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Rat Control in Macadamia Orchards

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Rats damage an estimated 5-10% of the annual Hawaiian macadamia nut crop. Gross production of macadamia nuts in Hawaii was 49 million pounds during the 1988-89 crop year (HASS, 1989.). Projected farm value losses due to rats was $2 to $ 4 million. These losses can be expected to grow as macadamia plantings increase and young orchards continue to come into production.

Biology of Rats in Macadamia Orchards

Three species of rat are found in Hawaii. Polynesian rats (*Rattus exulans*) migrated to the Hawaiian islands with early Polynesian settlers; Norway rats *R. norvegicus* and black rats *R. rattus* invaded sometime after the arrival of Captain Cook in the 1770's. All three species have been trapped in and around macadamia nut orchards. Black rats are the most frequently seen, most common rodent in orchards, and destroy more nuts. The following discussion focuses on black rats in Hawaii.

Black rats, commonly called roof rats, are the only rat that readily climbs trees. They live in colonies, share nesting and feeding sites, and depending on the orchard, nest in the canopy branches and leaves or in underground borrows. Where tree foliage is thick and the orchard has closed-in and canopies interlocked, rats spend most of their time in trees (Pank et al, 1978). In young orchards that have not closed in, rats tend to nest underground. A'a lava or rock outcrops make an ideal burrowing sites. Abundant ground cover and low drooping branches also encourage ground nesting (Fellows, 1979). Rats leave their burrows rat harvest nuts on the tree and then store nuts underground.

Daily movements of rats in macadamia orchards have not been well documented. They undoubtedly vary among areas, seasons, population densities, and due to other factors. Where noncrop lands border orchards, rats move freely between the two areas (Pank et al, 1978). Radio-tracked black and Norway rats in one Kau macadamia nut orchard moved an average distance of 143 ft (44m) ranging from 45 to 300 ft during a 18-day period (Pank et al, 1976). Smythe (1967) reported an average home range of 3,000 ft ^{2} (280m^2) about 4.8 trees of Polynesian rats in one orchard in Keaau.

Rats eat nuts in any stage of development ranging in age from immature on the tree to mature nuts on the ground. Premature nut drop and possible compensatory growth confound the task of projecting yield

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reductions due to early season rat damage. Nuts stored by rats also complicates the task of assessing damage accurately. Nonetheless, many growers suffer substantial losses and need effective control measures.

Control

The quickest and most common means of reducing troublesome rodent populations is applying rodenticides. Several zinc phosphide bats are currently registered for use in macadamia orchards. Two oat and two pelleted commercial formulations of this toxicant are available. Recent laboratory tests (Tobin, 1990) indicate that the pelleted baits may be more effective that the oat baits against black rats (Table 1). However, poor moisture resistance has limited the effectiveness of past formulations of pelleted baits under the wet conditions present in Hawaii (Fellows et al, 1982; Pank et al, 1982). The durability of currently available pelleted baits should be evaluated before use in orchard.

Regulations allow up to four applications of zinc phosphide baits per year, with a maximum of 5 lb/acre/application and 20 lb/acre/yr. Baits should be applied when and where rat activity is evident. Application early in the season, before any nuts have developed, helps to reduce populations before appreciable damage occurs. Bait acceptance by rats is likely to be greater at this time because macadamia nuts, a highly preferred food is in short supply.

Baits may be broadcast by aircraft, truck or knapsack blower, or by hand, placed in bait stations on the ground or in trees, or put in burrows. Baits broadcast or placed in bait stations may be applied up to 30 days prior to harvest. When bait stations are used, uneaten bait must be removed from the ground and trees prior to mechanized harvest. No preharvest interval is required for baits placed in burrows provided that nuts are not picked out of burrows.

The relative effectiveness of the three baiting techniques probably varies in different orchards. A study conducted in one mature orchard near Hilo (Fellows et al, 1978) indicated that 97% of all rats captured had consumed bait placed in trees, 80% had consumed bait placed in burrows, and 76% had consumed bats broadcast on the ground. In other orchards with younger trees or more favorable burrowing substrate, ground and burrow baiting may be more effective than tree baiting.

Other factors to consider when deciding how to apply rodenticides. Bait freshness is important. Fellows' study (1978) was during a prolonged dry period, yet burrow bait molded within 3 days of application. Broadcast bait appeared fresh 4 days after application, and bait in trees did not begin to mold until the first rain 10 days later. Coating baits with wax or placing them in plastic bags protects them from moisture but also reduces acceptance by rats.

Time, labor and possible consumption of bait by nontarget species also are important when selecting an application technique. Placing bait in bait stations or burrows requires less bait, allows for the selective placement of bait where signs of rat activity are evident, reduces the exposure of nontarget species to baits, but also requires more time and labor that broadcasting bait. Nontarget animals such as northern cardinals *Cardinialsis cardinialis* and doves, *Geopelia striata* and *Streptopelia chinensis* sometimes eat broadcast baits, although research indicates mortality is minimal (Fellows, 1982). Growers should examine the conditions in their orchards, assess possible hazards to nontarget species, and choose the application technique most suitable for their particular situation.

In spite of their widespread use, rodenticides often do not give adequate control. This is due in part to the neophobic nature of rats: they are wary of new and unfamiliar food and are reluctant to eat toxic baits. Rats that consume only a small sublethal amount of an acute rodenticide often develop bait shyness and refuse to eat any more of the bait. Prebaiting with nontoxic food similar to the toxic bait to be used increases bait consumption and improves efficacy. If zinc phosphide-treated oats are to be applied, prebait with nontoxic oats 3-10 days ahead of time. Rabbit or hog pellets are an appropriate prebait for some zinc phosphide pellets.

Even when rodenticides result in substantial population reduction, control frequently is only temporary. A mild climate and abundant food and cover favor the survival and breeding of rats in noncrop areas, from which movement to orchards is a constant problem. Control of populations in windbreaks and noncrop areas helps to slow down such such reinvasion.

Few rodenticides, however, are registered for the control of rats in noncrop areas. Zinc phosphide baits are approved for use only within orchards. Anticoagulants such as fumarin, pival, and diphacinone, although not registered for use within orchards, have been used around the periphery of orchards to slow down reinvasion. When used, anticoagulants may not be applied over bodies of water, roads, residential areas, or areas inhabited by livestock, and must be placed in tamper-proof bait stations. Several investigators have warned of possible secondary hazards to predators eating dead or dying rats that have been poisoned with anticoagulants (Engeman and Pank, 1984; Hirata and Pank, 1979, Mendennall and Pank, 1980). The use of anticoagulants is prohibited where they pose hazards to rare or endangered species such as the Hawaiian hawk *Buteo solitarius*.

Trapping may be an effective form of control in certain localized situations, although its cost-effectiveness for reducing populations in large orchards is questionable. Trapping is used when constraints preclude using rodenticides. Standard rat snap traps either placed on the ground near burrows, rat trails or tree trunks, or secured to lower limbs near the main

trunks of trees. Chunks of coconut are an effective bait. Prebaiting with grated coconut around the base of trees 3-10 days before setting traps increases trap success.

Good cultural practices help to reduce rat problems. Maintaining a clean orchard lowers its carrying capacity for rats. Eliminating or reducing ground vegetation removes protective cover and eliminates a potential source of food. Prompt removal of pruning and other debris eliminates nesting and resting sites. Establishing a buffer around the orchard slows down invasion from windbreaks and surrounding noncrop areas.

Table 1. Average consumption and mortality of black rats offered one of five commercial rodenticides during 3-day, no-choice feeding trails.

	bait consumption (g/rat)			
Bait[a,b]	Day 1	Day 2	Day 3	Mortality %
ZP Rodent Bait AG	2.0	0	0.1	70
Hopkins Zinc Phosphide Bait	1.0	0	0	80
HGP Zincphos Oats	0.4	0.1	0	30
KFE Zinc Phosphide Prepared-Rat	1.2	0	0	60

[a]Each bait was offered to five adult rats of each sex.
[b]Reference to commercial products does not imply endorsement by the U.S. Government.

SUMMARY

Black rats are a major economic problem in Hawaiian macadamia nut orchards. A favorable climate and an abundance of food and cover favor the proliferation and survival of these pests in and around macadamia nut orchards. Judicial selection of rodenticides and application techniques, together with proper cultural practices, can help to reduce crop loss.

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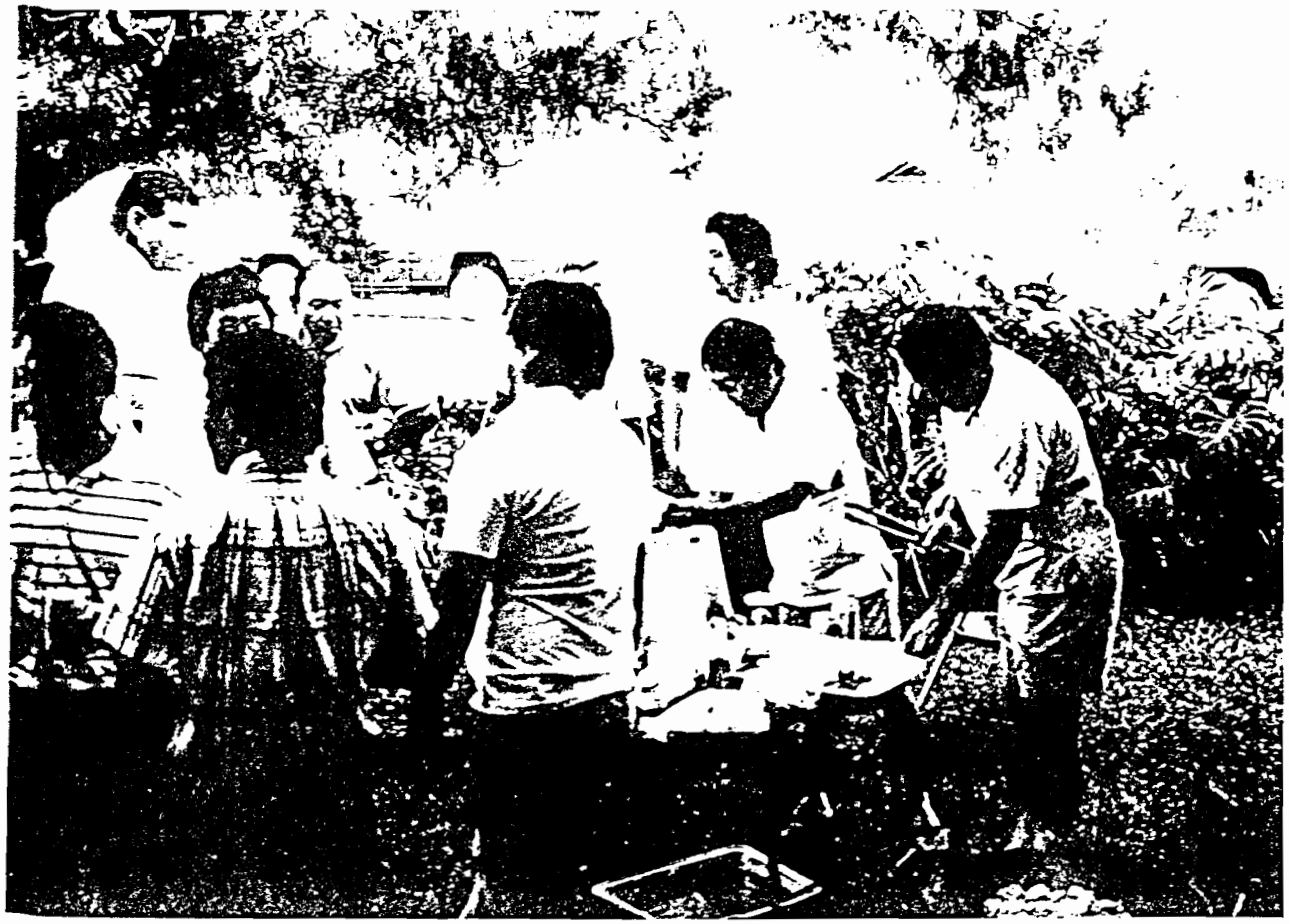

Participants at the 30th Annual Meeting enjoy the social hour.