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Abstract: The National Wildlife Research Center, formerly known as the Denver Wildlife Research Center (DWRC), collaborated with telecommunications and energy industries to evaluate cable resistance to pocket gopher damage for 29 years (1966 to 1995). Recently, DWRC's evaluation process was transferred to private contract laboratories. This review summarizes the chronology of key investigations and procedures that were used and first published on cable resistance to rodent damage. The longstanding cooperative goal of both DWRC scientists and industry engineers was the development of rodent-proof, buried cables and ducts. Even though most data collected were proprietary, extensive laboratory testing at DWRC provided data both for eliminating cables that demonstrated a high degree of vulnerability to pocket gopher damage and selecting candidate cables for field tests and further development. In the future, this area of wildlife damage research will expand as new fiber-optic cables are subjected to the same scrutiny as their metallic predecessors.

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Key Words: cable resistance, *Geomys bursarius*, Great Plains, pocket gophers, protocol

Although not well quantified, the damage caused by the plains pocket gopher (*Geomys bursarius)* to buried wire and cable costs the communications industry hundreds of thousands of dollars annually during the 1940s. Bell Laboratories began studying the effects of gopher damage to buried cables at their Chester, New Jersey laboratory during World War II. Based on these studies, cable engineers began incorporating thin steel tapes in the armor or sheath as a defense mechanism to protect some cables. Later, Bell Labs found that 0.01-inch thick copper tape or its equivalent in the armor or sheath would effectively resist gopher penetrations (Connolly and Cogelia 1970). This paper is a chronological review of the main studies that have occurred since Bell Labs first sought to develop cable resistance to rodent damage in the 1940s.

POCKET GOPHERS

Biology

The pocket gopher family (*Geomyidae*) consists of small to medium-sized American rodents (head and body are~5 to 9 inches) that have external fur-lined cheek pouches used in food gathering (Hall and Kelson 1959). Their prominent incisors are always exposed, allowing the pocket gopher to cut roots and use their incisors for digging without eating dirt (Grinnell 1923). Their large curved front claws are very efficient for digging, and are subject to great wear but exhibit compensatory growth (Howard 1953a). Pocket gophers are fossorial herbivores (Vaughan 1966) and are seldom seen above ground (Hill 1937). They prefer succulent plants in their diet, but feed predominantly on grasses (Miller 1964). Gophers are solitary and highly territorial, except during their spring breeding season when plural occupancy of burrow systems may occur (Hansen and Miller 1959, Vaughan 1962). Various species of pocket gophers have influenced the western rangelands since the Pliocene, with damage varying as a function of population size, season, habitat, and land use practices (Turner et al. 1973). Characteristic fan-shaped mounds indicate their presence and are produced by earth pushed out from their subterranean tunnel systems (Fagerstone and Ramey 1996). They never leave their burrows open for long and prefer a sealed burrow system, often with a round earthen plug indicating the last of the dirt to be pushed to the surface. Pocket gophers have caused great economic loss to ranchers, foresters (Chase et al. 1982), farmers (Burt and Grossenheider 1964), and buried cable (Howard 1953b).

The plains pocket gopher is one of the most widely distributed pocket gophers (Merriam 1906) and usually inhabits sandy and silty soils from the Rocky Mountains east to the Mississippi River and from Canada to southern Texas (Foster and Stubbendieck 1980). It inhabits grasslands, pastures, alfalfa fields (Luce et. al. 1981), and roadside and railroad rights-of-way. It is distinguishable from other species by 2 distinct grooves down the front of each upper incisor (Case and Sargeant 1982).

Geomyidae have evolved a rapid incisor growth rate; however, it is not essential for gophers to gnaw on hard objects to keep their incisors worn (Howard and Smith 1952). Howard and Smith (1952) observed captive pocket gophers grating their upper and lower incisors to keep them sharp, preventing undue growth.

The plains pocket gopher was selected for cable evaluations at DWRC because of the following factors: (1) it is widely distributed on the Great Plains from northern Minnesota to the gulf coast of Texas (Hall 1981), (2) it has a powerful upper body with large strong claws on the forefeet (Hall and Kelson 1959), (3) it shows rapid incisor growth that facilitates digging or gnawing (Howard and Smith 1952), and (4) it has been identified as a major cause of damage to buried communication and power cables (Howard 1953b, Connolly and Cogelia 1970).

CABLE RESEARCH

The 1940s and 1950s

The Long Lines Department of the American Telephone and Telegraph Company requested that DWRC examine gopher-damaged lines between Omaha, NE and Cheyenne, WY in 1943. The unpublished reports from DWRC revealed that gophers had stripped the plastic and jute coverings off cables in sections as long as 10 and 12 feet (Connolly and Landstrom 1969). Early results of pocket gophers gnawing on electric cables were published by Howard (1953b). Various manufacturers and users of cable supplied samples for testing and Howard assessed the gopher's ability to penetrate different types of insulation. With ample food available at all times, Botta's pocket gophers (*Thomomys bottae*) were confined individually to one section of the cage, blocking the passageway to the remainder of the cage with a six-inch sample of cable. Howard was able to determine that the gophers were unable to penetrate metallic insulating armors of interlocking galvanized steel, an overlapping stainless steel band, aluminum basket weave, and 1/8-inch and 1/4-inch hardware cloth. The gophers rapidly penetrated all non-metallic armored cables including: cotton braid with asphaltic saturant, asbestos with asphaltic saturant, 60% natural rubber, polyethylene, polychloroprene, thermoplastic, vinyl, glass braid over silicone, and glass yarn. Howard (1953b) warned that laboratory tests do not guarantee that potential insulators identified in the lab will be safe when buried in the field; however, he believed that these studies did demonstrate that this species may have the ability to penetrate all non-metallic and soft metallic kinds of armor. In addition, he felt that the inclusion of poisons or repellents in the insulating materials did not appear to be practical because of: hazards to factory employees and installation crews, leaching of these materials into the moist soils, persistence of pesticide's properties over time, and the behavior of gophers to avoid getting any of the treated material in their mouth while gnawing on the cable. Howard also believed that the damage to buried cable resulted from an animal's efforts to remove an obstruction in its tunnel system. He tested cable ≥ 1mm, and found that gophers seemed to exert less pressure possibly because they can make contact with only 1 set of incisors rather than 2 (i.e., all four). With this information, Howard felt that an insulation such as is found in 3/16-inch hardware cloth mesh should make an armor adequate to resist gopher attack on cable ≥ 1mm.

The 1960s, 1970s and 1980s

Materials, economic conditions, cable and wire designs had changed greatly by the 1960s (Mailen and Stansbury 1966; Tigner 1968), and Bell Laboratories decided to reevaluate the effectiveness of old and new cable designs in laboratory experiments. They sought cooperation from DWRC administrators and scientists in the 1960s, thus beginning the DWRC years of dedicated research to the cable research program. Initially, Anthony and Tigner (1967) examined gnawing damages by Norway rats (*Rattus norwegicus*) and mice (*Microtus spp.*) in a DWRC laboratory with repellents (Table 1). They found that 4 inch x 4 inch burlap bags treated with BioMet 12 containing lab chow repelled mice, but did not repel Norway rats. Tests in the field with BioMet 12 in 1966 and 1967 were on: AZ-cotton rats (*Sigmodon spp.*) and wood rats (*Neotoma spp.*); NM-wood rats, MA-meadow mice (*Microtus spp*), and the Panama Canal zone (tropical rodents-spp. not specified). The hand-coated cable placed in the field studies in the states did not fare as well as the mechanically-coated cable sent to the Panama Canal zone. Connolly and Landstrom (1969) reported that the DWRC designed and conducted laboratory exposure tests of new designs of cable for Bell Laboratories using a damage rating system (Table 1). Subsequently, Connolly and Cogelia (1970) reported results of tests having several primary objectives: (1) to measure the susceptibility of both present and proposed sheath and armor designs, (2) determine the minimum thickness of armor needed to prevent penetration, and (3) define how cable and wire diameters relate to gopher damage (Table 1). Connolly and Cogelia (1970) found that the gopher's natural tendency to chew things made it unnecessary to place incentives behind the barrier. The individual cages they used to house the plains pocket gophers were made of heavy gauge steel wire fabric about 7 x 7 x 11 inches. A steel plate with a 2-inch-diameter hole divided the cage into 2 sections. Cable and wire samples were mounted vertically across the hole so that the gopher had to chew its way through a cable if it wanted to get from one section into the other. Food was provided ad libitum. A 5-category rating scheme was used to evaluate the damage after exposure, ranging from no damage to complete severance of the armor and the conductors. These authors also made additional observations on pocket gopher biology, indicating that each incisor grows as much as 12 inches per year, and if the gopher does not grind these incisors down to a tolerable length, the overgrown incisors could interfere with eating. Also, because the incisors are located outside its mouth, it can chew anything without ingesting it, thus probably making the use of toxicants or repellents on the cables ineffective.

Connolly and Cogelia (1970) also found that of the plastic materials tested only glass-reinforced epoxy offered protection. Plastic materials incorporating rodent repellents were not effective, and cables > 2.1 inches in diameter appeared to be safe from the plains pocket gopher. Finally, although armored cables offered some degree of protection, corroded armor was less resistant to gopher penetration. The laboratory studies were augmented with field studies conducted at Washita National Wildlife Refuge in Oklahoma. Initial results indicated that all organic materials except fiberglass were easily damaged by the pocket gopher.

Cogelia, LaVoie, and Glahn (1976) examined material susceptibility to rodent damage using rodent biting pressure and chewing action to understand the reasons for sheathing failure. No previous studies dealt with biting pressure, gnawing frequency, or failure modes of cable designs (Table 1). Tests were conducted using a gnathodynameter noting the different positions of the incisors of the gray squirrels (*Sciurus carolinensis*), plains pocket gophers, and Norway rats on the bite-bar. Cogelia et al (1976) tested 16 to 18 individuals of each species, with the squirrel producing the greatest biting force, followed by the gopher and the rat. The test methods used by these scientists were used by the DWRC personnel to test thousands of cable samples from many cable companies seeking a method to evaluate their designs. All of the testing done in the 1980s was proprietary and so no publications were written on their results.

The 1990s

In the early 1990s, the Connolly and Cogelia protocol for evaluating cable resistance was modified by McCann (1995). That is, plains pocket gophers were first individually screened for a propensity to gnaw on cable. After demonstrating an inclination to gnaw on a representative cable, gophers were assigned to a pool for possible study participation. Ten pocket gophers were randomly selected from this pool, and each was presented one of 10 identical cable samples. Each sample was ~100-150 mm long and was attached horizontally across an opening of 51 x 50 mm in a stainless steel panel. All foodstuffs remained in the partition with the pocket gopher to eliminate any inducement to gnaw on the cable solely to obtain food. Daily inspection of the cable samples was performed by 2 researchers, independently assigning a damage score from a damage index ranging from 0 (i.e., no damage) to 5 (i.e., cable severed). The individual assessments were reviewed and discussed until a consensus score was reached. Most tests were of 7 days duration or terminated when the cable sample was severed. Evaluations were extended to 3 and 6 weeks for some cables depending on composition or construction. Some of the materials that proved most effective at deterring damage in these laboratory tests include: carbon steel, copper, brass, phosphor bronze, metal laminates, and various wire wrappings.

CONCLUSION

Since the 1950s, numerous laboratory evaluations have provided information that allowed elimination of cable insulations vulnerable to pocket gopher damage and identification of armors that may prove effective in field tests. Our current accumulated knowledge of pocket gopher gnawing of cables illustrates that much more information is needed about pocket gopher behavior before a final solution to this wildlife damage problem can be gained.

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LITERATURE CITED

Anthony, C. Jr. and J. R. Tigner. 1967. Rodent repellent cable coating development. Sixteenth Int. Wire and Cable Symp. Fort Mammoth, NJ. November 30, 1967.

Burt, W. H. and R. P. Grossenheider. 1964. A field guide to the mammals. The Riverside Press, Cambridge, MA. 289 pp.

Case, R. M. and A. B. Sargeant. 1982. Determining sex of plains pocket gophers by incisor width. Prairie Nat. 14(4):125-127.

Chase, J. D., W. E. Howard, and J. T. Roseberry. 1982. Pocket gophers. Pages 239-255 in J. A. Chapman and G. A. Feldhamer eds. Wild Mammals of North America. John Hopkins Univ. Press, Baltimore, MD.

Cogelia, N. J., G. K. LaVoie, and J. F. Glahn. 1976. Rodent biting pressure and chewing action and their effects on wire and cable sheath. Int. Wire and Cable Symp. 25:117-124.

Connolly, R. A. and N. J. Cogelia. 1970. The gopher and buried cable. The Bell Lab. Rec. 48(4):98-103.

Connolly, R. A. and R. E. Landstrom. 1969. Gopher damage to buried cable materials. Am. Soc. for Testing and Materials, Materials Res. and Stand. 9(12):13-18.

Fagerstone, K. A. and C. A. Ramey. 1996. Rodents and lagomorphs. Rangeland Wildlife. Society for Range Management, Denver, CO. (P. R. Krausman, ed). 83-132 pp.

Foster, M. A. and J. Stubbendieck. 1980. Effects of the Plains Pocket Gopher (Geomys bursarius) on rangeland. J. Range Manage. 33(1):74-78.

Grinnell, J. 1923. The burrowing rodents of California as agents in soil formation. J. Mammal. 4(3):137-149.

Hall, E. R. 1981. The mammals of North America. Second ed. John Wiley and Sons, New York, N.Y. 1181 pp.

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America. vol. 1, Ronald Press Co., New York, 546pp.

Hansen, R. M. and R. S. Miller. 1959. Observations on the plural occupancy of pocket gopher burrow systems. J. Mammal. 40:577-584.

Hill, J. E. 1937. Morphology of the pocket gopher mammalian genus Thomomys. Un. Calif. Pub. Zool. 42:81-171.

Howard, W. E. 1953a. Growth rate of nails of adult pocket gophers. J. Mammal. 34(3):394-396.

Howard, W. E. 1953b. Tests of pocket gophers gnawing electric cables. J. Wildl. Manage. 17(3):296-300.

Howard, W. E. and M. E. Smith. 1952. Rate of extrusive growth of incisors of pocket gophers. J. Mammal. 33(4):485-487.

Luce, D. G., R. M. Case, and J. L. Stubbendieck. 1981. Damage to alfalfa fields by plains pocket gophers. J. Wildl. Manage. 45(1):258-260.

Mailen, T. H. and R. E. Stansbury. 1966. Protection of geophysical communication and power transmission cable against rodent species attack by R-55 rodent repellent treatment. The Fifteenth Annual Wire and Cable Symp. The Shelburne Hotel, Atlantic City, NJ. Dec. 7-9,1966.

McCann, G. R. 1995. A method for evaluating cable resistance to damage by pocket gophers as adopted by the USDA/APHIS/ADC/DWRC. Int. Wire and Cable Symp. 44:604-606.

Merriam, C. H. 1906. Monographic revision of the pocket gopher family Geomyidae, exclusive of the species of Thomomys. North Am. Fauna 8. 262pp.

Miller, R. S. 1964. Ecology and distribution of pocket gophers (Geomyidae) in Colorado. Ecology 45(2):256-272.

Tigner, J. R. 1968. Chemical protection methods progress. Electronic Packaging and Protection. April.

Turner, G. T., R. M. Hansen, V. H. Reid, H. P. Tietjen, and A. L. Ward. 1973. Pocket gophers and Colorado mountain rangeland. Colorado St. Univ. Exp. Stn. Bull. 554S, Ft. Collins, CO 90 pp.

Vaughan, T. A. 1962. Reproduction in the plains pocket gopher in Colorado. J. Mammal. 43(1):1-13.

Vaughan, T. A. 1966. Food-handling and grooming behaviors in the plains pocket gopher. J. Mammal. 47(1):132-133.