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Ecological classification of the amphibian and reptilian fauna in the city of Plovdiv

ABSTRACT

The current study attempts to classify the amphibian and reptilian fauna in urban environment, characterized by: ecological plasticity and habitat preferences; temperature regime; humidity and level of synanthropy. Totally seven amphibian species (*Bufo bufo, Bufo viridis, Hyla arborea, Pelobates syriacus, Rana dalmatina* and *Pelophylax ridibundus*) and eight species of reptiles (*Mediodactylus kotschyi, Lacerta viridis, Lacerta trilineata, Podarcis tauricus, Emys orbicularis, Natrix natrix, N. tessellata* and *Dolichophis caspius*) are analyzed and classified in ecological groups according to the above mentioned characteristics.

Key words: Amphibia, Reptilia, ecological groups, classification, urban environment

Introduction

The increasing concentration of population in cities and the significant pace of development and expansion of urban areas have led to the emergence of specific conditions forming populations and communities, which differ considerably from the natural. With the emergence of modern cities is associated emergence of the urban ecosystems. The species composition, structure of populations and communities in these ecosystems is generally not random, but is a reflection of objective processes in specific conditions in urban areas (Vershinin, 1997).

Invariable component of the urban ecosystems are the amphibians and reptiles. They occur in a variety of terrestrial and aquatic habitats and therefore suffer in varying degrees the impact of human activity. This leads to reduction in their diversity, compared to natural environments and changes in the structure of their populations and communities. Scientific publications from recent years suggest possibilities for the use of amphibians and reptiles as a model animal groups in complex urban research (Vershinin, 1997; Bolshakov et al., 2001; Ficetola & Debernardi, 2004; Jellinek et al., 2004). However, this problem is still poorly studied in Europe and there are still gaps in the knowledge of the processes going on in the "urban" populations and communities of amphibians and reptiles.

The problem for clarification of the processes synanthropy and changes that occur in populations of amphibians and reptiles in urban environments is contemporary trend in the ecological studies in this area and the data from such research will contribute to the efficient planning of activities for the conservation and restoration of the urban batraho- and herpetofauna.

The aim of the current study is to classify the species of amphibians and reptiles, which occur in the city of Plovdiv in ecological groups, based on ecological plasticity and habitat preferences; temperature regime; humidity and level of synanthropy.

Materials and Methods

In the current study the amphibians and reptiles are classified in ecological groups, based on: 1) ecological plasticity and habitat distribution; 2) temperature regime; 3) humidity; 4) level of synanthropy. For these classifications we used the works of Angelov & Kalchev (1961), Beshkov (1972), Kamenov (1988), Beshkov & Nanev (2002), Mihov (2002) and Biserkov et al. (2007), with some modifications as well as the authors' personal observations, done during many field studies in Plovdiv City in the period 2002-2012.

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The polytopic/stenotopic dichotomy was defined in the following sense: polytopic species were defined as ecologically tolerant species that occur in more than 5 habitat types, while stenotopic species were ones occurring in less than 5 habitat types (see Mollov, 2011). The systematics follows Biserkov et al. (2007).

Results and Discussion

Ecological classification according to ecological plasticity and habitat preferences

From the amphibians - three species (*B. viridis*, *H. arborea* and *P. ridibundus*) can be classified as "polytopic". Two of them - *H. arborea* and *P. ridibundus* - inhabit all kinds of aquatic and semi-aquatic habitats, while *B. viridis* is well adapted to terrestrial habitats as well. The remaining three amphibian species, recorded in the city of Plovdiv (*B. bufo*, *P. syriacus* and *R. dalmatina*) are considered "stenotopic."

From the registered reptiles four species can be classified as "polytopic" - *M. kotschyi*, *L. viridis*, *P. tauricus* and *E. orbicularis.* The species that occupies most habitats is the green lizard that exhibits a preference for semi-wetland habitats. The other established lizards on the other hand, prefer dry and warm habitats. However the Kotschyi's gecko exhibit greater specialization in terms of habitats and is registered in habitats that are "uninhabitable" for the other recorded reptiles in the city. *L. trilineata*, *N. natrix*, *N. tessellata* and *D. caspius* can be classified as "stenotopic." *L. trilineata* is found in habitats similar to those inhabited by green lizard, but adheres to drier habitats and is absent from the inner parts of the city. *D. caspius* inhabit the ecotone zones between woodlands and open spaces in the city. That's why the species is registered in relatively small number of habitat types and have a limited distribution in the city.

When comparing the number of stenotopic and polytopic species from both classes in the city and its surroundings it is visible that for the amphibians the number of polytopic species in both zones is equal (3 species), while stenotopic species are absent from the city and are only found in the vicinity (Fig.1). The reason for this is either the absence or the excessive transformation, fragmentation and degradation of suitable habitats for these species in the city. Suitable habitats for amphibians are preserved to some extent only in the surroundings of the city. We observe the same trend for the reptiles as well – an increase of the number of polytopic species and reduction of the number of stenotopic species from the surrounding to the city center.

For more information of the habitat distribution of the amphibians and reptiles in the city of Plovdiv, please see Mollov (2011).

Ecological classification according to the temperature regime

Being ectothermic (poikilothermic) animals, amphibians and reptiles are hard to be classified in terms of temperature. Therefore, there is no universally accepted classification for these two classes of animals with regard to their requirements for environmental temperature. We propose the following classification in terms of temperature requirements in urban environments for the amphibians and reptiles registered in the current study:

1. *Thermophiles* – species, which prefer dry and hot habitats, usually with temperatures of 40-45°C and beyond. In the city of Plovdiv, there is only one species, which prefers such conditions and can be classified as "thermophile" – the Kotschyi's Gecko (*M. kotschyi*). On the hills of Plovdiv this species was frequently observed on sunny rocks and walls, usually with southern and eastern exposition.

2. *Mesothermophiles* – species, which prefer warm habitats, usually with temperatures between 30-40°C. From the recorded species in the study area, three lizard species from the Lacertidae family can be classified as "mesothermophiles" – *L. trilineata*, *L. viridis*, *P. tauricus*. All three species usually inhabit dry, sunny habitats (except for *L. viridis*, which prefers slightly humid habitats) and are most active at higher air temperature.

3. *Mesothermic* species – preferring moderate temperature values, usually between 20-30°C, less adapted to colder environments and usually inhabit forest habitats. From the recorded in the study area species, mesophilic are: *H. arborea*, *R. dalmatina*, *P. ridibundus* and *P. syriacus*. From the reptiles: *E. orbicularis*, *N. natrix*, *N. tessellata* and *D. caspius*. All mentioned above amphibians cannot tolerate heat and usually inhabit mid-humid habitats with moderate temperature. From the reptiles, mesophilic are all species, related to some extend to water and the *D. caspius*, which stays close to humid and forest habitats.

4. *Mesopsychrophiles* – species prefer slightly cooler habitats, generally temperatures between 10-20°C. In the city of Plovdiv and its surroundings we recorded only two such species of amphibians - *B. bufo* and *B. viridis*. Both toad

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species tolerate lower than moderate temperatures and their breeding season begins very early before all other registered amphibians in the research area amphibians - February-March (Beshkov & Nanev, 2002).

At lower temperatures, all species of reptiles and amphians fall into hibernation state and therefore they do not exist as typical psychrophiles (cryophiles).

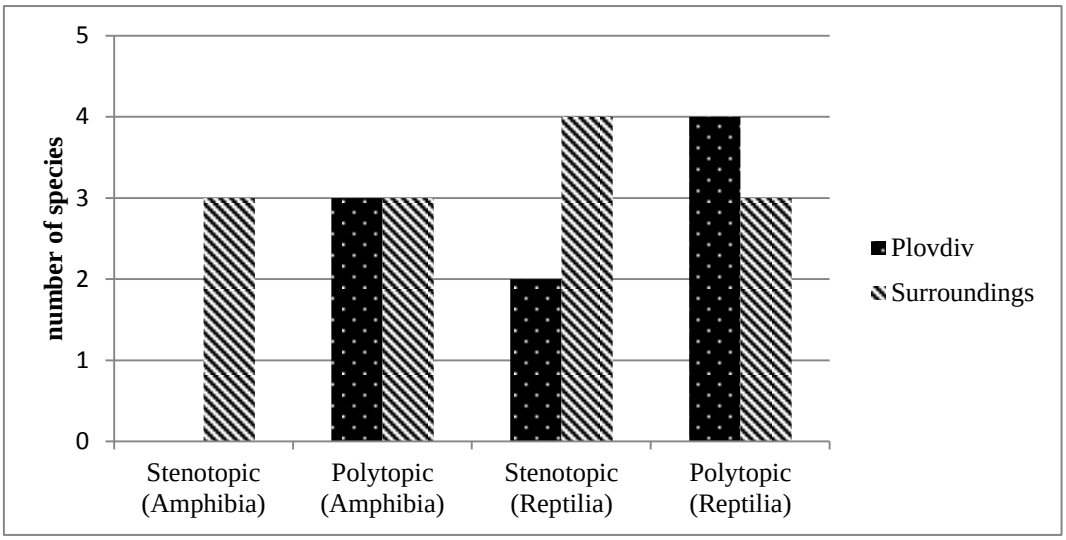

Figure 1. *Comparison between the amphibians and reptiles, regarding their habitat distribution in the city of Plovdiv and its surroundings.*

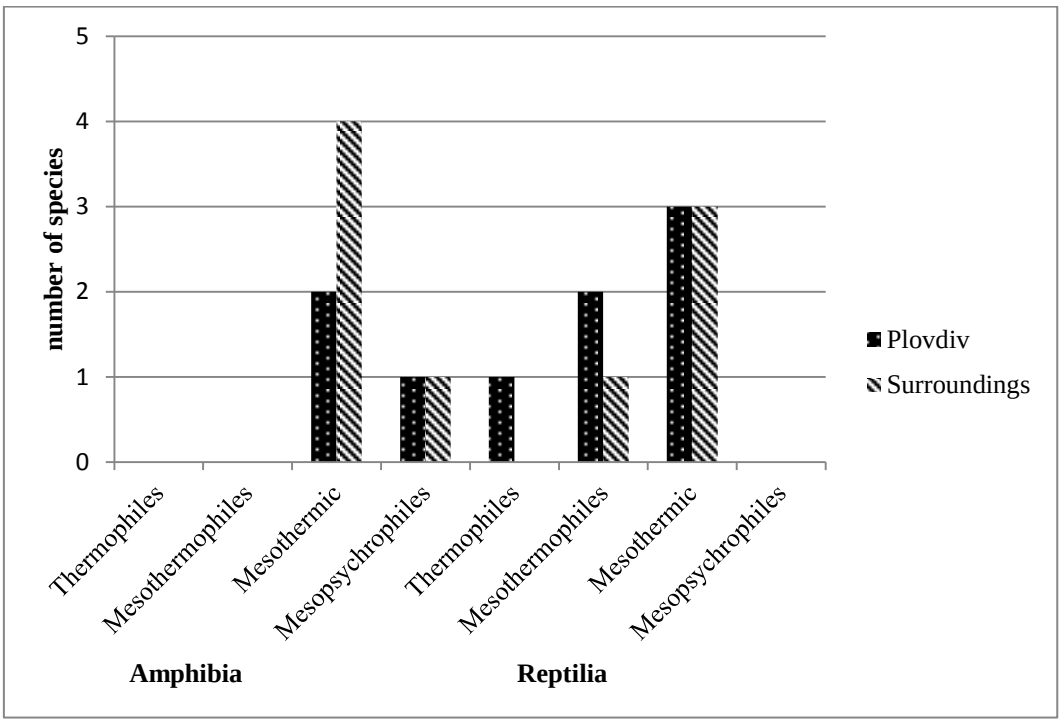

Figure 2. *Distribution of the ecological groups of amphibians and reptiles, concerning temperature in the urban part of the city of Plovdiv and its surroundings.*

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When comparing the number of species of amphibians and reptiles belonging to the mentioned above four separate ecological groups of animals in terms of the temperature in the city of Plovdiv and its surroundings, there is a significant difference between the two classes of animals (Fig. 2). There are no thermophilic and mesothermophilic amphibian species and in the surroundings there are two times more mesothermic species, than in the city. The number of mesopsychrophilic species is equal in the city and in the surroundings.

For the reptiles, there is a pattern that thermophilic and mesothermophilic species are preferring the central urban areas and there is approximately equal distribution in the city and in the surroundings of the mesothermic species. This pattern could be explained with the so-called "urban heat island effect" - the temperature in the center of big cities is one of a few degrees higher in comparison with its surroundings (Oke, 1982) due to a change in the nature of land cover. Because of this in the city are found only these reptiles that prefer higher temperatures and are better adapted to such conditions.

Ecological classification according to the humidity regime

Anurans can be classified in three ecological groups, regarding their requirements for humidity (after Angelov & Kalchev, 1961; Beshkov, 1972). We adopted these classifications with few changes regarding urban environment. In our opinion the presented below categories can be applied to reptiles as well, with some additions. We propose the following four ecological groups:

1. *Hydrophiles* – these are species that are strongly connected to the water basins and almost never leave them, or stick close to them. From the amphibians, recorded in Plovdiv, such species is only the marsh frog (*P. ridibundus*). From the reptiles to this group belongs the European pond turtle (*E. orbicularis*).

2. *Mesohydrophiles* – species that do not live permanently in the water, but always adhere to damp places. From the amphibians such species are the agile frog (*R. dalmatina*) and the European tree frog (*H. arborea*). From the reptiles such there are two such species – the two aquatic snakes (*N. natrix* and *N. tessellata*). The Dice snake and the Grass snake, however, can be attributed to an intermediate group in this classification between this ecological group and the next, as in some cases both can be found and spend considerable time away from any water basins (Beshkov & Nanev, 2002).

3. *Mesophiles* – species that enter the water only for reproduction, and the rest of the time spend in terrestrial habitats with moderate humidity. From the amphibians such species are two species of toads (*B. bufo, B. viridis*) and the Balkan spadefoot toad (*P. syriacus*). The latter species can again be classified as intermediate level between this group and the previous one as spadefoot toads stick to a moderately moist habitats, while both *Bufo* species are extremely drought resistant and can spend a long time in a fully dry areas without proximity of water basins (Beshkov & Nanev, 2002). From the reptiles to this group can be classified the Green lizard (*L. viridis*) and the Balkan wall lizard (*L. trilineata*) as well as *D. caspius*.

4. *Xerophiles* – drought-resistant species that avoid wetland habitats and are well adapted to hot and dry conditions. There are no amphibian species, registered in the city of Plovdiv, who can be classified in this category. From the reptiles xerophilic are *P. tauricus* and *M. kotschyi*. Both are extremely well adapted to hot and dry habitats abound in city centers.

When comparing the number of species of amphibians and reptiles belonging to the mentioned above four ecological groups of animals in the city of Plovdiv and the surrounding area, again there is significant difference between the two classes (Fig. 3). For the amphibians, which are more dependent on the availability of water, there was no significant difference in the number of species in the city and surrounding areas, as ponds and wetland habitats are located downtown as well as in the surrounding area of the city (see Mollov & Velcheva, 2010 and Mollov, 2011). For the reptiles, however, there is a visible trend of reduce of hydrophiles and increase xerophiles in the direction to the urban center. A known fact is that in urban areas higher levels of drainage of rainwater and higher evaporation due to impervious surfaces are observed (Leopold, 1968; Arnold & Gibbons, 1996). Therefore habitats in the city, with the exception of those located in the vicinity of permanent waters, have low to moderate humidity. The reptile species, which are not directly related to water, but stick to humid habitats, remain for the most part in the suburban and rural parts of the city. In the drier habitats in the central part remain only species that are well adapted to such conditions. Therefore xerophilic species are not recorded in the surroundings of the city.

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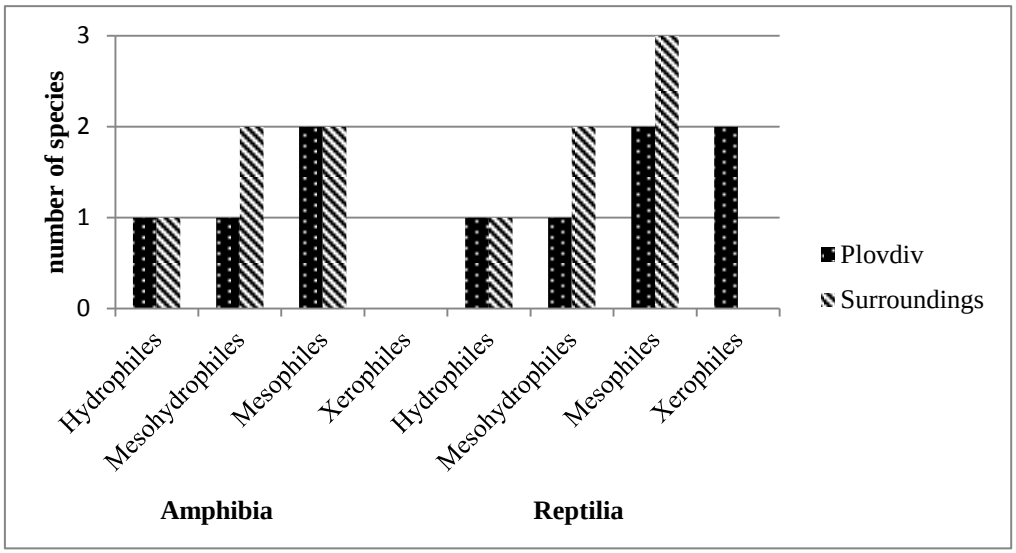

Figure 3. *Distribution of the ecological groups of amphibians and reptiles, concerning humidity in the urban part of the city of Plovdiv and its surroundings.*

Ecological classification according to the level of synanthropy

According to the classification given by Klausnitzer (1990) there are four ecological groups of animals in subordination to their level of synanthropy: *hemerophobes* – species, which avoid urban environment; *hemerodiaphores* – species, which existence doesn't depend on the anthropogenic transformation of the landscape; *hemerophiles* – species, which prefer habitats made by humans and *synanthropes* – species, which are directly connected with habitats made by man and their existence depend on the human activity. Synanthropes on the other hand are obligate and facultative. Obligate synanthropes are species that occur in a (micro) climatic zone in anthropogenic conditions only in urban areas, usually within the human settlements and they do not or rarely occur elsewhere in nature. Facultative (optional) synanthropes are species found in urban areas and human settlements, where they find optimal conditions for existence, while they can form natural populations in natural biotopes.

For full classification of the amphibians and reptiles, registered in the city of Plovdiv, based on their level of synanthropy, see Mollov (2014).

Conclusions

In the city of Plovdiv we identified seven amphibian species and eight reptiles. According to their habitat distribution - 4 amphibians are classified as "polytopic" and 3 as "stenotopic" and from the reptiles - 4 species are classified as "polytopic" and 4 as "stenotopic". There is a trend in both classes - an increase of the number of polytopic species and reduction of the number of stenotopic species from the surrounding to the city center.

Regarding the temperature regime the amphibians and reptiles are classified in four ecological groups - thermophiles, mesothermophiles, mesothermic and mesopsychrophiles. There are no amphibian species that are thermophiles and mesothermophiles and mesothermic species are predominant in the surroundings of the city. For the reptiles there is only one thermophilic species and there are no mesopsychrophiles.

Based on their humidity preferences the amphibians and reptiles are classified in four groups - hydrophiles, mesohydrophiles, mesophilic, and xerophiles. From the amphibians there are no xerophilic species. For both classes there is a visible trend of increase of drought-resistant species from the city center to the surroundings. According to their level of synanthropy amphibians and reptiles are classified in four ecological groups - synanthropes, hemerophiles, hemerodiaphores and hemerophobes.

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