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Reproduction of the Alpine newt *Ichthyosaura alpestris* recorded in streams of the Western Carpathians

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Abstract. In Central Europe, watercourses are not considered important breeding habitats for most amphibians, including the Alpine newt *Ichthyosaura alpestris*, for which the reproduction in a lotic habitat has rarely been documented. However, two breeding sites of this species were found during a herpetological survey conducted in the Western Carpathian foothills. Thirty-nine kilometers of small streams were visually searched between 2015 and 2020, and two occupied stream sections were sampled 27 and 20 times, respectively. The Alpine newt adults (mostly in May) and then the larvae (from the end of July to October) were observed in stream pools, which are slower-flowing and deeper than the surrounding parts of the stream channels. One site was occupied in each of the six years, while the other in three (2016–2017 and 2019) out of five, which indicates that the choice of these stream stretches as breeding sites was not a single-year, peculiar case. Nevertheless, reproduction of the Alpine newt in a lotic habitat remains a rare phenomenon, making it difficult to investigate the reasons for choosing this type of breeding habitat.

Keywords: Amphibians, breeding habitat, larval habitat, lotic ecosystem, watercourse, Western Carpathians.

Introduction

The Alpine newt *Ichthyosaura alpestris* (Laurenti, 1768) is a urodele amphibian widely distributed in both lowlands and mountains across western and central Europe, reaching heights of up to 2,500 m a.s.l. It is also present in eastern and southern Europe, inhabiting the Carpathians and mountainous regions of the Balkan Peninsula. Its natural range extends from Denmark in the north to Greece and Italy in the south, and from Spain and France in the west to Ukraine, Romania, and Bulgaria in the east. In addition, this species was introduced to some countries, e.g., the Netherlands, Germany, and Great Britain (Arntzen et al. 2009, Speybroeck et al. 2016, Naumov et al. 2020). The Alpine newt typically breeds in lentic habitats. These are usually bodies of water with a hydroperiod long enough to allow successful larval development and metamorphosis, although temporary ponds may also be used. It inhabits a great variety of aquatic habitats, including water bodies of natural and anthropogenic origin, varying in the degree of aquatic vegetation cover (Babik & Rafiński 2001, Arntzen et al. 2009, De Troyer et al. 2020, Naumov et al. 2020).

Watercourses in Central Europe, especially in the mountains, are considered a breeding habitat of minor importance for local amphibians (Dalbeck et al. 2007), except for the fire salamander *Salamandra salamandra*, for which they constitute a primary larval habitat (Babik & Rafiński 2001). Also, in the case of the Alpine newt, reproduction in flowing waters is considered a rare phenomenon (Arntzen et al. 2009, 2016) and has only exceptionally been reported (Breuil & Parent 1987, Denoël 2004a). This contribution describes two reproduction sites of the Alpine newt, located within small streams in the low-altitude foothill area in Central Europe, in the Western Carpathians.

Material and Methods

The systematic herpetological survey of the streams was carried out in the Western Carpathians (Poland), in an area of approximately 260 km^2 (Fig. 1). The area included low-altitude (300–500 m a.s.l.) foothills, located on the northern edge of the vast central-European mountain range of the Carpathians. The research area was predominantly agricultural land, with patches of mixed forests occupying about 20% of the total area, preserved mainly on the hilltops. Numerous streams originate there, covering the area with a dense network of small watercourses (<3 m width). Field visits were carried out on the initial spring sections of the streams, in which no fish (that could limit the occurrence of amphibians; Winandy et al. 2017, De Troyer et al. 2020) were observed. Visual inspections consisted of walking along the banks of watercourses (as long as the terrain conditions allowed) and searching the stream pools, which are slower-flowing and deeper than the surrounding parts of the stream channel, often formed in front of or behind the boulders or snags located within the watercourse. The surface of the bottom of such pools was visually scanned with the naked eye and using 10×42 binoculars in search of larvae or adult amphibians. Field visits were conducted irregularly, from late April to late October. Between 2015 and 2020, 92 stream sections with a total length of almost 39 km, located within 83 watercourses, were searched at least once (Fig. 1).

After discovering Alpine newts at two stream sections, these were subjected to separate monitoring using the abovementioned methods. The first section (from now on, referred to as A) was searched 27 times in 2015–2020, and the second section (B) was visited 20 times in 2016–2020 (Fig. 2). At each visit, the presence and absolute abundance of larvae and/or adult Alpine newts were recorded in each section.

Results

Alpine newts were recorded only in two out of 92 stream sections studied (2.2%), located close to each other in the central part of the study area (Fig. 1). In both sections, adults and larvae were observed in slow-flowing stream pools. Section A (Fig. 1) extended between 49.886546°N, 19.554515°E and 49.884581°N, 19.557460°E. It is a headwater section of the Dropa stream, 320 m long, located at 315–305 m a.s.l., with an approximate average channel slope of 3%, a width of 0.8–2 m, and a depth of up to 30 cm. The bottom is clay, gravel, and sand, with rocky fragments. The slow-flowing stretches are covered with a thin layer of organic sediments. The stream flows through a narrow strip of

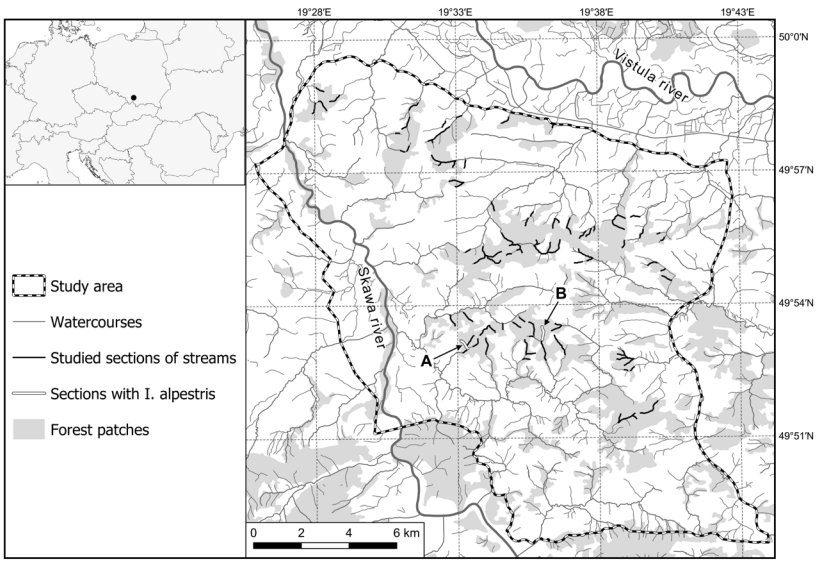

Figure 1. Location of the research area, all sampled stream sections, and sections where reproduction of the Alpine newt *Ichthyosaura alpestris* was recorded. Watercourses after MPHP (2010), forests after Corine Land Cover (2018).

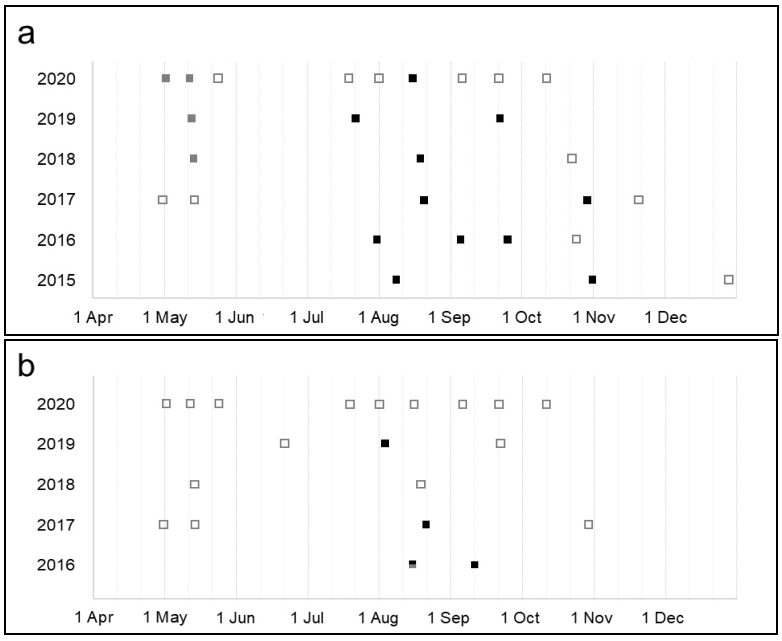

Figure 2. Phenology of the Alpine newt *Ichthyosaura alpestris* in the studied streams. The figure indicates field visits when adults (grey squares), larvae (black squares), or when no Alpine newts were recorded (empty squares). Note that section A (a) was searched in the years 2015–2020, while section B (b) in the years 2016–2020.

riparian black alder grove, surrounded by a 75–80-year-old fir forest with an admixture of oak and pine. During the 27 searches in section A, larvae were found 11 times between 20 July and 31 October (Fig. 2a), with a maximum of 30 larvae on 18 August 2017. Adult newts were observed four times, the most on 13 May 2018 (8 females and 2 males).

Section B (Fig. 1) extended between 49.891602°N, 19.602097°E and 49.889154°N, 19.602463°E. It is a source section of a nameless stream (a tributary of the Radysianka brook), 300 m long, located at 358–344 m a.s.l., with an approximate average channel slope of 5%, the width of 1.5–2 m, and a maximum depth of about 35 cm. The bottom is made of clay and sand, covered with organic sediments of up to 5 cm thickness. It is located within a narrow strip of riparian black alder grove, surrounded by an 80-year-old fir forest with an admixture of pine and oak, as well as a multi-species mixed forest dominated by 75-year-old pine stand, with a large share of beech, fir, wild cherry, poplar, oak, and black alder (Fig. 3). During the 20 visits to section B, larvae were observed four times between 14 August and 10 September (Fig. 2b), with the highest number (25 larvae) on 14 August 2016. One adult female was found on the same day, which was the only adult recorded in this section.

Section A was used as a breeding site during all six research seasons (2015–2020). Section B was utilized in three (2016–2017 and 2019) out of five seasons (Fig. 2). Alpine newt larvae were recorded in streams between the end of July and the end of October (Fig. 2). Although present in the study area, no fire salamander larvae were found in any of the stream sections occupied by the Alpine newts.

Discussion

Alpine newts breed in a great variety of freshwater habitats, including bodies of water of both natural and anthropogenic

origin (Babik & Rafiński 2001, Arntzen et al. 2009, De Troyer et al. 2020, Naumov et al. 2020). Among the former, they regularly utilize lakes (Denoël 2004b, Arntzen et al. 2009), oxbow lakes (Pabijan 2018), springs (Juszczyk 1987, Denoël 2004b, Kolenda et al. 2019), landslide mountain ponds (Pabijan 2018), mud-bathing places of large mammals (Pabijan et al. 2009) and beaver ponds (Dalbeck et al. 2007). However, most of the breeding sites of the Alpine newt are of artificial origin. Mostly they are various types of ponds, puddles and vernal/ephemeral pools, water-filled wheel ruts on forest roads, garden pools, post-mining ponds (in gravel, sand, clay, or peat excavations), or abandoned quarries (Juszczyk 1987, Babik & Rafiński 2001, Świerad 2003, Denoël 2004b, Dalbeck et al. 2007, Arntzen et al. 2009, Pabijan et al. 2009, Kopecký et al. 2010, Pabijan 2018, Naumov et al. 2020). They can also be very small and intensively used structures, like drinking troughs and watering basins for cattle (Denoël 2004b, Arntzen et al. 2009) and heavily modified and polluted industrial reservoirs (Juszczyk 1987). The wide range of habitats also includes drainage and roadside ditches (Babik & Rafiński 2001, Arntzen et al. 2009, Pabijan 2018) and artificial reservoirs created by damming watercourses (Kolenda et al. 2019). In addition, Alpine newts often use amphibian conservation ponds (Bringsøe & Mikkelsen 1997). The ecological plasticity of this species is further emphasized by the fact that its habitat preferences may show regional differentiation. For example, in southern Europe, this newt is more likely than elsewhere to inhabit large natural bodies of water, such as lakes (Denoël 2004b, Ćirović et al. 2008). In contrast, the most typical breeding habitat in the Western Carpathians are water-filled wheel ruts on forest dirt roads, followed by roadside ditches (Babik & Rafiński 2001).

Despite such a large diversity of breeding biotopes, lotic habitats are rarely used by the Alpine newt (Arntzen et al. 2009, 2016, Naumov et al. 2020). To my knowledge, from the Western Carpathians, for example, there are no reports of reproduction in flowing waters (Babik & Rafiński 2001, Pabijan 2018). However, Juszczyk (1987) observed mating behavior in lotic habitats but did not find larvae. Similarly, Świerad (2003) indicated that this newt uses mountain streams with slow current and backwaters as a mating habitat, although he did not specify whether breeding was successful there. Considering this, the larval observations reported here confirm the possibility of the Alpine newt reproduction in small watercourses of the Western Carpathians. Although it remains unclear with what success reproduction takes place in the studied streams, observations of larvae exceeding 40 mm in length, and therefore ready (according to Juszczyk 1987) for metamorphosis, suggest that larval development and reproduction itself is successful at least occasionally. Long-term observations of presence on the same sites prove that this species regularly uses the studied streams. Nevertheless, breeding in lotic habitats should be regarded as an exceptional phenomenon, as it was recorded only in two sections of streams several hundred meters long. Despite inspecting 39 km of watercourses in the study area, including many sections similar to those occupied, no more sites with the Alpine newt larvae or adults were found.

Observations indicate that the breeding phenology in the studied streams generally follows the pattern typical for the Alpine newt in Central Europe (Juszczyk 1987, Pabijan 2018). In spring (probably by the beginning of May), adults entered streams to mate and lay eggs. At the end of July and in August, in places where adults were observed and downstream, it was possible to detect the presence of larvae visually. After metamorphosis, the newts left the streams by the end of October. The larvae had not been recorded in the water earlier in the season, probably because detection at an early stage of development was unlikely due to their small size and poorly developed body pigmentation.

Figure 3. Habitat of a stream section B, occupied by the Alpine newt *Ichthyosaura alpestris*.

Alpine newts possibly use watercourses for reproduction when there are no otherwise suitable water bodies (Juszczyk 1987, Iftime 2004). Unfortunately, the collected data cannot confirm or exclude this explanation, although no suitable stagnant water breeding sites were present in the vicinity of the studied streams. Certainly, however, the use of the sites over several seasons indicates that the choice of streams for breeding is not a coincidence. It is worth noting that stream pools in which breeding of Alpine newts was found were characterized by a small area and low water flow, and their bottom was covered with a layer of organic sediments. This nature of the microhabitat is reminiscent of the preferred breeding sites of this species in the mountain areas – water-filled wheel ruts on forest roads and roadside ditches (Babik & Rafiński 2001, Pabijan 2018, Naumov et al. 2020). This similarity is more remarkable because in roadside ditches and even in rut systems (especially in spring and those located on sloping roads), there may be some flow (water

turnover; Babik & Rafinski 2001, Naumov et al. 2020, own observations). On the other hand, a clear difference is that stream pools show greater hydrostability, especially compared to ruts, which are often ephemeral and dry out during the season (Kopecký et al. 2010). It would seem that the hydrostability of the breeding habitat should be favorable and preferred, but if this is the case, breeding in streams should be recorded more frequently. Reasons for avoiding streams may include increased predation pressure in permanent habitats, where the spectrum of potential predators, such as fish (Winandy et al. 2017, which, however, were absent in the study streams) or aquatic macroinvertebrates (Schmidt & Van Buskirk 2005), is wider than in ephemeral pools on forest roads (Babik & Rafinski 2001). Yet another explanation for the presence of Alpine newts in streams was given by Roček et al. 2003 (after Naumov et al. 2020), who argued that these are probably individuals moving to breeding habitats, with the streams themselves acting as migration corridors. However, as reproduction occurred in the streams studied here, this explanation cannot be considered. In conclusion, determining why the Alpine newt selects stream habitats requires further, more detailed research, which is, unfortunately, hampered by the general rarity of this phenomenon.

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