The least weasel (*Mustela nivalis nivalis*) in north-western Taimyr, Siberia, during a lemming cycle

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Abstract: During the summers of 2005-2007 the least weasel (*Mustela nivalis nivalis*) near Mys Vostochniy, NW Taimyr, Siberia, was studied in relation to the fluctuating abundance of the Siberian lemming (*Lemmus sibiricus*). The number of lemmings largely determines the reproductive success of birds and predatory mammals on the tundra. The 2005 expedition to Mys Vostochniy occurred in a peak lemming year and was the only one out of nine carried out in the preceding 14 years in which least weasels were observed. They were abundant on the mainland, but were not observed on the nearby islands. A search plot of 1.5 ha was selected in order to gain an impression of the intensity of the predation on lemmings by weasels. 107 lemming winter nests with a diameter of ≥14 cm were found within the search plot, of which 52% showed signs of predation by weasels. Smaller lemming nests showed no signs of predation. This predation of lemmings corresponded with about 127 days on this particular search plot over winter, suggesting the presence of just one weasel. In 2006 no new lemming winter nests were built on the search plot. 6.5% of the lemming nests (*n*=92) checked in the wide surroundings showed signs of predation by weasels, indicating a continuing but limited presence of weasels in the winter of 2005-06. However, no weasel was spotted in 2006. In 2007, a build-up year of the lemming cycle, 36 new lemming winter nests were found within the search plot, but none showed signs of predation by weasels and no signs of the presence of weasels were found outside the search plot. In 2005 we found some dead weasels and we were able to catch others. We collected these data as we had found no published data about weasel from the Taimyr-part of Siberia. The weight of two males in moulting coat exceeded the maximum weight mentioned in the literature, and this was presumably related to the optimal food situation during the lemming peak in the spring of 2005. Two females were checked for litter size, 14 and 10 respectively. The reason for the sudden abundance of weasels near Mys Vostochniy in 2005 remains unexplained; either the first animals moved in from the south at the beginning of the lemming peak, or there was a very small, and hence hitherto unnoticed population, which was able to suddenly flourish. Weasels do not seem to have a major function in maintaining the multi-annual cycle of lemmings in Taimyr.

Keywords: least weasel, *Mustela nivalis*, Siberian lemming, *Lemmus sibiricus*, lemming cycle, moulting, reproduction, predation, tundra, Taimyr.

Introduction

Between 1990 and 2005 the Dutch Institute for Nature Research (now Alterra) in Wageningen organised nine expeditions to Mys Vostochniy (East Cape) on the northern side of the Pyasina delta, western Taimyr, about 200 km east of the town of Dikson, Siberia (figure 1). The purpose of these expeditions was to study the factors that influence the breeding success of the black bellied Brent goose (*Branta bernicla nigricans*) which shows a high annual variability, that has been shown to be related to the number of Siberian lemmings (*Lemmus sibiricus*) (Greenwood 1987, Summers & Underhill 1987). During peak lemming years, predators, such as the arctic fox (*Alopex lagopus*), the snowy owl (*Nyctea scandiaca*) and the Taimyr herring gull (*Larus argentatus*), that would normally feed on geese eggs and chicks, concentrate on lemmings as food, leaving the geese the opportunity of breeding relatively undisturbed.

Figure 1. Location of the study area in Taimyr, on the northern side of the Pyasina delta.

Figure 2. Least weasel near the camp site at Mys Vostochniy. *Photograph: Vasily Grabovskiy.*

It is not only the predators of geese nests that benefit from peak lemming years, other species also predate lemmings. Among these is the weasel (*Mustela nivalis*) which has a wide distribution on the Taimyr Peninsula (Yudin 1980). Of the different subspecies of weasel, the least weasel *Mustela nivalis nivalis* inhabits the northwest of Siberia and its presence in the Pyasina delta was recorded by Nowak and Pavlov (1995). However, during the nine preceding expeditions before 2005 the least weasel was not ever seen in the vicinity of Mys Vostochniy, even in the peak lemming years of 1991 and 1994 (Rykhlikova & Popov 1995). Dr Y. Kokorev, a biologist in Norilsk, who has visited the Pyasina delta every summer since 1978, had never seen least weasels in this area, but had sometimes observed a stoat (Y. Kokorev, personal communication). When the first expedition members arrived on 9 June 2005, it became immediately apparent that 2005 was a peak lemming year (Popov 2006) and they were surprised to find that there were weasels present, especially around the campsite (figure 2) and in the rocky outcrops of the tundra.

The questions arose as to when and from where these least weasels had colonised the area around Mys Vostochniy, and the role that they would play in the local ecosystem. A peak lemming year is usually followed by a low year and then by a build up year. To understand how the weasel population had reacted to the drastic change in the number of lemmings, the locations where weasels were spotted or caught in 2005 were checked again in 2006. In 2007 there was not enough time to do this.

Materials and methods

Taxonomic status of the least weasel

In order to compare data from the weasels we collected near Mys Vostochniy with data from previous literature, we had to decide which subspecies of *Mustela nivalis* these weasels belong to.

Figure 3. Least weasel showing the straight boundary line between the brown back and the white belly. *Photograph: Sim Broekhuizen.*

Within the genus *Mustela* the weasel shows one of the largest variations in body size. Apart from a clear sexual dimorphism, body size generally increases from north to south (King & Powell 2006), in contrast to what one would expect from the Bergmann rule (1847) and the Allen rule (1877). The same is true of skull size and tail length in relation to body length (Abramov & Baryshnikov 2000). This latter characteristic and the coat colouration have given rise to a large variety of subspecies being described. Reichstein (1993) listed 13 subspecies for Europe, Abramov and Baryshnikov (2000) described another nine for Asia, one for North Africa and, conform to Hall (1951) four for North America. According to the description of the typical *Mustela nivalis nivalis*, (made by Linnaeus in 1766 and based on specimens from northern Switzerland) the subspecies is white in winter and in summer has a white ventral side and brown dorsal side with the border between the two being almost straight (figure 3). These features differentiate this subspecies from *Mustela nivalis vulgaris* (Erxleben 1777) which occurs in Western and Central Europe. In this species the border between the brown and white in the coat is generally irregular, and the white ventral side may show small and irregular brown spots. Normally this subspecies does not turn white in winter, but within its range of distribution, some individuals are found with a 'nivalis' appearance (Reichstein 1993). Similarly the 'vulgaris' appearance is found now and then in animals that normally exhibit the 'nivalis' characteristics (Abramov & Baryshnikov 2000).

According to Abramov and Baryshnikov (2000) Siberia is inhabited by *Mustela nivalis nivalis*, except in the north-eastern part (east of the Omolon river) where the weasels are generally a little smaller and have a somewhat shorter relative tail length. Therefore they are regarded as a separate subspecies, *Mustela nivalis pygmaea* (Allen 1903). From the north-western part of Siberia Abramov and Baryshnikov (2000) mention *Mustela nivalis nivalis* from the Yamal peninsula. Volokh (1995) has identified this subspecies in the north-eastern part of the Gydan peninsula, west of Dikson.

Some authors before, however, are of the opinion that almost all of Siberia is inhabited by *Mustela nivalis pygmaea* (Gromov et al. 1963, Chernyavskii 1984), while Parovshchikov (1963) stated that "the northern or snow weasel, *Mustela nivalis nivalis*, is not similar to the Siberian, tundra or little weasel (short-tailed), *Mustela nivalis pygmaea*, which lives in the tundras", and: "(t)he southern boundary of distribution is the northern limits of the taiga and the forest tundras", while in the northeastern part of Russia, the tundras of Malozemel'skaja and Bol'shezemel'skaja, was inhabited by *Mustela nivalis pygmaea*, bordered in the south by a zone of hybridisation with *Mustela nivalis nivalis*. Ternovsky (1977) does not speak about the aspect of subspecies in *Mustela nivalis*, but rather mentions that the weasels living on the tundra are smaller compared to those from the taiga and suggests that this is due to the poor conditions on the tundra.

Parovshchikov (1963) describes the summer coat of *Mustela nivalis nivalis* as very dark-brown to brown on the back and pure white on the belly, while the summer coat of *Mustela nivalis pygmaea* is pale brownish with a rusty hue on the back. As all weasels in summer coat that were spotted during the expedition to Mys Vostochniy in 2005, had dark brown to brown dorsal fur (figure 4), we follow Abramov and Baryshnikov (2000) and recognise these weasels as being specimens of *Mustela nivalis nivalis*.

Of the four subspecies of the weasel in North America, *Mustela nivalis rixosa* most closely resembles *Mustela nivalis nivalis*, in terms of body size and coat colouration (Abramov & Baryshnikov 2000). We follow after several other authors (e.g. Blomquist et al. 1981, Frank 1974) in considering *Mustela nivalis rixosa* as being identical to *Mustela nivalis nivalis*.

Features of the weasels collected

In 2005, all the weasel observations by the expedition members were collected together, together with data about all the dead weasels found in the field and in fox dens, (the later

probably killed by arctic foxes). Some weasels were killed inadvertently, mainly in snap-traps used for lemming monitoring and one weasel drowned in a bucket of water on the campsite. During the last three weeks of the expedition in 2005, from 28 July to 15 August, weasels were live trapped during 44 trap days using self made 'seesaw-traps' with a tilting and closing floor, on the campsite, in rocky outcrops and on the beach, among the driftwood. These live trapped animals were individually marked with marker pens (figure 5).

In 2006, between 28 June and 21 July, for a period of seven days two or three live traps were placed every where that weasels had been caught or seen in 2005, except on the 'Vysokaya' hill, about 5 km from the camp. One trap was placed on two small rocky outcrops on the tundra. New live traps had been made for this purpose. To ensure that the trapping results were not influenced by the characteristics of the new traps, on most trap sites one or two new traps were placed together with a trap used in 2005. In total 140 trap days were involved.

Dead weasels were weighed, and the extent of winter whitening of the brown fur was noted. If possible, body length, and the length of the skull, tail, ear and hind foot were measured. From the males, the weight of the baculum was taken, and from the females the uterus was examined for embryos or placental scars. Usually only sex and body weight (sometimes also tail length) could be obtained from the live trapped individuals, since anaesthetics were not available on the 2005 expedition and live weasels are difficult to handle.

Weasel predation search plot

To estimate the extent of lemming predation by weasels, a search plot of 73-102 m wide and 172–191 m long, covering a total of about 1.5 ha, was systematically searched for the winter nests of lemmings and prey remains, such as fur, skulls and other skeletal remains. Most of the braincases of skulls of juvenile and sub-adult lemmings eaten by weasels were only opened on the back, in contrast to those of lemming skulls found in the pellets of the snowy owl (*Nyctea scandiaca*) and the pomarine skua (*Stercorarius pomarinus*), which were mostly heavily damaged (figure 6). At some of the lemming nests with lemming remains one or more weasel latrines with piles of faeces, were found. These faeces contained only lemming hair.

The search plot lay within a shallow, sloping valley with a high density of lemming nests. The vegetation was classified as 'grass-sedge marshy tundra', characterised by *Carex concolor, Carex bigelowii, Arcagrostis latifolia, Poa arctica, Salix reptans* and *Sphagnum sp*., changing on both sides into 'moss-sedge-*Cassiopa* tundra' with small hummocks that was characterised by *Cassiopa tetragona, Eryophorum polystachium* and *Chandonantus setiforme* (Rykhlikova & Popov 1995) (figure 7). All the lemming nests were marked with a numbered stick.

In July 2006 and 2007 the search plot was checked again for lemming winter nests and signs of predation. In addition, during random walks on the tundra, a much larger area was searched for fresh lemming nests and signs of predation.

To gain an impression of the age of the lemmings killed by weasels, the remains of lemming skulls were collected from the nests in the search plot. As a relative indication of the lemming's age the size of the diastema (distance between incisors and molars) in the upper jaw was measured whenever possible.

Results

Distribution of weasel observations

Figure 8 shows the locations of the weasel observations in 2005. The dead individuals recovered from the arctic fox den on the Vysokaya hill were probably caught near the den, as the foxes were harassed intensively by pomarine skuas during their foraging trips on the tundra. In 2005 the skua territories completely covered the lower tundra. On the higher hilly parts, where the fox dens were located, this was far less the

Figure 4. Three least weasels in summer coat (above), and one weasel moulting from winter to summer coat, found dead near Mys Vostochniy in 2005. *Photograph: Sim Broekhuizen*.

Figure 5. Weasel individually marked with – in this case – a blue stripe on the white throat. *Photograph: Sim Broekhuizen*.

Figure 6. Skulls of Siberian lemmings killed and eaten by the snowy owl (upper row), pomarine skua (central row) and weasels (bottom row). *Photograph: Sim Broekhuizen*.

Figure 7. Part of the sloping valley in which lemming winter nests were checked for the remains of lemmings killed by weasels. *Photograph: Sim Broekhuizen*.

case. There were 15 weasel catches (twelve different individuals) in the live weasel traps and eleven different weasels were caught in the lemming traps. The numbers in figure 8 indicate the minimum number of different individuals caught and observed in each location, the latter mostly by chance.

In 2005 we also checked lemming nests on the islands of Farwatterniy (110 nests) and Vyerkhniy (several dozens) (see figure 1). In none of these were the remains of lemmings killed by weasels found. In 2006 and 2007 no weasels, weasel tracks or other weasel signs were observed at all, either on the tundra, around the camp, or on either island.

Coat colour

With the exception of three individuals, all the weasels observed in 2005 were in summer coat, with the characteristic unicoloured brown dorsal fur separated by a straight line from the white fur on the ventral side. On 4 July the only least weasel in white winter coat (figure 9) was observed at a small mound of loose rocks. This individual then disappeared underground and for some time the sounds of a social gathering could be heard, indicating an encounter with one or more juveniles. Thus this was probably an adult female with a litter at that site.

On 8 July 2005 a dead male least weasel was found in a food cache of an arctic fox den on 'Vysokaya' hill. The coat of this specimen showed brown as well as white fur on its back, suggesting that it was moulting from its winter to summer coat (figure 10). Its date of death is unknown: in such cold conditions it could have been killed long before the date of recovery.

In the night of 14 / 15 July 2005 another moulting male weasel was inadvertently caught in a lemming trap; the central part of the fur on its back was already brown, while the edges were still white (figure 4, bottom). A visit to the Darwin Museum in Moscow (figure 11) with its collection of specimens and paintings suggested that this pattern of moult is the more common of the two. In England the moult to the summer coat also starts with a central brown band over the head and back (King 1979). All the other least weasels spotted after 15 July were in full summer coat.

Measurements

Data and measurements taken from live trapped or dead least weasels collected in 2005 are listed in appendices 1 and 2.

The body weight of the weasel males near Mys Vostochniy varied between 63 and 124 g, and that of the adult females between 75 and 55 g. The two heaviest males were both in moult from winter to summer coat and weighed 115 and 124 g. The next heaviest males were those found on 7 and 8 July: 103 and 94 g. The smallest female, weighing only 36 g, had no visible nipples and had the 'soft-faced' appearance of a juvenile. Figure 12 shows the measurements of body weight plotted against time.

The head-body length of the two moulting males from Mys Vostochniy were 20.0 and 20.2 cm respectively, so these were not only the heaviest, but also the largest, individuals. The length of males in summer coat varied from 16.5 to 18.9 cm (n=16).

One of the two females with embryos had had her head bitten off by an arctic fox. The other one had a head-body length of 16.5 cm and a total body length (including tail) of 18.0 cm. None of the other females could be measured, since they were all caught alive and no anaesthetic was available to be able to handle them comfortably.

Reproduction

In 2005 we were able to examine the reproductive status of two females: one found dead on 25 June in an arctic fox den, and the other caught unintentionally in a lemming trap on 7 July. Both females were pregnant with 14 and 10 embryos respectively. The uterus swellings were ca. 10 and 11 mm in diameter. The reproductive state of the other females could not be detemined as they were captured alive and were difficult to handle.

In mid June seven small individuals were

seen together on one of the rocky outcrops on the tundra. They clearly belonged to one litter (R. Bom and M. La Haye, personal communication), but it is uncertain whether they were the entire litter.

Predation of lemmings in or near winter nests in 2005

Predation and size of the lemming nests

On the search plot in 2005 remains of dead lemmings were only found in lemming winter nests with a diameter ≥14 cm. Of the 107 nests of that size that were inspected, one or more tufts of lemming fur were found in 56 (52 %). In 47 of these nests other remains of lemmings were also found, mostly parts of skulls (see figure 13). A total of 150 skulls were collected, apparently from lemmings killed and eaten by weasels, an average of 2.7 lemmings per nest with signs of predation. If all these lemmings lived inside the search plot, the predation rate during the winter of 2004-05 would have been 100 lemmings per hectare from an unknown period of weasel presence there.

In addition about 200 smaller lemming nests were found (diameter <14 cm), that had apparently been only in use for a short time. Of these, 41 were inspected for lemming remains, but in none of them were remains of dead lemmings found.

During the snow thaw in the beginning of June 2006 quite a number of wet lemming carcasses emerged from under the snow and were immediately eaten by gulls. Around 26 July 2006 a very fresh scat of an arctic fox was found containing lemming hair (S. Bakker, personal communication). This indicates that there were still lemmings present when the snow covered the tundra in the autumn of 2005. The number of fresh winter nests found in 2006, however, was much less than the year before and not a single winter nest was found within the search plot area. During walks across the tundra 92 lemming winter nests, which looked fresh enough to originate from the previous winter (2005-06), were checked for lemming remains. According to Sittler (1995) it is not always possible to distinguish nests of the past winter from nests of the year before, so there could have been some misjudgements. For comparison the nests on the search plot, that were marked in 2005, were still available. None of these nests looked really fresh, but, as the plot was located in a shallow valley, they may have been more exposed to wet conditions. Nevertheless, from the presence of nests in good condition outside the search plot (figure 14), we conclude that lemmings were still present when the tundra was covered with snow in the autumn of 2005.

Of the 92 lemming winter nests inspected during the summer of 2006, 42 had a diameter of ≥14 cm, four (9.5%) of these contained lemming fur and two of these also contained parts of a lemming skull. From the 50 nests with a diameter of <14 cm only one (2%) contained lemming fur. Next to two of the nests with lemming remains there was a weasel latrine. These observations indicate that not only did several lemmings survive until the tundra became covered with snow in the autumn of 2005, but that there were still some weasels present then. The percentage of predated winter nests in 2006 was, however, much lower than in the winter nests of the 2005 plot.

In the summer of 2006 only one lemming was seen and none were caught during the regular lemming inventory.

In June-July 2007, 38 new lemming winter nests were found in the search area, indicating re-colonisation of the plot. Of these nests, 28 had a diameter of ≥14 cm and 10 a diameter of <14 cm. In none of these nests was any sign of predation by weasels found, nor were any signs of weasel presence detected beyond the search area, during the three week expedition.

Use of lemming nests by weasels

On the 2005 search plot a weasel latrine was found in close proximity to 13 of the 56 nests with lemming remains, and more than one latrine was found near seven of these nests (figure 15). Such an accumulation of weasel faeces indicates that the lemming nest had been used or visited for at least several days by one or more weasels.

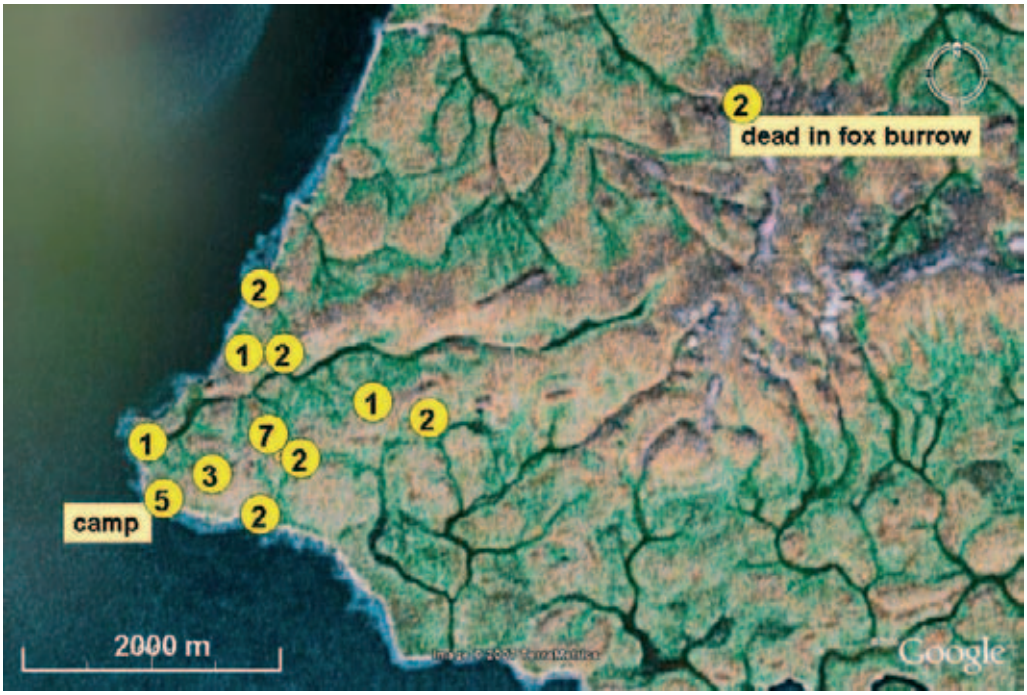

Figure 8. Map of the surroundings of Mys Vostochniy, with the locations of weasel observations and the minimum number of different individuals concerned.

Figure 9. Least weasel in winter coat, observed on 4 July 2005 near Mys Vostochniy. *Photograph: Sim Broekhuizen*.

Figure 10. Two male least weasels: left with two-coloured coat on the back. *Photograph: Sim Broekhuizen*.

Figure 11. Painting by K.A. Komarov in the Darwin Museum in Moscow of a least weasel and a stoat, both moulting from winter to summer coat.

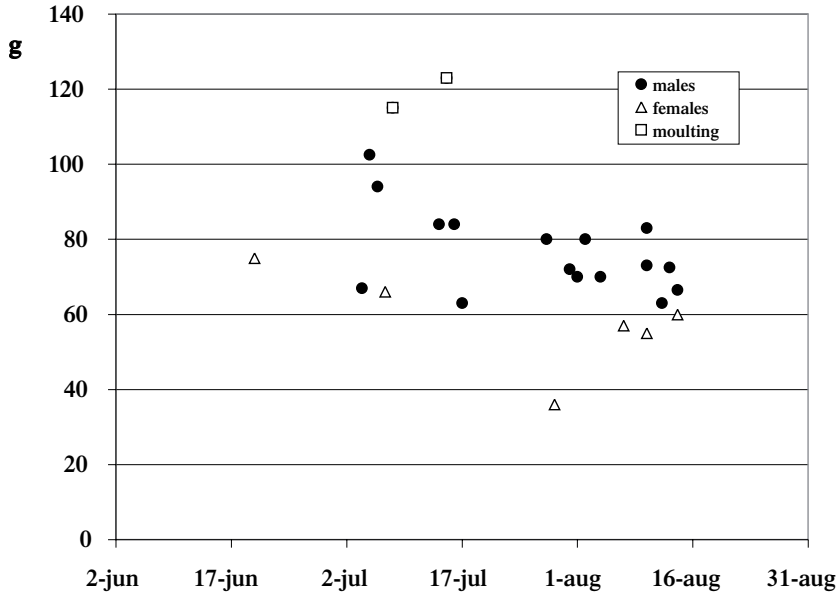

Figure 12: Body weight (g) of least weasels caught or found dead near Mys Vostochniy in 2005.

In 2005 three lemming nests lined with a thick layer of lemming fur were found on the search plot (figure 16). MacLean et al. (1974) found evidence that weasels occupy lemming nests during periods of inactivity and will increase the insulation properties of the nest by lining it with lemming fur. These nests may also have been used by a weasel for raising its young. Two of these lined nests contained the most lemming skulls, indicating that they were also used for catching prey. These nests were 52 m apart. The third lined nest contained only three lemming skulls and was located 42 m and 32 m respectively away from the two other nests. The three fur lined nests may have been used by three different female weasels, but it is also possible that one weasel used all three nests in succession. No other lemming nests with a lining of fur were found in the adjacent part of the valley, but the search was less intensive there than within the search plot area itself.

In 2006 one fresh small lemming nest, with a diameter of 13 cm, was found with a lining of lemming fur, in this case outside the 2005 search plot. The lining was relatively thin, compared to the linings found in 2005, making it unlikely this nest had been used by a female weasel for reproduction.

Age of the lemmings eaten by weasels

A total of 99 of the 150 skulls collected on the search plot in 2005 could be used as an indication of the age of the lemmings, by measuring the diastema, i.e. the gap between incisors and molars (figure 17).

The most common size of the diastema was between 9.0 and 9.5 mm and the majority (66%) of the values were between 8.0 and 10.0 mm. As the diastema of two dissected adult and reproductive females was 10.5 and 10.8 mm, and those of two adult reproductive males 11.5 and 11.9 mm, it seems that most of the lemmings killed by weasels were juvenile or sub-adult. The number of very young lemmings in the example is probably underrepresented, as the skull bones of very young lemmings are not yet fused, so they disintegrate after death.

Discussion

Origin of the weasels

The question of where all the least weasels in 2005 came from, while none were ever seen before, remains unanswered. The presence of adult animals in winter or moulting coat, and probably born in 2004, does not provide an answer to the question of whether they were already present in the area around Mys Vostochniy during the summer of 2004 (or even earlier) or, alternatively, whether they colonised the area shortly before or during the winter of 2004-05. If they were already there in summer, their numbers must have been so low that their presence was not detected during the short expedition, from 3 to 20 July in 2004.

Weasels can cover large distances in a short time. The white animal seen on 4 July was spotted running across the tundra covering a distance of about 400 m, which took only a mere few minutes. King and MacMillan (1982) mention recoveries of young males over distances of more than 20 km in the course of only a couple of weeks. In Oklahoma the range of distribution of the weasel expanded by 300 miles (483 km) in a period of a few years (Choate et al. 1979, cited by King & Powell 2006). Ternovsky (1977) points out the benefit of the white winter fur, as he observed weasels moving across the snow cover over distances of 1–3 km (at temperatures of -42 to -47 ºC) before they went under the snow again. So, theoretically, it is possible that in 2004 the area around Mys Vostochniy was colonised after the expedition left. The first colonisers may have travelled hundreds of kilometres.

On the other hand, and probably more likely, weasels may have been present in the area already, but at such a low density that they were not observed during the earlier expeditions. This might also have been the case in 2006, when no more weasels were observed after the high number observed in 2005. Indirect evidence for survival of some weasels was found in the several lemming winter nests with tufts of lemming fur including one with a small weasel latrine nearby and one lined with lemming fur. To detect such signs one has to have a trained eye, so it is possible that former expeditions missed these less obvious signs of weasel presence. In 2006 we also found two predated nests of snow buntings (*Plectrophenax nivalis*) in places tucked away between rocks that appeared inaccessible to any avian predator or to the arctic fox.

The least weasel situation near Mys Vostochniy in the years 2005-2007 seems very similar to the situation near Point Barrow (North-Alaska) in 1969 and the following years, where MacLean et al. (1974) studied the relationship between least weasels and brown lemmings (*Lemmus trimucronatus*). During the winter of 1968-69 there was a peak density of both lemmings and weasels, with 34.7% of the lemming nests occupied by weasels. In the summer of 1969 ten weasels were collected. In spring 1970 no lemming nests were found and nest predation could be considered as zero. A remarkable increase in lemming abundance occurred over the next winter, 1970-71, with 41.7 nests/ha in search areas, only 5.6% of which had been occupied by weasels. However, no weasels were seen. During the 1971-72 winter a decline in lemming breeding activity was observed (27.5 winter nests/ha), and during the summer of 1972 only 1.1% of the lemming nests examined showed evidence of weasel predation. Again, not a single weasel was seen during the summer of 1972. During the winter of 1972-73 there was another over-winter decline (14.4 nests/ha). In 1973 a single weasel was seen and none were caught, despite operating 49 trap sites during the season. Thus, it is not exceptional that least weasels remain unnoticed for several years and only become conspicuously present in peak lemming years.

Coat colour

The fur coat of the male weasel, still with a white crest but with (light) brown patches on its side as well (figure 10), and another weasel in complete white winter coat observed on 4 June (figure 9), illustrate a remarkable variation in moulting pattern and moulting time. This variation is also mentioned by Ternovsky (1977), who shows a photograph of two siblings, one already in

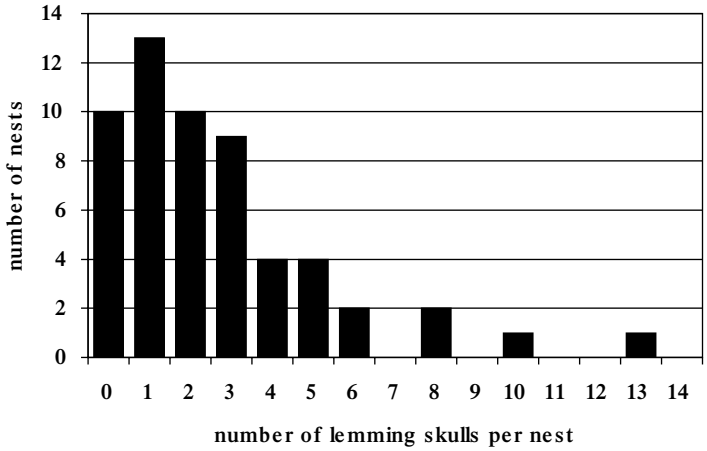

Figure 13. Distribution of the number of Siberian lemming skulls found on and in a lemming nest.

Figure 14. Lemming winter nests: left a nest most probably originating from the winter 2005-06, found in July 2006; right the freshest looking nest on the 2005 search plot, also found in July 2006. *Photographs: Sim Broekhuizen.*

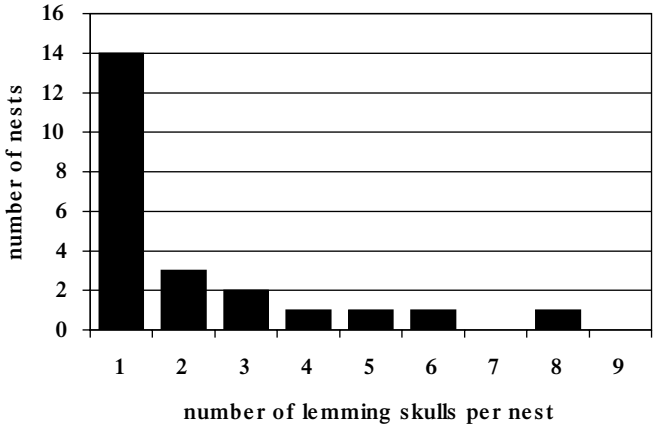

Figure 15. Frequency of the number of weasel latrines near lemming nests with remains of lemming skulls.

Figure 16. Lemming winter nest from the winter 2004-05, lined with a thick layer of lemming fur. *Photograph: Sim Broekhuizen.*

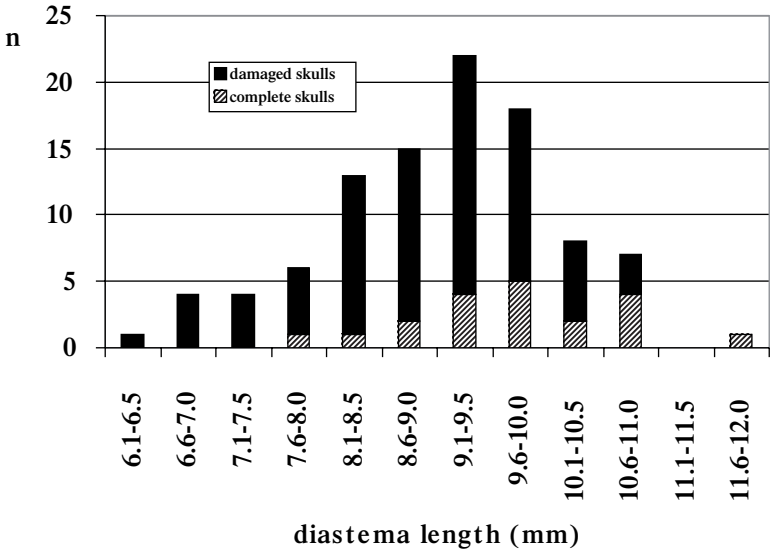

Figure 17. Distribution of diastema size of the Siberian lemming skulls found in lemming nests on the search plot in 2005.

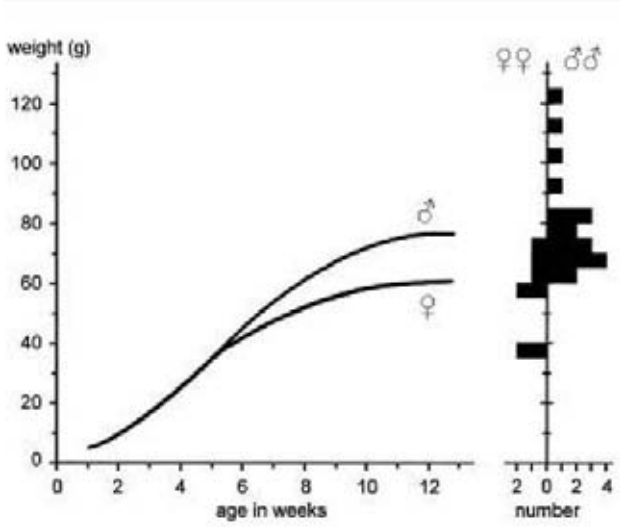

Figure 18. Body weights of least weasels from Mys Vostochniy (on the right), compared to the growth curves of a male and a female least weasel kept in captivity (on the left); curves after Heidt (1970).

moulting coat, the other still in white winter coat, indicating that the variation in moulting time is not just determined by age or external factors.

Weight and size

The body weights of the weasels near Mys Vostochniy in 2005 were high, compared to the data in the literature. The males we caught were considerably heavier than the previously measured maximum weight of 90 g, published by Stolt (1979) for males in northern Sweden, which is again higher than for males of *Mustela nivalis rixosa* from North America (table 1). Heptner et al. (1967, cited by King & Powell 2006) mention an average body weight for *Mustela nivalis nivalis* from Siberia of a mere 53 g.

The female weasels were also relatively heavy. The body weight of five of the six individuals (55-75 g) was more than the body weights published for *Mustela nivalis rixosa* (table 1). Heptner et al. (1967, cited by King & Powell 2006) give an average body weight of 41 g for female weasels from Siberia. However, the body weight of the two adult females with small embryos in their uterus (66 and 75 g) is similar to that of two pregnant least weasels caught by MacLean et al. (1974) in Alaska (69.0 and 70.2 g).

Figure 18 depicts quite a close resemblance between the body weight of the adult least weasels from Mys Vostochniy in 2005 (except for the four heaviest males) to the body weight shown on Heidt's growth curve (1970) of a male and female weasel, kept in captivity and probably well fed.

The measurements of the head-body length are inside the range given by Abramov and Baryshnikov (2000) for male weasels from Siberia: 14.2-20.0 cm. Barnfield (1974) recorded head-body lengths of 18.3-21.7 cm for male *Mustela nivalis rixosa*. Thus the males in our sample were not particularly long (see table 2). Similarly the only adult female measured was not extremely large compared to published records. This shows that the weasels we encountered were in relative good condition, especially those males moulting from winter to summer coat. The latter had gone through the lemming peak, which may have been at its highest during spring, just before the melting of the snow. This supports the opinion of Ternovsky (1977) that the body weight of weasels in the north of Siberia is determined mainly by the available food resources.

Table 1. Some ranges of body weight (g) of adult *Mustela nivalis*, mentioned in the literature.

Region	(Sub-)species*	Author(s)	Males	Females
N-Sweden	*M. n. nivalis*	Stolt 1979	- 90	
E-Siberia	*M. n. pygmaea*	Chernjasvsky 1984	36.0 - 60.5	23.5 - 32.5
Canada	*M. n. rixosa*	Banfield 1981	34.5 - 63.5	25 - 58
N-America	*M. rixosa*	Burt & Grossenheider 1976	39 - 63	28 - 39
Michigan	*M. rixosa*	Burt 1957	40 - 50	40 - 49
Michigan**	*M. nivalis*	Heidt 1970	75	60

* name used by the author(s)
** animals in captivity; data taken from graph.

Table 2. Some ranges of head-body length (cm) of adult *Mustela nivalis*, mentioned in the literature.

Region	(Sub-)species*)	Author(s)	Males	Females
Siberia	*M. n. nivalis*	Abramov & Baryshnikov 2000	14.2 – 20.0	
E-Siberia	*M. n. pygmaea*	Chernyavskii 1984	14.8 – 16.5	13.1 – 14.0
Canada	*M. n. rixosa*	Banfield 1974	18.3 – 21.7	17.0 – 18.1
N-America	*M. rixosa*	Burt & Grossenheider 1976	15.0 – 16.5	14.0 – 15.2
Michigan	*M. rixosa*	Burt 1957 (tail incl.)	18.9 – 20.5	17.2 – 17.6
Michigan**	*M. nivalis*	Heidt 1970 (tail incl.)	17.8	16.3

* name used by the author(s)
** animals in captivity; data taken from graph.

The variation in size and weight of the other males may be partly the result of age differences. The low weight of the bacula of the males caught on 4 and 16 July (see appendix 1) indicates that they were sub-adult. The variation in size and weight in the remaining males may also be the result of age differences, probably induced by differences in food availability during their juvenile development, as the lemming population was already decreasing at the time of arrival of the expedition, on 9 June 2005. In juvenile weasels the fastest period of weight increase is in their first two months (Delattre 1987).

Potential population growth

In contrast to the West European weasel *Mustela nivalis vulgaris*, the least weasel from North America is able to become pregnant and have litters during most months of the year (Hall 1951, Heidt 1970). During lemming peaks on the tundra they also have litters under the snow (Fitzgerald 1981). Frank (1974, cited by King & Powell 2006) found that the period of pregnancy was the same in *Mustela nivalis nivalis* as in *Mustela nivalis vulgaris* (about five weeks), but that the former, the least weasels, were already able to get into oestrus again five weeks after the birth of their last litter, whereas in the common weasel this happened only after weaning at eight to nine weeks. Providing conditions are optimal, female least weasels can thus become pregnant while still suckling the young of their last litter, and may thus have a new litter every 2.5 months. This is quite different from the stoat (*Mustela erminea*) which shows a delayed response to changes in prey density as it can have only one litter a year (King & Powell 2006). This delayed response in reproduction, and thus in predation, is thought to be the driving force in maintaining the regular four-year lemming cycle, as observed in the collared lemming in Greenland (Gilg et al. 2003), where the stoat is the main mammalian weasel predator. The least weasel is able to respond more quickly through reproduction to an increase in food resources.

The litter size of the least weasel can be large. King and Powell (2006) show that the number of embryos born in the wild may vary from 3-19 (Fitzgerald 1981: Alaska 7-16; Heptner et al.:

Mongolia 5-19; Danilov & Tumanov: USSR 4-10). Sundell (2003) mentions a slight increase of litter size from south to north and found the largest litter (14) in her Finnish breeding stock was born to the individual with the northernmost origin.

Assuming an average litter size of twelve around Mys Vostochniy, an age of sexual maturity of three months, a period of five weeks between litters and no pre- and postpartum mortality, one pair of adult least weasels may have produced a population of 264 individuals between the beginning of September 2004 (after the departure of the expedition, during which no weasels were observed) and the end of June 2005. In the Pyasina delta the conditions for the growth of the lemming population were favourable in 2004: with a good season for vegetation growth and the first snowfall at the end of September, which probably remained through to the following season (Y. Kokorev, personal communication). As shown by Mullen (1968) these factors promote a rapid growth in the lemming population, which in turn is favourable for the growth of the weasel population.

Although the maximum theoretical population growth will not have been reached, the large number of weasels in the summer of 2005 may have consisted of the offspring of a very sparse and previously undetected population of weasels in 2004. Ims and Fuglei (2005) stated: "A weakness of our present knowledge of the role of small mustelids in arctic ecosystems is that no quantitative population data (e.g. population density and demographic rates) are available". In this respect our 2005-2007 visits to Mys Vostochniy did not contribute in filling this gap.

In the absence of lemmings in the summer of 2006 the lack of observations of weasels was not surprising. However, the question remains whether there were no weasels at all, or whether some rare survivors remained unnoticed.

Influence on the ecosystem

The fact that in the former peak lemming years 1991 and 1994, when expeditions were at Mys Vostochniy, there were no weasels observed, suggests that weasel predation alone can not be a decisive factor in the cyclic fluctuations in lemming abundance, and supports the opinion of Lambin et al. (2006) that multiannual population cycles in rodents can not be explained exclusively by the interaction with specialist predators. Turchin et al. (2000) even argue that, in contradistinction to voles, population oscillations in lemmings are not caused by predation, but by the depletion of certain moss species, their main food resource in the critical winter period. Krebs (1964) describes a sharp decline in populations of the brown lemming (*Lemmus trimucronatus*) at Baker Lake (Northwest Territories, Canada) in 1960, in the virtual absence of predators.

This does not mean that weasel predation has no effect at all. During the snow cover period in the winter of 2004-05, when at least half of the larger lemming winter nests on the search plot were visited by weasels, their predation may have been the most important mortality factor for lemmings. It may have levelled off the top of the lemming's abundance, shortened the length of the period of winter reproduction, and accelerated the spring decline. At high prey densities least weasels kill more animals than needed to meet their known energy demands, a phenomenon known as "surplus killing" (Sundell et al. 2000). Equally when important avian lemming predators, such as Taimyr gulls and pomarine skuas, explored the area around Mys Vostochniy in the spring of 2005 and decided to reproduce there, the lemming population density must still have been very high. From that moment on the lemming predation by the least weasel was probably merely a minor factor in the total lemming mortality due to predation, because of the large array and high density of other predators: Taimyr gulls, pomarine skuas, snowy owls, roughlegged buzzards (*Buteo lagopus*) and arctic foxes. Both Krebs (1964) and Clough (1968), in a study of a population crash of the Norwegian lemming (*Lemmus lemmus*), have suggested that heavy predation may prolong the length of the low phase. On the other hand, an experimental vole

study by Norrdahl and Korpimäki (1995) points out that excluding avian predation did not affect the synchrony of population fluctuation with those in control areas, but only caused a lesser amplitude.

The functional effect of predation by weasels on the ecosystem around Mys Vostochniy remains unclear. The weasel's predation will have influenced the number of lemmings and, possibly, also that of eggs and chicks of breeding waders and other birds. The large number of lemmings known to have been killed by weasels (n=150) from the skull remains found in lemming winter nests on the search plot, may seem impressive, but we have no data of the population size of the lemmings or the total period of the weasels' predation. In fact, we lack much data that would be needed for a thorough understanding of the predation rate, such as the possible migration of lemmings in and out of the search plot, the number of weasels present and their range of activity under the snow. There may have been only one individual weasel active in and around the search plot that used the three fur lined nests in succession. In captivity a single weasel of about 80 grams has a daily food intake of about 28-32 g (East & Lockie 1964, Gillingham 1984, Moors 1977, Short 1961). The average weight of adult lemmings caught near Mys Vostochny in 2005 was about 85 g (I.Yu. Popov, unpublished data). MacLean at al. (1974), however, estimated that a 65-g least w easel living at an ambient temperature of -20 ºC would require about two 50-gram lemmings each day to satisfy its demand, but the snow cover and the insulation by the lemming nests will diminish the effect of the outside temperature. The 150 lemmings eaten on the search plot would represent about 127 weasel-days, provided all the lemmings had been adult, which was not the case. This reasoning suggests that between September 2004 and June 2005 there might well have been only one weasel on the search plot.

We can only speculate about the number of weasels present around Mys Vostochniy in the summer of 2005. We did not catch any males with a body weight less than 70 g and we caught only one female under 50 g. This may indicate a poor reproduction after June 2005, resulting in the apparent absence of the species in 2006. It is not clear whether there were really no weasels present; Sittler (1995) mentions the absence of direct observations of stoats in a study area in the Karupelv Valley (NE Greenland) in a year (1991) when 10 % of the 282 winter nests of the collared lemmings had been occupied by stoats.

In the summers of 2006 and 2007, when no weasels were observed in the area, the number of breeding small songbirds, such as Lapland longspurs (*Calcarius lapponicus*), snow buntings and horned larks (*Eremophila alpestris*), was much higher than in 2005. We can only speculate as to whether this increase in the number of breeding birds was related to the possible absence of weasels in those years.

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Samenvatting

De dwergwezel (*Mustela nivalis nivalis*) in noordwest Taimyr, Siberië, tijdens een lemmingcyclus (2005-2007)

In de zomers van de jaren 2005, 2006 en 2007 werd bij Mys Vostochny (Kaap West) in het noordwesten van het Siberische schiereiland Taimyr het voorkomen van de dwergwezel (*Mustela nivalis nivalis*) onderzocht. De belangrijkste prooisoort van de dwergwezel is hier de Siberische lemming (*Lemmus sibiricus*). De mate van aanwezigheid van lemmingen is bepalend voor het broedsucces van een aantal andere predatoren, zoals poolvos, sneeuwuil, ruigpootbuizerd, middelste jager en ook Taimyr zilvermeeuw. Wat betreft de lemming was 2005 een uitgesproken piekjaar, 2006 een even uitgesproken daljaar en 2007 een opbouwjaar. 2005 was het eerste jaar dat rond Mys Vostochny dwergwezels werden gezien, hoewel in de voorgaande 15 jaar negen expedities naar het gebied waren geweest, ook in de lemming piekjaren 1991 en 1994.

In 2005 werd een aantal morfologische gegevens van de dwergwezels verzameld aan de hand van zowel dieren die dood werden aangetroffen – veelal slachtoffers van poolvossen – als van dieren die met ter plaatse gemaakte wipvalletjes werden gevangen. Deze gegevens worden vergeleken met die uit de literatuur, waarbij de Amerikaanse ondersoort *Mustela nivalis rixosa* als identiek met de Eurazische dwergwezel wordt beschouwd.

De dwergwezel onderscheidt zich van de gewone wezel (*Mustela nivalis vulgaris*) doordat hij – net als de hermelijn - in de winter een witte vacht krijgt. Van de dieren die in 2005 tussen 17 juni en 16 augustus werden gezien of gevangen was op 4 juli een vrouwtje nog in winterkleed en twee mannetjes in de eerste helft van juli in overgangskleed. Deze mannetjes waren met lichaamsgewichten van 115 en 125 gram extreem zwaar, wellicht doordat ze opgroeiden bij een overvloed aan voedsel. Twee dood gevonden vrouwtjes waren drachtig van resp. 14 en 10 jongen, wat ook de gunstige voedselsituatie weergeeft.

Om een indruk te krijgen van de invloed van de wezels op de lemmingpopulatie werd in 2005 in een grazig dalletje met relatief veel winternesten van lemmingen een plot van ca. 1,5 ha uitgezet. Hierin werden 107 lemmingnesten met een diameter ≥14 cm gevonden, waarvan 52% tekenen van wezelpredatie vertoonden: ze bevatten haar en/of botten, meest schedels, van lemmingen. Bij kleinere nesten ontbraken predatiesporen. Uit de nesten werden 150 lemmingschedels verzameld, gemiddeld 2,7 per gepredeerd nest en 100 dieren per ha. Literatuurgegevens over de voedselbehoefte van wezels maken duidelijk dat al deze lemmingen gegeten zouden kunnen zijn door één enkele dwergwezel gedurende de hele winterperiode.

Gedurende de zomer van 2005 stortte de lemmingpopulatie in, mede als gevolg van de grote predatiedruk door middelste jagers die dat jaar alom aanwezig waren. In 2006 werden in het onderzoeksplot geen nieuwe lemmingnesten aangetroffen. Tijdens het verblijf van de expeditie werd slechts één levende lemming gezien, alhoewel uit onderzoek van lemmingnesten buiten het onderzoeksplot bleek dat er gedurende de winter 2005-06 nog wel lemmingen aanwezig waren en er ook nog predatie door dwergwezels had plaatsgevonden. Tijdens ons verblijf in 2006 werden echter geen dwergwezels gezien, gevangen of gespeurd.

In 2007 werden in het onderzoeksplot weer nieuwe winternesten van lemmingen aangetroffen: 28 met een diameter ≥14 cm en tien kleinere. In geen van deze nesten werden tekenen van predatie door wezels gevonden. Ook buiten het plot werden geen wezels of sporen van wezels waargenomen. Dit wil echter niet zeggen dat er beslist geen wezels aanwezig waren: onderzoek in Groenland heeft aangetoond dat in een lemmingdaljaar de aanwezigheid van hermelijnen daar alleen bleek uit vondsten van latrines, terwijl er geen dieren werden gezien of gevangen. Het speuren naar latrines van dwergwezels vraagt een getrainde blik en het is mogelijk dat daar tijdens voorgaande expedities onvoldoende aandacht aan is besteed.

Dwergwezels hebben een groot voortplantingsvermogen en ze kunnen daardoor snel op veranderingen in het voedselaanbod reageren. Dat ze daardoor ook verantwoordelijk zijn voor de vaak cyclische fluctuaties in de lemmingpopulaties is niet waarschijnlijk. In de lemmingpiekjaren 1991 en 1994 werden, in tegenstelling tot het piekjaar 2005, geen dwergwezels waargenomen. In de winter van 2004-05 was er beduidende predatie op de lemmingen door dwergwezels, maar in het begin van de zomer werd hun predatie overvleugeld door de predatie door middelste jagers. De mate van aanwezigheid van dwergwezels lijkt eerder volgend ten opzichte van de omvang van de lemmingpopulatie dan dat die de veroorzaker is van de fluctuaties in de aantallen lemmingen.

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Appendix 1. Measurements of male least weasel *(Mustela nivalis nivalis)*, collected between 19 June and 15 August 2005 near Mys Vostochniy.

Collection date	Location	Fur on back	Body weight (g)	Head-body (mm)	Tail (mm)	Tail/head-body (%)	Ear (mm)	Hind foot (mm)	CBL*	Baculum weight (g)	Remarks
June 19	tundra	brown							38.0		partly eaten
July 4	trap	brown	67	165	11.8	7.2	13.6	24.0	32.7	0.013	
July 5	trap	brown	104	188	20.2	10.7	12.4	25.6	35.7		
July 7	trap	brown	94	183	15.4	8.4	14.0	24.8	34.6	0.027	
July 8	fox den	moulting	115	200	15.0	7.5	15.0	26.0	39.0	0.029	
July 15	camp	brown	84	186	15.5	8.3	14.1	25.0		0.018	drowned in bucket
July 15	trap	moulting	124	200	16.6	8.3	15	26.8		0.035	
July 15	trap	brown	84	186	14.5	7.8	14.1	23.6		0.028	
July 16	trap	brown	63	165	17.8	10.8	12.9	22.5		0.011	
July 29	live trap	brown	80								released
July 31	live trap	brown	72								released
Aug. 1	live trap	brown	70								released
Aug. 2	live trap	brown	80								released
Aug. 4	live trap	brown	70								released
Aug. 6	trap	brown		176	19.7	11.2	13.9	25.5	35.9	0.022	partly eaten
Aug. 10	live trap	brown	73					22			released
Aug. 10	live trap	brown	83	189	20	10.6	13	27		0.032	died after recapture
Aug. 12	live trap	brown	63					22			released
Aug. 13	live trap	brown	72								released
Aug. 14	live trap	brown	67	171	22	12.9	12.8	*24.4*		0.020	died in trap
mean			81	183	17.1	9.4	13.7	24.6	36.0	0.025	

* *condylobasal length (mm)*

Appendix 2. Measurements of female *Mustela nivalis nivalis*, collected between 19 June and 15 August 2005 near Mys Vostochniy.

Collection date	Location	Fur on back	Body weight (g)	Head-body (mm)	Tail (mm)	Tail/head-body (%)	Ear (mm)	Hind foot (mm)	CBL*	Embryos *(n)*	Remarks
June 20	fox den	brown	75							14	
July 7	trap	brown	66	165	15.0	9.1	12.5	20.4	30.6	10	
July 17	live trap	brown									lactating
July 29	live trap	brown	36								juvenile
Aug. 7	live trap	brown	57								
Aug. 10	live trap	brown	55					19			
Aug. 14	live trap	brown	60								
mean			58								

* *condylobasal length (mm)*