Martes zibellina (Carnivora: Mustelidae)

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Source: Mammalian Species, 43(1):75-86. 2011.
Published By: American Society of Mammalogists
DOI: 10.1644/876.1
URL: http://www.bioone.org/doi/full/10.1644/876.1

MAMMALIAN SPECIES 43(876):75–86

Martes zibellina (Carnivora: Mustelidae)

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Abstract: *Martes zibellina* (Linnaeus, 1758) is a mustelid commonly called the sable. It is a widespread Siberian species that inhabits a spectrum of localities in the mountain and plain taiga, and also coniferous and deciduous forests in 6 countries. Main resources and largest part of its distribution area are located in Russia. *M. zibellina* is common in many zoos of large cities and breeding populations are maintained in fur farms in the Russian Federation, Finland, and probably other countries. *M. zibellina* is comparatively well studied, primarily because of its value as a furbearer. The number of individuals is estimated in the range of 1.1–1.3 million and recent estimates of annual production (after 2000) are 300,000–400,000 pelts from the wild. Annual sales at auctions from fur farms are about 10,000–20,000 pelts.

Key words: China, furbearer, Japan, Kazakhstan, Korea, Mongolia, mustelid, Russia, taiga dweller

Synonymies completed 1 January 2011
DOI: 10.1644/876.1
www.mammalogy.org

Martes Pinel, 1792

Mustela Linnaeus, 1758:45. Part.
Martes Frisch, 1775:11. Unavailable name (International Commission on Zoological Nomenclature 1954).
Martes Pinel, 1792:55. Type species *Martes domestica* Pinel, 1792 (= *Mustela foina* Erxleben, 1777), by original designation.
Zibellina Kaup, 1829:31, 34. Type species *Mustela zibellina* Linnaeus, 1758, by Linnaean tautonomy.
Mustela Blasius, 1857:8. No type specimen mentioned; said to contain *Mustela martes* and *Mustela foina*.
Pekania Gray, 1865:107. Type species *Martes pennanti*: Gray, 1865 (= *Mustela pennanti* Erxleben, 1777), by monotypy.
Foina Gray, 1865:108. Type species *Martes foina*: Gray, 1865 (= *Mustela foina* Erxleben, 1777), by monotypy.
Charronia Gray, 1865:108. Type species *Martes flavigula*: Gray, 1865 (= *Mustela flavigula* Boddaert, 1785), by monotypy.
Lamprogale Ognev, 1928:26. Replacement name for *Charronia* Gray, 1865; preoccupied by *Charonia* Gistel, 1848, a mollusc genus.

CONTEXT AND CONTENT. Order Carnivora, family Mustelidae, subfamily Mustelinae, tribe Mustelini, genus *Martes*. *Martes* has 8 extant species (Anderson 1970; Wozencraft 2005). Anderson (1970) recognized 3 subgenera: *Pekania* (*pennanti*), *Charronia* (*flavigula* and *gwatkinsii*), and *Martes* (*americana*, *foina*, *martes*, *melampus*, and *zibellina*). The following key to 8 living species is derived from characters described in Anderson (1970). Characters

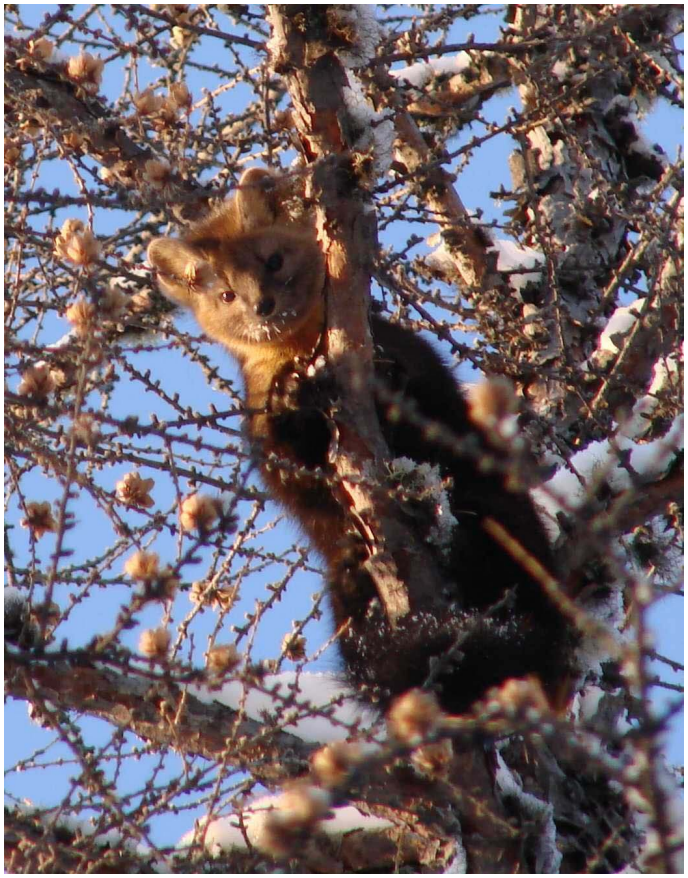

Fig. 1.—Adult female *Martes zibellina* from Yakutia, Russia. Used with permission of the photographer E. S. Zakharov.

6 and 7 were modified from Novikov (1956) and Gorner and Hackethal (1988).

1. Species present in North America 2
   Species not present in North America 3
2. Total length < 700 mm; tail < 300 mm; condylobasal length: male < 90 mm, female < 82 mm ..... *M. americana*
   Total length > 700 mm; tail > 300 mm; condylobasal length: male > 90 mm, female > 82 mm *M. pennanti*
3. Total length > 800 mm; tail > 300 mm; condylobasal length: male > 93 mm, female > 85 mm 4
   Total length < 800 mm; tail < 300 mm; condylobasal length: male < 93 mm, female < 85 mm 5
4. General coloration from dark brown to black. Distributed in forests of southern India *M. gwatkinsii*
   General coloration yellow-brown, hind legs and tail dark brown. Distributed in forests of southeast Asia, except southern India ..... *M. flavigula*
5. General coloration sandy, fawn, or yellow-brown; darker on legs, belly, and tail. Distributed in Japan and Korea ..... *M. melampus*
   General coloration ranging from light brown to nearly black, frequently with light bib (= throat patch). Distributed in Eurasian mountains and forests including Sakhalin Island and Hokkaido Island 6
6. Tail is short, not more than one-half body length; small, indistinct bib, frequently absent; forehead lighter than back; distance between bullae ≤ one-half their length ..... *M. zibellina*
   Tail > one-half body length; light, clear-cut bib; forehead has same coloration as back, distance between bullae > one-half their length 7
7. Bib is clear white, Λ-shaped; tail 250–320 mm; finger-pads are slightly furred; tip of nose flesh-colored or reddish; oral edge of palatine arch without, or negligible, outgrowth; length of inner lobe of M1 < 70% of its width; distance between mental foramina < length of lower canine (see Anderson 1970:8, 12) ..... *M. foina*
   Bib commonly yellow or orange, I-shaped; tail 220–260 mm, finger-pads are densely furred; tip of nose black; oral edge of palatine arch with clear outgrowth; length of inner lobe of M1 > 70% of its width; distance between mental foramina > length of lower canine (see Anderson 1970:8, 12) ..... *M. martes*

Martes zibellina (Linnaeus, 1758)
Sable

Mustela zibellina Linnaeus, 1758:45. Type locality "asia septentrionali," restricted by Thomas (1911) to "N. Asia;" further restricted by Ognev (1931:562) to "Tobol'skaya gub. v ee severnoi chasti" ["northern part of Tobol'sk Province"] [Russia].

M[ustela]. *melampus* Wagner, 1840:229. Type locality "Japan."

Mustela brachyura Temminck, 1844:33. Type locality "Japan and Kuriles."

Mustela zibellina var. *asiatica* (Brandt, 1855:6, 23). No type locality specified.

M[*ustela*]. *zibellina* var. *alba* (Brandt, 1855:14). No type locality specified.

M[*ustela*]. *zibellina* var. *fusco-flavences* (Brandt, 1855:14). No type locality specified.

M[*ustela*]. *zibellina* var. *ochracea* seu *ferruginea* (Brandt, 1855:14). No type locality specified.

M[*ustela*]. *zibellina* var. *maculata* (Brandt, 1855:14). No type locality specified.

Mustela zibellina var. *asiatica rupestris* (Brandt, 1855:14). No type locality specified.

Mustela zibellina var. *asiatica sylvestris* (Brandt, 1855:14). No type locality specified.

Mustela zibellina var. *kamtschatica* (Dybowski, 1922:349). Nomen nudum.

Mustela zibellina var. *baicalensis* (Dybowski, 1922:349). Nomen nudum.

Mustela zibellina var. *amurensis* (Dybowski, 1922:349). Nomen nudum.

Martes zibellina: Ognev, 1925:276. First use of current name combination.

Martes zibellina coreensis Kishida, 1927a:130. Type locality "Corean peninsula."

Martes zibellina hamgyenensis Kishida, 1927b:509. Type locality "Corean peninsula."

Martes zibellina tungussensis Kuznetsov, 1941:116. Type locality "Nizhnaya Tunguska river," Mid-Siberia.

Martes zibellina arsenjevi Kuznetsov, 1941:122. Nomen nudum.

Martes zibellina schantaricus Kuznetsov, 1941:122. Nomen nudum.

Martes zibellina averini Bashanov, 1943:53, Type locality "Southern Altai (Katon-Karagai district of East-Kazakhstan oblast)."

Martes zibellina arsenjevi Bobrinskii, Kuznetsov, and Kuzyakin, 1944:120. Type locality "Ussuri River basin."

Martes zibellina schantaricus Bobrinskii, Kuznetsov, and Kuzyakin, 1944:120. Type locality "Shantar Isle, lower basin of Amur River."

Martes zibellina altaica Jurgenson, 1947:179. Type locality "Altai mountains (Oyrotski oblast)."

Martes zibellina tomensis Timofeev and Nadeev, 1955:37. Type locality "Kuznetsky Alatau, Tom River."

Martes zibellina angarensis Timofeev and Nadeev, 1955:41. Type locality "Angarra River, Boguchanski district of Krasnoyarsk region."

Martes zibellina ilimpiensis Timofeev and Nadeev, 1955:44. Type locality "Kochechui and Kotui Rivers."
Martes zibellina vitimensis Timofeev and Nadeev, 1955:47. Type locality "Vitim and Mama Rivers."
Martes zibellina obscura Timofeev and Nadeev, 1955:47. Type locality "Chikoi River, Selenga Basin."
Martes zibellina jakutensis Novikov, 1956:185. Type locality "Aldan and Kurchum Rivers" (after Kuznetsov 1941).
Martes zibellina linkouensis Ma and Wu, 1981:196. Type locality "Linkou, Heilungjiang province" (northeastern China).
Martes zibellina jurgensoni Pavlinov and Rossolimo, 1987:63. Type locality "South-West Altai."

Context and Content. Context as for genus. Anywhere from 2 to 30 subspecies of *Martes zibellina* have been recognized (2 [Birula 1922, 4 [Monakhov 1976], 7 [Aristov and Baryshnikov 2001; Pavlinov and Rossolimo 1979], 17 [Heptner et al. 1967; Wozencraft 2005], and 30 [Larívière and Jennings 2009]). A revision of subspecies taxonomy is needed but this may prove difficult because the species is quite variable across its range and many introductions and reintroductions occurred throughout most of the species' range in Russia during the 1900s in efforts to restore the population (Abramov and Wozencraft 2008; Heptner et al. 1967; Larívière and Jennings 2009; Monakhov and Bakeyev 1981). Some beginning efforts have been made to clarify subspecific structure (Balmysheva and Solovenchuk 1999; Hosoda et al. 1997; Monakhov 2001b; Monakhov and Ranyuk 2010) but more work needs to be done. Wozencraft (2005) recognized the following 17 subspecies:

M. z. angarensis Timofeev and Nadeev, 1955:41. See above.
M. z. arsenjevi Bobrinskii, Kuznetsov, and Kuzyakin, 1944:120. See above.
M. z. averini Bashanov, 1943:13. See above; *altaica* Jurgeson and *jurgensoni* Pavlinov and Rossolimo are synonyms.
M. z. brachyura Temmink, 1844:33. See above.
M. z. ilimpiensis Timofeev and Nadeev, 1955:44. See above.
M. z. jakutensis Novikov, 1956:185. See above.
M. z. kamtschadalica (Birula, 1918:82). Type locality "Kamchatka;" *kamtschatica* (Dybowski) is a synonym.
M. z. linkouensis Ma and Wu, 1981:196. See above.
M. z. obscura Timofeev and Nadeev, 1955:47. See above.
M. z. princeps (Birula, 1922:08). Type locality "Bargusin Mountains, Transbaikalia;" *baicalensis* (Dybowski) and *vitimensis* (Timofeev and Nadeev) are synonyms.
M. z. sahalinensis Ognev, 1925:279. Type locality "Sahalin, Vedernikovo [= Saghalien, Wedernikovo]."
M. z. sajanensis Ognev, 1925:278. Type locality "Orsyba River, northern part of the Sajansky Mountains."
M. z. schantaricus Bobrinskii, Kuznetsov, and Kuzyakin, 1944:120. See above.
M. z. tomensis Timofeev and Nadeev, 1955:37. See above.
M. z. tungussensis Kuznetsov, 1941:116. See above.
M. z. yeniseensis Ognev, 1925:277. Type locality "Krasnojarsk district, the forests of the plain along Yenisei River."
M. z. zibellina Linnaeus, 1758:45. See above; *alba* (Brandt), *asiatica* (Brandt), *fusco-flavescens* (Brandt), *maculata* (Brandt), *ochracea* (Brandt), *rupestris* (Brandt), and *sylvestris* (Brandt) are synonyms.

DIAGNOSIS

Martes zibellina is slightly larger than other similar Holarctic martens (*M. martes* [European pine marten], *M. americana* [American marten], and *M. melampus* [Japanese marten]) but smaller than *M. pennanti* (fisher) and *M. flavigula* (yellow-throated marten) and has more dark coloration in the pelage. A variably sized yellowish (orange) patch (bib) occurs on throat and breast (Fig. 1), but it is sometimes absent; head usually lighter than back, sometimes whitish. Pelage is monotonic ranging from light brown (or sandy-yellow) to almost black; frequently occurs with sporadic white (gray or yellowish) hairs throughout the pelt. In the fur trade this is referred to as "sedina" (grayness [Fig. 2]). In general, *M. zibellina* is most similar morphologically to *M. martes*, *M. americana*, and *M. melampus* (Anderson 1970; Clark et al. 1987; Hagmeier 1961); however, it has a shorter tail and darker, more lustrous and silky pelage. Tail length with tip hairs is no more than one-half of body length (Ognev 1931). Skull bullae (Fig. 3) are extended and closer together than in *M. martes* and the beech marten (*M. foina*—Heptner et al. 1967). The internal one-half of the upper molar (Fig. 3) is wider than the external one-half (Aristov and Baryshnikov 2001). Bacula are 39–43 mm long (in adult males) with a forked end that forms an unclosed ring (Fig. 4) and so have morphological differences with *M. martes* and *M. americana* (Heptner et al. 1967; Pawlinin 1966).

Fig. 2.—*Martes zibellina* from a fur farm illustrating the "grayness" condition. Photograph by V. Monakhov.

Fig. 3.—Dorsal, ventral, and lateral views of skull and lateral view of mandible of an adult female *Martes zibellina*. Specimen from the private collection of Vladimir Monakhov. Condylobasal length is 78.7 mm. Photograph by V. Monakhov.

Fig. 4.—Lateral view of bacula (distal tip to right) of *Martes zibellina zibellina*: A) juveniles and B) adult animals. Specimens from collection of Zoological Museum, Institute of Plant and Animal Ecology, Ekaterinburg, Russia. Photograph by V. Monakhov.

GENERAL CHARACTERS

Martes zibellina has relatively short feet that are pentadactyl and semiplantigrade. Body mass (g) is 1,150–1,850 for males and 650–1,600 for females; body length (cm) is 32–53 for males and 30–48 for females; tail length (cm) is 13.0–18.0 for males and 12.0–16.0 for females; and height of ear (cm) is 4.9–5.7 for males and 4.3–5.5 for females (Monakhov and Bakeyev 1981). Males are about 8–12% ($\bar{X}$ = 9.03%) larger than females (Monakhov 2009).

Adult skull measurements (mm; mean ± *SE*, range) of *M. z. kamtschadalica* (196 males, 190 females), *M. z. arsenjevi* (201 males, 161 females), and *M. z. zibellina* (137 males, 116 females), respectively, were: condylobasal length—87.86 ± 0.14, 82.6–94.0; 80.97 ± 0.12, 75.0–84.8; 77.82 ± 0.12, 73.8–82.1; 71.27 ± 0.12, 68.0–75.8; 84.88 ± 0.16, 77.6–90.3; 77.70 ± 0.14, 74.5–84.5; length of maxillary toothrow—34.06 ± 0.06, 31.2–36.2; 30.98 ± 0.06, 28.8–34.7; 30.10 ± 0.07, 27.9–32.9; 27.98 ± 0.06, 25.3–29.8; 32.22 ± 0.08, 29.9–34.2; 29.07 ± 0.09, 26.6–34.2; maximum width of skull—38.59 ± 0.09, 35.7–41.5; 35.86 ± 0.07, 32.9–38.4; 34.94 ± 0.06, 32.4–37.3; 32.45 ± 0.07, 29.6–35.0; 37.68 ± 0.09, 35.0–41.1; 34.74 ± 0.08, 32.2–38.2 (Monakhov 2006b).

Length of guard hairs (mm; mean ± *SE*, males, females) is 51.33 ± 0.35, 46.04 ± 0.41 in animals from the Barguzin District and 53.3 ± 0.32, 46.70 ± 0.31 in those from the Vakh River basin. For the same 2 geographic areas, length of underfur is 32.34 ± 0.26, 26.87 ± 0.17 and 31.54 ± 0.20, 28.76 ± 0.26, respectively (Monakhov 2005a). Thickness of guard hairs (μm; mean ± *SE*, males, females) is 88.15 ± 0.94, 82.02 ± 0.90 in the Barguzin District and 88.06 ± 2.15, 85.02 ± 1.25 in the Vakh River basin; thickness of underfur for the same 2 geographic regions is 19.21 ± 0.30, 17.73 ± 0.20 and 19.56 ± 0.25, 19.06 ± 0.21, respectively (Monakhov 2005a). Geographical variation of body size, color, and fur quality of *M. zibellina* is considerable (Monakhov 2006b; Monakhov and Bakeyev 1981; Timofeev and Nadeev 1955). Based on the variation of these features, > 20 geographical races have been described. Four categories are used to describe color variation: golovka (the darkest), podgolovka, vorotovoy, and mekhovoy (the lightest—Heptner et al. 1967; Tavrovsky 1971). The largest *M. zibellina* dwell in Kamtchatka, Altai, and Ural forests and the smallest are found in Ussuri and Amur forests in Russia. Darkest pelages occur in the Baikal Region, Yakutia and Amur Basin, and the lightest in Trans-Urals, Russia (G. Monakhov 1976; V. Monakhov

2006b; Monakhov and Bakeyev 1981; Timofeev and Nadeev 1955).

DISTRIBUTION

Martes zibellina occurs in 6 countries: Russia, Mongolia, China, North Korea, Japan (Buskirk et al. 1994; Proulx et al. 2004), and Kazakhstan (Afanasyev 1960; Bashanov 1943; Kuznetsov 1948; Nasimovich 1973; Timofeev and Nadeev 1955). It occupies conifer forests of Siberia and northern and eastern Europe (Fig. 5). To the west, it extends to the Ural Mountains where it is sympatric with *M. martes* (Bakeyev and Sinitsyn 1994; Grakov 1994; Heptner et al. 1967; Monakhov 2005c). In Russia, Mongolia, Kazakhstan, and China, in the Altai and West Sajan mountains, distribution of *M. zibellina* overlaps with that of *M. foina* (Heptner et al. 1967; Proulx et al. 2004). Distribution of *M. zibellina* extends southward to 55–60°N latitude in western Siberia, and 42°N in the mountains of eastern Asia. In the southernmost part of its distribution *M. zibellina* tends to occur in peninsular or insular mountains. *M. zibellina* also occupies Sakhalin Island, off the eastern coast of Siberia (Heptner et al. 1967; Proulx et al. 2004).

In Mongolia, it occurs in the Altai Mountains of the far northwest and in forests around Lake Hovsgol (Heptner et al. 1967). The latter area is contiguous with the Trans-Baikal boreal forest region, which produces the best known and most valuable pelts of *M. zibellina* (Ognev 1931; Sabaneev 1875) and has the most continental climate experienced by any *Martes*, with warm summers but long, severe winters. In eastern Kazakhstan *M. zibellina* inhabits basins of the Bukhtarma and Uba rivers southwest of the Altai mountains (Heptner et al. 1967; Lobachev and Afanasyev 1982; Monakhov and Bakeyev 1981; Ternovsky 1977; Timofeev and Nadeev 1955). In China, *M. zibellina* currently occurs in a small area of the Xinjiang Uygur Autonomous Region, where the southern Altai Mountains enter China from the north. In northeastern China, it is now limited to the Daxinganling Mountains of Heilongjiang Province and Inner (Nei) Mongolia. In the Xiaoxingan ling Mountains of eastern Heilongjiang, persistence of *M. zibellina* is suspected but not confirmed (Helin et al. 1999; Ma and Xu 1994). *M. zibellina* also occupies the Changbaishan Mountains along the border with, and southward into North Korea. *M. zibellina* occurs in Hokkaido, the northernmost major island of Japan, in the main Japanese archipelago, and on the Korean peninsula (Anderson 1970; Corbet 1978; Hosoda et al. 1997; Proulx et al. 2004).

FOSSIL RECORD

Most subarctic mammal species were migratory during some point in their evolution; Anderson (1970) concluded that the genus *Martes* belonged in that category. She believed that the ancestor of *M. zibellina* and other species (*M. foina*, *M. martes*, *M. melampus*, and *M. americana*) was an early Pleistocene species like *M. vetus* (Anderson 1970). Between the Pleistocene and Holocene with retreat of glaciers and rapid expansion of forests, *M. zibellina* left refugia and settled into new suitable territories (Abramov 1967; Mensbir 1934; Monakhov 1976; Pawlinin 1966). *M. zibellina* has occurred in the Ural Mountains for about 20,000–40,000 years (Kosintsev 1996; Kuzmina 1966, 1982; Ponomarev 2001; Vereshagin 1982), but likely never occurred in high numbers until 8,000–10,000 years ago during postglacial time. Bones of *M. zibellina* in Altai have been dated > 100,000 years old (Derevjanko et al. 2003). No remains of *M. zibellina* > 20,000 years old have been found in Trans-Ural and western Siberia; however, this cannot necessarily be interpreted as its absence during that period (Bobkovskaya 2002; Kosintsev and Borodin 1990; Kuzmina 1982; Ponomarev 2001; Smirnov et al. 1986).

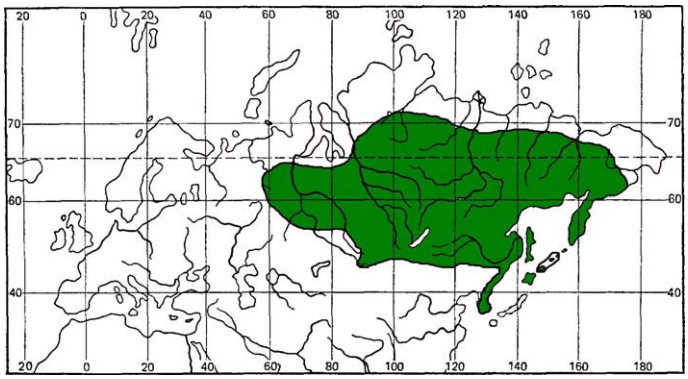

Fig. 5.—Geographical distribution of *Martes zibellina*.

FORM AND FUNCTION

Molting in *Martes zibellina* takes place in spring and autumn; the timing of molt is related to photoperiod (Monakhov and Bakeyev 1981). Spring molt begins in March and lasts about 2 months, and autumn ecdysis occurs from the end of August to November. *M. zibellina* has its winter pelage for 4–5 months and its summer pelage for 1.5–2.0 months.

Martes zibellina can be aged with 3 methods: cementum annuli in teeth (Klevezal and Kleinenberg 1969), width of the canine root canal (Smirnov 1960), and development of the mastication muscles and sagittal crest on the skull (Timofeev and Nadeev 1955). The first 2 methods produce similar results ($r = 0.95$) and are suitable for monitoring and commercial game management (Monakhov 2004a, 2005b). The 3rd method is simpler but less accurate and is recommended only for the preliminary assessment of age ratios in populations (Klevezal and Kleinenberg 1969). When large samples are studied for the purposes of

monitoring and management planning, the method proposed by Smirnov (1960) is preferable.

The dental formula is i 3/3, c 1/1, p 4/4, m 1/2, total 38. Dentition of *M. zibellina* is very similar to that of *M. martes* and *M. americana* (Clark at al. 1987). Length of M1 is 7.0–9.5 mm. Width of M1 is almost equal to length of P4. Length of internal lobus of M1 is more noticeable than external lobus and equal to nearly three-fourths of the crown width. Length of m1 is 7.8–10.6 mm (Aristov and Baryshnikov 2001). The vertebral formula is 7 C, 14 T, 6 L, 3 S, 15–16 Ca, total 45–46 (Ternovsky 1977).

In summer, *M. zibellina* has a low body mass, and in winter, body mass increases 7–10% (Tumanov 2003). Heat production in December is lower by 17–18% than in July (Afanasyev and Pereldik 1966). Body temperature of *M. zibellina* females is 39.9°C ± 1.0 *SE*, and respiration rate is 53 breaths/min (range: 48–62—Tumanov 2003). *M. zibellina* requires daily about 20% of its body mass in food. This amounts to catching 6–8 voles/day (Safronov 2002). Heart rate is 216 beats min^{-1} kg body $mass^{-1}$ for adult males and 269 beats min^{-1} 1 kg body $mass^{-1}$ for adult females. Females show high intensity of systole to diastole muscle work with a tenseness index of 463 ± 7.2 *SE* and systolic index of 55 ± 0.5 *SE* (Tumanov 2003).

The average fatness mass index of males and females, respectively, is 24.99 and 22.71‰ in May and 31.50 and 27.67‰ in November (Pavlyuchenko et al. 1979). The lowest recorded rate of metabolism for *M. zibellina* is 107 kcal/kg in December and the highest is 127 kcal/kg in July–August. The mean blood temperature of adult *M. zibellina* is 38.2°C (range: 36.0–40.4°C). Concentrations of erythrocyte ($\times 10^6$/mm^3) in blood are 7.2 in males and 8.2 in females; hemoglobin content is 144 g/l in males and 159 g/l in females (Pavlyuchenko et al. 1979). Mass (g; mean, range) of internal organs of 77 male and 95 female *M. z. zibellina* from the Yugan River basin, Russia, were: heart mass, 8.57, 6.3–12.8 and 6.44, 4.4–9.7; liver mass, 31.95, 18.5–60.5 and 25.87, 12.0–43.6; kidney mass, 3.77, 2.1–6.2 and 3.12, 1.9–4.8; and lung mass, 18.5, 8.5–31.0 and 13.75, 7.3–25.8 (Monakhov 2001a).

Martes zibellina possesses a high cerebral index, 17‰ ± 0.3‰ in males and 20‰ ± 0.4‰ in females. These are 2-fold more than what is recorded in the more specialized American mink (*Neovison vison*—Ternovskaya 2006).

ONTOGENY AND REPRODUCTION

The breeding season for *Martes zibellina* generally occurs from mid-June to early August (Afanasyev and Pereldik 1966). Ovulation is induced by copulation (Pavlyuchenko et al. 1979) and lasts from 15 June to 15 August (Kler 1941; Starkov 1939). Length of spermatozoan head is about 8 μm, and its flagellum is 55 μm; fertilized ova are 900–1,100 μm in diameter, and develop into blastocysts of 554–722 μm in diameter by September and 1,200–1,250 μm at late February (Pavlyuchenko et al. 1979). Gestation lasts 245–298 days (Kler 1941) and 7.5–8.0 months of diapause. Duration of embryonic development after implantation (true pregnancy) is 30–35 days (Pavlyuchenko et al. 1979). Births take place from 25 March to 3 May (Kler 1941).

Body length of newborns is 11–12 cm, and body mass is 25–30 g (Starkov 1947). Incisors appear 38 days after birth. Deciduous teeth are replaced by permanent teeth at 3–4 months of age. Month-old offspring have a mean mass of 260 g, and at 2 months of age, they are 600 g (Starkov 1947). Litter size is 1–7 kits, with an average range of 2.5–3.5 (Heptner et al. 1967). In Russia, mean number of corpora lutea differs geographically from 2.52 in the Sayan Mountains to 4.47 in Kamchatka (Monakhov and Bakeyev 1981) to 4.97 near Demjanka River (Ob Basin—Monakhov 2006a). Maximum number of corpora lutea in the wild is 8 for *M. z. zibellina*; and in captivity, 9 corpora lutea were noted at Saltikovsky fur farm (Monakhov 2004b, 2006a). Sex ratio at birth is 53 males : 47 females (n = 3,622—Monakhov and Bakeyev 1981).

Typically, *M. zibellina* reaches full reproductive potential at > 2 years of age (Monakhov and Bakeyev 1981). Juveniles (age class 0) do not reproduce; the mating period takes place in July–August when they are only 2–3 months old. Yearlings in age class 1 (14–15 months old) do not always reach sexual maturity by the end of the breeding season and thus do not fully realize their reproductive potential (Manteifel 1934; Rayevsky 1947; Zaleker 1950). In 1978–1990, the portion of pregnant females in their 2nd year was 76.4% and the number of corpora lutea was 2.96/female in the northern Sub-Urals, and 23.4% and 0.64 in the Kizir population of west Sayan Mountain country, respectively. In contrast, for the same areas, females 2 years of age and females > 2 years of age were 94.2% and 4.06 and 56.6% and 1.92 (Monakhov 2005b), respectively. Similar observations occur in other wild populations of *M. zibellina* (Belov 1980; Kartashov 1989) and in those from fur farms as well (Mamatkina and Monakhov 1970; Pavlyuchenko et al. 1979).

ECOLOGY

Population characteristics.—The average proportion of males in populations of *Martes zibellina* is 54.5% ± 0.08% *SE* (n = 13,997—Monakhov and Bakeyev 1981). Age composition is highly variable among populations. Subyearlings (juveniles) can represent 30.5–75.6% of a population (Monakhov 2005b), averaging 44.8% (Monakhov and Bakeyev 1981). The estimated proportion of juveniles is often very high, in contrast with the natural rate of population growth and observed litter size, which may be a result of the predominant removal of juveniles in the hunting process (i.e., selective catching, shooting, and trapping—Monakhov 1983a, 2005b; Monakhov and Bakeyev 1981). Age structure of *M. zibellina* defined by

the method of Klevezal and Kleinenberg (1969) was: juveniles = 62.7%; yearlings = 12.6%; 2–4 year olds = 2.5–4.3%; 5–7 year olds = 1.6–2.5%; and > 8 year olds = 0.6–1.2% in Trans-Urals (n = 2,150) and 75.6%, 0.6%, 2.7–4.9%, 0.8–2.5%, and 0.2–0.7%, respectively, in the western Sayan Mountains (n = 1,765—Monakhov 2005b). Annual survival rates of *M. zibellina* were 19.9% for juveniles, 44.0% for yearlings, and 75.9–79.4% for individuals 2–9 years of age in Trans-Urals and 33.0%, 59.6%, and 49.3–75.8%, respectively, for individuals in the western Sayan Mountains (Monakhov 2005b; Sokolov 1979). Only two 18-year-old individuals from a sample of 2,150 animals in the northern Sub-Urals (Monakhov 2005b) were found. Thus, the number of senescent animals in the population is very low. Nineteen-year-old males (Afanasyev and Pereldik 1966) and 22-year-old females (Ternovskaya 2006) have been noted in fur farms. Total number of feral *M. zibellina* is estimated at 1.1–1.3 million individuals (Bakeyev et al. 2003; Borisov and Lomanov 2006; Safonov et al. 2006).

Space use.—*Martes zibellina* occupies dense coniferous taiga forests, flatlands, and mountainous areas in Siberia (Heptner et al. 1967). *M. zibellina* is found in the spruce (*Picea*), larch (*Larix*), pine and cedar (*Pinus*), and birch (*Betula*) forests of northern and southern Siberia and Russian Far East. Home ranges of *M. zibellina* are 4–30 km^2 (Heptner et al. 1967). *M. zibellina* has a permanent home range and also utilizes a few temporary ranges (Gusev 1966). Home-range sizes and travel rates depend on abundance and availability of food, climate, age, sex, and population density of animals. Adult *M. zibellina* occupy areas 2–3 times larger than juveniles. If food availability is low, *M. zibellina* moves widely; young *M. zibellina* tend to leave their 1st permanent ranges under such conditions (Bakeyev and Sinitsyn 1994; Heptner et al. 1967). The average travel rate is 7.3–10.6 km/day for males and 6.5–12.0 km/day for females (Gusev 1966). Among marked *M. zibellina*, 83% of males and 96% of females moved out no further than 30 km from tagging locations (Chernikin 2006; Komarov 1972; Sutula and Popov 2001). Maximum distances traversed by ear-tagged males (no females registered) were 100–200 km (Bakeyev et al. 1980; Chernikin 2006) and up 300 km after translocation releases (Bakeyev and Sinitsyn 1994). On a few occasions *M. zibellina* has been captured 130–160 km beyond the described distribution range for the species range (Monakhov 2010).

Diet.—*Martes zibellina* is a euryphagous predator (Bakeyev et al. 2003; Heptner et al. 1967; Monakhov and Bakeyev 1981; Timofeev and Nadeev 1955). Foods of *M. zibellina* are well studied in winter (harvesting period). In the mountain taiga of Sayan and Trans-Baikal, stomach and fecal samples of *M. zibellina* contained 64–80% mammals (mainly small), 6–12% birds, 33–77% nuts of *Pinus sibirica* and *P. pumila*, and 4–33% berries; similar proportions were found in the plain taiga of western Siberia (75–90%, 24–80%, 20–53%, and 20–63%, respectively—Monakhov and Bakeyev 1981). The prey of *M. zibellina* also can include larger mammals such as chipmunks (*Tamias sibiricus*), pikas (*Ochotona*), squirrels (*Sciurus* and *Pteromys*), muskrats (*Ondatra*), marmots (*Marmota*), mountain hares (*Lepus timidus*), and musk deer (*Moschus moschiferus*—Chernikin 2006; Khlebnikov 1977; Monakhov and Bakeyev 1981; Moskov 1973; Zirjanov et al. 2001). Tavrovsky (1971) and Chernikin (2006) recorded mustelids (*Mustela erminea* [ermine] and *M. nivalis* [least weasel]) as prey for *M. zibellina* of Baikal and Yakutia. Cannibalism in *M. zibellina* was shown by Kolichev (1976) in Yenisei and Trans-Baikal regions. The diet of *M. zibellina* occasionally includes fish (Monakhov and Bakeyev 1981; Tavrovsky 1971).

Diseases and parasites.—Fourteen species of parasitic worms have been identified in *Martes zibellina* (Petrov 1941): 2 trematodes, 2 cestodes, and 10 nematodes. Bakeyev et al. (2003) reported 34 species of helminths found in *M. zibellina*. Helminths are localized in frontal sinuses and respiratory organs and digestion. For *M. zibellina* of Kamchatka Peninsula 19 species of helminths were found, localized in the respiratory organs, alimentary tract, and muscles. Genera most often registered were *Crenosoma*, *Thominx*, *Filaroides*, *Soboliphyme*, *Capillaria*, *Mesocestoides*, *Thaenia*, and *Ascaris* (Tranbenkova 2001). Young animals have the highest intensity of helminth infections (Monakhov 1983b, 1999). Fungal skin disease in *M. zibellina* as the result of *Cephalosporium* (class Hyphomycetes) has been documented (Stepanenko 2007). Twenty-one species of fleas (two of which are specific: *Chaetopsylla zibellina*, Vermipsyllidae; and *Ceratophyllus paradoxus*, Ceratophyllidae) and 3 species of gamasid mites (Gamasidae) have been recorded for *M. zibellina* (Bakeyev et al. 2003).

Interspecific interactions.—*Martes zibellina* is trophically related to 36 species of mammals, 220 species of birds, and 21 species of plants (Bakeyev et al. 2003; Gusev 1966). *M. zibellina* is prey for 8 species of mammals (brown bear [*Ursus arctos*], wolf [*Canis lupus*], red fox [*Vulpes vulpes*], arctic fox [*Vulpes lagopus*], wolverine [*Gulo gulo*], yellow-throated marten [*Martes flavigula*], tiger [*Panthera tigris*], lynx [*Lynx lynx*] and 8 species of birds (eagle-owl [*Bubo bubo*], 2 eagles: golden eagle [*Aquila chrysaetus*] and white-tailed eagle [*Haliaeetus albicilla*], raven [*Corvus corax*], hawks: goshawk [*Accipiter gentilis*] and sparrow-hawk [*Accipiter nisus*], and 2 owls: great gray owl [*Strix nebulosa*] and northern hawk owl [*Surnia ulula*]). Intraspecific competition likely occurs among *M. zibellina* and 28 species of mammals and 27 species of birds (Chernikin 2006; Monakhov and Bakeyev 1981).

HUSBANDRY

Since 1928, *Martes zibellina*, commonly known as the Russian sable in the fur trade, has been reared on fur farms. The 1st offspring from captive females occurred in 1931 (Afanasyev and Pereldik 1966; Manteifel 1934). Commerical breeding has occurred since 1933 (Pavlyuchenko et al. 1979).

Fig. 6.—A male *Martes zibellina* illustrating dark coloration of fur produced by selective breeding at a fur farm in Russia. Photograph by V. Monakhov.

M. zibellina is a valuable furbearer species with registered auction sales in 2010 of about 11,000 farm pelts for an average price per pelt of $167.00 (for the same period about 366,000 wild pelts were sold for an average price per pelt of $138.00—http://www.sojuzpushnina.ru). In comparison, for 2006–2009 the average annual sales during auctions were 358,670 (range 328,500–415,400) pelts of feral *M. zibellina*, with an average price per pelt of $123.10 (range $85.70–160.0—http://www.sojuzpushnina.ru). Presently, a race of large *M. zibellina* with black coloration and adapted to life in captivity is favored on fur farms (Fig. 6).

Animals are reared in standardized sheds—each holding 260 individual cages (Pavlyuchenko et al. 1979). Captive *M. zibellina* are fed by-products from the meat and dairy industry, zooplankton, and vegetables (Afanasyev and Pereldik 1966; Pavlyuchenko et al. 1979).

Among harvested feral *M. zibellina* and those reared in fur farms, animals with an unusual pelage are sometimes reported (Bakeyev et al. 2003; Pavlyuchenko et al. 1979). Some animals will have whitish (partial albino), spotted (feet and muzzle [Fig. 7]), golden, speckled, or blue fur. Trapezov (2006) believes that by artificial selection it is possible to create the same color types in *M. zibellina* that are found in captive *Neovison vison* (American mink).

BEHAVIOR

Martes zibellina is solitary in nature. It is an adroit, tireless, and strong predator with excellent hearing and well-developed hunting skills that allow it to locate prey based on sounds and smell (Bakeyev et al. 2003). The movements of *M. zibellina* are typical of a terrestrial animal, moving mainly by small jumps 40–70 cm in length. When escaping the pursuit of a predator, it can extend its jumps up to 3–4 m in length (Timofeev and Nadeev 1955). Adult animals can easily detect hunting dogs from a distance and escape. Juveniles will climb up trees or hide in refuges.

Fig. 7.—A female *Martes zibellina* with white-spotted pelage from a fur farm. Photograph by V. Monakhov.

Martes zibellina uses scent glands located on the posterior part of the abdomen for scent communication and marking its territory (Aristov and Baryshnikov 2001; Rozhnov 2002).

Some researchers (Bakeyev et al. 2003; Shaposhnikov 1956) report that *M. zibellina* shows agonistic behavior to *Mustela sibirica* (the Siberian weasel) and *Mustela erminea*.

According to Petrashov (1971), 72% of *M. zibellina* are active during twilight times, 18% at night, and 10% in the daytime. During the reproductive season it is active in the daytime (Devyatkin 1993). In snowfalls and rainy weather *M. zibellina*, as a rule, seeks shelter. Movement significantly goes down when there is a hard frost (Chernikin 2006; Rayevsky 1947; Timofeev and Nadeev 1955), and individuals may stay in refuges up to several days (Stroganov 1969; Timofeev 1948).

Martes zibellina chooses a variety of refuges: in tree hollows and under tree roots, fallen wood, stone piles, between rocks, and in precipitous banks of rivers and creeks. It is difficult to find the den without trained dogs, especially those dens containing litters. *M. zibellina* will choose the driest areas of taiga for the litter den. The den floor is often covered with dry grass, lichens, feathers, and fur. Excrement of kits is often found near the den (Chernikin 2006). Young

animals spend considerable time engaged in play behavior (Ternovsky 1977) and the play reflex also is demonstrated by adults when hunting and interacting with prey and during sexual interactions (Ternovsky 1977). Young disperse in August (Dulkeit 1957; Sabaneev 1875; Tavrovsky 1971).

The predatory instinct is reduced in *M. zibellina* during seasons when an abundance of vegetable foods are available. In years that forage is reduced, *M. zibellina* often will spend more time in the proximity of human settlements. When searching for food, *M. zibellina* shows crepuscular activity such as do its main prey—mice and voles (Chernikin 2006). Width of the controlled hunting strip is up to 10 m (Chernikin 2006). *M. zibellina* does not use permanent refuges in winter and very few records document food stocking (Timofeev and Nadeev 1955). However, in some cases, described by Chernikin (2006), pantries were found in May–June and contained carcasses of the Siberian chipmunk (*Tamias sibiricus*), least weasel (*Mustela nivalis*), up to 7 voles (*Microtus* and *Myodes* [formerly *Clethrionomys*]), and the cones of *Pinus sibirica* and *Pinus pumila*.

GENETICS

Martes zibellina has a diploid number (2n) of 38 chromosomes and a fundamental number (FN) of 66; autosomes consist of 5 pairs of metacentric, 10 pairs of submetacentric, and 3 pairs of acrocentric chromosomes (Aristov and Baryshnikov 2001; Orlov and Malygen 1969). The X chromosome is medium in size; the Y chromosome is a small metacentric (Orlov and Malygen 1969).

Both *M. zibellina* and *M. martes* occur in the Urals. This is a zone of introgression and here, these 2 species provide a hybrid, called the kidus or kidas (Grakov 1994; Jurgenson 1947). Results based on mitochondrial DNA indicate a high degree of reciprocal introgression of the 2 species in the northern Urals (Rozhnov et al. 2010). This suggests that hybridization is common within this zone of sympatry. The kidus is intermediate between *M. zibellina* and *M. martes* in morphological features. It has coarser fur than *M. zibellina*, a bright spot on the throat, a long, bushy tail, and a larger head. Kidus also has been raised on fur farms by crossing the 2 species. Grakov (1981) reported no offspring for self crossing the hybrids and only in 1 case were offspring obtained from back crossing the hybrids with *M. zibellina* or *M. martes*; this involved a cross of a female kidus and a male *M. martes* (Grakov 1981). The male kidus is sterile (Grakov 1994).

CONSERVATION

In the early 20th century, numbers of *Martes zibellina* were very low because of overharvesting (Heptner et al. 1967; Sabaneev 1875; Timofeev and Nadeev 1955). To restore its populations, hunting and trapping were stopped and mass reintroductions (nearly 20,000 individuals) occurred from 1940 to 1960 (Pavlov et al. 1973); these efforts were considered successful (Gusev 1971; Monakhov 1978, 1995, 2006b; Monakhov and Bakeyev 1981; Nasimovich 1973; Tavrovsky 1971).

Martes zibellina is listed as a species of ''Least Concern'' by the International Union for Conservation of Nature and Natural Resources (Abramov and Wozencraft 2008). Its major threats are commercial hunting, logging of the dense coniferous forests in some areas, and the introduction in some areas of *Martes melampus*, which is a competitor (Abramov and Wozencraft 2008). *M. zibellina* is considered endangered in the southern part of its range but its widespread distribution and presumably large population size are thought to prevent the type of decline required to reach threatened status (Abramov and Wonzencraft 2008).

ACKNOWLEDGMENTS

I thank an anonymous reviewer for the suggestions on improving this account and V. Hayssen for the opportunity to publish this work. I also am grateful to A. V. Abramov, Yu. M. Baranovsky, G. F. Baryshnikov, E. M. Chernikin, A. A. Darensky, V. S. Kriuchkov, A. A. Sinitsyn, V. P. Novikov, I. Ya. Pavlinov, V. D. Petrenko, O. L. Rossolimo, V. V. Shurigin, A. S. Valentsev, and A. G. Vasiliev for access to skull collections. E. S. Zakharov kindly provided the photo for Fig. 1.

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Associate editor of this account was DAVID M. LESLIE, JR. ALFRED L. GARDNER and RYAN NORRIS reviewed portions of the synonymies. Editors were MEREDITH J. HAMILTON and VIRGINIA HAYSSEN.