March 1990

NATIVE HETEROMYID RODENTS AS PESTS OF COMMERCIAL JOJOBA

Rex O. Baker
Department of Plant and Soil Science, California State Polytechnic University, Pomona, California

NATIVE HETEROMYID RODENTS AS PESTS OF COMMERCIAL JOJOBA

REX O. BAKER, Department of Plant and Soil Science, California State Polytechnic University, Pomona, California 91768.

ABSTRACT: After crop losses of 5 to 60% were noted on two 500-acre Jojoba (Simmondsia chinensis) plantings in a desert area of southern California, a study was conducted to identify the animals responsible. Various population census and pest-identification techniques were utilized. Four native rodents of the Heteromyid family, not previously known to be pests of Jojoba, were found to be present in sufficiently high numbers to cause severe economic crop loss. The Bailey's pocket mouse (Perognathus baileyi) was the only rodent previously known to survive on Jojoba beans as a food source. A natural chemical, cyanogenic glucoside, was thought to be the plant protective material responsible for previous failure of rodents to survive on Jojoba in field and laboratory studies. Most of the rodent species found in this investigation were also observed in the laboratory and survived on a ration consisting almost entirely of Jojoba beans for 6 to 10 months. The ability of these rodents to survive on Jojoba beans suggests the possible co-evolutionary development of detoxification mechanisms. Cultural and population reduction practices were recommended and implemented following this study resulting in greatly reduced crop losses.

Proc. 14th Vertebr. Pest Conf. (L.R. Davis and R.E. Marsh, Eds.)
Published at Univ. of Calif., Davis. 1990.

INTRODUCTION

The purpose of this study was to determine which native animals were responsible for losses of from 5 to 60% of the seed crop from two large Jojoba (Simmondsia chinensis) plantations, and to develop an animal damage reduction program to reduce future losses to acceptable levels. The plantations were located near Niland, California, in a lower Sonoran environment consisting of sandy, sandy gravel and sandy loam soils. The Jojoba plantings were adjacent to native flora consisting of mesquite, creosote bush, desert holly, lightly scattered grasses, and numerous other lower desert plants. No native wild Jojoba was observed in the nearby plant community. Jojoba is an evergreen deciduous shrub that grows throughout the southwestern United States and northern Mexico. It is found in coastal areas, interior valleys, and especially in the Sonoran Desert-type areas. The seeds of Jojoba are harvested for extraction of a unique liquid wax. The material is often called oil even though it does not contain oily chemicals typically found in seed oils.

Jojoba was planted commercially on thousands of acres in Southern California and Arizona in the early 1980s as the "oil investment of the 1980s." The seeds were thought to have been protected by a natural chemical, 2-cyanomethylenecychohexyl glucoside, simmondsin, which animals-especially rodents-would refuse to eat (Ellinger 1973, Sherbrooke 1976, Kuepper 1981). Many studies of native rodent communities in similar Sonoran Desert areas, where Jojoba is a native plant, had only associated one rodent, Bailey's pocket mouse (P. bailey), with the plant (Rosenzweig and Winakur 1969, Brown 1973, Sherbrooke 1976, Rogers 1978). Sherbrooke (1976) studied the utilization of Jojoba seed by three pocket mouse species and the Merriam kangaroo rat (Dipodomys merriami) and found that only Bailey's pocket mouse would eat the Jojoba seed and survive for more than a few days. The other three species sampled the beans and then refused to eat until starvation occurred. Due to these and other studies, growers felt rodents and other pest animals held little threat to the crop.

Poor Jojoba crop prices and other economic factors led to elimination of harvest and eventually to termination of irrigation and other cultural practices on most plantings in the mid-1980s. This lack of proper management contributed to the build-up of rodents in the plantations. When prices for Jojoba seed products rebounded in 1988, growers prepared to harvest Jojoba fields that had not been totally abandoned. Plants were skirt pruned, watered, and the ground was smoothed for the anticipated harvest. According to crop production managers for the plantings subject to this study, a good crop of beans (seeds) were on the plants and harvest beds in June of 1988. As harvest neared in July, the crop suddenly began to disappear. Before harvest could be accomplished, from 5 to 60% of the crop had been removed from numerous plots. The beans disappeared so rapidly that growers began to suspect that the crop had been harvested by the wrong crews.

The nocturnal behavior of many rodents, especially those dwelling in lower Sonoran Desert habitats, often delays detection of the animal until populations reach high levels or crop damage becomes apparent. Rodents like the Heteromyid rats and mice are often found in high enough populations to pose a potential threat of substantial economic losses to high-value crops. Those crops that have seeds, nuts, or other products suitable for hoarding in burrows or other cache areas are the most susceptible to damage due to the hoarding habits of these opportunistic rodents. Hoffmeister and Goodpaster (1954) found as many as six Heteromyid rodent species co-existing on as little as 1 acre and all of them were seed eaters; and as Sherbrooke (1976) and others have found, the pocket mice and kangaroo rats cache large amounts of seeds. Sherbrooke found as many as 32 Jojoba seedlings emerging from one burrow following a rain, and others buried in shallow areas near where they can defend the food. Kangaroo rats are often found in densities of 10 to 12 per acre but may be found in a highly desirable area, such as seed crops, at 35 per acre. Pocket mice are found from as few as 4 to 5 and as high as 20 per acre (Bateman 1967).

METHODS

Site Evaluation

Field plots were inspected for plant damage, seed loss from the plants and the soil area under the plants, as well as gnawing on the irrigation system. Survey patterns were planned by going over plot maps (Figs. 1 and 2) with irrigators and other employees to identify known problem areas, and to identify other suspect or high-risk areas such as dry washes, rubble piles, old equipment storage yards, or areas adjoining heavy brush. The two sites were known as the California Jojoba Plantation (CJP) with about 500 acres, and the WFC Plantation with about 400 acres. The size of the project and limited time available confined the focus of the study to the most important problem areas and to finding solutions to the crop loss problem rather than a more comprehensive study of the ecology of the animals involved. The entire perimeter of the plantings and all interior roads were smoothed with a drag to prepare for observing fresh track, trail, and scat sign each of the 3 survey nights. Additional tracking patch areas were placed at various points within the two plantations. Live traps were placed throughout the plantings and adjacent to trails revealed by the drag lines with emphasis being placed on heavy activity areas. Twenty-five live traps of four different sizes from 3 x 3 x 9-in Sherman traps to 10 x 12 x 24 in. Tomahawk traps were reset and checked early each morning and evening. Traps were baited with Jojoba seeds and oat groats. All animals captured were identified and released except for the last morning when eight animals in good condition were kept for confirmation of identification and further study.

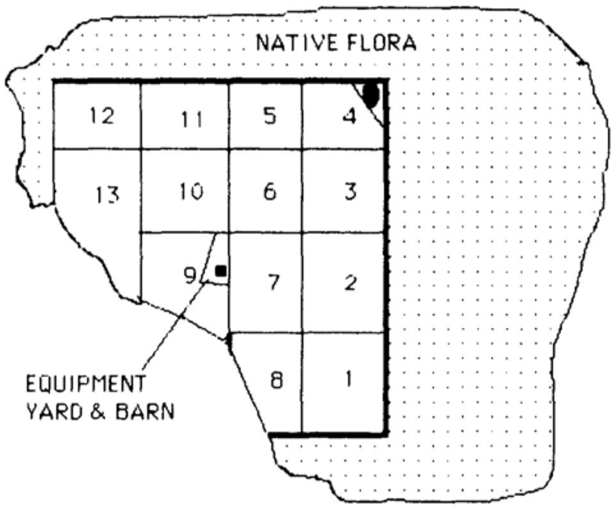

Figure 1. California Jojoba plantation.

Bait preference plots were placed in 27 locations throughout the plantings. Oat groats, rolled barley, rabbit pellets, cracked corn, chicken scratch, a mix of canary and rape seed, whole oats, and safflower seeds were placed in equal amounts in piles in random order nightly for the 3 nights. Each bait was also broadcast in plots and then evaluated by placing a grid over the area and counting bait in four random square-foot areas.

Infrared passive receiving devices, (MD1) units developed by Vergil Duncan and Dale Kaukeinen, were placed near active appearing runways and burrows (Kaukeinen 1979). Eight of these devices were used near kangaroo rat and other rodent burrows that were closed when observed in the daytime to verify activity that might otherwise not be evidenced by tracks due to windy conditions and the nocturnal nature of the animals. Some of the units were buried adjacent to burrows to reduce any neophobic reactions by the animals (Baker 1985).

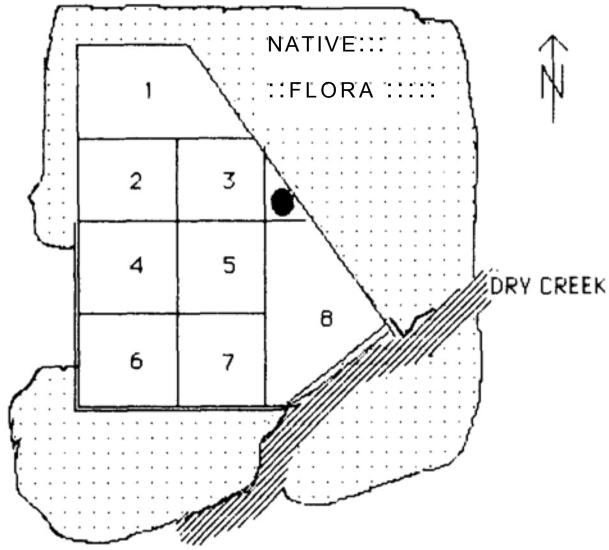

Figure 2. WFC Jojoba plantation.

In addition to the census methods discussed, night spotlighting and daytime wildlife observations were made in the plantings and adjacent wildland areas. Several burrow systems were excavated to identify food caches, bait preference, and habitat behavior.

Laboratory Study

Two or three specimens of each species of Perognathus found were returned to the laboratory at California State Polytechnic University, Pomona, for confirmation and identification and to conduct further food preference testing, and to observe the ability of these animals to survive on Jojoba seed. One individual of each species was separated and fed lab chow, oat groats and water ad libitum, while one or two of each of the three species were offered Jojoba seed, oat groats and rabbit pellets along with water for 10 days. At the conclusion of the first study designed to confirm bait preference data gathered in the field, control animals were maintained on non-Jojoba diets and test individuals were maintained on Jojoba and oat groats for several months and then on Jojoba only for about 6 months.

RESULTS

Site Evaluation

California Jojoba Plantation-Light-to-heavy Jojoba bean removal had occurred in many areas of the plantation. Current feeding was noticeable in trace-to-light amounts only, indicating that much of the damage had occurred earlier. This was verified by the presence of many old inactive burrows, old rodent carcasses and low trap rates in most of this planting. The rodent carcasses were the result of some prior spot-baiting control efforts by the grower. Debarking of lower branches and light foliage feeding was also indicative of low populations. Irrigation pipe had also been damaged by the burrowing mice and rats and predators, such as badgers and coyotes, digging after the rodent prey.

Burrow excavation in areas with active burrows revealed Jojoba bean caches ranging in size from a handful to several pounds.

Tracks in the drag areas around the field indicated that the pocket mice and kangaroo rats causing damage were established in the field-not migrating nor otherwise moving in and out of the field (Fig. 3). Cottontail rabbits (Sylvilagus auduboni) and jackrabbits (Lepus californicus) were residing in the brush outside the field, especially near checks 11 and 12 where they had fed on weeds, an occasional Jojoba bean, and Jojoba foliage.

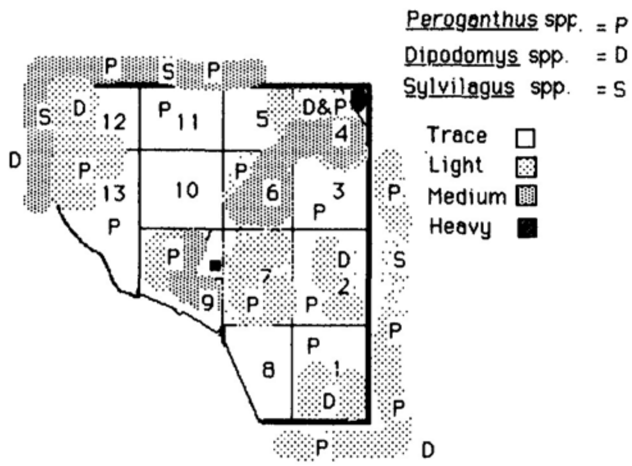

Figure 3. California Jojoba plantation small animal population survey results.

Trapping revealed the presence of two species of pocket mice, long-tailed pocket mouse (P. formosus) and spiny pocket mouse (P. spinatus). The pocket mice were not separately identified to species in the field and for discussion will all be treated the same. The pocket mice were captured at the rate of 15 per 100 trap sets in checks 4, 6, and the east side of #9. The infestation level in these checks appeared to be low to medium. Other checks trapped had less than 5 per 100 trap sets. Although deermice (Peromyscus spp.) carcasses were found and live specimens were seen near the borders of checks, none were trapped indicating a very low population. Kangaroo rat (Dipodomys spp.) burrows were observed in checks 1, 2, 4, and 6, in very light numbers. However, none were trapped even though MD-1 actimeters indicated burrows were active each night.

WFC Plantation-Jojoba beans were currently being removed from the field in light-to-heavy amounts in numerous checks but especially the southeast checks, 5, 7, and 8 (Fig. 4). Checks 4 and 6 also had current light-to-medium damage. Debarking of plants was much more noticeable on this plantation and could be observed by flagging (dead branches) while walking or driving the field. Several plants had been damaged by Botta's pocket gopher (Thomomys bottae) in check #8. More damage of irrigation pipe was noted in check 8, probably due to greater numbers of pocket gophers and kangaroo rats.

Only two kangaroo rat burrows were partially opened in this area and both revealed Jojoba and oat groats from our bait preference plots.

Tracks in the perimeter drags indicated rabbit and small rodent movement into checks #7 and 8 from the bushy bank and creek area in addition to the resident population.

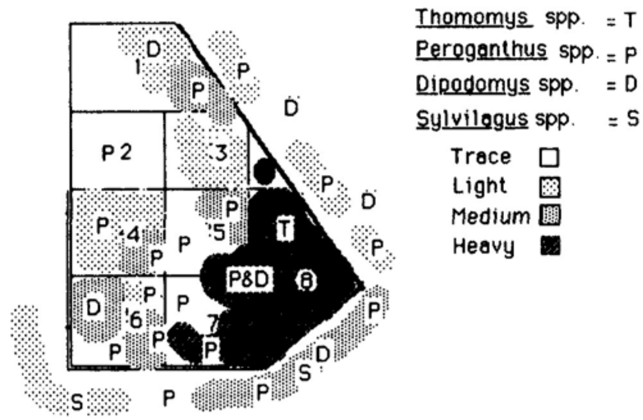

Figure 4. WFC Jojoba plantation small animal population survey results.

Spiny pocket mouse and desert pocket mouse (P. penicillatus) were captured at a combined rate of 25 per 100 trap sets in check 7 and 8. The desert kangaroo rate (D. deserti) was trapped at the rate of 10 per 100 trap sets. This number is lower than expected for the amount of fresh burrow sign-one for every 2 to 3 plants, and the Md-1 actimeter counts which indicated from 40 to nearly 1000 movements per night.

There are often two or three burrow entrances for each adult kangaroo rat. This rat is known to forage up to 200 to 300 feet, but where populations are high the range would be expected to be much smaller, especially due to the solitary existence, strong defense of the burrow systems and food caches, and aggressive behavior when in tight areas.

Bait Preference Plot Results

Bait piled in plots frequented by rats and mice had the following preference results expressed as percent of total consumption: Oat groats 31%, rabbit pellets 19%, cracked corn 14%, canary and rape seed mix 12%, white oats, rolled barley, and safflower all under 10%, each with whole oats being the least preferred. Bait piles frequented by rabbits around the field perimeter of the plantations had rabbit pellets as the preferred bait and rolled barley as the second best. Broadcast bait preferences in rat and mouse plots were as follows: Rabbit pellets 50%, rolled barley and oat groats about 15% each, and all other baits below 8% acceptance. Several plots attracted harvester ants and the data from these plots were deleted.

Laboratory Study Results

One control mouse died within 2 months, but all mice on Jojoba remained in good health. When fed Jojoba seed and oat groats, the total consumption/night ranged from 1.4 g to 2.5 g with oat groats accounting for 80 to 90% of the diet; when only Jojoba was fed, the consumption stayed at about the same level (1.4 to 2.5 g). When Jojoba was removed for several weeks and only oat groats and lab chow was available, consumption declined about 20 to 30%; when the Jojoba seeds were re-introduced, all the mice immediately began caching the seeds and some began eating them even though it was daylight. They were previously rarely observed out of the nesting chambers in the daytime. As a final study, all but the control animals were kept on only Jojoba seed, and all three species (P. spinatus, P. formosus and P. penicillatus) survived for 6 to 10 months before some were lost to handling accidents and cold weather when the heat was accidentally left off for several days in unexpected very cold weather. The control specimens were also lost at the same time.

PEST MANAGEMENT PROGRAM DEVELOPMENT

Reproduction of these heteromyids often occurs two or three times a year, with two to five young per litter when food and desirable harborage is available. Burrow systems of most of the pocket mice and kangaroo rats appear to be solitary except for mother families, where young and mother occupy the same burrow until independence (Iverson 1967). Therefore native brush should be kept cleared for 20 or more yards around the field and between crop rows by disking, which should reduce feed and disturb burrows and allow for easy detection for new burrows. To reduce available food sources Jojoba seed should be harvested even in marginal economic periods to reduce the potential for increases in damaging pest animal populations. Harvest should also be initiated as soon as possible due to the increased pressure from native animals, as the hot dry climate decreases food and water availability in native flora areas. Mechanical, cultural, and chemical management techniques may be of assistance in stimulating an early harvest.

Heavy plastic fencing to exclude rodent pests does not appear to be cost effective due to climate and the presence of large animals which both often cause rapid deterioration of the fences. Quarter-inch hardware cloth (36 inches wide) with a 6-inch metal band at the top and buried 6 to 12 inches deep in the soil would assist in excluding both pocket and deer mice. Windblown sand and weeds would be expected to drift against the fence and in time decrease its effectiveness. Although a control option, wire-mesh fences are not thought to be cost effective at this time.

Pest Animal Detection

Irrigators and other field personnel should be provided forms to report observance of rodents, burrows or crop damage and be encouraged to report at least every 2 weeks on rodent conditions. They should be trained to recognize fresh burrows, plant gnawing (bark stripping) or other rodent sign. Irrigation valve locations often serve as "pit traps" and similar devices could be placed throughout the fields as detection devices if burrowing is not detectable. Live or dead rodents would be found in these pits easily.

Pest Animal Population Reduction

Zinc Phosphide (1%) oat groat bait was applied at the rate of one teaspoon lightly scattered in runways near active burrows. The bait was used after prebaiting with a tablespoon of lightly crimped oat groats scattered every 20 to 30 feet in active runways near burrows in every third row. Only areas with light or heavier populations were treated and bait was only applied where prebait was well accepted.

The bait application was made prior to preparation of the soil for harvest, about 60 days prior to harvest. The bait was applied using ATC-type vehicles with fertilizer side-dressing equipment that was calibrated to be activated by the rider to apply the proper amount of prebait and bait when needed to the burrow areas, which were usually under the plants.

CONCLUSION

The occurrence of four different Heteromyid rodent species co-existing in native wildland areas is not unusual but the finding of this scenario in a commercial crop was not expected. However, the most unique fact revealed in this study is the occurrence of the desert, spiny, and longtailed pocket mice and the desert kangaroo rat, which have apparently been surviving on Jojoba seeds to the point of being severe economic pests, when they have not previously been known to survive on Jojoba seed.

One may conclude that, as Sherbrooke (1976) stated in previous studies, the animals not surviving on Jojoba seed may have had an inability to detoxify the cyanogenic glucoside in Jojoba seed due to inexperience rather than the absence of a detoxification mechanism. This hypothesis would seem to be have been correct since this field and laboratory study illustrated other Heteromyids could develop the same detoxification ability as P. bailevi.

The application of (1%) zinc phosphide oat groat bait and improved cultural practices resulted in reducing Jojoba crop losses to rodents in 1989 to less than 2%.

ACKNOWLEDGMENT

Financial support and cooperation was provided by California Jojoba of Redwood City, California, WFC Jojoba Group of Niland, California, and Mr. Don Barioni of Golden State Management. The author would also like to thank his dedicated son, Brad, who worked tirelessly at my side for 18 to 20 hours a day during the field trials, and Rex E. Marsh for his valuable advice and vast resource of knowledge, and for maintaining and sharing a tremendous collection of references.

LITERATURE CITED

BAKER, R. O. 1985. Field efficacy study of bromadiolone oat groat bait (0.01%) on Spermophilus beecheyi by spot bait application. Chempar Chemical (Unpubl.).

BATEMAN, A. C. 1967. Home Range Studies of a Desert Nocturnal Rodent Fauna, Ph.D. Thesis. University of Arizona, Tucson.

BROWN, J. H. 1973. Species diversity of seed-eating desert rodents in sand dune habitats. Ecology 54:775-787

ELLINGER, C. A., A. C. WARES, JR., and R. E. LUNDIN. 1973. Simmondsin, an unusual 2-cyanomethylenecyclohexyl glucoside from Simmondsia, California. J. Chem. Soc, Perkin Trans. 1:2209-2212.

HOFFMEISTER, D., and W. GOODPASTER. 1954. The mammals of the Huachuca Mountains, southeastern Arizona. Ill Biol. Monogr. 24: 1-152.

IVERSON, S. L. 1967. Adaptations to Aid Environments in Perognathus parvus. Ph.D. Dissertation, University of British Columbia.

KAUKEINEN, D. E. 1979. Field methods for census taking of commencal rodents in rodenticide evaluations. Pages 68-83 In: Vertebrate Pest Control and Management Materials, ASTM-STP68 (J.R. Beck, ed.). American Society for Testing and Materials, Philadelphia, PA.

KUEPPER, T. A. 1981. Jojoba Oil Investment of the Eighties. Desert Pacific Jojoba, Oxnard California, pp. 60-61.

ROGERS, J. G. 1978. Repellents to protect crops from vertebrate pests: Some consideration for their use and development. American Chem. Soc. Symposium Series No. 67, Flavor Chemistry of Animal Foods, pp. 150-165.

ROSENZWIEG, M.L., and WINAKER, J. 1969. Population ecology of desert rodent communities: Habitats and environmental complexity. Ecology 50:558-572.

SHERBROOKE, W. C. 1976. Differential acceptance of toxic Jojoba seed by four Sonoran Desert Heteromyid rodents. Ecology 57:596-602.