therefore most domestic water is sold by vendors and stored in metal drums by the householders, which are the major source of *Ae. aegypti.* This area was described in detail by ten Houten et al. (op. cit.)[4].

*Treatments.* There were two treatments two months apart, and their respective target dosage rates were 0.05 and 0.10 ppm a.i. It required three teams four days for each treatment. Each team consisted of a supervisor and two mosquito scouts. They carried the emulsifiable concentrate of triflumuron (6,5%), a pipette for measuring in the filed, a can of spray paint, a mixing bucket, and two vials for treating. Sixteen ml (1 st treatment) or 32 ml (2nd teratment) of triflumuron were diluted in ten litres of water in the measured and marked bucket. The vials were also marked: 12, 25, and 37 ml, and when completely full the vial held 50 ml. Various sizes of containers were treated, necessitating the use of different amounts of the solution, e.g. two full vials for a standard metal drum. Categories of containers were defined as small and standard drums; small, medium, and large jars; and standard and large cement baths. Miscellaneous containers around the houses were emptied of water and turned upside down but left untreated. Because water is continually being removed and added, each container was treated as though it were full. After treating, the containers were marked with a spot of paint, then recorded as to type, size and location by house number.

*Evaluation.* A five ha area within the 27 treated ha was selected for evaluation. It was located on the SE corner of the test area with no possibility of *Ae. aegpyti* production south or east for over a km, the nearest point of potential production being NW at least 500 m distant. A check area was selected about one km west, and it was very similar to the test area. Entomological evaluations were carried out four times a week, i.e. weekly larval survey and landing rate catch in each of the two areas.

Four mosquito scouts captured mosquitoes landing on them over a three hour period beginning from 0930 hours. They would move to adjacent or nearby houses every twenty minutes, thus catches were made in 36 houses during each survey. The captured mosquitoes were brought to the laboratory, killed, identified, and the next morning ovaries were dissected for parous determinations.

Metal drums, jars, cement baths, and miscellaneous containers were surveyed weekly in both areas, over 100 homes inspected each time, and each container recorded as negative or positive for larvae and/or pupae. Previous experience in this area has shown that more than 99% of the immatures in these containers are *Ae. aegypti*, therefore, no attempt was made to identify them.

Just before and subsequent to the second treatment, pupae were collected from drums in both areas and brought to the laboratory for observations of degree of successful adult emergence. Shortly after treatment, when pupae were scarce or impossible to find in the test area, IV stage larvae were collected and their fate observed.

## RESULTS

### Simulated Domestic Water Use

Table 1 shows the percentage of successful pupation and adult emergence of *Ae. aegypti* from water jars treated with various dosages of Triflumuron.

**Table 1. Percent of successful pupation and adult emergence from introduced *Aedes aegypti* larvae in water jars treated with Triflumuron.**

| Dosage rate (ppm) | % of introduced I instar : | Number of weeks after treatment | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | −1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0.004 | pupating | 70.8 | 13.3 | 8.3 | 23.3 | 42.5 | 47.5 | 45.8 | 50.0 | 60.8 | – | – |
| | emerging | 68.3 | 8.3 | 5.8 | 21.7 | 36.7 | 42.5 | 44.2 | 46.7 | 52.5 | – | – |
| 0.011 | pupating | 82.5 | 6.7 | 0.8 | 9.2 | 27.5 | 41.7 | 37.5 | 48.3 | 44.2 | – | – |
| | emerging | 73.3 | 4.2 | 0 | 9.2 | 25.8 | 35.0 | 36.7 | 45.8 | 40.0 | – | – |
| 0.034 | pupating | 67.8 | 6.0 | 0.4 | 11.2 | 13.4 | 32.0 | 22.6 | 40.8 | 40.4 | – | – |
| | emerging | 61.7 | 3.0 | 0 | 10.0 | 12.0 | 26.6 | 20.4 | 37.1 | 35.3 | – | – |
| 0.10 | pupating | 46.0 | 7.9 | 0 | 3.4 | 0.4 | 15.0 | 22.0 | 21.6 | 33.8 | – | – |
| | emerging | 44.0 | 4.2 | 0 | 3.4 | 0 | 6.2 | 18.8 | 20.0 | 32.9 | – | – |
| 0.33 | pupating | 47.4 | 5.8 | 0 | 0 | 0 | 1.2 | 5.4 | 19.2 | 28.4 | 38.3 | 45.0 |
| | emerging | 44.2 | 4.6 | 0 | 0 | 0 | 0 | 2.9 | 18.8 | 25.8 | 38.3 | 41.7 |
| 1.0 | pupating | 30.8 | 8.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10.0 | 37.5 |
| | emerging | 29.2 | 8.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10.0 | 32.5 |
| check | pupating | 47.8 | 49.6 | 51.1 | 50.0 | 48.2 | 58.5 | 52.5 | 52.2 | 64.1 | 61.1 | 68.4 |
| | emerging | 44.8 | 49.2 | 50.0 | 49.3 | 46.3 | 54.4 | 48.9 | 50.3 | 61.9 | 60.6 | 65.0 |

The lowest rate tested was 0.004 ppm a.i., and this greatly reduced adult emergence; however, complete suppression of adults was at dosage rates above this level (0.011—1.0 ppm). Schaefer et al. (1978)[5] showed 100% inhibition of *Ae. nigromaculus* in small field plots treated at 0.001 ppm. They also showed that *Ae. nigromaculus* were successfully emerging from the plots 4—5 days after treatment of 0.1 ppm. The present tests show complete suppression of *Ae. aegypti* for two weeks at 0.01 ppm., four weeks at 0.1 ppm, and eight weeks at 1.0 ppm.

In Table 1 the combined pupal and emergence mortality is the difference between the rate of pupation and the rate of successful emergence. With the degradation of this IGR, a point is reached where a sufficient number of larvae survive and pupate, only then alowing post larval mortalities to be measured. For about two weeks these later stage mortalities are significantly higher than normal, i.e. as compared to the mortalities in untreated jars. However post larval mortality rates never approach those for the larvae. For example, the overall larval mortality in the untreated check jars during the period of observation was 45% of the introduced larvae; the pupal/emergence mortality was just under 4% of those that had successfully pupated. For all of the treated jars during the first two consecutive weeks that 5% or more of the introduced larvae had successfully pupated, the overall larval mortality was 84%, and the pupal/emergence mortality was only up to 16.5% of those that had pupated.

Field Trial

*Treatments.* During each of the two treatment cycles, triflumuron was put into more than 3200 drums, over 900 jars, and about 300 cement baths. About 620 living compounds were inspected during each treatment. Of the total compounds 1.2% were locked, thus not treated. This was about the same during both rounds. During the first treatment cycle 1.5% refused entry, but this was greatly improved during the second treatment round with only 0.5% refusals. These untreated houses probably contributed negligible numbers of mosquitoes. Most locked houses and all refusals were of higher income levels, which normally had considerably less stored water and little of nil mosquito production.

The 6.5% EC formulation of triflumuron was diluted to 0.01% (1st treatment) and 0.02% (2nd treatment) in water in the field for application. Although the respective target dosage rates were 0.05 and 0.10 ppm, later calculations of quantity of IGR used and sources treated showed that the overall actual rates were 0.042 and 0.075 ppm respectively for the 1st and 2nd treatments.

*Adult Mosquito Population.* After the first treatment there was a measureable decrease in adult *Ae. aegypti* caught landing on man in the treated area for three to four weeks (Table 2); however, in spite of the increased dosage, this reduction was not as obvious after the second treatment.

**Table 2. Landing and parous rates of *Aedes aegypti*, before and after treatment with Triflumuron.**

| Days after treatment * | Treated area | | | Check area | | |
|---|---|---|---|---|---|---|
| | Number female caught per m.h. | number dissected | % parous | Number female caught per m.h. | number dissected | % parous |
| −16 | 3.2 | 11 | 63.6 | 4.9 | 23 | 65.2 |
| −10 | 3.2 | 30 | 60.0 | 3.0 | 28 | 64.3 |
| 5 | 0.8 | 8 | 87.5 | – | – | – |
| 8 | 1.8 | 12 | 83.3 | 4.9 | 27 | 59.3 |
| 15 | 0.9 | 11 | 90.9 | 4.2 | 39 | 61.5 |
| 23 | 1.3 | 15 | 66.7 | 4.4 | 46 | 67.4 |
| 29 | 1.0 | 11 | 72.7 | 4.9 | 54 | 64.8 |
| 36 | 2.2 | 21 | 66.7 | 5.0 | 52 | 65.4 |
| −6 | 1.1 | 12 | 58.3 | 3.0 | 28 | 75.0 |
| 7 | 2.1. | 23 | 65.2 | 2.2 | 23 | 65.2 |
| 15 | 1.2 | 13 | 69.2 | 3.8 | 39 | 61.5 |
| 22 | 2.2 | 26 | 61.5 | 7.1 | 77 | 67.5 |

* Catch in check area two days earlier.

Lumping two weeks of catches made prior to the first treatment, there was no difference in pretreatment parous rates between those caught in the test area and the check area (61.0% and 64.7%, respectively). Lumping the parous determinations of two weeks of catches after the first treatment, the treated area showed a significantly higher parous rate than that shown from the check area (87.1% and 60.6%, respectively; $p < 0.01$). Although the parous rate increased after the second treatment, no significance could be shown.

*Immature Mosquito Population.* In this area drums had a greater rate of positivity, produced more mosquitoes per container, and were more consistent than any other type of container; therefore, for a more reliable picture of the immature *Ae. aegypti* prevalence, Table 3 gives indices of drums only. It shows that any time after treatment it was possible to find active larvae, although their numbers were greatly reduced the first week. This population returned to normal at about two weeks after IGR application. No pupae were found during the immature survey four days after the second treatment. Overall, the pupal population was reduced for about two weeks.

Table 3. Immature population indices of *Aedes aegypti* in drums treated with Triflumuron.

| Days after treatment* | Larvae | | | | | | Pupae | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Treated | | | Check | | | Treated | | Check | |
| | Number of drums examined | container index | Breteau index | Number of drums examined | container index | Breteau index | Container index | Breteau index | Container index | Breteau index |
| −12 | 278 | 39.6 | 110 | 132 | 33.3 | 44 | 15.5 | 42 | 16.7 | 22 |
| −4 | 267 | 19.5 | 161 | 143 | 47.6 | 68 | 19.5 | 52 | 11.9 | 17 |
| 7 | 279 | 15.1 | 44 | 206 | 68.9 | 156 | 3.6 | 10 | 40.8 | 89 |
| 14 | 314 | 30.1 | 51 | 268 | 58.2 | 86 | 11.5 | 19 | 13.4 | 20 |
| 28 | 367 | 34.9 | 71 | 318 | 55.3 | 98 | 20.7 | 42 | 28.0 | 49 |
| 35 | 316 | 48.1 | 84 | 285 | 43.2 | 68 | 30.4 | 53 | 16.5 | 26 |
| −20 | 188 | 53.7 | 112 | 136 | 29.4 | 44 | 10.6 | 22 | 19.9 | 30 |
| − 7 | 321 | 55.8 | 99 | 244 | 42.2 | 57 | 32.7 | 58 | 30.7 | 42 |
| 4 | 346 | 10.4 | 30 | – | – | – | 0 | 0 | – | – |
| 9 | 433 | 17.3 | 42 | 307 | 50.2 | 86 | 1.6 | 4 | 28.3 | 48 |
| 14 | 349 | 64.5 | 125 | 299 | 62.2 | 103 | 19.8 | 38 | 31.8 | 53 |
| 21 | 347 | 72.3 | 139 | 242 | 57.9 | 78 | 33.7 | 65 | 30.2 | 41 |
| 28 | 320 | 67.8 | 121 | 258 | 41.9 | 60 | 36.6 | 65 | 23.3 | 33 |

* Survey in check area two days earlier.

*Successful Adult Emergence.* Fourth stage larvae, although greatly reduced in number, were never difficult to find in the area after treatment. However, none matured to adult until the collections made two weeks after treatment (Table 4). At this two week period, pupae could readily be found, but their successful adult emergence rate was still lower than in the check area.

simulating field conditions in that tests was similar to that of methoprene and slightly shorter than diflubenzuron under the same testing conditions[3]. Compared with triflumuron test done in this experiment, those three IGR were less effective, since triflumuron could suppressed adult *Ae. aegypti* emergence up to four weeks.

**Table 4. Mortality of pupae and larvae collected from drums in Triflumuron treated area.**

| Days after treatment* | Treated area | | | | | Check area | |
|---|---|---|---|---|---|---|---|
| | Collections of IV larvae | | | Collections of pupae | | Collections of pupae | |
| | Number collected | Percent larval mortality | Combined % larval and pupal mortality | Number collected | Percent mortality | Number collected | Percent mortality |
| 4 | 83 | 100 | 100 | 1 | 100 | – | – |
| 7 | 100 | 100 | 100 | 2 | 50 | – | – |
| 9 | 50 | 92 | 100 | 18 | 0 | 100 | 1.0 |
| 14 | 100 | 21 | 60 | 81 | 3.7 | 100 | 2.0 |
| 21 | – | – | – | 200 | 2.0 | 167 | 1.8 |
| 27 | – | – | – | 160 | 1.9 | 180 | 0.6 |

* Collections from check area made two days earlier.

## DISCUSSION AND CONCLUSION

Laboratory tests of OMS–2014 (Vetrazin) on *Ae. aegypti* with dosage rates between 0.4 and 0.8 mg/l were effective over three and six days[6]: similar tests done by Herald et al. (1980)[2], using triflumuron against *Ae. aegypti* with measured dosage rates between 5.17 ppb ($LC_{50}$) and 51.42 ppb ($LC_{90}$) were effective over 24 hours. The duration of effect of OMS–2014 againts *Ae. aegypti* in water jars

Precise measurement of mosquito survival in earthenware water jars treated with triflumuron showed that dosage rates of 0.034 and 0.10 ppm a.i. suppressed succesful adult *Ae. aegypti* emergence for two weeks and about four weeks, respectively. On this basis, a target dosage rate of 0.05 ppm was set for a field trial. The target for a second treatment was set at 0.10 ppm.

Subsequent to the treatments, calculations showed under dosages, a mean

actual output of 0.042 ppm for the first treatment and 0.075 ppm for the second. Under the normal variations of field application, the actual individual dosages were probably both above and below this calculated mean. Also, field conditions carry more variables than exist in laboratory simulations, e.g. missed sources, increased domestic water usage, refusals and locked houses, and the possibility of low dosages being applied.

Some of these factors may have played a substantial role in this field trial, resulting in a shorter duration of impact on the immature mosquito states and a lower adult population impact than led to expect from results of the jar tests, simulating field conditions. However, this field trial did show that after applications of small quantities of triflumuron there was a measurable reduction in adult *Ae. aegypti* population, a significant increase in parous rate, a definite decrease in number of containers with larvae, a pronounced reduction of a number of containers with pupae, and a latent killing effect on active larvae for about two weeks.

## SUMMARY

First instar larvae were introduced into screened water jars simulating domestic use. The jars were treated with various dosages of triflumuron, and the fate of the introduced I stage larvae was recorded. At 0.004 ppm a.i. adult emergence was greatly reduced for two weeks, at 0.10 ppm it was completely suppressed for about four weeks, and at 1.0 ppm no adults successfully emerged until the ninth week.

For a two week period after the a.i. had degraded to a level low enough to allow some larvae to successfully pupate, there was consistently a higher pupal/emergence mortality than from either pretreatment or concurrent check jars.

A field trial of two treatments of triflumuron over a 27 ha residential area was carried out at application rates of 0.042 and 0.075 ppm a.i. Adult *Ae. aegypti* populations were only slightly depressed, but the pupal index was zero at four days after treatment. A latent kill is shown in the field with an inhibition of successful adult emergence for about two weeks.

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