Rat Control Research in Hawaii

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About the Author: Mark Tobin received an A.B. degree in zoology from the University of California at Berkeley and M.S. and Ph.D. degrees in wildlife ecology from the University of California at Davis. For his graduate research, Mark studied bird pest problems in grape vineyards. He also worked on rodent and bird problems in fruit crops as a research associate at Cornell University. Since 1988 Mark has been project leader of the Hawaii Field Station of the Denver Wildlife Research Center, U.S. Department of Agriculture. The primary mission of the station is to conduct research involving the ecology, impact, and control of rodents in Hawaiian agricultural crops.

INTRODUCTION

Rat damage results in millions of dollars worth of losses annually for the Hawaiian sugarcane industry. Rodent gnawing on the internodes of growing plants kills stalks and increases the incidence of secondary infection. The resulting damage diminishes juice quality and reduces yields.

Three species of rats are implicated. Polynesian rats *(Rattus exulans)*, the smallest of the three, immigrated to Hawaii with early Polynesian settlers possibly as early as 1,400 years ago. Norway rats *(R. norvegicus)* and black rats *(R. rattus)* invaded sometime after the arrival of Captain Cook in 1778. Most rodent damage to Hawaiian sugarcane is caused by Polynesian and Norway rats, and to a lesser degree by black rats. The latter is a major pest in macadamia nut orchards.

Various methods have been employed to control rats in sugarcane, including trapping, introducing predators, hunting with dogs, and poisoning. Most have met with limited success. In 1966 the Denver Wildlife Research Center (DWRC), then part of the U.S. Fish and Wildlife Service, opened a field station in Hilo. The primary mission was to conduct research to increase our understanding of the biology, impact, and control of rodents in sugarcane. In 1970 these efforts, together with those of the Hawaiian Sugar Planters' Association (HSPA), resulted in the registration of zinc phosphide for use in sugarcane. In 1983 budgetary restraints forced a temporary closing of the laboratory, but in 1988 Congress restored funding and the station reopened under the auspices of the U.S. Department of Agriculture (USDA). Below I describe research currently being conducted at the Hawaii Field Station.

RAT POPULATIONS

In 1989 we conducted an extensive trapping study to determine the relative abundances of the three species of rats in Hawaiian sugarcane fields. We focused our efforts on four plantations that historically have received high levels of damage: Mauna Kea, Hamakua, and Ka'u plantations on the island of Hawaii and Lihue Plantation on Kauai. At each plantation we randomly selected 14 fields greater than 12 months of age and set 50 snap traps in each field for four consecutive nights. We captured a total of 1,000 rats on all four plantations during 11,200 trap-nights. Although the Lihue Plantation on Kauai has sustained heavy rat damage in the past, fewer rats were captured there during the present study than on any of the three plantations on Hawaii. This low capture success on the Lihue plantation may have been due to a normal seasonal or annual decline in rat populations. On Hawaii Island, total capture success for all species combined did not vary significantly among the three plantations. It did vary among species, though. Norway rats were more abundant than either of the other two species, and Polynesian rats were more numerous than black rats. Of the 56 fields surveyed, Norway rats were the most numerous species in 35 fields, while Polynesian rats predominated in 16 fields. Thus, although both Norway and Polynesian rats are abundant in Hawaiian sugarcane fields, their relative importance varies among fields. Overall, black rats are a

minor pest species in sugarcane. These data are being analyzed further to determine the effects of various crop characteristics, environmental variables, and other factors on rat numbers.

Zinc Phosphide Bioassays

Zinc phosphide is the only toxicant registered for the control of rats in sugarcane fields. Five commercial baits currently are registered. Two oat formulations (KFE Zinc Phosphide Prepared-Rat Bait* and HGP Zincphos Oats) are the most widely used. Three pelleted formulations (ZP Rodent Bait AG, Ridall-Zinc, and Hopkins Zinc Phosphide Pellets) also are available. During 1989, we conducted bioassays with individually caged animals to evaluate the efficacy of these baits. Mortality for the various baits ranged from 7/10 to 10/10 for Polynesian rats, 3/10 to 8/10 for black rats, and 0/10 to 8/10 for Norway rats. All baits were most effective against Polynesian rats and, with one exception, least effective against Norway rats.

The variation among the three species in their susceptibility to zinc phosphide baits is due to at least two factors: differences in toxicity and differences in body sizes. The LD_{50}, or dose that is lethal to 50% of the animals tested, is 23 mg/kg body weight for Polynesian rats, 21 mg/kg for black rats, and 46 mg/kg for Norway rats. Thus, zinc phosphide is twice as toxic to Polynesian rats as to Norway rats. Adding to this difference is the greater size of Norway rats. A typical adult Norway rat weighs about 2.5 times as much as a typical adult Polynesian rat: 170 g (or about 0.4 lb) compared to 65 g (or 0.15 lb). Considering both toxicity and body size, a typical Norway rat must consume about 14 oat groats to ingest an LD_{50} dose, compared to only 3 oat groats for a typical Polynesian rat and 6 oat groats for a typical black rat.

Although oats are the most widely used bait in sugarcane fields, in our laboratory studies mortality for all three species was higher with the pelleted baits. Past formulations of pelleted baits have had limited effectiveness because of poor moisture resistance. Thus, the durability of the pelleted baits we tested should be evaluated before their field use is recommended under the wet conditions present in Hawaii.

Past field studies indicate that oat baits can reduce damage by 30-45%, especially where Polynesian rats are the predominant species. The low mortality achieved with the commercial oat baits in this study may have been due in part to marginal bait quality. We evaluated a zinc phosphide oat bait prepared in our laboratory with better quality oats. Mortality was similar to that with the two commercial oat baits and was 9/10 for Polynesian rats, 7/10 for black rats, and 3/10 for Norway rats. This indicates that the poor control of Norway rats with the commercial formulations was due to more than poor quality bait.

During all of the zinc phosphide tests we conducted, consumption for each species was greatest during the first day of the test and declined to 0 by the third day. Rats that consumed less than a lethal dose stopped eating rather than ingest more toxicant. This phenomenon, known as bait shyness, is a common problem with acute, or fast acting, rodenticides such as zinc phosphide, particularly if they have a distinctive taste or odor. To avoid bait shyness, acute baits must be formulated and applied in such a way that rats consume a lethal amount of toxicant in a single feeding. The history of rat control in Hawaii is replete with examples of acute rodenticides that were effective initially but lost their usefulness due to bait shyness. This includes previously used toxicants such as barium carbonate, strychnine alkaloid, 1080, and thallium sulfate, as well as zinc phosphide.

Another phenomenon that reduces bait effectiveness and increases bait shyness is neophobia, or a fear of new things. Rats have a natural tendency to limit their intake of unfamiliar foods such as rodenticides broadcast in their environment. Prebaiting with nontoxic bait similar to the rodenticide bait to be used helps to reduce neophobia and increase initial bait acceptance. In the 1930s and 1940s prebaiting was a standard practice in Hawaiian sugarcane fields, but few today follow this procedure. We recently initiated a study to evaluate prebaiting for enhancing consumption and efficacy of zinc phosphide oats. We plan to broadcast untreated oats in sugarcane fields 10-14 days before broadcasting zinc phosphide oats. We will monitor rat populations before and after each of four applications in each field and assess damage just prior to harvest. Yields also will be eval-

uated. If prebaiting enhances bait efficacy, it should result in higher mortality, less damage, and, ultimately, greater yields.

Cholecalciferol Bioassays

We also evaluate new or candidate materials for possible registration for use in sugarcane fields. Cholecalciferol, a rodenticide registered for controlling rats around buildings and structures, may be an effective alternative to currently registered zinc phosphide baits. The active ingredient, Vitamin D_3, is purported to be effective against rats but relatively safe for nontarget animals. In addition, cholecalciferol's reputed lack of secondary hazards should facilitate registration in Hawaii.

We conducted a series of bioassays to establish a range of concentrations for which cholecalciferol is effective against each of the three species. We offered individually caged rats oats treated with cholecalciferol at rates ranging from 0.035% to 0.75%. Mortality ranged from 6/10 to 10/10 for Polynesian rats, from 0/10 to 6/10 for black rats, and from 1/10 to 8/10 for Norway rats. At 0.075%, the concentration registered for commensal use, mortality was 10/10 for Polynesian rats, 6/10 for black rats, and 1/10 for Norway rats. In another series of bioassays, we offered the commercial pelleted formulation Quintox to individually caged rats during 3-day no-choice feeding trials. Mortality was 7/10 for Polynesian rats, 3/10 for black rats, and 4/10 for Norway rats. These tests indicate that cholecalciferol, at least at the concentrations tested, may be effective for controlling Polynesian rats but not Norway rats or black rats.

VARIETAL RESISTANCE

Another avenue of research being pursued at the Hawaii Field Station involves evaluating the relative susceptibility of various sugarcane varieties to rat damage. A long-term project recently was initiated to assess rat damage to standard and candidate varieties of sugarcane. The study is being conducted in conjunction with HSPA's FT-7 standardized yield comparison field tests. The ultimate objective is to identify and select for characteristics that confer resistance to rat damage. Possible selection factors include rind hardness, stalk diameter, degree and timing of lodging, resistance to souring, and potential for compensatory growth.

SUMMARY

The USDA/DWRC Hawaii Field Station conducts an ongoing research program to investigate the biology and impact of rats in sugarcane and to find cost-effective and environmentaliy safe methods of control.

*Reference to commercial products or entities does not imply endorsement by the U.S. government.