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Herpetofauna of the Pieprzowe Mountains Nature Reserve and adjacent areas

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Abstract
The study was focused on determining the sites of amphibian and reptile occurrence in the Pieprzowe Mountains Nature Reserve (area 18.01 ha) and adjacent areas (total area 58.81 ha). The investigations also involved the biology of breeding in the selected species, as well as determining threats and protection measures.
Situated in the eastern part of the Świętokrzyskie Voivodeship, the steppe-like Pieprzowe (Pepper) Mountains Nature Reserve was established in 1979. Its aim is to protect xerothermic assemblages inhabited by many species of rare plants including the largest European aggregation of roses growing wild. The area is located on a steep, sometimes rugged escarpment, which is part of the Vistula River erosional margin. The escarpment exposes Cambrian black pepper-like shales. The slope base is overgrown by a narrow belt of willow thickets. Above occur assemblages of xerothermic thickets with a few trees. The highest parts of the nature reserve are overgrown with xerothermic grasslands with the prevalence of feathergrass steppe (Festuco-Stipion class). The reserve is surrounded by riparian forests, waterlogged meadows and reservoirs of the Vistula former riverbed, the largest of which is an oxbow lake (5.16 ha).
The following species were documented in 2016-2017: smooth newt *Lissotriton vulgaris* L., great crested newt *Triturus cristatus* Laur., European fire-bellied toad *Bombina bombina* L., common toad *Bufo bufo* L., European green toad *Bufotes viridis* Laur., European tree frog *Hyla arborea* L., edible frog *Pelophylax esculentus* L., pool frog *Pelophylax lessonae* Cam., marsh frog *Pelophylax ridibundus* Laur., moor frog *Rana arvalis* Nilss., common frog *Rana temporaria* L., sand lizard *Lacerta agilis* L., grass snake *Natrix natrix* L. and common European adder *Vipera berus* L.
The studies were focused on biology of breeding and phenology in common toad and common frog.
The main threats posed on herpetofauna include: human presence, littering, fire raising and changes of water balance.

1. INTRODUCTION

Steppe nature reserves have rarely been the focus of interest for herpetologists. This results from the specific character of these areas, correctly associated with dry areas devoid of water reservoirs, which are indispensable for amphibian breeding. Poland lies within the biome of temperate deciduous forests (terrestrial region, Central European province), thus, steppes (xerothermic grasslands in particular) are not common here; moreover, they usually lie in the neighbourhood of completely different habitats. The Pieprzowe (Pepper) Mountains nature reserve, lying in direct vicinity of the Vistula former riverbed, is a good example of such an environment. It also contains waterlogged meadows, riparian forests, small rivulets and the Vistula River itself. Such environment is an opportunity for the occurrence of both reptiles and amphibians, ensuring suitable mating conditions. Furthermore, sunlit grasslands favour the presence of thermophilic species such as herpetofauna.
So far, faunal investigations of amphibians and reptiles were not conducted in the Pieprzowe Mountains Nature Reserve and its vicinity. This is a common case for the

entire eastern part of the Świętokrzyskie Voivodeship, with two publications regarding herpetofauna from the Staszów district [Juszczyk et al., 1989; Wojdan, 2013]. The distribution of amphibians and reptiles in the Sandomierz district was studied by Juszczyk et al. [1989], but in the part of the district located to the south of Sandomierz, whereas the Pieprzowe Mountains lie to the north of the town. The cited report should be treated as historical, due to the diminishing herpetofauna caused by progressive anthropopression [Blaustein and Wake, 1990; Alford and Richards, 1999; Carey et al., 2001; Crochet et al., 2004; Stuart et al., 2004; Nyström et al., 2007]. Therefore, this paper is focused on determining the occurrence and distribution of amphibians and reptiles in the Pieprzowe Mountains Nature Reserve and its vicinity, as well as the phenology of breeding in the selected species. The studies included also record the assessment of the observed threats.

2. STUDY AREA

The investigations were performed on an area of 58.81 ha (coordinates 50°40'–50°41'N and 21°46'–21°48'E), of which 18.01 ha is the area of the nature reserve (50°41'N and 21°47'–21°48'E). The study area lies in the eastern part of the Sandomierz Upland mesoregion [Kondracki, 2011]; with regard to administrative divisions, it belongs to the Świętokrzyskie Voivodeship, Sandomierz district, Dwikozy commune. Established in 1979, the Pieprzowe Mountains Nature Reserve was formed on part of the steep, in places rugged erosional margin of the Vistula River, located about 60 m above the valley bottom. The southern slope of the escarpment exposes middle Cambrian, black pepper-like shales across a large area of about 2 km. These rocks contain rare trilobite and brachiopod fossils. The prevailing rock types include clayey shales, sandstones and conglomerates. Loess soils dominate, assigned to the chernozems of forest-steppe settings; brown soils and bog soils are also present. The climate is temperate warm (annual mean of 7.8°C), with continental features [Alexandrowicz, 1972; Głowaciński and Michalik, 1979].

Vegetation of the Pieprzowe Mountains forms three distinctive belts. The base of the slope is overgrown by willow thickets with purple willow *Salix purpurea* L. Higher up occur xerothermic thickets with European dwarf cherry *Prunus fruticosa* Pall., with a low contribution of dwarf trees. The uppermost parts of the hills are overgrown by xerothermic grasslands, mainly of the feathergrass steppe (Festuco-Stipion class), with diverse xerothermic vegetation. The nature reserve is the largest European aggregation of roses growing wild. Their abundance has been estimated to several thousands of bushes [Popek 1967, 1983]. Numerous species of rare plants have been found in the reserve, for example, *Rosa kostrakiewiczii* Popek and French rose *Rosa gallica* L. The total number of plant species in the reserve reaches almost 400, with over 300 species of vascular plants and c. 50 species of lichens, liverworts and mosses [Głazek, 1978, 1980; Kozik, 1981]. Specific fauna includes entomofauna [Szymczakowski, 1972] and arachnofauna [Dembicka and Rozwałka, 2007], comprising, for example, xerothermic and disjunctive species.

The only surface waters in the Pieprzowe Mountains include a small stream flowing in a deep ravine in the western part of the reserve. It locally forms small pools, of which the largest, with an area of approximately 15 m^2, served as the study site location. Much larger reservoirs belonging to the Vistula former riverbed can be found in the vicinity of the reserve (Fig. 1). The closest reservoirs located to the south of the Pieprzowe Mountains are as follows: an oxbow lake (area 5.16 ha), including three study sites, and smaller ones situated to the east of the oxbow lake. The study was focused on five of them; for simplicity, they were referred to as: small lake (area 0.05 ha), large lake (area 0.9 ha), medium lake (area 0.4 ha), large pond (area 40 m^2) and small pond (area 25 m^2). A characteristic feature of these reservoirs is the common occurrence of water chestnut *Trapa natans* L. Beyond the nature reserve area, the studies were performed in the surrounding riparian forests, thicket assemblages and waterlogged meadows.

3. METHODS

The studies were performed in 2016-2017 in the nature reserve and its vicinity (Fig. 1). Due to its small acreage, the study area can be considered as one site; however, taking into account the habitat preferences of particular species, sites for the systematic observation and trapping of herpetofauna were also established. In the case of amphibians, they comprised water reservoirs, where the animals performed mating rituals. Only amphibian breeding spots were analysed, that is, shallow, nearshore waters (up to the depth of 1 m). Observations were made at different parts of the day, also at dusk. Tailless amphibians were depicted, for example, by surveying mating calls of male individuals. Some of the individuals were trapped for specific assignment, and then released in the trapping site. The trapping sites were inspected at least 3 times a month between March and June and twice a month between July and September, controlling also the presence of amphibian larvae and spawn. Neither morphometric measurements nor the determination of sex ratio were carried out since it would have required catching all the discussed populations.

The most abundant species, that is, common toad and common frog, were selected for phenological studies. Atmospheric and water (at the depth of 30 cm) temperatures were noted for each observation day. The following characteristic life-stages were included: 1) amplexus (from the earliest to the latest pair of individuals observed); 2) spawn in water (i.e., from the appearance of spawn till lack of spawn); 3) presence of larvae (from the hatching of first tadpoles till their metamorphosis; 4) metamorphosis (from the first metamorphosed individuals till the last metamorphosed individuals leaving the water reservoir).

Table 1. Amphibian observation and trapping sites in the study area

Species	Sites (numbers according to Fig. 1)								
	1	2	3	4	5	6	7	8	9
Lissotriton vulgaris	–	–	+	+	++	+	++	–	++
Triturus cristatus	–	–	+	+	–	+	++	–	–
Bombina bombina	–	–	–	–	+	+	–	–	–
Bufo bufo	–	++	+++	+++	+++	+++	+++	–	+++
Bufotes viridis	–	+	–	+	++	–	–	–	–
Hyla arborea	–	–	–	+	–	–	–	–	–
Pelophylax esculentus	–	++	++	++	++	–	+++	–	–
Pelophylax lessonae	–	+	++	++	++	+	+++	–	–
Pelophylax ridibundus	–	–	++	+	–	–	++	–	–
Rana arvalis	–	+	–	–	–	–	–	–	–
Rana temporaria	++	++	+++	+++	+++	+++	+++	++	+++

(+ scarce individuals, ++ prolific abundance, +++ very large amounts of individuals)

In the case of reptiles, the observation sites were those where reptiliofauna was abundant. Most observations were made in the morning and antemeridian hours. The frequency of the inspection was similar as in the case of amphibians, that is, 2-3 times a month.

4. RESULTS

4.1. Batrachofauna

Amphibians were observed in 9 selected sites (Figure. 1, Table 1). The trapping sites were: site 1 – pool of stream flowing along the creek; 2 – western part of oxbow lake; 3 – southern part of oxbow lake; 4 – eastern part of oxbow lake; 5 – small lake; 6 – medium lake; 7 – large lake; 8 – small pond; 9 – large pond.

A total of 11 amphibian species were noted in the study area (Fig. 2, Table 1). The observed species included: smooth newt *Lissotriton vulgaris* L., great crested newt *Triturus cristatus* Laur., European fire-bellied toad *Bombina bombina* L., common toad *Bufo bufo* L., European green toad *Bufotes viridis* Laur., European tree frog *Hyla arborea* L., edible frog *Pelophylax esculentus* L., pool frog *Pelophylax lessonae* Cam., marsh frog *Pelophylax ridibundus* Laur., moor frog *Rana arvalis* Nilss. and common frog *Rana temporaria* L. (Fig. 2, Table 1).

Smooth newt was common, with several to several tens of individuals trapped in single sites during the inspections. It was most abundant in smaller reservoirs, particularly those with dense aqueous vegetation. Great crested newt was less common, excluding site no. 7, in which several tens of individuals representing the species were trapped. European fire-bellied toad inhabited sites nos. 5 and 6 only. It was rather uncommon, with only slightly over ten individuals observed during the inspection. Males' voices could be heard in both the researched reservoirs. Common toad was present in almost all reservoirs, with even more than 100 individuals mating simultaneously at every site. After the mating season, it was the most commonly observed amphibian species in almost the entire area, with the exception of open areas (meadows, grasslands and fields). European green toad was observed in 3 mating sites (maximally up to several tens of individuals), but it was equally common beyond the reservoirs. It was noted within fields, meadows, grasslands, xerothermic thickets, and – more rarely – in forests. European tree frog inhabited mating site no. 4 only (over 20 individuals observed during the inspection). The males' voices of this species could be also heard.

All three species of 'green frogs' were observed in the study area, with the pool frog and the edible frog being common and abundant (hundreds of individuals observed). Marsh frog was present in three sites only, although it was relatively abundant (up to several tens of individuals). Two species of 'brown frogs' were noted in the study area, but they differed in abundance and range of occurrence. Moor frog inhabited one site only (no. 2), where barely over 10 individuals were observed (mating calls of a number of other male individuals were also depicted). Beyond the mating season, the species was rarely observed only

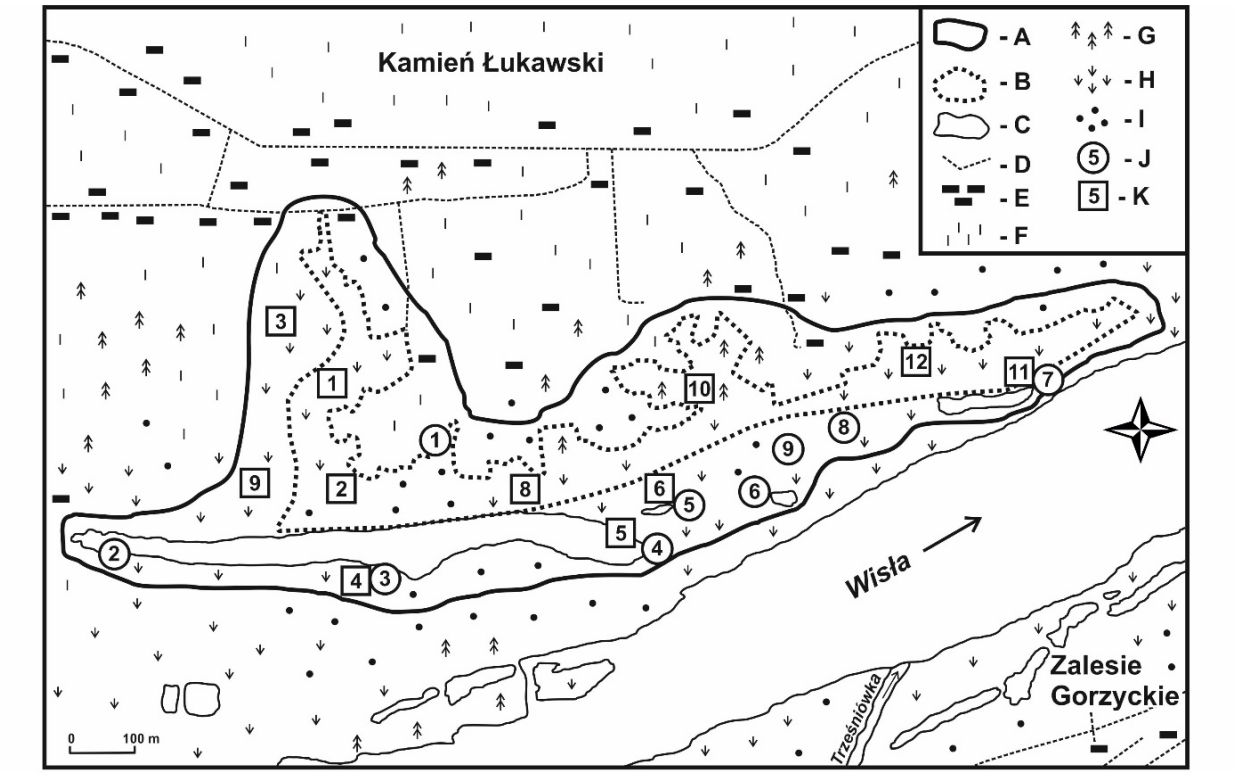

Figure 1. Distribution of observation sites of amphibians and reptiles in the study area
A – limits of study area, B – limits of nature reserve, C – surface waters, D – roads, E – inhabited areas, F – arable land, G – forests, H – forest-thicket communities, I – meadows and xerothermic grasslands, J – amphibian sites, K – reptile sites.

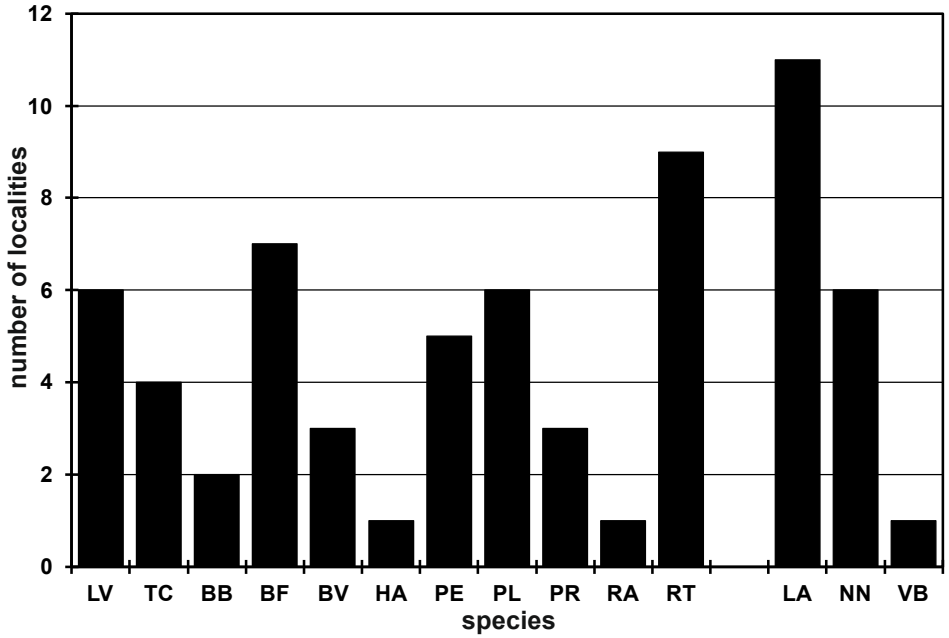

Figure 2. Number of observation sites of amphibians and reptiles in the study area. Amphibians: LV – *Lissotriton vulgaris*, TC – *Triturus cristatus*, BB – *Bombina bombina*, HA – *Hyla arborea*, BF – *Bufo bufo*, BV – *Bufotes viridis*, PE – *Pelophylax esculentus*, PL – *Pelophylax lessonae*, PR – *Pelophylax ridibundus*, RA – *Rana arvalis*, RT – *Rana temporaria*. Reptiles: LA – *Lacerta agilis*, NN – *Natrix natrix*, VB – *Vipera berus*.

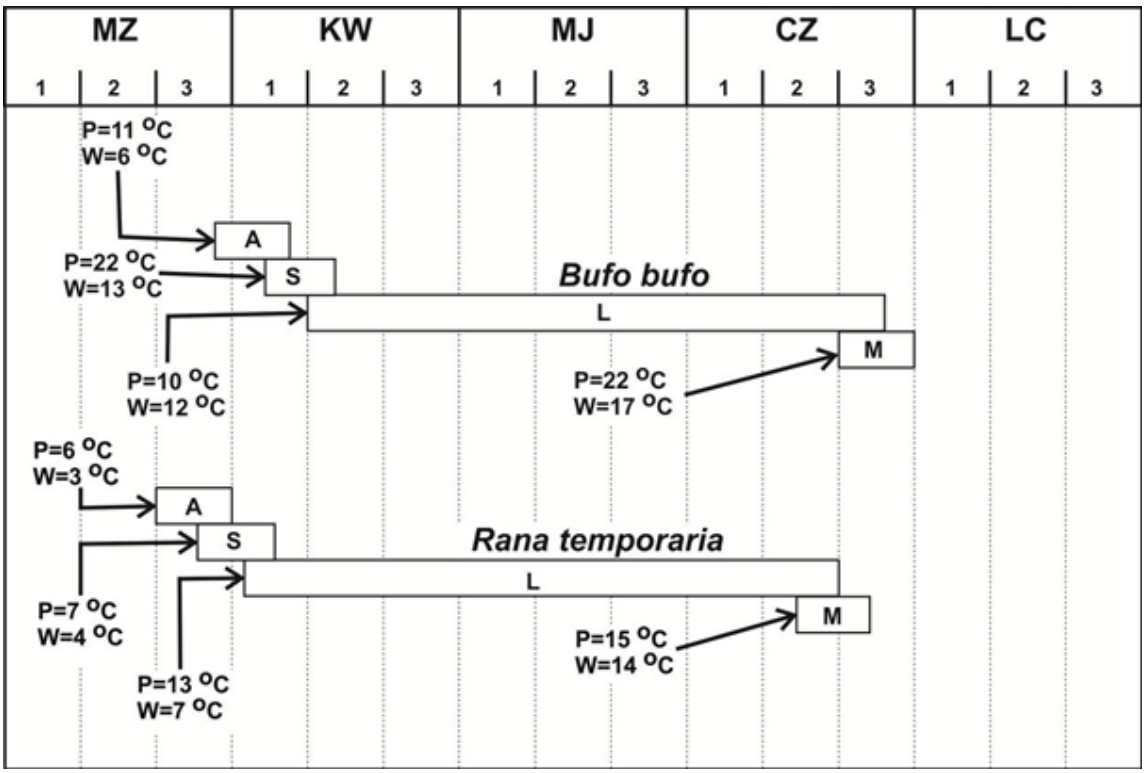

Figure 3. Breeding phenology in common toad and common frog in the study area.
MZ – March, KW – April, MJ – May, CZ – June, LC – July, 1-3 – decades, A – amplexus, S – spawn, L – larvae (tadpoles), M – metamorphosis, P – atmospheric temperature, W – water temperature.

in the western part of the study area. Common frog was very common and reached higher abundance than the remaining amphibians. It inhabited even a small pool (site no. 1), and in larger reservoirs, mating was performed by hundreds of individuals at the same time (Fig. 2, Table 1).
In 2016, breeding phenology was investigated in two most prolific species of amphibians in regard to the studied area: common toad and common frog (Fig. 3). Amplexus in common toad (Fig. 4) was noted for the first time on 28.03 (atm. temp. 11ºC, water temp. 6ºC), and for the last time on 8.04. Spawn was observed between 5.04-14.04, tadpoles between 11.04-27.06, and metamorphosis between 21.06-30.06. Breeding of common frog was as follows: amplexus from 21.03 (atm. temp. 6ºC, water temp. 3ºC) till 31.03, spawn between 25.03-6.04, tadpoles between 3.04-20.06, and metamorphosis between 14.06-24.06 (Fig. 3).

Figure 4. Common toad in amplexus (Phot. D. Wojdan)

4.2. Reptiliofauna

In the case of reptiles, the observation sites were areas with the highest abundance. Reptile observations were performed in twelve selected sites (Fig. 1, Table 2). They included forest-thicket sites (nos. 1, 3, 5-9, 11 and 12), riparian forests (site no. 10), meadows and xerothermic grasslands (sites nos. 2 and 4).
Reptile fauna was represented by three species: sand lizard *Lacerta agilis* L., grass snake *Natrix natrix* L. and common European adder *Vipera berus* L. (Fig. 2, Table 2). Sand lizard occurred abundantly and commonly in all the analysed settings (excluding the water reservoirs). Up to over ten individuals, mostly females, were observed during each inspection. The species was observed in almost the entire study area and its vicinity (e.g., Kamień Łukawski village). Grass snake occurred in five sites (nos. 4-6, 8 and 9), in direct neighbourhood of the reservoirs in the largest

Table 2. Reptile observation sites in the study area

Species	Sites (numbers according to Fig. 1)											
	1	2	3	4	5	6	7	8	9	10	11	12
Lacerta agilis	+	+	+	–	+	+	+	+	+	+	+	+
Natrix natrix	–	–	–	+	+	+	–	+	+	–	+	–
Vipera berus	–	–	–	–	–	–	–	–	–	+	–	–

abundances. Single snakes, rarely over five individuals were usually observed. Common European adder was observed only once at site no. 10 (Fig. 2, Table 2). That was an individual of brown variety.

The largest threats to herpetofauna include spring grass fires, caused by burning out vegetation by citizens of Kamień Łukawski. Two such cases were observed, potentially threatening fire of the nature reserve. Constant human presence in the study area, grazing and littering, including littering of reservoirs, were documented. Moreover, smaller pools and ponds (not included as study sites) dried up in May or June. As a result, amphibian larvae (mainly tadpoles of common frog and common toad) perished in these reservoirs.

5. DISCUSSION

So far, the Pieprzowe Mountains Nature Reserve has not been the focus of interest of herpetologists. The nearest area studied was Sandomierz [Juszczyk et al. 1989]. Unfortunately, beside the qualitative composition of herpetofauna there are no other data on this site. The report of Juszczyk et al. [1989] was focused on the Vistula corridor; therefore, it may be assumed that the Sandomierz site included the reservoirs of the Vistula former riverbed, lying at a distance of over 2 km from the Pieprzowe Mountains. These areas comprise the same habitats as the Vistula former riverbed analysed near Kamień Łukawski.

Comparison of both sites points to full concordance of the quantitative composition, with the same eleven amphibian and three reptile species in both sites. The report of Juszczyk et al. [1989] does not supply precise faunal data, but gives information on herpetofauna from the Vistula corridor from a vast area between Cracow and Sandomierz (a total of 64 sites). This dataset indicates that some species are almost absent or occur in a few sites only. From among the herpetofauna inhabiting central Poland, Juszczyk et al. [1989] have not documented the presence of European common spadefoot *Pelobates fuscus* Laur. and smooth snake *Coronella austriaca* Laur. in the Vistula corridor. The latter species also does not occur in the Pieprzowe Mountains area; similarly, as the European common spadefoot *Pelobates fuscus* Laur. viviparous lizard *Lacerta vivipara* Jacquin and deaf adder *Anguis fragilis* L. Juszczyk et al. [1989] did not note the latter three species in Sandomierz. However, they were observed in a few sites located more to the south. Based on this, it should be assumed that the composition of herpetofauna in the Pieprzowe Mountains is rather typical for the Vistula corridor. This refers, however, to abundantly inhabited areas, because in most sites Juszczyk et al. [1989] observed an impoverished species composition of amphibian and reptile fauna. When it comes to the comparison of the discussed nature reserve area with total indigenous herpetofauna of Poland [Głowaciński & Sura, 2018], it turns out that 58% and only 30% of the national species of amphibians and reptiles are found here, respectively.

With regard to breeding biology and phenology of the common frog and the common toad, the analysed year 2016 was characterised by an early spring, due to which both studied amphibian species began their mating season in the third decade of March (Fig. 3). This is a common phenomenon and is not necessarily connected with global warming. The dates of particular phases of the breeding cycle of common frog were within ranges observed in the previous years in neighbouring areas, that is, Staszów [Wojdan and Kasprowicz, 2010] and Opatów districts [Wojdan, 2013]. Phenology of common toad was not analysed earlier in these areas, but it is similar to the nearest areas from the Kielce district [Wojdan, 2016].

The threats observed (fire raising, human presence, grazing, littering) were indirectly caused by the close vicinity of anthropogenic environments (arable fields and inhabited areas) and habitat fragmentation. Most amphibians do not occur in urbanized areas, even those with dispersed housing, as it has been described from different parts of the world [Pellet et al., 2004; Riley et al., 2005; Hamer and McDonnell, 2008; Pillsbury and Miller, 2008]. To a lesser degree, batrachofauna avoids farmlands, particularly those with large acreage [Guerry and Hunter, 2002; Ficetola and De Bernardi, 2004; Weyrauch and Grubb, 2004]. Habitat fragmentation is very often the reason for herpetofauna isolation and, in consequence, its disappearance [Knutson et al. 1999; Kolozsvary and Swihart, 1999; Lehtinen et al., 1999; Cushman, 2006]. Some species are extremely sensitive to anthropopressure, as evidenced in the other areas in the case of European tree frog [Andersen et al., 2004] and moor frog [Vos and Chardon, 1998]. Also, in the Pieprzowe Mountains area, these two amphibians occupied only one breeding site each. The study area is

surrounded from three sides by villages (Kamień Plebański, Kamień Łukawski and Podgórze), with the Vistula River occurring to the south. This locality to some degree contributes to the isolation of the study area, because the nearest neighbourhood lacks similar habitats, with the exception of the Vistula river margins.

6. SUMMARY

In summary, despite a small area of occurrence, the herpetofauna of the Pieprzowe Mountains and their vicinity is abundant and diverse. The presence of amphibians and reptiles is favoured by the presence of appropriate habitats, but is restricted by anthropopressure caused by the close vicinity of anthropogenic environments. A strategy aimed at protecting the herpetofauna of this area should be based on the conservation of the above-mentioned habitats, water basins in particular.

REFERENCES

ALEXANDROWICZ S. W.: Góry Pieprzowe – klasyczne odsłonięcie utworów kambru. Chroń. Przyr. ojcz., 1972, 28, 5-6, s. 5–10.

ALFORD R. A., RICHARDS S. J.: Global amphibian declines: a problem in applied ecology. Annu. Rev. Ecol. Evol. S., 1999, 30, s. 133–165.

ANDERSEN W., FOG K., DAMGAARD C.: Habitat fragmentation causes bottelnecks and inbreeding in European tree frog (Hyla arborea). Proc. R. Soc. London B, 2004, 271, s. 1293–1302.

BLAUSTEIN A. R., WAKE D. B.: Declining amphibian populations: a global phenomenon? Trends Ecol. Evol., 1990, 5, s. 203–204.

CAREY C., HEYER R., WILKINSON J., ALFORD R., ARNTZEN J., HALLIDAY T., HUNGERFOD L., LIPS K., MIDDLETON E., ORCHARD S., RAND A.: Amphibian declines and environmental change: use of remote sensing data to identify environmental correlates. Conserv. Biol., 2001, 15, s. 903–913.

CROCHET P. A., CHALINE O., CHEYLAN M., GUILLAME C. P.: No evidence of general decline in amphibian community of Southern France. Biol. Conserv., 2004, 119, s. 297–304.

CUSHMAN S. A.: Effects of habitat loss and fragmentation on amphibians: a review and prospectus. Biol. Conserv., 2006, 128, s. 231–240.

DEMBICKA A., ROZWAŁKA R.: Nowe stanowiska gryziela stepowego Atypus muralis Bertkau, 1980 w dolinie Wisły. Chroń. Przyr. ojcz., 2007, 64, s. 13–29.

FICETOLA G. F., DE BERNARDI F.: Amphibians in a human-dominated landscape: the community structure is related to habitat features and isolation. Biol. Conserv., 2004, 119, s. 219–230.

GŁAZEK T.: Flora Gór Pieprzowych pod Sandomierzem. Fragm. Flor. Geobot., 1978, 24, 2, s. 197–224.

GŁAZEK T.: Góry Pieprzowe pod Sandomierzem jako osobliwy obiekt przyrodniczy. Ochr. Przyr., 1980, 43, s. 91–128.

GŁOWACIŃSKI Z., SURA P.: Atlas płazów i gadów Polski. Status, rozmieszczenie, ochrona, z kluczami do oznaczania. PWN, Warszawa, 2018.

GUERRY A.D., HUNTER M. L.: Amphibian distributions in a landscape of forests and agriculture: an examination of landscape composition and configuration. Conserv. Biol., 2002, 16, 3, s. 745–754.

HAMER A. J., MCDONNELL M. J.: Amphibian ecology and conservation in the urbanising world: a review. Biol. Conserv., 2008, 141, 10, s. 2432–2449.

JUSZCZYK W., ZAKRZEWSKI M., ZAMACHOWSKI W., ZYŚK A.: Płazy i gady terenów nadwiślańskich między Oświęcimiem a Sandomierzem. Stud. Ośr. Dokumen. Fizjograf., 1989, 17, s. 293–305.

KNUTSON M. G., SAUER J. R., OLSEN D. A., MOSSAN M. J., HIEMESATH L. M., LANNOO M. J.: Effects of landscape composition and wetland fragmentation on frog and toad abundance and species richness in Iowa and Wisconsin, U.S.A. Conserv. Biol., 1999, 13, 6, s. 1437–1446.

KOLOZSVARY M. B., SWIHART R. K.: Habitat fragmentation and the distribution of amphibians: patch and landscape correlates in farmland. Can. J. Zool., 1999, 77, s. 1288–1299.

KONDRACKI J.: Geografia regionalna Polski. Wyd. Nauk. PWN. Warszawa, 2011.

Kozik R.: Porosty (Lichenes) Gór Pieprzowych koło Sandomierza. Fragm. flor. et geobot., 1981, 27, 4, s. 641–648.

LEHTINEN R. M., GALATOWITSCH S.M., TESTER J. R.: Consequences of habitat loss and fragmentation for

wetland amphibian assemblages. Wetlands, 1999, 19, 1, s. 1–12.
NYSTRÖM P., HANSSON J., MÅNSSON J., SUNDSTEDT M., RESLOW C., BROSTRÖM A.; A documented amphibian decline over 40 years: possible causes and implications for species recovery. Biol. Conserv., 2007, 138, s. 399–411.
PELLET J., GUISAN A., PERRIN N.: A concentric analysis of the impact of urbanization on the threatened European tree frog in an agricultural landscape. Conserv. Biol., 2004, 18, s. 1599–1606.
PILLSBURY F. C., MILLER J. R.: Habitat and landscape characteristics underlying anuran community structure along an urban-rural gradient. Ecol. Appl., 2008, 18, 5, s. 1107–1118.
POPEK R.: Róże Gór Pieprzowych koło Sandomierza. Cz. I, Fragm. Flor. et Geobot., 1967, 13, 4, s. 459–474.
POPEK R.: Róże Gór Pieprzowych koło Sandomierza. Cz. II, Fragm. Flor. Geobot., 1983, 29, 3-4, s. 345–353.
RILEY S. P. D., BUSTEED G. T., KATS L. B., VANDERGON T. L., LEE L. F. S., DAGIT R. G., KERBY J. L., FISHER R. N., SAUVAJOT R. M.: Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams. Conserv. Biol., 2005, 19, s. 1894–1907.
SZYMCZAKOWSKI W.: Owady Gór Pieprzowych. Chroń. Przyr. ojcz., 1972, 28, 5-6, s. 19–26;
GŁOWACIŃSKI Z., MICHALIK S.: Kotlina Sandomierska. Wiedza Powszechna, Warszawa, 1979.
STUART S. N., CHANSON J. S., COX N. A., YOUNG B. E., RODRIGUES A. S. L., FISCHMAN D. L., WALLER R. W.: Status and trends of amphibian declines and extinctions worldwide. Science, 2004, 306, s. 1783–1786.
VOS C. C., CHARDON J. P.: Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*. J. Appl. Ecol., 1998, 35, s. 44–56.
WEYRAUCH S. L., GRUBB T. C.: Patch and landscape characteristics associated with the distribution of woodland amphibians in an agricultural fragmented landscape: an information-theoretic approach. Biol. Conserv., 2004, 115, s. 443–450.
WOJDAN. D.: Herpetofauna Cisowsko-Orłowińskiego Parku Krajobrazowego. Parki nar. Rez. Przyr., 2016, 35, 4, s. 43–55.
WOJDAN D.: Herpetofauna rezerwatu przyrody „Dziki Staw". Parki nar. Rez. Przyr., 2013, 32, 1, s. 71–78.
WOJDAN D., KASPROWICZ M.: Herpetofauna Jeleniowskiego Parku Krajobrazowego. Kulon, 2010, 15, s. 49–56.