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Smooth newt *Lissotriton vulgaris* and common toad *Bufo bufo* populations persisting in the unusually small area of Sommers Island in the Baltic Sea

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ABSTRACT - Sommers Island is an abandoned 20 ha patch of land in the Baltic Sea. It is inhabited by isolated populations of smooth newt (*Lissotriton vulgaris*) and common toad (*Bufo bufo*). The island demonstrates the small area in which it is possible to have a stable population of newts and toads for a period of at least several decades, probably much longer. Most reproduction of both species occurred in one pool with an area of about 100 m². The total area of optimal terrestrial habitat is about 2.5 ha, with an additional 3.5 ha of sub-optimal habitat available. The island is inhabited by about 123 adult newts and several dozen adult toads.

INTRODUCTION

Habitat loss and fragmentation threaten the stability of animal populations (Haddad et al., 2017). Consequently, it is important to understand the minimum possible population size and minimal habitat area required for the survival of particular species (Reed et al., 2003). This information is urgently needed for amphibians due to the global declines of the past few decades. Even species that were considered to be common and abundant have experienced drastic reductions in their numbers because of pollution, climate change, the spread of the infectious fungus *Batrachochytrium*, and other factors (D'Amen & Bombi, 2009; Denoel, 2012; Houlahan et al., 2000; Spitzen-van der Sluijs et al., 2016). The minimal size of an amphibian population can be estimated by both monitoring and the modelling of reproductive rates (Petranka et al., 2004). Further information can be gained by examining extremely small populations that have been stable for a long time especially those on small, isolated islands. We discovered an apparently stable population of amphibians on the small Sommers Island located in the Baltic Sea. Herein we present our observations of the size of amphibian habitats and the number of breeding adults on Sommers Island.

MATERIALS AND METHODS

Study site

Sommers Island is located in the Gulf of Finland of the Baltic Sea. It occupies an area of about 20 ha and has a complex shape consisting of several headlands connected by small necks of land (Fig. 1). The distance to the mainland, i.e. to the northern coast of the Gulf of Finland, is 34 km. The other nearest land is Moschny Island, which is larger and 22 km away. The water around Sommers Island is brackish, salinity usually fluctuates from 2 – 3 ‰, but can reach 5‰ (Batalkina et al., 2007). Typical marine fishes (mainly herring) occur there (Popov, 2014).

The island represents a congregation of rocks, partly covered by a thin layer of soil and with sparse tree cover. General information on its environment is scarce, with few scientific publications on this topic. The island was annexed by Russia after the war with Sweden in 1722, at which time it was unpopulated (Bergholtz, 2018), and not used by people until 1808, when a lighthouse and a caretaker's house were built there. After the Second World War, a new lighthouse was built on the island, which still exists, and later on a military base was constructed. In 2005, an automatic radio tower was built and the island abandoned. Since then, the island is very rarely visited by people. Military specialists occasionally visit to maintain the radio tower, but visits by other people are usually not allowed. Access by researchers is difficult. The 'discovery' of the island in biological terms occurred only in 2017 during an expedition of the Russian Geographical Society. It turned out that animals had colonised or re-colonised the island, and a relatively rich fauna was forming: 23 species of birds, two species of mammals and two amphibian species were found. The two amphibians were the smooth newt, *Lissotriton vulgaris*, and the common toad, *Bufo bufo*. Although these two species are considered common and are widely distributed on the mainland, populations of smooth newt, and to a lesser extent common toad, have been reportedly declining (Kinne, 2006; Cooke, 1972; Carriera & Beebee, 2003). For newts, the main threats are destruction of small water bodies suitable for their reproduction, the introduction of fishes into their breeding sites, and pollution (Skei et al., 2006). Cases of the extinction of newt populations and other amphibians due to the invasive Chinese sleeper, *Perccottus glenii*, have been reported in adjacent regions (Reshetnikov, 2003).

Figure 1. Sommers Island: aerial photograph and scheme of its location (available from https://www.bing.com/ [accessed 8 December 2017])

Observations of breeding adults

We observed and photographed the island from the lighthouse. The lighthouse is 53 m high, and is located on a hill 16 m high. This height allows observation of the entire surface of the island. Visually and with the help of photographs, we determined the type and location of distinct habitats, including water bodies suitable for amphibian reproduction. We identified nine small pools that could be used for breeding by one or both amphibian species (Table 1). After identifying the pools, we visited them and delineated their boundaries using GPS Garmin Etrex 20. In this way, we composed a map of the habitats of the island (Fig. 2).

The time of year for which we were granted access to the island coincided with the breeding season of *L. vulgaris*; consequently, we were able to count breeding adults, which were concentrated in the shallow pools located in depressions in granite rocks. We surveyed for newts in the pools for eight days (7-14th June 2017). Two observers participated in the counts, walking around the perimeter of pools during daytime. Most newts were concentrated just in one pool, which is the largest one; we counted newts there each day. We inspected the other eight pools 2-5 times and performed the final observations on 14th June. We used the highest number counted as an estimate of the total number of breeding adults. The common toads had bred prior to our surveys, and tadpoles were already abundant in June; therefore, we were not able to count breeding adult toads. We estimated their distribution based on the locations we found adults on land and the tadpoles in the pools.

RESULTS

We identified several habitats on the island, including bogs, grasslands, different 'forest' types, plots of shrubs and barren land. We found evidence of amphibians breeding in nine pools, with newts breeding in all of them; however, we found toad tadpoles in only four pools (Fig. 2, Table 1). Most newts occurred in the largest pool, with a maximum area of 100 m² and a depth of 10-40 cm (Fig. 3). The size of the pool fluctuated depending on precipitation, but it cannot be larger than the maximum dimensions given here since, being on the top of a rock, any water added would just overflow. During periods of low air temperature, the newts were not active, but when the air temperature increased, we found dozens of them. During the eight days of the survey we counted the following numbers of newts in the largest pool: 5, 4, 16, 35, 55, 11, 10, and 93. Moreover, we found 18 recently dead adult newts. Probably, they became frozen (the frosts often happen in spring in the studied area). In the other pools, we usually found two or three newts, but did find as many as 15 (Table 1). The maximum number of breeding adults newts recorded was 123.

The pool with the highest number of newts was located in optimal habitat for summer activity on land. It was close to the alder 'forest' and grasslands originating from the abandoned settlement (military post) (Table 2). Here there is relatively fertile soil and dense vegetation, which could support small invertebrates suitable for newt consumption. Moreover, an accumulation of dead reeds and wood was found on the shore close to the alder 'forest'. It is also

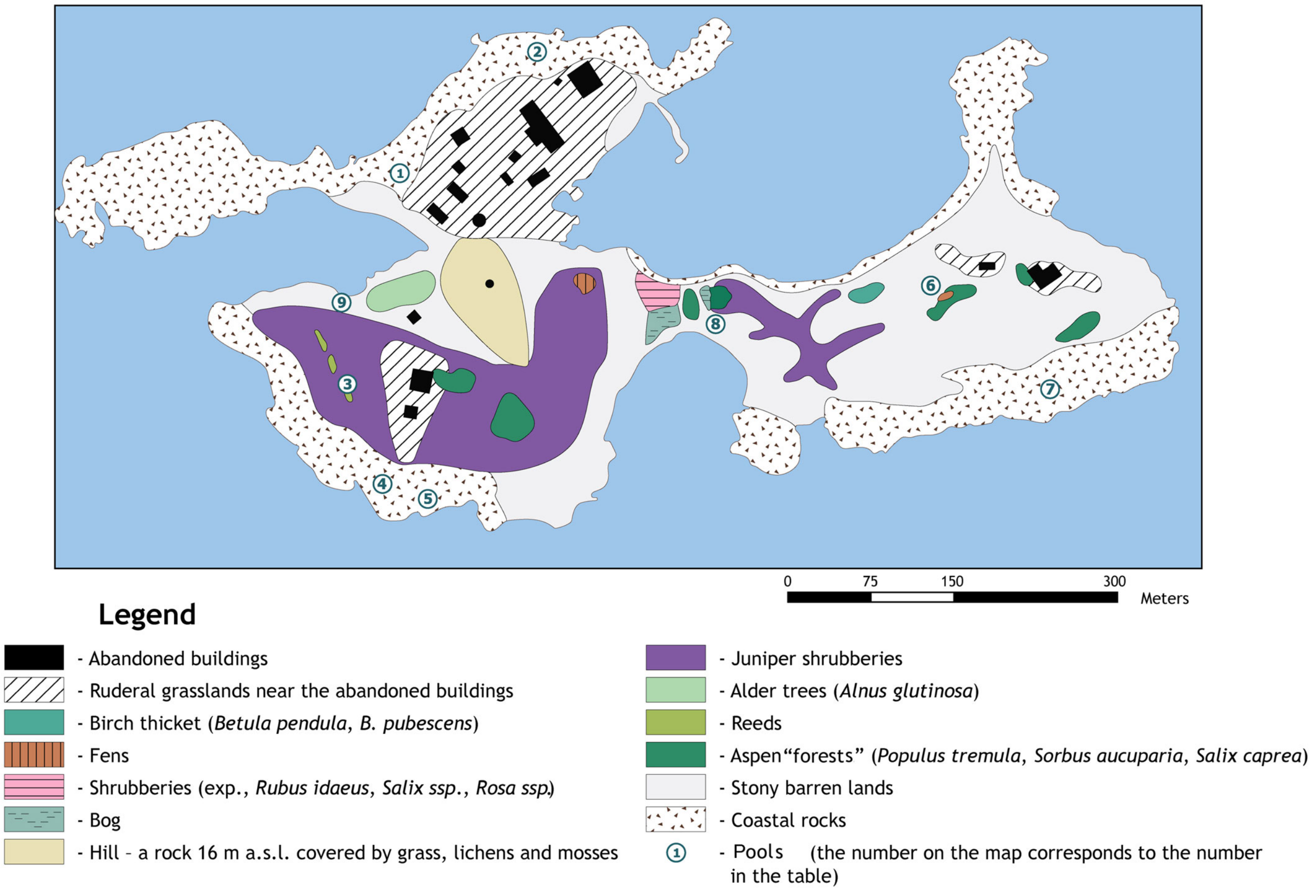

Figure 2. The location of habitats on Sommers Island

suitable for the summer activity of newts, one newt juvenile (3 cm long) was found there. The other pools are surrounded by less productive habitats. The trees and grasslands are sparser there. The main part of the island is hardly suitable for newts. There is no continuous soil and plant coverage, and rocks covered by a thin layer of lichens occupy the main part of the island. The total area of optimal habitat for newts is about 2.5 ha, which is supplemented by 3.5 ha of sub-optimal habitat (shrubs, aspen 'micro-forest' and birch thickets).

As for the toads, just nine adult individuals were observed. These were in the grasslands around the abandoned buildings in the western part of the island. In the pools nearby, several thousand toad tadpoles were observed. Moreover, a small number of tadpoles was noted in the eastern part as well; there are also small plots of grassland associated with the remains of fortifications. Like newts, the toads tended to occupy the habitats with relatively high productivity, so the terrestrial habitats may be the same for both species. Given the limited habitat, the total number of toads may be no more several dozen individuals.

Potential natural enemies of amphibians on the island are not numerous. Snakes were not observed, and mammals are represented by grey seal (*Halichoerus grypus*) and northern bat (*Eptesicus nilssonii*) which are not known to affect amphibians. Furthermore, the island is primarily an open area in which the mammals and snakes, or the indications of their activity, would be clearly visible. It is unlikely that any species would remain undetected. Among the birds, perhaps, some of them could occasionally eat amphibians. Currently, the number of birds on the island is growing and, possibly, in the future this could affect the amphibian populations. Now there are mostly gulls and terns that feed at sea, but also occasional ravens (*Corvus corax*), kestrels (*Falco tinnunculus*), and the red-backed shrikes (*Lanius collurio*).

Figure 3. The main breeding site of amphibians in the Sommers Island

Table 1. Details of pools and the presence of amphibians on Sommers Island

Pool	Co-ordinate	Area (m²)	Maximum number of newts recorded	Presence of toad tadpoles
1	N 60.20795 E 27.64005	100	93	+
2	N 60.20896 E 27.64225	5	3	+
3	N 60.20626 E 27.63923	49	2	-
4	N 60.20546 E 27.63991	26	3	+
5	N 60.20535 E 27.64051	23	15	-
6	N 60.20705 E 27.64841	17	1	-
7	N 60.20625 E 27.65041	7	3	+
8	N 60.20675 E 27.64511	6	1	-
9	N 60.20691 E 27.63911	16	2	-

Table 2. Areas of land habitats of Sommers Island

Habitat	Area (ha)
Alder thicket (*Alnus glutinosa*)	0.14
Hill – a rock 16 m a.s.l., covered by grass, lichens and mosses	0.59
Fens	0.03
Aspen 'forest' (*Populus tremula*, *Sorbus aucuparia*, *Salix caprea*)	0.37
Bog	0.08
Birch thicket (*Betula pendula*, *B. pubescens*)	0.04
Ruderal grasslands near the abandoned buildings	2.41
Shrubberies (*Rubus idaeus*, *Salix* ssp., *Rosa* ssp.)	0.09
Juniper shrubberies	2,95
Reeds	0.02
Abandoned buildings	0.37
Coastal rocks	6.82
Stony barren lands	6.26

DISCUSSION

Sommers Island demonstrates that amphibian populations can exist, at least temporarily, in a very small area: a few hundred newts and toads can live on a plot of land of effectively only about 2.5–6 ha. The size of the populations in the past is unknown, but was probably not significantly larger than during the last few decades. Since few people have lived on Sommers Island, there is no reason to believe that amphibians had more or less habitat than they do now. Rather, the presence of people inevitably leads to trampling down of grass, the destruction of trees and the direct extermination of animals. These impacts would be partly compensated for by kitchen gardens constructed around the houses, in which the amphibians could find suitable habitats, but the area is extremely small. Most of the surface of the island was, and still is, stony barren land. Unfortunately, there is almost no information about the historical condition of the island before its economic and military use. There is only a small note from 1723 stating that the island consists of sand and stones (Bergholtz, 2018).

Regular, active replenishment of these populations from elsewhere is unlikely since although the water in the Baltic Sea is brackish, the migration of amphibians for long distances through it is only likely to happen rarely if at all. It is possible that amphibians arrived in earlier periods during the formation of the Baltic Sea and/or arrived in the last one or two hundred years during the period of the island's economic development. They could have been transported accidentally or intentionally, although the latter is unlikely (the island was used predominantly by the military). In any case, the amphibians must have been established on the island before 2005 since that is when it was finally abandoned.

We believe that both the size of the stable amphibian populations on Sommers Island and the size of the habitat they occupy are the smallest currently known for amphibians. We searched the literature for occurrences of amphibian populations on extremely small islands (<20 ha); however, such populations either occupy larger areas, or are not as isolated from the mainland as the populations on Sommers Island. Populations of the common frog (*Rana temporaria*) and common toad have been reported living in small islands (1-16 ha) of the Baltic Sea (Seppa & Laurila, 1999), but these islands are located in 'skerries' – a zone of heavily rugged coastline, to which a large number of small islands adjoin. The distance to the mainland is relatively short, only about 0.6-2.5 km. Dispersal and gene flow between islands and from mainland to island were indicated for both amphibian species. Similar habitat is known on the Kumari Island of the Moonsund Archipelago of the Baltic Sea with an area of 16 ha and distance to the mainland of 5.35 km. There are populations of common toad, natterjack toad (*Epidalea calamita*), moor frog (*Rana arvalis*) and common frog (Lepik, 1995). Several small islands of the Lake Erie, USA, that are 3-312 ha and 1.1-19.1 km from the mainland are inhabited by the American bullfrog (*Lithobates catesbeianus*), mudpuppy (*Necturus maculosus*), American toad (*Anaxyrus americanus*), spring peeper (*Pseudacris crucifer*), green frog (*Lithobates clamitans*), northern leopard frog (*Lithobates pipiens*), red-backed salamander (*Plethodon cinereus*) (King et al., 1997). Since Lake Erie is a freshwater lake, migrations of amphibians to the islands take place rather often. As for the similar islands surrounded by salt water, at least four cases are known. Two of them have been reported for the San Francisco Bay: a population of arboreal salamander (*Aneides lugubris*) inhabits the S. Farallon Island, which is 28 ha and located 32.9 km from the mainland; a population of California slender salamander (*Batrachoseps attenuates*) inhabits the island Erba Buena which is 78 ha and 2.5 km from the mainland (Anderson, 1960). Two cases are known for the islands of the Atlantic coast of Spain: a population of fire salamander (*Salamandra salamandra*) occurs on the island San Martino which has an area of 143 ha and is 6.1 km from the mainland; populations of Bosca's newt (*Lissotriton* *boscai*) and Iberian painted frog (*Discoglossus galganoi*) inhabit the island Salvora that has an area of 196 ha and is 3.7 km from the mainland (Cordero Rivera et al., 2007). In all these cases, there is not enough information about size of the populations; however, they might have been significantly larger than the number of newts and toads of the Sommers Island as the other islands are more favourable for amphibians; Sommers Island is an extreme habitat due to its cold climate and low biological productivity. Not only for newts or toads, but also for other vertebrates, the recorded numbers on Sommers Island seems to be close to the possible minimum.

The data we have obtained are interesting in the light they throw on the importance of metapopulations (Smith & Green, 2005) – populations existing as distinct units with exchange between them that facilitate long-term survival. Our data illustrate that amphibians can do without metapopulations when not disturbed. Isolated and genetically depleted populations are less resistant to environmental changes and less likely to survive (Allentoft & O'Brien, 2010; Lesbarreres et al., 2005). Nevertheless, with low levels of anthropogenic impact perhaps even very small populations can be stable. This suggests even very small areas may have value for the conservation of amphibians, provided they are subject to little anthropogenic impact.

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