

The range of the masked shrew (*Sorex caecutiens* Laxmann, 1788) extends to southern Scandinavia

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Abstract: The discovery of the masked shrew (*Sorex caecutiens*) in 2003 in southern Norway, 500 km southwest of its known range, initiated the mapping of its actual range. Through the revision of museum specimens, the analyses of owl pellets and the summarising of Swedish trapping data, the apparent gap between its northern and its southern populations could be reduced. The species' occurrence in southern Scandinavia is presumably restricted to areas above the timberline. It most likely occurs in more areas and specifically on the transboundary mountain ridge of Norway and Sweden. The species shows a distinct variation in pelage colouration, according to age and time of the year. This makes its identification difficult. Genetic research should reveal how the masked shrew colonised Scandinavia after the last glaciation.

Keywords: *Sorex caecutiens*, masked shrew, immigration history, owl pellet analysis, Scandinavia, biogeography, pelage variation, revision of museum specimens, snap trapping.

Introduction

Until the beginning of the 21st century the westernmost range of the masked shrew (*Sorex caecutiens* Laxmann, 1788) was marked by a single record from the Norwegian municipality of Hattfjelldal, approximately 100 km south of the Arctic circle (Sulkava 1990, Pucek 1999).

This view changed dramatically when in 2003 a population of masked shrews was discovered in the municipality of Vågå, southern Norway, 500 km southwest of its known distribution (Finch & van der Kooij 2005). The population was discovered through iden-

tification of 20 specimens in a considerable bycatch of small mammals from pitfall traps meant to collect epigeic arthropods (e.g. Naujok & Finch 2004). The discovery immediately raised questions about its origin and immigration history (Finch & van der Kooij 2005).

The masked shrew was recorded at Mount Blåhø from the timberline at 900-1050 m a.s.l. to the top at 1617 m a.s.l. The mountain is to the north, east and south separated by two deep valleys from other mountainous and alpine areas. Additional trapping by Finch and van der Kooij in 2004 in the nearest mountains produced no further records of the masked shrew.

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Material & Methods

To investigate whether the population on Mount Blåhø in southern Norway really is isolated from the rest of the species range we made use of three different approaches. The data are presented according to the UTM coordinate system, WGS 1984, in 10 x 10 km square units. The map plots are presented as 50 x 50 km square units (figure 1).

Revision of Norwegian Museum material

As part of the Norwegian Mammal Atlas Project (Syvertsen et al. 1996) we revised in 2005 and 2006 all Soricidae in the collections of the following museums: Natural History Museum (Oslo), NTNU University Museum (Trondheim), Helgeland Museum (Mo i Rana) and Tromsø University Museum (Tromsø).

Owl pellet analysis in Sør-Trøndelag

We conducted owl pellet analyses in Sør-Trøndelag county. Mapping the distribution of small mammals from owl pellet analyses has been a well-used method in the Norwegian Mammal Atlas Project. However, the use of the method increased in 2007 when the third author demonstrated an effective way to extract bones from owl-pellets by the use of NaOH (Obuch 2014). From then on, the analyses of owl pellets have been intensified in Sør-Trøndelag county. Until the breeding season of 2014, 5700 individuals of rodents and shrews have been extracted from samples of pellets from Tengmalm's owl (*Aegolius funereus*) nestboxes in the Røros-area.

Swedish trapping data

Swedish trapping data on small mammals were summarised. The data are part of the National Environmental Monitoring Pro-

gramme (NEMP) in Sweden (Anonymous 1985). One of the prime purposes of this monitoring is to detect deviations from 'normal' density variations. The deviations could be 'early warnings' of environmental disturbances, like climate warming (Hörnfeldt 2004).

The research areas vary in size (table 1). At Vindeln (the easternmost area) the area was a 100 x 100 km square. This square contained around 60 plots of 1 ha. The mountainous areas Vålådalen/Ljungdalen, Ammarnäs and Stora Sjöfallet consisted of 40 plots of 1 ha each. The plots were normally distributed over a range of altitudes, in a way that represented different mountainous habitats.

Within each plot of 1 ha, 50 metal snap-traps were set as a diagonal transect through the plot with ten groups of traps containing five traps each, within two metres. The distance between each group was about ten metres. It is a standard trapping method, used over many decades (Hörnfeldt 1978). The method approximates to the following numbers of traps (in brackets) in the different areas: Vålådalen/Ljungdalen (2100), Ammarnäs (2200), Vindeln (3000) and Stora Sjöfallet (2050). The traps were baited with dried apple, and soaked in vegetable oil and wheat flour. They were checked once a day on three subsequent days, both in spring and fall, each year.

All animals were individually labelled, collected, and preserved at the Swedish Museum of Natural History in Stockholm. They are of great importance for future research on for example environmental pollution, pathogens or reproductional failure.

Results

Revision of museum specimens

Eleven specimens of the masked shrew were revised in the collection of the Natural History Museum of Oslo (table 2), none in the other collections. All but one individual were misidentified and listed as pygmy shrews

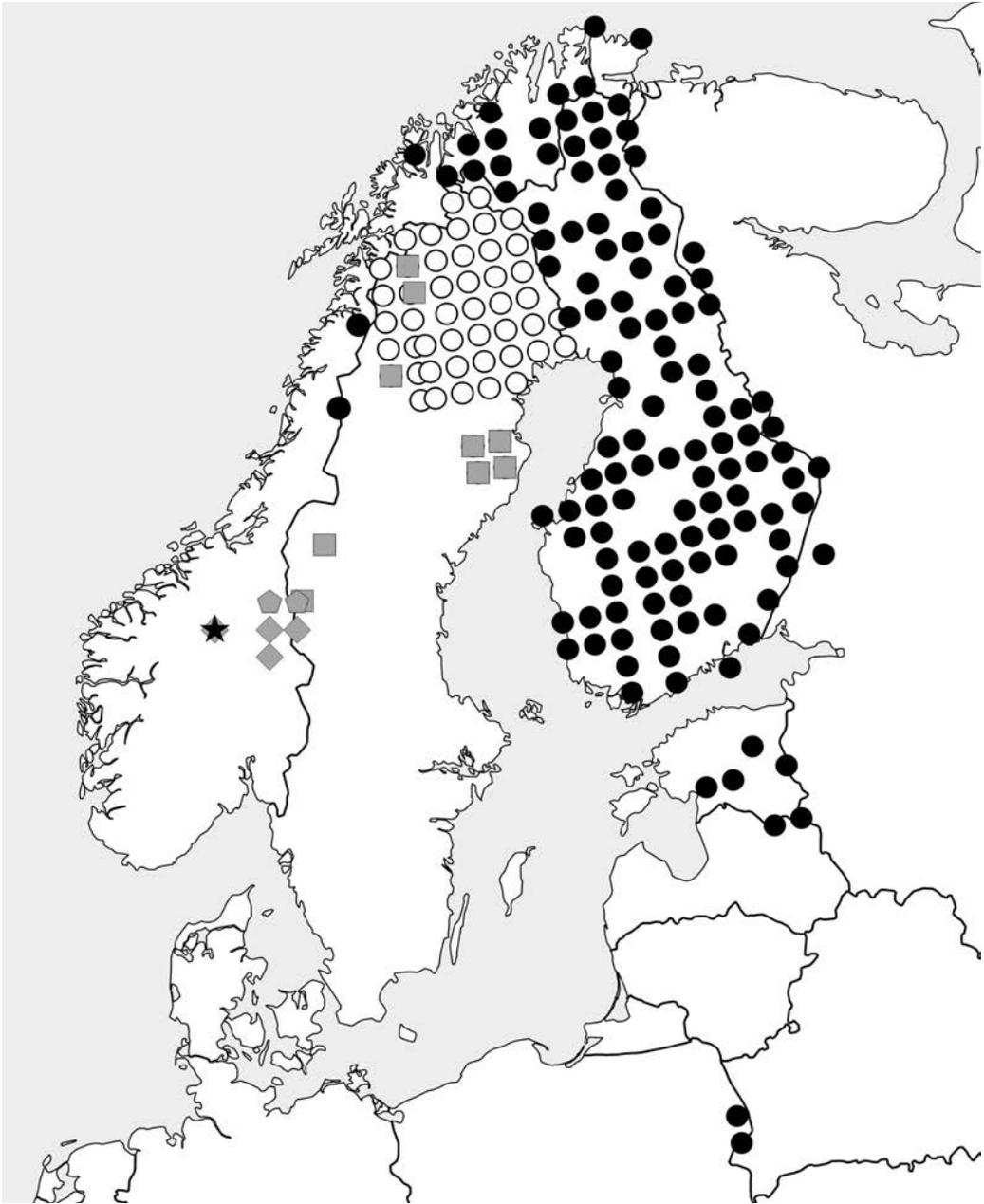


Figure 1. Occurrence of *Sorex caecutiens* in Europe exclusive of Russia and Belarus (adapted after Finch & van der Kooij 2005). The star represents the population at Mount Blåhø. The grey symbols reveal new data presented in this article: revised museum specimens (diamonds), prey items of Tengmalm's owl (*Aegolius funereus*) (pentangles) and Swedish trapping data (squares). The open circles in Sweden represent UTM-squares where the occurrence is partially based on expert judgement and not on actual records (e.g. Mitchell-Jones et al. 1999).

Table 1. The location of small mammal trapping areas in Sweden.

Area	Municipality	County	UTM 10 x 10 km square
Välådalen/Ljungdalen	Åre/Berg	Jämtland/Härjedalen	33VUK74, 33VVL10, 33VVL20
Ammarnäs	Sorsele	Västerbotten	33WWP51, 33WWP52, 33WWP60
Vindeln	Vindeln	Västerbotten	34WCV98, 34WDS00, 34WDS03, 34WDS10, 34WDS13, 34WDS15, 34WDS18, 34WDS30, 34WDS32, 34WDS33, 34WDS35, 34WDS52, 34WDS62, 34WDS65, 34WDS67, 34WDS82, 34WDS84, 34WDS87, 34WDS97
Stora Sjöfallet	Gällivare	Norrbottnen	33WXR12, 33WXR20

Table 2. Revised *Sorex caecutiens* from the collection of the Natural History Museum of Oslo.

NHMO Collection nr.	Original identification	Date	UTM 10 x 10 km square	Altitude	Locality	Municipality	County	Leg.	Prep.
10419	<i>S. minutus</i>	01 Aug 1996	32VNP19	940	Storhuset (Tjernet)	Dovre	Oppland	Field Study Group VZZ	cranium, skin
10340	<i>S. minutus</i>	10 Aug 1996	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	G. Westereng	cranium, skin
10353	<i>S. minutus</i>	15 Aug 1996	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	G. Westereng	alcohol
10356	<i>S. minutus</i>	16 Aug 1996	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	G. Westereng	alcohol
M 20289	<i>S. minutus</i>	23 Aug 1996	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	B. Westereng	alcohol
10700	<i>S. minutus</i>	08 Aug 1998	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	G. Westereng	alcohol
11183	<i>S. araneus</i>	19 Aug 1998	32VPP24	700	Fuggsjømyrene	Rendalen	Hedmark	B. Westereng	alcohol
187-74	<i>S. minutus</i>	30 July 1974	32VPP47		Bottølen, Femund	Engerdal	Hedmark	G. Westereng	alcohol
188-74	<i>S. minutus</i>	30 July 1974	32VPP47		Bottølen, Femund	Engerdal	Hedmark	G. Westereng	alcohol
28-76	<i>S. minutus</i>	13 Aug 1976	32VPP57	680	S. Femunden close to Sørken	Engerdal	Hedmark	G. Westereng	alcohol
30-76	<i>S. minutus</i>	14 Aug 1976	32VPP57	680	S. Femunden close to Sørken	Engerdal	Hedmark	G. Westereng	alcohol

(*Sorex minutus*). Only one was misidentified as common shrew (*Sorex araneus*).

Owl pellet analysis

Seventeen individuals of the masked shrew from ten different localities were found (table 3). The owl pellet analyses show that the species occurs only in low numbers in the diet of the Tengmalm's owl, at an altitude of about 600-700 m a.s.l.

Swedish trapping data

The masked shrew was trapped in low numbers within each study-area (table 4). The relative frequency in the trapping data increases from southern to northern Sweden.

Discussion

The presented data clearly show a distinctly smaller gap between the range of the masked

shrew in northern Scandinavia and the record from Mount Blåhø (figure 1). It is, however, questionable whether the complete actual distribution range of the species is uncovered now. There are still vast areas in Scandinavia where no trapping has been done and no owl pellets have been analysed.

But even in areas where trapping studies or owl pellet analyses have been carried out, the species might have been overlooked by misidentification or by the use of methods which are less sensitive to smaller shrew species. For example, snap-traps are less effective than pit-falls (Hanski & Kaikusalo 1989, Sulkava 1990).

Small mammals in general, and shrews are no exception, can be difficult to identify by external traits. Field guides often fail in presenting realistic drawings of the less studied small mammals. This is presumably due to the lack of field experience with these species by the artists or by the authors. Field guides – meant for use in the field – seldom take geographic, seasonal and age variation of characters into account. To identify species correctly, extensive field experience is often needed.

Interestingly, one of the misidentified specimens from the Museum of Natural History in Oslo was collected in 1996 by a field work camp organised by the Dutch Mammal Society and the Norwegian Zoological Society (Gundersen 1999, Bekker et al. 2015). The first author (JvdK), who, at the time, had no field experience of external traits of the masked shrew, participated in this camp and collected the small mammals, which unfortunately had died in the live-traps. At that time, the species was not recognised and was confused with the pygmy shrew. It wasn't until 2002-2003 when the first author extensively trapped small mammals in the Pasvik valley (northeastern Norway, at the Russian border) and conducted an extended study trip to the museum collection of Oulu University (Finland) that he felt confident of the external traits of the species. This was of use some years later, when he revised the museum collections.

The difficulty to distinguish the masked

shrew from the pygmy shrew is also demonstrated by the publication of a supposed masked shrew from the Netherlands (van den Brink 1953). Van den Brink, author of the first field guide of the mammals of Europe, had found a shrew in 1928 in a Scots pine (*Pinus sylvestris*) plantation on inland sand dunes near Appelscha, in the province of Friesland. Although van Leeuwen (1954) proved that it was a pygmy shrew, van den Brink (1955a, 1955b) persisted that it was a masked shrew.

The masked shrew displays an extensive variation in pelage colouration. In Scandinavia one can differentiate between at least four different pelages: winter, spring and summer pelage of adults and summer pelage of subadults. The summer pelage of the subadult (figure 2) looks like the two-coloured summer pelage of pygmy shrews, whereas the summer pelage of the adults (figure 3) looks like the three-coloured summer pelage of adult common shrews (Sulkava 1990; Jeroen van der Kooij, personal observations). The skin variation led until the middle of the last century to the belief of the existence of two sympatric species: *Sorex lapponicus* and *Sorex centralis* (Sulkava 1990). With the notable exception of Twisk et al. (2010), most field guides only display the pelage of subadults.

To distinguish the masked shrew from the pygmy and common shrew it is important to consider the relative tail length, the hind foot length, the bicoloured tail with a distinct brush and the cranial characters (Sulkava 1990, van der Kooij 1999).

Our research revealed the occurrence of the masked shrew at several places in southern Scandinavia. Whether the species occurs in low densities there, as the pellet analyses and the trapping data suggest, remains unclear. Additional owl pellet analyses (25,000 small mammal prey items from tawny owl (*Strix aluco*; the Tengmalm's owl doesn't occur here) demonstrates the absence of the species from the lowlands in Sør-Trøndelag county. The masked shrew may therefore be confined to areas above the timberline, where

Table 3. *Sorex caecutiens* remains from samples of pellets from Tengmalm's owl (*Aegolius funereus*) nestboxes in Mid-Norway. Samples from Grøtberget and Sætra nord were analysed without the use of NaOH, which produces less prey items. The percentage is therefore not calculated here.

Number of <i>S. caecutiens</i>	% <i>S. caecutiens</i> in vertebrate prey	% <i>S. caecutiens</i> in shrews	Sampling date	Breeding period	UTM 10 x 10 km square	Altitude	Locality	Municipality	County
1	1.3	5.1	17 Sept 2014	May 2014	32VPQ13	610	Våtstrupet	Os	Hedmark
1	-	-	Autumn 2002	2002	32VPQ23	675	Grøtberget	Roros	Sør-Trøndelag
1	0.8	0.1	1 Oct 2011	May 2011	32VPQ23	660	Påskén gård	Roros	Sør-Trøndelag
3	0.9	18.8	5 Oct 2011	May 2011	32VPQ23	640	Møllennmannsdalen	Roros	Sør-Trøndelag
3	1.8	13.6	18 Oct 2014	May 2014	32VPQ23	630	Kvernbekken	Roros	Sør-Trøndelag
1	-	-	Autumn 2002	1985/1994	32VPQ33	650	Sætra nord	Roros	Sør-Trøndelag
3	1.5	5.1	1 July 2011	May 2011	32VPQ51	690	Rosanden	Roros	Sør-Trøndelag
2	1.1	13.6	1 Sept 2014	May 2014	32VPQ42	670	Langen	Roros	Sør-Trøndelag
1	0.3	0.8	05 Sept 2014	after 1987	32VPQ52	675	Koltjønna	Roros	Sør-Trøndelag
1	0.8	25.0	04 Oct 2011	May 2011	32VPQ53	685	Feragen øst (north off Øya)	Roros	Sør-Trøndelag

Table 4. Small mammals caught in four trapping areas in Sweden. Numbers are given in percentage of the total number of catches.

Area	Period	Number of individuals	<i>Sorex araneus</i>	<i>Sorex caecutiens</i>	<i>Sorex minutus</i>	<i>Myodes glareolus</i>	<i>Myodes rutilus</i>	<i>Myodes rufocanus</i>	<i>Microtus agrestis</i>	<i>Microtus oeconomus</i>	<i>Lemmus lemmus</i>	<i>Myopus schisticolor</i>
Vålådalen/Ljungdalen	2001-2014	9264	6.1	0.2	0.2	38.6		33.4	11.4	1.5	7.1	1.6
Ammarnäs	1995-2014	14,594	11.8	0.3	0.2	40.0		16.9	21.0		8.9	1.0
Vindeln	1979-2014	18,304	6.4	0.5	1.1	73.8		6.3	9.9			2.0
Stora Sjöfallet	2001-2014	6600	7.2	0.6	0.2		14.9	55.1	11.3	2.3	7.6	0.8

the Tengmalm's owl does not breed and only infrequently hunts. The, from north to south, decreasing proportion of area above the timberline in the trapping areas could explain why its relative frequency in the trapping data decreases from north to south. Further analysis of the data may confirm this phenomenon.

Our work stresses once again the importance of preserving dead animals or tissue samples from fieldwork. To establish the southern border of the range of the masked shrew and to determine to what degree the different populations are isolated from each, further research is needed. The transbound-

ary mountain ridge of Norway and Sweden, with vast areas above the timberline, probably provide the most suitable habitats to study the masked shrew's occurrence between the established northern and southern records. In addition, the occurrence in northern Norway and Sweden should be investigated further. An often referred map of its occurrence in Sweden is at least partially based on expert judgement and not on actual records (Mitchell-Jones et al. 1999, p. 21).

Whether the masked shrew, after the last glaciation, colonised the Scandinavian peninsula through the northern route alone is presumable but cannot be finally established by distribution data. For that purpose, genetic (phylogeographic) analyses are needed.

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Figure 2. Subadult *Sorex caecutiens* in summer pelage (21 July 2003, Pasvik, Sør-Varanger, Norway). Photo: Jeroen van der Kooij.



Figure 3. Adult *Sorex caecutiens* in summer pelage (21 July 2003, Pasvik, Sør-Varanger, Norway). Photo: Jeroen van der Kooij.

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Samenvatting

Nieuwe gegevens over de noordse spitsmuis (*Sorex caecutiens* Laxmann, 1788) reduceren het gat in de verspreiding tussen Noord- en Zuid-Scandinavië

De ontdekking van een nieuw voorkomen van de noordse spitsmuis in Zuid-Noorwegen in 2003, 500 km ten zuidwesten van het bekende verspreidingsgebied, gaf aanzet tot nader verspreidingsonderzoek. Door het controleren van collecties, het pluizen van braakballen en het samenstellen van Zweedse vangstgegevens kon aangetoond worden dat de soort ook voorkomt op verschillende plaatsen in het tussenliggende gebied. Verwacht wordt dat de noordse spitsmuis op nog meer plaatsen voorkomt, met name in het grensgebergte van Noorwegen en Zweden. Het voorkomen in Zuid-Scandinavië is waarschijnlijk beperkt tot gebieden boven de boomgrens. Het kleurpatroon van deze spitsmuis verandert met leeftijd en tijd van het jaar, waardoor de herkenning wordt bemoeilijkt. Genetisch onderzoek moet uitwijzen hoe de soort na de laatste ijstijd Scandinavië heeft gekoloniseerd.

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