

Chapter 3

TAXONOMY

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INTRODUCTION

Although two subspecies of the Red-tailed Chipmunk (*Tamias ruficaudus simulans*, *Tamias ruficaudus ruficaudus*) and two subspecies of the Least Chipmunk (*Tamias minimus selkirki*, *Tamias minimus oreocetes*) from the Kootenay region of southeastern British Columbia are on the province's Red/Blue List (Cannings et al. 1999), the taxonomic status of these taxa is unclear. One objective of the chipmunk study was to evaluate the systematic status of these four taxa, and their validity as distinct taxonomic or evolutionary significant units (see Nagorsen et al. 2000) that warrant conservation or special management.

Howell (1929) recognized two subspecies of *T. ruficaudus* (*T. r. simulans* and *T. r. ruficaudus*) largely on the basis of pelage. Based on their distinct male genital bones (bacula), White (1953) speculated that *T. r. simulans* and *T. r. ruficaudus* were distinct species. In a study of geographic variation among populations from Washington, Idaho, and Montana, Patterson and Heaney (1987) demonstrated that the two taxa were differentiated in bacular morphology, but overlapped in cranial morphology. They suggested that the two taxa were differentiated at the species level, although they noted that detailed studies of possible hybridization in contact zones were needed. Cowan (1946) described the general distribution of the two subspecies in Canada and summarized five cranial measurements for *T. r. ruficaudus*. However, morphological variation among Canadian populations of the two subspecies has not been assessed.

Twenty-one subspecies are recognized for *T. minimus* (Verts and Carraway 2001). The only taxonomic study applying modern techniques was done on several taxa from the south-western United States (Sullivan 1985; Sullivan and Petersen 1988). Taxonomy of *T. minimus* populations inhabiting the western Cordillera of Canada was last assessed more than 50 years ago by Cowan (1946) and the taxonomic validity of the two Red Listed subspecies in British Columbia is unknown. *T. m. selkirki* is an isolated subspecies restricted to high elevations in the Purcell Mountains described by Cowan (1946) from only five museum specimens all taken from the type locality (south-west of Invermere). Clearly a modern study with larger samples is needed to assess the taxonomic status of this population. *T. m. oreocetes* is a small, pale subspecies restricted to alpine habitats in the extreme southern Rocky Mountains of western Canada and Montana. Its differentiation from *T. m. borealis* the adjacent subspecies in the Canadian Rocky Mountains has not been assessed with a modern taxonomic study. The precise distributional limits of this subspecies in Canada is also contentious (Cowan 1946; Crowe 1943; Banfield 1958).

A preliminary taxonomic study of these chipmunk taxa was summarized by Nagorsen et al. (2000). However, it included few historical museum specimens and none of the voucher specimens taken 1998-99. Our analysis reported herein is more comprehensive. It includes the voucher specimens taken in 1996-99 and samples of historical museum specimens from British Columbia and Alberta housed in eight museums. We analyzed pelage, cranial, and genital bone (i.e., baculum and baubellum) morphology. Because they are conservative characters, male and female genital bones have proven to be important taxonomic characters for studying geographic variation and subspecies in various chipmunks (Sullivan 1985; Patterson and Heaney 1987).

METHODS

Our techniques for measuring skulls, bacula, and baubella; and describing pelage colour are summarized in detail in Chapter 2. All taxonomic analyses were based on adult animals with fully erupted, permanent dentition (see Chapter 2 for ageing methods). Although *T. minimus* and *T. ruficaudus* demonstrate sexual size dimorphism (Sheppard 1965; Levenson 1990), sample sizes were inadequate for some groups to separate sexes in our analyses of body size and cranial morphology. All morphometric analyses were done with SYSTAT® 9 programs (SPSS Inc.).

A. *Tamias ruficaudus*

We assessed pelage colour and morphometric differences in body, cranial, bacular, and baubellar measurements in two samples: *T. r. simulans* from the southern Selkirk Mountains of British Columbia and *T. r. ruficaudus* from the southern Rocky Mountains of British Columbia and Alberta (see Appendix 3-1). Sample sizes were inadequate to assess possible geographic variation within these subspecies in Canada. Because *T. r. simulans* and *T. amoenus luteiventris* cannot be discriminated reliably from cranial or pelage traits (see Chapter 2), we restricted our sample of *T. r. simulans* to 28 specimens identified from either genital bone preparations or radiographs that revealed images of genital bones preserved in their study skins. Our sample of *T. r. ruficaudus* consisted of 22 specimens identified from genital bones (preparations or radiographs) and an additional 12 specimens lacking genital bones that were verified from cranial measurements using the discriminant function described in Chapter 2. All were classified as *T. r. ruficaudus* with probabilities of 0.97 to 1.0. Details on the samples of genital bones, study skins, and skulls used in the analyses are summarized in Appendix 3-1.

We assessed fur colour from the underside of the tail in 23 *T. r. simulans* and 31 *T. r. ruficaudus*. Colour codes were based on colour charts in Smithe (1974, 1975, 1981). We calculated standard univariate statistics and compared means of bacular measurements of the two taxa with paired t-tests based on separate group variances and Bonferonni adjusted probabilities. As an ordination technique, we assessed the bacular data (log transformed) with a principal components analysis using a variance-covariance matrix. With this technique data are treated as a single statistical sample with no *a priori* assumptions of groups. Univariate statistics were calculated for body and cranial measurements; we compared means among the two taxa with one-way analyses of variance. Cranial measurements were also assessed with a multivariate analysis of variance (MANOVA) and a two-group discriminant analysis. A jack-knife procedure (leave-one-out method) was used as a cross-validation technique to assess classification error in our discriminant functions (Lance et al. 2000). Because multivariate methods require full data sets, we excluded specimens missing more than one measurement from the discriminant analyses. A single specimen was missing a value for zygomatic breadth. We estimated a value for this variable with a maximum likelihood algorithm. Our sample for the discriminant analysis consisted of 26 *T. r. simulans* and 30 *T. r. ruficaudus*.

B. *Tamias minimus*

We assessed variation in genital bone morphology and cranial morphology among selected samples of *T. m. selkirki*, *T. m. oreocetes*, and *T. m. borealis* from British Columbia and south-western Alberta. Bacular variation was analyzed in three samples: 1)

T. m. selkirki from the Purcell Mountains of British Columbia, 2) *T. m. oreocetes* from the Sheep River and Middle Kootenay Pass in the southern Rocky Mountains of British Columbia and Alberta, and 3) *T. m. borealis* from Fort Nelson in northeastern British Columbia. Because there are no baubellar preparations associated with historical museum specimens of *T. minimus* from western Canada, the analysis of baubellar variation was limited to the samples of voucher specimens of *T. m. selkirki* and *T. m. oreocetes* taken 1997-1998 from the Purcell and southern Rocky Mountains of British Columbia. We used five samples to evaluate geographic variation in cranial morphology: 1) *T. m. selkirki* from the Purcell Mountains, British Columbia; 2) *T. m. oreocetes* from the Sheep River area, Rocky Mountains, Alberta; 3) *T. m. borealis* from Banff National Park, Rocky Mountains, Alberta; 4) *T. m. borealis* from Jasper National Park, Rocky Mountains, Alberta, and 5) *T. m. borealis* from Fort Nelson in northern British Columbia. Only specimens taken from the north side of the Bow River were included in the Banff sample (see Banfield 1958; Meredith 1975). The Fort Nelson sample was in the Taiga Plains ecoregion east of the northern Rocky Mountains. Details on the samples of genital bones and skulls used in the analyses are summarized in Appendix 3-2.

We calculated standard univariate statistics and compared means of bacular and cranial variables with one-way analyses of variance (ANOVA). Post hoc comparisons of pairs of means were done Tukey's studentized range statistic. Baubellar data were too few for significance tests. Bacular and cranial measurements were also assessed with a multivariate analysis of variance (MANOVA) and a canonical variate analysis. Because multivariate methods require full data sets, we excluded skulls missing more than one measurement from the discriminant analyses. For specimens missing single variables, we estimated their values with a maximum likelihood algorithm. Our sample for the discriminant analysis consisted of Purcells-14, Sheep River-50, Banff-20, Jasper-28, Fort Nelson-12.

RESULTS

A. *Tamias ruficaudus*

The two subspecies demonstrated pronounced differences in pelage colour. *T. r. ruficaudus* skins had a dark reddish wash in the dorsal pelage that extended along the shoulders and nape. The colour of the underside of the tail was bright rufous ranging from Raw Sienna to Antique Brown (Fig. 3-1). *T. r. simulans* tended to be duller than *T. r. ruficaudus*. Their skins lacked the bright rufous wash on the shoulders and nape. The colour of the underside of the tail was paler ranging from Cinnamon to Antique Brown (Fig. 3-1). For photographs of study skins of the two taxa see Chapter 2.

T. r. ruficaudus and *T. r. simulans* differed in 5 of 9 bacular measurements (Table 3-1). A bivariate plot of component scores for the 19 specimens on the first two principal components (Fig. 3-2) revealed no overlap among the two samples on the first axis but substantial overlap on the second axis. Component correlations for the first principal component derived from the nine bacular measurements for the 19 specimens demonstrated that this vector described a pattern of variation that mainly contrasted increasing keel height, basal width, neck width, and shaft bend with decreasing total length and shaft length. *T. r. simulans* differed from *T. r. ruficaudus* in having shorter, broader, and more robust bacula. Representative bacula of the two subspecies are

illustrated in Chapter 2. In total, the two components accounted for 77.14% of the variation in the bacular data with the first component accounting for most (62.26%).

Sample sizes of baubella were too small to test for differences among their means (Table 3-2) but the two samples showed no overlap in their ranges for total length and width of the base (Fig. 3-3). *T. r. simulans* differed from *T. r. ruficaudus* in having longer and broader baubella. Representative baubella of the two subspecies are illustrated in Chapter 2.

The two samples differed in 3 of 5 body measurements (Table 3-3). *T. r. ruficaudus* was larger than *T. r. simulans* for 8 of 10 cranial measurements. The MANOVA revealed that the centroids of the two taxa were different (Wilk's Lambda = 0.279, $F=11.642$, $P<0.0001$). The canonical discriminant function described a pattern of variation that contrasted increasing interorbital width and diagonal length of the orbit with decreasing maxillary toothrow length. Discriminant scores for the two groups separated clearly on the discriminant vector (Fig. 3-4) with only one individual of each subspecies overlapping scores from the other group. The jack-knifed analysis correctly classified 28 of 30 (93%) *T. r. ruficaudus* and 22 of 26 (85%) *T. r. simulans*.

B. *Tamias minimus*

Bacular measurements showed minor differences among the three samples (Table 3-4); nevertheless, the MANOVA demonstrated pronounced differences among the three group centroids (Wilks' lambda= 0.041, $F=5.213$, $P=0.0001$). The canonical variate analysis revealed three discrete groups. The first axis accounted for 89% of the variation and it clearly separated the northern sample of *T. m. borealis* from *T. m. selkirki* and *T. m. oreocetes*. This vector described a pattern of variation that contrasted increasing tip width with decreasing keel height, tip angle, and neck width. The second axis accounted for about 10% of the variation and it separated *T. m. selkirki* from *T. m. oreocetes*. This vector contrasted increasing total length and basal width with decreasing shaft and tip length. The two canonical variates essentially accounted for the entire variation in the bacular data. *T. m. oreocetes* had a longer baubellum than *T. m. selkirki* (Table 3-5) but the small sample sizes prohibited a rigorous analysis of population variation in this structure.

Body and cranial measurements for the five groups are summarised in Table 3-6. Means of the 6 body and 10 cranial measurements differed among the five samples. Generally the five groups demonstrated considerable overlap, but 6 of 10 cranial measurements for the Purcells sample formed unique subsets (Table 3-6). The univariate statistics suggest a clinal pattern with cranial and body size increasing with latitude especially among the samples from the Rocky Mountains. A MANOVA demonstrated marked differences among the five group centroids (Wilks' lambda= 0.193, $F=5.680$, $P<0.0001$). The first two canonical variates from the cranial data (Fig. 3-6) summarised 89.7% of the variation among the groups with the first canonical variate accounting for 80.5%. The ordination of the five samples on the first two canonical variates shows no discrete non-overlapping groups. Skulls from the Purcells fall to left of the plot but overlap to some extent with the Sheep River and Banff samples. The three samples from the Rocky Mountains (Sheep River, Banff, Jasper) and the Fort Nelson sample overlap substantially with no evidence for any morphometric discontinuities in the Rocky Mountains.

DISCUSSION

A. Tamias ruficaudus

Two distinct bacular morphs of *T. ruficaudus* occur in western Canada. Their morphology and geographic distribution is concordant with the pattern described by Patterson and Heaney (1987) for the two subspecies (*T. r. simulans*, *T. r. ruficaudus*) in Washington, Idaho, and Montana. Although several researchers (White 1953, Patterson and Heaney 1987) have used the baculum of *T. ruficaudus* as a taxonomic character, there has been no comparable study on the baubellum or os clitoris bone, the homologous female structure. Sutton (1982) examined six *T. r. simulans* and a single *T. r. ruficaudus*, but he pooled measurements from both taxa in his description and he illustrated the baubellum only for *T. r. simulans*. Samples are small, but our data demonstrate that the baubellum also differs among these two taxa. Baubellar variation should be assessed in other populations to determine if there are two distinct morphs concordant with the patterns of bacular variation.

The northern populations of *T. r. ruficaudus* and *T. r. simulans* are also differentiated in cranial morphology and pelage colour. In Canada, *T. r. simulans* exhibits greater differences in cranial and pelage morphology from *T. r. ruficaudus* than it does from contiguous or parapatric populations of *T. amoenus*. A similar pattern was reported by Sutton and Patterson (2000) for *Tamias siskiyou* and *Tamias senex* in California where inland and coastal forms of the two species taxa resemble each other more than inland and coastal populations of the same species. Although *T. r. ruficaudus* and *T. r. simulans* from the central core area of the range overlap in cranial morphology (Patterson and Heaney 1987), Canadian populations show little morphological overlap. These northern forms of *T. ruficaudus* appear to represent two extremes in a clinal pattern of increasing cranial size that extends from the Selkirk Mountains of Washington and British Columbia to the Rocky Mountains of northern Montana and Canada. This cranial variation may reflect natural selection or ecophenotypic variation associated with some environmental or ecological gradient. According to Patterson (1981, 1983) cranial morphology in chipmunks largely reflects ecological conditions.

Patterns of geographic variation in pelage colour among *T. ruficaudus* populations across the range have not been assessed quantitatively. *T. r. simulans* is generally described as being paler and less rufous than *T. r. ruficaudus* (Howell 1922, 1929; Best 1993). Gambs (1965) reported clinal variation in the intensity of the ventral tail colour among populations in the United States. According to Gambs (1965) populations at the extremes show marked differences in tail colour but populations from the core of the range evidently converge in pelage colour. The colour differences shown by *T. r. ruficaudus* and *T. r. simulans* in Canada are consistent with this pattern. Patterns in geographic variation in pelage colour among chipmunk populations are usually interpreted as a response to selection for camouflage (Patterson 1984, Sutton and Patterson 2000). The dull pelage of *T. r. simulans* in British Columbia is concordant with selection for concealing colouration against a dark background. The Selkirk Mountains of British Columbia are in an interior wet belt region with high precipitation. Most *T. r. simulans* occurrences are from the interior cedar-hemlock biogeoclimatic zone where forests are dominated by western redcedar and western hemlock (Meidinger and Pojar

1991). Dark or dull pelage is common trait of chipmunks populations associated with humid coastal forests (Sutton and Patterson 2000).

The maps in Gambs (1965), Hall (1981), and Patterson and Heaney (1987) imply that the distributions of *T. r. simulans* and *T. r. ruficaudus* are in contact in extreme southern British Columbia. Our data (see Chapter 4) show no evidence for a northern contact zone in Canada. At the northern edge of their range, the two taxa appear to be allopatric separated by about 180 kilometres. This pattern is probably a legacy of postglacial dispersal by these two taxa. The southern Columbia and Rocky Mountains of Canada were covered by the Cordilleran ice sheet during the last glaciation; glacial retreat in this region began by about 13,000 to 12,000 BP (Clague 1981). We hypothesize that the two northern forms of *T. ruficaudus* were derived from separate source populations that were isolated south of the Cordilleran ice sheet in the United States during the last glaciation. Isolated by physiographic barriers associated with the Kootenay River system in the Rocky Mountain Trench and the Creston Valley and intervening populations of *T. amoenus* in the Purcell Mountains, Canadian populations of *T. r. ruficaudus* and *T. r. simulans* have probably been allopatric throughout the entire Holocene.

A study of mtDNA by Good and Sullivan (in press), demonstrated distinct western and eastern haplotypes of *T. ruficaudus* that are concordant with the distribution of the *T. r. ruficaudus* and *T. r. simulans* bacular forms. The only contact zone between *T. r. simulans* and *T. r. simulans* where the critical test of introgression or hybridization can be made is in central Idaho and western Montana (Hall 1981, Patterson and Heaney 1987). Patterson and Heaney (1987) found no intergrades in bacular morphology in this region suggesting that *T. r. simulans* and *T. r. ruficaudus* were incipient or sibling species. But their geographic coverage was spotty. Good and Sullivan (2001), however, reported some introgression in mtDNA in a contact zone in the Clearwater drainage of central Idaho. Some males with *T. r. ruficaudus* haplotypes evidently had the *T. r. simulans* bacular form. Until more research is done to assess hybridization in the contact zone, it is prudent to treat *T. r. simulans* and *T. r. ruficaudus* as two well differentiated subspecies. From the perspective of conservation biology, it may be a mute point if these two forms represent sibling species or distinct subspecies. In Canada, the two taxa differ in genital bone morphology, cranial morphology, pelage colour, distribution, and ecology (see Chapter 4). Therefore, it is appropriate to consider them as separate evolutionary significant units for management or conservation.

B. Tamias minimus

Clifford Carl and George Hardy first discovered the isolated population of *T. minimus* in the Purcell Mountains of British Columbia in 1944 when they collected two specimens from the Paradise Mine west of Invermere (Carl and Hardy 1945). They assigned their specimens to the subspecies *T. m. oreocetes*; however, in his unpublished field notes Carl noted that they may represent a new undescribed subspecies. Based on the two RBCM specimens and three additional specimens taken in 1945, Cowan (1946) formally described and named this isolated population in the Purcell Mountains as *T. m. selkirki*. Cowan's criteria were based on pelage colour and tail length. His conclusion that *T. m. selkirki* has a shorter tail is not supported by our data (Table 3-6). We did not assess variation in pelage colour among our five groups. There are few adult study skins of *T. m.*

oreocetes in museum collections. The large sample from Sheep River for example collected as part of Sheppard's (1965) dissertation research, consists of skulls that lack associated skins. Although *T. m. selkirki* may be brighter than *T. m. borealis* with paler feet, and narrower median stripes (Cowan 1946), it is difficult to quantify these differences and to separate variation associated with seasonal moults.

Our morphometric analysis, however, suggest that *T. minimus* in the Purcell Mountains are differentiated from populations in the adjacent Rocky Mountains and lends support to Cowan's (1946) classification of this population as a distinct subspecies. The divergence in bacular morphology is noteworthy as various researcher have noted its importance as a taxonomic character in chipmunks (Patterson 1984; Sullivan 1985; Sullivan and Peterson 1988). Although the multivariate patterns of cranial variation show no non-overlapping groups, *T. minimus* from the Purcell Mountains demonstrate some divergence from the Rocky Mountains populations. Interestingly, the Fort Nelson population which is about 700 km north of the Banff and Jasper samples, shows less divergence from the Rocky Mountain populations than the population in the Purcell Mountains.

Known from only two localized areas above treeline (see Chapter 4), *T. m. selkirki* is allopatric with other populations of *T. minimus* in western Canada. Nearest populations of *T. minimus* in the Rocky Mountains are 80 to 100 kilometres east along the continental divide. They are separated from *T. m. selkirki* by extensive montane and lowland forests inhabited by *T. amoenus* (see Chapter 4) and the isolating barrier of the Columbia River in the Rocky Mountain trench. We hypothesize that *T. m. selkirki* is a relict population that was isolated in alpine habitats of the Purcell Mountains during the early postglacial. Given its broad ecological and habitat affinities (Verts and Carraway 2001) and its adaptation to boreal conditions, *T. minimus* would be expected to be first chipmunk species to colonize a postglacial landscape. It may have been widespread throughout the southern Columbia Mountains and Rocky Mountains in the open forest-tundra habitats associated with the late Pleistocene (Hebda 1995). With the shift to a warm dry period during the early Holocene and the development of pine and spruce forests (Hebda 1995), *T. minimus* was displaced from forested habitats by *T. amoenus* and *T. ruficaudus* through competitive exclusion but managed to persist in alpine landscapes where this species has a competitive and physiological edge (Sheppard 1971; Meredith 1975, 1977).

All of the *T. minimus* associated with the southern Columbia and Rocky mountains in Canada may be derived from a single lineage of that colonized this region in the early postglacial. According to this scenario, *T. m. selkirki* diverged from the Rocky Mountain populations during the past 10,000 to 12,000 years in response to selection pressures associated with minor environmental differences or genetic drift in a small isolated population. It is debatable that such recent divergence warrants recognition taxonomically as a subspecies. Smith and Patton (1988) supported the subspecies concept if it was applied to evolutionary units that share similar morphological and genetic traits, and a common biogeographic history rather than local variants attributable to genetic drift in small populations. Patterson (1980) described a subspecies of *Tamias quadrivittatus* from the Organ Mountains of New Mexico that he attributed to rapid divergence in a small isolated population during Recent time. On the other hand, Patterson (1982) concluded that populations of *T. minimus* in the south-western United States that were isolated from the southern Rocky Mountains in the postglacial demonstrated negligible

differentiation (but see Sullivan 1985). Alternatively, *T. m. selkirki* could represent a separate lineage of *T. minimus* derived from populations that share a separate phylogeographic history from populations in the Canadian Rocky Mountains and northern boreal forests. These competing hypotheses can only be tested with molecular studies.

T. m. oreocetes was described and named by Merriam (1897) as a distinct species (*Eutamias oreocetes*) on the basis of the type specimen taken from the Rocky Mountains of Montana. In his vague description, he distinguished it from *T. minimus* (subspecies not given) by its darker and heavier dorsal stripes and smaller skull. Howell (1922, 1929) reduced this taxon to a subspecies of *T. minimus* (*T. m. oreocetes*); he speculated that it ranged from northern Montana to south-western Alberta. According to Howell (1929), it differs from *T. m. borealis*, the adjacent subspecies in Canada, by: paler dorsal stripes, paler hind feet, a shorter tail, and a shorter skull. Nevertheless, in his remarks Howell (1929) astutely noted: "By reason of the small number of specimens available it is impossible to satisfactorily characterize this form. Most of the specimens are in worn winter pelage, there being but one in fresh summer pelage, and that not entirely complete". Subsequent taxonomic accounts (Crowe 1943; Banfield 1958; Soper 1964) essentially repeat Howell's (1929) diagnostic traits. However, Cowan (1946) described clinal variation in body measurements among small samples of *T. minimus* from the Canadian Rocky Mountains and the Peace River area and suggested that pelage traits were most reliable for distinguishing *T. m. oreocetes* and *T. m. borealis* particularly in their contact zone.

The geographic limits of the distribution of *T. m. oreocetes* in Canada has also been contentious. Cowan (1946) and Cowan and Guiguet (1965) suggested that it was restricted to the extreme southern Rocky Mountains in the Waterton Lakes-Akamina Pass area. The only potential ecological barrier for north-south dispersal by *T. minimus* in that region would be the Crowsnest Pass, a wide low elevation pass (1360 m) that separates alpine habitats by a 4 km-wide gap where populations of *T. amoenus* could isolate alpine populations of *T. minimus*. However, most researchers (Crowe 1943; Banfield 1958; Meredith 1975, 1977) consider the range of *T. m. oreocetes* to extend along the continental divide as far north as Banff and Yoho National parks where it is separated from *T. m. borealis* to the north by the Bow River and Kicking Horse Pass and intervening low elevation populations of *T. amoenus*.

If *T. m. oreocetes* is a valid taxon, then a sharp step-cline delimiting it from *T. m. borealis* would be expected across the Bow River area. Univariate variation in body measurements and multivariate patterns of cranial variation show no evidence for a step-cline or sharp morphometric discontinuity among the Rocky Mountains populations. The patterns of variation are consistent with the clinal trend suggested by Cowan (1946). This cline may reflect selection along an environmental or ecological gradient. Although our samples of *T. m. oreocetes* and *T. m. borealis* differ in bacular morphology, no genital bone samples are available for Rocky Mountain *T. m. borealis* and our analysis was limited to a single sample of *T. m. borealis* from northern British Columbia 700 to 800 km north of the *T. m. oreocetes* bacular sample. Additional samples from intervening areas in the Rocky Mountains may reveal morphological overlap.

Definitive conclusions about the taxonomy of *T. minimus* in the southern Columbia and Rocky Mountains of Canada are hindered by inadequate specimen samples. Bacular

samples from areas in the Rocky Mountains north of the Bow River are essential to evaluate bacular morphology among the Rocky Mountain populations. As most of this region falls within the boundaries of Banff and Jasper national parks, acquiring new specimen material is likely impossible. Radiographs of historical museum specimens collected in Banff and Jasper that are housed in the Canadian Museum of Nature revealed preserved genital bones in some skins. It is conceivable that these can be removed from the skin, cleared, and stained for measurement. A sample of skull and bacular specimens from the extreme southern Rocky Mountains is also needed to evaluate Cowan and Guiguet's (1965) proposed distributional limit south of Crowsnest Pass for *T. m. oreocetes*. *T. minimus* specimens available from this region consist only of our vouchers taken at Middle Kootenay Pass in 1998 and a few historical museum specimens from Waterton Lakes National Park. These collections comprise only 6 adult skulls and 4 bacular specimens—too few to use as a separate group in our analyses.

Molecular studies with allozymes and DNA are also essential to resolve the systematics of *T. m. selkirki* and *T. m. oreocetes*. Tissue samples for DNA analysis were collected from our voucher specimens of *T. m. selkirki* and *T. m. oreocetes* taken in 1997–98. Although the RBCM has no facilities for DNA analysis, the tissues are being stored for potential future research. Piaggio and Spicer (2000) reported high divergence in mitochondrial DNA among several subspecies of *T. minimus*. Their results suggest that *T. minimus* may consist of several distinct phylogeographic lineages.

CONCLUSIONS

1. In Canada at the northern periphery of their distributions, *T. r. ruficaudus* and *T. r. simulans* differ in male and female genital morphology, cranial morphology, and pelage colour. The genital bone morphology of these northern forms is concordant with the occurrence of two non-overlapping morphs throughout the range; their differences in pelage and cranial morphology are consistent with clinal patterns that are associated with ecological or environmental gradients.
2. Because the northern forms of *T. ruficaudus* are allopatric, the only potential contact zone for testing introgression is in Idaho and Montana. Until detailed genetic studies are done in the contact zone, taxonomic status of the two forms is unresolved. However, because they differ in morphology, distribution, and ecology the Canadian populations of *T. r. ruficaudus* and *T. r. simulans* should be treated as distinct evolutionary units for conservation and management.
3. Inadequate samples prohibit definitive conclusions on the taxonomy of *T. minimus* in the southern Columbia and Rocky Mountains of Canada. Existing data demonstrate that *T. m. selkirki* is differentiated from Rocky Mountain populations of *T. minimus* in male genital bone (bacula) morphology and cranial morphology. Because it is allopatric separated by 100 km from *T. minimus* in the Rocky Mountains and represents a relict population, we recommend that it be considered a distinct taxonomic unit. Molecular studies are needed to evaluate genetic divergence in this population.
4. There are inadequate bacular samples from Rocky Mountain *T. minimus* populations to assess geographic variation in male genital bone morphology, but univariate analysis of

body measurements and multivariate analyses of cranial morphology suggest clinal patterns with no evidence for a step-cline across the Bow River the putative boundary between *T. m. oreocetes* and *T. m. borealis*. Given this pattern of clinal variation in the Rocky Mountains, the taxonomic validity of *T. m. oreocetes* is dubious. However, until more bacular samples are obtained and molecular studies are done, it is prudent to continue to recognize populations south of the Bow River and Kicking Horse pass in the Canadian Rocky Mountains as a separate subspecies, *T. m. oreocetes*.

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Table 3-1. Bacular measurements (means \pm 1 standard deviation, ranges) for the two subspecies of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. Linear measurements in millimetres, tip angle in degrees. Based on specimens taken in 1996-99 and historical museum specimens.

Measurement	<i>T. r. ruficaudus</i> (N=8)		<i>T. r. simulans</i> (N=11)		Student's t-test	
	Mean	Range	Mean	Range	<i>t</i>	<i>P</i>
Total length	5.10 \pm 0.09	4.74-5.52	4.14 \pm 0.21	3.82-4.48	9.056	<0.001
Shaft length	4.41 \pm 0.08	4.07-4.74	3.58 \pm 0.07	3.43-3.70	11.897	<0.001
Tip length	1.56 \pm 0.04	1.37-1.74	1.65 \pm 0.06	1.52-1.75	-2.277	ns
Base width	0.77 \pm 0.03	0.63-0.93	0.86 \pm 0.06	0.75-0.93	-2.579	ns
Tip width	0.59 \pm 0.02	0.52-0.67	0.56 \pm 0.05	0.54-0.67	1.456	ns
Shaft bend	0.55 \pm 0.01	0.52-0.59	0.62 \pm 0.04	0.56-0.70	-4.243	0.005
Neck width	0.27 \pm 0.01	0.22-0.30	0.34 \pm 0.04	0.29-0.41	-4.491	0.003
Keel height	0.51 \pm 0.01	0.48-0.52	0.60 \pm 0.03	0.56-0.67	-6.815	<0.001
Tip angle	121.4 \pm 2.0	118.0-124.0	120.1 \pm 2.94	116.0-125.0	1.092	ns

Table 3-2. Baubellar measurements (means \pm 1 standard deviation, ranges) for the two subspecies of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. All measurements in millimetres. Based on specimens taken in 1996-99.

Measurement	<i>T. r. ruficaudus</i> (N=8)		<i>T. r. simulans</i> (N=3)	
	Mean	Range	Mean	Mean
Total length	2.25 \pm 0.19	2.00-2.56	2.90 \pm 0.28	2.73-3.22
Base width	0.52 \pm 0.03	0.47-0.56	0.64 \pm 0.02	0.62-0.67
Flange length	0.92 \pm 0.07	0.82-1.02	0.98 \pm 0.12	0.84-1.09
Keel height	0.45 \pm 0.04	0.40-0.53	0.48 \pm 0.01	0.47-0.49

Table 3-3. Body measurements, weights, and cranial measurements (means \pm 1 standard deviation, ranges) for the two subspecies of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. Weights in grams, linear measurements in millimetres. Based on voucher specimens taken 1996-99 and historical museum specimens.

Measurement	<i>T. r. ruficaudus</i>			<i>T. r. simulans</i>			ANOVA	
	Mean	Range	N	Mean	Range	N	F	P
Total length	222.4 \pm 8.8	207-235	32	225.8 \pm 6.3	216-237	22	2.85	ns
Body length	127.5 \pm 7.8	114-145	31	123.9 \pm 6.0	116-135	23	2.71	ns
Tail length	94.7 \pm 4.5	85-102	31	102.1 \pm 5.9	93-115	22	24.47	<0.001
Hind foot	33.7 \pm 1.1	32-36	23	33.0 \pm 1.3	30-35	28	3.31	Ns
Ear	17.1 \pm 1.5	14-19	16	15.8 \pm 1.7	13-19	23	6.03	0.019
Weight	66.0 \pm 5.8	53.5-78.7	16	54.7 \pm 4.8	44.2-64.6	22	45.07	<0.001
Greatest length	35.3 \pm 0.54	34.0-36.1	31	34.1 \pm 0.71	32.3-35.5	26	39.74	<0.001
Zygomatic breadth	19.6 \pm 0.34	18.9-20.2	31	19.0 \pm 0.35	18.4-19.6	26	35.92	<0.001
Nasal length	11.0 \pm 0.30	10.2-11.7	34	10.7 \pm 0.54	9.2-11.5	27	7.14	0.010
Maxillary toothrow length	5.5 \pm 0.14	5.2-5.8	34	5.4 \pm 0.23	4.8-5.8	28	1.55	ns
Interorbital width	7.5 \pm 0.25	6.8-7.8	33	7.2 \pm 0.23	6.6-7.6	28	18.96	<0.001
Nasal width	3.0 \pm 0.22	2.7-3.5	33	3.0 \pm 0.23	2.5-3.4	28	2.78	ns
Diagonal length of orbit	8.5 \pm 0.22	8.0-8.9	33	8.1 \pm 0.27	7.5-8.6	27	47.84	<0.001
Cranial depth	14.4 \pm 0.26	13.8-14.9	31	13.9 \pm 0.26	13.4-14.4	26	41.71	<0.001
Mandibular length	19.3 \pm 0.30	18.5-19.8	33	18.7 \pm 0.38	18.0-19.6	28	49.33	<0.001
Coronoid height	10.2 \pm 0.30	10.2-11.6	33	10.7 \pm 0.42	9.9-11.3	28	22.05	<0.001

Table 3-4. Bacular measurements (means \pm 1 standard deviation, ranges) for three subspecies of the Least Chipmunk (*Tamias minimus*) from British Columbia and Alberta. Linear measurements in millimetres, tip angle in degrees. Based on specimens taken in 1996-99 and historical museum specimens.

Measurement	<i>T. m. selkirki</i> (N=9)		<i>T. m. oreocetes</i> (N=7)		<i>T. m. borealis</i> (N=7)	
	Mean	Range	Mean	Range	Mean	Range
Total length	3.10 \pm 0.08	2.93-3.22	3.00 \pm 0.15	2.78-3.19	3.10 \pm 0.10	2.96-3.22
Shaft length	2.70 \pm 0.07	2.59-2.78	2.70 \pm 0.12	2.56-2.85	2.79 \pm 0.09	2.67-2.89
Tip length	0.63 \pm 0.06	0.56-0.70	0.68 \pm 0.02	0.67-0.70	0.76 \pm 0.06	0.67-0.85
Base width	0.44 \pm 0.04	0.37-0.52	0.43 \pm 0.07	0.33-0.52	0.49 \pm 0.05	0.41-0.56
Tip width	0.34 \pm 0.04	0.30-0.41	0.31 \pm 0.04	0.26-0.37	0.31 \pm 0.04	0.26-0.37
Shaft bend	0.23 \pm 0.03	0.19-0.26	0.21 \pm 0.03	0.19-0.26	0.25 \pm 0.03	0.22-0.30
Neck width	0.13 \pm 0.02	0.11-0.15	0.13 \pm 0.03	0.11-0.19	0.17 \pm 0.03	0.15-0.22
Keel height	0.23 \pm 0.02	0.22-0.26	0.23 \pm 0.04	0.19-0.30	0.26 \pm 0.04	0.22-0.30
Tip angle	136.6 \pm 1.0	135.0-138.0	139.0 \pm 4.61	129.0-141.0	141.4 \pm 2.57	138.0-145.0

Table 3-5. Baubellar measurements (means \pm 1 standard deviation, ranges) for the two subspecies of the Least Chipmunk (*Tamias minimus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia. All measurements in millimetres. Based on specimens taken in 1996-99.

Measurement	<i>T. m. selkirki</i> (N=5)		<i>T. m. oreocetes</i> (N=4)	
	Mean	Range	Mean	Mean
Total length	0.92 \pm 0.02	0.91-0.96	1.02 \pm 0.07	0.91-1.07
Base width	0.28 \pm 0.03	0.24-0.31	0.30 \pm 0.02	0.27-0.31
Flange length	0.46 \pm 0.20	0.44-0.49	0.46 \pm 0.02	0.44-0.49
Keel height	0.14 \pm 0.02	0.11-0.16	0.18 \pm 0.06	0.13-0.27

Table 3-6. Body measurements, weights, and cranial measurements (means ± 1 standard deviation, sample sizes in parentheses) for five samples of the Least Chipmunk (*Tamias minimus*) from British Columbia and Alberta. Weights in grams, linear measurements in millimetres. Purcells= *T. m. selkirki*; Sheep River=*T. m. oreocetes*; Banff, Jasper, Fort Nelson=*T. m. borealis*. Asterisks denote the probability of equality of means based on one-way ANOVA's. Letters in superscript define non-significant ($P > 0.05$) subsets of groups determined by Tukey's studentized range statistic.

Measurement	Purcells, BC		Sheep River, AB		Banff, AB		Jasper, AB		Ft. Nelson, BC	
Total length ***	185.5 \pm 6.0 ^a	(14)	191.9 \pm 8.7 ^{ab}	(46)	195.3 \pm 8.9 ^{bc}	(18)	206.0 \pm 6.2 ^d	(23)	203.2 \pm 5.4 ^{cd}	(13)
Body length ***	105.6 \pm 4.0 ^a	(14)	112.3 \pm 4.7 ^{bd}	(47)	113.4 \pm 5.4 ^{bd}	(18)	119.4 \pm 8.6 ^c	(23)	111.3 \pm 6.2 ^{bd}	(14)
Tail length ***	80.6 \pm 5.1 ^a	(15)	79.6 \pm 5.8 ^{ab}	(46)	81.9 \pm 7.6 ^{ab}	(18)	86.6 \pm 8.6 ^{acd}	(23)	92.6 \pm 3.0 ^{cd}	(14)
Hind foot *	30.6 \pm 4.0 ^a	(15)	31.1 \pm 0.9 ^{ab}	(49)	31.2 \pm 1.0 ^a	(18)	31.6 \pm 1.3 ^a	(25)	31.1 \pm 1.2 ^{ab}	(15)
Ear ***	14.0 \pm 1.2 ^a	(12)	15.8 \pm 1.0 ^a	(49)	14.5 \pm 0.9 ^a	(10)	14.6 \pm 0.7 ^a	(16)	15.0 \pm 1.3 ^a	(11)
Weight **	41.4 \pm 4.0 ^a	(12)	43.9 \pm 4.3 ^a	(50)	42.7 \pm 3.9 ^a	(5)	53.8 \pm 8.7 ^c	(16)	45.9 \pm 7.7 ^a	(13)
Greatest length***	31.3 \pm 0.36 ^a	(14)	31.8 \pm 0.47 ^{bd}	(50)	32.3 \pm 0.50 ^{cd}	(18)	32.7 \pm 0.6 ^{cd}	(28)	32.2 \pm 0.38 ^{bcd}	(12)
Zygomatic breadth ***	17.8 \pm 0.36 ^a	(14)	18.1 \pm 0.29 ^b	(45)	18.2 \pm 0.34 ^{bc}	(20)	18.5 \pm 0.34 ^d	(25)	18.3 \pm 0.36 ^{bcd}	(12)
Nasal length ***	9.0 \pm 0.36 ^a	(15)	9.2 \pm 0.33 ^b	(50)	9.5 \pm 0.29 ^{bc}	(19)	9.7 \pm 0.45 ^d	(28)	9.6 \pm 0.26 ^{bcd}	(12)
Maxillary toothrow length ***	4.9 \pm 0.15 ^a	(15)	4.9 \pm 0.17 ^{ab}	(50)	4.9 \pm 0.15 ^{abc}	(20)	5.1 \pm 0.16 ^{acd}	(28)	5.1 \pm 0.14 ^{acd}	(13)
Interorbital width ***	6.9 \pm 0.25 ^a	(14)	6.6 \pm 0.29 ^{ab}	(50)	6.7 \pm 0.21 ^{abc}	(20)	7.0 \pm 0.31 ^{ad}	(28)	6.7 \pm 0.31 ^{abcd}	(13)
Nasal width ***	2.1 \pm 0.19 ^a	(15)	2.1 \pm 0.14 ^{ab}	(50)	2.2 \pm 0.19 ^{abc}	(20)	2.3 \pm 0.26 ^{cd}	(28)	2.4 \pm 0.12 ^{cd}	(13)
Diagonal length of orbit **	7.3 \pm 0.29 ^a	(15)	7.4 \pm 0.32 ^{ab}	(50)	7.6 \pm 0.31 ^b	(20)	7.6 \pm 0.31 ^b	(28)	7.6 \pm 0.23 ^b	(12)
Cranial depth **	12.9 \pm 0.29 ^a	(12)	13.1 \pm 0.22 ^b	(49)	13.3 \pm 0.23 ^{bc}	(18)	13.4 \pm 0.21 ^c	(27)	13.5 \pm 0.30 ^c	(11)
Mandibular length ***	16.7 \pm 0.34 ^a	(14)	17.1 \pm 0.31 ^b	(50)	17.3 \pm 0.44 ^{bc}	(20)	17.7 \pm 0.34 ^d	(28)	17.3 \pm 0.36 ^{bc}	(13)
Coronoid height ***	9.2 \pm 0.36 ^a	(14)	9.8 \pm 0.30 ^b	(45)	9.9 \pm 0.30 ^{bc}	(19)	10.4 \pm 0.22 ^d	(28)	10.1 \pm 0.38 ^c	(12)

* $P < 0.05$

** $P < 0.01$

*** $P < 0.001$

Figure 3-1. Bar graph showing ventral tail colour for the two subspecies of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. Colours are ordered by decreasing rufous from left to right. Based on voucher specimens and historical museum specimens. Colour names and codes from Smith (1974, 1975, 1981). Sienna=Raw Sienna(136), Amber= Amber (36), Robin=Robin Rufous, Antique=Antique Brown (37), Mikado=Mikado Brown (121C), Cinammon=Cinammon (123).

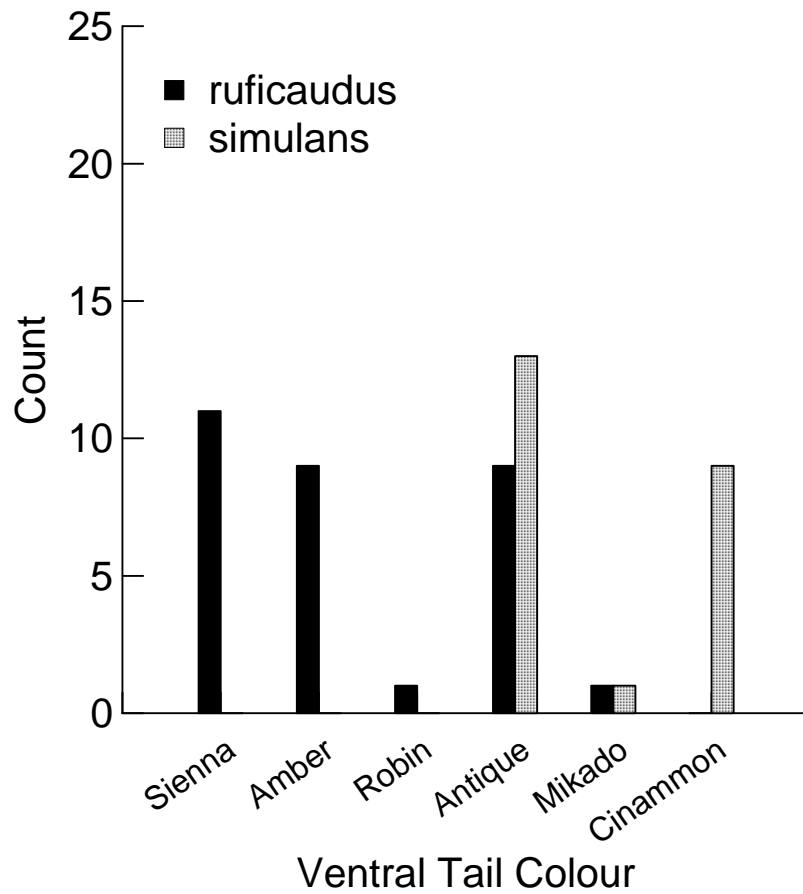


Figure 3-2. Projection of 19 bacular specimens of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta on the first two principal components derived from 9 bacular measurements. R= *T. r. ruficaudus*, S= *T. r. simulans*. Representative bacula all drawn to same scale.

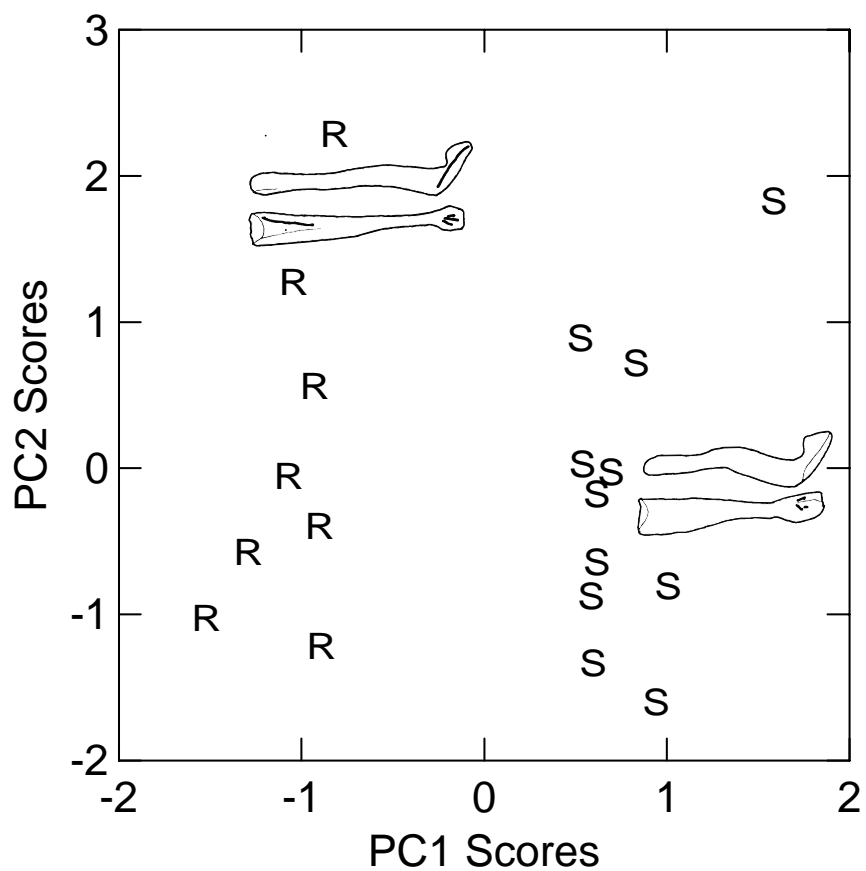


Figure 3-3. Bivariate plot of 11 baubellar specimens of the Red-tailed Chipmunk (*Tamias ruficaudus*) from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. R= *T. r. ruficaudus*, S= *T. r. simulans*. Representative baubella all drawn to same scale.

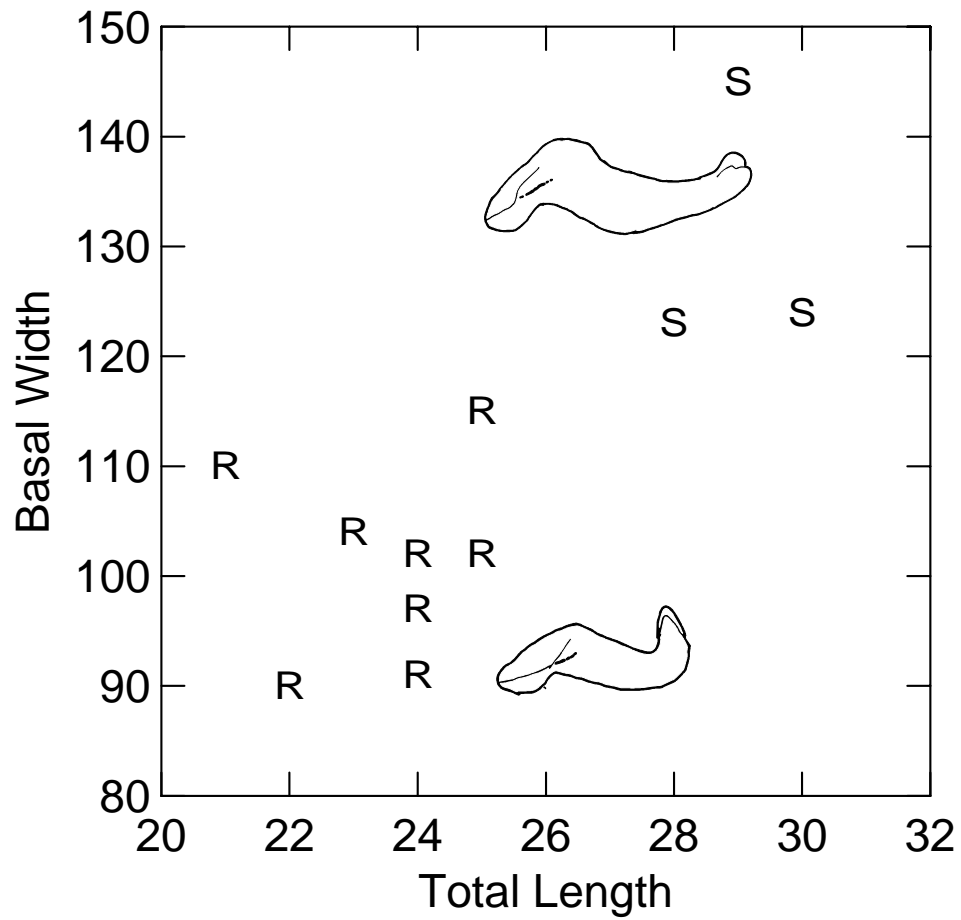


Figure 3-4. Histograms of discriminant scores for 30 *T. r. ruficaudus* and 26 *T. r. simulans* from the southern Selkirk Mountains and Rocky Mountains of British Columbia and Alberta. Based on a two-group discriminant analysis with 10 cranial variables.

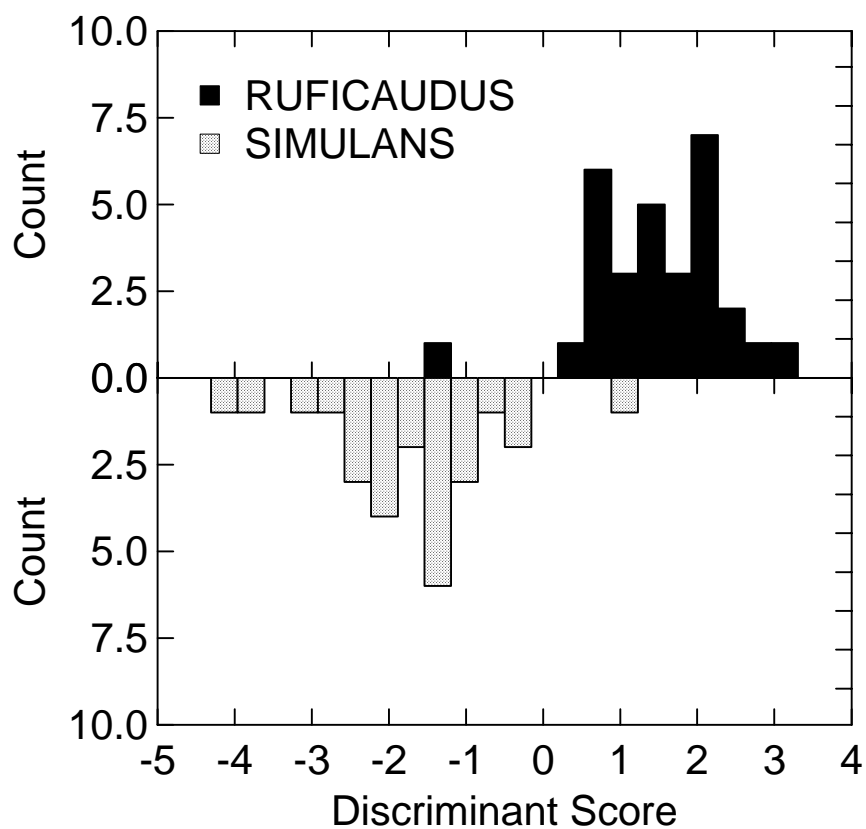


Figure 3-5. Projection of three bacular samples of the Least Chipmunk (*Tamias minimus*) on the first two canonical variates derived from nine bacular measurements. *T. m. selkirki*= Purcell Mountains, southern British Columbia; *T. m. oreocetes*= southern Rocky Mountains, British Columbia and Alberta; *T. m. borealis*= Fort Nelson area, northern British Columbia.

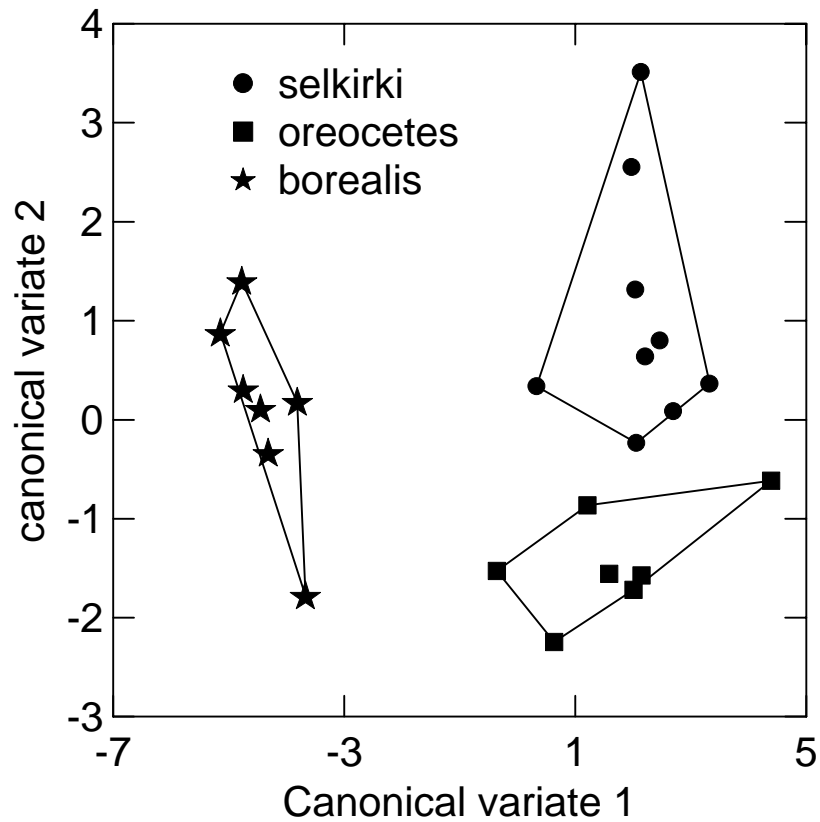
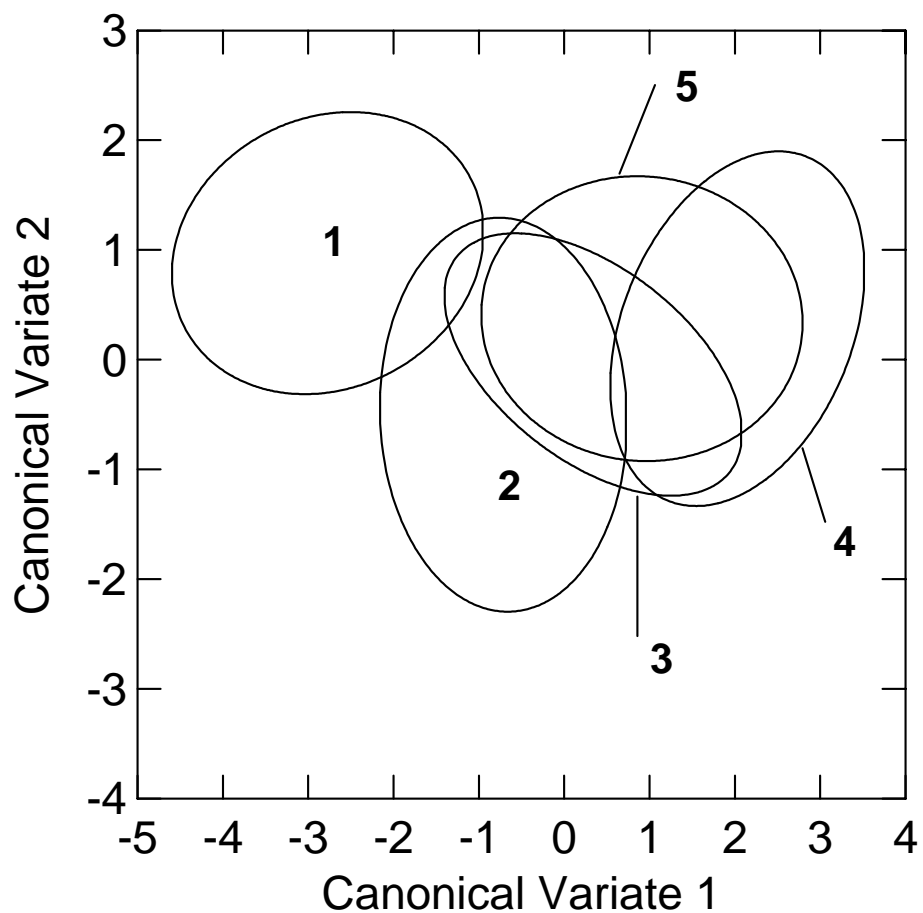


Figure 3-6. Projection of five samples of the Least Chipmunk (*Tamias minimus*) from British Columbia and Alberta on the first two canonical variates derived from 10 cranial measurements. Ellipses are confidence ellipses representing 1 standard deviation around the group centroids. 1=Purcells, BC; 2=Sheep River, AB; 3=Banff, AB; 4=Jasper, AB; 5=Fort Nelson, BC.



APPENDIX 3-1. TAMIAS RUFICAUDUS SPECIMENS EXAMINED

CMN= Canadian Museum of Nature, Ottawa; RBCM= Royal British Columbia Museum, Victoria; ROM= Royal Ontario Museum, Toronto; UAMZ= University of Alberta Museum of Zoology, Edmonton; UBC= Cowan Vertebrate Museum, University of British Columbia. "+" = Male, "*" = Female.

A. Genital Bones

Tamias ruficaudus simulans (11 +, 3 *)

BRITISH COLUMBIA. Church Creek: RBCM 19656 +, RBCM 19667 +. Giveout Creek: RBCM 19658 *, RBCM 19660 +, RBCM 19661 +, RBCM 19668 +, RBCM 20038 *. Gold Creek: RBCM 19654 +, RBCM 19655 +, RBCM 20036 *. Kootenay Pass [=Salmo-Creston Summit]: CMN 41277 +, CMN 41282 +, CMN 41286 +. Salmon River [=Salmo River?]: CMN 1008 +.

Tamias ruficaudus ruficaudus (8 +, 8 *)

ALBERTA. Castle River, headwaters: UAMZ 8174 +.
BRITISH COLUMBIA. Middle Kootenay Pass: RBCM 19875 +, RBCM 19880 +. Middlepass Creek: RBCM19885 *, RBCM 19884 +, RBCM 19887 *, RBCM 19906 *, RBCM 19907 +, RBCM 19914 +, RBCM 19915 *, RBCM 19916 +, RBCM 19917 *, RBCM 19918 *, RBCM 19919 *, RBCM 19920 +. Wall Lake: RBCM 19683 *.

B. Study Skins for Pelage

Tamias ruficaudus simulans (14 +, 9 *)

BRITISH COLUMBIA. Boundary Lake: ROM 28444 *. Church Creek: RBCM 19656 +, RBCM 19667 +, RBCM 19668 +. Creston, Kootenay Flats: ROM 28422 *. Giveout Creek: RBCM 19658 *, RBCM 19659 *, RBCM 19660 +, RBCM 19661 +, RBCM 20038 *. Gold Creek: RBCM 19654 +, RBCM 19655 +, RBCM 20036 *. Kootenay Pass [=Salmo-Creston Summit]: CMN 41277 +, CMN 41266 +, CMN 41267 +, CMN 41269 *, CMN 41272 +, CMN 41274 +, CMN 41283 *, CMN 41286 +. West Creston, Kootenay Flats: ROM 28453 +, ROM 28454 *.

Tamias ruficaudus ruficaudus (20 +, 11 *)

ALBERTA. Castle River, headwaters: UAMZ 8174, +. Spionkop Ridge: UAMZ 8154 *. Waterton Lakes National Park [no other data]: UBC 1632 *. Waterton Lakes National Park, Akamina Pass: CMN 18524 +. Waterton Lakes National Park, Cameron Lake: CMN 16010 +, CMN 16018 +, UBC 3547 *. Waterton Lakes National Park, Mount Carthew: CMN 16025. Waterton Lakes National Park, Sage Creek: UBC 1630 +, UBC 1631, +. Waterton Lakes National Park, Sheep Mountain: CMN 4598 +.
BRITISH COLUMBIA. Akamina Pass: RBCM 3571 +, UAMZ 1635 *, UBC 1625 +, UBC 1627 +, UBC 1628 +, UBC 1629 +. Middle Kootenay Pass: RBCM 19875 +, RBCM 19880, +. Middlepass Creek: RBCM 19884 +, RBCM19885 *, RBCM 19887 *, RBCM 19906 *, RBCM 19907 +, RBCM 19914 +, RBCM 19915 *, RBCM 19917 *, RBCM 19918 *, RBCM 19919 *, RBCM 19920 +. Wall Lake: RBCM 19683 *.

C. Skulls

Tamias ruficaudus simulans (17 +, 11 *)

BRITISH COLUMBIA. Boundary Lake: ROM 28444 *. Church Creek: RBCM 19656 +, RBCM 19666 *, RBCM 19667 +, RBCM 19668 +. Creston, Kootenay Flats: ROM 28422 *. Giveout Creek: RBCM 19658 *, RBCM 19659 *, RBCM 19660 +, RBCM 19661 +, RBCM 19662 *, RBCM 20038 *. Gold Creek: RBCM 19654 RBCM 19655 +, RBCM 20036 *. Kootenay Pass [=Salmo-Creston Summit]: CMN 41277 +, CMN 41265 +, CMN 41266 +, CMN 41267 +, CMN 41269 *, CMN 41272 +, CMN 41274 +, CMN 41282 +, CMN 41283 *, CMN 41286 +. West Creston: French's Farm: CMN 10169 +. West Creston, Kootenay Flats: ROM 28453 +, ROM 28454 *.

Tamias ruficaudus ruficaudus (14 +, 20 *)

ALBERTA. Castle River, headwaters: UAMZ 8174, +. Spionkop Ridge: UAMZ 8154 *. Waterton Lakes National Park [no other data]: UBC 1632 *. Waterton Lakes National Park, Akamina Pass: CMN 2889 *, CMN 18524 +, Waterton Lakes National Park, Cameron Lake: CMN 16018 +, CMN 16010 +, UBC 3547 *. Waterton Lakes National Park, Lone Lake: ROM 23112 *. Waterton Lakes National Park, Mount Carthew: CMN 16025. Waterton Lakes National Park, Sage Creek: UBC 1630 +, UBC 1631 +. Waterton Lakes National Park, Sheep Mountain: CMN 4598 +. Waterton Lakes National Park, Summit Lake, CMN 16026 *.

BRITISH COLUMBIA. Akamina Pass: UAMZ 1635 *, UBC 1625 +, UBC 1626 *, UBC 1628 +, UBC 1629 +. Middle Kootenay Pass: RBCM 19875 +, RBCM 19880, +. Middlepass Creek: RBCM19885 *, RBCM 19884 +, RBCM 19887 *, RBCM 19906 *, RBCM 19907 +, RBCM 19914 +, RBCM 19915 *, RBCM 19917 *, RBCM 19918 *, RBCM 19919 *, RBCM 19920 +. Wall Lake: RBCM 19683 *.

APPENDIX 3-2. TAMIAS MINIMUS SPECIMENS EXAMINED

AMNH= American Museum of Natural History, New York; CMN= Canadian Museum of Nature, Ottawa; PMA= Provincial Museum of Alberta, Edmonton; PSM= James Slater Museum, University of Puget Sound, Tacoma; RBCM= Royal British Columbia Museum, Victoria; ROM= Royal Ontario Museum, Toronto; UAMZ= University of Alberta Museum of Zoology, Edmonton; UBC= Cowan Vertebrate Museum, University of British Columbia, Vancouver.

A. Genital Bones

T. m. selkirki (9 +, 5 *)

BRITISH COLUMBIA. Bruce Creek Drainage: RBCM 19924 +; RBCM 19925 +. Mount Brewer: RBCM 19754 *; RBCM 19755 +; RBCM 19758 +; RBCM 19760 *; RBCM 19762 +; RBCM 19765 +; RBCM 19761 *. Paradise Mine: RBCM 19740 +. Springs Creek: RBCM 19741 +; RBCM 19743 *; RBCM 19744 +; RBCM 19745 *.

T. m. oreocetes (7 +, 4 *)

ALBERTA. Sheep River: UAMZ 8180 +; UAMZ 8181 +; UAMZ 8182 +. BRITISH COLUMBIA. Middle Kootenay Pass: RBCM 19872 +; RBCM 19873 *; RBCM 19876 *; RBCM 19908 +; RBCM 19909 +. Middlepass Creek: RBCM 19912 +; RBCM 19913, *. Todhunter Creek: RBCM 19893 *.

T. m. borealis (7 +)

BRITISH COLUMBIA. Fort Nelson: RBCM 10620 +; RBCM 10621 +; RBCM 10622 +; RBCM 10625 +; RBCM 10626 +; RBCM 10628 +; RBCM 11141 +.

B. Skulls

Sample 1- Purcells (10 +, 5 *)

BRITISH COLUMBIA. Bruce Creek Drainage: RBCM 19924 +; RBCM 19925 +. Mount Brewer: RBCM 19754 *; RBCM 19755 +; RBCM 19758 +; RBCM 19760 *; RBCM 19762 +; RBCM 19765 +. Paradise Mine: Paradise Mine: RBCM 5028 +; UBC 1552 +; CMN 34512 *; RBCM 19740 +. Springs Creek: RBCM 19741 +; RBCM 19743, *; RBCM 19744 +; RBCM 19745 *.

Sample 2- Sheep River (27 +, 23 *)

ALBERTA. Highwood Summit: CMN 41233 *. Sheep River: PSM UAMZ 8180 +, UAMZ 8181 +, UAMZ 8182 +. 10 mile radius of University of Alberta Biological Station: PSM 24590 *, PSM 24592 *, PSM 24593 *, PSM 24594 *, PSM 24595 +, PSM 24596 +, PSM 24597 +, PSM 24598 +, PSM 24599 *, PSM 24600 *, PSM 24601 +, PSM 24602 *, PSM 24603 *, PSM 24604 +, PSM 24606 +, PSM 24609 +, PSM 24610 *, PSM 24611 +, PSM 24613 *, PSM 24616 +, PSM 24618 *, PSM 24621 +, PSM 24622 +, PSM 24623 +, PSM 24624 *, PSM 24627 *, PSM 24629 +, PSM 24630 +, PSM 24631 +, PSM 24633 +, PSM 24633 +, PSM 24634 +, PSM 24635 *, PSM 24637 +, PSM 24638 +, PSM 24642 *, PSM 24645 *, PSM 24649 +, PSM 24653 *, PSM 24658 +, PSM 24662 *, PSM 24664 +, PSM 24667 *, PSM 24668 *.

Sample 3- Banff (11 +, 7 *, 2 unknown sex)

ALBERTA. Banff National Park, Baker Lake: UBC 1647 *. Banff National Park, Banff, 12 mi W: AMNH 141659 +, AMNH 14166 +, CMN 18634 *; UBC 1672 +. Banff National Park, Cascade Basin: CMN 10887 +; CMN 10889 *. Banff National Park, Castle Mountain: CMN 18660 +, CMN 18662 *. Banff National Park, Fortymile Creek: CMN 10875 +. Banff National Park, Inglismaldi Mountain: UBC 1673 *. Banff National Park, Parker's Ridge: CMN 1979-180 sex?. Banff National Park, Pipestone River: UBC 759 +. Banff National Park, Sunwapta Pass: CMN RK77-2 *; CMN RK77-16 sex?; CMN RK-20; CMN RK-77-63 *; CMN RK77-66 +. Canmore: CMN 278 +. Jasper National Park, Sunwapta Pass: UBC 1949 +.

Sample 4- Jasper (16 +, 12 *)

ALBERTA. Jasper National Park, [no other data]: CMN 3333 +, CMN 3578 *, CMN 3583 +; UAMZ 8141+; UAMZ 8142 +; UAMZ 8143 +; UAMZ 8144 +; UAMZ 8145 +; UAMZ 8146 *; UAMZ 8147 *; UAMZ 8148 *; UAMZ 8149 *; UAMZ 8150 *; UAMZ 8151 +; UAMZ 8152 *; UAMZ 8223 *. Jasper National Park, Jasper, 6 mi N : CMN 10848 +. Jasper National Park, Jasper-Banff Highway: CMN 16032 +. Jasper National Park, Jonas Creek: CMN RK77-25 *. Jasper National Park, Maligne Canyon: CMN 18778 *. Jasper National Park, Medicine Lake: CMN 18763 *; CMN 18764 *. Jasper National Park, Miette River: CMN 3272 +. Jasper National Park, Mount Sassenach: CMN FN 3129 +. Jasper National Park, Parker's Ridge: CMN RK-77-70 +. Jasper National Park, Snake Indian River: CMN 16853 +. Jasper National Park, Tekarra Creek: UBC 1022 *. Prairie Creek, 40 mi N Jasper: CMN 10839 +.

Sample 5- Fort Nelson (9 +, 6 *)

Fort Nelson: RBCM 9436 +, RBCM 9437 *. Kotcho Lake: RBCM 10620 +, RBCM 10622 +, RBCM 10623 *, RBCM 10624 *, RBCM 10628 +, RBCM 11141 +, RBCM 10629 *, RBCM 11142 *, RBCM 16025 +, RBCM 16027 +, RBCM 16026 +, RBCM 11140 *. Muskwa River at Alaska Highway: CMN 17453 +.