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Distribution and foraging habitats of bats in northern Finland: *Myotis daubentonii* occurs north of the Arctic Circle

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Abstract. We studied the occurrence of bats in the river basins of northern Finland during the summers of 2005 and 2006. *Eptesicus nilssonii*, *Myotis daubentonii*, *Myotis brandtii* and/or *M. mystacinus* and *Plecotus auritus* occurred north of 64 °N. The most abundant species were *E. nilssonii* and *M. daubentonii*. *Myotis daubentonii* foraged almost exclusively on rivers and typically simultaneously with *E. nilssonii*. *Eptesicus nilssonii* foraged typically in habitats related to water but also in man-made habitats and in habitats related to forests. The northernmost observation of *M. daubentonii* was made at 66° 40.95' N just above the Arctic Circle. The northernmost observation of *Plecotus auritus* was made at 64° 25.51' N and that of *Myotis brandtii/mystacinus* at 66° 21.75' N.

Bats, Chiroptera, distribution, northern Europe, *Eptesicus*, *Myotis*, *Plecotus*

Introduction

Myotis daubentonii (Kuhl, 1819) occurs in Europe and Asia from the coast of the Atlantic Ocean to the coast of the Pacific Ocean (Bogdanowicz 1994). This species is one of the most common bat species in Europe with a range spanning from 63° N in Fennoscandia (Nyholm 1965, Ahlén & Gerell 1989) and Russia (Bogdarina & Strelkov 2003) to 40° N in Greece (Helversen & Weid 1990). *Myotis brandtii* (Eversmann, 1845), *Myotis mystacinus* (Kuhl, 1819), *Eptesicus nilssonii* (Keyserling et Blasius, 1839) and *Plecotus auritus* (Linnaeus, 1758) have been reported to occur above 63° N in Finland, but only *E. nilssonii* occurs in the whole country and frequently above the Arctic Circle (Mitchell-Jones et al. 1999, Siivonen & Sulkava 1999). The distribution of *P. auritus* reaches 63–64° N, and one individual has even been found in Hiipinä, Russia (67° 30' N) (Siivonen & Sulkava 1999). *Myotis brandtii* and *M. mystacinus* can be found up to 65° N and 64° N, respectively (Mitchell-Jones et al. 1999).

Myotis daubentonii typically hunts insects from and close to the surface of water bodies (trawling behaviour), but it occasionally also forages in deciduous and mixed forests (e.g. Ahlén 1990, Bogdanowicz 1994, Boonman 1996, Russo & Jones 2003). *Myotis daubentonii* mostly eats Diptera (Swift & Racey 1983, Beck 1995). Besides insects, it is able to catch small floating dead or jumping fish (Siemers et al. 2001). Kalko & Schnitzler (1989) have classified the species as an edge-space trawling forager. *Myotis daubentonii* emits only short frequency-modulated (FM) signals (Bogdanowicz 1994). These echoes give more detailed information about the habitat and are needed in a cluttered environment (e.g. Russ 1999).

Myotis daubentonii follows linear landscape elements on its flight paths and hesitates to cross open spaces (Limpens & Kapteyn 1991). In northern parts of its distribution (60 °N), the species searches for shady places to hunt during light summer nights (Nyholm 1965) suggesting that the lightness of summer nights may restrict its distribution northwards. In north-eastern Finland (Kusamo region) irregular topography creates noticeable differences in elevations, e.g. deep canyons and cliffs in woodland. The cliffs and the canyon walls shade the surface of the rivers flowing down in the canyons offering potential flight paths and foraging areas for *M. daubentonii*. The aim of this study was to determine if *M. daubentonii* occurs in the river basins of northern Finland. In addition, information on the occurrence of other species was gathered when searching for *M. daubentonii*. No systematic bat mapping has been carried out in northern Finland before.

Material and Methods

Study area

This study was conducted in the northern boreal forest zone (Ahti et al. 1968) in the regions of Kainuu and North Ostrobothnia 64° 00' – 65° 15' N (23 Aug – 2 Sept 2005) as well as North Ostrobothnia and Lapland 65° 15' – 68° 00' N (28 July – 7 Aug 2006) in northern Finland. We started our search for *M. daubentonii* at 64° N in the river basins of Pyhäjoki, Siikajoki and Oulujoki where the species had not been found before. In northern Finland, summer usually begins in June and ends in August. During summer, the mean daily temperature is consistently above 10 °C. The 0 °C limit of mean annual temperature runs slightly to the south of the Arctic Circle. The regions north of the Arctic Circle (66.3° N) are characterized by 'polar days', when the sun does not set at all. The northernmost parts of Finland have 73 'polar days' yearly. The average annual precipitation in the study area is 600 mm. The temperature extremes range from 30 °C in the summer to –50 °C in the winter (Drebs et al. 2002).

Data collection

The study was conducted in late summer. In August, nights are getting darker and consequently it is easier to find *M. daubentonii*, which comes to forage in more open places (Nyholm 1965). We searched for foraging bats during entire nights, because in northern Europe, bats forage during the whole night (Nyholm 1965). We stopped on all bridges and river banks to listen with bat detectors. We particularly investigated deep river valleys where cliffs and canyon walls shaded the surface of rivers offering potential flight paths and foraging areas for the species. To detect and identify bats we used Pettersson D240x, D200, and D100 bat detectors as well as the sound analysing programme BatSound Pro 3.3 (Pettersson Elektronik Ab, 2004) with the DAQCard-6062E of National Instruments with a portable computer, which enabled us to see real-time sonograms in the field (e.g. Ahlén 1981, Russ 1999). When commuting from one water body to another we searched for other bat species. We placed two bat detectors on the roof of a Land Rover, the Pettersson D240x, tailored to continuously scan and play 0.1-second time-expansion sounds, and the Pettersson D100, which is a heterodyne detector. Whenever we observed a bat we recorded the place and the habitat where the bat foraged as well as the date of the observation. In a case a bat foraged on a river we recorded the width of the river. Summer nights are light in northern Europe, so to confirm the identification of the species we observed the behaviour, body size, ear size, colouring, as well as wing movements of the bats (e.g. Ahlén 1990). Bats are extremely scarce in northern Finland, and the number of bats foraging simultaneously is not high, making it possible to count their exact number. By using a bat detector and visual observations, the identification of species is possible. The only exceptions are sibling species *M. brandtii* and *M. mystacinus*, which have similar echolocation calls (e.g. Ahlén & Baagøe 1999). As this study was non-invasive, we neither captured nor handled bats, and therefore these two species are presented together as *M. brandtii/mystacinus* in this paper.

Results

Above 64 °N we observed 202 *E. nilssonii*, 75 *M. daubentonii*, six *P. auritus* and three *M. brandtii/mystacinus*. Two *M. daubentonii* were swarming and 73 foraging (Table 1). These individuals foraged almost exclusively on rivers (7% on the rivers the width of which was $1<x\leq5$ m, 45% on the rivers the width of which was $5<x\leq50$ m, 48% on the rivers the width of which was >50 m). Only three of them foraged on lakes. Seventy-six per cent of *M. daubentonii* foraged simultaneously with *E. nilssonii*. *Myotis daubentonii* was found up to 29° 0.6' E, 64° 52.3' N, but then the species was abruptly absent (Fig. 1). Between 65° N and 66° N no *M. daubentonii* was found.

Table 1. Description of habitats where *Myotis daubentonii* [*Md*] was found in northern Finland; simultaneous foraging with *Eptesicus nilssonii* [*En*] is indicated
Tab. 1. Popis biotopů severního Finska, kde byl dokumentován netopýr vodní (*Myotis daubendonii*) [*Md*]; vyznačen je současně zaznamenaný lov netopýra severního (*Eptesicus nilssonii*) [*En*]

place	date	street lamps	N *Md*	N *En*	activity	habitat
occurrence of *M. daubentonii* at 64–65 °N						
Hyrynsalmi	23. 8. 2005	0	1	0	foraging	lake
Jaala	24. 8. 2005	0	2	4	foraging	river
Kajaani	24. 8. 2005	0	1	1	foraging	river
Kuhmo	22. 8. 2005	white light	30	10	foraging	river
Kuhmo	22. 8. 2005	0	1	1	foraging	river
Kuhmo	22. 8. 2005	0	1	0	foraging	river
Kuhmo	22. 8. 2005	0	5	1	foraging	river
Kuhmo	22. 8. 2005	0	2	0	foraging	rapid
Kuhmo	22. 8. 2005	0	1	0	foraging	strait
Kuhmo	22. 8. 2005	0	2	0	foraging	rapid
Kuluntalahti	24. 8. 2005	yellow light	3	0	foraging	river
Paltamo	24. 8. 2005	0	1	1	foraging	river
Paltamo	24. 8. 2005	0	2	1	foraging	river
Piippola	26. 8. 2005	0	2	6	foraging	river
Ristijärvi	23. 8. 2005	0	1	1	foraging	shore*
Ruukki	25. 8. 2005	0	2	12	foraging	river
Ruukki	25. 8. 2005	0	1	2	foraging	river
Siikajoki	25. 8. 2005	0	2	2	swarming	graveyard
Suomussalmi	23. 8. 2005	0	1	1	foraging	lake
Suomussalmi	23. 8. 2005	0	2	0	foraging	river
Suomussalmi	23. 8. 2005	0	2	5	foraging	river
Tyrnävä	26. 8. 2005	0	2	0	foraging	river
occurrence of *M. daubentonii* north of 66 °N						
Kuusamo	5. 8. 2006	0	3	1	foraging	river
Kuusamo	5. 8. 2006	0	1	2	foraging	river
Kuusamo	3. 8. 2006	0	2	0	foraging	river
Salla	4. 8. 2006	0	1	0	foraging	river
Salla	4. 8. 2006	0	1	0	foraging	river

* *M. daubentonii* foraged on the shore of Hyryskoski rapid (over a road next to riparian deciduous forest)

All the northernmost observations of *M. daubentonii* were made in deep river valleys of the Koutajoki catchment area, which flows to the White Sea in Russia (Fig. 1). This catchment area is a vast uninhabited forest rich in small lakes. In it we found eight *M. daubentonii*. All of them foraged over quiet waters just below rapids. We also found *E. nilssonii* foraging simultaneously with *M. daubentonii* at two sites. On the Kuusinki River one *E. nilssonii* and three *M. daubentonii* foraged simultaneously at 29° 42.2' E, 66° 14.7' N. On the Kitka River two *E. nilssonii* foraged simultaneously with one *M. daubentonii* at 29° 25.0' E, 66° 15.6' N. On the Oulanka River two *M. daubentonii* foraged simultaneously at 29° 20.0' E, 66° 22.1' N. The northernmost observation of *M. daubentonii* was made on the Savina River in Salla (28° 57.8' E, 66° 41.0' N) just above the Arctic Circle (Fig. 1). In addition, another *M. daubentonii* foraged on the Ala-Kieskis River above the Arctic Circle at 29° 02.0' E, 66° 36.1' N.

All *E. nilssonii* that we observed were foraging. The habitats in which this species foraged are described in Table 2. Fifty-nine percent of them foraged in habitats related to water from which 75% foraged over rivers. On average, approximately three *E. nilssonii* foraged in one locality,

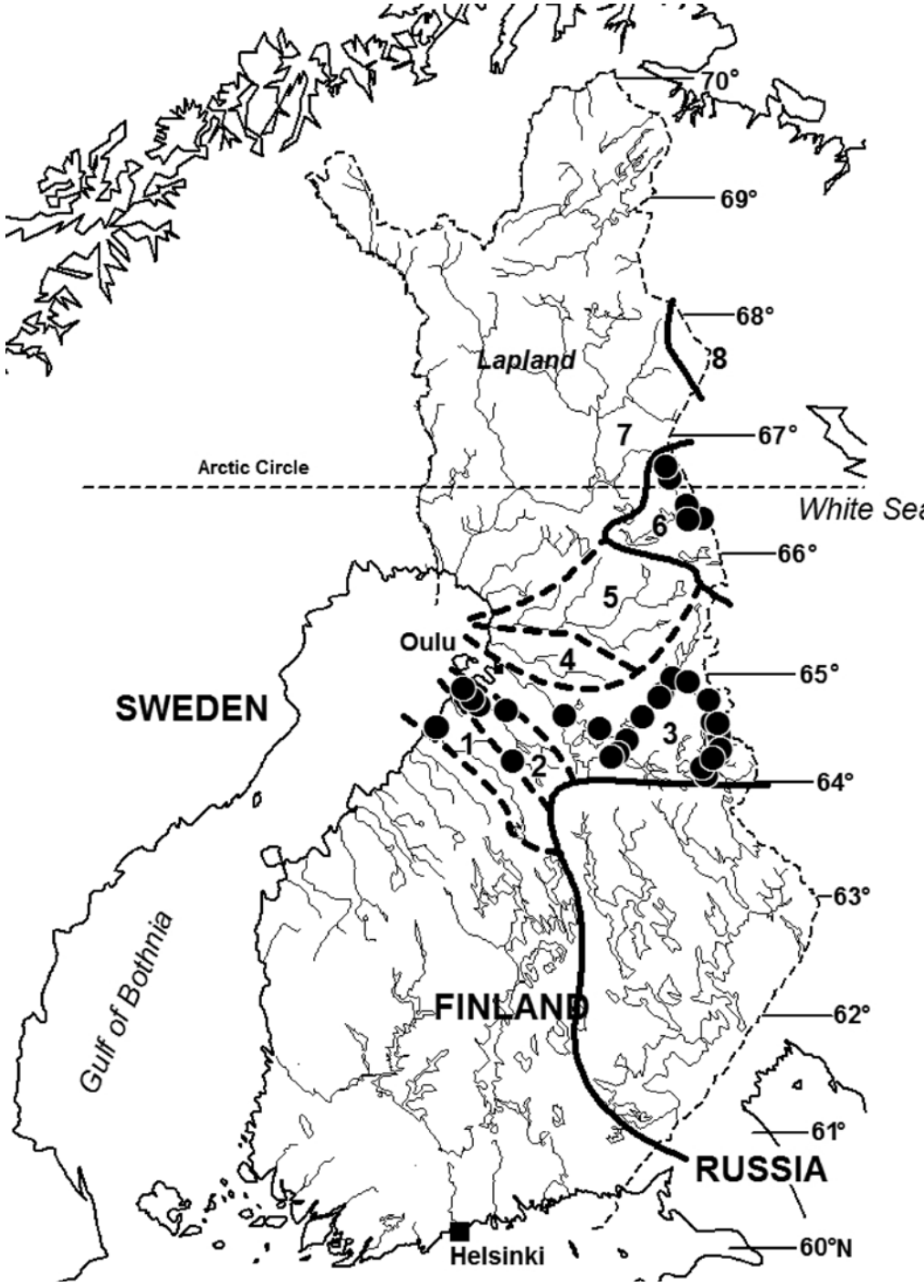
70°
69°
68°
Lapland
8
7
67°
Arctic Circle
White Sea
6
66°
5
Oulu
4
65°
SWEDEN
3
1
2
64°
63°
Gulf of Bothnia
FINLAND
62°
61°
RUSSIA
Helsinki
60°N

Table 2. Description of habitats where *Eptesicus nilssonii* foraged in northern Finland north of 64° N
Tab. 2. Popis biotopů severního Finska severně od 64° s. š., kde byl dokomentován netopýr severní (*Eptesicus nilssonii*)

habitat	*E. nilssonii* occurrence (n=202) in %	average N of inds. / site
lake	3.0	1.2
strait (lake)	4.0	4.0
river	46.5	2.9
shore with vegetation edge	0.5	1.0
bridge	5.0	10.0
grassland	1.0	2.0
urban area	13.4	3.9
park	5.9	6.0
road	5.0	10.0
site for earth material extraction	1.5	3.0
rural area	5.0	2.5
deciduous woodland	0.5	1.0
coniferous woodland	3.0	3.0
deciduous woodland edge	2.0	2.0
mixed woodland edge	2.0	1.3
coniferous woodland edge	1.5	1.5
edge of a park	0.5	1.0
total	100	3.0

with a maximum of 12 individuals foraging simultaneously. This species was also found between 65 °N and 66 °N. Above 64° 00' N we also observed *M. brandtii/mystacinus* and *P. auritus*.

In the Koutajoki catchment area we found three *M. brandtii/mystacinus*: one foraged in the mixed forest of the Oulanka River valley at 29° 20.0' E, 66° 21.8' N; one foraged in the mixed forest of the Kitka River valley at 29° 24.8' E, 66° 15.6' N; and one foraged in the mixed forest of the Kuusinki River valley at 29° 42.6' E, 66° 14.8' N. These forests where *M. brandtii/mystacinus* hunted were tall. *Eptesicus nilssonii* also foraged in these three river valleys. We did not find any *M. brandtii/mystacinus* between 64° 00' – 66° 14' N.

Plecotus auritus was observed in two places above 64° 00' N. The northernmost observation of this species was made at 25° 47.1' E, 64° 25.5' N in Rantsila in northern Finland, where one *P. auritus* foraged around bushes on the river side simultaneously with one *E. nilssonii* that foraged over the river bank. Five *P. auritus* foraged in an old arboretum that has reverted to a wild state in Kajaani at 27° 43.8' E, 64° 13.8' N. An old flume surrounded by bushes flowed next to the arboretum where one *M. daubentonii* and three *E. nilssonii* foraged simultaneously over the flume.

←
Fig. 1. New records of *Myotis daubentonii* in northern Finland. We searched for *M. daubentonii* in the catchments of Pyhäjoki (1), Siikajoki (2), Oulujoki (3), Kiiminkijoki (4), Iijoki (5), Koutajoki (southern part) and Vienan Kemi (6), Kemijoki (eastern part; 7) and Koutajoki (northern part; 8). New records of the species are marked on the map with black dots. One dot represents all the individuals counted in the same area. *Myotis daubentonii* occurred in the catchments of Pyhäjoki, Siikajoki, Oulujoki and Koutajoki (southern part).
Obr. 1. Nové nálezy netopýra vodního (*Myotis daubentonii*) v severním Finsku. *Myotis daubentonii* byl vyhledáván v povodí řek Pyhäjoki (1), Siikajoki (2), Oulujoki (3), Kiiminkijoki (4), Iijoki (5), jižní části povodí řeky Koutajoki a řeky Vienan Kemi (6), východní části povodí řeky Kemijoki (7) a severní části povodí řeky Koutajoki (8). Nové nálezy druhu jsou v mapce vyznačeny plnými kroužky. Jeden kroužek představuje všechny jedince zjištěné na jednom území. *Myotis daubentonii* se vyskytl v povodích řek Pyhäjoki, Siikajoki, Oulujoki a v jižní části povodí řeky Koutajoki.

Discussion

The northernmost individuals of *M. daubentonii* occurred in the Kuusamo-Salla region, where they foraged in river valleys of the Koutajoki catchment area. There the climate is more continental (cold winters and warm summers) than in the other parts of Finland. In this region, the mean yearly temperature is –0.8 °C (1967–2003), and the coldest and warmest temperatures ever measured are –48.0 °C and 32.1 °C respectively. The microclimate of the river valleys where the bats foraged are even more continental than in the surrounding upland, i.e. the winters are colder and the summers warmer. Valleys are protected from winds and therefore the warm summer air as well as the cold winter air remains in the valleys (Koutaniemi 1983). The growing season lasts 135 days. The snow covers the ground approximately 200 days yearly (Oulanka Research Station 2006), and the precipitation of snow is the highest in the whole of Finland (Koutaniemi 1983). Snow acts as good insulation against cold if bats hibernate in natural crevices. In the Koutajoki catchment area there are deep canyons, the walls of which may serve winter roosts for bats. There exists no study concerning insect availability in the canyons, but according to Paavola (pers. obs.) and Siikamäki (pers. obs.) the insect density in river canyons is much higher than in the surrounding areas (infertile pine-dominated forest). Many facts may affect to this higher density, e.g. larval stages of Chironomidae, Culicidea and Simulidae need water habitats, the mosaic of aquatic and terrestrial habitats, more diversified vegetation, higher productivity, and better microclimate in the summer compared to the surrounding areas.

Myotis daubentonii prefers to hunt in the darkness (Nyholm 1965), and the lightness of summer nights is one factor that may restrict the distribution of this species towards the north, because dark hunting places are difficult to find during the light summer nights of northern Finland. In the Kuusamo region, however, there are noticeable differences in elevations, e.g. deep canyons and cliffs in woodland. The cliffs, the canyon walls and tall forests shaded the surface of the rivers where *M. daubentonii* hunted, offering shaded flight paths and hunting places for this species. *Eptesicus nilssonii* occurs up to 70° N in Fennoscandia and typically forages in valleys (Speakman et al. 2000) and canyons (Iso-Iivari 1988) in the northernmost part of its distribution. Similar to Rydell (1989), *E. nilssonii* foraged over lakes and other open areas to a minor extent.

In the Koutajoki catchment area, rivers flow to the White Sea in Russia, and rivers serve as flight paths for *M. daubentonii* suggesting that the distribution of the species continues on the Russian side of the border. On both sides of the border there are vast uninhabited forest areas rich in small lakes (i.e. the transboundary nature protected territory of Oulanka-Paanajärvi). Surveys should be carried out in the Paanajärvi region in north-western Russia to confirm this theory.

The occurrence of *M. daubentonii* as well as *M. brandtii/mystacinus* in the Koutajoki catchment area suggests that the warmness of the summer is an important factor for the distribution of these species. The coldness of winters is not crucial if a bat can find suitable hibernation sites.

Similar to *E. nilssonii* (Rydell 1989), *M. daubentonii* searched for dark places to forage, and we suggest that the best time to map the bats above 63° N would be in August when nights are darker and bats forage in more open habitats. The important areas to be mapped in the very northern parts of its distribution would be shady rivers flowing deep in canyons and valleys.

Souhrn

Rozšíření a lovné biotopy netopýrů v severním Finsku: netopýr vodní (*Myotis daubentonii*) se vyskytuje na sever od polárního kruhu. Výskyt netopýrů v povodí řek v severním Finsku byl studován v létě roků 2005 a 2006. Severně od 64° severní šířky byl zjištěn výskyt netopýra severního (*Eptesicus nilssonii*),

netopýra vodního (*Myotis daubentonii*), netopýři komplexu netopýra vousatého (*Myotis brandtii* a/nebo *M. mystacinus*) a netopýr ušatého (*Plecotus auritus*). Nejhojnějšími druhy byly zjištěny *E. nilssonii* a *M. daubentonii*. *Myotis daubentonii* lovil téměř výhradně nad řekami a velmi typicky současně s *E. nilssonii*. *Eptesicus nilssonii* lovil typicky v biotopech blízkých vodě a také antropogenních biotopech a biotopech svázaných s lesy. Nejsevernější výskyt *M. daubentonii* byl zjištěn v severní šířce 66° 40,95' N, těsně nad severním polárním kruhem. Nejsevernější pozorování *Plecotus auritus* bylo zaznamenáno na 64° 25,51' s. š. a netopýrů komplexu *Myotis brandtii/mystacinus* na 66° 21,75' s. š.

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