

Mammal populations on islands of the Věstonice Reservoir Nature Reserve, southern Moravia (Czech Republic)

Populace savců na ostrovech přírodní rezervace Věstonická nádrž, jižní Morava

Gašpar ČAMLÍK, Kateřina POLEDNÍKOVÁ & Lukáš POLEDNÍK

ALKA Wildlife, o.p.s., Liděřovice 62, 380 01 Peč, Czech Republic; www.alkawildlife.eu

received on 4 June 2015

Abstract. In 2009–2014, a survey of medium-sized to large mammals was carried out on the islands of the Central (Věstonice) Reservoir. It is a lowland water reservoir located in southern Moravia (Czech Republic) at the junction of three rivers, Dyje, Jihlava, and Svratka. Several non-invasive survey methods were used: camera traps (altogether 1759 “camera trap-nights”), monitoring rafts (2674 “raft-nights”) and tracking tunnels (160 “tunnel-nights”). Additional methods included random observations and monitoring of animal tracks, scats and other signs. Overall, 13 mammal species from the focal group were identified on the islands of the Věstonice reservoir: five rodent, six carnivore and two even-toed ungulate species. The phenomenon of occurrence of the stone marten (*Martes foina*) on islands is unique for the Věstonice reservoir.

Key words. Mammals, fauna, islands, Věstonice reservoir, monitoring rafts.

INTRODUCTION

Mammal populations on islands tend to be a rather neglected topic. The studies published so far either explore the degree of isolation of the islands and how this isolation (determined by the distance from the shore, water flow rate, or its depth) influences the occurrence of the studied mammals (e.g. GLIWICZ 1980, ZOELICK et al. 2005), or conversely, they deal with the importance of islands for migration – that is, for the interconnection of populations on the opposite river banks (ROMANOWSKI et al. 2007, 2008). Other papers concerning island mammals study their influence on ground-nesting water birds. These studies, therefore, tend to focus on predators. Long-term research concerning the effects of the American mink on island bird nesting colonies were undertaken in Scotland (CRAIK 1995, 1997, 1998, 1999, 2000, CRAIK & CAMPBELL 2000) or in western Poland (BARTOSZEWICZ & ZALEWSKI 2003); island predators and their impact on birds have also been studied in the USA (e.g. ZOELICK et al. 2004). This paper summarizes the results of the monitoring of medium-size to large mammals performed between 2009 and 2014 on the islands of a Central European lowland water reservoir, stressing the difference between semi-aquatic and terrestrial species. For semi-aquatic species, islands are a part of a continuous preferable habitat, whereas for terrestrial species they represent patches of suitable habitat separated by strong or slight barriers (depending on the species).

STUDY AREA

The monitored territory is the Central (Věstonice) reservoir, an artificial lake of 1017 ha, part of the Nové Mlýny reservoir cascade. The Central reservoir was completed in 1981; and it has been filled permanently since 1987. It is situated in squares no. 7165 and 7065 in the animal grid mapping system (SLAVÍK 1971). On two sides it is interconnected with two other lakes – the Upper (Mušov) and the Lower (Novomlýnská) reservoir. It is located at the junction of three rivers: Dyje, Jihlava and Svatka. The Dyje river reaches the Mušov reservoir, from which it flows into the Věstonice reservoir. The Jihlava and Svatka rivers (the Dyje's left-bank tributaries) meet about 300 metres before the Věstonice reservoir's backwater, and flow into it directly. In the vicinity of this inflow several islands can be found. The reservoir is located at the site of the former village of Mušov. When the village was being demolished, an embankment was piled up around the local church, later resulting in an island. The other islands in the reservoir were made in a similar way; 5 embankments and 4 islands were piled up. Some other islands were formed naturally from what is called "Věstonice sands". The total area of the islands is approximately 61 ha (Fig. 1, Table 1). At present, the vegetation and the condition of the islands is influenced, above all, by their management. On some of the islands, steppe-like or ruderal vegetation is maintained through annual mowing; some other islands are covered with gravel and kept free of any vegetation. Unmaintained islands have overgrown mainly with willows (*Salix* sp.) or the black locust (*Robinia pseudoacacia*). The reservoir freezes over irregularly.

Since 1993, the reservoir is part of a wetland of international significance, and in 1994 the Věstonice reservoir Nature Reserve was established there in order to protect the rich water bird nesting and roosting site. Since 2004 the locality is listed as a Special Protection Area (Birds Directive Site) in the European Union's Natura 2000 network. Five bird species are protected at the site: the white-tailed eagle (*Haliaeetus albicilla*), common tern (*Sterna hirundo*), greylag goose (*Anser anser*), bean goose (*Anser fabalis*), and white-fronted goose (*Anser albifrons*). Bird colonies are found on islands mainly in the western half of the reservoir.

Based on their character and location, the areas are classified into four island zones and one littoral zone (Fig. 1):

(1) **The fish factory zone** (Fish processing facility in Mušov) – a predominantly littoral zone comprising three islands with a solid basis in the south-western part of the reservoir. These represent the only remnants of the bridge pillars across the Dyje river. The islands are maintained, hosting colonies of the common tern (*Sterna hirundo*) and the black-headed gull (*Larus ridibundus*). Sporadically, the tufted duck (*Aythya fuligula*) nests there, too.

(2) **The zone around the Kostelní island.** These are artificial land elevations piled up in the western part of the reservoir, on the remains of the former village of Mušov. Numerous bird colonies of, above all, black-headed gulls (*Larus ridibundus*), common terns (*Sterna hirundo*) and Caspian/yellow-legged gulls (*Larus cachinnans/michahellis*) are found there. Birds also commonly nesting there include the greylag goose (*Anser anser*), gadwall (*Anas strepera*), mallard (*Anas platyrhynchos*) and red-crested pochard (*Netta rufina*). The Ivaňský island hosts colonies of tree-nesting species such as the great cormorant (*Phalacrocorax carbo*) or the black-crowned night heron (*Nycticorax nycticorax*).

(3) **The Jihlava and the Svatka confluence zone.** The area of the Jihlava and the Svatka confluence is a variegated area with islands, coves, varying water depth and large areas of littoral vegetation. As two larger streams (Svatka and Jihlava) meet at this point, migration and colonization by semi-aquatic mammals add further importance to this site. No ground-nesting bird colonies were found at the time of the survey. Single nests of the greylag goose (*Anser anser*), gadwall (*Anas strepera*), mallard (*Anas platyrhynchos*) and red-crested pochard (*Netta rufina*) were found.

(4) **The Písky islands and their surroundings** – the eastern part of the reservoir. Unlike the other islands, these were natural land elevations before the reservoir was completed. In the past they hosted steppe-like xerophytic species. After the reservoir was filled and before the islands became overgrown, there were large bird colonies of, in particular, common terns (*Sterna hirundo*) and black-headed gulls (*Larus ridibundus*).

No ground-nesting bird colonies were found at the time of the survey. Single nests of the greylag goose (*Anser anser*), gadwall (*Anas strepera*) and mallard (*Anas platyrhynchos*) were found.

(5) **The coastal zone** – littoral vegetation along the banks of the reservoir. This area is not specifically dealt with in this paper, although it is included to give a comprehensive overview of species occurrence.

METHODS

The five defined zones were surveyed in three seasons (four years): October–November 2009, April–June 2010, and September 2013–July 2014 (Table 2).

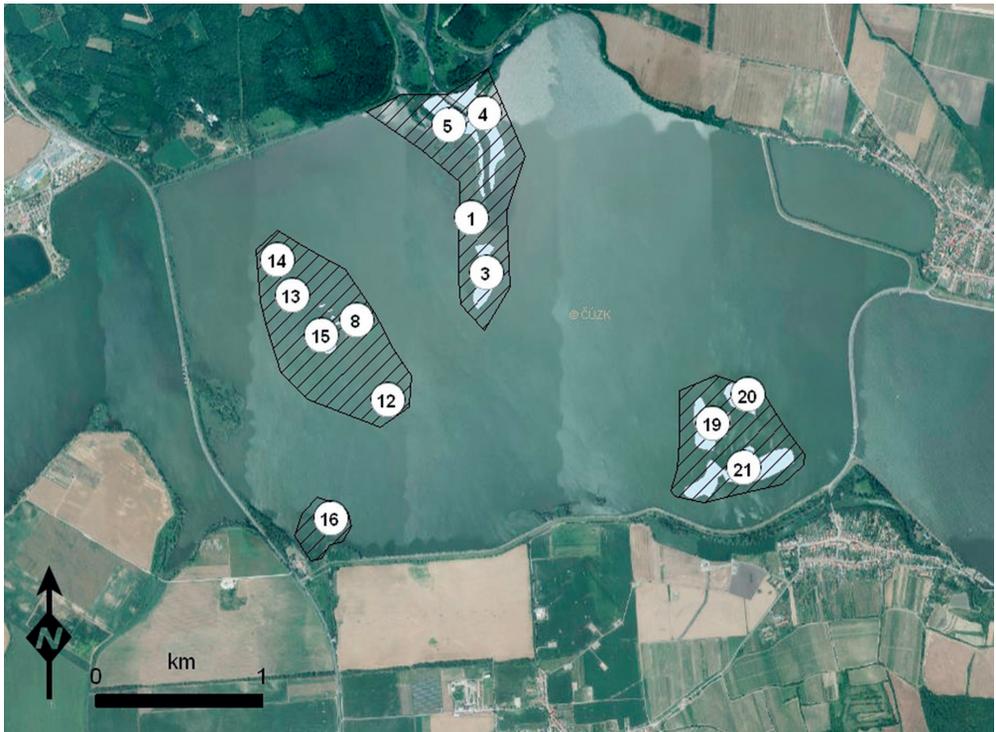


Fig. 1. Location of the islands at the Věstonice Reservoir. The fish factory zone: 16 – Pillars I–III; the zone around the Kostelní island: 8 – Deponie I–VI, 12 – Hřbitovní island, 13 – Ivaňská (old) road, 14 – Ivaňský island, 15 – Kostelní island; the Jihlava and Svratka confluence zone: 1 – island below the confluence, 3 – Southern Artificial island, 4 – Left Bank island at the confluence, 5 – Right Bank island at the confluence; the Písečný islands and their surroundings: 19 – Písečný s lagunou island, 20 – Písečný severní island, 21 – Písečný velký island.

Obr. 1. Umístění ostrovů na Věstonické nádrži. oblast u rybárny: 16 – Pilíř I–III; Oblast okolo Kostelního ostrova: 8 – Deponie I–VI, 12 – Hřbitovní ostrov, 13 – Ivaňská (stará) cesta, 14 – Ivaňský ostrov, 15 – Kostelní ostrov; oblast soutoku Jihlavy a Svratky: 1 – Ostrov pod soutokem, 3 – Jižní umělý ostrov, 4 – Levostranný ostrov na soutoku, 5 – Pravostranný ostrov na soutoku; Ostrovy Písečný a jejich okolí: 19 – Písečný ostrov s lagunou, 20 – Písečný ostrov severní, 21 – Písečný ostrov velký.

Table 1. Summary and characteristics of the islands of the Věstonice reservoir.

Tab. 1. Přehled a charakteristika ostrovů na Věstonické nádrži.

Explanations / vysvětlivky: zone: 1 – fish factory zone (fish processing facility in Mušov) / oblast u rybárny (Zpracovna ryb Mušov); 2 – zone around the Kostelní island / oblast okolo Kostelního ostrova; 3 – Jihlava and Svatka confluence zone / oblast soutoku Jihlavy a Svatky; 4 – Písky islands and their surroundings / ostrovy Písky a okolí; 5 – coastal zone / přibřežní zóna nádrže; area: in m², according to / plocha v m², podle <http://sgi.nahlizenidokn.cuzk.cz/marushka/>; D – distance from the shore (m) / vzdálenost od břehu (m); B – bird colony presence (colonies of gulls, terns, or large numbers of nesting pairs of geese and ducks on the island during the survey) / přítomnost ptačí kolonie (kolonie racků, rybáků, případně větší počet hnízdních párů husí a kachen na ostrově během průzkumu)

island name jméno ostrova	zone zóna	area plocha	D	B	habitat character typ biotopu
Pillar I	1	91	119	+	maintained – gravel
Pillar II	1	28	141	+	maintained – gravel
Pillar III	1	25	159	+	maintained – gravel
Hřbitovní	2	3,300	825	+	maintained – ruderal vegetation
Kostelní	2	21,400	750	–	maintained – ruderal, steppe-like, wetland vegetation
Deponie I	2	155	820	+	maintained – ruderal vegetation; since 2011 maintained – gravel
Deponie II	2	294	840	+	unmaintained – shrubs
Deponie III	2	1170	800	+	maintained – ruderal vegetation
Deponie IV	2	750	790	+	maintained – ruderal vegetation
Deponie V	2	896	795	+	maintained – ruderal vegetation
Deponie VI	2	703	790	+	unmaintained – shrubs
Ivaňská (old) road	2	647	799	+	unmaintained – ruderal vegetation, shrubs
Ivaňský	2	5700	590	+	unmaintained – shrubs and trees
below the confluence	3	364	990	–	unmaintained – shrubs; since 2013 maintained – gravel
Southern Artificial	3	112360	800	–	unmaintained – willow-poplar floodplain forest
left bank island at the confluence	3	132780	12	–	unmaintained – willow-poplar floodplain forest
right bank island at the confluence	3	153300	13	–	unmaintained – willow-poplar floodplain forest
Písečný s lagunou	4	47500	573	–	maintained – 1.4 ha steppe-like vegetation, remnants of willow-poplar floodpl. forest
Písečný severní	4	37700	570	–	unmaintained – black locust forest
Písečný velký	4	97900	130	–	maintained – 1 ha steppe-like vegetation, remnants of black locust and poplar forest

Several non-invasive methods were used: camera traps, monitoring rafts and tracking tunnels – all of them focused on medium-size to large mammal species. Additional methods included random observations and monitoring of animal tracks, scats and other signs.

Camera trap monitoring. Camera traps are automated cameras activated by a heat sensor. They photograph warm-blooded animals (birds and mammals). Camera traps were installed in places with a clear view, along animal paths, in open areas, in places where the animals leave the water etc. In order to increase

the probability of capturing the animals, baits were placed in front of the camera traps at a distance of 3–7 metres. Sardines, jam or stewed fruit were used as baits in all cases, and they were replaced during each inspection. In 2009–2010 the camera traps were set up to be active at night, approximately one hour before sunset and after sunrise. In 2013 and 2014 the camera traps were in operation all day. Two types of camera traps were used – Scout Guard and SpyPoint BF6.

Raft-based monitoring. Monitoring rafts are floating surfaces covered with a soft, permanently-soaked layer (a mixture of clay and sand), in which animals leave a track, allowing their detection. It is a standardized non-invasive monitoring method (REYNOLDS et al. 2004). Although developed specifically for the monitoring of the American mink, the rafts can also detect some other animal species frequenting lakesides and riversides (muskrats, water voles, brown rats etc.). Our rafts carried no bait, the animals visited them out of curiosity or because the shape of the vegetation-covered raft resembled the nest of certain water birds (POLEDNÍK & POLEDNÍKOVÁ 2010). The rafts were placed adjacent to the island shores or along dam banks.

Tracking tunnel monitoring. A method used for the identification of up to marten-like animals. It detects animals that like tunnels and corridors. An ink-soaked area is installed on the floor inside the tracking tunnel, with paper strips at both ends for recording footprints as the animal leaves the tunnel. A commercially available product – GOTCHA TRAPS (New Zealand) – was used.

Random observations and monitoring tracks, scats and other signs. During all visits to the site, all observations relating to mammals were recorded. We inspected places with a suitable ground (muddy areas, ashes, sands etc.) and looked for mammal footprints. Areas with a potential to find other animal signs, especially scat and food remains were also checked.

RESULTS

The monitoring effort in 2009–2014 was at least 2674 “raft-nights”, 1759 “camera trap-nights” and 160 “tunnel-nights” (see Table 2).

Overall, 13 medium-size to large mammal species were identified on the islands of the Věstonice reservoir: five rodent (Rodentia) species, six carnivore (Carnivora) species, and two even-toed ungulate (Artiodactyla) species (see Table 3). The total species richness differed among the zones, being highest in the Jihlava and Svratka confluence zone (n=13), followed by the Písky islands (n=9), the zone around the Kostelní island (n=7) and the fish factory zone (n=7). Most of the semi-aquatic mammals were the same for all the zones: the water vole, muskrat, coypu, beaver and otter. However, in the Jihlava and Svratka confluence zone other two alien semi-aquatic carnivores were recorded: the American mink and the raccoon.

Table 2. Summary of monitoring effort at the Věstonice reservoir – number of trap-nights (number of positions)

Tab. 2. Souhrn monitorovacího úsilí na Věstonické nádrži – počet expozičních nocí (počet posic)

year rok	rafts rafty	camera traps fotopasti	tracking tunnels přůchozí tunely	total úhrnem
2009	573 (18)	175 (7)	0	748 (25)
2010	768 (17)	348 (12)	160 (5)	1276 (34)
2013	452 (10)	416 (4)	0	868 (14)
2014	881 (10)	820 (6)	0	1701 (16)
total	2674 (55)	1759 (29)	160 (5)	4593 (89)

Table 3. List of medium-size to large mammals recorded at the Věstonice reservoir; species registered on the islands are in bold.

Tab. 3. Přehled středně velkých až velkých savců zaznamenaných na Věstonické nádrži; druhy zjištěné na ostrovech jsou označeny tučně.

Explanations / vysvětlivky: 1 – fish factory zone / oblast u rybárny; 2 – zone around the Kostelní island / oblast okolo Kostelního ostrova; 3 – Jihlava and Svatka confluence zone / oblast soutoku Jihlavy a Svatky; 4 – Písky islands and their surroundings / ostrovy Písky a okolí; 5 – coastal zone / příbřežní zóna nádrže; rf – raft / raft; ct – camera trap / fotopast; ob – observation / pozorování

species / druh	zone / zona					year / rok				method / metoda		
	1	2	3	4	5	2009	2010	2013	2014	rf	ct	ob
<i>Castor fiber</i>	+	+	+	+	+	+	+	+	+	+	+	+
<i>Arvicola amphibius</i>	+	+	+	+	+	+	+	+	+	+	?	+
<i>Ondatra zibethicus</i>	+	+	+	+	+	+	+	+	+	+	+	+
<i>Rattus norvegicus</i>	+	–	+	–	+	+	+	+	+	+	–	+
<i>Myocastor coypu</i>	+	+	+	+	+	+	+	+	+	+	+	+
<i>Mustela erminea</i>	–	–	–	–	+	–	+	–	–	–	–	+
<i>Mustela putorius</i>	–	–	+	–	–	+	+	–	–	–	+	–
<i>Neovison vison</i>	–	–	–	–	+	–	+	+	+	+	–	–
<i>Martes foina</i>	–	+	+	+	+	+	+	+	+	–	+	+
<i>Meles meles</i>	–	–	–	+	–	–	–	–	+	–	+	–
<i>Lutra lutra</i>	+	+	+	+	+	+	+	+	+		+	+
<i>Vulpes vulpes</i>	–	–	+	+	–	–	–	+	+	–	+	+
<i>Procyon lotor</i>	–	–	+	–	–	–	+	–	–	+	–	–
<i>Sus scrofa</i>	–	–	+	–	–	+	+	+	+	–	+	+
<i>Capreolus capreolus</i>	+	+	+	+	+	+	+	+	+	–	+	+

When considering terrestrial mammals only, the results are similar: the highest number of species was found in the Jihlava and Svatka confluence zone (n=6), followed by the Písky islands (n=4), the zone around the Kostelní island (n=2) and lowest numbers in the fish factory zone (n=1).

Apart from the focal group of mammals – medium-size to large mammals – other species of mammals were recorded by chance. These include three bat (Chiroptera) species: the common pipistrelle (*Pipistrellus pipistrellus*), Daubenton's bat (*Myotis daubentonii*) and the common noctule (*Nyctalus noctula*), and three small rodent (Rodentia) species: the yellow-necked mouse (*Apodemus flavicollis*), the bank vole (*Clethrionomys glareolus*), and the harvest mouse (*Micromys minutus*).

Comments concerning the identified species

Eurasian beaver (*Castor fiber*) – repeatedly detected in the study area. Also, in all zones beaver resting places (lodges or holes) were found, and it is likely that one or more beaver families live in each zone seasonally or throughout the year.

Muskrat (*Ondatra zibethicus*) – repeatedly detected in all zones, inhabits all larger islands (Kostelní, Hřbitovní, Ivaňský, islands in the Jihlava and Svatka confluence zone, and the Písky islands).

European water vole (*Arvicola amphibius*) – repeatedly detected on all larger islands (Kostelní, Hřbitovní, Ivaňský, islands near the confluence, and the Písky islands). Produces soil excavations in most places.

Brown rat (*Rattus norvegicus*) – detected by rafts repeatedly during 2010, in the Jihlava and Svratka confluence zone. In 2013 and 2014 registered in the fish factory zone and in the coastal zone at the northern dam. So far it has not been found on the more distant islands.

Coypu (*Myocastor coypu*) – repeatedly detected by both camera traps and raft monitoring: in the Jihlava and Svratka confluence zone (2009), on the Kostelní island and on the Písky islands (2010) and it was registered again during the 2013 and 2014 monitoring, on the islands of Kostelní and Hřbitovní, on the Písky islands, and at the northern dam.

Stoat (*Mustela erminea*) – not found on the islands, it was observed once below the northern dam in the spring of 2014.

European polecat (*Mustela putorius*) – captured twice by camera traps on the islands in the Jihlava and Svratka confluence zone, during the 2009 and 2010 monitoring.

American mink (*Neovison vison*) – during the 2009 and 2010 raft monitoring it was only detected once in the latter year, at the dam near the Jihlava and Svratka confluence. In the same year, footprints and a latrine were found under the bridges over the Jihlava river, in the close vicinity of the reservoir (800 m). The mink was, therefore, present in the wider area. The 2013 and 2014 survey outlined a different situation: the mink was detected repeatedly and all along the banks of the reservoir. The average visitation frequency of the rafts located at the shore of the Věstonice reservoir was one footprint per 1341 “raft-nights” in 2009 and 2010, increasing to one footprint per 266 “raft-nights” during 2013 and 2014. Thus, comparable data indicate that the mink colonization of the locality took place in these particular years. The mink has not been found on the islands yet.

Stone marten (*Martes foina*) – captured repeatedly by camera traps on the Kostelní island between 2009 and 2014. Each registered snapshot or observation concerned a single specimen of the species. Food remains were found in the church tower and attic. The stone marten was also repeatedly recorded on the Left Bank island at the Jihlava and Svratka confluence. Scat was found on both islands. In 2010 the species was also found on the Písečný severní island. It was only registered there twice and no scat was found before or after.

European badger (*Meles meles*) – a single occurrence confirmed by camera traps on the Písečný velký island in February 2014.

European otter (*Lutra lutra*) – its scat was found repeatedly in suitable places practically on all islands, and the species was frequently captured by camera traps too.

Red fox (*Vulpes vulpes*) – repeatedly detected in the Jihlava and Svratka confluence zone and on the Písky islands too. No evidence of occurrence of the species on distant islands was collected.

Northern raccoon (*Procyon lotor*) – detected only once, in 2009, on a raft in the Jihlava and Svratka confluence zone.

Wild boar (*Sus scrofa*) – the species was captured repeatedly by camera traps and left its footprints on the islands near the Jihlava and Svratka confluence.

European roe deer (*Capreolus capreolus*) – captured by camera traps or seen on all larger islands: repeatedly on the islands in the Jihlava and Svratka confluence zone, on the Southern

Artificial island, and on the Písky islands; it was, however, also once spotted on the Kostelní island, in the reeds along the shore in the fish factory zone (2009), and once swimming in the middle of the reservoir. A fawn was found on the Southern Artificial island in 2013.

Daubenton's bat (*Myotis daubentonii*) – detected in 2010 by a camera trap on the island below the confluence; according to its coloration and flitting above water surface it was identified as a Daubenton's bat, although it was impossible to verify the species. In the autumn of 2014, a group of bats was seen hunting between the Písky islands and the dam.

Common pipistrelle (*Pipistrellus pipistrellus*) – one specimen was registered in the spring of 2012 inside the church tower (the Kostelní island).

Common noctule (*Nyctalus noctula*) – foraging individuals registered in the autumn of 2014.

an unidentified bat – old tracks and signs (a pile of droppings) of a larger bat species found in the attic of the church.

Bank vole (*Clethrionomys glareolus*) – registered once in the summer of 2014 on the Písečný velký island.

Harvest mouse (*Micromys minutus*) – a nest was found in the summer of 2012 on the Ivaňský and the Kostelní island.

Yellow-necked mouse (*Apodemus flavicollis*) – inhabits all larger islands (Kostelní, Hřbitovní, Ivaňský island, on the islands in the Jihlava and Svatka confluence zone, and the Písky islands). Gradation of numbers was observed in certain years. For instance, in the summer of 2012 hundreds of individuals were registered on the Kostelní island.

DISCUSSION

Methods

The objective of all surveys undertaken in this study was to monitor semi-aquatic predators that can affect colonies of nesting birds. Thus, the monitoring design and methods were selected to record medium-size to large mammalian species. Monitoring rafts represent a suitable method for the identification of semi-aquatic mammal species. The rafts were developed specifically for the monitoring of the American mink, but they can also detect some other animal species frequenting lakesides and riversides – muskrats, water voles, brown rats, raccoons etc. (REYNOLDS et al. 2004, POLEDNÍK & POLEDNÍKOVÁ 2010). The height of the roof of rafts used pre-determined the raft for the monitoring of animals not bigger than the mink (water vole, muskrat). However, the tracks of the Eurasian beaver, coypu, racoon and otter were also detected on the rafts occasionally.

Response time (i.e. how soon the animal gets photographed after the sensor detects it) is a limiting factor in camera traps. The traps used have the triggering time around 1.4 seconds and are suitable for detecting species that are medium- to large-size and move about relatively slowly – such as even-toed ungulates, canids (foxes, raccoon dogs, feral dogs) and procyonids (raccoons), larger rodent species (beavers, coypus, muskrats, water voles, rats); and mustelid species including namely the otter, badger, stone marten, and polecat. The American mink is, according to our experience, difficult to capture by camera traps, probably due to its small size, thermo-isolation and quick way of moving.

Tracking tunnels were also utilized in the 2010 monitoring. This method is used for the detection of smaller mustelid species such as the stoat and the weasel (KING et al. 1994).

Other mammal species such as small terrestrial rodents (Rodentia), insectivores (Eulipotyphla) or bats (Chiroptera) were out of the scope of the survey, and data concerning these species were usually gathered randomly, as a by-product of the above-mentioned methods. Data about these particular species on the islands need to be considered incomplete and the presence of these groups deserves further survey.

Species identified on the islands

Overall, 15 medium-size to large mammal species were identified on the islands of the Věstonice reservoir or its shore. The same number of species (15) was observed on the islands on the Vistula river in Poland, representing an area of 50 ha in total (ROMANOWSKI et al. 2008). The focal species composition was rather similar, differing in occurrence of four more species on the islands of the Věstonice reservoir (coypu, polecat, stone marten, and raccoon). Two species are alien in Europe and thus probably not established in the study area on the Vistula river. The European polecat was recorded twice on the island close to the mainland (12 m). The phenomenon of occurrence of the stone marten on islands is unique for the Věstonice reservoir.

According to their way of life and the aspects of their occurrence, the identified mammals can be classified into two groups.

The first group consists of mammals that permanently inhabit the entire reservoir area including the islands because aquatic habitat is their preferable habitat type. These are semi-aquatic mammals with an ability to manoeuvre in water effortlessly, such as the Eurasian beaver, European water vole, muskrat, coypu and European otter which were recorded repeatedly there. Given their life history and habitat requirements, their occurrence on the islands is not surprising but natural and their presence at the reservoir has been already known from previous distribution surveys (ANDĚRA & GAISLER 2012). Additionally, two other semi-aquatic species, the American mink and the racoon, were recorded sporadically in the area, although the habitat is suitable there. We can expect the colonisation of the islands in the near future. The American mink is already widely distributed in the Czech Republic and also the mainland around the Věstonice reservoir was colonised by the mink in 2012 (ANDĚRA & GAISLER 2012). As four of the species mentioned above (muskrat, coypu, American mink and racoon) are non-native species and are potentially dangerous predators for ground-nesting birds, active management of these species is recommended.

The mammals in the second group are primarily terrestrial, their island settlements being a secondary habitat (or their populations persist since the flooding of the reservoir). The islands as such are “patches” of usable habitat surrounded with a temporary or permanent barrier of unsuitable habitat (water). All terrestrial mammals regularly occur in the mainland surrounding the Věstonice reservoir (ANDĚRA & GAISLER 2012). The key factor determining their occurrence was the degree of isolation of the islands, the distance from the shore. The most accessible islands are three islands in the confluence of the Jihlava and Svatka rivers, which hold the highest number of terrestrial species, followed by the Písky islands with moderate distance from the mainland. Even the most distant islands (in the zone around the Kostelní island) are used by several terrestrial mammal species. On relatively accessible islands in the fish factory zone, located 119, 141 and 159 m from the shore, no terrestrial mammals were identified. These islands are quite small (approximately 47.93 m²) and provide no hiding places. These findings

are in concordance with the American study of islands on the Snake river (ZOELLICK et al. 2004, 2005), where the key factors influencing the occurrence of predators on the islands were the degree of isolation of the islands together with water flow rate (negligible in our study).

Comments on selected species / groups of species

American mink

The American mink was proved at the shore of the Věstonice reservoir in very close vicinity of the islands in the Jihlava and Svratka confluence zone. So far no mink has been recorded on the islands with bird colonies. The increase in visitation frequencies amongst the years suggests gradual colonization of the site. The average visitation rate recorded on two sites with a long-term mink settlement in the Czech Republic is about one footprint per 25–63 “raft-nights”, whilst at newly occupied places it varies between one footprint per 354–1200 “raft-nights” (POLEDNÍK & POLEDNÍKOVÁ 2010). Thus the visitation rate at the Věstonice reservoir shore revealed by the present study corresponds to early establishment of the American mink population in the area. This conclusion is also supported by the fact that the rafts with the mink tracks were located at the northern bank of the Věstonice reservoir – close to the main potential migration route of the mink, the Jihlava river, where the species is present in a long term (ANDĚRA & GAISLER 2012).

Brown rat

The presence of brown rat follows a similar pattern to that of the American mink. As the detectability of the species using rafts and camera traps is relatively high, it can be concluded that the rat appears quite rarely in the area, only in the Jihlava and Svratka confluence zone and the coastal zone. No rats have been recorded on islands with bird breeding colonies so far.

Stone marten

Apart from the islands near the Jihlava and Svratka confluence zone – which are separated from the mainland by a relatively narrow canal (about 12 m) and, therefore, easily accessible – the marten was also identified on more distant islands, too: namely, on the Kostelní island (located 750 m from the mainland) and on the Písečný severní island (570 m).

On the Kostelní island (area of 2.1 ha) at least one marten lives permanently: it was detected during all monitoring activities, and its tracks and signs are regularly found there. The size of the stone marten’s home territory ranges between 12 and 211 ha, becoming larger in summer and smaller in winter; males have larger territories than females, and adult martens have larger territories than immature individuals (WILSON & MITTELMEIER 2009). Compared to these facts, the island inhabited by the marten is about six times smaller than the minimum registered territory. Therefore, the question is whether the marten uses the neighbouring islands as well, or whether its home territory also includes the banks of the reservoir, located at least 750 m from the island. Or whether the home range of this individual is small in size (as the area of the particular island) but big enough to survive, or whether the individual swims regularly. No martens were detected by camera traps on the neighbouring islands, and no scats have ever been found there. The stone marten is an opportunist eater, making use of whatever food is currently available resulting in either a broad diet spectrum (ANDĚRA & GAISLER 2012) or high level of specialization on single prey species, e.g. the water vole (WILSON & MITTELMEIER 2009). The Kostelní island hosts a strong water vole population, it is located near bird nesting colonies; some birds even build their nests on the very island. The stone marten was not found on the Vistula river islands in Poland, despite inhabiting both banks of the river (ROMANOWSKI et al. 2008).

On the Písečný severní island (area of 3.7 ha) the stone marten was only registered once, and no tracks and signs were found. Considering the small size of the island and therefore the high potential detectability by camera traps, the fact that martens tend to accept bait readily, and that scat is quite easy to find, we can conclude that the marten does not inhabit the island permanently. As it was detected in the spring period, it is evident that it was a migrant that reached the island by swimming across the water.

Red fox

The fox inhabits both islands in the Jihlava and Svratka confluence zone and the Písky islands. The size of their home range depends on the habitat, and tends to range between less than 40 up to 4000 ha (WILSON & MITTELMEIER 2009), whereas the total area of these islands is much smaller. Therefore the territory of foxes recorded on the islands in the Jihlava and Svratka confluence zone and the Písky islands must also include a part of the mainland, located 12 m and 130 m, respectively, from the islands. Even about 4-month-old cubs were captured by camera traps on the Písečný velký island. However, as this was the only record of the fox family there, we suppose that the island was not the area of reproduction and all the family just swam there once.

Badger

The species probably does not inhabit the islands permanently. It was only registered once by a camera trap on the Písečný velký island; no tracks and signs such as footprints have been found. If the badger lived there permanently, it would have been detected several times, considering the relatively small size of the island (9.7 ha). The badger was also regularly spotted on the Vistula river islands in Poland (ROMANOWSKI et al. 2008). However, the size of the Písečný velký island is too small to constitute the complete home range of an individual badger, as e.g. in England the size of the badger territory ranged between 50 and 150 ha, and in Białowieża between 840 and 2550 ha (WILSON & MITTELMEIER 2009). It is, therefore, likely that the species uses the relatively accessible Písky islands rather occasionally.

Small terrestrial mammals on the islands

Small terrestrial mammals such as the bank vole, harvest mouse and yellow-necked mouse were identified on the islands. The question is whether they had migrated to the islands or whether their populations persist since the flooding of the reservoir (about 1981) – and, therefore, to what extent they are isolated from the mainland populations. GLIWICZ (1980) and ROMANOWSKI et al. (2008) postulate that if small rodents find suitable conditions on islands, their populations there reach a higher density compared to open populations in the mainland countryside. However, the density of small rodents was not studied consistently, so it is not really possible to compare it with the results of other surveys.

Bats

From the Chiroptera order, the common pipistrelle (*Pipistrellus pipistrellus*) was randomly spotted in the church; probable finds include the Daubenton's bat (*Myotis daubentonii*) and the common noctule (*Nyctalus noctula*). Nevertheless, there are a number of potential hideouts on the islands, so it is likely that the reservoir in fact hosts more chiropteran species.

SOUHRN

Na ostrovech a v přibřežní zóně PR Věstonická nádrž proběhl v letech 2009–2014 monitoring středně velkých až velkých savců. Jako jeho metody byly zvoleny především plovoucí rafty s celkovým počtem

min. 2674 “raftonoci” a fotopasti s celkovým počtem min. 1759 “past'onoci”. Celkem bylo na ostrovech Věstonické nádrže zjištěno 13 druhů středně velkých až velkých druhů savců: pět druhů hlodavců (Rodentia), šest druhů šelem (Carnivora) a dva druhy sudokopytníků (Artiodactyla). Oblast byla rozdělena podle ostrovů a jejich vzdálenosti od pevniny na zóny. Bohatost druhů se mezi jednotlivými zónami lišila. Nejvyšší byla v oblasti soutoku Jihlavy a Svratky (n=13), následována soustavou ostrovů Pisky (n=9), oblastí okolo Kostelního ostrova, kde jsou ostrovy nejvzdálenější (n=7) a oblastí u rybárny, kde je nejmenší rozloha ostrovů (n=7). Většina semiakvatických savců byla pro všechny zóny stejná: hryzec vodní (*Arvicola amphibius*), ondatra pižmová (*Ondatra zibethicus*), nutrie říční (*Myocastor coypu*), bobr evropský (*Castor fiber*) a vydra říční (*Lutra lutra*). Nicméně v oblasti soutoku Jihlavy a Svratky byly zaznamenány dvě invazní semiakvatické šelmy: norek americký (*Neovison vison*) a mýval severní (*Procyon lotor*). Pokud bereme v úvahu pouze terestrické savce, jsou výsledky obdobné: nejvyšší počet druhů byl v oblasti soutoku Jihlavy a Svratky (n=6), následována soustavou ostrovů Pisky (n=4), oblast okolo Kostelního ostrova (n=2) a nejnižší čísla v oblasti u rybárny (n=1). Zajímavý je trvalý výskyt kuny skalní (*Martes foina*) na Kostelním ostrově.

A c k n o w l e d g e m e n t s

The publication of this paper was supported by the Operational Programme Cross-Border Cooperation Slovak Republic – Czech Republic 2007–2013, which provided financial aid to the project “NEOVISION – New challenges in the protection of biodiversity on the Czech and Slovak border territory”, no. 22420220026. The project was also funded from the public budget of the Czech Republic. Monitoring in 2009 and 2010 was funded from the budget of the South Moravian Region administration. Thanks are due to our colleagues and collaborators Petr BERKA, Sergi MUNNE, Štěpán ZÁPOTOČNÝ for their help in field survey and support.

REFERENCES

- ANDĚRA M. & GEISLER J., 2012: *Savci České republiky: popis, rozšíření, ekologie, ochrana* [Mammals of the Czech Republic: Description, Distribution, Ecology, Conservation]. Academia, Praha, 285 pp (in Czech).
- BARTOSZEWICZ M. & ZALEWSKI A., 2003: American mink, *Mustela vison* diet and predation on waterfowl in the Słońsk Reserve, western Poland. *Folia Zoologica*, **52**: 225–238.
- CRAIK J. C. A., 1995: Effects of North American mink on the breeding success of terns and smaller gulls in west Scotland. *Seabird*, **17**: 3–11.
- CRAIK J. C. A., 1997: Long-term effects of North American Mink *Mustela vison* on seabirds in western Scotland. *Bird Study*, **44**: 303–309.
- CRAIK J. C. A., 1998: Recent mink-related declines of gulls and terns in west Scotland and the beneficial effects of mink control. *Argyll Bird Report*, **14**: 98–110.
- CRAIK J. C. A., 1999: Breeding success of common gulls *Larus canus* in west Scotland I. Observations at a single colony. *Atlantic Seabirds*, **1**(4): 169–181.
- CRAIK J. C. A., 2000: Breeding success of common gulls *Larus canus* in west Scotland II. Comparisons between colonies. *Atlantic Seabirds*, **2**(1): 1–12.
- CRAIK J. C. A. & CAMPBELL B., 2000: Bruce Campbell's islands revisited: changes in the seabirds of Loch Sunart after half a century. *Atlantic Seabirds*, **2**(3–4): 181–194.
- GLIWICZ J., 1980: Island populations of rodents: their organization and functioning. *Biological Reviews*, **55**(1): 109–138.
- KING C. M., O'DONNELL C. F. J. & PHILLIPSON S. M., 1994: *Monitoring and Control of Mustelids on Conservation Lands*. Department of Conservation, Wellington, New Zealand, 36 pp.
- POLEDNÍK L. & POLEDNÍKOVÁ K., 2010: *Monitoring, regulace a eradikace norka amerického v České republice – metodická doporučení* [Monitoring, Regulation and Eradication of the American Mink in the Czech Republic – Methodical Recommendations]. ALKA Wildlife, o.p.s., Peč, 30 pp (in Czech).

- REYNOLDS J. C., SHORT M. J. & LEIGH R. J., 2004: Development of population control strategies for mink *Mustela vison*, using floating rafts as monitors and trap sites. *Biological Conservation*, **120**: 533–543.
- ROMANOWSKI J., 2007: Vistula river valley as the ecological corridor for mammals. *Polish Journal of Ecology*, **55**(4): 805.
- ROMANOWSKI J., DUDEK D. & KOWALCZYK K., 2008: The role of islands in maintaining the connectivity of habitat for mammals in middle Vistula river valley. *Ecohydrology & Hydrobiology*, **8**(2): 411–418.
- SLAVÍK B., 1971: Metodika síťového mapování ve vztahu k připravovanému fytogeografickému atlasu ČSR [Methodics of the grid mapping in the concern of the prepared phytogeographical atlas of the Czech Republic]. *Zprávy Československé Botanické Společnosti*, **6**: 55–62 (in Czech).
- WILSON D. E. & MITTERMEIER R. A. (eds.), 2009: *Handbook of the Mammals of the World. Volume 1. Carnivores*. Lynx Edicions, Barcelona, 727 pp.
- ZOELICK B. W., ULMSCHNEIDER H. M., CADE B. S. & STANLEY A. W., 2004: Isolation of snake river islands and mammalian predation of waterfowl nests. *Journal of Wildlife Management*, **68**: 650–662.
- ZOELICK B. W., ULMSCHNEIDER H. M. & STANLEY A. W., 2005: Distribution and composition of mammalian predators along the Snake river in southwestern Idaho. *Northwest Science*, **79**(4): 265.