THE RESPONSES OF GERMAN WASPS, *VESPULA GERMANICA*, TO INGESTION OF THE MICROBIAL TOXIN, AVERMECTIN B1

J.J. DYMOCK, S.A. FORGIE and P.J. WIGLEY

DSIR Plant Protection, Mt Albert, Auckland

SUMMARY

Adults from two wild German wasp (*Vespula germanica* F.) nests in suburban Auckland were treated in late summer 1991 with the microbial toxin, avermectin B1. The toxin was dispensed in a honey solution at 1, 10 and 100 µg/g from containers placed at the nest entrances. It was not consumed at 100 µg/g. Within 3 days of administering 10 µg/g avermectin to both nests, the number of worker wasps entering and leaving nests was reduced by 54% and several hundred dead and paralytic wasps were found at the nest entrances.

Keywords: German wasps, *Vespula germanica* F., microbial toxin, avermectin B1

INTRODUCTION

Avermectins are macrocyclic lactones, produced by the actinomycete, *Streptomyces avermitilis*, which were originally isolated as anthelmintic agents. They are also highly active against insect species in several orders, phytophagous mites and the plant parasitic nematode, *Meloidogyne* sp. (Putter *et al* 1981). Avermectin B1 acts by blocking the neuro-transmitter, gamma aminobutyric acid (GABA) (Campbell *et al* 1983). In many invertebrates GABA-mediated nerves regulate the peripheral muscles and ingestion of avermectins results in paralysis of the limbs. However, the avermectin family of compounds do not readily penetrate the central nervous system of mammals where GABA also functions as a neurotransmitter. They are now commonly in commercial use for the treatment of parasites in cattle, horses, pigs and sheep (Campbell *et al* 1983). Studies have shown that avermectins eliminated in the faeces of treated stock have an insecticidal effect on the larvae of economically important dung breeding Diptera and beetles (Wall and Strong 1987).

Avermectin B1 displays a slow toxic action in insects relative to conventional organophosphates and pyrethroids. Putter *et al* (1981) noted that insects in contact with foliar residues of avermectin B1 died approximately 4 days after initial exposure. Exposure of lepidopterous larvae to avermectin B1 rapidly produced paralysis in the pseudopodia. As a result of this, feeding inhibition was observed at dose levels considerably lower than those which produce direct insect mortality.

Studies in the USA have demonstrated the adverse effects of avermectin B1 on vespid wasps. In the USA, Parrish and Roberts (1984) noted that avermectin B1 produced both acute (within 24 h) and chronic (after 6 days exposure) mortality of fifth instar *Vespula maculifrons* (Buysson). Larvae were force-fed avermectin B1 mixed with strained baby food using a hypodermic needle. An acute LC₅₀ of 38.4 µg/g and chronic LC₅₀ of 2.99 µg/g avermectin was recorded. Pupation was also completely inhibited when larvae were fed 10 µg/g avermectin. Concentrations of 0.01 and 0.1 µg/g avermectin had no adverse effect on mature fifth instar larvae. In Hawaii, tuna catfood baits with 100 µg/g avermectin B1 depressed forager populations of the western yellowjacket, *Vespula pensylvanica* (Saussure), by 67% after 7 weeks (Chang 1988). The acceptance level of avermectin was inversely related to the concentration. The yellowjackets did not take any bait at 200 µg/g, 15% at 100 µg/g and 93% at 10 µg/g. The number of foragers increased immediately the bait was removed but forager populations were significantly reduced in the following year in treated areas.

Proc. 44th N.Z. Weed and Pest Control Conf. 1991: 38-41

In New Zealand, poisoning of vespid wasps with 1% sodium monofluoroacetate (compound 1080) has proven effective but there have been problems with reinvasion and the high mammalian toxicity of this poison (Spurr 1990). Ideally a poison bait for wasps should kill developing larvae and the queen(s) but need not affect foragers immediately. The latter should still be able to bring bait to the nest. We report the effect of an avermectin-based microbial toxin on two German wasp (*Vespula germanica* F.) nests in suburban Auckland, and discuss its potential usefulness in controlling wasp populations.

METHODS

Two naturally established German wasp nests in a concrete/scoria retaining wall on the Mt Albert DSIR campus were observed throughout March and April 1991. The nests were 4 m apart at the same height above the ground and faced north. Wasp activity was measured by taking 10 one-minute counts of workers entering and leaving the nests; these were always taken at 11 am to eliminate any effect of diurnal variation in activity.

Initially, on 27 March, two bait stations containing a blend of jam and fish catfood were established, c.100 m from the nest entrances, but no bait was consumed. On 3 April 100 g of blended fish catfood containing 10 µg/g avermectin B1 (AVID 1.8 EC) was directly inserted into the entrance of Nest 1. This was repeated again on 4 April using 200 g of bait. Corresponding amounts of avermectin-free bait were inserted into Nest 2. Because of the difficulty of measuring the amount of bait consumed by wasps using this method, the entrance of each nest was modified so that avermectin could be accurately dispensed in a honey solution. The nest entrances were extended by attaching open-ended clear plastic cages so that workers could still move freely in and out. Honey solution (100 ml) was dispensed from inverted containers slotted into the top of the cages. From 8 April wasps from Nest 1 were supplied with avermectin B1 at concentrations of 1, 10 and 100 µg/g in a honey solution (95 ml honey and avermectin in 5 ml water) while the wasps from Nest 2 were fed a control solution (95 ml honey and 5 ml water) (Table 1).

Wasps from both nests were fed 10 µg/g avermectin B1 from 19 April onwards. The number of dead wasps and larvae found at the entrance of the nests was recorded. Nest 1 was excavated on 1 May and Nest 2 on 3 May.

RESULTS AND DISCUSSION

By 8 April Nest 1, which had been exposed to 10 µg/g avermectin B1 in catfood bait over a 2 day period, was less active than the untreated Nest 2 and consumed only 41% as much honey over a 24 h test period (Table 1). However Table 1 shows that avermectin B1 up to levels of 10 µg/g did not deter feeding in Nest 1 compared to that of Nest 2. Conversely, at a concentration of 100 µg/g, no avermectin B1 was consumed by wasps (Table 1). It is possible that they were deterred by the odour of the solvents, emulsifiers and coagulants which were present in the avermectin solution or were able to detect the avermectin B1 directly.

TABLE 1: Amount of honey with various concentrations of avermectin B1 consumed over 24 h by German wasps from Nest 1 and as a percentage of the amount of untreated honey consumed by Nest 2.

Concentration avermectin (µg/g)	Consumption Nest 1 (ml)	Consumption by Nest 1 as a % of Nest 2
0	39	41
1	43	45
10	50	53
10	53	56
100	0	0

The mean traffic rate from Nest 1 during the initial experiments dropped from 43 wasps per minute to 20 during the time that avermectin B1 was administered, while the traffic rate from Nest 2 remained constant at 48 wasps per minute. When 10 $\mu\text{g/g}$ avermectin was administered to both nests from 19 April onwards traffic rates were reduced by 56% and 52% after 3 days for Nests 1 and 2 respectively (Fig. 1). At this time paralysed wasps were found at the nest entrances which showed erratic leg movements and were unable to walk or fly. Larvae were first discarded at the entrance of Nest 2 3 days after treatment with avermectin B1 began.

By April 25 the traffic rate at Nest 1 and 2 had declined further to only 14% and 39% respectively of that prior to the addition of avermectin B1 (Fig. 1). In total 483 workers, 36 drones and three queens were found dead at the nest entrance and among surrounding foliage near Nest 1 and 349 workers, 15 drones and two queens at the entrance of Nest 2. Within 10 days of treatment a total of 152 dead larvae had been collected at the entrance to Nest 2. There were no unusual deaths of larvae, pupae or developing queens in either of the nests on excavation.

Fig. 1: Wasp traffic rate and amount of 10 $\mu\text{g/g}$ avermectin B1 consumed by German wasps in Nests 1 and 2.

Results of this work show that avermectin B1 at 10 µg/g has a paralytic effect on German wasp workers, drones and emerging queens after 3-10 days exposure to the toxin. The only effect of avermectin on immature wasps was evidenced by the larvae discarded from Nest 2. Avermectin B1 did not have an immediate effect on worker activity. This may be an advantage, however, because adult foragers could continue to bring bait to the nest.

If foraging wasps could be induced to feed on protein bait containing avermectin B1, the danger to honey bees would be reduced. As a toxin with no mammalian toxicity which causes paralysis of adult wasps, avermectin B1 may prove to be a viable alternative to compound 1080 and should be tested against the common wasp, *Vespula vulgaris* (L.). Large-scale appraisal of its potential in areas with high wasp densities may be advisable.

ACKNOWLEDGEMENTS

We would like to thank Dr David Greenwood for advice on bait preparation.

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