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PROPOSAL OF THE MONITORING METHODOLOGY OF THE VIVIPAROUS LIZARD *Zootoca vivipara*

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Abstract. The viviparous lizard (*Zootoca vivipara*) is a species of the Squamata order from the family of lizards (Lacertidae) covering the wide range – from Western Europe, including British islands and Ireland to the far reaches of Asia with limit of occurrence on the Japanese island of Hokkaido. The population of the viviparous lizard is not regularly monitored and does not have specific monitoring rules. Currently, numerous publications in the press and media inform about the progressive intensification of agriculture, intensity of tourist traffic or the increasingly progressive urbanization of the environment, which contributes to the migration of viviparous lizards from these areas. It has been suggested that because of human interference with the environment, viviparous lizards retreat to intact natural habitats. This is related to decrease in the area of occurrence of these reptiles and less frequent observations than before. The work presents a proposed methodology of viviparous lizard monitoring based on the evaluation of population status indicator – relative abundance and habitat condition indicators such as availability of breeding places and availability of hiding places. The aim of the article is to present indicators of the population status and habitat condition indicators, additionally to establish terms and frequency of surveys within the framework of the possibility to conduct monitoring studies of viviparous lizard populations.

Key words: viviparous lizard, *Zootoca vivipara*, monitoring, indicator.

INTRODUCTION

Viviparous lizard is a small reptile of delicate build which leads a diurnal lifestyle. It occurs in the following four subspecies: *Zootoca vivipara vivipara* (Lichtenstein, 1823), *Zootoca vivipara pannonica* (Lác and Kluch 1968), *Zootoca vivipara carniolica* (Mayer et al. 2000), *Zootoca vivipara louislantzi* (Arribas 2009) – all four live in Europe. The viviparous lizard inhabits a wide variety of habitats, as it has the ability to acclimatize to different climates and altitudes (Aragon et al. 2006) and also it is a moisture-loving species (Eplanova et al. 2018). In international law they are included in Bern Convention Annex II as well as Annex IV of the Habitats Directive, but without redacted national monitoring rules. According to the assessment degree of threatened species listed in the Red List of the International Union for Conservation of Nature (IUCN Red List), this species is included in the category of least concern species (LC) (Agasyan 2019).

The maximum body length of sexually mature individuals is 15.6 centimeters and usually weighs from 2 to 5 grams (Crews and Gans 1992). The reptile's head is not too big and poorly demarcated from the torso. The scales on the back are of the same size, small, hexagonal and slightly convex. Viviparous lizards have only two shields located behind their nasal aperture – one behind the nostril and the other one on the cheek behind the nasal opening (Dudek et al. 2014). The coloration of reptiles is dark brown in different shades – from light gray brown to dark chocolate or brownish black (Smith 1964). There are three rows on the back of dark circular spots that sometimes merge to form a uniform band along the body. Dark spots are often accompanied by light spots, scattered irregularly or occurring on dark spots (Crews and Gans 1992). Morphological variability between the subspecies of *Zootoca vivipara* depends on the habitat (Ljubisavljević et al. 2010) and is hardly noticeable. Moreover, morphological variation was more frequent and distinct in males (Arribas 2009).

Viviparous lizards reach sexual maturity at age of 2 years, whereas females mature more slowly than males. Mating begins from May to June. Males choose their a female partner in terms of a darker coloration and usually pair within 30 seconds of meeting the female and then copulate with her several times from 5 to 30 minutes (Avery and Tromp 1977). Both males and females have multiple partners. Viviparous lizard is one of the few reptiles are that representatives of reproductive bimodality (Lantz 1927; Braña and Bea 1987). In all four subspecies of *Zootoca vivipara* we distinguish viviparous and oviparous individuals. There is a relationship between the way of producing offspring and the climate: in the north and at high altitudes viviparous is dominant, whereas in the south it is oviparous (Surget-Groba et al. 2006). *Zootoca vivipara vivipara* is viviparous over most of its range (Pecio 2012), while it is oviparous in the most southwestern part of the world (Heulin et al. 1997; Surget-Groba et al. 2006). *Zootoca vivipara louislantzi* (Arribas 2009) and *Zootoca vivipara carniolica* are oviparous, while *Zootoca vivipara pannonica* is viviparous (Surget-Groba et al. 2006).

The breeding season falls once a year, while at higher altitudes in the mountains, lizard females give birth once every two years (Chamaille-Jammes et al. 2006). Pregnancy lasts approximately 3 months. Viviparous females provide protection for the growing young by hiding them in their bodies (Diesener and Reichholf 1997). Viviparous offspring are born surrounded by an egg shell, from which they claw its way within one day (Horváthová et al. 2013). Oviparous females lay their eggs, hidden in plant areas near water. Both oviparous and viviparous lizards give birth to offspring from July to September. Moreover, both of them give a similar number of offspring, which varies from 5 to 11 juveniles.

In October, as soon as the frost comes, lizards go to hibernation, most often in mossy, grass litter (Bauwens 1981). Waking up from hibernation takes place in February at the earliest, but the lethargy usually ends in March. Food consumption is regulated by the lizard's internal body temperature. In nature, this species stops consuming food when the body temperature drops below 27°C (Avery 1975). Viviparous lizards feed on invertebrates, mostly focusing on hemipterans (for example cicadas), spiders and mealworms. Sometimes they also feed on insects, earthworms and centipedes. In emergency situations, viviparous lizard sheds its tail, escapes into the water, pretends to be dead or creates a camouflage in its surroundings (Aragon et al. 2006).

Natural causes that pose a threat to the viviparous lizard's populations are predation by larger predators such as snakes, hedgehogs, shrews and even domestic dogs and cats (Avery and Tromp 1977). In addition, viviparous lizards are host to parasitic protozoa of the genera *Haemogregarina* and *Plasmodium*, an external parasitic mite. These parasites negatively affect the lizards' immune system and reduce their energy reserves. Severe infections can sometimes lead to death (Clobert and Oppliger 1997; Sorci et al. 1997). Also on the sand lizard *Lacerta agillis*, there were found the ectoparasites of the common tick – larvae and nymphs (Sorci et al. 1997). Parasites occurred on about 20% of the observed lizards. This problem affected both sexes equally as well as young individuals. There are also local threats to the viviparous lizard, such as loss of the natural environment (Böhme 1997). It is the result of the intensification of agriculture, urbanization processes and the development of tourism, mostly in mountainous regions. The aim of this study was to propose methods of monitoring the species *Zootoca vivipara*.

DETERMINATION OF POPULATION STATUS INDICATORS

Monitoring of the viviparous lizard can be performed by counting juveniles and adults encountered in a selected study area. Regardless of the terrain (uplands, peat bogs, forest edges), a thorough site penetration (including lifting and inspecting objects lying on the ground – that can be potentially hiding places for lizards) was adopted as the primary method for studying the relative abundance. The viviparous lizards are counted by the “on the lookout” method during the day because of their increased daily activity. It is recommended to carefully and gently pick up all objects that can be lifted (for example flat stones, branches, tree trunks). Moreover, it is advisable to move carefully and slowly through the surveyed area to avoid frightening the lizards.

To determine the relative abundance of viviparous lizard populations in the selected study area, a standard method of counting individuals is indicated. Counting the lizards is performed twice during the season and the result of each count is recorded on the observation sheet. The abundance indicator is the maximum number of individuals per research area from observations of two counts. This indicator reflects the abundance status of viviparous lizards quite well. The number of lizards presented in the study area may also be an approximation of the population status throughout the potentially inhibited area.

In view of that *Zootoca vivipara* species is covered by least concern (LC), genetic monitoring is not necessary. However, it could be done by using molecular markers to identify individuals, subspecies or populations by determining genetic material in mitochondria in moults (fragments of shed skin). Moults are easily distinguished from shed skin by snakes based on abdominal scales – snakes have broad scales that run in a single row, while lizards have small scales that run in several rows.

The common holotype for viviparous lizards is ZFMK: 68438, while sequence differences between mitochondrial haplotypes occur in each viviparous lizard subspecies, and no morphological peculiarities are noted. Genotyping should be done on the basis of sequence differences in the hypervariable region of mtDNA or a comparison of the mtDNA hypervariable regions tested (2 regions with multiple sequence differences give us the ability to distinguish different individuals from each other – HV1 and HV2).

DETERMINATION OF HABITAT STATUS INDICATORS

There are two indicators that have been selected for exploration of habitat status:

- availability of breeding places – this indicator is an expert assessment and determines suitable breeding sites on a three-point scale based on the knowledge of the preferences and mating dates of viviparous lizards in the area and own experience in a specific terrain;
- availability of hiding places – this indicator is an expert assessment and identifies the availability of hiding places on a three-point scale based on the knowledge of viviparous lizards preferences in this regard and own experience in a particular area.

INDICATORS

Indicator of the population status – relative abundance and indicators of habitat status – availability of breeding places and availability of hiding places are shown in Table 1. The evaluation system is taken from the meteorological guide (Makomaska-Juchiewicz and Bonk 2012).

Table 1. Population and habitat status indicators.

| Indicator | Measure | Means of measurement / determination |
|---------------------------------|-----------------------|---|
| The population status | | |
| Relative abundance | number of individuals | Indicator defined as the number of lizards observed in the study area, the maximum number from two counts or the maximum number of different individuals observed during counts |
| The habitat status | | |
| Availability of breeding places | descriptive indicator | Indicator determined by an expert on a three-point scale (availability of convenient potential egg-lying places – high, medium or low / none) |
| Availability of hiding places | descriptive indicator | Qualitative assessment of potential hiding places; indicator determined by the expert on a three-point scale (availability of hiding places – high, medium, low) |

Valorization of indicators of the population status and habitat status are presented in Table 2.

Table 2. Valorization of indicators of the population and habitat status

| Indicator | Evaluation* | | |
|---------------------------------|--|---|---|
| | FV | U1 | U2 |
| The population status | | | |
| Relative abundance | same condition as before or increase | decrease by one scale step from the previous state** | decrease of two or more scale steps from the previous state or the first scale step |
| The habitat status | | | |
| Availability of breeding places | high availability of convenient potential egg-lying places | average availability of convenient potential egg-lying places | low / none availability of convenient potential egg-lying places |
| Availability of hiding places | high number of potential hiding places | medium number of potential hiding places | low number of potential hiding places |

*FV – proper condition, U1 – unsatisfactory condition, U2 – bad condition.

**In order to valorize the indicator, the size of the population has been set on a five-point scale: 1° – < 10 individuals; 2° – 11–30 individuals; 3° – 31–50 individuals; 4° – 51–100 individuals; 5° – > 100 individuals. Automatically, the relative abundance quantity of population is defined as bad when the abundance corresponds to the first degree of the scale.

Note: in case when the area is monitored for the first time and it is impossible to relate the results of observations to previous data, some of the examined indicators (relative population abundance) must be assessed by a contractor on the basis of their expert experience.

For each assessment of the population index, a certain number of points should be awarded: for FV – 2 points, for U1 – 1 point, for U2 – 0 point.

Total evaluation for the population status: FV – 2 points, U1 – 1 point, U2 – 0 point.

A specific number of points should be awarded for each habitat indicator assessment: for FV – 2 points, for U1 – one point, for U2 – 0 point.

Overall evaluation for the habitat condition status: FV – 2 points, U1 – 1 point, U2 – 0 points.

OVERALL EVALUATION

The overall assessment should take into account the state of the population, the status of the habitat and the perspectives for the conservation of the species. The most important indicator is population status, therefore if the viviparous lizard has not been observed or its status is assessed as bad (U2), the overall evaluation is also bad (U2). In case when the population status of viviparous lizard is assessed as good (FV) or unsatisfactory (U1), the parameter with the lowest value decides about the general assessment.

MAINTENANCE PROSPECTS

The assessment of the conservation prospects is a forecast of the species' situation on the study area consisting of the state of the population and the habitat status in a 10–15 years perspective. This is an individual expert assessment based on the knowledge of the terrain and careful observation of a current changes and threats in the environment, as well as negative impacts.

The following scale was used to assess the prospect of viviparous lizard behavior:

- FV – very good or good prospects. Population abundance data, the presence of favorable habitat conditions and the absence of significant threats indicate that the population will expand or remain stable in the foreseeable future;
- U1 – average prospects. There is a risk that the current condition will deteriorate or the unsatisfactory conditions will not improve;
- U2 – bad prospects. The current good or average status will be at risk of deteriorating significantly or the current bad status will stay unchanged;
- XX – insufficient data to assess prospects.

SELECTION OF MONITORING AREAS AND THEIR SUGGESTED SIZE

Due to viviparous lizard high ecological plasticity, it can live in areas even greatly changed by humans, such as allotment gardens. In this regard any areas should be selected as a study terrain for this species. Terrains of different types should be chosen – wetter habitats such as forest edges, peat bogs, forest clearings and wet meadows, riverside scrub, or even ruderal habitats as well as mountainous areas. Monitoring areas should primarily

include places where viviparous lizard has been seen. However, the terrains where the presence of this species has not yet been found should not be omitted, in order to recent years when there has been an increase in the area of its occurrence. For the first study that is carried out, the site should be defined by the previous terrain reconnaissance and cartographic data.

Monitoring of the area potentially inhabited by the viviparous lizard should be carried out in a remote area (for example mid-forest glade), or in a more extensive area (for example piedmont or upland areas). Afterwards designate an observation area (for example 2 hectare) and then focus on observations on this study terrain.

TIME AND FREQUENCY OF TESTS

There was no firm date set for the first field inspection. The selection of a convenient date depends on the discernment of a local expert observing viviparous lizards. However, monitoring works should be performed mainly in the monthly period: February – October. It is recommended to carry out two checks on each study area at intervals of approximately 5–10 days. Annual monitoring of sites should be performed, as other factors, particularly weather, can also influence abundance dynamics. Most likely, after testing the methods, it will be possible to reduce the frequency of the tests due to current common occurrence of this species and its classification in the category of least concern – LC (Agasyan 2019).

EQUIPMENT AND MATERIALS FOR TESTING

The following equipment will be necessary to carry out this monitoring according to the proposed method:

- optical equipment (binoculars),
- notebook and pencil / pen (for taking notes),
- protective and masking clothing,
- camera (for the preparation of photographic documentation),
- GPS receiver (to accurately assess the geographic location of the position),
- detailed topographic maps.

CURRENT PREDICTIONS AND SPECIES THREATS

Tables 3 and 4 are presenting the list of the most important current and future threats as well as expected impact on the viviparous lizard and its habitat at the study area. Impact/threat coding is used in accordance with Annex E of the standard Data Form for Natura 2000 areas.

Impact influence: + – positive, – – negative, 0 – neutral.

Impact intensity: A – strong, B – moderate, C – weak.

Table 3. Current threats on the *Zootoca vivipara*

| Code | Name of activity | Intensity | Impact | Synthesis description |
|------|-----------------------------|-----------|--------|---|
| 190 | agriculture intensification | C | – | loss of the natural environment |
| 962 | parasitism | C | – | hosts of parasitic protozoa of the genera Haemogregarina and Plasmodium |
| 965 | Predation | C | – | predation from natural enemies: snakes, hedgehogs, shrews |

Table 4. Future threats and anticipated impact of *Zootoca vivipara*

| Code | Name of activity | Intensity | Impact | Synthesis description |
|------|-----------------------------|-----------|--------|---|
| 190 | agriculture intensification | C | – | migration of lizards to other areas or reduction of species abundance |
| 962 | parasitism | C | – | severe infections ending in death can lead to population reduction |
| 965 | predation | C | – | intensified predation from natural enemies can reduce the population |

Zootoca vivipara populations are considered as stable, yet the species is protected in some countries by the law within its range (for example in Switzerland) and still there are more areas where viviparous lizards are secured (Agasyan 2019). The strategic point for properly organized protection of this lizards is securing their mating places, because at that time most specimens die. It happens because the lizards are so busy fighting that they do not pay attention to their surroundings.

CONCLUSIONS

The methodology for assessing the conservation status of the viviparous lizard and its monitoring has been developed solely on the scientific publications. Assessment of population status indicators is based on close, careful observation and search for individuals in a given area, while habitat status indicators are based on the availability of hiding places and places of breeding. The methods presented in this work are simple and minimally invasive because they do not require killing lizards or even destroying habitats. In conclusion, the proposed methodology and indicators with their evaluation presented in this work needs to be tested in the field in order to be verified by close studies or multi-annual monitoring.

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PROPOZYCJA METODYKI MONITORINGU JASZCZURKI ŻYWORODNEJ

Zootoca vivipara

Steszczenie. Jaszczurka żyworodna (*Zootoca vivipara*) jest gatunkiem z rzędu łuskonośne (Squamata) z rodziny jaszczurek właściwych (Lacertidae), o światowym zasięgu występowania od zachodniej Europy, w tym wysp brytyjskich oraz Irlandii, po najdalej wysunięte krańce Azji, z granicą występowania na japońskiej wyspie Hokkaido. Populacja tego gatunku nie jest regularnie monitorowana; nie ma określonych krajowych zasad monitoringu. Obecnie liczne publikacje zwracają uwagę na postępującą intensyfikację rolnictwa, wzrost ruchu turystycznego i coraz bardziej postępującą urbanizację środowiska, co przyczynia się do migracji jaszczurek żyworodnych z tych rejonów. Sugeruje się, że poprzez ingerencję człowieka w środowisko jaszczurki żyworodne wycofują się do nienaruszonych naturalnych środowisk. Wiąże się to ze zmniejszeniem obszaru występowania tych gadów oraz z mniej licznymi obserwacjami niż dotychczas. W niniejszym artykule przedstawiono propozycję metodyki monitoringu jaszczurki żyworodnej opartego na ocenie wskaźnika stanu populacji – względnej liczebności oraz wskaźników stanu siedliska w postaci dostępności miejsc do rozrodu oraz dostępności kryjówek. Celem artykułu jest przedstawienie wskaźników stanu populacji oraz wskaźników stanu siedliska, dodatkowo ustalenie przykładowych terminów i częstotliwości badań w ramach możliwych do przeprowadzenia badań monitoringowych populacji jaszczurki żyworodnej.

Słowa kluczowe: jaszczurka żyworodna, *Zootoca vivipara*, monitoring, wskaźnik.

