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PART 5 Northern Europe

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Cover image: The natterjack toad *Epidalea calamita* is a European endemic. The image shows a calling male in the city of Jena, Thuringia, Germany. In highly industrialized countries with a dense human population, the species often colonizes secondary habitats like quarry pits or wasteland within large cities. Photo: Andreas & Christel Nöllert.

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65 Decline and conservation of amphibians in Latvia

Aija Pupina, Mihails Pupins, Andris Ceirans and Agnese Pupina

Abbreviations and acronyms used in the text and references

Bd	Batrachochytrium dendrobatidis
Bsal	Batrachochytrium salamandrivorans
IUCN	*International Union for the Conservation of Nature*
GE	*genomic equivalents*
RDB	*Red Data Book of Latvia*
HD	*Habitats Directive*
LEGM	*Latvian Environment, Geology and Meteorology Centre*
MKN	*Ministru Kabineta Noteikumi (the documents, approved by the Cabinet of Ministers of Latvia)*
qPCR	*quantitative polymerase chain reaction or real-time polymerase chain reaction*

I. Introduction: The country and its amphibian fauna

Latvia – officially the Republic of Latvia (in Latvian: Latvija, Latvijas Republika) – is a country of the Baltic region of northern Europe and lies on the east coast of the Baltic Sea and its Gulf of Riga. Latvia has been a member of the European Union since 2004. The total area of Latvia is 64,589 km^2; its length from north to south is 210 km and from east to west is 450 km. Latvia has land borders with Estonia in the north (343 km), with Lithuania in the south (588 km), with Belarus in the southeast (161 km), and with Russia in the east (276 km) (Central Statistical Bureau Republic of Latvia 2012). Latvia also shares its borders with Estonia, Sweden and Lithuania in the Baltic Sea. A relatively large proportion of Latvia's perimeter, relative to its surface area, transects various natural habitats also shared by neighbouring countries. This ecological continuity with adjacent countries is reflected in similarities in their amphibian faunas.

The largest part of the territory of Latvia is at a height of not more than 100 m above sea level. Latvia has a temperate seasonal climate that can also be described as oceanic/maritime (Central Statistical Bureau Republic of Latvia 2012). Latvia has four well-defined seasons of approximately equal duration. In winter the average temperature is –6°C, with minima of –20° to –30°C, usually lasting for several weeks; winter conditions include a short day-length, a constant mantle of snow up to 0.7 metres deep, total freezing of small ponds, and persistent ice 15–20 cm thick on larger ones. Such conditions affect survival of amphibians overwintering either underwater or on land,

especially in their first year of life, and declines occur during winter. The average air temperature is 19°C in summer, with maxima of 25°–30°C commonly occurring, especially in the country's interior. It often rains, especially in the second part of the summer (Latvian Biodiversity Clearing-House Mehanism 2015) (Figure 65.1), thereby creating numerous large and small ponds and other wetland habitats used by amphibians.

There is a moderate marine climate in the western coastal regions of Latvia, with warmer winters and cooler summers than in the eastern continental part of the country; this regional difference in climate influences the distribution of the amphibian fauna within Latvia.

Of the total surface of Latvia, agricultural land covers 23, 909 km^2 (44.0%) and forest 29, 996 km^2 (55.2%); inland fresh waters cover the remaining 419 km^2 (0.8%). The largest lake is Lubans with a surface area of 80.7 km^2; the deepest lake is Dridzis with a depth of 65.1 m. The longest river in Latvia is the Gauja, which is 452 km long. The longest river flowing through the territory of Latvia from Belarus is the Daugava, which has a total length of 1,005 km of which 352 km are within the territory of Latvia. There are many lakes, rivers, large and small ponds and other small bodies of water used by amphibians as habitats and migratory routes.

The average density of the human population is 34.3/km^2. There are five economic/political planning regions in Latvia: Kurzeme, Latgale, Riga, Vidzeme and Zemgale. They differ in relief, climate and level of economic and agricultural development, as well as in urban saturation which is important for the composition and distribution of the amphibian fauna.

Nowadays amphibians are represented by 13 permanently resident species in Latvia – 11 anurans and two caudates; all have Least Concern IUCN Red List Status for Europe, but with some species exhibiting changes in population density in Latvia (Table 65.1).

Latvia is the most northern country of the European Union in which the European fire-bellied Toad *Bombina bombina* resides, and the species reaches the northern extreme of its distribution there (Kuzmin *et al.* 2008). Latvia is also the most northern extent in the EU of the European tree-frog (*Hyla arborea*). *Hyla arborea* was officially declared as extirpated in Latvia but was successfully reintroduced into the country using zoocultures established from animals caught in Belarus (Zvirgzds 2003).

Four species – the green toad *Bufotes viridis*, the natterjack toad *Epidalea calamita*, the common spadefoot toad *Pelobates fuscus* and the northern crested newt *Triturus cristatus* – reside in Latvia near the northern borders of their European distribution. *Epidalea calamita* is encountered mainly near the coast of the Baltic Sea and in central Latvia; over the past few years it has been observed in the southeastern part of the country as well. The other three of these species are encountered

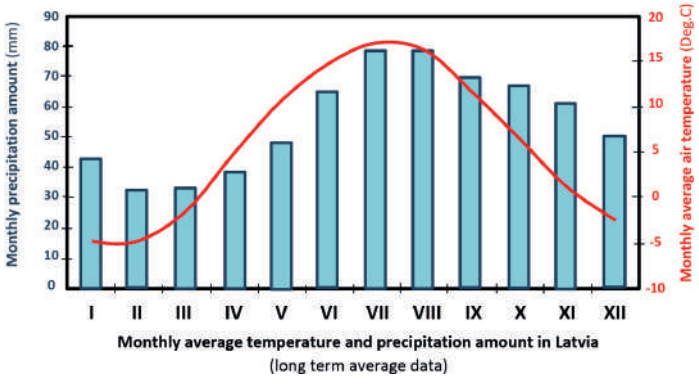

Fig. 65.1 Long-term monthly averages of air temperature and precipitation in Latvia (Latvian Environment, Geology and Meteorology Centre 2015).

Table 65.1 The species of amphibians present in Latvia, their IUCN status for Europe (IUCN 2014) and the trends of their populations in Latvia.

Species	English Name	Latvian Name	IUCN Red List Status (Europe)	IUCN Population trend (Europe)	Population trend in Latvia
Lissotriton vulgaris (Linnaeus, 1758)	Smooth Newt	Parastais tritons	Least Concern	stable	stable
Triturus cristatus (Laurenti, 1768)	Northern Crested Newt	Lielais tritons	Least Concern	decreasing	decreasing
Bombina bombina (Linnaeus, 1761)	European Fire-bellied Toad	Sarkanvēdera ugunskrupis	Least Concern	decreasing	decreasing generally, but increasing at some localities
Hyla arborea (Linnaeus, 1758)	European Tree Frog	Parastā kokvarde	Least Concern	decreasing	increasing
Pelobates fuscus (Laurenti, 1768)	Common Spadefoot Toad	Brūnais varžukrupis	Least Concern	decreasing	decreasing
Bufotes viridis (Laurenti, 1768)	European Green Toad	Zaļais krupis	Least Concern	decreasing	unknown
Epidalea calamita (Laurenti, 1768)	Natterjack Toad	Smilšu krupis	Least Concern	decreasing	decreasing
Bufo bufo (Linnaeus, 1758)	Common Toad	Parastais krupis	Least Concern	stable	stable
Pelophylax lessonae (Camerano, 1882)	Pool Frog	Dīķa varde	Least Concern	decreasing	stable
Pelophylax kl. *esculentus* (Linnaeus, 1758)	Edible Frog	Zaļa varde	Least Concern	decreasing	stable
Pelophylax ridibundus (Pallas, 1771)	Eurasian Marsh Frog	Ezera varde	Least Concern	increasing	unknown
Rana arvalis (Nilsson, 1842)	Moor Frog	Purva varde	Least Concern	stable	stable
Rana temporaria (Linnaeus, 1758)	Common Frog	Parastā varde	Least Concern	stable	stable

throughout most of Latvia, except in the north, but their populations are mostly small and fragmented.

Four other Latvian amphibians are abundant over the entire country and occur in a wide range of habitats: the smooth newt *Lissotriton vulgaris*, the common toad *Bufo bufo*, the common frog *Rana temporaria* and the moor frog *Rana arvalis*. *Pelophylax* spp. are also widely abundant throughout Latvia and are even encountered in urbanized habitats (Rimicans *et al.* 2010; Pupins and Pupina 2011a) (Table 65.2).

II. Threats to amphibians in Latvia

According to the official national requirements for development of Species Conservation Plans, factors posing threats to the habitats, ecosystems and populations of the protected species in Latvia can be divided into those of natural origin and those of anthropogenic origin. These can, of course, act synergistically. Threats of either kind are of less concern for amphibians that are widespread in Latvia, however, than they are for species that are represented by small or fragmented populations.

A relatively cold climate is a permanent natural cause of paucity and limited abundance of amphibian species in Latvia, such as *Triturus cristatus*, *Bombina bombina*, *Hyla arborea*, *Bufotes viridis*, *Epidalea calamita* and *Pelobates fuscus*. Of course, all species of Latvian amphibians are generally adapted to the Latvian climate as confirmed by their persistence there over a long period of time. However, the Latvian climate does pose challenges to amphibians in terms of achieving thermo-optimality and finding suitable habitats for feeding, breeding (Pupina and Pupins 2009) and overwintering. Therefore, the cold (–20° to –30°C) Latvian winters with relatively thin layers of snow are dangerous for amphibians overwintering in terrestrial sites, such as burrows or among

Table 65.2 The species of amphibians present in Latvia and their distribution and status in the country (Caune 1992; Pupins and Pupina 2011a; Pupina and Pupins 2012).

Species	Status in Latvia	Distribution in Latvia
Lissotriton vulgaris	common	whole territory
Triturus cristatus	rare	whole territory
Bombina bombina	very rare	southern part of Latvia
Hyla arborea	very rare	western part of Latvia (reintroduced)
Pelobates fuscus	rare	south and central territory, excluding the north of Latvia
Bufotes viridis	rare	south and central territory, excluding the north of Latvia
Epidalea calamita	very rare	central and western part of Latvia, near the Baltic sea; southeastern part of Latvia
Bufo bufo	common	whole territory
Pelophylax lessonae	common	whole territory
Pelophylax kl. *esculentus*	common	whole territory
Pelophylax ridibundus	common	south and central territory, excluding the north of Latvia
Rana arvalis	common	whole territory
Rana temporaria	common	whole territory

roots, and may lead to high mortality. Additionally, during such winters small ponds freeze all the way to the bottom and, in deeper ones, the oxygen regimen worsens, thereby causing the death of hundreds of amphibians overwintering there. Cool, short summers often occur in Latvia, with the result that some tadpoles, especially of southern species like *Bombina bombina*, do not have time to go through metamorphosis and gain sufficient weight before overwintering (A. Pupina and M. Pupins, unpublished data). In the relatively cool Latvian climate, amphibians mostly choose small, stagnant ponds, well heated by the sun, for reproduction. Therefore, when a dry, hot summer occurs, such ponds often dry up, resulting in mass mortality of amphibian larvae (A. Pupina, M. Pupins, unpublished data) (Figure 65.2).

Long-term anthropogenic transformation of habitats for agricultural use led to a reduction in the number of ponds in Latvia, and in impairment of habitat suitable for amphibians. The dams and ponds of beavers (*Castor fiber*), which are optimal for amphibians in Latvia, also are often destroyed by land-owners (Pupins and Pupina 2007). Drainage of wetlands, deforestation and formation of dams along riversides, straightening of small rivers and their subsequent transformation into soil-reclamation canals have been traditionally carried out over several decades in Latvia. These works were especially developed during the Soviet occupation of Latvia and led to the disappearance of tens of thousands of bodies of water, including small ponds, especially in the central part of Latvia. Phreatic decline, caused by melioration, and the wide use of fertilizers in agriculture during the Soviet time led to rapid eutrophication and to many of the remaining ponds becoming choked with weeds, which as a result became too dark and cold, and thus inappropriate for amphibians (Pupins and Pupina 2006; Pupina *et al.* 2012). Also, aquatic and terrestrial habitats continue to be overgrown by bushes and canes nowadays because of deagrarianization, which is becoming the main reason for degradation of amphibian habitats in Latvia.

Mortality on roads is an important negative factor for Latvian amphibians, especially during the spring and autumnal mass migrations, and for small populations of declining species. For example, in spring 2014 the authors counted 224 flattened adult and young *Rana temporaria* in Daugavpils on a 200-m stretch of asphalt road between breeding and wintering habitats. Also, 26 flattened or injured adult *Bufo bufo*, most of them in amplexus (Figure 65.3), were found on a 50-m section of unsealed road near the town of Akniste. There are no traffic signs in Latvia warning drivers of amphibian crossings, and barrier fences guiding amphibians to tunnels under the roads

Fig. 65.2 Drying *Pelophylax* sp. tadpoles in a pond where *Pelobates fuscus*, *Triturus cristatus*, and *Bombina bombina* are also living (Katriniski, Demene, Daugavpils novads; 55° 43′ 10.56″ N; 26° 32′ 54.51″ E). Photograph by Aija Pupina.

Fig. 65.3 Mortality on a road: flattened and injured adult *Bufo bufo* in amplexus (Akniste; 56°10′ 8.61″ N; 25° 43′ 16.25″ E). Photograph by Mihails Pupins.

Fig. 65.4 Burning old grass on the shore of a pond used by *Bombina bombina*, *Pelobates fuscus*, *Lyssotriton vulgaris* and *Pelophylax* sp. (Daugavpils novads; 55° 50′ 5.62″ N; 26° 29′ 3.43″ E). Photograph by Agnese Pupina.

are not used; therefore, mortality on roads is very high and can lead to fragmentation or extirpation of small populations.

Burning of dried grass is widely practised in Latvia. Such burning is carried out in the early spring on warm, sunny days and is very dangerous for amphibians that are migrating from overwintering sites to ponds for reproduction (Pupins and Pupina 2006). The authors have many times observed such fires near the edges of ponds inhabited by the declining species *Triturus cristatus*, *Bombina bombina*, *Pelobates fuscus* and some others (Figure 65.4). The authors have a dozen times found live amphibians with half-burnt bodies, injured by the burning of grass (Figure 65.5).

The degradation and disappearance of the majority of factories and agricultural firms in Latvia after the end of the Soviet occupation led to the appearance of a great number of derelict buildings, communication lines and shafts acting as mortal traps for amphibians. We managed to count 38 atrophied individuals of amphibians in just one shaft in Kumbuli, Daugavpils region.

There are a great number of illegal dumps around many Latvian villages, i.e. in forests, slashes, drains, marshes and bodies of water, which are the main habitats of amphibians. These dumps are the source of pollution of the environment of amphibians (Figure 65.6) wherein they are also injured by cuts from broken glass (Figure 65.7).

Fig. 65.5 Effect of burning grass: adult *Rana temporaria* burned while migrating to a breeding pond (Daugavpils novads; 55° 50′ 6.11″ N; 26° 29′ 4.60″ E). Photograph by Agnese Pupina

Fig. 65.6 Rubbish (empty bottle) and *Bombina bombina* in the breeding biotope of *Rana temporaria*, *Triturus cristatus*, *Pelobates fuscus*, *Pelophylax* sp., and *Bombina bombina* (Katriniski, Demene, Daugavpils novads; 55° 43′ 10.56″ N; 26° 32′ 54.51″ E). Photograph by Agnese Pupina.

Fig. 65.7 Adult *Rana temporaria* showing wound caused by broken glass in a rubbish dump (Kalkunes pagasts, Daugavpils novads; 55° 50′ 14.04″ N; 26° 29′ 27.25″ E). Photograph by Mihails Pupins.

Fig. 65.8 This invasive fish *Perccottus glenii* found in a breeding pond of six amphibian species (Microreserve Ilgas, territory Natura 2000, Skrudaliena pagasts, Daugavpils novads; 55° 41′ 32.88″ N; 26° 46′ 14.61″ E). Photograph by Mihails Pupins.

Invasive predators are dangerous for amphibians in Latvia, one of which is a fish, the Chinese sleeper (*Perccottus glenii*) (Figure 65.8). Having become established in small, warm bodies of water, which are the main habitats used by amphibians for reproduction in Latvia, this species can fully destroy or seriously damage the larvae of amphibians (Pupins and Pupina 2012a). *Perccottus glenii* was found by the authors in catchment basins of almost every large river and in many lakes of Latvia (Pupins and Pupina 2012b); it was found in the territories of many populations of *Bombina bombina* and *Triturus cristatus*, and continues to extend its distribution (Pupina and Pupins 2014; Pupina *et al.* 2015).

Another invasive predator in Latvia regarded as dangerous for larvae of amphibians is the widely spread fish *Carassius auratus*, whose natural range is eastern Asia. This species was imported into Latvia in 1948 and released before 1990 into at least 180 (23%) of Latvian lakes and into many other bodies of water (Andrusaitis 2003). We have discovered that in Latvia amphibians avoid using bodies of water for reproduction if fish are present (personal observations). Introduction of invasive and local fish into water inhabited by amphibians is carried out by local citizens and by anglers; *Perccottus glenii* is sold on the Internet (A. Pupina, M. Pupins, and Ag. Pupina, unpublished data).

There are seven species and subspecies of exotic freshwater turtles that we recorded in the wild in Latvia: *Trachemys scripta troostii*, *Mauremys caspica*, *Mauremys rivulata*, *Pelodiscus maackii*, *Trachemys scripta elegans* (Pupins and Pupina 2011b), *Trachemys scripta scripta*, *Graptemys pseudogeografica kohnii* (M. Pupins, A. Pupina, unpublished data); mainly single individuals of *Trachemys scripta elegans* successfully overwinter and attempt oviposition (Pupins 2007; Pupins and Pupina 2012c). These carnivorous species can be dangerous for small populations of declining species of amphibians, especially in the south of the country (Pupins and Pupina 2006), and they can also introduce exotic parasites.

Dangerous new predators for adult amphibians in Latvia are invasive mammals that are becoming widespread in the country: the raccoon dog (*Nyctereutes procyonoides*) (29,200 individuals registered in 2014), the American mink (*Neovison vison*) (23,200 individuals registered in 2014), and probably the muskrat (*Ondatra zibethicus*) (5,500 individuals registered in 2014) (NeoGeo.lv 2014).

Research on the presence and distribution of local or exotic parasites in the *Pelophylax* kl. *esculentus* complex was carried out in Latvia in 2017. One-hundred-and-forty-one adult and juvenile specimens were collected for parasitological examination. The parasites found belong to the following systematic groups: Protozoa, Monogenea, Digenea, Nematoda and Acanthocephala. Fifty-five *Pelophylax* kl. *esculentus* complex tadpoles were examined. Three Trematoda species in their larval stage: *Alaria alata*, *Diplostomum* sp., *Opisthioglyophe ranae* and *Diplodiscus subclavatus* in its adult stage were detected in different organs of the tadpoles. One Nematoda, *Thelandros tba*, a common parasite of frog tadpoles, was observed in the intestine (Kirjusina *et al.* 2018a, 2018b).

One-hundred-and-thirty-five samples of *Pelophylax* kl. *esculentus* complex from 42 locations were checked for the presence of *Batrachochytrium dendrobatidis* (*Bd*) and *B. salamandrivorans* (*Bsal*) using qPCR in August 2017. *Bsal* was not detected in any sample. *Bd* infection was detected in 18 (43%) locations and in 53 (39%) samples. The infection intensity in the *P.* kl. *esculentus* complex reached a maximum of 143.0 genomic equivalents of zoospores (GE) in a water basin near Jurmala city (Kulikova *et al.* 2018).

Taking into account that *Xenopus laevis* and other tropical species of amphibians are widely sold in pet shops in Latvia and by Internet (Pupins and Pupina 2011a), it can be assumed that *Bd*, and other species of exotic parasites can be found in many populations of Latvian amphibians.

III. Declining species and species of special conservation concern

The Red Data Book (Andrusaitis 2003) is not the official nature protection document in Latvia; rather that role is taken by a popular book. The status of the species in the Red Data Book of Latvia does not directly influence practical actions towards species or their protection and can only serve for educational or illustrative purpose.

There is a special document in Latvia approved by the Cabinet of Ministers "Ministru kabineta noteikumi # 396" (Ministru kabineta noteikumi 2004) which contains a list of specially protected species in Attachment 1, including six species of amphibians. These are *Hyla arborea*, *Epidalea calamita*, *Bufotes viridis*, *Triturus cristatus*, *Bombina bombina* and *Pelobates fuscus*, all of which are species of special conservation concern in Latvia and in the European Union (Table 65.3).

In 2003 (Andrusaitis 2003) *Hyla arborea* was considered as extirpated in Latvia. However, in 1987 the Laboratory of Ecology, led by herpetoculturist Dr. Juris Zvirgzds-Zvirgzdiņš, was founded for remediation of this species at the Riga National Zoo. He considered widespread amelioration and a complete extirpation of beavers, *Castor fiber*, from Latvia to be the reasons for the decline of the treefrog (J. Zvirgzds-Zvirgzdiņš, personal communication). Using *Hyla arborea* that had been brought from Belarus for the formation of a breeding group and bringing 4,110 young individuals that had been bred in zooculture for reintroduction into nature in 1988–1992, the Riga National Zoo formed a stable population of *Hyla arborea* in Liepajas novads in southwestern Latvia (56° 30′ N) (Zvirgzds *et al.* 1995; Zvirgzds 2003). This population has been continuously increasing in numbers and extending its area of distribution. Now the area of expansion occupies Kurzeme and at least 1,000 km^2 in Kalvene, Vaiņode, Aizpute and Priekuli (Zvirgzds 2003). However, the present distribution of this species in Latvia does not mean that the danger of decline has disappeared. There was also an opinion that *Hyla arborea* had never inhabited Latvia and that it had been introduced into the country as an alien species (Caune 1992; A. Berzins, personal communication).

Epidalea calamita is a very rare species in Latvia, mainly inhabiting the coastal region of the Baltic Sea and its Gulf of Riga and the central part of Latvia (Caune 1992; Berzins 2008; Pupins and Pupina 2011a). Over the past few years it has been discovered in Dviete in the southeast of Latvia (E. Racinskis, personal communication). A. Berzins (2008) wrote that

> "… the Natterjack Toad inhabits mainly open, well-warmed landscapes with light, sandy soils. There it lives in sand dunes, glades of pine forests, sand and gravel quarries and meadows … … The reason for decline in the Natterjack Toad is complex and not fully understood, … and it reflects a continuous change in the cultural landscape over the past hundred years. The former distribution in Latvia included many sandy exposed coastal areas, but also inland sand or gravel pits with open ground and with oligotrophic and shallow breeding waters. The open exposed areas on poor and sandy

Table 65.3 The species of amphibians of special conservation concern and their status in Latvia (Latvian Environment, Geology and Meteorology Centre 2015; Ministru kabineta noteikumi 2004; Andrusaitis 2003).

Species	Category in Red Data Book of Latvia	Relevant EU legislation	Bern Convention	Protected species in Latvia (MKN #396)
Triturus cristatus	2 (*vulnerable species*)	HD II, IV	II	Yes
Bombina bombina	1 (*endangered species*)	HD II, IV	II	Yes
Hyla arborea	0 (*extinct species*)	HD IV	II	Yes
Pelobates fuscus	4 (*undetermined species*)	HD IV	II	Yes
Bufotes viridis	3 (*rare species*)	HD IV	II	Yes
Epidalea calamita	2 (*vulnerable species*)	HD IV	II	Yes

soils with a natural fluctuating water regime have become rare and the ground often becomes overgrown by dense vegetation, leading to changed microclimate …".

Bufotes viridis occurs throughout the whole territory of Latvia except for its northern part (Caune 1992; Pupins and Pupina 2011a). Nowadays the northern border of its current European distribution is partly located in Latvia; the populations of the species are tessellated, and their number is not large. It tends to live in anthropogenic landscapes and in the basins of large rivers in Latvia (Rimicans *et al.* 2010). The main reason for its decrease in number is the rapid overgrowing of terrestrial habitats and small ponds by bushes following the abandonment of unprofitable farms, thereby destroying habitat essential for this species. As an example, a large population of *Bufotes viridis*, which earlier had bred on the flood meadows used by local citizens for haymaking and as pasture for cows, disappeared in Niderkuni, Daugavpils, between 1987 and 2005 (A. Pupina and M. Pupins unpublished data).

Triturus cristatus is rare in Latvia; the species is tessellatedly distributed through the whole of the country (Caune 1992; Pupins and Pupina 2011a), also in the northern part; the populations are not large and are fragmented.

Bombina bombina is the rarest species of amphibian in Latvia. Until 2004 only two populations were known: at Islice (Bauska) and Ilgas (Silene), with up to ten vocalizing males in each population (Andrusaitis 2003). In 2004 A. Pupina, Ag. Pupina, and M. Pupins discovered a new population in Ainavas (Daugavpils region) (Pupins and Pupina 2006) and during the following years they came across populations in Demene, Medumi, Ilukste, Aizkraukle and Eglaine (Pupina and Pupins 2007; Pupins and Pupina 2011a).

All populations known in Latvia reside within 0–20 km from the southern and southeastern border of Latvia (Kuzmin *et al.* 2008; Pupina and Pupins 2008). The main reasons for the decline are the overgrowing of habitats by bushes and canes (Pupina *et al.* 2012); the occurrence of fish in ponds, especially the invasive *Perccottus glenii*; cleaning of soil reclamation canals; and destruction of dams and bodies of water produced by beavers. Two of the present authors (A. Pupina and M. Pupins) observed some cases of *Pelophylax* sp. actively preying upon juveniles of Bombina *bombina* (Figure 65.9). They also noticed an increase in some *Bombina bombina* populations and an

Fig. 65.9 *Pelophylax* sp. eating juvenile *Bombina bombina* (Demenes pagasts, Daugavpils novads; 55° 42′ 47.91″ N; 26° 29′ 54.88″ E). Photograph by Aija Pupina.

expansion of the species to the north, possibly influenced by climatic changes in Latvia (Pupina and Pupins 2010, 2013a).

Pelobates fuscus is spread throughout the territory of Latvia (Caune 1992; Pupins and Pupina 2011a); this species is inclined to live in mellow and sandy soils, including agricultural ones (Rimicans *et al.* 2010). The populations are not large and are tessellatedly expanded and fragmented, especially in the north of Latvia. The main reasons for the decrease in numbers are the overgrowing of meadows by bushes following cessation of haymaking, the overgrowing of breeding ponds by bulrushes, and the invasion of ponds by fishes.

Bombina bombina, *Triturus cristatus* and *Pelobates fuscus* often are sympatric in breeding ponds (Pupina and Pupins 2009). The main reasons for this species' decrease in numbers are (1) drainage of wetlands, (2) the overgrowing of breeding ponds by bushes, especially ponds in forests and bordering forests, and (3) invasion of ponds by fishes.

All of these species of amphibians are currently living in Latvia at the northern edge of the species' European distribution, or close to it (Caune 1992; Pupins and Pupina 2011a) and are vulnerable to climatic changes. The Latvian Climate Research Agency stated that

> "… during the 20th century the average air temperature in Latvia has risen by 1 degree. This increase is even more apparent in the years of the 21st century, which have already passed. During the past 100 years, there have been fluctuations in annual rainfall, which tended to rise from the beginning of the second half of the 20th century" (Latvian Biodiversity Clearing-House Mechanism 2015) (Figure 65.10).

Such changes of climate, namely increase of the temperature and humidity, can lead to changes both in the habitats of rare Latvian amphibians (e.g. a more rapid invasion of water by vegetation; changes in floral composition) and in distribution and number of amphibian species and its main invasive threat *Perccottus glenii* in Latvia, especially in those habitats on the northern border of the species' ranges (Nekrasova *et al.* 2018; Tytar *et al.* 2018).

IV. Conservation of amphibians in Latvia

All amphibians are protected in Latvia as an integral part of nature; there also are special measures for conservation of particularly protected species. The conservation of amphibians in Latvia is carried out on several levels: (1) the legislative level (adoption of laws, norms and requirements by government and competent organizations, aimed at amphibian conservation); (2) the planning level (development and approval of the Species Protection Plans for specially protected species of

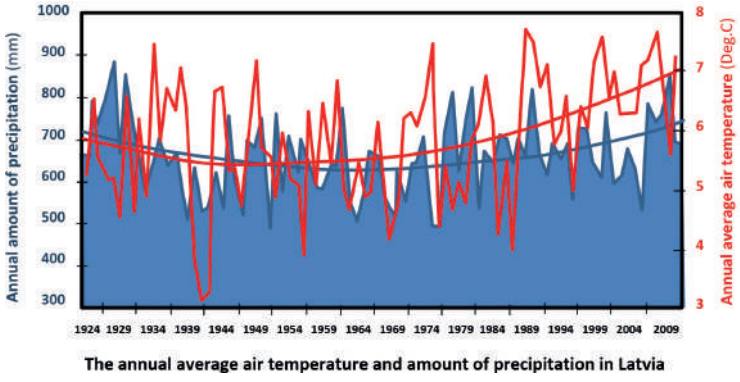

Fig. 65.10 The annual average air temperature and precipitation amount in Latvia (Latvian Environment, Geology and Meteorology Centre 2015).

amphibians in Latvia and of the Nature Conservation plans for specially protected natural reservations); (3) the level of territorial protection of nature (amphibian conservation on protected nature reserves); (4) the project-actions level (implementation of projects for conservation, financed by local governments and by the European Union); and (5) the level of particular specialists' and landowners' private actions. An official permit of the Nature Conservation Agency of Latvia is required for any action affecting particularly protected amphibians or their respective protected territories in Latvia. Such actions are assessed by a certified expert of the Nature Conservation Agency in the category named "Amphibians and Reptiles" or "Amphibians". There were five of these experts in Latvia in 2018 (Expert Register of Nature Conservation Agency 2018). In fact, all the amphibian conservation measures in Latvia described below were developed and implemented with the involvement of at least of one of these experts.

A. The legislative level

Latvia, as a member of the European Union, executes all its legislative norms and there are laws and regulations that are directly or indirectly involved with the conservation of nature, including amphibians. The most important Latvian laws are the Environmental Protection Law [Par vides aizsardzibu], Law On Specially Protected Nature Territories [Par ipasi aizsargajamam dabas teritorijam], General Regulations on Protection and Use of Specially Protected Nature Territories [Ipasi aizsargajamo dabas teritoriju visparejie aizsardzibas un izmantosanas noteikumi], Regulations on the Content and Elaboration Procedure of the Nature Protection Plan for Specially Protected Nature Territories [Noteikumi par ipaši aizsargajamas dabas teritorijas dabas aizsardzibas plana saturu un izstrades kartibu], Law on the Conservation of Species and Biotopes [Sugu un biotopu aizsardzibas likums], and others.

The Regulations on the List of the Specially Protected Species #396 [Noteikumi par ipasi aizsargajamo sugu un ierobezoti izmantojamo ipasi aizsargajamo sugu sarakstu Nr. 396] are the most important ones aimed particularly at conservation of declining amphibians in Latvia wherein an official list of six specially protected species is given: *Hyla arborea*, *Epidalea calamita*, *Bufotes viridis*, *Triturus cristatus*, *Bombina bombina* and *Pelobates fuscus* (Ministru kabineta noteikumi Nr. 396; 2004).

The Regulations for the Establishment, Conservation and Management of Micro-reserves #45 [Mikroliegumu izveidosanas, aizsardzibas un apsaimniekosanas noteikumi Nr. 45] are also important because they allow the development of micro-reserves for three species of the specially protected amphibians in Latvia: *Epidalea calamita*, *Bombina bombina* and *Triturus cristatus*.

B. The planning level

There are programmes and plans developed in Latvia that are indirectly or directly aimed at amphibian conservation. The most important of the general plans are the National Programme on Biological Diversity, the Latvian Environmental Policy Guidelines for 2014–2020.

A legislatively approved provision on the Plans for Management of Species exists in Latvia, i.e. Species Conservation Plan. Such plans are a national strategy for conservation of a particular species and describe the state of that species in Latvia, indicate the threats against it and its habitats, and offer measures for conservation of the species. In 2018, there were two plans approved for two amphibian species: *Bombina bombina* (Pupins and Pupina 2006) and *Epidalea calamita* (Berzins 2008). Such plans are updated every five to ten years.

There are many Nature Protection plans elaborated for particular specially protected territories in Latvia. Such plans also include measures aimed at conservation of specially protected amphibian species: as an example, *Bombina bombina* in microreserves Natura 2000 Ilgas, Islice, Katriniski and Strauti.

C. The level of territorial protection of nature

This level is related to the existence and operation of protected natural reserves. There are micro-reserves in Latvia that were founded for the conservation of specially protected declining amphibian species. The following micro-reserves and Natura 2000 territories were chosen for the conservation of *Bombina bombina*: Katriniski micro-reserve, Strauti micro-reserve (Demenes pagasts, Daugavpils novads) (Pupina and Pupins 2014b); Ilgas micro-reserve (Skrudalienas pagasts, Daugavpils novads); Īslīce micro-reserve (Īslīces pagasts, Bauskas novads). For conservation of *Epidalea calamita*: Puzes Reserve (Ventspils novads); Garkalnes Reserve (Dobeles novads); Karateru Reserve (Limbazu novads); Ainazi Reserve (Limbazu novads); Adazi Rezerve. *Hyla arborea*: in Embute pagasts, Liepajas novads (Berzins 2008). Other sympatric declining amphibian species often inhabit the same micro-reserves; for instance, *Pelobates fuscus* and *Triturus cristatus* occur in the micro-reserves of *Bombina bombina* (Pupina and Pupins 2009). Amphibian species inhabiting all the specially protected territories are protected according to the norms of those territories.

D. The project actions level

Particular projects for conservation of specially protected amphibian species and their habitats are implemented in Latvia with the aid of the EU European Commission and LIFE Programme; the Ministry of Environmental Protection and Regional Development and its structural units (Administration of Latvian Environmental Protection Fund, Nature Conservation Agency), local governments (Daugavpils city council) and organizations (e.g. Riga National Zoo, Latgales Zoo, Daugavpils University, Latvian Fund for Nature and Latgales Ecological Society).

Such projects can be international or national and usually foster complex actions: (1) conservation *in-situ*, (2) conservation *ex-situ*, (3) research (ecology, distribution, threats, habitats, herpetoculture), planning (Pupina and Pupins 2013b), and monitoring, (4) education of local inhabitants, and (5) dissemination of results. For example, three projects for conservation of rare amphibians have been implemented in Latvia and are co-financed by the European Commission and LIFE Programme:

The 2010–2014 LIFE project "Conservation of rare reptiles and amphibians in Latvia" (acronym: LIFE-HerpetoLatvia; LIFE09NAT/LV/000239) was co-financed by the European Commission: Country: Latvia. Target amphibian species: *Bombina bombina*. Two new microreserves and new Natura 2000 territories "Strauti" and "Katriniski" were created in Demene parish; 27 ponds were restored or created; more than 4,000 *Bombina bombina* juveniles were raised in amphibians' aquaculture (Figure 65.11); and released for population enforcement in 2013–2014 (Figure 65.12). The Project is very successful; both project sites are populated by *Bombina bombina*; also an additional site "Ilgas" which was improved for *Emys orbicularis* (Pupina and Pupins 2014a, 2014b).

The 2004–2009 LIFE project "Protection of habitats and species in Natura Park Razna" (LIFE04NAT/LV/000199) was co-financed by the European Commission. Country: Latvia. Target amphibian species: *Bombina bombina*. New ponds were created in Nature Park Razna and juvenile *Bombina bombina* were introduced to establish a new population.

The 2004–2008. LIFE project "*Bombina* in the Baltic Region – Management of fire-bellied toads in the Baltic region" (LIFE-Bombina number LIFE04NAT/DE/000028) was co-financed by the European Commission. Countries: Germany, Denmark, Sweden and Latvia. Target species: *Bombina bombina*. In two microreserves and Natura 2000 territories "Islice" and "Ilgas", new ponds were created and juveniles were released for population enforcement. The Project was very successful (Brockmuller and Drews 2009).

Many conservation projects and research on amphibians in Latvia have been executed with the financial support of the Latvian Environmental Protection Fund and Nature Conservation Agency.

Fig. 65.11 Breeding laboratory and recirculation system for amphibians in Rare Reptiles and Amphibians Breeding Centre (LIFE-HerpetoLatvia Project, Latgales Ecological Society, Ainavas, Daugavpils novds; 55° 50′ 65″ 5.65″ N; 26° 29′ 6.60″ E

Fig. 65.12 Releasing of *Bombina bombina* in restored pond where *Pelophylax sp*., *Triturus cristatus*, and *Pelobates fuscus* also are breeding (LIFE-HerpetoLatvia Project, Katriniski microreserve, Demene, Daugavpils novads; 55° 43′ 10.56″ N; 26° 32′ 54.51″ E).

V. Monitoring of amphibians in Latvia

Latvia undertakes long-time monitoring and scientific analyses of amphibian population trends. The first methodology for a state-financed amphibian monitoring programme was developed in 2005 as part of a national biodiversity monitoring programme. It consisted of two major parts: Natura-2000 monitoring and whole-state or so-called "background" monitoring. Biodiversity of Natura-2000 sites were surveyed by formally approved monitoring methods during the EMERALD Project realized by the Latvian Fund for Nature in 2001–2004. Among other protected species, there were two Habitats Directive Annex-II amphibian species for which project datasheets were prepared: great crested newt (*Triturus cristatus*) and fire-bellied toads (*Bombina bombina*). *Triturus cristatus* was registered in seven territories, but *Bombina bombina* only in two. The information consisted mostly of presence-absence data with some evaluation of available habitats. The methodology for Natura 2000 was developed in 2007 by an environmental consulting company, Estonian, Latvian & Lithuanian Environment.

The methodology for "background" monitoring was approved in 2006 by a state agency: Latvian Environment, Geology and Meteorology Centre. Unlike monitoring by Natura 2000, the methods were applicable to all amphibian species. This monitoring was performed only once, in 2008, by the company Estonian, Latvian & Lithuanian Environment. It consisted of two types of surveys. The first was the counting of vocalizing males in spring in three repetitions on the same transect at intervals of two weeks. The other method was the setting of three-armed drift fences twice a season – in late spring and in autumn. In each case traps were set for a period of about one week during which they were checked three times. Trapped amphibians were removed and released, but not marked. Using a random stratified sampling method, a total of nine squares, each 1 x 1 km, in different places of Latvia were selected for monitoring. There was a transect ~0.5–1 km long for counting vocalizing males (for periods of one hour) and one drift-fence trap (four buried buckets and six metres of fence) in each. Results from vocalizing males and from the traps in spring generally were poor, but in autumn the results from traps were better, with up to 30 amphibians captured for each check of the traps. Only the most common species were recorded (*Lissotriton vulgaris*, *Bufo bufo*, *Rana arvalis*, *Rana temporaria*, *Pelophylax* sp.). Results are available in the form of a report accompanied by datasheets from the field on the Nature Conservation Agency's home site (http://biodiv.daba.gov.lv).

In 2013, a state-approved biodiversity monitoring programme and a methodology for monitoring amphibians were significantly reworked and expanded by the Latvian Fund for Nature during a state-financed project.

The State monitoring programme for amphibians began in 2015 and was finished in 2018. It consisted of a vocalizing anuran survey on 65 plots that covers the whole territory of the state and included monitoring of the great crested newt at 21 sites where this species was recorded in 1980–2010. A survey of vocalizing anurans indicated the presence of green frogs (*Pelophylax* sp.) in 100% of visited 5 x 5 km squares; common toad (*Bufo bufo*) – 93%; common frog (*Rana temporaria*) – 83%; moor frog (*Rana arvalis*) – 80%; spade-foot toad (*Pelobates fuscus*) – 13%; treefrog (*Hyla arborea*) – 10 %; and fire-bellied toad (*Bombina bombina*) – in 5%. Data from a survey by handnet of the great crested newt (*Triturus cristatus*) confirmed its presence in 60% of historical sites.

We have been conducting personal monitoring of *Bombina bombina* since 2000 in the previously known population at Ilgas, and since 2004 in newly discovered populations at Demene, Ainavas, Medumi, Bauska and Verdini. Methods of monitoring include the counting of vocalizing males and visual accounting, partly looking for tadpoles and eggs. The characteristics of ponds, the presence of fishes (especially the invasive *Perccottus glenii*) and the degree of overgrowing by vegetation were also estimated. We explored all known localities in Latvia 1–4 times per season

until 2011; the localities have been selectively explored in 2012–2017 because of an increase in the number of localities found to contain this species (> 300). The results have been entered in the database and published (Pupina and Pupins 2008, 2010, 2012, 2013a; Pupina *et al.* 2008).

VI. Conclusions

Latvia, with its large quantity of humid habitats and small ponds, non-freezing bodies of water and other places for overwintering, undeveloped agricultural industry and decreasing human population, generally corresponds to the needs of the amphibian species that inhabit it. However, Latvia is a northern European country and a half of all the Latvian amphibian species – *Triturus cristatus*, *Bombina bombina*, *Hyla arborea*, *Bufotes viridis*, *Epidalea calamita*, *Pelobates fuscus*, *Pelophylax* sp. – reach the northern border of their European distribution in or near Latvia. Therefore, their populations in Latvia are few in number and are fragmented. These species have special requirements for optimizing their habitats in Latvia, i.e. increasing the permanence and luminance of non-freezing ponds used by amphibians for overwintering. The progressive overgrowing by bushes, shading, and degradations of such habitats contribute to the decline of the amphibian populations. The increasing threats of anthropogenic origin – mortality on roads, invasive species of fishes, invasive mammalian predators, invasive freshwater turtles and new parasites may lead to the decline of the few amphibian species inhabiting Latvia, and accordingly their European area of distribution will decrease. The climatic changes in Latvia can have both positive and negative meaning for Latvian amphibians. Because of climatic change, research is urgently needed on (1) the peculiarities of the ecology and distribution of declining amphibians on the northern border of Latvia; (2) optimization of biotopes and enhancement of the endangered populations using animals from zooculture; and (3) performance of the necessary measures aimed at protecting limited populations and at uniting them into metapopulations by establishing population bridges, including trans-border ones, for making genetic contact with stronger southern populations.

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