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COMPARATIVE EVALUATION OF INSECTICIDES FOR CONTROL OF THE COFFEE LEAF MINER *Leucoptera coffeella* Guer. IN TWO CARIBBEAN ISLANDS

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ABSTRACT

Between 1985 and 1991, various insecticides were evaluated in Jamaica and Dominica for the control of the coffee leaf miner (*Leucoptera coffeella* Guer.). Carbofuran (Furadan 10G) reduced infestations at all sites but for longer periods (4-8 months) in Jamaica than in Dominica (2-4) months. The synthetic pyrethroid lambda cyhalothrin provided effective control in Dominica but had an adverse effect on populations of the parasite *Mirax insularis*. The effect of soil and rainfall conditions on the efficacy of carbofuran is discussed.

INTRODUCTION

The production of coffee (*Coffea arabica* L.) is a major component of the agricultural economy of Jamaica. In Dominica, it is being actively promoted as a diversification crop and approximately 100ha have recently been established. Most are interplanted into existing banana plantations.

The coffee leaf miner (*Leucoptera coffeella* Guer.; Lepidoptera: Lyonetiidae) is an established pest of coffee in the Caribbean, Central America, and Brasil. This insect was first described in the mid-nineteenth century in Guadeloupe and Martinique (Pickmann Mann., 1892). It was responsible for the abandonment of coffee cultivation in those islands at the time. Similarly, it prevented the re-establishment of coffee cultivation in St. Lucia (Box, 1933). The pest and its natural enemies were studied in Dominica and Jamaica in the early twentieth century (Anon., 1939, Gowdey, 1921).

Leaf miner outbreaks in Jamaica over the past decade are associated with the wide-scale use of insecticides against the coffee berry borer, a pest introduced into that island in 1979. Similar outbreaks have been observed in some Central American countries (García Lizama, 1979). Although endemic in Dominica, damaging populations only occur at low altitudes (< 300m).

The adult, a small silvery moth, oviposits on coffee leaves. The larvae tunnel between the epidermal layers, feeding on the parenchyma. The resultant blotch mines become necrotic and reduce the photosynthetic surface. Severe infestations result in defoliation and subsequent death of the plant.

Various insecticides have been evaluated for the control of this pest but most foliar-applied insecticides disturb the natural enemy balance and often worsen the problem. Soil-applied systemic insecticides such as carbofuran can control insects feeding in the foliage, and in their granular form pose a reduced risk to humans and other nontarget organisms. This is compatible with an IPM strategy for the pest.

This paper reports on field trials conducted in Jamaica (1985-1987) and Dominica (1989-1990) to compare the efficacy of carbofuran to the insecticides then in current use for leaf miner control and to assess the effect of various soil and environmental factors on its efficacy.

MATERIALS AND METHODS

The field trials were conducted at five locations: in Jamaica at Aenon Town and Unity Valley, St. Ann; Grove Place, Manchester; Orange River, St. Mary; and in Dominica at Belles. Altitude and rainfall parameters for these sites are given in Figure 1. Four sets of trials were conducted following a randomized complete block design with three replicates. The plots consisted of five plants, (6 ± 2 years old), except where otherwise indicated.

Trial 1.

This was sited at Grove Place, Orange River and Unity Valley, Jamaica. The treatments tested were carbofuran (Furadan 10G) applied at 2, 4, and 7 gai/plant and Dimethoate EC60 at 2.5l ai/ha. Dimethoate had been used for leaf miner control.

Trial 2.

Two subsidiary experiments were conducted at Unity Valley. Firstly, carbofuran at 2, 4, and 7 gai/plant was applied broadcast approximately 4 weeks before flowering and similar doses broadcast onto the other plots during fruit set, about 8 weeks later. Secondly, carbofuran at 2, 4 and 7 gai/plant was broadcast onto the soil surface for comparison with similar doses incorporated into the soil.

Trial 3.

This trial was conducted only at Aenon Town. It was originally designed to evaluate the effectiveness of pesticides against the nematode *Meloidogyne incognita*. Since the pesticides used also possess insecticidal properties, their effects on populations of the leaf miner were assessed.

A randomized complete block design with three replicates and split-plots were used in this experiment. The main plots, comprising 10 trees each, received an experimental dose in January, approximately four weeks before the onset of flowering. Four months later in May, a similar dose was applied to five of the trees in each plot. Each main plot therefore consisted of two sub-plots treated with one or two applications of the experimental dose.

Treatments were: Carbofuran (1,1+1, 2,2+2 and 7 gai/plant), Ethoprop (3,3+3, 6, and 6+6 gai/plant), and Phenamiphos (2,2+2, 4, and 4+4 gai/plant).

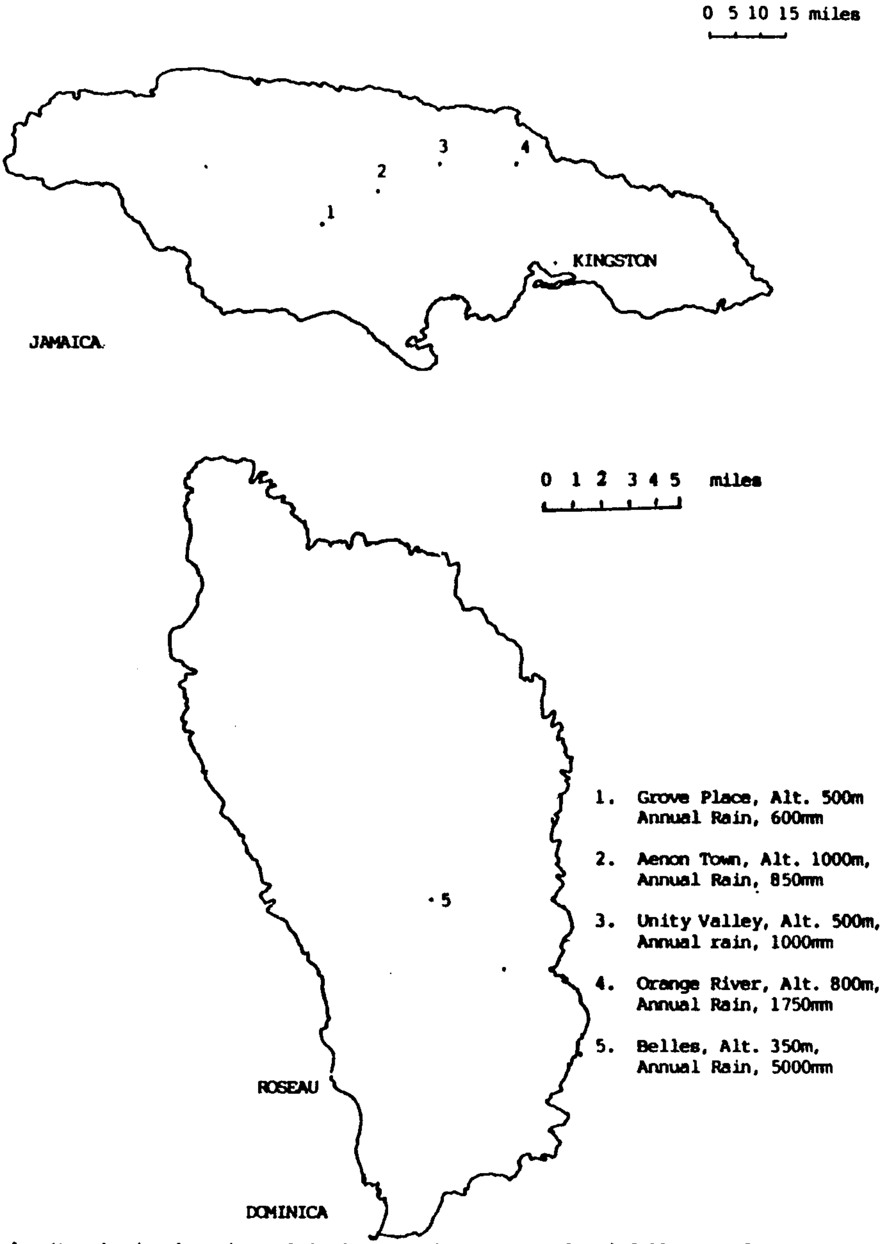

Fig 1. Map showing location, altitude (m), and mean annnual rainfall (mm) of experimental sites in Jamaica and Dominica.

Trial 4.

This was conducted at Belles, Dominica. The treatments applied were carbofuran at 4 and 7 gai/plant and lambda cyhalothrin (Karate 2.5EC) at 10 gai/ha. The synthetic pyrethroid Karate had been in use for 1-2 years for leaf miner control.

All granules were broadcast by hand onto the soil surface around each tree in a wide band extending outwards from the trunk to the drip circle. In Trial 1, one application of carbofuran was made at each site approximately 4 weeks after the commencement of berry production. In Trial 4, two applications of carbofuran were made, the second at 4 months after the first. Dimethoate and Karate were applied to the foliage of the plants thrice at monthly intervals with amotorized mist blower. Untreated controls were maintained in all experiments.

Data from all the experiments were collected at monthly intervals. On each sampling, 20 mined leaves were removed from trees in each plot. In the laboratory, the number of mines and pupal cocoons on each leaf were counted. All the mines on 10 leaves per plot were dissected to determine larval population and mortality. The remaining 10 leaves were incubated for emergence of leaf miner adults and their associated parasites.

During the course of the experiments in Jamaica, soil samples were taken from all experimental sites. These were analyzed for pH, organic matter content, and average particle size, factors which influence the efficacy of insecticides in soil. Associations between these parameters and the observed residual efficacy of carbofuran were tested by Spearmann's coefficient of rank correlation.

All other data were subjected to analysis of variance (ANOVA). Data recorded as percentages were given angular transformations before analysis.

RESULTS AND DISCUSSION

Trial 1.

At Orange River, carbofuran at 4 and 7 gai/plant reduced the number of live larvae from a pre-treatment level of 32/100 leaves to zero within one month of application and no live larvae were found in the entire post-treatment period. At 2 gai/plant, the larval population was reduced to very low levels (Fig. 2a). Throughout this period, the average population of live larvae in this treatment was 3 ± 0.4 larvae/100 leaves. Treatment with dimethoate reduced the larval population to 7.5 ± 1.7 larvae/100 leaves, significantly higher than in the carbofuran treatments but significantly lower than in the untreated plots where the mean density was 27 ± 6.6 larvae/100 leaves.

At Unity Valley, leaf miner larval population density was higher than at Orange River in both treated and untreated plots (Fig. 1b), with a pre-treatment population of 84 larvae/100 leaves. As at Orange River, these densities were lowest in plots treated with carbofuran. In those plots,

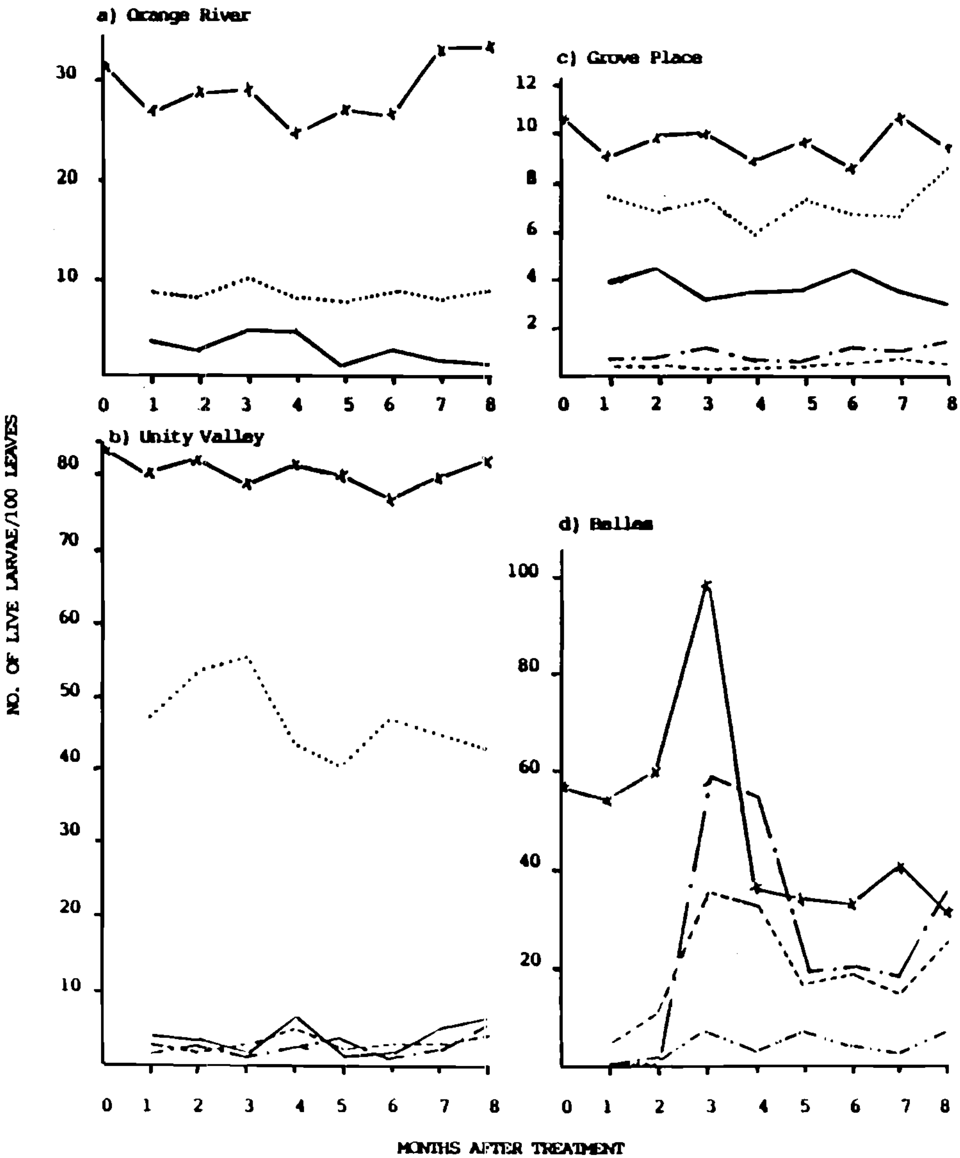

Fig. 2 Mean no. of live larvae/100 leaves of L. coffeella in various experimental treatments. (x——x Control, ... Dimethoate, —— Carb. 2g, —— . ——, Carb. 4g, - - - - - Carb. 7g, — — . . — — Karate).

although the larval density was associated with the lowest dose of carbofuran, there were no significant differences between the doses ($P > 0.05$). Larval populations were 4.8±1.9, 2.3±1.1, and 3.3±1.4 larvae/100 leaves in the 2, 4, and 7 gai treatments respectively. Of interest is the observation that larval density in plots receiving the 4 gai dose was less than that at 7 gai.

Larval populations were reduced to these levels within one month of carbofuran application and were maintained with relatively little variation throughout the period of post-treatment assessments (Fig. 2b).

Treatment with dimethoate reduced the larval population to 49.1±8.7 larvae/100 leaves, significantly higher than in the carbofuran treatments ($P < 0.001$), but about half that in the untreated control which was 80.0± 3.6 larvae/100 leaves.

Pre treatment larval density was the lowest at Grove Place (10.5 larvae/100 leaves). Here, as at all other sites, this density was significantly reduced within one month of carbofuran application (Fig. 2c). These low levels were also maintained without significant variation throughout the post-treatment period. The mean population levels in the various treatmnts were 3.6±1.8, 1.2±0.7, and 0.6±0.1 larvae/100 leaves in the 2, 4, and 7 gai treatments, respectively. Dimethoate also reduced the larval population to 7.4 ± larval/100 leaves. This was not signficantly below the control level of 9.6±1.4 larvae/100 leaves ($p = 0.08$).

High levels of larval mortality were obtained in plots treated with carbofuran in contrast to the relatively low mortality levels in the dimethoate treated and the untreated plots (Table 1). In plants treated with the 2 gai dose at Orange River, mortality was 9 per cent. Since no larvae were found in the plants with the higher dose, mortality was presumably 100 per cent. At Unity Valley, mortality levels were lowet than at Orange River. Here, the dose of 2 gai inflicted mortality of 71 per cent. Similar mortality (71 per cent) was inflicted at 4 gai but a significantly higher level (84 per cent) was recorded at 7 gai per plant. At Grove Place, mortality levels were comparable to those at Unity Valley, being 68, 73, and 81 per cent, respectively, in the 2, 4, and 7 gai treatments.

Mortality due to dimethoate was 50, 20, and 28 per cent at Orange River, Unity Valley, and Grove Place, respectively. In the untreated control, mortality levels were respectively 1, 6.1, and 5 per cent.

In the plots treated with carbofuran, adults emerged only from leaves of those plants receiving 2 gai at Unity Valley (Table 1). The emergent population was very low: less than 7 adults per 100 leaves. In all other doses at all locations, no adults emerged at all during the entire post-treatment period. At all the experimental sites, large numbers of adults emerged from the untreated peats and those treated with dimethoate.

The eulophid wasp, Achryosocharis sp. was the only parasite that emerged from the incubated leaves, and only at Unit Valley. There were no

Table 1. Effect of various insecticide treatments on populations of the coffee leaf miner and its associated parasite *Achryosocharis* sp. at three locations in Jamaica.

Treatment	% larval mortality			Emerging adult/100 leaves			Total no. of para-sites
	Grove Place	Orange River	Unity Valley	Grove Place	Orange River	Unity Valley	
Carbofuran 2 gai/plant	65	96.7	70.6	0	0	6.7	18
Carbofuran 4 gai/plant	73	-	71.4	0	0	0	13
Carbofuran 7 gai/plant	81	-	83.2	0	0	0	15
Dimethoate 21/ha	28	50	20	6	3.3	23.3	0
Control	5	1	6	7.3	26.7	26.7	21

significant differences in the number from the carbofuran treatments and from the control (Table 1). However, none emerged from dimethoate-treated leaves.

Rank correlation analysis indicated that there were no significant associations between the various soil parameters measured and any of the biological characteristics of the leaf miner populations which were estimated.

Trial 2.

Leaf miner populations in the 2 gai and 4 gai pre-bloom treatments were not significantly different from the corresponding post-bloom treatments (Table 2). Pre-bloom applications of 7 gai/plant, however, resulted

Table 2. Effect of time and mode of application of carbofuran on leaf miner populations at Unity Valley, Jamaica.

Treatment (gai/plant)	No. of larvae/ 100 leaves	% larval mortality	No. of emerging adults/100 leaves
Carbofuran (2)*	4.86	70.6	6.8
Carbofuran (4)*	2.3	71.4	0
Carbofuran (7)*	3.3	83.2	0
Carbofuran (2)o	0.1	88.4	0
Carbofuran (4)o	0.3	81.5	0
Carbofuran (7)o	0.3	93.0	0
Carbofuran (2)+	5.2	70.0	15.1
Carbofuran (4)+	3.0	80.1	11.3
Carbofuran (7)+	1.9	85.3	2.6
Carbofuran (2)-	4.5	72.0	5
Carbofuran (4)-	3.1	75.2	0
Carbofuran (7)-	0.7	86.0	-
Control	80.8	6.1	266.7

*Broadcast　　0 - Soil incorporated
+Pre-bloom　　- - Post-bloom

in a significantly lower population than that in the post-bloom treatment ($p < 0.05$). There were no significant differences in the levels of larval mortality achieved by the pre-bloom and post-bloom applications. However, significantly larger numbers of adults emerged from the leaves in all of the pre-bloom treatments ($p < 0.05$).

Soil incorporation of carbofuran resulted in leaf miner larval populations which were significantly below ($p < 0.05$) those resulting from the broadcast mode of application (Table 2). Mortality in these larvae was also significantly higher in all the incorporated treatments ($P < 0.05$), the highest mortality (93 per cent) being recorded for the 7 gai dose. No adults emerged except for emergence of 6.7 adults/100 leaves in the broadcast treatment.

Trial 3.

Only carbofuran and phenamiphos caused significant reductions in the larval population levels. Carbofuran was the most effective treatment in this respect. Although the larval densities achieved in all the carbofuran treatments were not significantly different, there was a residual population associated with the single applications of 1g and 2 while the split 2g and 4g and the single 7g treatments completely eliminated the larvae from the leaves (Table 3).

Table 3. Effect of single and split applications of various granular insecticides on leaf miner populations at Aenon Town, Jamaica.

Treatment (gai/plant)	No. of larvae/ 100 leaves	% larval mortality	No. of emerging adults/100 leaves
Carbofuran (2)	4.2	65	13.3
Carbofuran (1+1)	0	-	0
Carbofuran (2)	2.1	57	0
Carbofuran (2+2)	0	-	0
Carbofuran (7)	0	-	0
Ethoprop (3)	39.1	24.2	146.7
Ethoprop (3+3)	29.7	21.6	113.3
Ethoprop (6)	57.2	27.6	86.7
Ethoprop (6+6)	37.3	22.8	106.7
Phenamiphos (2)	17.6	34.3	33.3
Phenamiphos (2+2)	12.9	48.1	20.0
Phenamiphos (4)	17.7	51.4	43.3
Phenamiphos (4+4)	16.9	57.5	50.0
Control	40.1	23.9	307.0

Larval populations associated with phenamiphos were significantly higher than those treated with carbofuran, but significantly lower than in the untreated controls ($p < 0.05$). None of the doses of ethoprop had any significant effect on the leaf miner larval population.

Highest levels of larval mortality were inflicted by carbofuran in the two treatments where larvae were still present. In the various phenamiphos treatments, larval mortality was 2-3 times that in the untreated controls (Table 3).

No leaf miner adults emerged from the leaves receiving doses of carbofuran above 1 gai/plant. Adult emergence was also significantly reduced by all doses of phenamiphos ($p < 0.05$). However, large numbers of adults emerged from the ethoprop-treated plants and the untreated plants.

Trial 4.

Over the entire post-treatment period, the populations of live larvae in the plots treated with carbofuran were significantly lower than in the untreated control (Fig. 2d). Population densities were 33.8±8.5 and 31.6± 6.8 larvae/100 leaves in the 5 and 7 gai treatments, respectively, and 45.4±10.6 larvae/100 leaves in the control. Densities in the plots treated with Karate (8.3±1.6 larvae/100 leaves) were significantly lower in the other treatments ($p < 0.01$).

All treatments caused significant reduction in larval population in the immediate post-treatment period. However, by 3 months after treatment (MAT) populations in the carbofuran-treated plots had climbed back to levels identical to the control. The second application of carbofuran at 3 MAT achieved similar results (Fig. 2d). Monthly applications of Karate maintained the larval populations at very low densities throughout the experimental period.

Estimates of larval mortality and the emergence of both adult leaf miners and the parasite Mirax insularis are shown in Table 4. Karate inflicted highest mortality and fewest adults emerged from those treated leaves. No parasites occurred in this treatment, however.

Table 4. Effect of various insecticide treatments on populations of the coffee leaf miner and its associated parasite, Mirax insularis in Dominica.

Treatment	% larval mortality	No. of emerging adults/100 leaves	Total no. of parasites
Carbofuran 5 gai/plant	37.4	38	12
Carbofuran 7 gai/plant	48.2	30	8
Lamdacyhalothrin	65.7	12	0
Control	26.5	51	17

Overall Results.

The results from Jamaica demonstrate that single applications of carbofuran can give extended control of leaf miner infestations. Extended control can be provided over a wide range of soil conditions and the main natural enemies are not adversely affected.

Pre-bloom applications of carbofuran provided increased leaf miner control. However, fruit set and observed berry production were adversely affected by this practice. Similarly, although soil incorporation was more effective, berry production was reduced, most likely due to damage of the surface feeding roots during the process of incorporation. Split applications did not improve the efficacy of the pesticide. Dimethoate is not as effective, and has a harsh impact on natural enemies. Campbell et al. (1967) came to similar conclusions in Guatemala. Conversely, in Dominica carbofuran did not provide effective residual control of the pest. The synthetic pyrethroid Karate provided effective control but eliminated natural enemies.

The reduced residual efficacy of carbofuran may be due to two factors. The experimental site was in an area of very high rainfall (≃ 7000mm/yr). This may have caused rapid leaching of the pesticide. Similar effects of rainfall have been observed with Disulfoton, a soil applied systemic insecticide used against Leucoptera meyricki in Kenya (Wanjala and Dooso, 1979).

Also, the coffee stand in Dominica was in a banana plantation which has received 3-4 applications of carbofuran annually over the past 5 years. Various studies have shown that such continuous applications of carbofuran enchance the ability of soil microorganisms to degrade this pesticide, thereby reducing its residual efficacy (Racke and Coates, 1988; Ramanand et al., 1988; Dzantnor and Felsot, 1989; Suett, 1989). The previous applications of carbofuran also may be partially responsible for the results in Dominica.

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