Biology and Conservation Challenges of Badgers in the East Kootenay Region of British Columbia

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ABSTRACT

Badgers (*Taxidea taxus*) are Red-listed in British Columbia. We summarize preliminary badger home range size and habitat requirement data from the East Kootenay region of British Columbia. Home ranges were 10–200 times larger than reported from studies in the United States. Using the minimum convex polygon method, female home ranges averaged 54 km^2 and males 509 km^2. Low trap success, large home ranges, predominantly adult captures, high mortality, and low natality suggest a small population, particularly in the north. Burrows used by radio-tagged badgers had more commonly been re-used than recently excavated ($P < 0.001$). Most (77%) had Columbian ground squirrel (*Spermophilus columbianus*) burrows within 50 m, which exceeded their relative availability ($P < 0.001$). The percentage of radio-locations on nonforested land (57%) was greater than the relative availability of such habitats ($P < 0.001$), although forested land with crown closure of up to 85% was used. Badgers occurred closer to paved roads than expected ($P < 0.001$). Soils for most radio-locations were medium to moderately coarse textured, and half occurred on fluvioglacial material. All available biogeoclimatic zones were used, including the Ponderosa Pine (PP), Interior Douglas-fir (IDF), Montane Spruce (MS), Engelmann Spruce–Subalpine Fir (ESSF), and Alpine Tundra (AT), but 77% of radio-locations were in the IDF. Diet analysis revealed that both males and females consumed ground squirrels, red-backed voles, beetles, sparrows, loons, and fish. Conservation of badgers is hindered by lack of information on them and their prey, failure to recognize their role as a wide-ranging carnivore, and the degree of change occurring in their primary habitat of open forest and grassland. A successful conservation plan will require education, cooperation with private landowners, protection or enhancement of key habitat elements, and, potentially, translocation of badgers into depleted areas.

Key words: badger, East Kootenay, home range, radiotelemetry, *Taxidea taxus*.

Badgers (*Taxidea taxus*) have recently been up-listed to Red status in British Columbia, meaning that they are considered threatened or endangered (Conservation Data Centre 1999). They had previously been Blue-listed, largely because the low-elevation grasslands and open forests in which they usually live are rapidly being altered or lost through forest ingrowth, subdivisions, roads, and other developments. They are limited to south-central and southeastern British Columbia, including the Cariboo, Thompson-Nicola, Okanagan, extreme southern West Kootenay/Boundary, and the southern East Kootenay, including the upper Columbia valley (Rahme et al. 1995).

Badgers are adapted to capturing fossorial prey, which constitute their primary diet in most locations (Salt 1976, Lampe 1982). However, badgers are opportunistic feeders and supplement their diet with a wide variety of mammals, birds, eggs, reptiles, amphibians, invertebrates, and plants (Messick 1987). There has been little research done to define badger habitat requirements. Generally, they have been studied in open, often intensely agricultural landscapes (Todd 1980, Warner and Ver Steeg 1995) and shrub-steppe habitats (Messick and Hornocker 1981), although they are known to occur from below sea level to elevations higher than 3,660 m (Lindzey 1982). Despite their threatened status in British Columbia, there had been no intensive radiotelemetry-based research on badgers anywhere in Canada until now. In order to provide the information that is currently lacking, the East Kootenay Badger Project was initiated in 1995–96. The objectives were to:

- determine home range size, dispersal patterns, and habitat use patterns based on radiotelemetry data;
- develop a habitat suitability algorithm based on soil types, forest cover, and proximity to roads and houses;
- facilitate the use of this information by resource managers and provide input directly into forest harvesting plans and

construction development plans; and
- provide public education to improve the understanding of badger ecology and to decrease the likelihood of them being intentionally killed.

STUDY AREA

The radiotelemetry portion of the study included portions of the upper Columbia and upper Kootenay valleys of southeastern British Columbia (the East Kootenay). This included the grasslands and open forests of the Ponderosa Pine (PP), Interior Douglas-fir (IDF), and Montane Spruce (MS) biogeoclimatic zones (PPdh2, IDFun, IDFdm2, and MSdk variants) from 49°30'N to 50°50'N. Monitoring extended beyond the boundaries to follow badger movements. The habitat and ground squirrel survey of random sites was limited to the IDF zone between 49°45'N and 50°50'N. Most of the study area fell within the East Kootenay Trench ecosection of the Southern Rocky Mountain Trench ecoregion, which is part of the Southern Interior Mountains ecoprovince.

METHODS

Trapping and Radio-transmitter Implants

Trap sites were identified by field-checking locations of previous sightings or known ground squirrel colonies. Badgers were trapped at burrow entrances using #1½ soft-catch leghold traps baited with meat (ground squirrels, rabbits, or beef liver) and scented with Carmen's Canine Call (R. Carmen, New Milford, PA). Traps were checked at least once daily. Trapped badgers were noosed and hand-injected with a sedative. This was initially 10 mg/kg of Telazol mixed at 100 mg/ml, but later a combination of 0.3 mg/kg of Midazolam mixed at 1.0 mg/ml and 9 mg/kg of Ketamine mixed at 100 mg/ml was used. Surgical implantation of an intraperitoneal transmitter was conducted either in the veterinary clinic or in the field (following Hoff 1998). Blood, fecal, upper premolar tooth, and hair samples were taken. When badgers were alert, they were released either at the original trap sites if the holes were still intact, or at nearby burrows. Teeth of study animals, along with those from roadkilled carcasses obtained from the British Columbia Ministry of Environment, Lands and Parks were sent to Matson's Lab (Milltown, MT) for aging.

Monitoring

Badgers were usually located weekly from April to September and either twice-monthly (years 2 and 3) or monthly (year 4) from October to March. A fixed-wing aircraft (Cessna 172) was used to radio-locate animals. After the animals were located from the air, a hand-held receiver and antenna were used by a ground-based observer to locate burrows. The UTM (universal transverse mercator) coordinates, forest cover type, and soil type were identified from provincial forest inventory planning (FIP) maps and Lacelle (1990) or Witteneben (1980). In addition, a site assessment was conducted. This described burrow type and size, cover type, distance to nearest change in cover type, presence and characteristics of trees or stumps within 2 m of burrow, proximity and type of 3 nearest roads, proximity and type of 2 nearest buildings, slope angle and aspect, distance to nearest change in slope, and number of ground squirrel and badger holes within 1 m of either side of 4 50-m, perpendicular transects originating at the burrow. When it was obvious whether burrows had been freshly dug or previously dug, they were classified as "new" or "old." The same data (except burrow age) were collected at 201 random plots in the IDF. Data reported in this document were collected from the summer of 1996 to September 1998.

Home Range Calculations

Home ranges were calculated using the program Calhome (Kie et al. 1994). Both the adaptive kernel (ADK) and the minimum convex polygon (MCP) methods were used. Only the locations where badgers were known to have moved from the previous locations were included in home range calculations. Home range was not calculated for dispersing juveniles.

Diet Analysis

Four gut samples and 14 scat samples from roadkills and study animals were sent to Pacific Identifications (Victoria, BC) for analysis. Dr. Susan Crockford used skeletal remains from the samples to compare to collections from the University of Victoria and the Royal British Columbia Museum.

RESULTS

Badger Capture and Status Summary

Twelve badgers were radio-tagged, including 6 adult males, 4 adult females, and 2 juvenile females. Ages of adults at the time of capture ranged from 1 to 10 years. Adult males weighed 7.7–11.8 kg and females weighed 5.9–8.6 kg. Both juveniles died in the year of capture (1 of apparent cougar predation and 1 of apparent starvation or coyote predation). In addition, 1 adult male was roadkilled and 1 adult female appeared to have been killed by a cougar. At the time of writing, the transmitter of 1 adult male was in mortality mode, but was under several metres of snow in the alpine zone so it had not yet been determined whether this animal was actually dead.

Home Ranges and Dispersal

Males had larger home ranges than females by roughly 10 times ($t = 2.88$, $df = 6$, $P = 0.03$; Table 1). For females, there appeared to be a continuous reduction in home range size from north to south. The 3 males in the northern part of the

Table 1. Home ranges (km^2) and standard deviation of radiotagged adult badgers, listed from north to south for each sex. MCP = minimum convex polygon method, ADK = adaptive kernel method.

Identification no.	Sex	*n*	months	100% MCP	95% ADK	75% ADK
3	F	126	26	84	310	56
1	F	144	27	55	195	40
5	F	27	8	52	96	37
7	F	53	14	24	34	8
Mean F		4		54 (25)	158 (121)	35 (20)
2	M	57	11	513	819	222
4	M	75	20	765	1,119	367
6	M	37	15	695	1,184	716
12[a]	M	7	1	2	5	3
9	M	30	7	63	90	25
11[a]	M	10	3	42	65	35
Mean M		4		509 (315)	803 (501)	333 (293)

[a] Not included in calculation of mean, because of small sample (<25 radio-locations over <6 months).

study area had much larger home ranges than the 1 in the south. Of the 2 juvenile females radio-tagged, 1 dispersed 21 km south-southeast from her natal area before death, and the other dispersed 5 km east from her capture site before her death in August 1998.

Habitat Use

On 3 different occasions—in July, September, and November—1 male travelled from valley bottom (approximately 800 m) to the alpine (2,200–2,400 m). Another male also travelled to the alpine on 1 occasion in July. Radio-tagged badgers used the IDFdm2, IDFun, MSdk, ESSFdk, and AT biogeoclimatic zones, which are all of the biogeoclimatic variants in and around the study area. However, 77% of the locations were in the IDF.

Badgers used old burrows at least twice as many times as they dug new ones (binomial test, $P < 0.001$; $n = 321$). Many burrows appear to be used year after year, and in 2 cases 2 badgers used the same burrow at different times.

Most badger burrows (77%; $n = 297$) had Columbian ground squirrel (*Spermophilus columbianus*) holes on at least 1 of 4 50-m transects originating at the burrow (binomial, $P < 0.001$). The proportion of telemetry locations having ground squirrels did not differ between the IDF and the ESSF/AT/MS ($\chi^2 = 0.34$, $P = 0.56$) or the PP ($\chi^2 = 0.00$, $P = 0.97$). Therefore, radio-locations from all biogeoclimatic zones were compared to random plots in the IDF, in which only 5% had ground squirrel holes ($n = 201$). There were ground squirrel burrows significantly more often near badger burrows than in a random sample of the landscape ($\chi^2 > 28.2$, $P < 0.001$).

The proportion of radio-locations falling within 50 m of a paved road differed between the IDF and both the higher elevation biogeoclimatic zones (MS/ESSF/AT; $\chi^2 = 5.0$, $P = 0.025$) and the PP ($\chi^2 = 10.5$, $P = 0.001$). Therefore, only data from radio-locations in the IDF were compared to random plots in the IDF. Significantly more of the radio-locations were within 50 m of a paved road (22%; $n = 226$) than were random plots (4%; $n = 201$; $\chi^2 > 16.82$, $P < 0.001$). The mean distance from a paved road for radio-locations was significantly less (0.7 km) than for random plots (4.6 km; t = 4.66, df = 595, $P < 0.001$). This data was not biased by the ease of locating animals from the road, because animals were first located from a fixed-wing aircraft and then tracked to the burrow on the ground.

Based on forest cover mapping within the IDF zone, there were significantly more badger radio-locations in nonforested habitats (56%; $n = 440$) than these habitats were represented in random plots (28%; $n = 201$; $\chi^2 > 24.0$, $P < 0.001$). For nonforested habitat types, the most common forest cover map classification of radio-locations was open range, followed by cultivated, urban, and "not satisfactorily restocked" (recent cutblocks).

Most of the radio-locations from forested sites (85%) were in polygons having 6–45% crown closure. There was some use (15%) in forests having 46–85% crown closure, but none were in very dense forest (86–100% crown closure). Badgers used all age classes, ranging from stands with trees in the dominant canopy layer being 1–20 years old (7.5%) to 141–250 years (10.3%).

Soil maps of Lacelle (1990) and Witteneben (1980) identify the decile of each of up to 3 soil associations present in each polygon. When 2 strongly contrasting textures are within 1 m of the surface, the subsurface texture is classified separately from the surface texture. For this analysis, only the dominant surface-layer association was considered. The highest percentage of radio-locations in the IDF zone (52%; $n = 390$) were in surface soils of silt loam and gravely silt loam, which is medium-textured. Random plots in the IDF zone were also most often on medium-textured soils (69%; $n = 201$). Moderately coarse-textured soils of fine sandy loam and gravely sandy loam were used more often by badgers

Table 2. Comparison of mean home ranges (km²) in the East Kootenay to those found in other studies, based on 100% minimum convex polygon (MCP) method.

Study location	Source	Females	Males
Idaho	Messick and Hornocker (1981)	2	2
Wyoming	Minta (1990)	3	8
Colorado	Hoff (1998)	8[a]	25[a]
Illinois	Warner and Ver Steeg (1995)	13	44
East Kootenay	this study	54	509

[a] Figures based on 95% adaptive kernel method. No calculations were presented for 100% MCP.

than they were available in the IDF zone landscape (48 vs. 29%; $\chi^2 = 20.8$, $P < 0.001$).

Diet

Of the 18 gut or scat samples, 5 had no bone or hair. These 5 may have contained meat, soil, or other material. The 13 remaining samples contained Columbian ground squirrel (5), voles appearing to be red-backed vole (*Clethrionomys gapperi*; 4), beetles (Coleoptera; 3), sparrows or a similar species (Passerinidae; 2), common loons (*Gavia immer*; 2), a small salmonid (Salmonidae; 1), and a large sucker (*Catostomus* sp.; 1). All food types occurred in both male and female samples.

DISCUSSION

The data presented in this report are preliminary. They are based on 3 years of research and only 12 radio-tagged animals. Therefore, the results must be interpreted with caution. Furthermore, the data summarized here only represent habitat use, except in cases where data are compared to random plots in the IDF zone. Habitat selection cannot be fully determined yet, as availability of the habitat attributes surveyed has not been compared with use via a GIS (geographic information system) analysis. In the final year of the project, a habitat suitability algorithm will be produced.

Home Range

Home range sizes documented in this study were 10–200 times larger than any reported in the literature, as summarized in Table 2. A dispersed prey base was probably a significant contributor to these large home ranges. Only 5% of random plots (0.785 ha) within the IDF biogeoclimatic zone had any ground squirrel burrows (Newhouse 1999). Low badger density because of mortality and low reproductive output also likely contributed to large home range size. As Apps (1996) noted for bobcats (*Lynx rufus*), another species near its range limit in the East Kootenay, it is likely that populations are limited by increased mortality and decreased fecundity, so they simply spread into a greater available space. Thus, the resulting large home ranges may not necessarily reflect total resources required by individuals. The percentage difference between the mean size of female and male home ranges also appeared to be higher here than elsewhere, being roughly tenfold here versus 1 to 3 times elsewhere (Table 2). It may be that there was so little home range overlap between females here (in fact there were probably gaps of vacant habitat) that males had to travel proportionately farther to have a home range encompassing a given number of females.

Indications of Population Density

Indications from the first 3 years of trapping and radiotelemetry suggest that the badger population in the study area was very low, particularly in the northern portion (upper Columbia valley). This statement is based on the following observations:

- Of 12 badgers trapped, only 2 were juveniles, 1 was 1 year old, and the remainder were all at least 3 years old. Juveniles should be more susceptible to trapping as they are less trap-wary and can travel great distances when dispersing from natal ranges.
- The 2 radio-tagged juveniles both died before their first winter.
- Of the 10 adults radio-tagged, 2 or 3 died. This mortality exceeded observed natality.
- In 1996, neither of the females captured appeared to have had young that year. In 1997, 3 of 4 females failed to produce young, and the other had only 1 kit with her at the time of capture, despite litter sizes in other studies of up to 5 (Lindzey 1982). None of the 3 radio-tagged adult females reproduced in 1998. Messick and Hornocker (1981) found that fecundity rose with age and the proportion of productive females of all ages in a given year averaged 57%. The females trapped in this survey were all between the ages of 3 and 6, so higher fecundity would be expected. Messick and Hornocker (1981) speculate that if badgers are induced ovulators, as suggested for other mustelids, then frequent copulation over an extended period might ensure a high conception rate. The low population density in the East Kootenay may have resulted in reduced frequency of copulation and hence low productivity.
- Despite extensive trapping efforts in 1997, no additional badgers were captured in the upper Columbia.

- Home ranges were much larger than in other studies.

In contrast, there may be a somewhat higher population in the southern portion of the study area (upper Kootenay valley). This is based on the following observations:

- In 1 location in the south, a mother and 2 kits were seen. Subsequently an adult female was roadkilled there and a juvenile female and adult male were radio-tagged. DNA evidence suggests that the roadkilled female was not the mother of the juvenile (Newhouse unpubl. data). This indicates that there had been at least 2 adult females, 2 kits, and an adult male in a single location.
- Additional unmarked badgers were sighted in the south twice in 1998 and twice in 1997, and an untagged badger set off traps in the south in 1997.
- The only productive female was captured near the south end of the study area and she had a very small home range (24 km^2, compared with a mean of 64 km^2 for the other 3 adult females).

If badger populations are more dense farther south, it could be related to the availability of northern pocket gophers (*Thomomys talpoides*), which, in the Rocky Mountain Trench, only occur south of about 49°45'N. The width of the trench increases farther south, and has more major, low-elevation tributaries, making badgers less prone to having long, linear movement patterns. Having the ability to move in 2-dimensional space (in the south) rather than essentially 1-dimensional space (in the north) could potentially make them less vulnerable to disturbance and mortality. However, more radio-tagged animals would be required to adequately assess relative population densities and reasons for differences between areas.

Habitat Use

The use of the alpine zone on 3 occasions by 1 male and on 1 occasion by another male could have been a result of searching for Columbian ground squirrel or hoary marmot (*Marmota caligata*) colonies. On 1 occasion it did appear that the male had been hunting ground squirrels in an avalanche path near to the ridge where he was radio-located. However, no site assessments were done on these locations due to the expense of travelling to them. Verbeek (1965) reported observing a badger at 3,100 m hunting a young yellow-bellied marmot (*M. flaviventris*) in Wyoming.

The high degree of re-use of burrows by badgers may be part of a predation strategy, because we also noted frequent use of badger burrows by Columbian ground squirrels. Alternately, re-using burrows might reflect badgers repeatedly occupying certain locales and simply conserving energy by not digging new holes. Whatever the reason, this pattern of use suggests that significant conservation value could be gained by protecting known burrows during forest harvesting or other developments.

The high occurrence of Columbian ground squirrel burrows near badger burrows, relative to the dearth of ground squirrel burrows found in random plots, supports the notion that ground squirrels are a primary food source. This is consistent with the appearance of ground squirrels as the most common item in scat and gut samples. Burrows that were not found in association with ground squirrels could have been the result of badgers resting in nonforaging areas en route to foraging areas, or simply using a different food source.

The fact that 22% of radio-locations within the IDF zone were within 50 m of a paved road while only 4% of IDF zone random locations were within 50 m of a paved road suggests that badgers were not avoiding roads. There may actually be an attraction to roads, as disturbed soil appears to support higher ground squirrel populations (Ketcheson and Bauer 1995), and Warner and Ver Steeg (1995) reported a high use of edges, possibly for travel lanes. Badgers do eat carrion, so the locations falling near paved roads might be partially a result of an attraction to roadkills. Regardless of the reason, there is a potential for high roadkill mortality among badgers. Since 1996, 1 radio-tagged male badger has been killed on Highway 93/95 and at least 6 untagged badgers have been killed in the East Kootenay (Newhouse unpubl. data).

One of the striking features of the data relating to cover type is that badgers were found in almost every category. This points to this species' inherent flexibility and is, to some extent, expected of a carnivore that diet analysis shows to rely on a variety of food sources. However, certain habitat types were used much more consistently than others. The higher number of nonforested, compared to forested, habitats among radio-locations probably relates to a higher prey density in nonforested areas. Likewise, forest cover polygons labelled as open range or cultivated were used extensively by badgers. The apparently high use of the urban category primarily reflected the use of golf courses or rural road rights-of-way, which are often labelled as "urban" on forest cover maps.

Almost all of the radio-locations were in moderately coarse-textured and medium-textured surface soils of silty loam and sandy loam. Half of the soils were of fluvioglacial parent material. These soils appeared to be selected, as they were used significantly more than they were available in the landscape based on random plots within the IDF biogeoclimatic zone. They are generally friable and relatively well-drained, which makes them ideal both for badgers and their fossorial prey. The finer-textured soils would probably be prone to flooding and collapse because of poor drainage, while coarse-textured soils might not have sufficient cohesion to prevent collapse.

MANAGEMENT IMPLICATIONS

Badgers in British Columbia present unique conservation challenges. Assuming that the preliminary results of this study are indicative of other locations in British Columbia, badgers concentrate their habitat use in valley-bottom habitats, which typically are being heavily impacted by human development. Even within the low-elevation stratum (the IDF in this study) badgers appear to be disproportionately found near roadsides, which can lead to high direct mortality. Their overlap with human-inhabited areas also makes them susceptible to shooting, trapping, poisoning, and loss of prey. The badger's niche as a wide-ranging carnivore, at least in the East Kootenay, is not widely recognized. Based on studies done elsewhere, it is easy to assume that badgers have only a small home range, which can lead to the mistaken assumption that multiple sightings of badgers over a wide area represent many individuals. This may lead to unrealistically high population estimates. The use of a wide range of habitats, including forested and nonforested sites and all biogeoclimatic zones, coupled with a lack of information about Columbian ground squirrel habitat preferences, population cycles, and sensitivity to habitat alterations, makes badger habitat management difficult. However, habitat preferences identified upon completion of this project should, in theory, allow the conservation or enhancement of key habitat elements. A significant proportion of badger habitat is on private land and First Nations reserves, so education and cooperative ventures with landowners will be a key ingredient to successful conservation plans. Translocation may also be required in the northern portions of the badger's range, as some local populations may no longer be self-sustaining.

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