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ABSTRACT: The badger (Taxidea taxus). because of its strong propensity for digging, is considered North America's fossorial carnivore, feeding mostly on ground squirrels, pocket gophers, and mice throughout much of the western and midwestern continent. Badger excavations, primarily in search of food, produce mounds and deep holes which can damage alfalfa and other crops and damage farm equipment and water systems. Depredations include poultry, waterfowl, and eggs. Overall, the badger is considered a relatively minor vertebrate pest. As a furbearer it is considered a renewable natural resource. Most local pest problems are currently reduced through leghold trapping and shooting. Habitat modification through continuous rodent control is effective and a long-lasting badger control method.

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INTRODUCTION

Many New World predators opportunistically excavate inhabited burrows in pursuit of prey, but the North American badger is morphologically specialized for digging through soil in its search for rodents. It has probably remained unchanged, at least morphologically, since the mid Pliocene (Long 1972, Wagner 1976). T. taxus is the only extant member of its subfamily (or tribe; see Long 1981), and since the late Pliocene it has been the sole occupant of the fossorial carnivore niche in the New World (Petter 1971, Wagner 1976, Long 1981). This long and variable evolutionary period has produced a robust carnivore that, although specialized for digging, remains fairly adaptable in habitat and prey selection. Badgers have extremely acute auditory and olfactory senses, capable of hearing and smelling through considerable depths of soil. They rely on a compact, highly powerful muscle and skeletal structure for rapidly breaking ground and excavating soil and rocks.

Badgers, like most vertebrates that are pests in some situations, may be neutral or desirable in others. This paper specifically addresses the badger as a pest species and only touches upon its furbearer status. The badger, its biology, and relevance to natural ecosystems, has been the subject of many publications, yet relatively little has been published on the badger as a pest and thus a major reason for this paper which emphasizes the problems in California. Historically, their diggings and mounds and raiding of poultry yards put badgers on the pest list of ranchers and farmers. Their damage is not only of concern to agriculturalists; their costly damage to roads and levees has in some regions of the country made badgers a persistent serious pest to highway and other departments as well.

BIOLOGY

Diet and Habitat

Diet studies (reviews in Lindzey 1982, Long and Killingley 1983) confirm the badger's digging efficiency and propensity to feed on rodents. Ground squirrels, pocket gophers, and various mouse species make up the bulk of its diet throughout its range. However, the diet varies by area and season and includes insectivores, lagomorphs, reptiles, amphibians, birds, eggs, and arthropods. The badger is widely distributed over western and northcentral United States, and from southern Canada to northern and central Mexico, but thrives best in treeless regions with friable soils. The clearing of forests, draining of wetlands, and development of agriculture by European settlers in the last century, which has changed the distribution and densities of rodents, is believed to have led to general expansion of the badger's range to the north and midwest in its current range (Moseley 1934, Bennitt 1939, Leedy 1947). Conversely, local and regional reduction of rodents, particularly ground squirrels and prairie dogs, may have decreased badger densities in some areas of its former range. Nugent and Choate (1970) cautiously considered that sparse populations in New York and possibly elsewhere in the East may have become established from releases or escapes of badgers formerly raised in commercial furbearer operations.

Distribution

Apparently, badgers are more abundant now than in the 1900s, perhaps even more than in the 1930s, although their densities are lower in many cultivated and otherwise altered habitats (Scott 1937, Deems and Pursley 1978,1983, Long and Killingley 1983). Many biologists have noted that badgers have been reinvading previously occupied areas. For example, Gremillion-Smith (1985) believes that two major land-use practices in southern Illinois and Indiana may contribute to improvements in the quality of badger habitat: substantial increases in crop acreages and in surface-mining of coal, creating relief in an otherwise flat topography, have produced large expanses of both temporary and permanent grassy areas. The latter practice especially results in habitat, soils, and foodbase more suitable for burrows and capable of supporting large rodent populations.

Reproduction. Life Cycle and Populations

Badger breeding peaks in late July and early August; following a 6-month delayed implantation and 5-week gestation, 1-5 (mode= 2) young are born around April 1. A minority of females breed during their first year (age 4 months), males the second (age 16 months). Males are 20 to 40% larger than the average 7-kg female. Age at first breeding, parturition dates, proportion of females breeding, litter size, age structure, and sex ratio vary with population dynamics (including the degree with which man reduces the population), habitat quality, latitude, and elevation (Wright 1966, Messick et al. 1981, Minta 1985). Juveniles disperse during the first breeding season or by autumn and remain solitary except for breeding and for females rearing young. Badgers are capable of variable periods of torpor to escape short-term or seasonal desiccation and cold. Home ranges vary from 167 ha (Messick and Hornocker 1981) to an order of magnitude larger (Lampe and Sovada 1981, Minta unpubl. data), with males using more than twice the area of females. Population densities are highly variable and few have been measured. Lindzey (1971) estimated .4 km^2 in northern Utah; Messick and Hornocker (1981) estimated as high as 5 km^2 in the densest part of their study area during a population peak; Minta and Mangel (ms. in review) estimated a minimum post-dispersal population of 2 km^2 in northwest Wyoming. For general reviews of the badger see Lindzey (1982) and Long and Killingley (1983).

BADGERS AS FURBEARERS

Low values for badger fur have done little to endear the badger to trappers except during the 1920s and 1970s when there were substantial increases in the demand for long-hair fur and pelt prices rose accordingly (Grinnell et al. 1937, Hall 1946, Long and Killingley 1983). Badger fur is prime from late December through mid-March and is best in February (Stains 1979). Generally, pelt values are 2 to 6 times higher in colder latitudes than in southern climes. The fur has long tri-colored guard hairs giving the pelage a coarse look and texture, but these properties make it among the best for shedding soil and water. Consequently, the fur is favored for collars and the hair is used for shaving and paintbrushes. The tough resilient skin was used to make drums and step rugs by American Indians.

Deems and Pursley (1983) reported that in recent years the North American badger harvest has yielded 30 to 40 thousand pelts, valued at over $ 1 million dollars annually. Harvest and hunting has become more regulated in recent decades. In the 31 states and provinces for which badgers are present, 5 offer total protection, 13 have hunting seasons, and 22 have trapping seasons. Of those states and provinces that allow some form of harvest, 11 have year-round harvesting and 13 have limited harvesting. Five states attempt population inventories. The senior author learned from a mail survey of 28 states and provinces conducted in 1981 that the impetus for increased regulations came from concern over perceived population drops, apparently an effect of the exponential increase in badger pelts marketed (2,000 to 42,000) from 1972 to 1978 in North America (sec also Long and Killingley 1983). Compared to many other furbearer populations, the badger's lower reproductive potential has made it particularly susceptible to heavy harvest as a furbearer. The elevated fur harvest of the 1970s bear this out. This is particularly true for northern latitudes where Canadian provinces experienced population declines (Drescher 1974, Salt 1976, Long and Killingley 1983).

FURBEARER-PEST PROBLEMS

The motivation for trapping badgers specifically for the value of their pelts is distinctly different from taking badgers as pests. Although the motivation differs, the two objectives may be interrelated in several ways and both may have an impact on badger populations.

Badgers trapped or killed by some other method because of their pest status may be skinned and the pelts prepared for later sale. In these situations some value is realized from the pelt, which partly compensates for damage or the cost of control. Salvaging pelts of badgers killed because of their pest status is far less common today than prior to the 1940s. The time and effort required to skin the animal and prepare the pelt seldom make it worthwhile, regardless of the price of the fur, unless the person is relatively experienced. Depending on the region and time of year, such pelts may not be in prime condition.

On the other hand, a farmer or rancher with a persistent badger problem may encourage trapping of badgers and other furbearers on his property during the trapping season. In this way, both the professional trapper and farmer derive some benefits and a natural resource is put to good use.

ASSESSMENT OF BADGER PROBLEMS IN CALIFORNIA

Badgers are distributed throughout nearly all of California, but they have reportedly declined or disappeared in many areas of the state and were recently listed as a Mammalian Species of Special Concern by the California Department of Fish and Game (Williams 1986). However, since no study of the badger populations in California has been made, these current observations may not be valid. Larsen (1987) conducted a badger sighting survey similar to that of Grinnell et al. (1937) and found highest abundance in the northeastern region of the state and along the south coastal area. Badgers are classified as furbearers with a designated trapping season and no bag or possession limit. In the 1985-86 season pelts sold for a low $2.70 to $5.00 and made up only 0.34% of the overall furbearer harvest.

The geographical, biological, and agricultural diversity of California makes the state an interesting example of a variety of badger pest problems. In California, the government agency responsible for the majority of predator animal control is the U.S. Department of Agriculture Animal Damage Control service, commonly referred to as ADC. In the last decade (1978-87), ADC-reported resource losses due to badgers totaled $85,372 from crop damage, $16,000 from miscellaneous property damage, $4,080 from irrigation and

water impoundment damage, and $1,960 from depredation on domestic fowl. During this ten-year period, 1,456 badgers were destroyed for pest reasons and another 23 pest badgers trapped and released. An additional and 843 badgers were trapped accidentally as non-target species and of these 589 were released. Badgers are occasionally captured incidentally while trapping coyotes and other livestock predators and, if the badger is not a problem in the area and is in good health, these are frequently released. There was large year-to-year variation in type and extent of resource loss. Between 1978 and 1983 the proportion of badgers taken increased from 1 to 2% of the total depredating predator animals taken each year, with a slight decrease through 1987. Coyotes, striped skunks, raccoons, and opossums accounted for most of the animals taken by ADC for depredation or public health reasons. The distribution of badger problems was reportedly patchy throughout California. The biggest problem area was in the three far northeastern counties (Lassen, Modoc, and Siskiyou). Although the south coastal range regions also have relatively high densities of badgers, complaints of damage are low and sporadic.

While ADC personnel may conduct the majority of badger control in California, the agency does not have contracts for working in all the counties, thus their reported losses must be considered conservative. Farmers and ranchers will often handle their own badger problems, especially where no ADC personnel are available. Hence, the number of pest badgers taken by the landowner will not be reflected in the ADC reports.

The increase of badger problems in the northern counties can be traced to an apparent population explosion over the last 8 or 9 years (V. Bisnet, pers. coram.). Problems are greatest in areas of developing agriculture, followed by established agriculture, with few concernable badger problems in rangeland. R. Clark (pers. comm.) believes that recent badger population increases may be due to generally higher ground squirrel populations on some properties. Greatestdamage is to alfalfa and grain fields with some losses to potato production. Machinery damage has been serious enough that some farmers have installed seatbelts for the unexpected jar of wheels dropping into holes. Where the habitat and available food base is good, badger reproduction is high; two litters of 5 and one litter of 6 have been verified. Control is accomplished by trapping and burrow fumigation with gas cartridges but ADC as well as the California DepartmentofFood and Agriculture and theCounty Agricultural Commissioner's personnel emphasize to their constituents that rodent control is the most effective badger control method.

TYPES OF DAMAGE AND PEST PROBLEM

Crops

Damage caused by badgers takes several forms. Badgers may be most troublesome in alfalfa-growing areas where they may dig in search for food or to construct dens. Their digging may kill relatively large spots of alfalfa by the holes dug, and displaced soil may bury additional alfalfa, killing plants or retarding growth. In the West, most of their digging in alfalfa is in search of voles, ground squirrels and pocket gophers. In searching for pocket gophers they dig many shallow "exploratory" excavations and may produce relatively deep holes or shallow trenches up to 3 m long. In a Minnesota study, Lampe (1976) estimated that free-ranging badgers were successful in capturing pocket gophers in an estimated 73 % of the attempts. The total volume of displaced soil at the average site of pocket gopher predation was 182 liters and involved 16.4 exploratory and excavatory holes.

Equipment

Badger dens and extensive diggings may slow harvesting and cause farm implement and equipment damage when a wheel drops into an excavation. Equipment damage is thought to be the most costly badger-related problem because of down time and delays in harvest, in addition to the actual costs of equipment repairs. Overall costs to alfalfa production in California are not available but individual alfalfa growers often can cite the costs of specific breakdowns because of badger activities.

Water Management

The badger's burrowing activities damage earthen dams, levees, and dikes, causing water loss, erosion, and expensive repairs. Rodents, and therefore badger activity, are often concentrated along field edges and along watercourses in farmlands. Todd (1980) studied badgers in an agriculturally developed, semi-arid desert region of southern Idaho. Areas of this region with intensive irrigated agriculture (e.g., alfalfa) and interspersions of annual vegetation supported greater numbers of badgers and ground squirrels (Spermophilus beldingi) than those of native vegetation and crested wheatgrass (Agropyron cristatum). The majority of residents contacted on the study felt that the badger was a nuisance and a pest because of its prolific digging habits. Badger holes in irrigated fields and canal banks usually meant a loss of irrigation water. Badger burrows may cause malfunctions of wheel-type sprinkler systems or other self-propelled sprinkler systems when a wheel drops in a deep badger hole. Such equipment malfunctions or damage may go undetected for some time, causing substantial water loss.

Badgers have been implicated in flood control disasters because their burrowing activities cause dam and levee failures. As an example, the failure of a dam which held 6,500 acre-ft of water resulted in estimated losses of $ 1 to $2 million dollars (Prospect Reservoir Dam, Colorado, 1980).

Accidents Involving Livestock

The badger's digging activities are a menace to horsemen because horses occasionally step in burrows, breaking a leg or throwing the rider (McCracken and Van Cleve 1947, Hawbaker 1969, Long and Killingley 1983). Although there are few reported cases, fear of horse injury is one of the major complaints to ADC and County Agricultural Commissioner's offices throughout the badger's range. Cattle are much less prone to such accidents. However, in

California and much of the West this is not considered a big problem and rarely requires corrective action in the way of removing badgers unless the burrowing occurs in horse-riding arenas, jumping courses, or in or alongside a frequently used equestrian trail. Riding stables may fear lawsuits should someone be injured in such an accident or a valuable horse seriously injured. Riders unfamiliar with the terrain should be warned of the hazards of badger dens and diggings so they can avoid those areas or at least avoid galloping through those particular pastures.

Other Property and Structures

Badger burrows are a significant problem in the shoulders of paved roads in the central and northern plains of North America, particularly in the more arid areas (D. Wade, pers. comm.). This results from better moisture conditions in the shoulders and road ditches leading to better vegetation (i.e., more green and lush for longer periods) which leads to greater rodent populations in these areas. As a consequence, badger burrows in road shoulders and under the pavement or blacktop cause the need for frequent and costly road repairs. Water entering the burrows, freezing, and thawing are common causes for undermining and weakening the road surface and the failure of pavement shoulders. Highway departments in those states commonly complain of this problem.

Similarly, buildings such as pump houses, storehouses, and barns located away from human habitation are undermined, causing settling and foundation cracking. On rare occasions badgers will disfigure golf courses and cemeteries while digging for grubs, pocket gophers, or meadow voles (Peterson et al. 1976). The damage is similar but generally more disfiguring than that of skunks, which occurs more frequently.

WILDLIFE AND LIVESTOCK DEPREDATION

Livestock

Where badgers are numerous and/or exceptionally short of food, they occasionally prey on newborn lambs (Johnson 1983). Such occurrences are apparently very rare. Range-raised chickens and domestic turkeys are sometimes killed but these instances are exceptional (Henderson and Craig 1932, Long and Killingley 1983). Bremner (1946) reported that badgers became a severe menace to the poultry industry in a few counties in California. Over a short period of years, badgers killed many hundreds of chickens and some turkeys as well as destroying their eggs. Badgers entered buildings through dug tunnels and cached killed poultry in nearby dens and tunnels (3-39 fowl per den; also reported by Dew (1957) in Canada). Predators which kill a surplus of prey (i.e., more than they can eat at the time) can cause substantial losses.

On the average, only a few such poultry instances are reported to ADC personnel annually in California (losses to domestic fowl in a ten year period 1977-87 amounted to $1,960), making it a very minor overall problem although it may be a relatively serious problem to a few. Pen-reared pheasants have also fallen prey to badgers. In Canada badgers reportedly attack poultry and domestic waterfowl (Dew 1957, Ray and Dorrance 1976). They gain access by burrowing under fences or beneath the walls of poultry houses with earthen floors. With the exception of turkeys and domestic waterfowl, most commercial poultry is now raised off the ground and thus badgers are much less a problem today than in the past. Because much of the badger's activities occur nocturnally, they are almost never observed in an act of killing domestic animals.

Domestic Dogs

When a dog tangles with an adult badger, the dog is most apt to come out second best and may be seriously wounded. The badger's ferocity is legendary. Badgers maintain a defensive posture, retreating below ground if at all possible; however, boars can be more aggressive during the breeding season. Its strength, low center of gravity, and thick, tough skin are advantages at close quarters, but its main defense is extremely loose skin. There are very few places an attacker can grip a badger from which the badger cannot turn within its skin to counterattack. Its neck is so muscular that to gain a lasting or damaging hold is very difficult. Some dogs learn to turn badgers on their backs and kill them by biting the chest (D. Wade, pers. comm.). Most animals heed the badger's aposomatic coloration and pugnacious confidence when cornered. Whether or not there is a confrontation between a dog and badger often depends on the temperament and breed of dog. The veterinarian's bill for saving a defeated dog's life can be substantial.

CONTROL METHODS

Overall, badgers are considered a relatively minor vertebrate pest economically to agricultural interests, but to individual farmers or ranchers they may cause serious losses. Table 1 summarizes ADC reports fora sample of states within the badger's western distribution. In the majority of these annual reports, resource or economic losses due to badger activity is not reported. Reported losses are relatively low when compared with other vertebrate pest losses and are mostly from poultry depredation, crop and property damage, and soil and water losses. Badgers are a very small portion of all carnivore/furbearer pests taken (% GT in Table 1), especially considering that many badgers reported in the table were not target animals but taken incidentally while trapping coyotes. Depending on the area, a relatively high percent of these were released.

While badgers may cause concernable-to-serious economic losses to individual farmers or landowners, in California these occurrences are relatively few considering the vast acreage in agricultural and livestock production. In other regions they may be a much more serious and persistent problem. Habitat modification through reducing its major prey, such as pocket gophers and ground squirrels, is the best prevention. However, this approach is generally too slow in producing results to solve an immediate or ongoing problem. Badger problems in California are for the most part sporadic and infrequent so that only occasionally does an animal or a few individuals need to be removed. Rarely can even local

TABLE 1. Annual ADC-reported badger take for selected states in the years 1977,1982, and 1987. Some values may not be consistent among states and/or among years within states. Missing or unavailable data are denoted by a dash (-). Blank spaces denote zeros. "Other" methods of capture were mostly by denning, M44, spotlighting and shooting, and livetrapping. % GT refers to percent badgers of the total annual carnivore/furbearer take for the state. Destr=destroyed and Rel = released badgers. If data were inconsistent or unavailable for an entire year, that year is not reported.

State	Year	Leghold	Snare	Shot	Other	Total	% GT	Target		Nontarget	
								Destr	Rel	Destr	Rel
Arizona	1977	42				42	2.7	-	-	-	15
	1982	31		1	1	33	1.4	8		5	20
	1987	28				28	1.4	17	3	4	4
California	1977	104				104	0.9	-	-	-	72
	1982	237	3	18	4	262	1.6	120		63	73
	1987	208	2	19	35	264	0.8	212	2	21	29
Colorado	1982	6	3			9	0.4			5	4
	1987	22	3		1	26	1.0	23		3	
Montana	1977	111		4		115	1.8	-	-	-	-
	1982	67	10			77	2.1	76			1
	1987	7	2	2		11	0.2	11			
Nebraska	1977	105	4	3	1	113	4.3	-	-	-	-
	1982	78	1		12	91	5.5	70		9	12
	1987	62	3	2	1	68	3.9	66			2
Nevada	1977	32				32	-			-	-
	1982	36				36	-			26	10
	1987	61			10	61	1.3			49	12
New Mexico	1977	228	19	3		250	2.6	-	-	-	-
	1982	168	2		3	173	3.2	37		94	42
	1987	151	27	1		179	2.6	10		133	36
North Dakota	1977	14		2		16	1.4	-	-	-	-
	1982	22	1	1		24	1.7	4		3	17
Oklahoma	1977	19	1			20	0.3				6
	1982	20				20	0.4	6	1	8	5
South Dakota	1977	2	1			3	0.2	-	-	-	-
	1982	27	3	8		38	1.7	18		20	
	1987	57	6	5	5	73	1.7	41		7	25
Texas	1977	1				1	0.0	-	-	-	-
	1982	88	25		1	114	0.7	12		77	25
	1987	34		10	20	235	1.0	64		137	3
Utah	1977	41				41	1.0	-	-	-	-
	1982	37	3			40	0.9			37	3
	1987	101	6			107	2.2	4		98	5
Washington	1977	-	-	-	-	7	0.3	-	-	-	-
	1982	10				10	-	-	-	-	-
	1987					0	0.0				
Wyoming	1977	158				158	2.2	-	-	-	-
	1982	7				7	0.1	7			
	1987	1				1	0.0	1			

(farm or ranchwide) population reduction be justified. In situations where badger problems are more serious and persistent, regional population reduction may be warranted from both a biological and economic point of view. In some regions the taking of badgers in sufficient numbers as furbearers may keep the population relatively reduced and therefore may reduce the incidences of pest problems.

Trapping and shooting are the effective methods currently available. Todd (1987) analyzed Canada-wide furbearer species harvests taken by various capture methods. For badgers 69% were taken by leghold traps, 26% by kill traps, 5% by shooting, and none by snares. This provides a good indication of the effectiveness of the various techniques. In California, more than 90% of the badgers taken

(target and nontarget) by ADC personnel are leghold trapped and most of the remainder are shot. These figures are fairly comparable to other states. Farmers and ranchers have more opportunity to shoot badgers than do ADC personnel and thus shooting ranks higher than trapping with this group.

There are no toxicants (either fumigants or poison baits) currently registered for use on badgers. With the high costs of pesticide registration and low demand, it is unlikely that pesticides (including nontoxic repellents) will again be available for badgers. In addition to indirect control through habitat modification (i.e., reducing their available food) and direct control by trapping and shooting, repellents and fences have been used in other parts of the world. Past and current methods of control are discussed below.

Identification of Badger Activity

Badger burrows can be identified by their slightly elliptical opening, averaging 20 cm by 22 cm, with the long axis being horizontal. The mound adjacent to the entrance is a fan-shaped pile of soil that is typically 1 m long by 1 m wide. Tracks and trenches formed during digging often are present on the mound. The much smaller and shallower secondary exploratory digs are frequently present in the immediate vicinity of a main excavation. These diggings can range in size from shallow scratchings for locating food to deeper, connected penetrations dug in an effort to obtain food. Badgers reoccupy older burrows by "reaming" or throwing out caved-in soil, in which case smaller amounts of fresh soil will be deposited on the old soil from the original excavation. Many squirrel burrow systems are likely to have a history of badger excavation and reaming which can produce an accumulation of larger tunnels and mounds over the years. Squirrels readily reoccupy and further modify these excavations to their advantage; consequently, tunnels become smaller but the mounds remain large.

Natal badger dens can be located by virtue of their noticeably larger mounds and more scattered and compacted soil. Trampled vegetation and worn paths in the immediate vicinity during spring and summer are clues to their occupation.

A major clue to burrow occupation by a badger is the dirt plug a badger commonly throws behind it when it has decided to stay within a burrow or when it has been disturbed. The plug is rarely at the entrance but can frequently be seen from an angle or felt with a cautiously probing, gloved hand. Another clue to occupation is tracks. Badgers rarely dig vertically downward, thus the burrow is usually oriented in a way that tracks on the mound are evident when the badger leaves. A badger occupying a hole has often thrown the freshest soil over the mound, covering many of its prior tracks. The duration of occupation is extremely variable; nonetheless, longer occupancy tends to occur more seasonally during very cold or hot periods and briefer occupancy periods during the breeding season. Depending on the diet and climate, the rate of excavation dramatically increases in early summer and declines again in autumn within temperate latitudes. Scats are not a reliable sign; they are often covered or deposited within burrows and they are difficult to differentiate from other carnivores.

When there is snow, soil may be thrown upon the surface and when snow is deep enough and crusted, the badger burrows his way under the snow pack. Once under, badgers may travel short distances in the subnivean space with their excavations likely to go unobserved because the dirt is beneath the crust. Snow holes, or burrows penetrating the crust, are common but are difficult to detect from any distance. In subfreezing temperatures, an occupied burrow is more likely to have a large amount of frost at the entrance from the badger's respiration.

A badger can be detected in a burrow by sticking a steel rod into burrow soil and placing the other end directly against one's ear and skull (amplifying microphones also work). A very loud noise or a person imitating a hissing badger will likely cause the badger to move or dig, the vibrations of which are easily transmitted through earth and steel. Trained dogs have also been used successfully for detecting occupied burrows.

Traps

A No. 3 leghold trap is generally needed to hold a sturdy badger, although a strong No. 2 will sometimes hold them. Because the badgers front feet are so large, a wide jaw spread is needed. Blake & Lamb No. 2 1/2 (super single long-spring trap), No. 3 Victor double long-spring trap with or without offset jaws, No. 3 jump trap, and No. 3 double-coil spring trap, have been used to take badgers. All have a 14-cm (5 1/2-inch) jaw spread. Badgers do become trap-wise and have been known to dig out traps and flip them over to set them off (McCracken and Van Cleve 1947). They will also sometimes bury the traps with additional soil so they won't trip or may dig another entrance/exit hole. Messick and Hornocker (1981) and Minta (1985) reported that radio-collared badgers were sometimes very skillful at avoiding traps. If a badger is trapped and escapes, there is less chance of trapping it again in the same way.

One or preferably two traps can be set inside the den opening. If possible, they should be placed to the sides of the hole because of the badger's widespread feet. The traps should be slightly sunken and the treadle covered with pliable, low-noise material (badgers have extraordinarily acute pressure sensors in their feet) and then lightly covered with soil. If a badger is known to be in a hole, no bait or scent is necessary. If a badger is meant to be lured to a hole, the bait or scent should be beyond the traps in the hole. You cannot expect results with sets of uncovered traps. Burrow entrance sets (just outside the opening) are also commonly used with the trap or traps set slightly off-center to the entrance. The jaws of the trap should be parallel with the animal's direction of travel so the badger will pass between the jaws, not over them(Kreps 1944). Traps must be well concealed but human odors are not a large concern. A "dirt hole trap set" used for foxes and coyotes is said to be fairly effective for badgers (McCracken and Van Cleve 1947, Hawbaker 1969), especially if set near recent badger activity.

Since badgers are good diggers and can sometimes loosen trap stakes, some recommend the use of trap drags, such as a small log (Henderson 1978). Stakes are adequate in all but the more crumbly soils and should be 45 cm (18 inches) or more in length and driven out of sight for best results. Iron rebar sections with swivel attachments work well.

Badgers are attracted to the odor and texture of fresh soil. Throughout the year, but especially from June to August, badgers are highly attracted to the odors of other badgers; thus, the most productive place to make a set is where badgers have been active. Food baits are more effective in winter and spring than summer and fall. We found that strong poultry meat (not rotten) was the most effective meat bait, although others worked nearly as well. Once a badger has been caught in a set, that set should continue to be used if there are other pest badgers in the area. The combination of disturbed soil mixed with the urine, feces, and glandular secretions released by a trapped badger is an unbeatable attractant for the next badger. Schildman et al. (1980) stated that almost any type of predator lure will prompt badgers to investigate. There is little reason to doubt the best lure for badgers will contain its scent glands and be sparingly applied to, or used in conjunction with, bait or badger feces.

Snares have been used with mixed success. One method for capturing a badger entering a burrow is to stake the snare outside burrow entrance and pin the taut cable to roof of burrow and the formed loop to sides of burrow. Loops should be as wide as burrow and suspended no more than "two fingers" above floor of burrow (because a badger's neck is as thick or thicker than its head, the loop should catch one or both front legs). If the loop is placed well within the burrow, the badger will most likely be locked into it before it can effectively respond. For capturing a badger on its way out of a burrow, securely position the loop just inside the entrance with the cable leading to a stake off to one side and somewhat behind the likely exit direction.

No. 330Conibeartrap(25 cm [10-inch] square jaws) has been used in sets at badger dens (Bateman 1979). Because they are powerful kill-type traps, they present a potential danger to children and domestic animals, especially dogs, when set on land. Conibear traps of this size should be used only with great caution, if at all.

Some say that badgers are relatively easy to trap (Lindzey 1982, Johnson 1983), while other sdo not share their opinion (Hawbaker 1969). Food availability, seasonal and regional differences, previous trapping pressure in the area, and trapping experience may explain the differences in opinion.

Live-catch, wire-mesh or box-type traps are neither recommended nor commonly used for trapping badgers. Badgers are reluctant to enter such traps and, once trapped, they tend to fight the trap and often injure themselves and damage the pelt. Culvert-type traps made of drums are somewhat more effective and less damaging to the badger but unwieldy to transport and carry in the field.

Habitat Modification

The best way to reduce the problem of badgers in alfalfa fields or pastures is to control the rodents, such as pocket gophers or ground squirrels, that are being fed upon and attracting the badgers to the area. This indirect management approach does not give immediate results but eliminates the need to kill badgers.

Repellents

It is interesting that in Britain it has been suggested that European badgers (Meles meles) can be repelled from gardens and lawns with repellents such as an absorbent rope soaked in substances like old diesel oil or renardine (Neal 1986). The rope is stretched between stakes about 125 mm off the ground to surround the area to be protected. It is said that this is much more effective if used before entry becomes an established pattern (Neal 1986). Our badger (a different subfamily or tribe) is quite a different animal from the European badger and is unlikely to be repelled by such an approach. We know of no attempts at repelling badgers in this country and there are no specific badger repellents registered in the United States.

Frightening

Johnson (1983) reports that badgers may be discouraged from an area by bright lights. High-intensity lamps may be used to light up a farmyard to discourage badgers from preying on poultry and captive-bred game birds. The results should be immediate but may not last long.

Fences

Badger-proof fences have been erected in Britain. Sturdy sheep netting erected on timber and rail fences, with the netting projected outward at the bottom some 16 to 18 inches at soil level and slightly below, keeps the badger from digging beneath (Neal 1986). Neal (1986) also indicated that single-strand wire and flexinet fences also proved effective when electrified with a fence charger.

Johnson (1983) states that because North American badgers are so adept at digging, fences are not very effective for excluding them. As a control measure, we find no references to the use of badger fences, even experimentally, in this country. However, to study fossorial predation of pocket gophers, Lampe (1976) successfully confined badgers by lining subsurface sides and bottom of large enclosures (0.9 m deep) with 14-gauge, welded wire fencing (25 mm mesh).

Shooting

When an individual badger must be dispatched to resolve a problem, it can be done most selectively by shooting, providing it is legal to do so. A rifle or shotgun is effective. The shooter should stay downwind if possible to prevent detection (Henderson 1978). If the shooter cannot avoid being detected, badgers are less likely to immediately retreat below ground when the observer is not on foot; for example, in a vehicle (unless the vehicle is associated with danger).

The best time is during the cool of the morning when badgers may lay on their mounds warming themselves in the sunlight or in the late afternoon-early evening when more above-ground activity is visible.

From our interviews, professional furbearer trappers and those farmers and ranchers dealing with badger pests indicate that shooting is mostly an opportunity to be taken advantage of during their daily activities. In Todd's (1980) study of badgers in southcentral Idaho, 79 of 106 (74.5%) badger mortalities were man induced, most commonly by shooting. Road kills accounted for 20.8% of the mortalities. However, Messick etal. (1981) conclude that, compared to a thoroughly studied population in a less agriculturally developed area in southwestern Idaho (Messick and Hornocker 1981), Todd's (1980) badgers have apparently adapted to human pressures through increased wariness and decreased movements and home range size.

Fumigants

Gas cartridges or "smoke bombs," as they are sometimes called, have been used for the control of marmots, ground squirrels, prairie dogs, foxes, badgers, and coyotes (Anderson 1969). The cartridges are about 9 cm (3 1/2 inches) long and 4 cm (1 1/2 inches) in diameter and made by USD A, APHIS, ADC. A fuse is inserted in the cartridge, which is placed in the entrance of the burrow and ignited. The lighted cartridge is pushed well into the den and the entrance tightly sealed with soil. When ignited, the gas cartridges produce poisonous gases, including carbon monoxide and oxides of sulfur, nitrogen and phosphorus. Death may also be due in part to suffocation. Cartridges are sometimes used in winter when occupied burrows are easier to detect and steel traps are more difficult to use.

Although not currently registered, both methyl bromide and carbon bisulfide are effective fumigants for badgers and have been used extensively in the past for ground squirrel control in California (Ray et al., no date).

Bremner (1946) tried various methods including cyanide for controlling chicken-killing badgers. Cyanide dust forced into badger holes which were then tightly packed with soil failed because the badger was thought to have blocked off the tunnel to avoid the toxic gas. Bremner (1946) found that carbon bisulphide, although better, gave only about 50% control and the material had to be applied in spring while the soil was moist enough to retain the fumigant and before there was a danger of fire.

Cyanide powder, which produces hydrocyanic acid gas, is the method currently used in Britain where badger control is used to reduce the spread of bovine tuberculosis in cattle (Evans and Thompson 1981). The cyanide powder is blown into the burrow by a portable engine-powered fan. The engine-powered fan was originally developed as an improved method of gassing rabbit (Orvctolagus cuniculus) warrens (Ministry of Agriculture, Fisheries, and Food 1968).

Toxic Baits

Currently there are no toxicants registered for badger control although strychnine baits have been used in the past (Fitzwater 1983). Past experience proved strychnine to be an effective toxicant for badgers when placed in the center of a small bite-sized bait of raw hamburger, lard or tallow (Anderson 1969). These baits, sometimes referred to as "tallow baits" or "single lethal placed baits," were placed in areas frequented by badgers. Special efforts were taken in placement to make them as selective as possible for the badger. The bait was covered with a cow chip, handful of grass, or some other natural material to hide it from birds. Bremner (1946) thought strychnine-poisoned eggs were far more successful then den fumigants, using one grain (65 mg) of strychnine, stirred into a small hole in the side of an egg, and one or two eggs placed in an active den about 2 feet from the entrance. Strychnine is no w prohibited for control of most predatory animals, including badgers.

DISCUSSION AND CONCLUSION

Today there is a greater appreciation for our native wildlife and their conservation for the sake of interest, diversity, aesthetics, and the best and wisest use of a natural resource. The place of various mammalian species in the ecosystem is now better understood by agriculturists and others, and it is recognized that most animals that are pests in some situations may be neutral or desirable in others. There is some evidence, at least in isolated instances, that under certain circumstances the badger's role as a predator of pest rodents may compensate in part for the damage it may do (Silver 1928, Hall 1946, Koford 1958). Rarely, however, do predators have a sufficient impact on pest rodent populations to push them below the economic threshold; thus, although they feed on pest rodents, they probably have little impact on their populations and cannot be considered a significant rodent control measure.

Because badgers are part of our diverse native wildlife and a furbearer resource, they should not be categorically considered a pest. Failure to maintain and appropriately manage viable populations of badgers may result in their being made a totally protected species or even placed on the threatened species list. Such safeguard actions would be detrimental to farmers with pest problems and to professional fur trappers who, through the fur harvest, wisely use an available renewable resource.

Badgers are generally considered a relatively minor vertebrate pest; however, in a few situations and more widely in some regions, their damage amply justifies corrective action requiring direct control measures. Control through trapping or shooting is normally directed at a few offending or potentially troublesome animals. Although local population reduction may be indicated in some regions it is rarely considered in California. Preventive control through reduction of rodents such as pocket gophers and ground squirrels, which represent major prey, is considered the best and most lasting approach to badger problems. This has dual benefits as it reduces rodent damage as well.

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