Research Note

Insecticidal effects of acetophenone against *Culex quinquefasciatus* (Diptera: Culicidae)

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Abstract: Acetophenone, a keton, was demonstrated to cause acute and delayed types of insecticidal and ovicidal activities against the mosquito, *Culex quinquefasciatus* Say, under laboratory conditions. At 0.05–10 ppm, acetophenone induced cumulative (larvicidal+pupicidal+adulticidal) mortality in a concentration-activity manner. Delayed activity of acetophenone was detected in the F₁ progeny showing lower fecundity and significant larval mortality. Morphological aberrations were evident in the larvae, pupae and adults, *i.e.*, larval shortening, larval-pupal intermediates and incomplete emergence of adults at 0.05–10 ppm. Acetophenone also caused significant ovicidal activity at concentrations of 0.1–10 ppm.

Introduction

Acetophenone, a keton, was found an important component of the pheromone system of the web-spinning larch sawfly *Cephalcia lariciphila* Wachtl and the beech bark beetle, *Taphrorychus bicolor* Herbst (Barker *et al.*, 1983; Kohnle *et al.*, 1987).

Acetophenone and its derivatives were also isolated from parts of many plant species (Gonzalez *et al.*, 1983; Buttery *et al.*, 1984; Junior, 1984; Aldesanmi *et al.*, 1986; Urones *et al.*, 1987; Yoshizaki *et al.*, 1987). Borthakur *et al.* (1986) reported that some new phosphorodithioate esters of substituted acetophenones showed insecticidal activity at 2,000–10,000 ppm against *Drosophila melanogaster* Meigen.

The search for new compounds, such as natural products and their analogues, for the control of insect pests and vectors of diseases continues due to the problems associated with the wide use of conventional chemical insecticides, *i.e.*, development of resistance and environmental pollution.

This paper presents data on the insecticidal effects of acetophenone against the pestiferous urban mosquito, *Culex quinquefasciatus* Say.

Materials and methods

The insecticidal effects of acetophenone against *Cx. quinquefasciatus* were studied by treating late 3rd instar larvae of a laboratory colony (reared from field-collected egg rafts at 28±1°C for >30 generations in the laboratory). Acetophenone (purity 99%) was obtained from British Drug House, England. Twenty larvae were placed in 150 ml glass beakers containing 100 ml of distilled water. Acetophenone, dissolved in 0.1 ml acetone, was suspended in the beakers at 0.05–10 ppm. The treatments were replicated four times. Each treatment was run with one control containing 0.1 ml of acetone. Rabbit chow was added as larval food source. The number of dead larvae, dead pupae and dead adults were counted daily. The emerged adults were introduced into 25×25×25 cm cages and the females were fed on pigeon blood. The males and females were supplied with 10% sugar solution. Number of the deposited eggs, egg hatchability and mortality in each developmental stage were determined for the F₁ progeny. Larvae and pupae of the F₁ progeny were reared in 400 ml beakers containing 200 ml of water and were supplied with rabbit chow as food source.

Ovicidal activity of acetophenone was studied by introducing 20 pigeon blood-fed females and excessive number of males into 25×25×25 cm cages. In these cages, 400 ml beakers containing 200 ml of water were placed and then treated with 0 (control), 0.1, 1 and 10 ppm of acetophenone. The males and females were supplied with 10% sugar solution. This experiment was replicated three times. The number of deposited eggs and egg hatchability were determined daily until no eggs were deposited.

Larvae and adults were reared in a glass-door cooled incubator adjusted at 28±1°C. The day-night regime was that of January–April 1989. Statistical analysis followed Zar (1974).

Results

Insecticidal effects. Various types of insecticidal effects were observed in *Cx. quinquefasciatus*.

Table 1 Insecticidal effect of acetophenone in developmental stages of *Cx. quinquefasciatus*.

Concentration (ppm)	Larval mortality (%)	Cumulative mortality* (%)
0	5.2±2.5**	5.6±2.3**
0.05	32.7±7.9	49.6±8.6
0.1	47.2±2.0	64.4±2.7
0.5	56.5±2.8	66.0±4.4
1.0	67.1±3.7	79.5±6.0
5.0	76.0±1.8	85.3±2.1
10.0	82.5±5.9	92.5±1.2

* Mortality of larvae+pupae+adults.

** Mean±standard error of the mean.

quefasciatus after treatment of late 3rd instar larvae with acetophenone. Death occurred in the larvae, pupae and adults at 0.05–10 ppm. The larval mortality progressed with concentration reaching 82.5% at 10 ppm (Table 1). Larval mortality was significantly dependent on concentration (r 0.82 at $p<0.05$, $Y=-7.1575+0.17X$). The larval LC_{50} was 7.94 ppm. Regression analysis revealed that the LC_{90} for cumulative mortality was 6.41 ppm (r 0.81 at $p<0.05$, $Y=-11.8188+0.2026X$).

Acetophenone also demonstrated delayed insecticidal effects against the F_1 progeny of survived mosquitoes which were treated at the late 3rd larval instar. The delayed effects involved increase in preovipositional period, lower number of egg rafts per female and significant increase in the larval mortality of the F_1 progeny (Table 2). The LC_{90} for larval mortality (F_1 progeny) was 1.36 ppm (r 0.87 at $p<0.05$, $Y=-1.7697+0.0348X$). Cumulative mortality in the F_1 progeny was also significantly dependent on concentration (r 0.94 at $p<0.05$, $Y=-4.3363+0.066X$) with LC_{90} of 1.60 ppm.

Morphological aberrations. Acetophenone induced morphological aberrations in the larvae, pupae and adults when treated at the late 3rd larval instar. The larval aberrations involved shortening of newly-molted 4th instar larvae accompanied with pale coloration of the integument which was followed by death. These larvae were equal to approximately 0.5–0.7 the size of normal larvae. This type of aberration was observed in larvae treated with 0.05–10 ppm of aceto-

Table 2 Delayed effects of acetophenone in the F_1 progeny of *Cx. quinquefasciatus*.

Concentration (ppm)	No. females tested*	No. females fed on blood	Preoviposition period (days)	Rafts/female	Eggs/raft	Hatchability (%)	Mortality (%)	
							Larval	Cumulative**
0	15	7	3.6	0.70	103	99.2	20.2	23.3
0.05	12	8	6.5	0.50	103	88.1	48.0	64.4
0.1	10	7	4.0	0.28	107	92.6	62.2	70.1
0.5	8	6	9.0	0.17	111	90.1	66.0	74.1
1.0	6	4	9.0	0.25	113	98.4	74.2	79.2

* Survived females. ** Mortality of larvae+pupae+adults.

phenone. Some of the dead 4th instar larvae (at 0.05–0.1 ppm) were incapable of completing the molting process, although they showed obvious dorsal splitting. A few of the dead larvae (at 0.1–5 ppm) showed larval-pupal intermediate characters similar to those induced by insect growth regulators (IGRs) such as diflubenzuron (Mohsen *et al.*, 1986) and cyromazine (Awad and Mulla, 1984; Mohsen and Al-Chalabi, 1988). Dark pigments on the thorax of some larvae were also observed at 0.1 ppm. Death in the pupae occurred at the late pupal stage which showed well-developed dark appendages. The majority of dead adults were incapable of completing successful emergence. Morphological aberrations in the progeny were observed only in the adult stage, *i.e.*, incomplete emergence.

Ovicidal activity. Acetophenone induced ovicidal activity in the eggs which were deposited in treated water (Table 3). The ovicidal activity was concentration-dependent as indicated by the significant decrease in hatchability ($r = -0.99$ at $p < 0.01$, $Y = -0.2601X + 20.9132$). The highest number of egg rafts were deposited on water treated with 1 ppm of acetophenone (Table 3).

Discussion

The results of the present study revealed that acetophenone may induce acute and delayed types of insecticidal and ovicidal effects against *Cx. quinquefasciatus* including IGR types of morphological aberrations. These insecticidal effects have been also reported for natural and synthetic products against the same mosquito species such as diflubenzuron (Mohsen *et al.*, 1986), cyromazine (Awad and Mulla, 1984; Mohsen and Al-Chalabi, 1988) and precocene-I (Mohsen *et al.*, 1988). The actual LC_{90} for both larval and cumulative mortalities was higher than the LC_{90} s for delayed mortality of the F_1 progeny. It is expected that smaller amounts of acetophenone were sufficient to induce mortality in the various developmental stages of the F_1 progeny due to build up of the insecticidal effect at longer period of time.

The findings of the present study merit further research on acetophenone in regard

Table 3 Ovicidal effect of acetophenone in *Cx. quinquefasciatus*.

Concentration (ppm)	Total No. of eggs	Hatching (%)
0	473 (7)*	95.7±3.1**
0.1	367 (6)	82.5±13.5
1.0	1,105 (16)	73.3±8.1
10.0	502 (6)	42.7±18.2

* Number of egg rafts. ** Mean±standard error of the mean.

to its mode of action, nontarget effects and efficiency under field conditions.

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