ESTIMATING SELECTION FOR ENDOSULFAN RESISTANCE IN COFFEE BERRY BORER IN NEW CALEDONIA

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High levels (500-1000x) of endosulfan resistance in the coffee berry borer *Hypothenemus hampei* (CBB) (Coleoptera: Scolytidae) have developed in five important coffee (*Coffea canephora* var. *robusta*) producing areas on the east coast of New Caledonia (Brun *et al* 1989, 1990). Coffee is grown in New Caledonia in small (0.25 ha) plantations as a key cash crop, but infestations of CBB can reach 90-100% if not adequately controlled. Detection of endosulfan resistance occurred after 8 years of biannual applications from truck-mounted airblast sprayers, which followed 7 years of lindane use (Brun *et al* 1989).

Resistance frequency in roadside samples from affected areas depended on whether the field was a modern open plantation, or a traditional type grown under native forest canopy, and the recent history of insecticide applications (Brun *et al* 1990). An important feature of the control operation which is relatively unique is the treatment of fields from roadsides, using directional airblast sprayers. Insecticide deposition is characterised by a tendency for the majority of the droplets to be deposited within 20 m of the sprayers (Parkin *et al* 1991). This is thought to account for the higher resistance levels found near the roadsides compared to the far sides of fields (Brun *et al* 1989; Brun and Suckling 1989).

The aim of the pilot study reported here was to determine if field bioassays could be used to estimate differential mortality equivalent to the process of selection for resistance during treatment of coffee plantations by truck-mounted sprayers. It was part of ongoing work to develop resistance management practices for this cosmopolitan pest.

The plantation was at Pocreu, near La Foa on the west coast of New Caledonia. The average tree height was 2.5 m, with tree spacings of 3 x 1 m. The field was 105 m long, and the bioassay transect was conducted along rows away from the roadside on December 15, 1989.

The response of the reference susceptible strain from La Foa (LA2) to endosulfan was reported by Brun *et al* (1989). The resistant strain was field-collected from Ponérihouen (field PN402) prior to use, and comprised 64.2% resistant phenotype (resistance levels were measured by the Potter Tower direct spray method of Brun *et al* (1989), using the diagnostic dosage of 400 ppm endosulfan, the $LC_{99.95}$ of susceptibles).

Thirty healthy adult females of each strain were placed in folded filter paper packets lined with fine nylon gauze, and clamped on three sides with bull clips. Packets were attached to stakes placed in coffee interrows at two heights (1 m and 2m), at five distances from the roadside point of planned spray application (0, 5, 10, 20 and 40 m). Control packets were maintained under similar conditions nearby. A standard spray application of 0.7% v/v endosulfan (Thiodan 35 EC, Hoechst AG, Federal Republic of Germany) was made by a BSE Super IV (1987) sprayer mounted on a light truck, nominally at 150 litres/ha. A gentle breeze (0-0.7 m/s) was blowing in the direction of spray application. Conditions were partly overcast, with a shade temperature of 29 °C. Packets were removed from the field after 6 hours, and beetle mortality assessed at 10 hours post-treatment, with interim storage at 25 °C. The mode of exposure of the insects

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in this test was similar to the indirect exposure method, which has been tested at a range of temperatures, concentrations, and time intervals (Brun *et al* 1991).

Control mortality of beetles in the packets was 3% for the susceptible strain and 10% for the resistant strain. The proportions surviving treatment have been corrected by Abbott's formula (Abbott 1925) (Table 1). There was generally greater survival at 1 m, compared with the 2 m height, suggesting that droplet and vapour penetration was inhibited by the dense coffee foliage. All susceptible beetles were killed at distances up to, and including, 10 m from the roadside, while a proportion of resistant insects survived at all locations. Selection was probably continuing to operate for high resistance near the roadside. Some susceptible insects survived at 20 m from the point of insecticide treatment, and it seems likely that survival would have increased with increasing distance from the point of application. Significantly more resistant insects survived at 20 m (X^2, $P<0.05$), indicating that selection for resistance could operate on beetles outside berries at the time of treatment, even at 20 m from the point of insecticide application. Since the field-collected resistant strain contained only 64.2% resistant phenotype beetles, a larger difference would be likely with a pure resistant strain. Assuming no further mortality, the average selective value (Cook 1971) of susceptibles (fitness S/fitness R) at both heights was still only 72% that of resistant beetles at 20 m from the point of application.

The majority of beetles present in a coffee field would be inside berries at most times during the year, so assessment of mortality inside berries would more accurately estimate selection on the total population. However, the differential mortality between phenotypes and gradual decrease in mortality with distance from the point of treatment is strongly suggestive of a mechanism for the development of the clines in resistance reported by Brun and Suckling (1989) and Brun *et al* (1991). While the proportion of survivors alive after 10 hours is likely to be different from the true relative fitness of the two phenotypes, due to some subsequent additional mortality and other factors affecting beetle survival and reproduction, these data illustrate an approach which could be used to study directional selection for resistance in the field.

TABLE 1: The proportion of survivors of female coffee berry borer phenotypes (endosulfan resistant and susceptible), 10 hours after field application of endosulfan (n = 30 per point) in New Caledonia.

Strain	Test height	Distance from Roadside (m) 0	5	10	20	40
Susceptible	1 m	0	0	0	0.59	1.00
	2 m	0	0	0	0.55	0.90
Resistant	1 m	0.63	0.48	0.46	0.62	1.00
	2 m	0.15	0.20	0.22	0.96	1.00
Mean selective value (S/R)		0	0	0	0.72	0.95

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