A REVIEW OF THE INFLUENCE OF THE URBANIZATION ON THE VERTEBRATE FAUNA IN THE CITY OF PLOVDIV

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ABSTRACT

The current paper reviews the available literary data as well as original unpublished data on the distribution and the species' richness of the vertebrate fauna (Pisces, Amphibia, Reptilia and Mammalia) in the city of Plovdiv (South Bulgaria) and its relations to the level of urbanization. The species richness of each vertebrate group was presented, along a spatial gradient denoted by three points, representing low, moderate, and high levels of urbanization. We recorded no visible total general pattern of decrease of the total species richness in all studied vertebrate groups from the rural zones to the city center. Some differences in species richness along the urban–rural gradient apparently exist among the taxa. The only vertebrate group that showed a degrease pattern in the species richness from the rural to urban zones were the amphibians. Similar pattern was recorded in the reptiles, except for the urban zone, where a slight increase in the species richness was observed. The fishes and mammals showed very peculiar distribution pattern along the urban-rural gradient with highest species richness in the suburban zone. Possible explanations of these patterns are discussed.

Keywords: amphibians, fishes, mammals, Plovdiv, reptiles

Introduction

As urbanization is spreading rapidly across the globe, a basic challenge for conservation is to understand how it affects biodiversity. Although urbanization often causes extinctions of native species, the complex nature of urban land use can have a complicated influence on local biodiversity. Several studies have described the effects of urbanization on species richness, indicating that urbanization can affect species richness either positively or negatively, depending on several variables. Some of these variables include: taxonomic group, spatial scale of analysis, and intensity of urbanization (17).

According to Marzluff (15) and Chace & Walsh (10) recent reviews of birds (the most-studied group on this issue) indicate that species richness generally decreases with increasing urbanization in most cases or doesn't change significantly. A lot less attention on is given to the other vertebrate taxa, especially aquatic and semi-aquatic species (fishes, amphibians and reptiles).

The aim of the current paper is to analyze the urbanization impacts on the biodiversity, by reviewing all available studies on the species richness of the vertebrate fauna including: fishes, amphibians, reptiles and mammals in the city of Plovdiv, as well as to document how species richness changes along urban-to-rural gradients in the different taxa.

Materials and methods

For the purposes of the current study, we reviewed all available published studies on the spatial distribution and species richness of the vertebrate fauna (fishes, amphibians, reptiles and mammals), conducted on the territory of the city of Plovdiv. We also used our original unpublished data.

The species richness of each vertebrate group was plotted along a spatial gradient denoted by three points, representing low, moderate, and high levels of urbanization. Our designation of low, moderate and high levels of urbanization was based on the following criteria. A high level of urbanization was assigned for habitats that represented the urban core (the historical and administrative center of the city). A moderate level of urbanization was assigned for habitats in suburban areas, i.e., outside the urban core but not including undeveloped or rural areas. A low level of urbanization represented rural or undeveloped areas beyond the suburban fringe (after McKinnley (17) with changes).

Statistical analysis was performed with chi-square test

and cluster analysis to examine differences among the four vertebrate groups. Deviations in the chi-square values from the expected null hypothesis (evenly distributed species richness in the three studied zones) therefore indicate that taxa respond differently to urbanization. This statistical test was used because it is nonparametric and therefore does not require the data to be normally distributed (11). The computer software "Statistica v. 7.0" was used to perform the tests (23).

Results and Discussion

A total of 19 studies that reported spatial distribution and species richness data in the city of Plovdiv, as well as original data from our observations, were used for the analysis. This includes: 2 studies on fishes (13, 25); 9 studies on amphibians and reptiles (2,3,6,7,8,9,14,20,21) and 10 studies on mammals (2,4,5,12,12,16,18,19,22,24).

The summary of the species richness changes along the urban–rural gradient in the four groups indicating that some differences apparently exist among the taxa (**Fig. 1**).

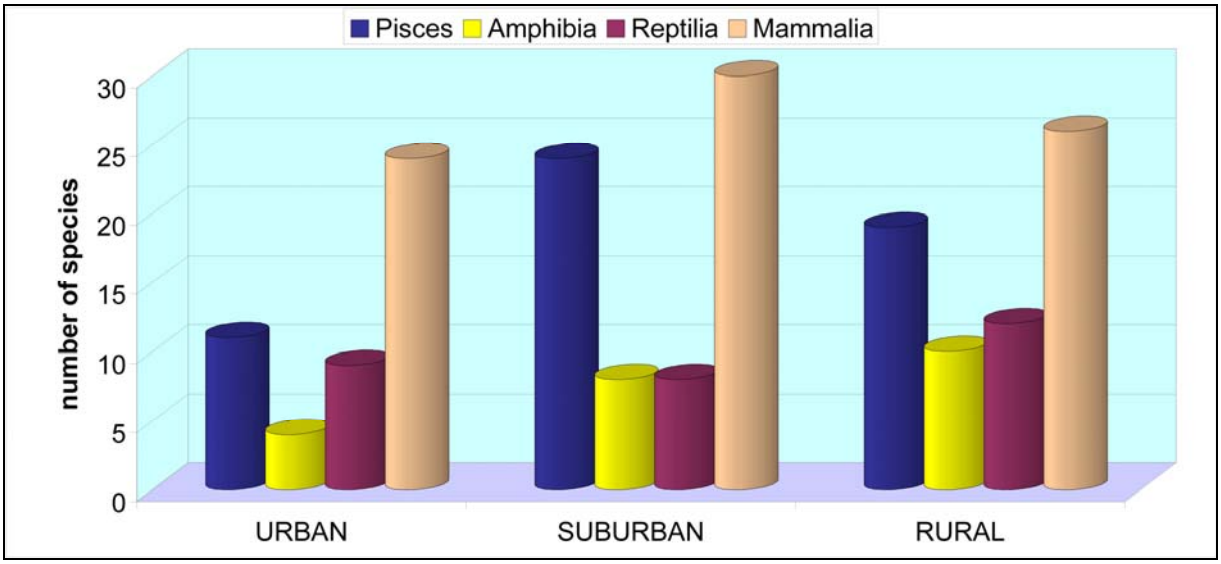

Fig.1. Species richness of the four vertebrate taxa in the three zones

There is no visible total general pattern of decrease in the total species richness of all studied vertebrate groups from the rural zones to the city center. The chi-square values for the three zones are as follows: urban – χ^2=18.17, df=3, p=0.0004; suburban - χ^2=21.66, df=3, p=0.00007; rural - χ^2=9.48, df=3, p=0.023.

The only vertebrate group that showed a degrease pattern in the species richness from the rural to urban zones were the amphibians (**Fig.1, 2A**). Ten amphibian species were recorded (10 species in the rural zones, 8 in the suburban zone and 4 species in the urban core), which represents 52.62% of the Bulgarian batrachofauna. According to our results it appears that the amphibians are one the most sensitive animals concerning the degree of urbanization. Their survival is directly dependent on the availability of freshwater basins for the reproduction. With the increase of the level of urbanization and the anthropogenic pressure the habitats suitable for amphibians drastically decrease, which explains the lower number of species in the urban core, compared with the suburban and rural zones.

Similar pattern was recorded in the reptiles, except for the urban zone, where a slight increase in the species riches was observed (**Fig.1, 2A**). The total number of reptiles species recorded in the city of Plovdiv was 14 (12 species in the rural zones, 8 in the suburban zone and 9 species in the urban zone), which represents 37.84% of the Bulgarian herpetofauna. The slight increase in species richness in the urban zone could be explained by the presence of the hills of Plovdiv in the center of the city. The hills are peculiar "green islands" inhabited by species which otherwise cannot survive in the hostile urban environment (some lizards species). Other significant factor is Maritsa River flowing through the middle of the city, which presents suitable habitats for the aquatic reptiles. On the other hand, most of the species reported by various authors in the

early XX century for the rural zones of the city were few snake species, which are now probably extinct. These species were not discovered during our observations, perhaps because the majority of rural areas are turned now into arable lands.

The fishes and mammals show very peculiar similar distribution pattern along the urban-rural gradient (Fig.1, 2A). The fishes are presented with 25 species (19 species in the rural zones, 24 in the suburban zone and 11 species in the urban zone), which represents 17.61% of the Bulgarian freshwater ichtyofauna. The reason for the higher species richness in the suburban and rural zones is the presence of small floods and standing water basins in this part of Maritsa River, as well as some deeper parts, inhabited by some fish species, absent in urban canalized stretch. Respectively only the reophilous species could be expected in central city stretch of the river, and both fish of running and standing waters can be met in its suburban and urban parts. Other favoring factor is the existence of the State Fishery – Plovdiv, as well as Parvenetska River and many irrigation canals, located in the suburban and rural zones of the city. Also the significant pollution from various city sources perhaps is also a limiting factor for the fish distribution.The most numerous taxa in the city of Plovdiv were the group of the mammals (**Fig.1, 2A**). The town was inhabited by a total of 36 species, around 1/3 of the Bulgarian teriofauna (central city part - 24, suburban - 30, and rural areas - 26 species). They were presented by two major ecological groups: terrestrial (insectivores, carnivores, hares and rodents) and flying (bats). The first group was decreasing in diversity consequently from rural areas to the city center, as it would be expected similar to any other animal terrestrial taxa here, which is loosing their terrestrial habitats (12 species – urban, 16 – suburban, 18 – rural). In the second group (the bats) a reverse situation was observed. The lowest species richness we recorded at the rural areas (8 species), a little higher in the central parts (12 species), and the most numerous were the suburban town areas (18). This fact could be explained by the numerous suitable habitats in urbanized areas (i.e. roosting and feeding sites). In the Upper Thracian Valley, where city of Plovdiv is situated, large agricultural lands dominate the landscape with a scarcity of natural habitats for bats. The urbanized areas in the case of the bats play the role of specific "islands" for native woodland bat species, and new habitats for invasion of synanthropic or rock-roosting ones.

The cluster analysis also showed that the two groups - fishes and mammals and the amphibians and reptiles show similar species richness distribution pattern along the urban-rural gradient (**Fig. 2A**).

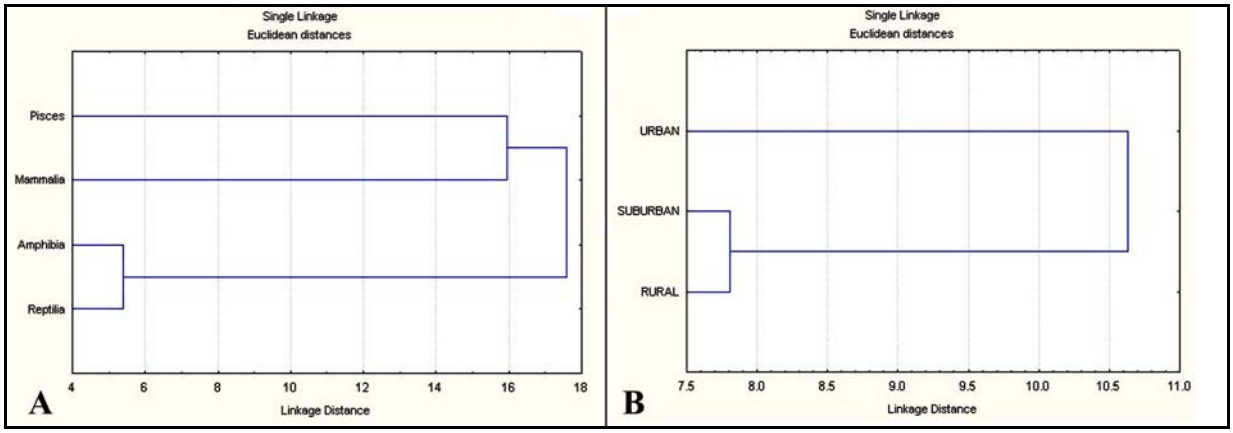

Fig.2. A) – A dendrogram showing the similarity of the species richness distribution pattern among the four vertebrate groups; B)– A dendrogram showing the similarity between the three zones of urbanization level, based on the total number of species of the four vertebrate groups.

Based on the same analysis the urban zone is divided from the suburban and rural, which show the biggest similarity, based on the total number of species of the four vertebrate groups (**Fig. 2B**). Some studies showed that the greatest variety of land use, as well as species richness often lies in the transition zone between the city center and the outskirts. The mosaic of land use patterns in the transition zone, with moderate intensities of disturbance, increases species diversity by increasing habitat diversity (17, 26). This could probably explain the highest species richness in the suburban zone of the fishes and mammals. In addition to high habitat diversity caused by spatial heterogeneity, a second factor that could increase species richness in urban areas is human-aided dispersal of introduced (nonnative) species into urban areas (17). In the city of Plovdiv this is the case for some fishes, reptiles and mammals.

Despite any conclusions reached here we must remind that

urban-rural gradient studies are clearly a simplification of the complex patterns produced by urbanization. The specific impacts of urbanization on species richness will varies, depending on such variables as the geographic location of the city (including its natural ecological matrix) and many historical and economic factors that are unique to each city (1,17).

Our results, based on 19 studies as well as our own data indicated that, for all studied vertebrate groups extreme urbanization (as found in urban core areas) reduces species-richness in most cases. Much of this is predictable by a species-area effect via the loss of suitable habitats and the degradation of remaining habitat by pollution, traffic and other human disturbances. However, the effects of moderate levels of urbanization (i.e., suburban areas) vary significantly among groups, showing a less consistent tendency to reduce species richness. Further research may determine the possible explanations for cases where species richness is increased by moderate levels of urbanization. Potential factors to be examined would include the relative roles of: alien species, spatial scale, spatial heterogeneity, and intermediate disturbance dynamics.

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REFERENCES

1. **Alberti et al.** (2001) *In* J. Marzluff, R. Bowman, R., Donnelly (eds.) Avian ecology in an urbanizing world. Kluwer, Norwell, Massachusetts, p. 68–85.
2. **Angelov P.** (1960) Godishnik na muzeite v Plovdiv, **III**, 7 – 40 (In Bulgarian).
3. **Angelov P., Kalchev B.** (1961) Priroda i znanie, **XIV**(2), 18 – 21
4. **Batchvarov G.** (1963) Trav. Sci. de L'Ecole Norm. Super. Plovdiv, Biologie, **1**(1), 99–101 (In Bulgarian).
5. **Benda et al.** (2003) Acta Soc. Zool. Bohem., **67**, 245–357.
6. **Buresh I., Tsonkov I.** (1933) Mitteil. aus den Königl. Naturwiss. Institut. in Sofia – Bulgarien, **6**, 150–207 (In Bulgarian).
7. **Buresh I., Tsonkov I.** (1934) Mitteil. aus den Königl. Naturwiss. Institut. in Sofia – Bulgarien, **7**, 106–188
8. **Buresh I., Tsonkov I.** (1941) Mitteil. aus den Königl. Naturwiss. Institut. in Sofia – Bulgarien, **14**, 171-237 (In Bulgarian).
9. **Buresh I., Tsonkov I.** (1942) Mitteil. aus den Königl. Naturwiss. Institut. in Sofia – Bulgarien, **15**, 68–145 (In Bulgarian).
10. **Chace J., Walsh J.** (2006) Landsc. Urban Plan., **74**, 46–69.
11. **Fowler et al.** (1998) Practical statistics for field biology. John Wiley & Sons, Chichester.
12. **Georgiev D.** (2005) IUCN Otter Spec. Group Bull., **18**(1), 6 – 13.
13. **Georgiev D.** (in press) Animalia.
14. **Kovachev V.** (1912) The Herpetological Fauna of Bulgaria. Publ. "Hristo G. Danov", Plovdiv (In Bulgarian)**.**
15. **Marzluff J.** (2001) *In* J. Marzluff, R. Bowman, R., Donnelly (eds.) Avian ecology in an urbanizing world. Kluwer, Norwell, Massachusetts, p. 19–47.
16. **Markov G.** (1957) The insectivorous mammals in Bulgaria. Fauna of Bulgaria. Bull. Zool. Inst. BAS, Sofia. (In Bulgarian)
17. **McKinney M.** (2008) Urban Ecosyst., **11**, 161–176.
18. **Mitev D., Miteva E.** (1991a) Trav. Sci. Univ. Plovdiv "P. Hilendarski", Biologie, **29**(6), 107-115 (In Bulgarian).
19. **Mitev D., Miteva E.** (1991b) Trav. Sci. Univ. Plovdiv "P. Hilendarski", Biologie, **29**(6), 117-122 (In Bulgarian).
20. **Mollov I.** (2005) Animalia, **41**, 79-94.
21. **Mollov et al.** (2007) *In* Scientific Researches of the Union of Scientists in Bulgaria - Plovdiv, Series B. Natural Sciences and the Humanities, Vol. VIII. "Technics, Technologies, Natural Sciences and Humanities" Session, 26 October 2006, p. 132-136 (In Bulgarian).
22. **Peshev T., Mitev D.** (1977) Ann. Univ. Sofia, Fac. Biol., **68**(1), 5-13.
23. **StatSoft Inc.** (2004) STATISTICA (Data analysis software system), Vers. 7. Computer software. www.statsoft.com.
24. **Tilova et al.** (2005) Animalia, **41**, 135–144.
25. **Velcheva I., Mehterov N.** (2005) Animalia, **41**, 69-78
26. **Zerbe et al.** (2003) Landsc. Urban Plan., **62**, 139–148.