Using pheromones for location and suppression of phycitid moths and cigarette beetles in Hawaii—a five-year summary

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Abstract

This paper summarises observations during a five-year period to evaluate the efficacy of various pheromone-enhanced techniques for the location and suppression of phycitid moths and cigarette beetles, *Lasioderma serricorne* (Fabricius), in field situations in Hawaiian food facilities.

Location of infested products was accomplished using a fixed grid triangulation technique based on the inverse relationship between the number of captures per trap and the relative proximity of the infestation. This technique was successfully employed to locate hidden infestations of cigarette beetles and phycitid moths in various food facilities.

Pheromone mass trapping was found to be a cost-effective alternative to general (ULD) fogging for the suppression of phycitid moths. Increasing the number of pheromone moth traps in a food warehouse while reducing the frequency of general fogging progressively suppressed the phycitid moth captures during a three-year period.

In two food warehouses, pheromone mass trapping suppressed Indianmeal moth and cigarette beetle populations with and without regular pesticide treatments. Captures of these insects declined more rapidly in the regularly treated warehouse.

Pheromone enhanced mortality (PEM) techniques employ pheromone lures in conjunction with pyrethrin fog and/or cyfluthrin to suppress populations of stored-product insects. Several PEM techniques were employed to suppress populations of: 1. cigarette beetles in a bakery using time-mist foggers (battery operated aerosol); 2. phycitid moths in a grain elevator using spot applications of cyfluthrin; and 3. both phycitid moths and cigarette beetles in a feed warehouse using a combination of time-mist foggers and cyfluthrin.

Introduction

For the past five years, Food Protection Services has studied and evaluated a variety of pheromone enhanced techniques to locate, suppress and control phycitid moths and cigarette beetles in field situations in Hawaii. The following paper summarises long-term field observations in various Hawaiian food and feed facilities. Most of this work stemmed from a need to solve specific insect infestation problems. As data from each facility was collected and analysed, comparisons were made and the following series of semi-controlled field studies evolved.

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Location of Infestation using Fixed Grid Triangulation

Continuous monitoring of large food storage facilities was implemented using large numbers of pheromone traps deployed in fixed grid patterns at 4 to 15 m intervals. The fixed grid technique facilitated early detection, location and removal of insect sources before the fugitive insects had a chance to migrate to other infestable products. This technique was employed at each of the facilities discussed in this paper.

Using the fixed grid triangulation technique, the layout of the pheromone trapping grid is not changed from week to week. Figure 1 shows a representative facility diagram with pheromone trap positions. The distance between traps remains constant and the lures in the traps are all the same age. Circles are drawn on the facility trapping diagram around each of the three trap sites having the highest number of captures in an active area. The relative sizes of the circles are estimated by converting the number of captures at each site to their respective percentage share of the combined total captures at the three sites. Then, each percentage share is subtracted from 100. The resultant numbers approximate the relative distances from the infestation and the radiuses of the triangulation circles drawn on the diagram.

Example: the number of captures at site 5 = 76 insects, site 6 = 41 and site 2 = 13. The total number of captures at these three sites equals 130 insects. Therefore, the percent share of captures at each of the sites is: 58%, 32% and 10% respectively. Subtract each of the percentage values from 100. The resulting numbers (42, 68, and 90) have a ratio of 4:7:9 and approximate the relative distances of each trap from the source of the insects. These numbers are used as radiuses of the circles drawn on the trapping diagram. The area where the three circles intersect indicates the approximate location of the infestation.

While this technique has limitations, it has been successful in locating both cigarette beetle, *Lasioderma serricorne* (Fabricius) and phycitid moth infestations in food warehouses.

Pheromone Trapping as an Alternative to General Fogging

The cost effectiveness of pheromone mass trapping as an alternative to general (ULD) fogging was investigated in a food warehouse. Phycitid moth populations had persisted in spite of a relatively costly fogging program in the warehouse. It was found that general fogging at three to four-week intervals had little effect on the number of moth captures in the warehouse. Fogging was phased out over a three-year period as shown in Figure 2.

A pheromone moth trapping grid was set up in the ca 42 500 m^3, warehouse. The initial low level monitoring at ca 1 trap/8500 m^3 was steadily increased to mass trapping levels of ca 1 trap/530 m^3. The number of weekly moth captures in the

facility decreased from 61 to 27 as the level of pheromone trapping was increased as shown in Figure 3. The annual cost of the moth mass trapping program was about one-third the $6000 annual cost of the phased out fogging program as shown in Figure 4.

Pheromone Mass Trapping for Population Suppression

Two infested food warehouses were studied to determine the effects of increasing levels of pheromone trapping on Indianmeal moths, *Plodia interpunctella* (Hubner) and cigarette beetles, *Lasioderma serricorne* (Fabricius). In warehouse HW, standard chemical pest control measures were regularly employed including: weekly ULD fogging, time-mist fogging, fumigation, removal of infested products, and residual spraying around infested areas. In cohort warehouse HT, approximately half the size, limited ULD fogging and spraying were done initially, but stopped. Periodically, dry pet food items were fumigated in containers.

Warehouse HW had a volume of ca 79000 cm^3 and the trapping density for moths was increased 12-fold from N=30 to N = 372 (ca 1 trap/2630 m^3 to 1 trap/210 m^3). The number of cigarette beetle traps increased from N=30 to N= 61 (ca 1 trap/2630 m^3 to 1 trap/1300 m^3) during the 2.25 years of observation.

The average weekly moth captures decreased ca 96% from an average of 512 during the first quarter of monitoring to 18 during the last quarter. Cigarette beetle captures decreased ca 99% from 573 to 7 during these same periods. Figure 5 shows cigarette beetle average weekly capture data compared with the number of traps deployed by quarter. Figure 6 shows Indianmeal moth average weekly capture data and Figure 7 presents the same data on a weekly basis.

At the conclusion of this 120-week mass trapping program, a comprehensive inspection of every food item in the warehouse revealed no products which were actively infested by either insect. The two species which had been pheromone mass-trapped were no longer found and no captures were recorded in the pheromone traps during the last weeks of observation. In contrast, a number of products were still infested by all of the other stored-product insects which were present at the beginning of the trapping program. These principally included: red flour beetles *(Tribolium castaneum)*, drugstore beetles *(Stegobium paniceum)*, merchant grain beetles *(Oryzaephilus mercator)*, red-legged ham beetles *(Necrobia rufipes)*, and *Trogoderma* sp.

In warehouse HT, the number of cigarette beetles and Indianmeal moths also declined as the level of trapping in the ca 33000 m^3 facility was increased from ca 1 trap/3300 to ca 1 trap/330 m^3 as shown in Figures 8 and 9. Although the mass trapped insects were not completely eliminated in this warehouse, they were suppressed. The average weekly number of cigarette beetle captures decreased 81% from 73 during the first year to 14 during the fifth year of observation. The average weekly moth captures increased initially as the number of traps was increased, but then decreased 75% from eight during the third year to two during the fifth year.

Pheromone Enhanced Mortality

Pheromone enhanced mortality (PEM) techniques employ pheromone traps and/or lures in conjunction with minute amounts of pyrethrin fog and/or cyfluthrin to suppress populations of stored-product insects. Several PEM techniques were successfully employed to suppress phycitid moth and cigarette beetle populations.

Pheromones and Time-mist Foggers

The long-term effects of pheromone trapping with and without continuous time-mist fogging on cigarette beetle populations in two infested bakeries, DA and HC, were observed over a five-year period. Bakery DA had a volume of ca 13900 m^3 and bakery HC had a volume of ca 14300 m^3. Both bakeries had previously been ULD fogged in futile attempts to control the infestations.

The level of pheromone trapping in each facility was slowly increased from ca 1 trap/1410 m^3 to mass trapping levels of ca 1 trap/240 m^3. Several types of battery-operated time-mist foggers were deployed adjacent to the pheromone traps along the heavily infested back wall area in bakery DA. Each fogger dispensed ca 52 mg of 0.975–1.80% pyrethrin aerosol every 7.5–15 minutes. The products and food equipment were covered with plastic sheeting before the foggers were activated each night during non-production hours.

Weekly ULD fogging was discontinued in bakery DA during the first year after the time-mist foggers were installed. The number of time-mist fogger units deployed ranged from 10–24. ULD fogging was started and stopped several times for three to four month periods during the first three years in order to assess the separate and combined effects of both types of fogging. No ULD fogging was done in bakery DA during the last two years of observation.

The average weekly number of cigarette beetles captured in bakery DA with time-mist fogging declined steadily over the five years from 464 during the first year to 121 during the fifth year as shown in Figure 10.

Bakery HC was pheromone trapped, but no regular ULD fogging was conducted in the facility. The average weekly number of captures in the bakery HC remained relatively constant once the maximum trapping levels were reached as shown in Figure 11.

A total of 60 pheromone traps were deployed in each bakery during the last two years of observation. The cost of the pheromone trapping program (N=60) was ca $180/month. The additional cost of time-mist fogging in bakery DA was ca $180 month. The cost of the previous ULD fogging program in bakery DA was ca $400/month. The use of pheromone trapping in combination with time-mist fogging cost slightly less and was more effective than weekly ULD fogging.

Pheromones and Cyfluthrin

Short-term, rapid suppression of fugitive phycitid moths was achieved in a grain elevator by placing pheromone lures on 20 cyfluthrin treated spots (ca 1 m^2) on the outside of the silo cones in the elevator base and on 10 spots on the corrugated walls in the top section of the elevator. During the initial 21-week observation period, this technique was employed twice for two-week periods when the moth populations in the elevator began to increase. The number of fugitive moths seen and pheromone trap captures in the elevator declined dramatically, but rebounded after a few weeks when the treatment was stopped (Fig. 12).

A total of 28548 pycitid moths were captured in the elevator during the first 21 weeks of observation. Of these, 15731 moths (55%) were captured in the traps (N=20) at the top of the elevator and 12 817 moths (45%) were captured in the traps in the base (N=40).

Long-term effects of this suppression technique were investigated during the subsequent 22-week observation period. Moth lures were placed on the inside of each of the 40 silo top hatch covers. The inside surface of the hatch covers were spot treated with 1% cyfluthrin wettable powder. The hatch covers were dusted off and resprayed approximately every two

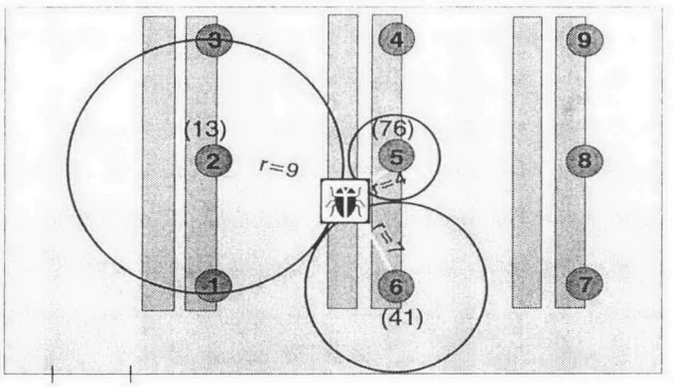

Fig. 1. Fixed grid triangulation technique.

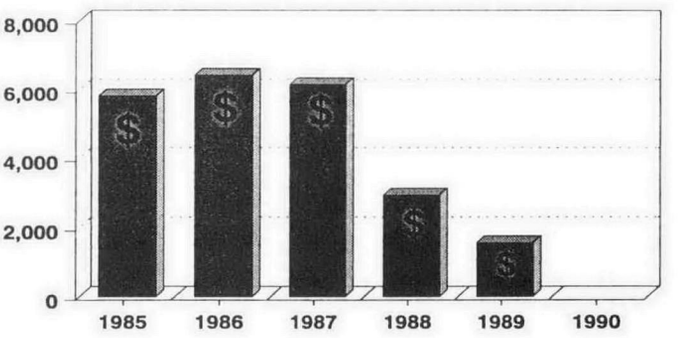

Fig. 2. ULD fogging cost in warehouse HM, 1985–90.

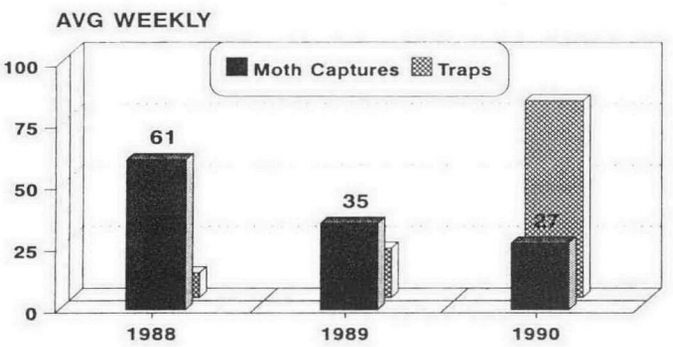

Fig. 3. Pheromone trapping effects on moth captures in warehouse HM.

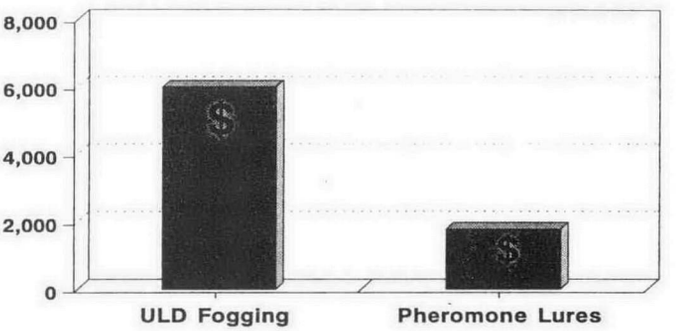

Fig. 4. ULD fogging vs pheromone costs in warehouse HM.

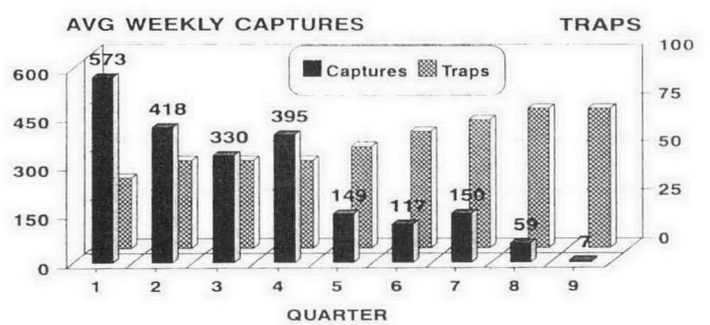

Fig. 5. Pheromone trapping effects on cigarette beetle captures in warehouse HW.

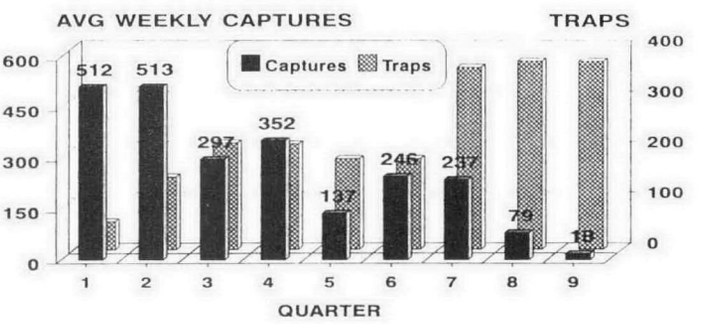

Fig. 6. Pheromone trapping effects on Indianmeal moth captures in warehouse HW (quarterly basis).

weeks. No additional chemical treatments were done in the base of the elevator. The arrays of pheromone traps in both the elevator top and base were monitored weekly.

The number of moth captures declined from 28 548 during the first 21 weeks to 9557 during the last 22 weeks of continuous treatment at the top of the elevator. Moth captures in the top section of the elevator declined 84% from 15 731 during the first 21 weeks to 2535 during the last 22 weeks and remained suppressed during treatment. There were 12 817 moths captured in the elevator base during the first 21 weeks and an additional 7022 captured in this untreated area during the second 22 weeks. Moth captures in the base rebounded initially, but subsequently declined 45% compared to the previous 21-week period.

This technique proved to be highly effective for both immediate and long-term suppression of fugitive moths in the grain elevator. The percent reduction in moth captures in the treated top section of the elevator was double that of the untreated bottom section (Fig. 13).

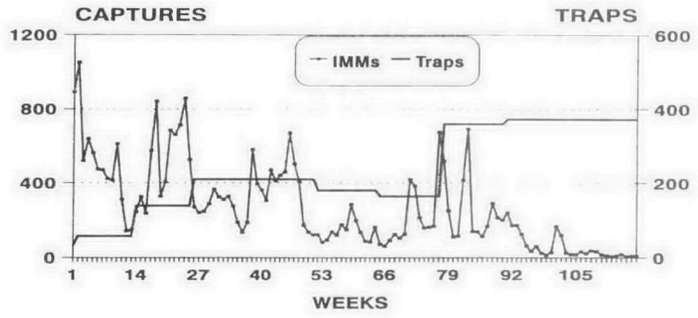

Fig. 7. Pheromone trapping effects on Indianmeal moth captures in warehouse HW (weekly basis).

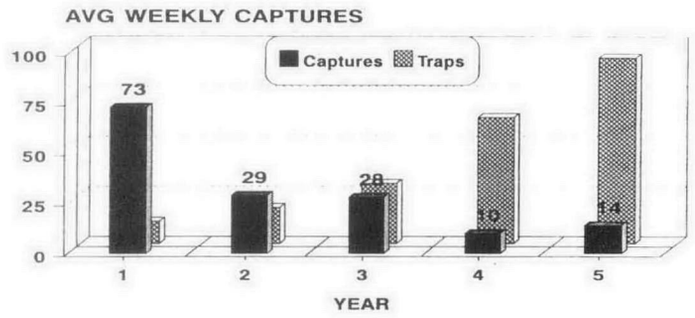

Fig. 8. Pheromone trapping effects on cigarette beetle captures in warehouse HT.

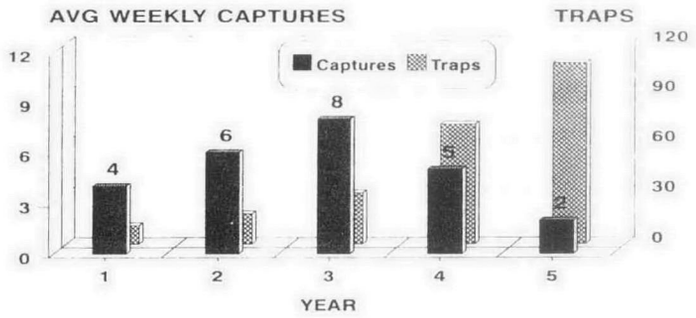

Fig. 9. Pheromone trapping effects on Indianmeal moth captures in warehouse HT.

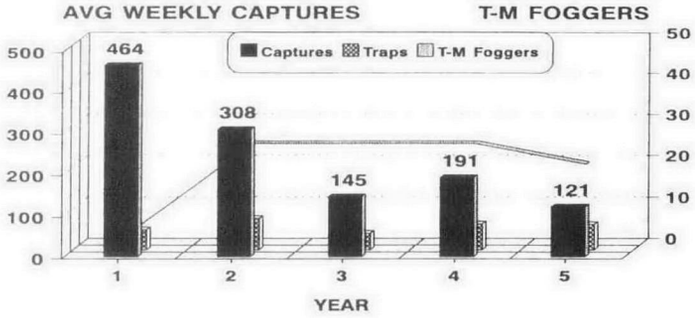

Fig. 10. Pheromone trapping and time-mist fogging effects on cigarette beetle captures in bakery DA.

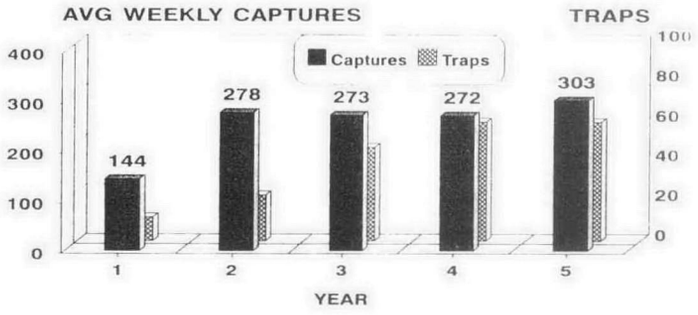

Fig. 11. Pheromone trapping effects on cigarette beetle captures in bakery HC.

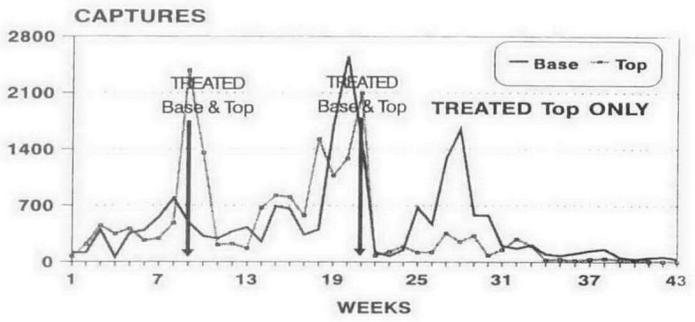

Fig. 12. Pheromone and cyfluthrin effects on phycitid moth captures in a grain elevator (weekly basis).

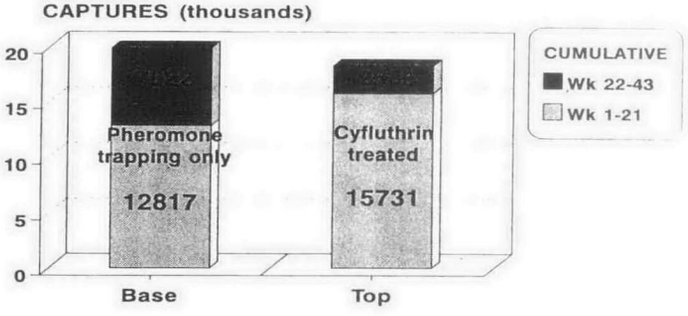

Fig. 13. Pheromone and cyfluthrin effects on phycitid moth captures in a grain elevator (by location in elevator).

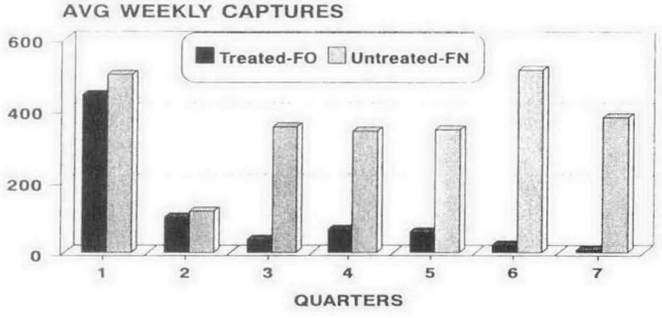

Fig. 14. Comparison of cigarette beetle captures in treated and untreated warehouses FO and FN.

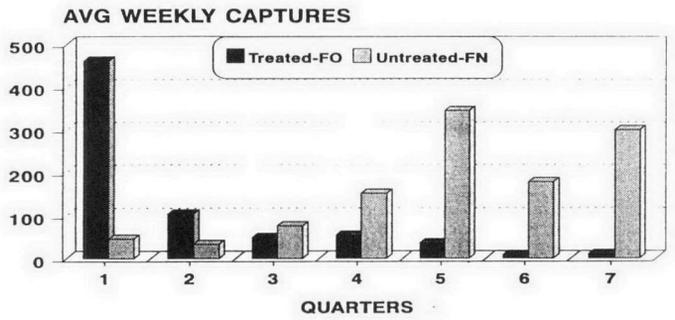

Fig. 15. Comparison of phycitid moth captures in treated and untreated warehouses FO and FN.

Pheromone Mass-trapping with Time-mist Foggers and Cyfluthrin

The combined effects of pheromone attractants in combination with time-mist fogging and spot treatment were evaluated during two-year observation period in two feed warehouses. Both warehouses were heavily infested with a variety of stored-product insects including phycitid moths and cigarette beetles.

Time-mist foggers were set up inside the treated warehouse FO along the front wall behind pheromone trapping arrays. Wall sections behind each of the trapping arrays were spot treated with 1% cyfluthrin wettable powder. The time-mist foggers operated continuously and the front wall spots were cleaned and resprayed monthly.

Average weekly cigarette beetle captures in the treated warehouse FO declined from 444 to 7 during the seven quarters of PEM treatment. Average weekly moth captures dropped from 461 during the first quarter to 10 during the last quarter of observation. Capture rates for these same two insects in untreated warehouse FN remained the same or increased during this same period (Figs 14 and 15).

Pheromone enhanced mortality resulting from the use of pheromone attractants in conjunction with the minute amounts of pyrethrin and cyfluthrin was highly effective in suppressing both fugitive phycitid moths and cigarette beetle in this feed warehouse.

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