# Effects of Pesticides and Fungicides Used on Grapevines on the Mealybug Predatory Beetle *Nephus 'boschianus'* (Coccinellidae, Scymnini)

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**The effects of frequently used grapevine insecticides and fungicides on adults of the predatory beetle *Nephus 'boschianus'* of vine mealybug, *Planococcus ficus* (Signoret), were determined under laboratory conditions. When applied as cover sprays the pesticides chlorpyrifos, endosulfan, cypermethrin, chlorfenapyr and mercaptothion were very toxic to the predator, whilst the fungicides penconazole, fosetyl-Al, mancozeb and an insecticidal soap plus oil mixture were harmless. These results suggest that the insecticides may be harmful to a biological control system where *N. 'boschianus'* populations were dominant during the season. The three fungicides and the soap plus oil mixture, however, should be compatible with biological control by *N. 'boschianus'*.**

Integrated grape production in South Africa currently mainly includes pesticides for the control of key pests such as vine mealybug, *Planococcus ficus* (Signoret), the weevils *Phlyctinus callosus* (Schönherr) and *Eremnus cerealis* (Marshall), and the fruit flies, *Ceratitis rosa* (Karsch) and *C. capitata* (Wiedemann). Additionally, preventative spray programmes against the fungal diseases, i.e. powdery mildew, *Uncinula necator* (Schwein) Burrill, downy mildew, *Plasmopara viticola* (Berk & Curt) Berlese & De Toni, *Botrytis cinerea* Pers.: Fr. and *Phytophthora cinnamomi* Rands are also applied in commercial vineyards. With increased focus on integrated pest management (IPM), organic production and more stringent export requirements regarding insecticide residues on fruit, the use of natural enemies will become more essential. This is particularly applicable in the case of *P. ficus,* as this insect can successfully be suppressed by biological control (Myburgh *et al.*, 1973). The effect of natural ene-

TABLE 1

Pesticides[1] and fungicides[2] screened for detrimental effects on the mealybug predatory beetle *Nephus 'boschianus'*. Formulations, field concentrations, pests/diseases targeted and range of concentrations tested are included.

| Chemical tested (Trade name) | Formulations | Field concentration | Pest/disease targeted | Range of concentrations tested: mL/100L, g/100L |
|---|---|---|---|---|
| chlorpyrifos[1] (Chlorpyrifos) | EC, 480g/L | 100mL/100L<br>200mL/100L<br>400mL/100L | *Planococcus ficus* (mealybug)<br>*Formicidae* (ants) | 800; 400; 200; 100; 50; 20; 10; 5; 2.5; 1; 0.2; 0.04; 0.008 |
| endosulfan[1] (Endosulfan) | SC, 475g/L | 125mL/100L | *Colomerus vitus* (erinose mite) | 125; 62.5; 31.25; 15.62; 7.81 |
| cypermethrin[1] (Cypermethrin) | EC, 200g/L | 10mL/100L | *Phlyctinus callosus, Eremnus cerialis* (weevils) | 200; 100; 50; 25; 12.5; 6.25; 3.13; 1.56; 0.78; 0.39 |
| chlorfenapyr[1] (Hunter) | SC, 360g/L | 35mL/100L | *Frankliniella occidentalis* (thrips) | 132.89; 88.59; 59.06; 39.38; 35; 26.25; 17.5; 8.75; 4.38; 2.19 |
| mercaptothion[1] (Malasol) | EC, 500g/L | 175mL+8kg sugar or protein hydrolysate/100L | *Ceratitus rosa, C. capitata* (fruit flies) | 393.75; 262.5; 175; 116.67; 77.78; 51.85; 34.85; 23.04; 15.36; 10.24; 6.83; 4.55; 3.35; 3.03; 2.33; 2.02; 1.94; 1.62; 1.35 |
| soap plus oil[1] (Super insecticidal soap + Spraytech oil) | 10mL/2mL | 200g/100L | *Planococcus ficus* (mealybug) | 1280; 640; 320; 160; 80; 40; 20; 10; 5 |
| mancozeb[2] (Mancozeb) | WP, 800g/kg | 200g/100L | *Plasmopara viticola* (downy mildew) | 3200; 1600; 800; 400; 200 |
| penconazole[2] (Topaz) | EC, 100g/kg | 30-45mL/100L | *Uncinula necator* (powdery mildew) | 23040; 11520; 5750; 2880; 1440; 700; 360; 180; 90; 45 |

mies such as the previously undescribed *Nephus 'boschianus'* (Whitehead pers. com, 2000) can be optimised by using chemicals that have little or no effect on them. The effect of six insecticides and three fungicides was therefore evaluated to identify those suitable for use in an IPM programme.

## MATERIALS AND METHODS

*Nephus 'boschianus'* was reared on *P. ficus* cultures under controlled conditions. A range of concentrations (some of which 'range finder' concentrations) of commercial formulations of nine chemicals was used (Table1).

Assays with each chemical included a control of distilled water. The bioassays were conducted in Munger cells as described by Hassan (1992). The pesticides were sprayed onto glass plates using a standard Potter's precision spray tower. The glass plates were allowed to dry for 10 min, after which the Munger cells were assembled and 50 adult *N. 'boschianus'* introduced into the cells. All Munger cells were ventilated with air at 70 to 80 % relative humidity and kept in a cooled incubator at 24.5"±1°C. Mortality was recorded after 48 h. Data were analysed using probit analysis (Finney, 1952) and the computer programme, POLO PC (LeOra Software 1987, 1119 Shattuch Avenue, Berkeley, California 94707).

## RESULTS AND DISCUSSION

Analysis of data concluded that the slopes for all chemicals, except fosetyl-Al, were positive. This indicated that there was an increase in mortality with an increase in concentration, except in the case of fosetyl-Al (Table 2; Figs. 1, 2 & 3).

The indices of significance for potency estimation (g) for the insecticides chlorpyrifos, cypermethrin, chlorfenapyr, and the mercaptothion bait mixture were considerably less than 1 (chlorpyrifos 0.098; cypermethrin 0.14; chlorfenapyr 0.29; mercaptothion 0.06). Therefore, the estimates of the fiducial limits of the

TABLE 2

Probit regression parameters estimated from bioassay data using nine chemicals on *Nephus 'boschianus'*.

| Pesticide | Intercept (“Standard error) | Slope (“Standard error) | D.F. |
|---|---|---|---|
| chlorpyrifos | -0.5(±0.68) | 5.4(±0.66) | 12 |
| endosulfan | 2.97(±0.34) | 1.59(±0.23) | 4 |
| cypermethrin | 4.89(±0.09) | 1.08(±0.1) | 9 |
| chlorfenapyr | -0.29(±0.5) | 3.48(±0.32) | 9 |
| mercaptothion | 2.74(±0.23) | 6.86(±0.64) | 18 |
| soap plus oil | 2.12(±0.52) | 0.45(±0.21) | 8 |
| mancozeb | -61.78(±8670568)[x] | 18.38(±2473665)[x] | 4 |
| fosetyl-Al | -3.35(±9730454)[x] | 1.59-14(±3064902)[x] | 4 |
| penconazole | 2.3(±0.41) | 0.44(±0.12) | 9 |

[x]Data not reliable for determination of $LC_{50}$ and $LC_{90}$.

$LC_{50}$ (concentration at which 50% of included individuals are killed) and $LC_{90}$ values were reliable (Finney, 1952) (Table 3).

In the case of penconazole (g=2.67) and the soap plus oil mixture (g=8.4), the g values were greater than 1. Therefore, although the $LC_{50}$ and $LC_{90}$ values were estimated, estimates of the fiducial limits could not be made (Finney, 1952) and are not given. As no correlation between concentration and mortality was evident for mancozeb and fosetyl-Al, no attempts were made to estimate the $LC_{50}$ and $LC_{90}$ values for these pesticides.

The two field concentrations of chlorpyrifos and the field concentration for the mercaptothion EC bait mixture (Table 3; Fig.1) were considerably higher than the $LC_{50}$ and $LC_{90}$ for these pesticides, making them the most toxic of those tested on *N. 'boschianus'*.

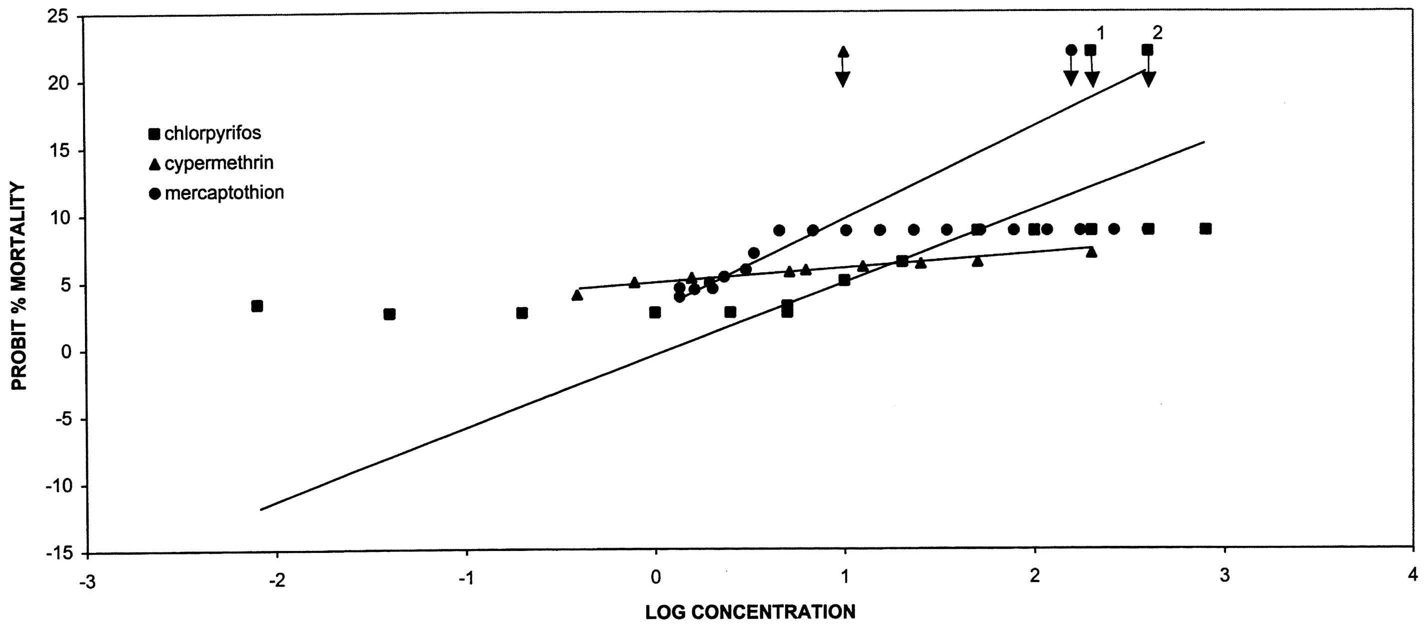


FIGURE 1

Probit mortality on log concentration for the insecticides chlorpyrifos, cypermethrin and mercaptothion. The field concentrations are indicated with arrows (■[1] for mealybugs, and ■[2] for ants).

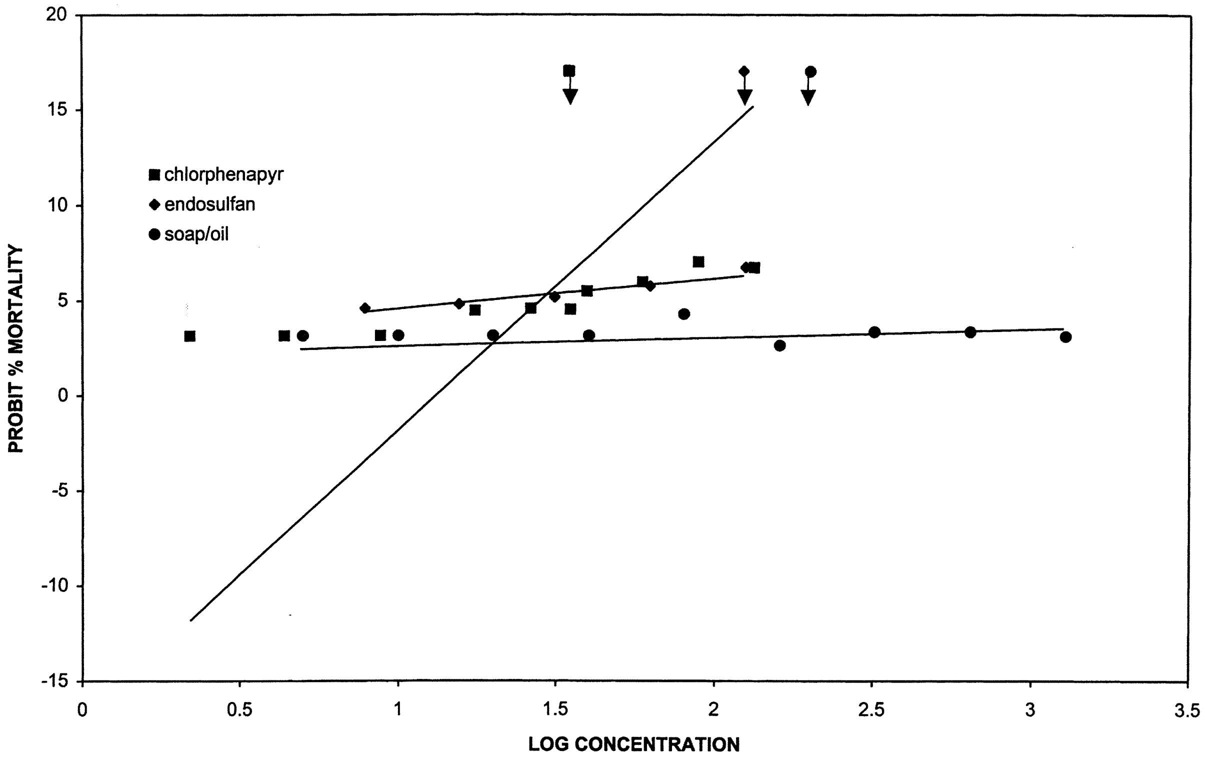


FIGURE 2

Probit mortality on log concentration for the insecticides chlorfenapyr, endosulfan and the soap plus oil mixture. The field concentrations are indicated with arrows.

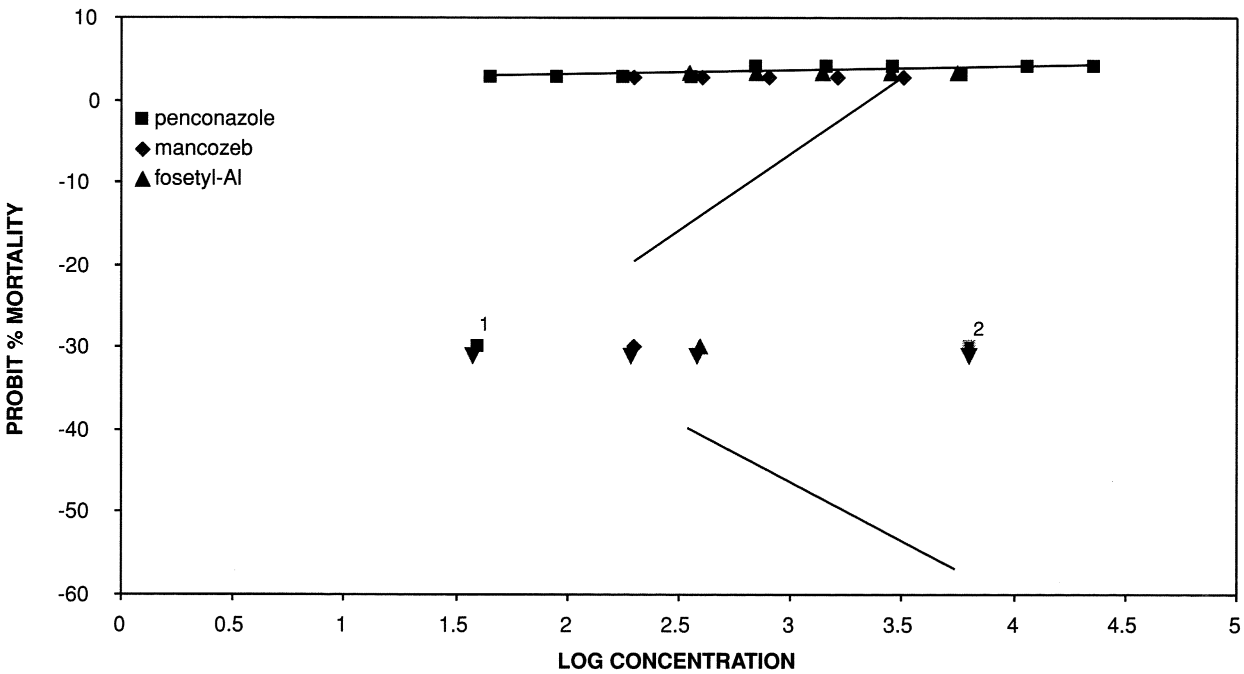


FIGURE 3

Probit mortality on log concentration for the fungicides penconazole and fosetyl-Al. The field concentrations are indicated with arrows (■[1] for 30mL/100L, ■[2] for 45 mL/100L).

TABLE 3
Field concentrations, $LC_{50}$, and $LC_{90}$ of the pesticides tested on *Nephus 'boschianus'* the mealybug predatory beetle.

| Chemical | Field dose mL/100L | $LC_{50}$ (mL/100L) | 95% Fiducial limits | $LC_{90}$ (mL/100L) | 95% Fiducial limits |
|---|---|---|---|---|---|
| chlorpyrifos | 400 (ants)<br>100-200 (mealybug) | 10.48 | 9.3 – 11.8 | 18.1 | 15.9 – 21.6 |
| endosulfan | 125 | 18.67 | 11.4 – 26.7 | 118.61 | 70.5 – 345.4 |
| cypermethrin | 10 | 1.26 | 0.7 – 2 | 19.54 | 11.7 – 41.4 |
| chlorfenapyr | 35 | 33 | 27.2 – 39.4 | 76.97 | 60.8 – 113.3 |
| mercaptothion | 175 | 2.14 | 2 – 2.2 | 3.28 | 3.1 – 3.6 |
| soap plus oil | 20mL + 2mL | 0.22 + 7 | – | 0.15 + 10 | – |
| mancozeb | 200 | – | – | – | – |
| fosetyl-Al | 350g | – | – | – | – |
| penconazole | 30 – 45 | 0.16 + 7 | – | 0.14 + 10 | – |

Chlorpyrifos is a broad spectrum, relatively persistent insecticide. Its effect can be countered if applied as a spot and stem barrier treatment against ants (Ueckermann, 1998). In this way it will reduce its effect on the predator. Additionally, the high numbers of *N. 'boschianus'* present in early summer (October to December) will not be affected if chlorpyrifos cover sprays are applied prior to budding (July to August) as recommended for *P. ficus* control.

The mercaptothion bait mixture was more toxic to *N. 'boschianus'* than chlorpyrifos (Table 3; Fig.1). The current practice of fruit-fly bait sprays during the season is thought to cause minimal harm to beneficial organisms. *N. 'boschianus'* beetles, however, consume any moisture available on vines, especially during the hot summer months (Whitehead, pers. com., 2000). This need could, however, result in these beetles being attracted to this mixture to its detriment.

The field concentrations at which endosulfan and chlorfenapyr are used were just above the $LC_{90}$ values (Table 3; Fig. 2). These concentrations were therefore not as detrimental as chlorpyrifos to *N. 'boschianus'*. Both chemicals, however, have a broad spectrum of activity, suggesting that their use in insect pest management systems should be kept to a minimum. A full cover application of endosulfan during summer against erinose mite, and of chlorfenapyr early in the season against Western flower thrips (Nel *et al.,* 1999), will therefore probably influence *N. 'boschianus'* populations negatively.

Cypermethrin was slightly less toxic to *N. 'boschianus'* than chlorpyrifos, with the field concentration higher than the $LC_{50}$, but lower than the $LC_{90}$ (Table 3; Fig. 1). Cypermethrin is registered for use on weevils throughout the season (Nel *et al.,* 1999). Full cover applications of cypermethrin during the season will probably also be detrimental to *N. 'boschianus'* populations.

The soap plus oil mixture, an organic pesticide to be registered shortly, had no impact on *N. 'boschianus'*. Both the $LC_{50}$ and $LC_{90}$ values were much higher than the proposed field dose (Table 3; Fig. 2). This pesticide could contribute to integrated pest management in vineyards should field data prove efficacy against vine mealybug.

The $LC_{50}$ value of penconazole (Table 3; Fig. 3) was much higher than the field concentration (Nel *et al.,* 1999) and it should therefore not be detrimental to *N. 'boschianus'*. Mancozeb and fosetyl-Al also did not appear to be detrimental to *N. 'boschianus'*, as there was no increase in mortality of the predator with increasing concentrations of these fungicides (Fig. 3).

## CONCLUSIONS

When applied as cover sprays the insecticide chlorpyrifos and the mercaptothion bait mixture were highly toxic to *N. 'boschianus'*, whilst endosulfan, chlorfenapyr and cypermethrin were less toxic. The soap plus oil mixture had no effect on *N. 'boschianus'*, while the fungicides penconazole, fosetyl-Al and mancozeb should also not affect *N. 'boschianus'* populations. Further field confirmation of these results are needed before final conclusions can be made concerning the effect of these chemicals on *N. 'boschianus'*.

## LITERATURE CITED

Finney, D.J., 1952. Probit Analysis. A statistical treatment of the sigmoid response curve. Cambridge University Press.

Hassan, S.A., 1992. Guidelines for testing the effects of pesticides on beneficial organisms: Description of test methods. IOBC/WPRS Bulletin 1992/XV/3.

Myburgh, A.C., Whitehead, V. B. & Daiber, C. C., 1973. Pests of deciduous fruit, grapes and miscellaneous other horticultural crops in South Africa. Entomology Memoir Department of Agricultural Technical Services Republic of South Africa, No. 27.

Nel, A. K. M., Ramautar, N. & Van Zyl, K., 1999. A guide to the control of plant pests. National Department of Agriculture, Directorate Communication, Private Bag X144, Pretoria, 0001.

Ueckermann, P., 1998. Ant control in vineyards. Wynboer Tegnies 105, 8-9.

Whitehead, V.B. 2000. Personal communication.