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The problem of rats in our Hawaiian sugar cane fields has been with us for a long time. Early records tell of heavy damage at various times on all the islands where sugar cane is grown. Many methods were tried to control these rats. Trapping was once used as a control measure, a bounty was used for a time, gangs of dogs were trained to catch the rats as the cane was harvested. Many kinds of baits and poisons were used. All of these methods were of some value as long as labor was cheap. Our present day problem started when the labor costs started up and the sugar industry shifted to long cropping. Until World War II cane was an annual crop. After the war it was shifted to a two year crop, three years in some places.

Depending on variety, location, and soil we raise 90 to 130 tons of sugar cane per acre, which produces 7 to 15 tons of sugar per acre for a two year crop. This sugar brings about \$135 dollars per ton.

This tonnage of cane is a thick tangle of vegetation. The cane grows erect for almost a year, as it continues to grow it bends over at the base. This allows the stalk to rest on the ground or on other stalks of cane as it continues to grow. These stalks form a tangled mat of stalks and dead leaves that may be two feet thick at the time of harvest. At the same time the leafy growing portion of the stalk will be sticking up out of the mat of cane ten feet in the air. Some of these individual stalks may be 30 feet long and still growing at the time of harvest. All this makes it very hard to get through a cane field as it is one long, prolonged stumble over and through the cane.

It is in this mat of cane that our three species of rats live. Two species are familiar to most people in the pest control field. Rattus norvegicus and Rattus rattus. In the latter species we include both the black rat and the alexandrine rats, their habits seem to be the same in Hawaii. Our third rat is the Polynesian rat, Rattus exlans, locally called the Hawaiian rat. This is a small rat, the average length head to tip of tail is nine inches and the average body weight is 65 grams. It has dark brownish fur like the alexandrine rats, and a grey belly. It is found in Indonesia, on most of the islands of Oceania and in New Zealand. All three rats live in our cane fields and the brushy and forested portions of our islands. The norway and alexandrine rats are found in and around the villages and farms, the Polynesian rat is only found in the fields and waste areas.

The actual amount of damage done by rats is small, but destruction they cause is large. The rats gnaw through the rind of the cane stalk and eat the soft juicy and sweet tissues inside. They will hollow out one to several nodes per stalk attacked. The effect to the cane stalk is like ringing a tree. After this attack the stalk above the chewed portion usually dies, and sometimes the lower portion too. If the rat does not eat through the stalk the cane stalk could go on living and producing sugar at a reduced rate. Generally an injured stalk does not last long. Disease and souring organisms get in the

injury and kill the stalk. And if this isn't enough, some insects are attracted to the injured stalk and will sometimes bore in and kill it. An injured stalk of cane doesn't have much of a chance.

A rat may only gnaw out six inches of a 30 foot stalk and the whole stalk will die. If the rat only destroyed what he ate we could ignore them but they cause the death of too much cane. This dead, dying, and souring cane cause several direct and indirect losses. First we lose the sugar that the cane would have produced. We harvest all of our cane mechanically so we haul the dead and souring cane to the mill where we have to grind it with our good cane and the bad cane reduces the purity of the sugar juices we squeeze from the cane. Rats reduce our income and run up our overhead.

The question is often asked what our rats cost us. We do not have any exact figures but we do have some good estimates. At times the rats will damage 10% of the cane, this averages out to about one ton of sugar per acre, and this ton of sugar is worth about \$135 dollars. To this add the cost of harvesting, hauling and crushing the rat damaged cane. At times the damage may go up to 20 to 30 per cent so it is easy to see that rats can cost money.

Total costs of rat damage to the industry are hard to make. We have 26 plantations but not all of them have rat problems. Generally speaking the dry plantations that have to irrigate their cane do not have a rat problem, the wet plantations do. On wet plantations the rat population varies up and down, influenced by factors that we can't detect. In some places the rat problem is chronic. So, taking these factors and some others into consideration, we lose a million plus dollars in income to rats this and every year, and this is a conservative estimate.

With our shifting and fluctuating rat populations, our problem is to find out where the rats are located. We have a standardized trap census system. Snap traps are set out at 50 foot intervals through the area to be checked. The traps are read each morning for two mornings and the total catch is averaged for the two nights that they were set. If no control program is being used in the area and the average index of rats caught is over 5% a control program is needed. If a control program is in progress, and the index is over 2%, the control efforts should be stepped up.

To estimate actual damage some plantations cut and pull a standardized sample of cane from the field. In this way they can actually measure the amount of damage that the rats are doing. But the samples are few since they are difficult to take and the men do not like to do this kind of work.

The main purpose of these sampling methods is to save baiting areas where there are no rats.

Our control is methods based on anti-coagulant treated rolled oats. Warfarin, Prolin, Ratafin, Fumarin, and Pival are some of the anti-coagulants used here in, Hawaii. The only other bait used from time to time as conditions seem to warrant is thallous sulfate treated rolled oats. But this only works well when prebaiting is done with unpoisoned rolled oats for a few days before the poisoned oats are put out.

Our baits are placed in feeding stations around the edges of the fields and in the fields where possible. Generally speaking a cane field is virtually impassable without a lot of effort after it is a year old. To add to my previous description of a cane field add two more nasty factors. The edges of the sugar cane leaves will give a very annoying cut if they are drawn across your skin, and some cane varieties have brittle hairs like glass wool on them and the effect on your skin is annoying to say the least. So workers hate to go into cane fields and if they do, they can place so few stations per day that their efforts cost too much for the amount of rat control gained. Where there are roads through the fields or irrigation ditches, stations are placed.

We use three types of bait dispensers here in Hawaii. The one used longest is a temporary station made of cardboard treated with wax. This has been cut and crimped in such a way that it can be stapled together to form a covered bait pan that looks like a miniature covered wagon without wheels. These cost about 6¢ each, hold about one half pound of bait and last about one to three months depending upon the climate where they are put out. To extend the life of these stations we are developing a similar station made out of a plastic coated paper.

Another station is the HS-PA inverted "T" bait dispenser. This is made of plastic pipe or thin tubes of tinsplate. The vertical tube holds the bait and it feeds out through both ends of the horizontal tube that rests on the ground. The station is held vertical by driving a stake into the ground to the same height as the vertical tube and putting a tin can over both. Over here, all joints of the station must be water tight, some of our plantations get almost 100 inches of rain per year.

The third is an "L" shaped station formed of plastic pipe. It is heated, crimped, and bent to form the "L". It works much the same as the inverted "T" but has only one feeding opening.

The last two stations can hold up to five pounds of oat baits, the total amount depends on the length and diameter of the vertical tube. These stations are priced at about a dollar but they are durable and last for years.

The "L" and "T" stations, have one other advantage, they only have to be checked every one or two months and the bait is there all the time. The waxed cardboard stations have to be replaced when they give out, so they are checked and refilled every ten to fifteen days. These stations are placed in and around the edges of the cane fields 75 to 100 feet apart. The actual spacing depends on individual plantation practice.

The actual time of placing the stations in the field depends on plantation practice and the age of the cane. Rats don't come into the cane fields until the sugar cane is about one year old. Some plantations place their stations in and around the fields then, others keep the stations filled all the time through the full life of the crop. The latter method is the best since it keeps the residual rat population at a low level, this makes control cheaper and easier.

With our baits in the sugar cane fields for a long period of time, our high humidity and warm temperatures cause molding. We tested many of the mold

inhibitors that are used in food products. They didn't work well enough. We finally settled on paranitrophenol. At a level of 3/10 of one per cent we get very good mold control. This preservative level inhibits some rats from feeding on the baits, but many more rats will not feed on moldy bait.

Birds are a problem on all plantations. They can empty one of the waxed cardboard stations in one day, a "T" or "L" station with five pounds of anti-coagulant bait in a week. The anti-coagulant baits do not kill our birds, they just attract big flocks of them. It costs money in bait consumed and manhours to put the bait out to feed just birds, and there is no bait for the rats. We tried to make bird proof stations, they were in a large measure rat proof too. The answer is to conceal the stations well in the cane or brush where the rats are living, but this makes them hard to find when it comes time for refilling.

Another method for localized short term rat control in Hawaii is the double torpedo. They are hand made by twisting about 1/2 teaspoonful of thallous sulfate treated oats in a square of wax paper. Then you place a teaspoonful of unpoisoned oats in a larger piece of wax paper, place the poisoned oat packet on top and twist all together. This makes a tailed waxed paper ball about the size of a walnut. These are thrown into waste areas and field edges at the time of harvest. Essentially what you have is a prebaited packet.

In our search to improve our methods we have looked into many baits. Our problem is to please the palates of three species of rats. The anti-coagulant baits get rid of the norway rats rather quickly, the alexandrine rats fairly well, but do poorly on the Polynesian rats. The last rat has become a major problem. We are trying to develop a bait to suit the latter's habits and taste. This would be a bait that could be placed in the feeding stations or dropped inside the cane fields from a plane, the gulchs that border many of our cane fields, and the native forest in some areas. Some biscuit type commercial pet foods looked good, they stood up well under our wet conditions and were well taken by the rats. They became unavailable when some of the pet food makers did not want their foods used as rat baits or some changed their formulas to ones our rats didn't like. We don't have such a bait at the present time and we are still looking for one.

After years of work we have found, like everyone else in the field of rodent control, that there is no easy way to kill rats. If everything is taken into consideration, we have a harder job to control our rats than most people. We have found that an intensive rat control program using the methods and the materials that we advise will give adequate control on our Hawaiian sugar cane plantations.

Such a program takes good hard working men, and they are becoming hard to get. That is one reason we are looking for good baits to be placed by air. One other problem that all people in this business have is public relations, we hope that more effective poisons that are specific on rats can be developed, for it looks like the uses of poisons will become more restrictive in the future.