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A northern refugium of the Mediterranean water shrew *Neomys anomalus* in Słowiński National Park (N Poland)

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Abstract: The influence of recent anthropogenic and climatic changes on the distribution or population size of individual species should be especially pronounced at the boundaries of their geographical ranges. Therefore, in summers 2008-2010, we live-trapped small mammals and analysed habitat features on 14 study plots comprising various wet habitats of Słowiński National Park (at the Baltic coast in northern Poland) in order to recognize the current distribution and population size of *Neomys anomalus* Cabrera, 1907 in its northernmost population in Europe. *N. anomalus* was, however, captured only on one plot – a wet, unmown meadow crossed by unkempt drainage ditches, situated on the Gać Peninsula (Półwysep Gacki). This result, compared to historical data, suggests that neither the abundance of *N. anomalus* has increased nor its range has been extended. We give a detailed description of the habitat in this study plot. The information can be useful in the protection of this rare shrew species with very specific habitat requirements.

Keywords: *Neomys anomalus*, habitat selection, unmown meadows, distribution, protected species

INTRODUCTION

The protected and poorly investigated Mediterranean water shrew *Neomys anomalus* Cabrera, 1907 is one of the rarest and most interesting species of shrews (Mammalia: Soricidae) in Poland. This species is slightly smaller but morphologically very similar to the Eurasian water shrew *Neomys fodiens* (Pennant, 1771). The latter is much more frequent and widespread throughout the country. Both species are semi-aquatic but *N. anomalus* is less adapted to this lifestyle: it has proportionately smaller feet with fewer fringes and a shorter tail with a shorter keel on its ventral side than *N. fodiens* (Pucek 1984). In the Białowieża Forest, *N. anomalus* occurs more frequently in ecotones than in dense forest stands or open sedge swamps, and prefers wet places but located at some distance from deep water (Rychlik 2000). It dives less often than *N. fodiens* and ineffectively forages in deep water (Rychlik 1997; Soares

& Rychlik 2009), thus its diet includes a smaller proportion of aquatic invertebrates and it mostly consists of typical terrestrial organisms (e.g. earthworms and terrestrial beetles) and of prey living in shallow water and mud (Churchfield & Rychlik 2006).

The geographical range of *N. anomalus* in Poland is divided into 3 populations: north-western in Pomerania, southern in the Sudetes and Carpathians, and eastern in the Białowieża Forest (Pucek & Raczyński 1983). Due to human-made and climatic changes, in recent decades a number of species have changed their geographic ranges, also among shrews (Frey 1992; Vogel et al. 2002; Siemers et al. 2006). This also may apply to *N. anomalus*, which is a stenothermic species (Rychlik 1998) and could extend its range. Therefore, we focused on its northernmost population, located in Słowiński National Park (SNP). The Park comprises various types of terrestrial and aquatic ecosystems, including those preferred by water shrews: wet meadows and sedge swamps crossed by numerous drainage ditches.

Data on the presence of this species in SNP are scarce. Obertaniec (1977) found *N. anomalus* in pellets of barn owls *Tyto alba,* collected in Smołdzino (located outside SNP). Also Lesiński & Rusin (1996) found remains of *N. anomalus* in barn owl pellets from the village of Gać (south-eastern part of SNP). In both cases, it is possible that the owls hunted their prey in the Park. However, Obertaniec (1977) trapped intensively small mammals on 6 plots located in the western part of SNP and did not capture any specimen of *N. anomalus*. Only Hejduk (1998) caught 10 specimens on wet meadows north of Gać. The data suggest that in the past the population of *N. anomalus* in SNP was very dispersed and small.

The existence of suitable habitats, as well as climate warming and anthropogenic changes in recent decades (e.g. ceased drainage, abandonment of some agricultural lands) might have contributed to an increase in its local population size or extension of its range. Therefore, there was a need to examine the various habitats in different parts of SNP in order to recognize the current distribution and population size of the Mediterranean water shrew in the Park.

MATERIAL AND METHODS

In 2008-2010 in late July or early August we trapped small mammals and analysed habitats on 14 study plots in eastern and central parts of SNP (Fig. 1). The investigations covered a variety of habitats (mostly wet) characteristic of SNP (Table 1). Plant names used in habitat descriptions follow Mirek et al. (2002).

The trapping was conducted using the CMR method with individual marking of all small mammals by trimming numbers, i.e. small areas of fur on animals' back and/or sides. Box traps of 'dziekanówka' type (http://pulapki.republika.pl/foto/gryzon3.jpg, produced by PPUH A. Marcinkiewicz) were used on all the study plots. They were placed in 10-m intervals in lines (along drainage ditches or water channels) or in grids 10 m × 10 m. In addition, cone pitfalls were used on 2 plots. Minced beef was used as bait for shrews in both types of traps. Oat flakes, grains, sunflower seeds and croutons fried in oil were also placed in the same traps to lure rodents. On plots where shrews were caught, the traps were set at 18:00, checked every 2 h, and blocked

Table 1. Description of the 14 study plots established in Słowiński National Park and success in trapping of the Mediterranean water shrew *Neomys anomalus*

Plot no.	Latitude and longitude	Plot description	Trapping season	No. and layout of traps	Trapping effort [trap-hours]	No. of captures of *N. anomalus*
1	54°41'48.39"N, 17°27'9.50"E	Along a straight and deep channel (water depth 20-60 cm) crossing a mown meadow; dominant plants: *Glyceria maxima, Carex acutiformis*	July 2008	21 box traps in a line	378	0
2	54°41'47.30"N, 17°27'17.38"E	Along a channel (water depth 10-50 cm) bordering with a mown meadow on one side and alder forest on another; dominant plants: *Glyceria maxima*, *Phragmites australis, Juncus effusus*	July 2008	21 box traps in a line	438	0
3	54°41'48.96"N, 17°27'22.45"E	Edge of alder forest *Ribo nigri-Alnetum*, water 30 cm below ground surface; dominant plants: *Deschampsia flexuosa*, *Juncus effusus*, *Alnus glutinosa*	July/Aug 2008	6 box traps and 4 pitfalls in a line	380	0
4	54°41'58.38"N, 17°27'22.73"E	Abandoned (unmown) wet meadow and overgrown drainage ditches with shallow water (up to 5 cm deep) or without water; dominant plants: *Juncus effusus*, *Carex acutiformis*, *Phragmites australis*	July/Aug 2008	36 box traps and 2 pitfalls in 4 lines set up in a quadrilateral	1772	15 (7 individuals)
5	54°41'50.74"N, 17°27'42.61"E	Inner part of alder forest *Ribo nigri-Alnetum*, water 5 cm below ground surface; dominant plants: *Carex acutiformis*, *Carex elongata*, *Oxalis acetosella*, *Alnus glutinosa*	Aug 2009	grid: 3 parallel lines of 10 box traps	3225	0
6	54°41'49.57"N, 17°27'52.39"E	Degenerated mesic mixed forest; dominant plants: *Deschampsia flexuosa, Oxalis acetosella, Vaccinium myrtillus, Luzula pilosa, Fagus sylvatica*, *Pinus sylvestris*, *Quercus robur*	Aug 2009	grid: 3 parallel lines of 10 box traps	3225	0
7	54°45'31.24"N, 17°30'39.20"E	Reeds *Phragmitetum communis* on moist soil surrounded by bog forest *Vaccinio uliginosi-Pinetum*; dominant plants: *Phragimtes australis, Phalaris arundinacea*, *Juncus effusus*	Aug 2009	grid: 3 parallel lines of 10 box traps	3225	0

8	54°45’32.83”N, 17°30’43.84”E	Coastal variety of *Vaccinio uliginosi-Pinetum* on moist soil; dominant plants: *Vaccinium uliginosum*, *Myrica gale*	Aug 2009	grid: 3 parallel lines of 10 box traps	3330	0
9	54°45’40.62”N, 17°30’17.58”E	Grey dunes *Helichryso-jasionetum* and their ecotone with *Empetro nigri-Pinetum* on dry subsoil; dominant plants: *Ammophila arenaria, Corynephorus canescens, Pinus sylvestris*	Aug 2009	grid: 3 parallel lines of 10 box traps	3090	0
10	54°45’11.22”N, 17°30’41.46”E	Plot composed of 3 lines: A = reeds *Phragmitetum communis* (shore of Lake Łebsko); with stagnant water 5-10 cm deep and dominant plant *Phragmites australis*; B = ecotone between reeds and alder forest *Ribo nigri-Alnetum*; with dominant plants *Phragmites australis, Deschampsia flexuosa, Alnus glutinosa*; C = meadow with *Stellario-Deschampsietum* and fragments of *Phalaridetum arundinaceae*; dominant plants: *Deschampsia caespitosa, Molinia cerulea, Juncus effusus*	Aug 2009	grid: 2 parallel lines of 10 box traps and a separate line (C) of 10 box traps	3240	0
11	54°41’59.74”N, 17°18’31.39”E	Community similar to Pomeranian fertile beech forest *Melico-Fagetum* on moist soil; dominant plants: *Molinia cerulea, Fagus silvatica, Quercus sessilis*	July 2010	grid: 3 parallel lines of 10 box traps	4350	0
12	54°41’52.96”N, 17°18’47.83”E	Peat alder forest *Sphagno squarrosi-Alnetum,* wet (water from 20 cm below ground surface to 20 cm deep); dominant plants: *Pteridium aquilinum*, *Molinia cerulea*, *Alnus glutinosa, Betula pubescens*	July 2010	grid: 3 parallel lines of 10 box traps	2700	0
13	54°41’40.00”N, s17°12’25.50”E	Reeds *Phalaridetum arundinaceae*, wet (water 0-30 cm deep); dominant plants: *Phalaris arundinacea*, *Carex pseudocyperus*, *Glyceria maxima*	Aug 2010	grid: 3 parallel lines of 10 box traps	1185	0
14	54°42’4.95”N, 17°12’38.43”E	Alder forest (shore of Dołgie Lake) and a mosaic of plant communities *Iridetum pseudacori* and *Cicuto-Caricetum pseudocyperi* (water 20-30 cm deep); dominant plants: *Carex pseudocyperus, Iris pseudoacorus, Carex nigra, Alnus glutinosa, Betula pubescens*	Aug 2010	grid: 2 parallel lines of 15 box traps	1125	0

around 4:00. On plots dominated by rodents (i.e. where shrews did not occur or appeared sporadically), traps were open non-stop and checked 4 times per day (about 0:00, 8:00, 15:00 and 21:00) to increase the chance of detection of *N. anomalus* during the day.

Trapped mammals, after weighing (in a plastic bag on a portable Pesola spring balance) and determination of their species, age, gender, and sexual activity, were immediately released at the place of capture. Animals captured for the first time were marked by fur trimming as mentioned above. The terminal part of tail (approximately 5 mm) of 5 specimens of *N. anomalus* and 5 of *N. fodiens* were cut for genetic research prior to release. Genetic results will be presented in a separate article.

RESULTS

Among the 14 study plots on which trapping was conducted, Mediterranean water shrews were trapped only on plot no. 4 (Table 1), situated on the Gać Peninsula (Fig. 1). Seven individuals were caught there (2 adult females and 5 juveniles). These animals were captured, in total, 15 times during 9 nights.

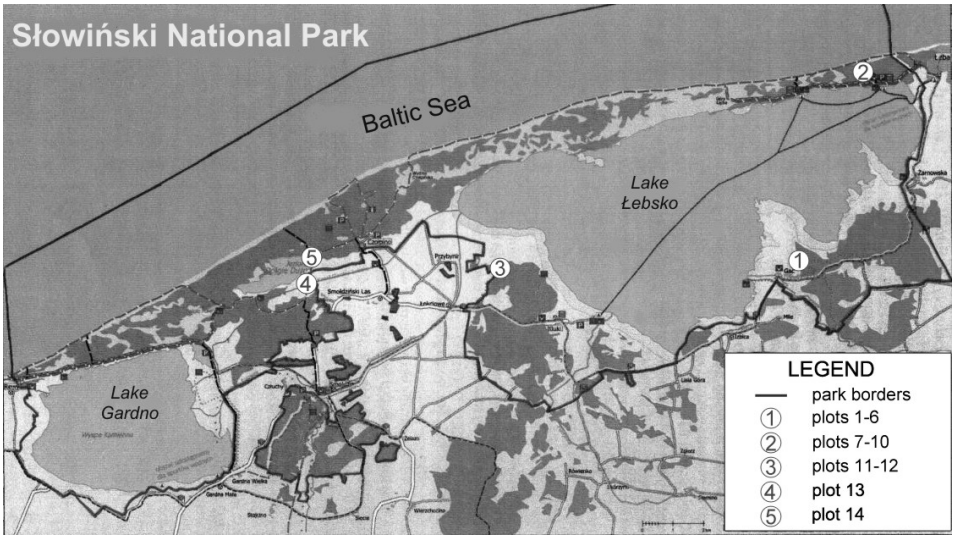

Fig. 1. Location of the 14 study plots in Słowiński National Park (see Table 1 for characteristic of the plots). Map modified from Florek (2008)

Plot no. 4 was a wet, unmown meadow crossed by unkempt drainage ditches of various water depth (or dried out). In places differing in soil moisture and plant cover, traps were positioned in 4 lines forming a quadrilateral, with lines R, T, and D running along the ditches, and line S intersecting the meadow.

Line R (where 2 individuals of *N. anomalus* were caught) bordered a ditch filled with water approximately 5 cm deep. *Lemna trisulca* dominated in water, while *Molinia caerulea* along the bank. The wet meadow, adjacent to the ditch, was overgrown with lush and very diverse grasses and herbs, such as *Juncus effusus*, *Rumex hydrolapatum*, *Deschampsia caespitosa*, *Plantago lanceolata*, *Potentilla repens*, and *Carex acutiformis*.

Line T (where *N. anomalus* was captured 4 times) ran along a dried-up ditch (although water table was just below the ground surface) overgrown with high wetland plants (mainly *Typha latifolia*, *Phragmites australis*, *Juncus effusus*, and *Phalaris arundinacea*). *Urtica dioica*, *Rumex hydrolapatum*, and *Juncus effusus* dominated outside the ditch.

Line D (where *N. anomalus* was trapped 7 times) bordered a dried-up ditch with a drier substratum than on the previous lines (water table was approximately 10 cm below the ground surface). *Typha latifolia*, *Phalaris arundinacea*, *Molinia cerulea*, and *Juncus effusus* dominated in the ditch, while low plants, such as *Potentilla repens*, *Dactylis glomerata*, *Plantago lanceolata*, *Mentha arvensis*, prevailed outside the ditch (Fig. 2). There was also a single alder tree *Alnus glutinosa*, near which *N. anomalus* was captured 4 times.

Fig. 2. Line D on plot no. 4 – the habitat preferred by *Neomys anomalus* in Słowiński National Park (photo A. Stachowiak)

Line S (2 captures of *N. anomalus*) crossed the meadow, with water level approximately 30 cm below the ground surface. Vegetation was dominated by herbs like *Juncus effusus*, *Lychnis flos-cuculi*, *Phalaris arundinacea*, *Polygonum persicaria*, and *Trifolium arvense*.

The common features of the all 4 lines were: dense (unmown) vegetation, wet ground, and lack of deep water, either stagnant or flowing. Full descriptions of the lines and of plots no. 1-14 are available in the work by Stachowiak (2009).

Although no specimen of *N. anomalus* was caught on the remaining 13 plots, we trapped there many individuals of various species of rodents (a total of 193 captures) and shrews (42 captures; Rychlik et al., in prep.). Those included both the semi-aquatic *N. fodiens* and shrews smaller than *N. anomalus* (i.e. *Sorex araneus* and *S. minutus*).

DISCUSSION

For the first time the presence of *Neomys anomalus* was reported for SNP by Obertaniec during his MSc study performed in 1975-1976 (Obertaniec 1977; Pucek & Raczyński 1983). Obertaniec (1977) found 69 specimens of *N. anomalus* in pellets of the barn owl *Tyto alba* collected in Smołdzino (now placed at the western border of SNP), and perhaps a few individuals in Czołpino (in the central part of SNP) – it is not clearly stated in his MSc thesis. At the same time, in his intensive snap-trapping sessions on 6 plots located in the western part of SNP and covering 6 different biotopes, no individual of *N. anomalus* was caught (Obertaniec 1977). In 1991, Hejduk (1998) captured 10 animals of this species in live-traps set along the drainage ditches across the wet meadows north of the village of Gać (south-eastern part of SNP). Lesiński & Rusin (1996) found 15 individuals of *N. anomalus* in barn owl's pellets collected in 1993 in the same village. The present study, carried out using similar methods and on the same site as in Hejduk's study, showed that after 17 years the population of *N. anomalus* still exists on the Gać Peninsula.

At this site, *N. anomalus* selects wet microhabitats, but not flooded or immediately adjacent to deep water. These microhabitats provide a dense cover of vegetation (thanks to not mowing the meadow). On the other hand, *N. anomalus* rather avoids places with high wetland vegetation. Similar microhabitat preferences were displayed by this species in the Białowieża Forest (Rychlik 2000, 2001). Thus, as previously suggested by Rychlik & Pucek (1995), also on the basis of the present results it can be concluded that leaving unmown wet meadows and sedge swamps seems to be indispensable for maintenance of this species.

It is interesting that a large proportion of our captures of *N. anomalu*s took place near a single tree standing in an open area. A similar trend in this species (and also in other shrews, e.g. *Sorex araneus* and *S. minutus*, and the root vole *Microtus oeconomus*) was observed by Rychlik (2000, 2001), who suggested that roots of trees and the gaps between tussocks of sedges and the tree trunks provide the animals with good shelters and nesting dens.

In total, 5 juveniles and 2 adult females of *N. anomalu*s were captured on plot no. 4. This means that the habitat of this plot provided suitable conditions and a sufficient

food base for *N. anomalus* to live and reproduce there. Thus, the population is likely to continue its existence in that area, unless the habitat conditions are disturbed.

The lack of *N. anomalus* in the other moist habitats investigated in SNP is worrying, especially because it seems to be absent even from the areas adjacent to plot no. 4. Our captures of other species of small mammals on all plots (including the semi-aquatic *N. fodiens* and shrews smaller than *N. anomalus*; Rychlik et al., in prep.) prove that our traps were not placed in wrong places and were sensitive enough to capture *N. anomalus*. Thus, the presence of this species only on one site indicates very specific habitat requirements of *N. anomalus*. This suggests also that despite the observed changes in climate and the use of meadows by man, neither the abundance of *N. anomalus* has increased nor its range has extended dramatically. However, it does not seem possible to us that the only site in the entire SNP inhabited by this species is a small area of the Gać Peninsula, especially that Obertaniec (1979) detected the presence of this species in several unprotected locations not far from SNP. Therefore, further, more detailed studies in different parts of the Park and adjacent areas are needed.

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