Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 98, No. 5, September 1989, pp. 325–329.

Insect growth regulator XRD-473 (OMS 3031), a prospective compound for control of mosquito vectors

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MS received 13 March 1989; revised 7 August 1989

Abstract. Insect growth regulating activity of a substituted urea compound XRD-473 (OMS 3031) was evaluated against the target species viz. *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* and non target species *Toxorhynchites splendens*. This compound inhibited the emergence of all these mosquito species with EI_{50} values of 9×10^{-5}, $1{\cdot}09 \times 10^{-4}$, $2{\cdot}22 \times 10^{-4}$ and $2{\cdot}14 \times 10^{-4}$ mg (ai)/l respectively. Emergence inhibiting activity of XRD-473 was found to be more than fenoxycarb, and S 21149 against one or other species. In stagnant polluted water, the activity of the compound against *Culex quinquefasciatus* was for shorter duration of 5 and 10 days at 0·02 and 0·2 kg(ai)/ha respectively whereas in clear water the activity was for longer duration i.e. 11 and 17 days at the same dosage. However, in drain the activity was negligible i.e. 12 days at 2 kg(ai)/ha. More than two weeks control of *Aedes aegypti* was obtained in cement tank at the treatment rate of 0·2 kg(ai)/ha whereas at the lower dose of 0·02 kg(ai)/ha this compound was effective for less than a week.

Keywords. Insect growth regulators; emergence inhibition: *Culex quinquefasciatus*: *Anopheles stephensi*: *Aedes aegypti*: XRD-473.

1. Introduction

Insect growth regulators or the third generation insecticides (Williams 1967) have emerged as a new frontier for insect control and have developed as a result of rational leads from basic entomological research on metabolic disruptors, moult inhibitors and behaviour modifiers of insects. Since the target site of action for these chemicals is specific and are known to disrupt only in certain species at certain times during the life cycle, these materials are thought to have fewer serious deleterious effects on the environment and also on non-target organisms (Retnakaran *et al* 1985). Though a large number of chemicals of this category were synthesized and evaluated, a few such as Dimilin (Ten Housten *et al* 1980; Ho *et al* 1987), methoprene (Dame *et al* 1976), penfluron and furyltriazine (Sexana and Kaushik 1986), fenoxycarb (Mulla *et al* 1985; Tyagi *et al* 1987), S 21149 (an oxime) and S 31183 (pyridine) (Estrada and Mulla 1986; Amalraj *et al* 1988a, b), OMS 3009, OMS 3013 and OMS 2015 (Amalraj *et al* 1988a, b) etc have been tried successfully against mosquito vectors. This paper highlights the effect of a benzoyl urea compound, XRD-473 (OMS 3031) against major vector mosquito species.

2. Materials and methods

XRD-473 (OMS-3031), a substituted urea compound N-[(((3, 5-dichloro-4-(1, 1, 2, 2, tetrafluoroethoxy)-phenyl)amino)carbonyl)-2, 6-difluorobenzamide], was obtained from Dow Chemical International Ltd, USA through WHO as 5% emulsifiable

concentrate (EC) for evaluating its insect growth regulating activity against vector mosquitoes.

2.1 *Laboratory evaluation*

The 5% EC formulation of XRD-473 was first dissolved in acetone and then suitably diluted for the required concentrations. In order to obtain different target doses, 1 ml of stock solution of appropriate concentration was added in 499 ml of water in enamel trays ($15 \times 10 \times 5$ cm). To each tray, 50 third instar larvae of test species were added. Four replicates were set for each concentration per test and a control was maintained for each species. The test was carried out at room temperature $29 \pm 1°C$ and humidity 60–70%. The larvae were provided with larval food. Mortality in each stage i.e. 3rd, 4th and pupae and the number of emerged adults from live pupae were recorded. Total emergence inhibition was calculated taking into account the mortality in all the stages from 3rd stage larvae to pupae including partly emerged adults and adults with morphological deformities. Emergence inhibition (EI_{50} and EI_{90}) was estimated by regression analysis (WHO 1975).

Pupae of all the mosquito species were also exposed at different concentrations (i.e. 0·01, 0·1 and 1 mg/l) and emergence inhibition was determined. Dead larvae, pupae and larval-pupal intermediates and partly enclosed adults were observed for morphological abnormalities.

2.2 *Field evaluation*

A preliminary survey of all the breeding habitats of *Culex quinquefasciatus* and *Aedes aegypti* in and around the study area was done and those habitats which supported heavy mosquito breeding were taken for trial. XRD-473, was evaluated against *Cx. quinquefasciatus* in different breeding habitats at varying rates (i.e. 0·02, 0·2 and 2 kg(ai)/ha). Four replicates were maintained for each concentration and a separate control was kept for each type of habitat. The compound was sprayed with the help of a hand sprayer, with a discharge rate of about 160 ml/min.

Density of immatures and rate of adult emergence were monitored before and subsequently on alternative days after treatment. Four dips at periphery and one at the centre per treated habitat were pooled in a tray and stage wise counting was done. Known number of live pupae and fourth instar larvae were brought to the laboratory for observing adult emergence. In cases where the treated habitat was negative of all stages, water samples were brought to the laboratory and known number of laboratory reared third instar larvae were added and observed for the emergence inhibition. Emergence inhibition (% EI) was calculated by the following formula:

$$\text{Emergence inhibition (\%)} = 100 - \frac{\text{(No. of adults emerged)}}{\text{(No. of pupae collected)}} \times 100.$$

Effective duration in days was determined by noting down the days up to which more than 80% inhibition in adult emergence was noticed. Symptoms of disruption of moulting process typical of any insect growth regulator (IGR) compounds were observed and recorded.

3. Results

Emergence inhibition activity (EI_{50} and EI_{90}) of XRD-473 on all the 3 vector mosquito species and on the non-target mosquito *Toxorhynchites splendens* are presented in table 1. This compound was found to be very effective on *Cx. quinquefasciatus* and among the 3 vectors it was least effective on *Anopheles stephensi.*

Table 2 shows the effect of this compound (in terms of percentage inhibition) on the pupae of these mosquitoes. Just as in the case of the larvae, this compound was most effective on the pupae of *Cx. quinquefasciatus*, while least inhibition was seen within the pupae of *An. stephensi.* However, the pupae of *T. splendens* (non-target species) was also observed to have a high percentage of inhibition especially at 1 mg/l.

XRD-473 was evaluated against *Cx. quinquefasciatus* in different breeding habitats such as cesspits, cement tanks and drains at 3 different treatment rates, i.e. 0·02, 0·2 and 2 kg(ai)/ha and the results are presented in figure 1. In cesspits this compound was found to be effective (80% EI) for 11 days at 0·2 kg(ai)/ha. When tested at a lower concentration of 0·02 kg(ai)/ha it was effective only for 6 days. More than 80% EI was observed for nearly 26 days at high treatment rate of 2 kg(ai)/ha. In contrast, in cement tank relatively at lower rate (0·02 kg(ai)/ha), 100% EI was observed for 12 days, while at 0·2 kg(ai)/ha it was effective for 17 days. Since there was steady flow of water in drains the effectiveness of the compound was drastically reduced due to dilution and at 0·2 kg(ai)/ha this IGR was effective only for 4 days and at 2 kg(ai)/ha it was effective for 12 days.

The compound was effective for two weeks (17 days) against *Ae. aegypti* in cement tanks at the application rate of 0·2 kg(ai)/ha. Whereas at the lower rate of 0·02 kg(ai)/ha this compound was effective for less than a week (figure 1).

Heavy larval mortality, malformation of the pupae resulting either in immediate death or delayed mortality due to incomplete emergence of adults from the pupal cuticle was observed during the period of effectiveness.

Table 1. Laboratory evaluation of IGR OMS-3031 against 3rd instar larvae of mosquito species.

Species	Regression equation	EI_{50} (mg/l)	EI_{90} (mg/l)
Cx. quinquefasciatus	$Y = 8{\cdot}51 + 0{\cdot}38 \log X$	$9{\cdot}000482 \times 10^{-5}$	$2{\cdot}688419 \times 10^{-3}$
Ae. aegypti	$Y = 8{\cdot}50 + 0{\cdot}38 \log X$	$1{\cdot}099641 \times 10^{-4}$	$3{\cdot}059457 \times 10^{-3}$
An. stephensi	$Y = 10{\cdot}6090 + 0{\cdot}667 \log X$	$2{\cdot}226043 \times 10^{-4}$	$1{\cdot}516718 \times 10^{-3}$
T. splendens	$Y = 19{\cdot}7473 + 1{\cdot}745 \log X$	$2{\cdot}140856 \times 10^{-4}$	$4{\cdot}457339 \times 10^{-4}$

Table 2. Effect of IGR OMS-3031 on pupae of mosquito species in the laboratory.

	% EI at different dosages (mg/l)		
Species	0·01	0·1	1·0
Cx. quinquefasciatus	58	75	94
Ae. aegypti	34	70	82
An. stephensi	14	18	45
T. splendens	11	54	96

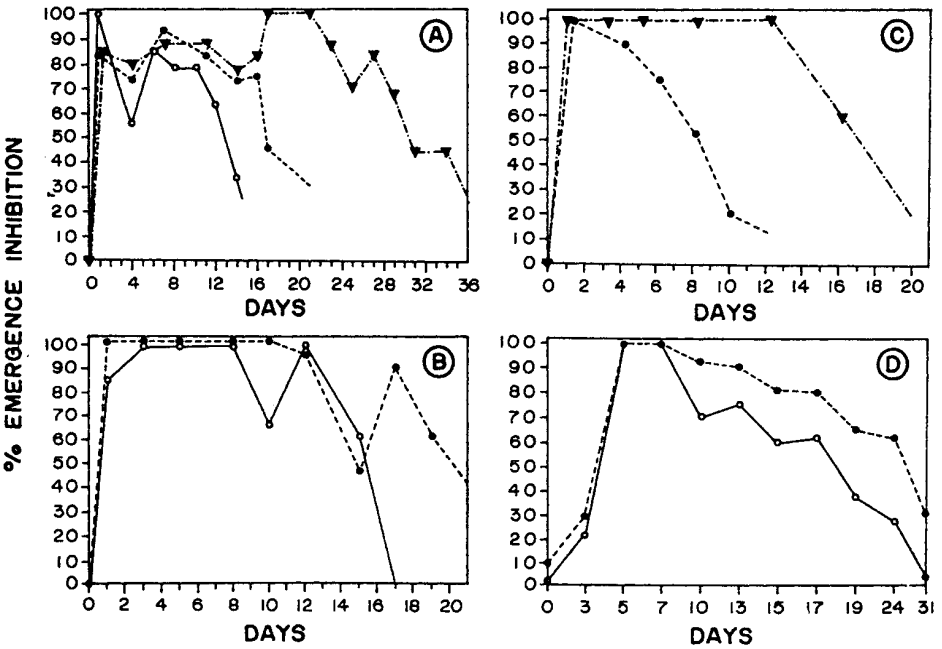

Figure 1. Field evaluation of XRD-473 (OMS 3031) against (i) *Culex quinquefasciatus* in (A) cesspits, (B) cement tanks and (C) drains and (ii) *Aedes aegypti* in (D) cement tanks. The dosages are 0·02 (○), 0·2 (●) and 2·0 (▼) kg(ai)/ha.

4. Discussion

The emergence inhibition activity of XRD-473 in vector mosquitoes in the laboratory was compared with that of other IGRs. In earlier studies (Tyagi *et al* 1987), fenoxycarb was found to induce 50% inhibition of adult emergence in *Cx. quinquefasciatus* at the concentration of 0·0017 mg/l which is 18 times more than the concentration required to get the same result with XRD-473. Similarly, when the results of S-21149, OMS 3009, OMS 3013 and OMS 2015 obtained under similar conditions (Amalraj *et al* 1988a, b) were compared with results obtained with XRD-473, it was found that the later compound was 154 times more effective than S-21149 against *Cx. quinquefasciatus* and as effective as S-21149 against *Ae. aegypti* and *An. stephensi*. EI_{50} of this compound and that of OMS 3009, OMS 3013 and OMS 2015 proved that all these IGRs are equally effective. This compound was less effective on the pupae which is in agreement with earlier observations with other IGRs.

The present study clearly shows the potential of this compound to inhibit emergence of *Cx. quinquefasciatus* in small confined breeding habitats such as cesspits at a dosage of 2 kg(ai)/ha for 26 days. Mulla and Darwazeh (1988) had reported that this compound was effective for 7 days at 0·056 kg(ai)/ha, in large dairy wastewater lagoons. In clear water bodies like cement tanks, the compound was effective for 17 days at 0·2 kg(ai)/ha and hence it would have to be applied fortnightly to check the breeding of these mosquitoes. Similarly in drains, this compound would have to be applied once in two weeks at 2 kg(ai)/ha to check the

proliferation of *Cx. quinquefasciatus*, a lower dosage may be sufficient in the case of stagnant blocked kutcha drains.

Though the effectiveness of this compound is limited to freshwater habitats, it can be incorporated in Integrated Vector Management programme. There are always some situations like profuse breeding of vector mosquitoes in cement tank, discarded tyres and drums in curing yards where water is clean but fish cannot be used either due to volume of water or due to unwillingness of people. In such situations IGRs can play useful role. Nonetheless, viewing the lethal effect of this compound on *T. splendens* there is imperative necessity for further study of this compound on non target organisms before being used in IVM programme.

Acknowledgements

The authors are grateful to Dr P K Rajagopalan and Dr P K Das, for guidance. Thanks are due to the Division of Vector Biology and Control, WHO, Geneva, for providing the chemical.

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