Mammalia 73 (2009): 281–298 © 2009 by Walter de Gruyter • Berlin • New York. DOI 10.1515/MAMM.2009.047

Diversity of Palaearctic chipmunks (*Tamias*, Sciuridae)

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Abstract

The diversity of Palaearctic chipmunks was analysed using a set of morphological (705 skulls from entire range) and genetic features (144 specimens, cytochrome *b* gene). Based on the results, we propose three taxa within *Eutamias sibiricus*. These are *E. s. sibiricus*, inhabiting Russia, the extreme northeast of the Korea Peninsula, Mongolia, Hokkaido Island, and northeast China; *E. s. barberi*, inhabiting the Korea Peninsula except for the extreme northeast region, and *E. s. senescens*, inhabiting central China.

Keywords: chipmunk; cytochrome *b* gene; morphology; *Tamias sibiricus*; taxonomy.

Introduction

Chipmunks from the genus *Tamias* Illiger 1811 inhabit both the Palaearctic and Nearctic. North American species exhibit high taxonomic diversity, as supported by morphometric, genetic, bioacoustic and biochemical data and host-parasite studies (Dunford and Davis 1975, Patterson 1981, Levenson et al. 1985, Nadler et al. 1985, Gannon and Lawlor 1989, Jameson 1999, Piaggio and Spicer 2001, Demboski and Sullivan 2003, Good et al. 2003). The current taxonomic checklist (Thorington and Hoffmann 2005) recognises 24 species of chipmunk in North America. By contrast, only one species is usually recognised in the Palaearctic, the Siberian chipmunk *T. sibiricus* Laxmann 1769 (Ognev 1940, Ellerman and Morrison-Scott 1951, Corbet 1978, Thorington and Hoffmann 2005). However, the earliest fossils of chipmunks known for Eurasia date from the Miocene in Greece (de Bruijn et al. 1980, de Bruijn 1989). This time scale should be sufficient for the accumulation of considerable genetic heterogeneity.

Taxonomic revisions of the Siberian chipmunk covering its entire range were carried out only on the basis of pelage coloration. Different authors recognise between four and nine subspecies of *T. sibiricus* (Formozov 1928, Ognev 1940, Ellerman and Morrison-Scott 1951, Gromov and Erbajeva 1995). Craniometric studies were only performed for chipmunks from the former USSR territory and revealed very poor intraspecific variation (Zubchaninova 1962, Tiunov 1980, Frisman et al. 1984). Several other studies involved specimens from geographically restricted areas (Jones and Johnson 1965, Levenson et al. 1985, Koh 1994).

Our recent data suggest that the diversity of Palaearctic chipmunks is substantially underestimated. A bioacoustic study showed that although the call structure of chipmunks from Russia is quite uniform, there is at least one locality (an introduced population in Freiburg, southern Germany) where calls are very different from those of both Siberian and North American chipmunks (Geinitz 1982, Lissovsky et al. 2006). An investigation of the cytochrome *b* mitochondrial gene of specimens from several localities in East Asia (Lee et al. 2008) revealed considerable genetic heterogeneity and indicated the remoteness of haplotypes of Korean chipmunks from those of specimens representing the more northern parts of the range.

The aim of the present study was to evaluate the taxonomic diversity of Palaearctic chipmunks over their entire distribution range using a combination of morphometric and genetic methods.

Materials and methods

Morphometric analysis

Specimens used in the morphometric study were taken from the collections of the Zoological Museum of Moscow State University (ZMMU), the Zoological Institute of the Russian Academy of Science, St. Petersburg (ZIN), the Natural History Museum (London), the Royal Ontario Museum (Toronto), and the State Darwin Museum (Moscow). The sample contained 705 intact skulls from 223 localities representing the entire range of the species (Appendix A).

Seventeen measurements were taken (accuracy 0.1 mm) for each skull as follows (Figure 1): condylobasal length (KBL), minimum distance between maxillary toothrows (DMT), length of the masseter plate (LMP), diastemal length (DL), alveolar length of the maxillary tooth-

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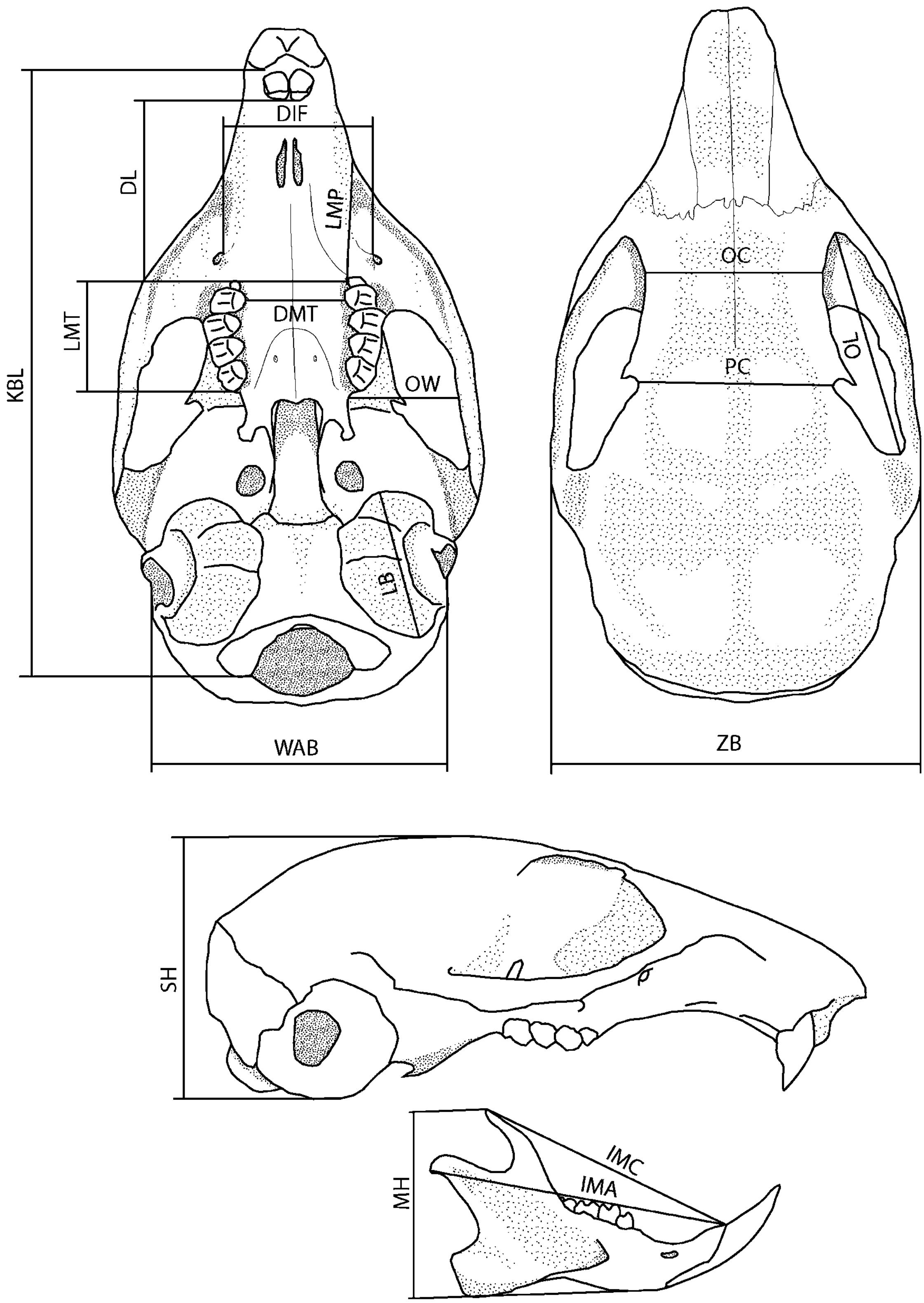

Figure 1 The scheme for cranial measurements. For abbreviations see the text.

row (LMT), distance between the medial edges of the infraorbital foramina (DIF), zygomatic breadth (ZB), post-orbital constriction (PC), width between the lateral edges of the auditory bullae (WAB), skull height (SH), orbital length (OL) and width (OW), length of the auditory bulla (LB), orbital constriction (OC), mandibular height (MH), distance between the incisor base and the apex of the mandibular articular process (IMA), and distance between the base of the incisor and the mandibular coronoid process (IMC). All calculations were performed on logarithmic measurements.

We used the skulls of chipmunks of different ages with fully erupted molars. All skulls were divided into three age categories, according to the degree of wear of the molar surface (Klevezal 2007). The first group included animals with growing P^4, the second, completely erupted but unworn P^4, and the third, worn P^4.

To exclude age bias, we used an orthogonal projection of initial data along the vector of age variation (Burnaby 1966). The vector of age variation was calculated as the first eigenvector of the between-group covariance matrix computed with MANOVA, in which the variable containing three age gradations was used as a grouping variable. We used only the first and third age classes in calculating the covariance matrix to avoid errors arising from inaccuracy in determining the second age class.

We used hierarchical two-factor MANOVA with geographical sample and sex treated as factors to evaluate the significance of differences between genders. There were five samples with $n>10$ and an approximately equal ratio of males and females included in the analysis.

The samples for hierarchical cluster analysis included only specimens collected in the same locality (223 samples in total). Only samples with $n>2$ were used in cluster analysis (70 samples). Cluster analysis was performed on the basis of a matrix of Mahalonobis distances using the unweighted pair group method with arithmetic mean. The bias induced by using samples of different sizes was corrected (Marcus 1993).

An analysis of posterior probabilities was performed using canonical discriminant analysis. The learning sample comprised specimens used in the cluster analysis and divided into three groups according to the results.

The following approach was applied as an ordination method. First, the set of eigenvectors of the within-group covariance matrix (with geographical sample as a group) was calculated. Second, the matrix of initial data and the matrix of eigenvectors were multiplied. This approach allows rotation of the initial data into the space of intergroup variation without distortion of the initial space.

Craniometric data were processed using standard modules of STATISTICA 6.0 (www.statsoft.com) and several custom algorithms written by A.A.L. using Statistica Visual Basic.

Genetic analysis

Complete sequences of the cytochrome *b* gene (1140 bp) for 144 specimens of Siberian chipmunk from 49 localities were analysed (Appendix B). Several specimens had no exact locality information, namely some individuals from the Heilongjiang Province of China (Lee et al. 2008) and a sample from a pet shop in Taiwan (Chang 2008). Protocols for DNA extraction, PCR amplification and sequencing were as described by Lee et al. (2008).

Thirty-two taxa of terrestrial sciurids for which complete cytochrome *b* gene sequences are available in GenBank were used as an outgroup. The list follows the original taxonomy provided by the submitters: *Tamias quadrimaculatus* Gray 1867, AF147657; *Tamias panamintinus* Merriam 1893, AF147656; *Tamias obscurus* J.A. Allen 1890, AF147651; *Tamias minimus* Bachman 1839, AF147646; *Tamias striatus* Linnaeus 1758, AF147670; *Tamias dorsalis* Baird 1855, AF157924; *Tamias townsendii* Bachman 1839, AF147676; *Tamias siskiyou* A.H. Howell 1922, AF147668; *Tamias senex* J.A. Allen 1890, AF147665; *Tamias merriami* J.A. Allen 1889, AF147644; *Tamias durangae* J.A. Allen 1903, AF147642; *Tamias dorsalis* Baird 1855, AF147641; *Tamias cinericollis* J.A. Allen 1890, AF147636; *Tamias canipes* Bailey 1902, AF147635; *Tamias bulleri* J.A. Allen 1889, AF147634; *Tamias amoenus* J.A. Allen 1890, AF147631; *Spermophilus citellus* Linnaeus 1766, AF100720; *Spermophilus spilosoma* Bennett 1833, AF157845; *Spermophilus adocetus* Merriam 1903, AF157844; *Spermophilus mexicanus mexicanus* Erxleben 1777, AF157848; *Spermophilus erythrogenys* Brandt 1841, AF157855; *Spermophilus pallidicauda* Satunin 1903, AF157866; *Spermophilus relictus* Kashkarov 1923, AF157867; *Spermophilus tridecemlineatus arenicola* A.H. Howell 1928, AF157870; *Marmota camtschatica* Pallas 1811, AF143922; *Marmota flaviventris* Audubon and Bachman 1841, AF143926; *Marmota himalayana* Hodgson 1841, AF143928; *Marmota marmota* Linnaeus 1758, AF143929; *Marmota menzbieri* Kashkarov 1925, AF143931; *Marmota monax* Linnaeus 1758, AF143932; *Marmota sibirica* Radde 1862, AF143938; and *Marmota vancouverensis* Swarth 1911, AF143939.

The optimal model of molecular evolution was calculated using Modeltest 3.7 (Posada and Crandall 1998). Models were evaluated separately for three codon positions. There were two models calculated. The first was based on all types of substitutions. In this case the first and third codon positions are explained by the general time-reversible model with some proportion of invariable sites (I) and continuous gamma-distributed rates (G) across sites (Lanave et al. 1984, Rodriguez et al. 1990) with the following parameters: first codon, T=0.21, C=0.29, A=0.30, G=0.21, R_{TC}=0.56, R_{TA}=0.06, R_{TG}=0.0001, R_{CA}=0.02, R_{CG}=0.01, R_{AG}=0.35, I=0.67, and G=1.44; third codon, T=0.29, C=0.29, A=0.40, G=0.02, R_{TC}=0.23, R_{TA}=0.01, R_{TG}=0.03, R_{CA}=0.01, R_{CG}=0.01, R_{AG}=0.71, I=0.01, and G=6.54. The second codon position is explained by the Tamura-Nei model with some proportion of invariable sites and continuous gamma-distributed rates across sites (Tamura and Nei 1993) with the following parameters: T=0.43, C=0.23, A=0.19, G=0.14, R_{TC}=0.58, R_{TA}, R_{TG}, R_{CA}, R_{CG}=0.04, R_{AG}=0.24, I=0.70, and G=0.64. The second model was based only on transversions and evaluated only base-pair frequencies and gamma-distributed rates across sites (for the first and third codon positions) (Jobb 2008). This model was used to correct supposed saturation in transitions (Figure 2); its parameters were as follows: first codon, TC=0.50, AG=0.50, G=0.1; second codon, TC=0.66, AG=0.34; and third codon, TC=0.58, AG=0.42, G=0.57.

Phylogenetic reconstructions were performed using the maximum likelihood (ML) algorithm. Only one sequence from each set of identical sequences was retained in the analysis. All calculations were performed using Treefinder (Jobb 2008). Bootstrap support values were calculated on the basis of 500 data replicates.

To check a molecular clock hypothesis, trees built with and without a molecular clock were compared using an ML ratio test with a χ^2 test and degrees of freedom calculated as the number of terminal groups minus 2 (Felsenstein 1981). Likelihood scores were calculated in PAUP*, beta-test version 4.0b10 (Swofford 1998) using the united evolution model for all three codon positions.

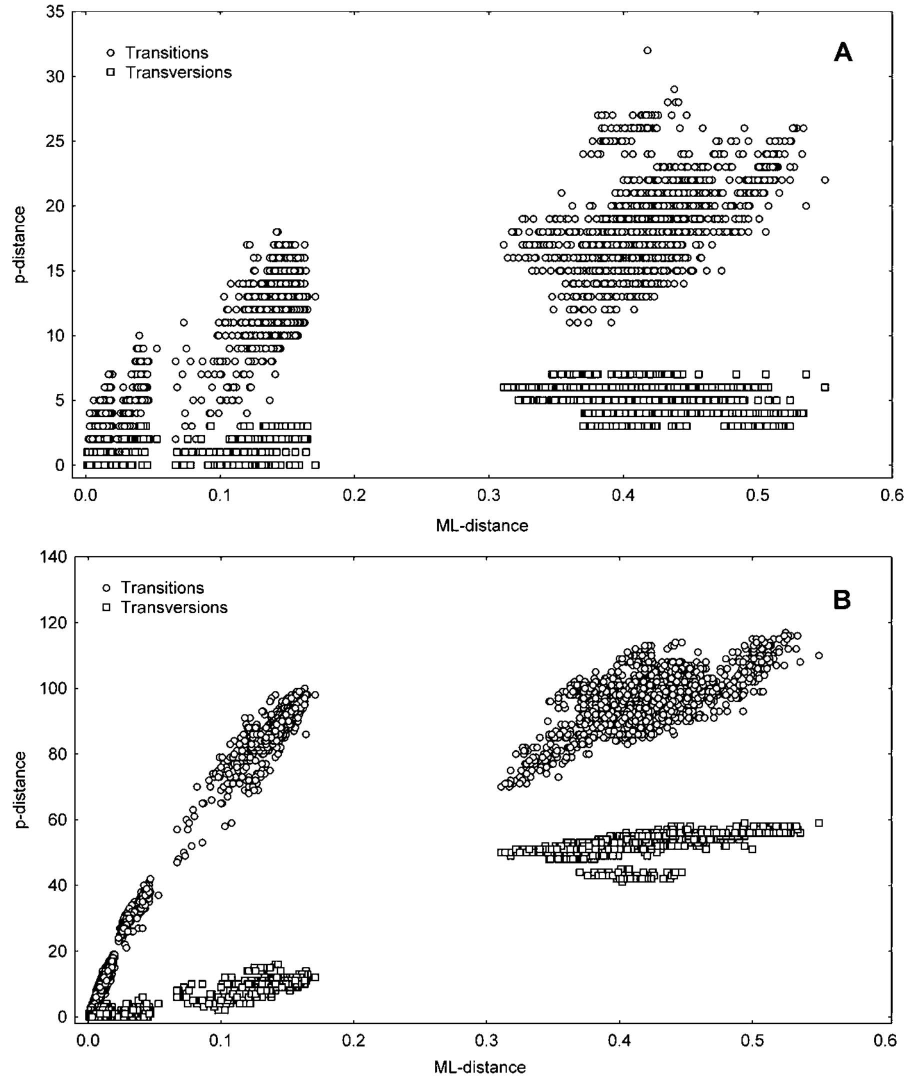

Figure 2 Pairwise p-distance calculated separately for transitions and transversions for (A) the first and (B) the third codon positions plotted against the maximum likelihood (ML) distance between species of terrestrial sciurids.

Divergence time was evaluated using Treefinder (Jobb 2008) with a model including only transversions. Timing the age of phylogenetic events was difficult, because it is unlikely that known events from chipmunk palaeontology can be used as reference points for calibrating tree chronology. Chipmunks appear simultaneously in the palaeontological chronicle in the lower-middle Miocene of both Europe and America (de Bruijn et al. 1980, de Bruijn 1989, Bailey 2004). Therefore we must assume that they already existed by then and had sufficient time for trans-continental dispersal. However, we cannot use such an ambiguous time estimate as a reference point. Recent molecular phylogenetic studies of chipmunks do not contain explicit hypotheses about divergence dates (Piaggio and Spicer 2001, Demboski and Sullivan 2003, Good et al. 2003, Good et al. 2008). Therefore, we adopted a chronological scale from Harrison et al. (2003), who provided divergence dates for ground squirrels and marmots. The following three divergence events were used as reference points: 1) splitting of *Spermophilus citellus* with the group containing *S. erythrogenys*, *S. relictus*, and *S. pallidicauda*; 2) splitting of this group from marmots; and 3) splitting of marmots from *S. adocetus*. Average between- and within-group distances were calculated in MEGA version 4 (Tamura et al. 2007).

Results

Sexual dimorphism of morphometric data was not observed (Wilks $\lambda=0.25$, $p=0.1$). Three broad geographic groupings could be delimited using the hierarchical cluster results (Figure 3). The first group includes samples from central China, in the vicinity of Beijing and in Shanxi and Shaanxi Provinces. The second cluster contain samples from the Korea Peninsula; it is subdivided into two parts, comprising samples from northern and central parts of the Korea Peninsula on the one hand and a sample from the southern extremity of the peninsula on the other. The third cluster, defined here as the northern group, contains the remaining samples and covers the territory of Russia, Kazakhstan, Mongolia, Japan, and northern China (Manchuria). There is no clear segrega-

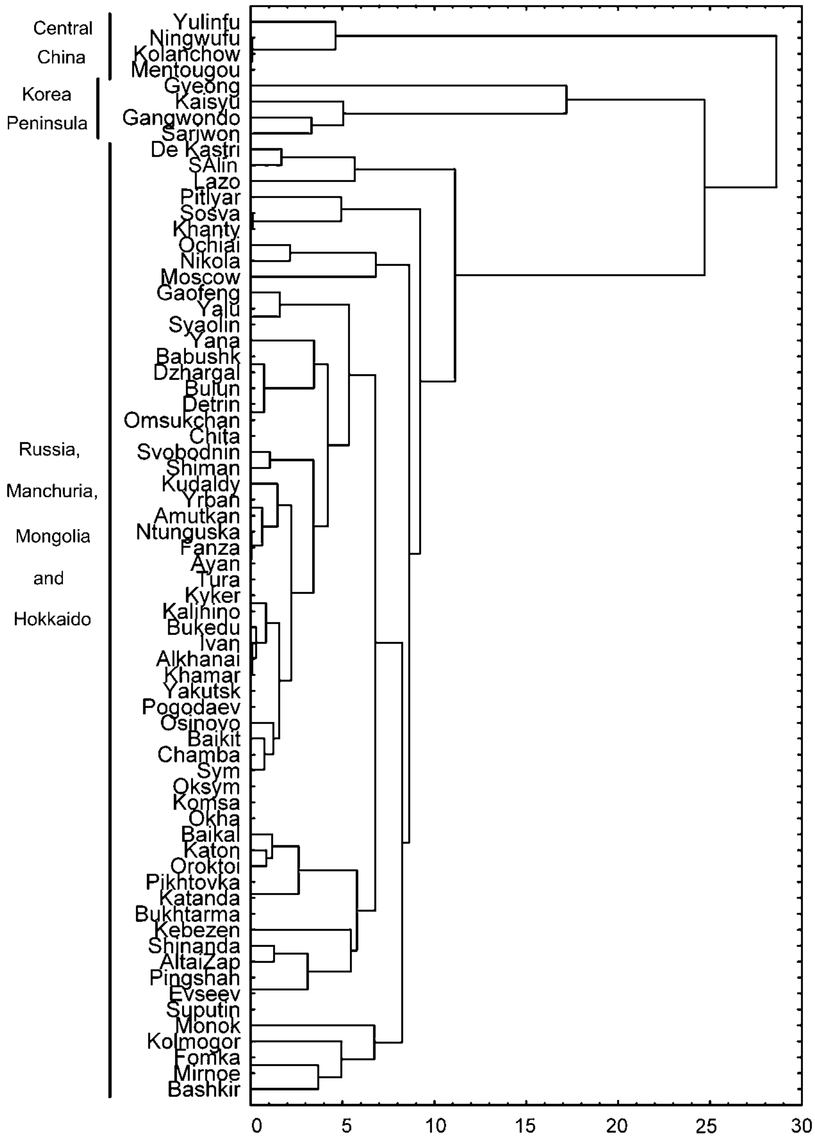

Figure 3 Dendrogram for hierarchical cluster analysis of craniometric features of *Tamias sibiricus* samples. For an explanation of the sample labels, refer to Appendix A.

tion within this last cluster, although the relationships between its members are in certain agreement with their geographical origin.

There is no clear segregation of geographical groups in the space of the axes of between-sample variation (Figure 4). After rotation of the axes, allowing maximisation of differences between the three clusters defined by hierarchical cluster analysis, the samples from central China and Korea Peninsula showed a slight tendency towards segregation (Figure 5). The first axes, which provide the best segregation between the groups, in both cases are most correlated with the width of the postorbital constriction (0.71) and the distance between medial edges of the infraorbital foramina (0.61). There is no clear segregation between groups in the space of these cranial measurements (Figure 6).

The three groups defined above exhibit notable differences in fur coloration. In chipmunks from central China, the upper part of the head is greyish-brown with a slightly undulating pattern. Dark dorsal stripes are deep brown with solitary light hairs. The central pair of light dorsal stripes is sandy grey. The lateral pair of light dorsal stripes is light ash-grey. The medial part of the rump is rufous with a red tint.

In chipmunks from the Korea Peninsula the upper part of the head is rufous brown. Dark dorsal stripes are very contrasting and are deep brown, nearly black. The central pair of light dorsal stripes is rufous-fiery red. The lateral pair of light dorsal stripes is ochraceous-sandy. The rump is very bright, rufous-fiery red. The rufous colour of the rump reaches the middle of the back in some specimens.

Chipmunks from the northern group are most variable. Specimens from the major part of the range are greyish brown or fulvous-brown on the upper part of the head. The dark dorsal stripes are sharp black. The central pair of light dorsal stripes is sandy. The lateral pair of light dorsal stripes is sandy grey. Differences in coloration between the central and lateral light dorsal stripes are weak. The medial part of the rump is brown or ochra-

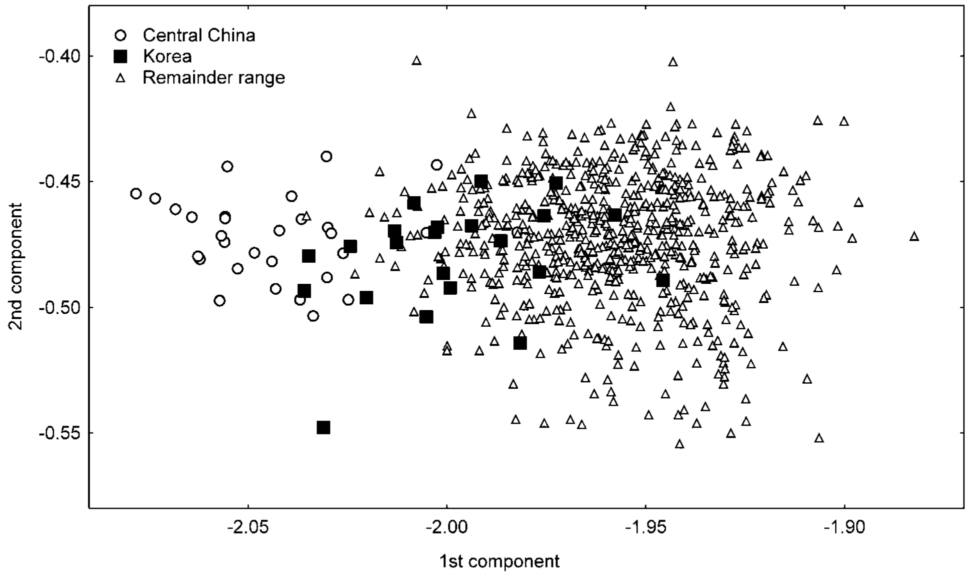

Figure 4 Distribution of *Tamias sibiricus* specimens in the hyperspace of maximised between-sample differences.

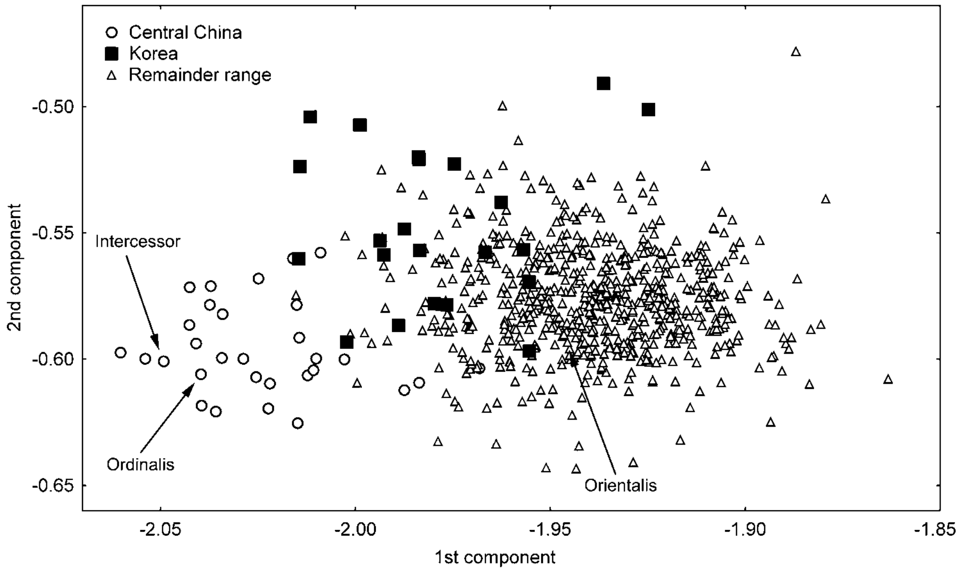

Figure 5 Distribution of *Tamias sibiricus* specimens in the hyperspace of maximised differences among three clusters obtained from hierarchical cluster analysis. Type specimens included in the analysis are denoted by arrows.

ceous. Chipmunks from Primorye, Sakhalin Island and Hokkaido Island are notably brighter: the upper part of the head is rufous, the light dorsal stripes are from ochraceous to red, and the rump is ochraceous-red.

Posterior probability analysis of morphometric data indicates that 99% of specimens included in hierarchical cluster analysis were identified correctly. One specimen from the central part of the Korea Peninsula was misplaced with the northern group, and one specimen from Manchuria was placed with Chinese samples. The majority (98%) of specimens omitted from cluster analysis owing to small sample sizes were placed with their most geographically proximate cluster, with few exceptions. Two specimens from Primorye and one from the shore of the Sea of Okhotsk were placed with the Korean cluster, and one specimen from the vicinity of Beijing was placed with the northern group. The fur coloration of these outlier specimens does not differ from other animals from the same localities. According to the posterior probability results, the southern most specimens from the northern group are found in the extreme northeast of the Korea Peninsula (Potaidong, Nongsadong, Musan) and near Anshan, Liaoning Province, China. The northernmost locality of the "central Chinese" chipmunks is in northeast Hebei (Wawayii Mountains, near Qinhuangdao).

Analysis of the cytochrome *b* gene revealed that base frequencies did not deviate from stationarity across taxa (χ^2=31.09, d.f.=321, p=1.00). A total of 102 haplotypes were found among 144 individuals, of which 37 haplotypes represent 41 individuals from the Korea Peninsula and 54 haplotypes represent 90 individuals from Russia, Japan, and Manchuria.

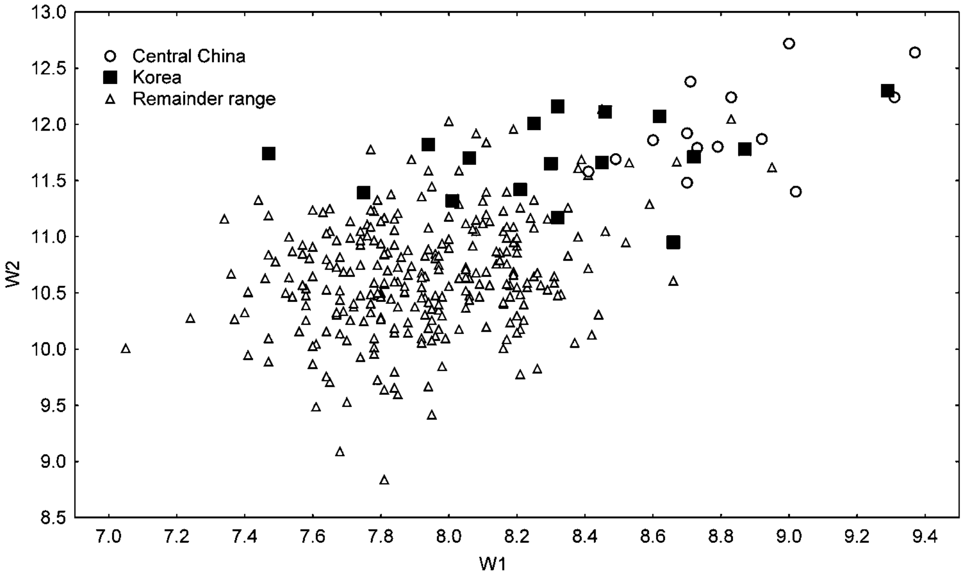

Figure 6 Distribution of adult (the third age group) *Tamias sibiricus* specimens in the plane constituted by the distance between the medial edges of the infraorbital foramina (W1) and the width of the postorbital constriction (W2).

The topology of phylogenetic trees plotted based on both types of substitutions and transversions only is shown in Figures 7 and 8, respectively. There are two large clades with high bootstrap support within *T. sibiricus*: chipmunks from the Korea Peninsula and chipmunks from the northern part of the range (Russia, Japan, and Manchuria). The third clade contains one specimen (petshop8) of unknown origin from a Taiwanese pet shop (Chang 2008).

Trees calculated with and without the molecular clock assumption differed significantly if both types of substitutions were taken into account ($p<0.01$) and showed no differences in the case of the transversion-based model ($p=0.06$).

Genetic distances are shown in Table 1. The average within-group distance for *Neotamias* (*sensu* Piaggio and Spicer 2001) calculated with both types of substitutions is 0.107. Maximum divergence (0.171) was observed between *T. obscurus* and *T. siskiyou*.

Projected divergence times for Siberian chipmunks, based only on ground squirrel and marmot data (Harrison et al. 2003), appear to be overestimated. For example, haplotype divergence within the Korean clade falls in the Pliocene, and splitting of the Korean and northern clades took place long before the Miocene. We considered this model unrealistic and in conflict with palaeontological data, and applied additional constraints by limiting the earliest time of divergence to the beginning of the Middle Pleistocene for the Korean and northern clades, and to the beginning of Pleistocene for the northern clade and the specimen petshop8. Such a model should roughly reflect the “not earlier than Pleistocene” scenario of radiation within clades. In this model, using the “Global rate MD” algorithm, the estimated times were 23 million years ago (mya) for *T. striatus* and *T. sibiricus* and 3.3 mya for the Korean and northern clades. Radiation within the latter two was dated at 0.53 and 0.47 mya, respectively. If the “Local rates MD” algorithm was used, the corresponding times were 17, 2.4, 0.42, and 0.114 mya, respectively.

Discussion

The sequence diversity observed for cytochrome *b* corroborates morphometric data and pelage coloration patterns in supporting the detached position of Korean chipmunks from the northern group. Assuming that the specimen petshop8 originates from central China (a highly probable assumption because the specimen was bought in China and does not belong to the same clade as the Manchurian specimens), we can suggest that three major genetic lineages of chipmunks exist: Korean, central Chinese, and northern clades. There is no obvious overlapping of the ranges of these three groups. Each group appears to have its own geographic structure, which warrants a more detailed study.

These groups have no sharp quantitative cranial differences (Figures 4 and 5). However, members of the northern group possess narrower nasal and medial parts of the skull (Figure 6).

The distribution of the northern group extends across all Manchuria, covering the extreme northeast of the Korea Peninsula and the Liaodong Peninsula. It is probable that the border between the Korean and northern chipmunks follows the foothills of the Changbai Mountains. The border between the central Chinese and northern groups might follow the Liaohe River valley.

Differentiation among chipmunks from the Korea Peninsula, central China and the northern part of their range was first suggested by Jones and Johnson (1965). However, this hypothesis was later rejected (Corbet 1978, Koh 1994) on the basis of clinal variation. Our study did not reveal any clinal variation in morphological features. Moreover, the scale of genetic differences

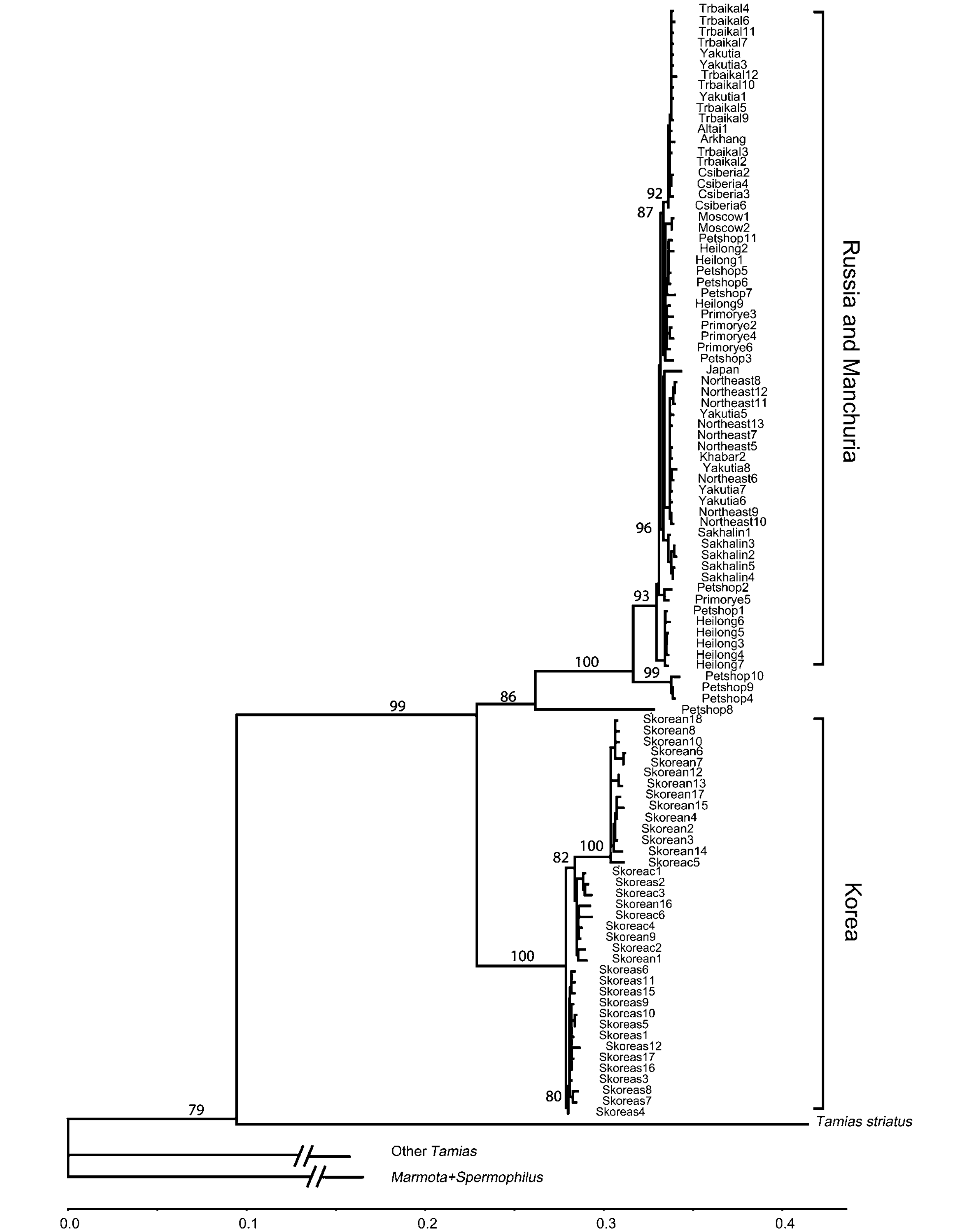

Figure 7 Maximum likelihood tree for *Tamias sibiricus* constructed using all types of substitutions for cytochrome *b*. Numbers on branches indicate bootstrap support; values <70 are not shown. For an explanation of the taxon labels, refer to Appendix B.

between the Korean and northern chipmunks is surprisingly high (Lee et al. 2008), with an ML distance of >0.14, which exceeds distances based on cytochrome *b* gene between many rodent species (Baker and Bradley 2006) and is considerably greater than the average distance between *Neotamias* species (*sensu* Piaggio and Spicer 2001). Estimated molecular divergence times for the Korean and northern haplotype groups go back to the upper Pliocene. Although this is a very preliminary result because of the non-rigorous time restriction model

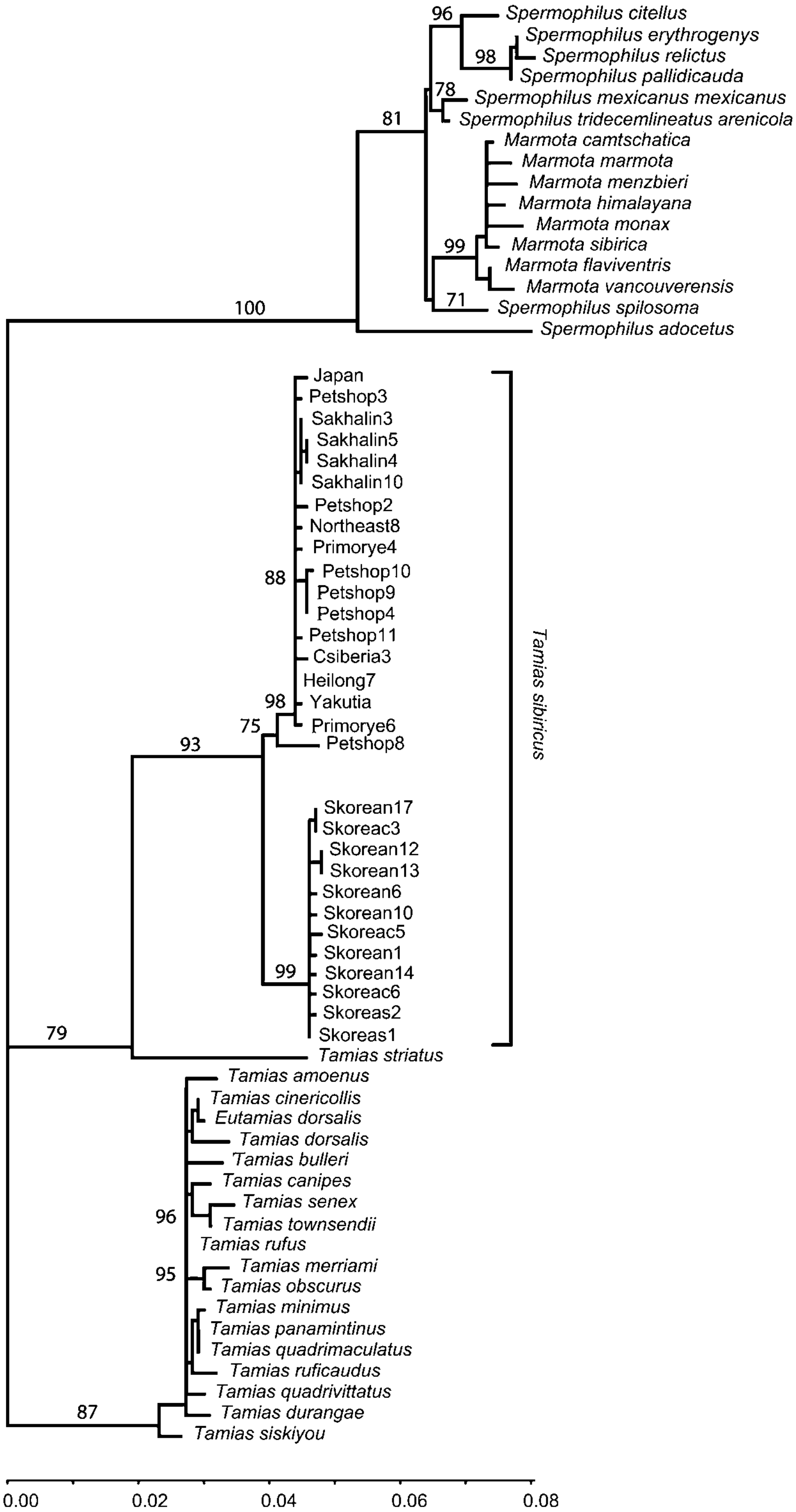

Figure 8 Maximum likelihood tree for terrestrial sciurids constructed using only transversions for cytochrome *b*. Numbers on branches indicate bootstrap support; values <70 are not shown. For an explanation of taxon labels, refer to Appendix B.

used, it nevertheless points to quite ancient splitting between the taxa studied.

Because we have no data of any kind from possible contact zones, we abstain from a discussion of the subspecific or full species status of the three taxa. Moreover, our assumption that the petshop8 specimen belongs to the central Chinese group needs additional confirmation. However, we see an immediate need for nomenclatural revision of the available species group names.

There are 16 names for nominal taxa of the species group currently synonymised with *T. sibiricus*. One of them, *Sciurus striatus* Pallas 1778, is permanently invalid as a secondary homonym replaced before 1961 (International Trust for Zoological Nomenclature 1999, Article 59.3). The skulls and skins of type specimens of four nominal taxa, *T. orientalis* Bonhote 1899, *Eutamias asiaticus intercessor* Thomas 1908, *E. a. ordinalis* Thomas 1908 and *E. s. jacutensis* Ognev 1935 (the last with a

Table 1 Between- and within-group maximum likelihood distances between sciurid taxa calculated from two models.

	North	Korea	China	*Tamias sibiricus*	*Tamias striatus*	*Neotamias*	Sciurids
North	0.001	0.144	0.122	–	0.417	0.432	0.824
Korea	0.013	0.001	0.127	–	0.390	0.400	0.785
China	0.010	0.016	–	–	0.418	0.471	0.810
Tamias sibiricus	–	–	–	0.006	0.407	0.421	0.809
Tamias striatus	0.052	0.050	0.051	0.051	–	0.462	0.892
Neotamias	0.070	0.068	0.071	0.069	0.067	0.008	0.708
Sciurids	0.114	0.112	0.110	0.113	0.115	0.100	0.021

Diagonal data represent average within-group distances corresponding to the “only transversions” model. Lower diagonal data represent average between-group distances for the same model. Upper diagonal data represent average between-group distances for the “all substitutions” model. North, northern group of *Tamias sibiricus*; Korea, Korean group of *Tamias sibiricus*; China, supposed Chinese specimen; Sciurids, marmots and ground squirrels.

broken skull), were included in the analysis. We also examined the topotypes of *E. senescens* Miller 1898, *E. a. altaicus* Hollister 1912, *Myoxus lineatus* Siebold 1824, *E. a. okadae* Kuroda 1932, and *E. a. umbrosus* Howell 1927 (the last with a broken skull). Two nominal taxa have no clearly defined type localities (*Sciurus sibiricus* Laxmann 1769 and *T. pallasi* Baird 1856); however, we examined some specimens from the type region. Finally, we did not observe types, but examined specimens from areas adjacent to the type localities of *Sciurus striatus a. asiaticus* Gmelin 1788, *Sciurus uthensis* Pallas 1811, and *E. s. barberi* Johnson and Jones 1955.

All the type localities lie within the ranges of the three groups defined here and there were no problems with precise placing of types or topotypes among these groups.

The only nominal taxon representing the Korean group is *E. s. barberi* Johnson and Jones 1955. The nominal taxa *T. orientalis* Bonhote 1899, *E. s. jacutensis* Ognev 1935, *E. a. altaicus* Hollister 1912, *Myoxus lineatus* Siebold 1824, *E. a. okadae* Kuroda 1932, *Sciurus sibiricus* Laxmann 1769, *T. pallasi* Baird 1856, *Sciurus striatus a. asiaticus* Gmelin 1788, and *Sciurus uthensis* Pallas 1811 all belong to the northern group. *Sciurus sibiricus* Laxmann 1769 is the senior synonym for this taxon. The nominal taxa *Eutamias a. intercessor* Thomas 1908, *E. a. ordinalis* Thomas 1908, *E. senescens* Miller 1898, and *E. a. umbrosus* Howell 1927 belong to the Chinese group, with *E. senescens* Miller 1898 being the senior synonym.

We did not observe specimens from Taibai Shan, Shaanxi, China (the type locality of *E. albogularis* Allen 1909) or, with one exception, from Sichuan and Qinghai Provinces, which are part of the known distribution range of chipmunks (Zhang et al. 1997, Obolenskaya 2008). Bearing in mind the geographical position of the type

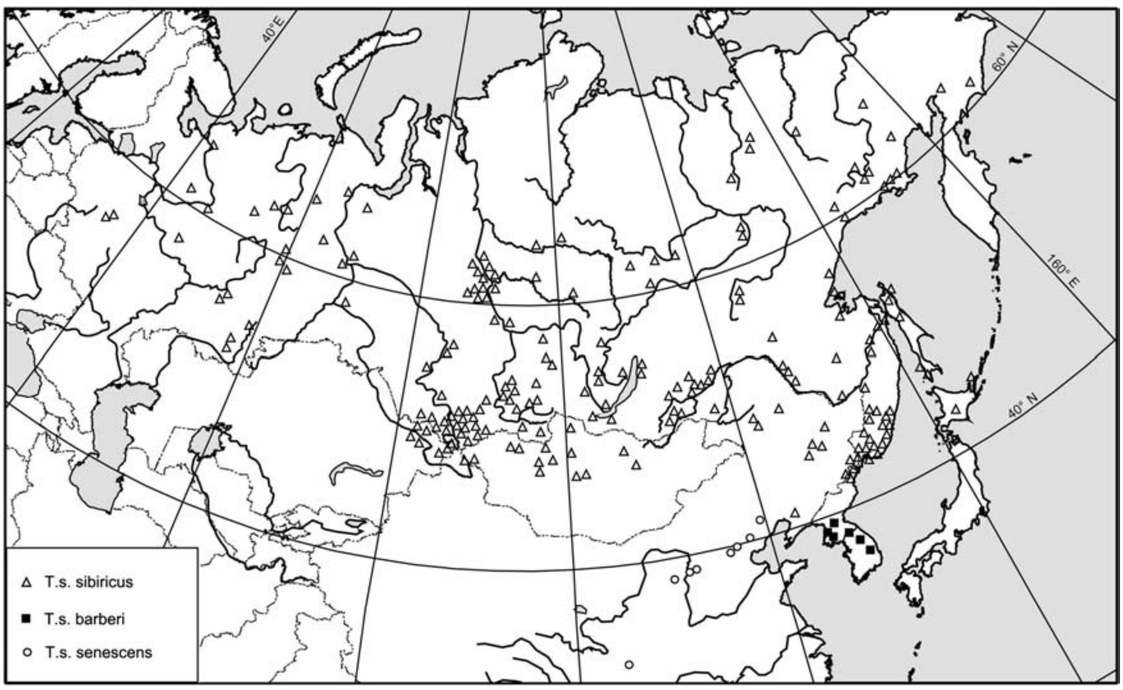

Figure 9 Distribution map of Siberian chipmunk taxa. Symbols correspond to the specimens used in morphometric analysis.

locality and the single specimen from Sichuan analysed, we can suppose that these chipmunks also belong to the Chinese group and hence could be synonymised with *T. s. senescens*.

Incidentally, our results could make some contribution to the discussion about the generic or subgeneric status of *Eutamias* and *Neotamias* taxa (Thorington and Hoffmann 2005). The genetic distances between three groups of chipmunks, especially in comparison with distances for the *Marmota-Spermophilus* group, are very large. The generic rank of three taxa within chipmunks should probably be recognised: *Tamias* (with *T. striatus*), *Eutamias* (with *E. sibiricus sensu lato*) and *Neotamias* (other American species).

Finally, based on a complex of characters including external morphology, morphometrics and cytochrome *b* data, we propose the definition of three taxa within *E. sibiricus*. Their valid names and distribution ranges are as follows: *E. s. sibiricus* Laxmann 1769, northern part of the range (Russia, extreme northeast of the Korea Peninsula, Mongolia, Japan and northeast China); *E. s. barberi* Johnson and Jones 1955, the Korea Peninsula except for the extreme northeast region; and *E. s. senescens* Miller 1898, central China, to the south of Liaoning Province (Figure 9). Additional investigations in possible contact zones will be required to confirm if these taxa deserve to be raised to species rank.

Acknowledgements

We thank collection curators A. Averianov (Saint-Petersburg), P. Jenkins (London), T. Sirokhina (Irkutsk), B. Lim (Toronto) and I. Fadeev (Moscow). We are also grateful to those who provided specimens for our study, our field collaborators and those who made valuable remarks on the manuscript: A. Borisenko (Guelph), A. Bogdanov (Moscow), N. Abramson (Saint-Petersburg), L. Emelyanova (Moscow), V. Lebedev (Moscow), A. Pilnikov (Krasnokamensk), A. Myslenkov and I. Voloshina (Lazo), K. Peleshko (Lazo), L. Levik (Moscow), N. Pozhidaeva (Terney), A. Obolenskiy (Novomoskowsk), Tae-Young Choi (Incheon), Young-June Kim (Seoul), Mi-Sook Min (Seoul), and two anonymous reviewers. The study was supported in part by the Russian Foundation for Basic Research (grants 06-04-49134, 07-04-10059, 08-04-10064, 09-04-00283 and 09-04-00035), the Korea Research Foundation Grant funded by the Korean Government (MOEHRD; KRF-2007-C00193-I00755) and the BK21 program for Veterinary Science, Seoul National University.

Appendices

Appendix A List of specimens used in morphometric analysis. Sample names in the first column indicate the samples used in cluster analysis.

Sample	Locality	No. of specimens
Russia		
	Moscow region, east side of Glubokoe Lake (introduced population)	1
Moscow	Moscow region, Ruzskiy district, vicinity of Porechye (introduced population)	3
	Arkhangelsk region, Kholmogorskiy district, vicinity of Yura village	1
	Arkhangelsk region, Ust'yanskiy district, vicinity of Chadroma village	1
	Vologodskaya region, Velikoustyugskiy district, Sukhona River, vicinity of Pecherza village	2
	Nizhny Novgorod region, Yakovlevo village	2
	Republic of Komi, Ust'-Kulomskiy district, vicinity of Pod'el'skoe	1
	Republic of Komi, Sosnogorsk district, vicinity of Voi-Vozhi village	1
	Republic of Komi, Troitsko-Pechorskiy district, Pechorskiy Zapovednik	1
	Republic of Bashkortostan, vicinity of Angasyak	1
	Republic of Bashkortostan, Dyurtyumskiy district	2
Bashkir	Republic of Bashkortostan, Bashkirskiy Zapovednik	3
	Republic of Bashkortostan, Mrakovskiy district	1
	Chelyabinsk region, Katav-Ivanovskiy district, Kirabinskoe village, 20 km E of Iremen' Mountain	1
	Sverdlovsk region, Karpinskiy district, Katlym village	1
	Sverdlovsk region, Denezhkin kamen' Zapovednik	2
	Khanty-Mansiyskiy Autonomous District, Berezovsiy district, Saranpaul' village, Lyapin River	2
	Sverdlovsk region, Novolyalinskiy district, Novaya Lyalya village	2
Sosva	Khanty-Mansiyskiy Autonomous District, Malaya Sos'va Zapovednik	4
Pitlyar	Russia,Yamalo-Nenetskiy Autonomous District, Pitlyar village	7
Khanty	Khanty-Mansiyskiy Autonomous District, Khanty-Mansiysk	4
	Khanty-Mansiyskiy Autonomous District, 80 km N of Khanty-Mansiysk	1
	Yamalo-Nenetskiy Autonomous District, vicinity of Poluy village	2
	Tyumen region, vicinity of Tobol'sk	2
	Novosibirsk region, vicinity of Novosibirsk	2
Kislovka	Tomsk region, Tomskiy district, Kislovka village	4
	Tomsk region, Tomsk district, former Kruglihina village	1
	Altaiskiy Kray, Krasnoshchokovskiy district, Khankhara village	1
	Altaiskiy Kray, Charyshskiy district, upper Inya River	1
	Altaiskiy Kray, Troitskiy district	1
	Republic of Gorno-Altai, Ongudayskiy district, Seminskiy Pass	1
Oroktoi	Republic of Gorno-Altai, Chemal'skiy district, upper Oroktoy River	8
Kebezen	Republic of Gorno-Altai, Turochakskiy district, Kebezen' village	16
	Republic of Gorno-Altai, Ulaganskiy district	1

(Appendix A continued)

Sample	Locality	No. of specimens
Katanda	Republic of Gorno-Altai, Ust'-Koksinskiy district, Katanda village	13
	Republic of Gorno-Altai, Turochakskiy district, Yailyu, N side of Teletskoe Lake	1
	Republic of Gorno-Altai, Teletskoye Lake, mouth of Koldor River	1
AltaiZap	Republic of Gorno-Altai, Altaiskiy Zapovednik	19
	Republic of Gorno-Altai, Ulaganskiy district, Kozhulgan River	1
	Republic of Gorno-Altai, Ulaganskiy district, upper Shavly River	1
	Republic of Gorno-Altai, Altai Mountains, Ukok Plateau, Dzhumaly River, tributary of Dzhazator	1
	Republic of Gorno-Altai, S Altai, Argut River, tributary of Katun	1
	Republic of Gorno-Altai, S Altai, between Bortoolvag and Kaiir Rivers, tributary of Argut	1
	Republic of Gorno-Altai, Rakhmanovskiye Klyuchi, southern side of Belukha Mountain	1
	Republic of Gorno-Altai, Kosh-Agachskiy district, Kara-Kol' Lake	1
	Republic of Khakassia, Tashtypskiy district, upper Erinat River	2
	Republic of Khakassia, Tashtypskiy district, Ana River	1
Monok	Republic of Khakassia, Tashtypskiy district, Monok village	3
	Republic of Tuva, Mongun-Taiyginskiy district, Kargy River, Semigorki	1
	Republic of Tuva, Tes-Khemskiy district, Kara-Khol' Lake	1
	Republic of Tuva, Biy-Khemskiy district, 30 km NE of Turan	2
	Republic of Tuva, Tandinskiy district, Chagytay Lake	1
Yrban	Republic of Tuva, Todzhinskiy district, Yrban village	3
	Republic of Tuva, Todzhinskiy district, Biy-Khem River	1
	Republic of Tuva, *sine loco*	1
	Krasnoyarskiy Kray, Turukhanskiy district, Eloguy River	2
Tura	Krasnoyarskiy Kray, Turukhanskiy district, Tura	3
	Krasnoyarskiy Kray, Turukhanskiy district, Enisey River, Verkhne-Imbatskoe	1
Mirnoe	Krasnoyarskiy Kray, Turuchanskiy district, Mirnoe research station	29
	Krasnoyarskiy Kray, Turukhanskiy district, Varlamovka village	2
Komsa	Krasnoyarskiy Kray, Turukhanskiy district, Enisey River, Komsa village	18
	Krasnoyarskiy Kray, Turukhanskiy district, vicinity of Bor village	2
Osinovo	Krasnoyarskiy Kray, Turukhanskiy district, Enisey River, Osinovo village	6
Baikit	Krasnoyarskiy Kray, Baykitskiy District, Podkamennaya Tunguska River, Baikit village	8
	Irkutsk Region, Tayshetskiy district, 23 km N of Tayshet	1
Ntunguska	Krasnoyarskiy Kray, Nizhnyaya Tunguska River, mouth of Uchami River	5
	Krasnoyarskiy Kray, Turukhanskiy district, Vorogovo village	2
	Krasnoyarskiy Kray, Eniseyskiy district, Oflatym Lake	1
Oksym	Krasnoyarskiy Kray, Eniseyskiy district, Oksym River, tributary of Sym River	4
Sym	Krasnoyarskiy Kray, Eniseyskiy district, Sym River, middle flow	3
Fomka	Krasnoyarskiy Kray, Eniseyskiy district, Enisey River, Fomka village	4
Kolmogor	Krasnoyarskiy Kray, Eniseyskiy district, Kolmogorovo village	9
Pogodaev	Krasnoyarskiy Kray, Eniseyskiy district, Pogodaevo village	4
	Krasnoyarskiy Kray, Shushensky district, 100 miles SE of Minusinsk, Yenisei River	2
	Krasnoyarskiy Kray, Ermakovskiy district, old Usinsk road, Malaya Oya station	1
	Krasnoyarskiy Kray, Ermakovskiy district, old Usinsk road, Kulumys station	1
	Krasnoyarskiy Kray, Kuraginskiy district, Mozharka village	2
	Krasnoyarskiy Kray, Boguchanskiy district, Maleevo village	1
Chamba	Krasnoyarskiy Kray, Tungussko-Chumskiy district, Chamba	4
	Krasnoyarskiy Kray, Kuraginskiy district, upper Saygonysh River	1
	Irkutsk region, Nizhneudinskiy district, Verhnie Gutary village	2
	Irkutsk region, Zhigalovskiy district, Ilga River, vicinity of Kochnya village	2
Alzamay	Irkutsk region, Nizhneudinskiy district, Alzamay	5
	Irkutsk region, Zhigalovskiy district, Zhigalovo	1
	Irkutsk region, Ust'-Kutskiy district, Ust'-Kut	1
	Irkutsk region, Baikalo-Lenskiy Zapovednik, upper Lena River	1
	Irkutsk region, Ust-Ordynskiy Buryatskiy district, Golovinskaya village	1
	Irkutsk region, Irkutskiy district, Listvyanka village	1
Shinanda	Republic of Buryatia, Severo-Baikal'skiy district, Shinanda River	6
Kudaldy	Republic of Buryatia, Barguzinskiy Zapovednik, Kudaldy River	8
	Republic of Buryatia, Barguzinskiy Zapovednik	2
Baikal	Republic of Buryatia, Baikal'skiy Zapovednik	3
Khamar	Republic of Buryatia, Khamar-Daban Mountains, Komarinskiy Range	8
	Zabaikal'skiy Kray, Akshinskiy district, Ermana Range	2
	Zabaikal'skiy Kray, Akshinskiy district, Onon River, Kazachenskiy village	1
Alkhanai	Zabaikal'skiy Kray, Dul'durginskiy district, to the S of Bal'zino village, Alkhanai Mountain	8
Ivan	Zabaikal'skiy Kray, Chita district, vicinity of Lake Ivan	7
Chita	Zabaikal'skiy Kray, Chita district, upper Chita River	3
Kyker	Zabaikal'skiy Kray, Tungokochenskiy district, Kyker village	29
	Zabaikal'skiy Kray, Nerchinskiy district, Zyul'zya River	1
	Zabaikal'skiy Kray, Nerchinsko-Zavodskiy district, Shivki village	1

(Appendix A continued)

Sample	Locality	No. of specimens
Kalinino	Zabaikal'skiy Kray, Nerchinskiy district, Kalinino village	6
	Zabaikal'skiy Kray, Mogochinskiy district, right bank of Shilka River, 8 km below the mouth of the Zheltuga River	1
	Zabaikal'skiy Kray, Mogochinskiy district, right bank of Shilka River, Chachakan River	2
	Zabaikal'skiy Kray, Aleksandrovo-Zavodskiy district, upper Kher-Khera River	1
	Republic of Yakutia-Sakha, Verkhoyanskiy Ulus, Tuostakh River, tributary of Adycha, 40 km from mouth	1
	Republic of Yakutia-Sakha, Mirninskiy Ulus, Chona River, Tuoy-Khoya village	1
	Republic of Yakutia-Sakha, Suntarskiy Ulus, Bilyuchan village	1
	Republic of Yakutia-Sakha, Suntarskiy Ulus, Suntary village	1
Yakutsk	Republic of Yakutia-Sakha, 30 km N of Yakutsk	8
	Republic of Yakutia-Sakha, vicinity of Yakutsk	1
	Republic of Yakutia-Sakha, Namskiy Ulus, Arbynskiy Nasleg	2
Yana	Republic of Yakutia-Sakha, Verkhoyanskiy Ulus, upper Yana River, Ken-Yuryakh village	3
	Republic of Yakutia-Sakha, Verkhoyanskiy Ulus, Burulah River, tributary of Adycha River	1
	Republic of Yakutia-Sakha, Momskiy Ulus, Indigirka River, mouth of Moma River	1
Amutkan	Republic of Yakutia-Sakha, Neryungri district, upper Amutkan River	18
	Republic of Yakutia-Sakha, Neryungrinskiy district, Kholodnikan Mountain	2
	Koryakskiy Autonomous District, Tilichikinskiy district, Anukvayam River	2
	Magadan region, upper Kolyma River, Ten'kinskiy district, Orotuk village	1
Omsukchan	Magadan region, Omsukchanskiy district, Gatchan River	3
Detrin	Magadan region, Ten'kinskiy district, Kolyma River, middle part of Detrin River	3
Bulun	Magadan region, Srednekanskiy district, Kolyma River, middle part of Bulun River	6
	Magadan region, Ten'kinskiy district, Kolyma River, Butygychag	2
	Magadan region, Ol'skiy district, Yagodnoe River	1
Babushk	Magadan region, Okhotskoe Sea, Babushkina Bay	4
	Magadan region, Sea of Okhotsk, mouth of Yama River	2
	Kamchatka region, mouth of Penzhina River	1
	Khabarovskiy Kray, Okhotskiy district, Uega village	2
	Khabarovskiy Kray, Okhotskiy district, vicinity of Okhotsk, Morekanskiy Cape	1
Ayan	Khabarovskiy Kray, Ayano-Mayskiy district, Ayan village	3
	Khabarovskiy Kray, Great Shantar Island	1
	Khabarovskiy Kray, Sea of Okhotsk, Tugurskiy Peninsula, Ul'banskiy Bay, Betti spit	1
	Khabarovskiy Kray, Chumikanskiy district, Tugurskiy Peninsula, Konstantin Bay	1
	Khabarovskiy Kray, Komsomo'sk-na-Amur district, Khungari River	2
De Kastri	Khabarovskiy Kray, Bolshoye Kizi Lake, mouth of Taba River	3
	Khabarovskiy Kray, lower part of Amur River, Sofiyskoe village	2
Nikola	Khabarovskiy Kray, Komsomol'sk-na-Amur district, Nizhne-Tambovskoe village	6
	Khabarovskiy Kray, Verhnebureinskiy district, Suluk village	1
	Amur region, Shimanovskiy district, vicinity of Kumara village	1
Shiman	Amur region, Shimanovskiy district, between Simonovo and Stepanovo villages	10
Svobodnin	Amur region, Svobodninskiy district, between Zigovka and Klimauts villages	10
	Amur region, vicinity of Blagoveshchensk	1
	Amur region, Zeysky Zapovednik, Tukuringra Range, Onon	2
Okha	Sakhalin region, Okhinskiy district, vicinity of Okha	11
	Sakhalin region, Okhinskiy district, vicinity of Lyugi village	1
	Sakhalin region, Tymovskiy district, vicinity of Argi-Pagi village	1
	Sakhalin region, Nevel'skiy district, vicinity of Lugovoe village	1
	Sakhalin region, Korsakov district, 30 km NW of Korsakov	1
	Sakhalin region, Kunashir Island, vicinity of Yuzhno-Kuril'sk	1
	Jewish Autonomous Region, Leninskiy district, Kukelevo village	1
	Khabarovskiy Kray'imeni Lazo district, Khor River	1
	Primorskiy Kray, Dal'nerechenskiy district, Bol'shaya Ussurka River, vicinity of Verbovka village	2
Evseev	Primorskiy Kray, Dal'nerechenskiy district, Evseevka village	4
	Primorskiy Kray, Dal'nerechenskiy district, Bol'shaya Ussurka River	1
	Primorskiy Kray, Novopokrovsky district, Kartun village	2
	Primorskiy Kray, Sikhote-Alinskiy Zapovednik, upper Ioldzykhe (Dzhigitovka) River	1
	Primorskiy Kray, Dal'negorskiy district, vicinity of Tetyukhe mine	2
SAlin	Primorskiy Kray, Sikhote-Alinskiy Zapovednik	8
	Primorskiy Kray, Ol'ginskiy district, Steklyanukha Shkotovskaya village	2
	Primorskiy Kray, Dal'negorskiy district, Khankheza (Bystraya) River	2
	Primorskiy Kray, Spasskiy district, vicinity of Gaivoron village	1
Lazo	Primorskiy Kray, Lazovskiy Zapovednik	17
	Primorskiy Kray, Lazovskiy district, 40 km SW of Sysoevka village	1
	Primorskiy Kray, Anuchinskiy district, 41 km N of Chernyshevka village	1

(Appendix A continued)

Sample	Locality	No. of specimens
Suputin	Primorskiy Kray, Ussuriyskiy district, Suputinka River	4
	Primorskiy Kray, Shkotovskiy district, Petrovka Village	1
	Primorskiy Kray, Nadezhdinskiy district, vicinity of Razdol'naya railway station	2
	Primorskiy Kray, Partizanskiy district, vicinity of Taezhnaya railway station	1
	Primorskiy Kray, Partizanskiy district, vicinity of Partizansk railway station	2
	Primorskiy Kray, Partizanskiy district, Bronvichi village	1
Fanza	Primorskiy Kray, Partizanskiy district, vicinity of Fanza railway station	3
	Primorskiy Kray, vicinity of Vladivistok, Okeanskaya railway station	1
	Primorskiy Kray, 25 km NE of Vladivistok	1
	Primorskiy Kray, Kedrovaya pad' Zapovednik	2
	Primorskiy Kray, Slavyanskiy district, Kraskino village	1
Kazakhstan		
	Semipalatinsk region, Sekisovka village	1
Pikhtovka	Vostochno-Kazakhstsnskiy region, Riderskiy district, Pikhtovka village	4
	Vostochno-Kazakhstsnskiy region, Ust'-Kamenogorskiy district	1
	Vostochno-Kazakhstsnskiy region, Leninogorskiy district	2
	Vostochno-Kazakhstsnskiy region, Markakol' Lake	1
Katon	Vostochno-Kazakhstsnskiy region, Katon-Karagay	8
Bukhtarma	Vostochno-Kazakhstsnskiy region, Bukhtarma River	11
Mongolia		
	Bayan-Ölgii Aymak, 25 km S of Dayan-Nur Lake	1
	Bayan-Ölgii Aymak, upper Dzhelty-Gol River	1
	Uvs Aymak, western part of Khan-Khukhiyiin-Nuruu Range	1
	Uvs Aymak, Khan-Khukhiyiin-Nuruu Range, Barun-Turun Somon	1
	Khövsgöl Aymak, 25 km N ofKhatgol, Arsay-Gol River	2
	Zavkhan Aymak, valley of Bogdyn-Gol River	1
	Zavkhan Aymak, 150 km N of Ulyasutay	1
	Zavkhan Aymak, Dzhugnay-Nur Lake	1
	Khövsgöl Aymak, Khangay Range, upper Tekesh River, tributary of Ider River	1
Dzhargal	Khövsgöl Aymak, 30 km S from Dzhargalant, Tarbagatay Range	6
	Arkhangai Aymak, Khangay Range, Mokhan-Daba Pass	1
	Arkhangai Aymak, Tsetserleg River, vicinity of Tavshruleh	1
	Selenge Aymak, Bayangol	1
	Khentii Aymak, S of Khentey Range, Khandgaite	2
Japan		
Ochiai	Central Hokkaido, Ochiai	7
China		
Bukedu	Inner Mongolia Autonomous Region, Great Khingan, Bokhedu railway station	11
Yalu	Inner Mongolia Autonomous Region, East slope of Great Khingan, Yalu railway station	3
	Heilongjiang Province, Sanjiaohejiehe River	1
Pingshan	Heilongjiang Province, Pingshan	3
	Heilongjiang Province, Maoershan railway station	2
Gaofeng	Heilongjiang Province, Gaofeng forest farm, Dahao	4
Syaolin	Heilongjiang Province, Xiaoling railway station	6
	Jilin Province, Daling	2
	Liaoning Province, vicinity of Anshan	1
	NE of Hebei Province, Wawayii Mountains	1
	Beijing	1
Mentougou	Mentougou, 15 miles W of Beijing	5
	Imperial tombs, 65 miles E of Beijing	2
Ningwufu	Shanxi Province, Ning-Wu-Fu	12
Kolanchow	Shanxi Province, 12 miles NW of Kolanchow	3
Yulinfu	Shaanxi Province,Yu-lin-fu, 4000 ft	6
	Sichuan Province, vicinity of Pingwu	1
North Korea		
	Hamgyong-Bukto Province, Musan	1
Kaisyu	Hwanghae-Namdo Province, Kaisyu surroundings	3
	Hamgyong-Bukto Province, Potaidong	1
	Hamgyong-Bukto Province, Nongsadong	1
Sariwon	Hwanghae-Bukto Province, Sariwon	3
	Hwanghae-Namdo Province, vicinity of Inritsu	1
South Korea		
	Kim-hoa, 65 miles NE of Seoul	2
Gangwondo	Gangwon-do Province	7
Gyeong	Gyeongsangbuk-do Province	3

Appendix B List of the specimens used for genetic analysis. Museum numbers starting with S correspond to the Zoological Museum of Moscow State University, ZIN, Zoological Institute of the Russian Academy of Science, IBPN, Institute of Biological Problems of the North FEB RAS, UAM, University of Alaska Museum of the North.

Sample	Locality	Museum specimen number	GenBank accession
moscow1	Russia, Moscow region, Ruzskiy district, vicinity of Porechye abandoned quarry, 55.610° N, 36.540° E	S-178929	FJ655206
moscow2	Russia, Moscow region, Ruzskiy district, vicinity of Porechye abandoned quarry, 55.610° N, 36.540° E	S-178929	FJ655207
arkhang	Russia, Arkhangelsk region, Ust'yanskiy district, vicinity of Chadroma, 61.199° N, 42.930° E	S-178881	FJ655208
altai1	Russia, Altay territory, Troitskiy district, railway station, Zagainovo, 52.867° N, 84.667° E	S-184044	FJ655215
altai2	Russia, Republic of Gorno-Altay, vicinity of Gorno-Altaysk, 51.920° N, 85.940° E	S-184045	FJ655214
altai3	Russia, Republic of Gorno-Altay, Ongudayskiy district, Seminskiy pass, Eloviy Klyuch River, 50.952° N, 85.738° E	S-183588	FJ655231
csiberia1	Russia, Kemerovo region, Kiya River, 55.890° N, 81.610° E	ZIN 96067	FJ655217
csiberia2	Russia, Kemerovo region, Kiya River, 55.890° N, 81.610° E	ZIN 96067	FJ655216
csiberia3	Russia, Republic of Khakassia, Askizskiy district, vicinity of Balyksu, right bank of Tom' river, 53.433° N, 89.169° E	S-183590	FJ655224
csiberia4	Russia, Krasnoyarsk territory, Manskiy district, railway station, Jayma, 54.851° N, 93.676° E	S-183592	FJ655226
csiberia5	Russia, Krasnoyarsk territory, Manskiy district, railway station, Jayma, 54.851° N, 93.676° E	S-183593	FJ655229
csiberia6	Russia, Krasnoyarsk territory, Ermakovskiy district, Oyskiy Range, opposite Kazachiy Klyuch spring, 52.798° N, 93.135° E	S-183591	FJ655232
csiberia7	Russia, Krasnoyarsk territory, Turuchanskiy district, Mirnoe research station, 62.270° N, 89.090° E		FJ655225
csiberia8	Russia, Krasnoyarsk territory, Turuchanskiy district, Mirnoe research station, 62.270° N, 89.090° E		FJ655227
csiberia9	Russia, Krasnoyarsk territory, Turuchanskiy district, Mirnoe research station, 62.270° N, 89.090° E		FJ655228
csiberia10	Russia, Krasnoyarsk territory, Turuchanskiy district, Mirnoe research station, 62.270° N, 89.090° E		FJ655230
yakutia	Russia, Republic of Yakutia-Sakha, Olekminskiy district, Lena River, 5 km down from Olekma mouth, 60.3660° N, 120.683° E	ZIN 97115	FJ655233
yakutia1	Russia, Republic of Yakutia-Sakha, Olekminskiy district, Biryuk River, 60.483° N, 119.431° E	ZIN 97117	FJ655236
yakutia2	Russia, Republic of Yakutia-Sakha, Olekminskiy district, Biryuk River, 60.483° N, 119.433° E	ZIN 97116	FJ655239
yakutia3	Republic of Yakutia-Sakha, Ust'-Mayskiy district, left bank of Aldan River, 59.836° N, 133.578° E	S-183451	FJ655222
yakutia4	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, left bank of Aldan River, 59.836 N°, 133.578° E	S-183450	FJ655223
yakutia5	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, left bank of Aldan River, 60.067° N, 133.962° E	S-183453	FJ655253
yakutia6	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy District, left bank of Aldan River, 60.067° N, 133.962° E	S-183461	FJ655255
yakutia7	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, left bank of Aldan River, 60.068° N, 133.962° E	S-183459	FJ655261
yakutia8	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, left bank of Aldan River, 60.067° N, 133.962° E	S-183452	FJ655262
yakutia9	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183462	FJ655254
yakutia10	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183460	FJ655256
yakutia11	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183458	FJ655257
yakutia12	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183455	FJ655258
yakutia13	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183457	FJ655259
yakutia14	Russia, Republic of Yakutia-Sakha, Ust'-Mayskiy district, mouth of Chabda River, tributary of Maya, 59.777° N, 134.814° E	S-183454	FJ655260
trbaikal1	Russia, west Transbaikalia, Buriatia Republic, Oshurkovo village, 51.933° N, 107.433° E		EU754767
trbaikal2	Russia, west Transbaikalia, Buriatia Republic, Oshurkovo village, 51.933° N, 107.433° E		EU754766

(Appendix B continued)

Sample	Locality	Museum specimen number	GenBank accession
trbaikal3	Russia, west Transbaikalia, Buriatia Republic, Oshurkovo village, 51.933° N, 107.433° E		EU754768
trbaikal4	Russia, Chita region, Akshinskiy district, Gazakina ravine, 35 km S of Aksha, 50.000° N, 113.080° E	S-180457	EU754770
trbaikal5	Russia, Chita region, Akshinskiy district, Gazakina ravine, 35 km S of Aksha, 50.000° N, 113.080° E	S-180458	EU754771
trbaikal6	Russia, Chita region, Aleksandrovo-Zavodskiy district, upper Kher-Khira River, 50.410° N, 118.110° E	S-178623	EU754772
trbaikal7	Russia, Chita region, Sretenskiy district, Chachakan River, right bank of Shilka River, 3 km below Firsovo, 52.331° N, 118.212° E	S-178624	EU754769
trbaikal8	Russia, Chita region, Mogochinskiy district, Grishkina River, left tributary of Shilka River, 53.478° N, 120.752° E	S-182068	FJ655238
trbaikal9	Russia, Chita region, Mogochinskiy district, Grishkina River, left tributary of Shilka River, 53.478° N, 120.752° E	S-182067	FJ655237
trbaikal10	Russia, Chita region, Mogochinskiy district, Amur River, Alignment 859, Amasar border post, 53.431° N, 121.996° E	S-182069	FJ655234
trbaikal11	Russia, Amur region, Skovorodinskiy district, Ignashino, left bank of Amur River, 53.459° N, 122.404° E	S-182072	FJ655235
trbaikal12	Russia, Amur region, Skovorodinskiy district, Ignashino, left bank of Amur River, 53.459° N, 122.404° E	S-182070	FJ655240
trbaikal13	Russia, Amur region, Skovorodinskiy district, Ignashino, left bank of Amur River, 53.459° N, 122.404° E	S-182071	FJ655241
northeast	Russia, Republic of Yakutia-Sakha, Indigirka River, 63.841° N, 142.041° E	S-182110	FJ655211
northeast1	Russia, Republic of Yakutia-Sakha, Indigirka River, 63.841° N, 142.041° E	IBPN 6076	FJ655212
northeast2	Russia, Republic of Yakutia-Sakha, Indigirka River, 64.273° N, 142.471° E	IBPN 6077	FJ655213
northeast3	Russia, Magadan region, upper Omolon River, 63.337° N, 158.591° E		FJ655218
northeast4	Russia, Magadan region, upper Omolon River, 64.450° N, 161.134° E	UAM Mamm 80574	FJ655219
northeast5	Russia, Magadan region, upper Omolon River, 63.330° N,158.580° E		FJ655210
northeast6	Russia, Magadan region, Ola River		AF147667
northeast7	Russia, Magadan region, Lake Gluhoe, 59.648° N, 150.333° E		EU754753
northeast8	Russia, Magadan region, vicinity of Magadan, 59.568° N, 150.722° E		EU754757
northeast9	Russia, Magadan region, vicinity of Magadan, 59.568° N, 150.722° E		EU754755
northeast10	Russia, Magadan region, vicinity of Magadan, 59.568° N, 150.722° E		EU754756
northeast11	Russia, Magadan region, vicinity of Magadan, 59.535° N, 150.798° E		EU754758
northeast12	Russia, Magadan region, vicinity of Magadan, 59.535° N, 150.798° E		EU754759
northeast13	Russia, Magadan region, vicinity of Magadan, 59.535° N, 150.798° E		EU754754
northeast14	Russia, Magadan region, vicinity of Magadan, 59.637° N, 150.786° E		EU754751
northeast15	Russia, Magadan region, vicinity of Magadan, 59.648° N, 150.333° E		EU754752
khabar1	Russia, Khabarovsk Territory, Badzhal Range		AF147666
khabar2	Russia, Khabarovsk Territory, Bolhoy Shantar Island, 54.940° N, 137.580° E		FJ655220
sakhalin1	Russia, Sakhalin region, vicinity of Yuzhnosakhalinsk, 47.241° N, 142.774° E	S-182111	FJ655221
sakhalin2	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655242
sakhalin3	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655245
sakhalin4	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655248
sakhalin5	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655249
sakhalin6	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655243
sakhalin7	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655244
sakhalin8	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655246
sakhalin9	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655247
sakhalin10	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655250
sakhalin11	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655251
sakhalin12	Russia, Sakhalin region, Noglikskiy district, Chayvo Bay, 52.530° N, 143.060° E		FJ655252
japan	Japan, Obihiro, Hokkaido, 42.860° N, 143.110° E		FJ655209
primorye1	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve Ta-Chingouza tract, 43.310° N, 134.210° E		EU754765
primorye2	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve, Ta-Chingouza tract, 43.310° N, 134.210° E	S-181377	EU754760
primorye3	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve, Ta-Chingouza tract, 43.310° N, 134.210° E	S-181376	EU754764
primorye4	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve, 43.310° N, 134.210° E		EU754761
primorye5	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve, 43.310° N, 134.210° E		EU754781
primorye6	Russia, Primorye territory, Lazovskiy district, Lazovsky Reserve, 43.310° N, 134.210° E		EU754763
skorean1	South Korea, Gyeonggi-do Province, Gapyeong County		EU754805

(Appendix B continued)

Sample	Locality	Museum specimen number	GenBank accession
skorean2	South Korea, Gyeonggi-do Province, Gapyeong County		EU754816
skorean3	South Korea, Gyeonggi-do Province, Gapyeong County		EU754818
skorean4	South Korea, Gyeonggi-do Province, Gapyeong County		EU754820
skorean5	South Korea, Gyeonggi-do Province, Gapyeong County		EU754817
skorean6	South Korea, Gangwon-do Province, Chuncheon city		EU754807
skorean7	South Korea, Gangwon-do Province, Hwacheon County		EU754808
skorean8	South Korea, Gangwon-do Province, Yanggu County		EU754809
skorean9	South Korea, Gangwon-do Province, Taebaek city		EU754803
skorean10	South Korea, Gangwon-do Province, Taebaek city		EU754810
skorean11	South Korea, Gangwon-do Province, Taebaek city		EU754813
skorean12	South Korea, Gangwon-do Province, Taebaek city		EU754812
skorean13	South Korea, Gangwon-do Province, Taebaek city		EU754814
skorean14	South Korea, Gangwon-do Province, Cheorwon County		EU754819
skorean15	South Korea, Gangwon-do Province, Cheorwon County		EU754821
skorean16	South Korea, Gangwon-do Province, Cheorwon County		EU754801
skorean17	South Korea, Gangwon-do Province, Cheorwon County		EU754822
skorean18	South Korea, Gangwon-do Province, Cheorwon County		EU754811
skoreac1	South Korea, Chungcheongbuk-do Province, Okcheon County		EU754800
skoreac2	South Korea, Chungcheongbuk-do Province, Goesan County		EU754806
skoreac3	South Korea, Chungcheongbuk-do Province, Goesan County		EU754798
skoreac4	South Korea, Chungcheongbuk-do Province, Danyang County		EU754802
skoreac5	South Korea, Chungcheongbuk-do Province, Chungju city		EU754815
skoreac6	South Korea, Gyeongsangbuk-do Province, Cheongsong County		EU754804
skoreas1	South Korea, Gyeongsangbuk-do Province, Daegu metropolitan city		EU754782
skoreas2	South Korea, Gyeongsangnam-do Province, Hapcheon County		EU754799
skoreas3	South Korea, Gyeongsangnam-do Province, Sancheong County		EU754791
skoreas4	South Korea, Gyeongsangnam-do Province, Sancheong County		EU754797
skoreas5	South Korea, Jeollabuk-do Province, Namwon city		EU754790
skoreas6	South Korea, Jeollabuk-do Province, Namwon city		EU754792
skoreas7	South Korea, Jeollabuk-do Province, Namwon city		EU754796
skoreas8	South Korea, Jeollanam-do Province, Gurye County		EU754795
skoreas9	South Korea, Jeollanam-do Province, Gurye County		EU754785
skoreas10	South Korea, Jeollanam-do Province, Gurye County		EU754789
skoreas11	South Korea, Jeollanam-do Province, Gurye County		EU754793
skoreas12	South Korea, Jeollanam-do Province, Gurye County		EU754787
skoreas14	South Korea, Jeollanam-do Province, Gurye County		EU754784
skoreas15	South Korea, Jeollanam-do Province, Gurye County		EU754794
skoreas16	South Korea, Jeollanam-do Province, Gwangju metropolitan city		EU754786
skoreas17	South Korea, Jeollanam-do Province, Gwangju metropolitan city		EU754788
skoreas18	South Korea, Jeollanam-do Province, Gwangju metropolitan city		EU754783
heilong1	China, Heilongjiang Province		EU754773
heilong2	China, Heilongjiang Province		EU754774
heilong3	China, Heilongjiang Province		EU754776
heilong4	China, Heilongjiang Province		EU754777
heilong5	China, Heilongjiang Province		EU754778
heilong6	China, Heilongjiang Province		EU754779
heilong7	China, Heilongjiang Province		EU754780
heilong8	China, Heilongjiang Province		EU754775
heilong9	China, Heilongjiang Province		EU754762
petshop1	From pet shop		EU051004
petshop2	From pet shop		EU051003
petshop3	From pet shop		EU051001
petshop4	From pet shop		EU050999
petshop5	From pet shop		EU050998
petshop6	From pet shop		EU050997
petshop7	From pet shop		EU050996
petshop8	From pet shop		EU050995
petshop9	From pet shop		EU050994
petshop10	From pet shop		EU050993
petshop11	From pet shop		EU050992
petshop12	From pet shop		EU051002
petshop13	From pet shop		EU051000

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