The effects of different dosages of the insecticide mixtures endosulfan/alphamethrin on adults of the biological control agent *Cyrtobagous salviniae* (Coleoptera: Curculionidae) against *Salvinia molesta*

C.H.G. SCHLETTWEIN AND J.H. GILIOMEE

Department of Water Affairs, Private Bag 13193, Windhoek, Namibia

Department of Entomology, University of Stellenbosch, Stellenbosch, 7600, Republic of South Africa

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ABSTRACT

The effects of the insecticide used for the control of *Glossina morsitans* (tsetse fly) on the weevil *Cyrtobagous salviniae* Calder & Sands were investigated. The latter is currently used as a biological control agent against the aquatic weed *Salvinia molesta* Mitchell. The survival of *C. salviniae* was measured after the application of an insecticide mixture of endosulfan and alphamethrin at different dosages. The results show that the adult weevil is susceptible to the chemicals, even at low dosages (6 g/ha endosulfan). The results also indicate that the immature stages are minimally affected at dosages of 6 and 12 g/ha, but are killed at 18 g/ha dosage. The weevil populations treated with 6 and 12 g/ha dosages recovered remarkably after three weeks, but those treated with a 18 g/ha dosages failed to fully recover during the time span of the experiment. In order to give the weevil the best chance of survival it is recommended that sprays against tsetse flies only be applied when the water temperatures are above 21° C and that the intervals of repeated applications be 21 days or more.

INTRODUCTION

In an effort to eradicate the tsetse fly *Glossina morsitans* from Botswana, the Botswana Government launched an aerial spraying operation along its northwestern border with Namibia during 1987. This followed its success in eradicating *G. morsitans* from large parts of the Okavango Delta by spraying an insecticide mixture (Davies & Bowles 1979). The unsprayed tsetse fly population on the northwestern border with Namibia subsequently posed a threat of reinfesting areas within the Okavango Delta where eradication had been achieved.

The Botswana authorities considered including the Kwando River belt and parts of the Linyandi marsh in Namibia in their aerial spraying operation. In the above mentioned areas the Directorate of Veterinary Services of Namibia applies conservative knapsack ground spraying methods on a regular basis. These successfully control the tsetse fly, but fail to eradicate the insect. The aerial spraying operation therefore offered an opportunity to both countries to solve their tsetse fly problem on a more permanent basis. Such a spraying operation, which aims at eradication, would consist of up to six applications at intervals of 16 - 21 days (Davies & Bowls 1979). Both countries involved are aware of the possible detrimental effects such an operation could have on the biological control programme against *Salvinia molesta* in the region. This plant is listed as "the worst weed in the world" by the 1985 Guinness World Book of Records. It is an aquatic fern which causes problems in many tropical and subtropical waters (Mitchell & Tur 1975; Edwards & Thomas 1977; Holm *et al.* 1977). The plant was first noticed in the Eastern Caprivi in 1948 and since then several efforts by Botswana, South Africa and Namibia were made to control the weed (Mitchell 1967; Edwards & Thomas 1977). The breakthrough only came in 1984 when an imported weevil *Cyrtobagous salviniae)* proved successful in controlling the weed (Hines *et al.* 1985; Schlettwein 1985; Giliomee 1986). Should the insecticides used against the tsetse fly also kill the weevil, it is most likely that the weed would quickly expand to its previous levels.

MATERIALS AND METHODS

The experiment was conducted under laboratory conditions with known weevil population densities since the population densities of the weevil are rather variable in the field (Room *et al.* 1984; Forno 1987). The experiment was conducted in the grounds of Mpacha Airport in the Eastern Caprivi Zipfel during the period 23 - 31 March 1987.

Fourteen days prior to spraying, four experimental weevil populations were established in four ponds (Porta Pools: 3.05 m diameter and 0,76 m deep). Each of these pools contained a loose *S. molesta* mat (100% cover) stocked with 1000 adult *C. salviniae.*

The insecticide mixture used consisted of the cyclodien compound endosulfan and the pyrethroid alphamethrin. Endosulfan is the active ingredient which kills the flies whereas alphamethrin acts as an irritant to mobilize them (Bowles, J. pers. comm. 1987). Both insecticides may have insecticidal effects on *C. salviniae* (Forno, I. W. pers. comm. 1989). The

compounds were dissolved in a petro - chemical solvent and applied at a dosage of 6 g/ha endosulfan and 0,1 g/ha alphamethrin (active ingredient). The same insecticides are used at similar dosages to control *G. morsitans* in the field. One pond (hereafter called the control) was not treated, while the remaining three ponds received one, two and three applications, respectively. Multiple sprays were applied to achieve the different dosages which might be used during the field applications. The sprays were applied from a light fixed-wing aircraft in order to simulate conditions during the actual spraying operation. All the sprays were applied at sunset at intervals of 10 min. No repetitions were possible due to the scarcity of plant and insect material.

Weevil populations were sampled by extracting them in Berlese Funnels (Boland & Room 1981). Only those insects that lived for more than 12 h after emerging from the Berlese Funnels were considered to have survived the treatment. Samples were taken daily for four days prior to spraying and further samples were collected 1 h, 12 h and 24 h after spraying. Thereafter, the populations were sampled daily for a month.

A water sample was taken from each pond 1 h after spraying in order to determine the amount of insecticide in the water. This was done to determine the possible influence of the poison on larvae and pupae which live on submerged parts of the plant.

Population densities of *C. salviniae* per unit surface area were determined for each sample. The assumption that the four populations were similar prior to spraying was tested by means of an analysis of variance (Snedecor & Cochran 1976). After spraying, survival rates of the adult insects were recorded and the four populations compared.

To determine the influence of the insecticide over time, the results were grouped as follows: The results of the week prior to spraying, and the results of week one, week two, weeks three and four, and weeks five and six after spraying respectively.

The determination of endosulfan and alphamethrin in the water was done by the South African Bureau of Standards. The determination was carried out in duplicate employing gas chromatography. Known amounts of alpha-endosulfan, beta-endosulfan, endosulfan sulphate and alphamethrin were added to proportions of the untreated control sample and analysed concurrently with the other samples to check the analytical techniques. The lowest limit of detection was 0,05 μg/l for all compounds.

RESULTS

Insect densities

Prior to spraying, densities of adult *C. salviniae* ranged between 16 and 22,75 per 0,20 m² and did not differ significantly from each other between ponds ($F = 0{,}879$; $P > 0{,}25$).

During the first two weeks after spraying, densities of adult insects dropped drastically in all of the treated ponds (Figure 1). However, during weeks three and four the weevil populations of pond 2 and 3 recovered to reach mean densities higher than that of the control population. This rise in the adult population density was probably due to emergence from a high pupal population which was not affected by the endosulfan applied at 6 g/ha and 12 g/ha. The weevils in pond 4 which recieved 18 g/ha recovered to only a moderate extent (Figure 1). Here the juvenile stages were probably adversely affected by the higher dosage of insecticide applied and consequently few new adults emerged. Another possibility is that insecticide residue levels were still lethal for newly emerged imagos.

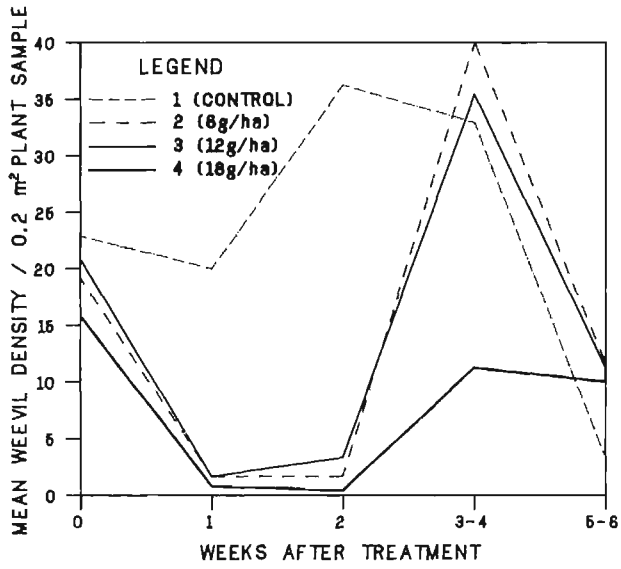

FIGURE 1: Mean population densities of adult *C. salviniae* treated with different dosages of an endosulfan / alphametrin mixture.

During weeks five to six of the experiment, the plants in ponds one, two and three showed signs of stress. This was probably due to the high weevil population densities during week 3-4 which started to control the weed. This deterioration of the weevils' only food source caused a notable decrease in their population density. Population densities in pond 4 (18 g/ha) during weeks five and six were similar to those during weeks three and four indicating that it had still not recovered completely from the spray treatment (Figure 1).

Water analysis

The residue levels for endosulfan and alphamethrin in the three treated ponds were in proportion to the dosages applied, but were nevertheless rather low. This is probably due to the fact that most of the chemical stayed on the plant mat and did not enter the water (Table 1).

DISCUSSION

The low numbers of live weevils one week after spraying clearly shows that these insects are highly suscept-

TABLE 1: Determinations of endosulfan and alphamethrin residues in water samples collected 1 h after spraying from ponds 2, 3 and 4.

		Residue content in µg/l			
Pond No.	Sampling date	Alpha-endosulfan	Beta-endosulfan	Endosulfan Sulphate	Alpha-methrin
2	26-March-87	0.34	0.30	<0.05	<0.05
3	26-March-87	0.38	0.30	<0.05	<0.05
4	26-March-87	0.61	0.55	<0.05	<0.05

Pond 1 was not treated and no residues of either endosulfan or alphamethrin were detected.

ible to these insecticides even when they are used at very low concentrations (6 g/ha). The effects of the various dosages on survival were not markedly different; a low dosage of 6 g/ha had a similar mortality effect to 18 g/ha.

However, the results also indicate that the weevil population can recover from single applications, even of relatively high dosages. This phenomenon can most probably be attributed to the position of the feeding instars of the juvenile stages. Forno *et al.* (1983) found that the eggs are deposited in unopened buds and that newly emerging larvae often feed inside the leaf bud. After 3 - 14 days they enter the base of the leaf bud and tunnel inside the rhizome or petioles where they complete their larval development (Forno *et al.* 1983; Sands & Schotz 1984). It would seem therefore that eggs and larvae were well protected against contact with the insecticide. The pupae are within a cocoon beneath the water surface and therefore similarly well protected during their development which takes between six and 12 days (Forno *et al.* 1983).

The adult weevils, however, are exposed and it is therefore not surprising that they are most susceptible to the chemicals. Since the eradication of *G. morsitans* requires repeated applications (up to six times) at 16 - 21 day intervals (Davies & Bowles 1979) only the adults that emerge during the first four days after spraying will be able to start ovipositing before being killed. After emerging as adults there is a preoviposition period of 6 - 14 days (Forno *et al.* 1983). Furthermore it should be noted that oviposition ceases at 21°C and that eggs fail to hatch at or below 19°C (Forno *et al.* 1983). Aerial sprays agains *G. morsitans* are applied during winter to keep the insecticide droplets suspended in the air for maximum periods (Bowles 1987 pers. comm.). During this period (June to August) surface water temperatures of the Zambesi River at Katima Mulilo ranged from 15,7°C to 18,8°C indicating that sprays applied during this time would kill the adult *C. salviniae* before oviposition.

Judging from the above information it appears that in the Eastern Caprivi Zipfel *C. salviniae* would survive aerial sprays against *G. morsitans* best if these sprays are applied during periods when surface water temperatures are above 21°C, i.e. from September, and when the intervals of repeated applications are kept long (21 days or more). This strategy would prevent the biological control agent of *S. molesta* from being eradicated by the chemical control of *G. morsitans.*

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