Macro- and microhabitat preferences of eastern Hermann’s tortoise
(*Testudo hermanni boettgeri*)

Marko Nikolić1,*, Jovana Cvetković1, Dragana Stojadinović1, Jelka Crnobrnja-Isailović1,2

Abstract. Macro- and microhabitat preference of *Testudo hermanni boettgeri*, the eastern subspecies of Hermann’s tortoise, was investigated utilizing modified methodology for the western subspecies which emphasized the importance of habitat heterogeneity preservation. The study objective was to explore the habitat preferences of the eastern subspecies of *T. hermanni*. Research was conducted within the same year at four localities in Eastern and Southeastern Serbia. Macrohabitat determination was conducted using a 0 to 5 land cover score system (coverage with herbaceous, bushy or tree vegetation) for 4 m² tortoise encounter surroundings. Microhabitat analysis was carried out by determining the plant species in closest contact with the tortoise in the moment of recording. Plants were classified into six groups: 1) aromatic, 2) bramble, 3) herbaceous, 4) thorny shrub, 5) tree and 6) non-thorny shrubs. $X^2$ test was used for comparison between expected and empirical habitat preference. Results confirmed that the most attractive macrohabitats for Eastern Hermann’s tortoises in this part of the Balkans are meadows and open shrublands, with the addition of dense forest (important in warmer months), what is concordant with earlier data from the Mediterranean part of former Yugoslavia. The most attractive microhabitats were “herbaceous plants”, followed by “bramble”.

Keywords: complex environment, eastern subspecies, habitat selection, meadows, shrublands, *Testudo hermanni*.

Introduction

Detailed knowledge on habitat preferences of threatened species is necessary for establishment of efficient protection measures (Wiktander et al., 2001). This applies also to Hermann’s tortoise (*Testudo hermanni*) from Europe which is considered Near Threatened due to declining population size across its relatively large species range (Bertolero et al., 2011). As fragmentation and loss of suitable habitats are increasing, these are now among the most significant factors of threat for Hermann’s tortoise (van Dijk et al., 2004; Bertolero et al., 2011; Fernández-Chacón et al., 2011). Numerous studies on the western subspecies (*T. h. hermanni*) revealed its preference toward specific habitats for specific purposes (Longepierre et al., 2001; Corti and Zuffi, 2003; Rugiero and Luiselli, 2006; del Vecchio et al., 2011; Corti et al., 2013; Berardo et al., 2015; Vilardell-Bartino et al., 2015): in some places, tortoises were selected both bushy and woody habitats for hibernation (probably due to a more stable local environmental temperature that enables them to survive the winter – see in Steen et al., 2007 and Vilardell-Bartino et al., 2015) while shrubs without spines were the most visited in the hottest parts of the summer days (Vilardell-Bartino et al., 2015); during the feeding period, the tortoises showed preference to spots with herbaceous vegetation, while blackberries were predominantly chosen for hiding, shelter and during the mating season. Studies on the Eastern Hermann’s tortoise (*T. h. boettgeri*) analyzed habitat preferences mostly on the broad scale, indicating meadows, bushes, shrubs and the edges of forests as the most preferable habitats both in Mediterranean parts and in the inland of the Balkans (Cruce and Răducan, 1976; Meek and Inskeep, 1981; Meek, 1985, 1988; Wright et al., 1988; Rozylowicz and Dobre, 2010; Rozylowicz and Popescu, 2013; Türkozan et al., 2015; Stojadinović et al., 2015).
It was also suggested that complex habitat matrices harbor relatively dense eastern Hermann’s tortoise populations due to (still) low human impact e.g. modest alteration of primary habitats (Stojadinović et al., 2017). However, studies that analyze preference of eastern Hermann’s tortoises on a finer scale of macro and micro habitats (see in Villardel-Bartino et al., 2015) have not been published so far.

Researchers face three problems when conducting studies for detailed determination of habitat preference and these are: characterization of the available microhabitat types, quantification of the relative abundance of different microhabitats and determination of the habitat spatial scale relevant to the focal organism (Del Vecchio et al., 2011). These authors revealed that western Hermann’s tortoises choose small patches of suitable habitat in a matrix of less desirable habitats, while this study attempted to investigate macro- and microhabitat selection in eastern Hermann’s tortoise where habitat degradation on a large scale is still lower (Rozyłowicz and Popescu, 2013; Stojadinović et al., 2017). To get more accurate information on possible variation, we have analyzed Hermann’s tortoises’ macro and microhabitat choice on several localities and in two seasons (spring and summer). The main goals of the study were to assess for 1) preferable macrohabitat type(s) and 2) microhabitat preferences, taking into consideration effects of locality and season.

Material and methods

The study sites

The study was conducted in year 2016 at four localities in Serbia – two situated in the eastern and two in the southeastern part of the country (fig. 1). Two localities are within the protected areas: in Eastern Serbia, it was locality Čermor near Donji Milanovac, situated in “Djerdap” National Park. In Southeastern Serbia, we selected locality Kunovica, situated in “Sićevoška klisura” nature reserve (table 1). “Djerdap” National Park has rich diversity of flora and fauna (Stevanović, 1996; Medarević, 2001; Ćrnobrnja-Isailović et al., 2015). “Sićevoška klisura” Nature Reserve is situated 15 km east of the city of Niš.

Figure 1. Map of Serbia with the study localities marked as following: 1 – Čermor, 2 – Gonjište, 3 – Kunovica, 4 – Pašina česma (see coordinates in table 1).

The vegetation in the area of Sićevo has a very diverse zone of thermophilic oak tree forests, inhabited by relatively rich and rare flora and fauna (Lazarević et al., 2007). The other two localities are composed mostly of human altered habitats: Gonjište near Kladovo is a complex of meadows, agricultural areas and vineyards. Pašina Česma near Leskovac is the abandoned complex of vineyards previously run by the public company and situated near popular local picnic place (Stojadinović et al., 2013).

Field procedures

The monitoring program followed general temporal dynamics described in previous studies of Stojadinović et al. (2013, 2017). It included two visits – one in May and other in July – considered in analysis as spring and summer (Chyela, 1981).

At every locality, researchers spent 3-7 consecutive days searching for tortoises by visual encounter survey method, from 8 a.m. to 7 p.m. during the day within defined area. At every locality eight people were involved in the fieldwork. Tortoises were determined for sex and age and permanently marked on first capture similar to Meek (1989) – by notching carapace plates in a manner that every tortoise gets unique identification number by specific combination of marked carapace plates (more details in Stojadinović et al., 2013). That enabled easy identification in future studies.

Macro- and microhabitat selection

Macrohabitat types were defined following the methodology in the study of Villardell-Bartino et al. (2015), with small modifications: we had no opportunity to apply radiotelemetry for tracking the tortoises, although it is the best
method for continuous monitoring of organisms (Kenward, 2001). Instead, both at first and every subsequent encounter we were recording the location coordinates of every tortoise seen using a GPS device, handheld model GARMIN eTrex Vista®. Every tortoise was photographed at the encounter place, with surrounding vegetation included in the square space projected around the tortoise of approximately 2 × 2 m in size.

The photographs were digitized in vector format and on the area of 4 m² we estimated the cover percentage of following plant types: a) grass, b) shrubs – up to 2 m and c) trees – higher than 2 m (see in Etienne and Prado, 1982). After that, we classified the patches in our study, according to Roura-Pascual et al. (2005), into one of nine macrohabitat types: barren land, grassland, open shrubland, dense shrubland, open woodland, wooded grassland, wooded grassland – shrubland, open forest and dense forest (supplementary table S1). This type of classification was previously applied by Vilardell-Bartino et al. (2015) to a study on western sub-

| Locality          | N     | E     | Min. alt. | Max. alt. | Area (ha) | H     | Ind/day/ha |
|-------------------|-------|-------|-----------|-----------|-----------|-------|------------|
| Čermor            | 44°26′59.56″ | 22°8′43.39″ | 190       | 263       | 3.1      | 1.40  | 2.94       |
| Gonjište          | 44°37′51.48″ | 22°31′35.77″ | 161       | 190       | 7.6      | 1.55  | 1.22       |
| Kunovica          | 43°18′8.00″   | 22°4′59.00″   | 318       | 452       | 23.0     | 1.83  | 0.48       |
| Pašina česma      | 43°2′29.76″   | 21°52′15.62″  | 285       | 366       | 15.0     | 1.16  | 0.38       |

The results are shown in table 2. Dense forest predominated on the localities Čermor and Kunovica (58% and 35% of the studied areas, respectively), while open habitat type predominated on the localities Gonjište and Pašina Česma (grassland, 46% of the studied area and dense shrubland, 66% of the studied area, respectively).

We marked 302 individuals during our study, 174 in the spring and 128 in the summer. In general, the records of the tortoises were not randomly distributed among macrohabitat types. The results of the Chi-square Goodness of fit test showed statistically significant difference between recorded and expected number of individuals in specific macrohabitat types per locality per season (table 3); in addition, the distribution of tortoises among macrohabitats and the proportion of individual macrohabitats in the total overall researched area was significantly correlated in most cases (table 2), which will be explained further in the text.

At Čermor, the dominant macrohabitat type was dense forest (58% of the total area, fig. 2, table 2), with 13% of individuals recorded in the spring and 48% in the summer. In the spring, the largest number of individuals was recorded...
Table 2. Percentage of habitat types within the researched localities (bold – dominant habitat type at the locality) and the percentage of tortoises recorded in different habitat types at every locality in spring and in summer (bold – highest % of tortoises recorded in individual macrohabitat per locality per season). For every locality and season, relation between % of tortoises recorded in specific macrohabitat and % that this specific macrohabitat contributes to the size of total investigated area was tested by Pearson Product-Moment correlation.

| Macrohabitat                | Čermor % of total area | Čermor % of tortoises recorded | Gonjište % of total area | Gonjište % of tortoises recorded | Kunovica % of total area | Kunovica % of tortoises recorded | Pašina Česma % of total area | Pašina Česma % of tortoises recorded |
|-----------------------------|------------------------|--------------------------------|--------------------------|---------------------------------|----------------------------|---------------------------------|-------------------------------|----------------------------------|
|                             | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer |
| Barren land                 | 2.53   | 12.9   | 0.0    | 0.0    | 0.13   | 5.1    | 0.0    | 0.0    | 1.58   | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    |
| Grassland                  | 14.27  | 35.5   | 16.7   | 46.10  | 50.0   | 29.2   | 8.00   | 30.4   | 58.1   | 15.36  | 28.6   | 32.3   | 15.36  | 28.6   | 32.3   | 15.36  | 28.6   | 32.3   | 15.36  | 28.6   | 32.3   |
| Open shrubland             | 1.83   | 6.5    | 2.4    | 1.99   | 16.0   | 0.0    | 13.76  | 3.8    | 6.5    | 3.63   | 7.1    | 6.5    | 3.63   | 7.1    | 6.5    | 3.63   | 7.1    | 6.5    | 3.63   | 7.1    | 6.5    |
| Dense shrubland            | 1.82   | 6.5    | 11.9   | 15.20  | 28.0   | 66.7   | 1.00   | 13.9   | 16.1   | 66.04  | 50.0   | 45.2   | 66.04  | 50.0   | 45.2   | 66.04  | 50.0   | 45.2   | 66.04  | 50.0   | 45.2   |
| Open woodland              | 2.54   | 12.9   | 2.4    | 1.03   | 0.0    | 0.0    | 8.25   | 1.3    | 0.0    | –      | –      | –      | –      | –      | –      | –      | –      | –      | –      | –      | –      |
| wooded grassland           | 6.15   | 0.0    | 2.4    | 4.38   | 0.0    | 0.0    | 8.22   | 10.1   | 0.0    | 2.80   | 7.1    | 0.0    | 2.80   | 7.1    | 0.0    | 2.80   | 7.1    | 0.0    | 2.80   | 7.1    |
| Wooded grassland-shrubland | 0.94   | 3.2    | 4.8    | –      | –      | –      | 9.66   | 2.5    | 3.2    | –      | –      | –      | –      | –      | –      | –      | –      | –      | –      | –      |
| Open forest                | 12.01  | 9.7    | 11.9   | 5.61   | 0.0    | 0.0    | 15.80  | 8.9    | 3.2    | 4.23   | 7.1    | 6.5    | 4.23   | 7.1    | 6.5    | 4.23   | 7.1    | 6.5    | 4.23   | 7.1    |
| Dense forest               | 57.91  | 12.9   | 47.6   | 5.90   | 0.0    | 4.2    | 35.18  | 24.1   | 12.9   | 6.37   | 0.0    | 9.7    | 6.37   | 0.0    | 9.7    | 6.37   | 0.0    | 9.7    | 6.37   | 0.0    |

Pearson’s r

|                  | Čermor | Gonjište | Kunovica | Pašina Česma |
|------------------|--------|----------|----------|--------------|
|                   | 0.23   | 0.96***  | 0.94**   | 0.92**       |

The symbol “–” means that this macrohabitat type does not exist in a locality. **P < 0.01; ***P < 0.001.
Table 3. The overall statistical significance ($\chi^2$ test) of difference between recorded and expected number of tortoises in individual macrohabitats per localities and per season.

| Locality   | Spring (sig.) | Summer (sig.) |
|------------|---------------|---------------|
| Čermor     | 0.000         | 0.000         |
| Gonjište   | 0.008         | 0.000         |
| Kunovica   | 0.000         | 0.000         |
| Pašina Česma | 0.550      | 0.114         |

Figure 2. Percentage of macrohabitat types within the studied localities (1 – barren land, 2 – grassland, 3 – open shrubland, 4 – dense shrubland, 5 – open woodland, 6 – wooded grassland, 7 – wooded grassland-shrubland, 8 – open forest, 9 – dense forest).

on grassland habitat type – 36%, vs. expected 14%, while in summer it was dense forest habitat type with 48% vs. expected 58% of individuals. The difference between observed and expected proportions of tortoise individuals was statistically significant in all cases (Chi square Goodness of fit test $p < 0.008$ and $p < 0.0001$ for spring and summer, respectively). The distribution of tortoises was highly correlated with the proportions of individual macrohabitats only in the summer (Pearson’s $r = 0.96$, $P < 0.001$).

At Gonjište, the dominant macrohabitat type was dense forest (35% of total area, fig. 2, table 2) with 24% and 13% of recorded tortoises recorded in the spring and summer, respectively. The largest number of individuals was recorded in the grassland habitat type – 30% recorded vs. 8% expected in the spring and 58% recorded vs. 8% expected in the summer. The difference between observed and expected proportions of tortoise individuals was statistically significant in all cases (Chi square Goodness of fit test $p < 0.008$ and $p < 0.0001$ for spring and summer, respectively). The distribution of tortoises was highly correlated with the proportions of individual macrohabitats only in the spring (Pearson’s $r = 0.94$, $P < 0.01$).

At the locality Kunovica, the dominant macrohabitat type was dense forest (35% of total area, fig. 2, table 2) with 24% and 13% of recorded tortoises recorded in the spring and summer, respectively. The largest number of individuals was recorded in the grassland habitat type – 30% recorded vs. 8% expected in the spring and 58% recorded vs. 8% expected in the summer. The difference between observed and expected proportions of tortoise individuals was statistically significant in all cases (Chi square Goodness of fit test $p < 0.0001$ and $p < 0.0001$ for spring and summer, respectively). The distribution of tortoises was highly correlated with the proportions of individual macrohabitats only in the spring (Pearson’s $r = 0.96$, $P < 0.001$).

At the locality Pašina Česma, dense shrubland was the most common habitat type (66% of total area, fig. 2, table 2) and the most favorable for tortoises in both seasons, with 50% of individuals recorded in the spring and 45% in the summer. The difference between observed and expected proportions of tortoise individuals was not statistically significant, but the distribution of tortoises was highly correlated with the proportions of individual macrohabitats in both seasons (Pearson’s $r = 0.92$ and $r = 0.88$ for spring and summer, respectively, $P < 0.01$).

Pearson product-moment correlation results showed that, in both seasons, distribution of tortoises among macrohabitats of Pašina Česma was concordant with their proportion in the total investigated area ($r = 0.92$ and $r = 0.88$ for spring and summer, respectively, $P < 0.01$); the same was approved at Gonjište in spring ($r = 0.94$, $P < 0.01$) and at Čermor in the summer.
Figure 3. Microhabitat preferences of Eastern Hermann’s tortoises per locality and per season.

\((r = 0.96, P < 0.001)\). On the contrary, distribution of tortoises in Kunovica was not correlated at all with the proportions of individual macrohabitats in the total investigated area at this locality (table 2).

At the microhabitat scale (fig. 3) we revealed that the herbaceous plants were the most common type of plants being in the closest contact with the recorded tortoises, except for locality Gonjište in the summer, where it was “bramble”. “Bramble” was also the second most common microhabitat type at all sites the tortoises were in contact with according to our results. At the locality Čermor, except “herbaceous”, large number of tortoises were found within microhabitats consisting of trees in the summer and aromatic plants in the spring.

Discussion

In this study, we analyzed macro- and microhabitat preference in four Hermann’s tortoise populations in Serbia. Additionally, these localities also represent two types of environment inhabited by tortoises – dominated by dense or open vegetation types.

Depending on the season, the eastern Hermann’s tortoises show somewhat different preferences toward specific macrohabitat types. The previous longitudinal study conducted at the locality of Kunovica (Stojadinović et al., 2017) has not confirmed that the tortoises select specific habitats for carrying out specific activities, but rather that certain particularities exist in their habitat preferences and activity patterns in the mixed landscape of oak forests, meadows, gardens, orchards and vineyards. Hermann’s tortoises in our study were mostly recorded in meadows and open shrublands (table 2), while less individuals were notified in the dense forest habitat type (similar with the results of Vilardell-Bartin et al., 2015 for western subspecies). However, increase of ambient temperature during the summer could have the largest influence on the high percentage of tortoises present in the dense forests and dense shrublands in this season. The findings of Meek (1988) on thermal ecology of \(T. hermanni boettgeri\) indicated that tortoises’ presence in the summer season, in different Mediterranean habitats of Montenegro, was high in shrublands, despite available wooded areas. However, dense shrubs act as effective shade enabling effective thermoregulation, which is in accordance to our finding. Additionally, Meek (1988) compared only shrub and woodland areas during different weather conditions, whilst in our study we distinguish 9 specific macrohabitats within completely different study design. Nev-
Nevertheless, Meek’s finding emphasize the importance of ambient temperatures in thermoregulation, as well as in habitat preference of eastern subspecies of *T. hermanni*. Tortoises’ preference to closed habitat type in our study was most pronounced at the locality Čermor. This locality abounds closed types of vegetation and favorable shelters for the tortoises during high summer temperatures. Kunovica locality is very similar to Čermor, but tortoises there mostly preferred grassland habitat type. The study conducted in Kunovica during the period 2010-2014 (Stojadinović et al., 2017) has shown that the frequency of tortoises there varied significantly among the years and it could happen that the meteorological conditions during data collecting were not favoring closed macrohabitat types. On the contrary, the localities Gonjište and Pašina česma lack the dense forest, and we suppose that tortoises there mostly choose dense shrubland because it provides the best available shelter from high ambient temperatures.

Our findings on the distribution of Eastern Hermann’s tortoises in this range of habitats supported results of previous studies carried out by Meek (1984, 1985, 1988) in the Mediterranean parts of Montenegro and Croatia and, for this part of subspecies area, by Stojadinović et al. (2017), but also provided detailed insight into the habitat preferences of Eastern Hermann’s tortoise on a finer scale. Despite research conducted by Rozylowicz and Popescu (2013), that confirmed selection of habitats on the rough scale of grasslands, shrubs and forest edges, it showed that tortoises haphazardly occurred in forest habitats. The fact that there is no statistically significant difference between the recorded and the expected number of individuals per habitat type on the Pašina česma locality can be explained by the uniformity of the local environment. There, 66% of the habitat there consisted of dense shrubland, while the other types of habitat are significantly less present (table 2). The cause of such one habitat structure is anthropogenic: this locality represents a neglected vineyard, which has been out of use for more than a decade. At this locality, we found that the distribution of tortoises among macrohabitats was concordant with their proportion in the total investigated area (Pearson’s $r = 0.92$ and $r = 0.88$ for spring and summer, respectively). Again, the reason can be the uniformity of the environment and perhaps low diversity of macrohabitats (see fig. 2) at this locality. Therefore, the largest number of tortoises there was, in both seasons, detected in the dominant habitat type – dense shrubland (fig 2.), in agreement with earlier studies in Greece, Croatia and Montenegro (Meek, 1984, 1985, 1988). On the other side, Gonjište and Čermor exhibited the same characteristics in some seasons. At the locality Gonjište, in the spring, the largest number of tortoises (even 50%) was recorded on the grassland habitat type, which is also the dominant habitat type on this locality (table 2). As the spring represents the main period of activity and nesting for tortoises (Vilardell-Bartin et al., 2015) and temperatures are not so high, we assume that this may be the reason for such spatial arrangement of tortoises among macrohabitat types. In the summer, temperatures are higher i.e. different habitat matrices among the localities. This also indicates the importance of precise definition of macrohabitats, in as much details as possible, to the point on how complex are the macrohabitats preferred by Eastern Hermann’s tortoises. That could be the explanation for some discrepancy between our and Stojadinović et al. (2017) study, and for difference in preferred habitats among the years of study at the Kunovica locality.
and therefore tortoises avoid open macrohabitat types, like meadows and open shrublands. For that reason, tortoises on the locality of Čermor, in the summer, would mostly choose dense forest ($r = 0.96$).

Our results showed that distribution of tortoises on the territory of Kunovica was not correlated with the proportion of individual macrohabitats ($r = 0.36$ in the spring and $r = -0.003$ in the summer). Kunovica also represents the largest investigated area in this study. In addition, this is the locality where all macrohabitat types from our list are present, and the dominant habitat type occupies less than 40% of the total territory. For comparison, the dominant macrohabitat type on other localities occupied more than 45% of the total territory (table 2). The high diversity of macrohabitat types in Kunovica, together with relatively low proportion of dense forest type could impact on relatively low number of tortoises recorded specifically in this macrohabitat.

The results of our study on the microhabitat scale showed that, throughout the year, the eastern subspecies of Hermann’s tortoise prefers herbaceous habitats in the both parts of season, bramble during the breeding season (spring) and slightly more bramble and trees in the summer (fig. 3). Eastern form of Hermann’s tortoises in general choose similar types of microhabitats in both seasons. In the summer, large number of tortoises at the locality Čermor was found within the microhabitats predominantly consisted of trees. Tortoises at the locality Gonjište were mostly found alongside of bramble, concordant with the fact that the majority of them choose dense shrubland habitat type at this locality (fig. 2), probably to avoid high midday temperatures in the absence of closed macrohabitats (see table 2).

This study has shown the complexity of eastern Hermann’s tortoise habitat requirements and the necessity for maintaining this habitat diversity on a fine scale. Continuous monitoring is obviously necessary for better understanding of ecology of Hermann’s tortoise, as this species is nowadays under tremendous anthropogenic pressure throughout its entire range. The results should contribute to efficient conservation planning related to either the preservation of already existing network of microhabitats important for the tortoises, or to their restoration where required (Rozyłowicz and Popescu, 2013; Couturier et al., 2014), where the knowledge on macro- and microhabitat use has considerable practical value for sustainable management. In the long term it should lead to minimalization of decline of natural populations and prevention of species extinction because of habitat degradation and/or destruction. It could also support implementation of ex situ conservation measures.

Acknowledgements. We are grateful to L. Luiselli and two anonymous reviewers for valuable comments that highly improved the final version of this manuscript. We are also indebted to many volunteers – members of Biological Society “Dr. Sava Petrović” from Faculty of Sciences and Mathematics University of Niš in Serbia, for participating in the fieldwork. For advices regarding statistical approach we are indebted to our colleague M. Djordjević. Authorities of Public Enterprise “Djerdap National Park” and “Srbija Šume – Šumsko gazdinstvo Niš” kindly allowed us to conduct field work in the selected protected areas and provided logistic support. Permits for field work were issued by the Ministry of Agriculture and Nature Protection No. 353-01-170/2016-17. This work was funded by Rufford Small Grants No. 18761-1 and 22238-2 for MN, JC and partly JCI and by Grant No 173025 Ministry of Education, Science and Technological Development of Republic of Serbia for DS and JCI.

Supplementary material. Supplementary material is available online at: https://doi.org/10.6084/m9.figshare.11627271

References

Berardo, F., Carranza, M.L., Frate, L., Stanisci, A., Loy, A. (2015): Seasonal habitat preference by the flagship species *Testudo hermanni*: implications for the conservation of coastal dunes. C. R. Biol. 338: 343-350.

Bertolero, A., Cheylan, M., Hailey, A., Livoreil, B., Willemersen, R. (2011): *Testudo hermanni* (Gmelin 1789) – Hermann’s tortoise. In: Conservation Biology of Freshwater Turtles and Tortoises: a Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonia Research Monographs, No. 5.
Macro- and microhabitat preferences of Hermann's tortoise

Meek, R. (1985): Aspects of the ecology of Testudo hermanni in southern Yugoslavia. Br. J. Herpetol. 6 (12): 437-445.

Meek, R. (1988): The thermal ecology of Hermann’s tortoise (Testudo hermanni) in summer and autumn in Yugoslavia. J. Zool. 215 (1): 99-111.

Meek, R. (1989): The comparative population ecology of Hermann’s tortoise, Testudo hermanni, in Croatia and Montenegro, Yugoslavia. Herp. J. 1: 404-414.

Meek, R., Inskeep, R. (1981): Aspects of the field biology of a population of Hermann’s tortoise (Testudo hermanni) in southern Yugoslavia. Br. J. Herpetol. 6: 159-164.

Roura-Pascual, N., Pons, P., Etienne, M., Lambert, B. (2005): Transformation of a rural landscape in the eastern Pyrenees between 1953 and 2000. Mt. Res. Dev. 5: 254-263.

Rozylowick, L., Dobre, M. (2010): Assessment of threatened status of Testudo hermanni boettgeri Mojisivo, 1889 (Reptilia: Testudinidae) population from Romania. North-West. J. Zool. 6: 190-202.

Rozylowick, L., Popescu, V.D. (2013): Habitat selection and movement ecology of eastern Hermann’s tortoises in a rural Romanian landscape. Eur. J. Wildl. Res. 59: 47-55.

Rugiero, L., Luisselli, L. (2006): Ecological modelling of habitat use and the annual activity patterns in an urban population of the tortoise, Testudo hermanni. Ital. J. Zool. 73: 219-225.

Steen, D.A., Sterrett, S.C., Miller, S.A., Smith, L.L. (2007): Terrestrial movements and microhabitat selection of overwintering subadult eastern mud turtles (Kinosternon subrubrum) in southwest Georgia. J. Herpetol. 41 (3): 532-535.

Stevanović, V. (1996): Samonikla botanička bašta. In: Nacionalni park Đerdap – Pamatvek prirode i čoveka, p. 72-82. Angelus, J., Ed., Ecolibri, Ministarstvo zaštite životne sredine Republike Srbije, Nacionalni park "Đerdap".

Stojadinović, D., Milošević, D., Cernobrnja-Isailović, J. (2013): Righting time versus shell size and shape dimorphism in adult Hermann’s tortoises: field observations meet theoretical predictions. Anim. Biol. 63: 381-396.

Stojadinović, D., Milošević, D., Cernobrnja-Isailović, J. (2017): Activity patterns and habitat preference of eastern Hermann’s tortoise (Testudo hermanni boettgeri) in Serbia. Turk. J. Zool. 41 (6): 1036-1044.

Türkøzan, O., Kiremit, F., Taskavak, E., Olgun, K. (2005): Status, distribution and population structure of land tortoises in European Turkey and southern Anatolia. Russ. J. Herpetol. 12: 209-216.

van Dijk, P.P., Corti, C., Mellado, V.P., Cheylan, M. (2004): Testudo hermanni. The IUCN Red List of Threatened Species 2004: e.T21648A9306057.

Vilardell-Bartino, A., Capalleras, X., Budó, J., Bosch, R., Pons, P. (2015): Knowledge of habitat preferences applied to habitat management: the case of an endangered tortoise population. Amphibia-Reptilia 36: 13-25.

Wiktander, U., Olsson, O., Nilsson, S.G. (2001): Seasonal variation in home-range size, and habitat area requirement of the lesser spotted woodpecker (Dendrocopos minor) in southern Sweden. Biol. Conserv. 100: 387-395.
Wright, J., Steer, E., Hailey, A. (1987): Habitat separation in tortoises and the consequences for thermo regulation and activity. Can. J. Zool. 66: 1537-1544.

Submitted: June 15, 2019. Final revision received: December 25, 2019. Accepted: January 16, 2020. Associate Editor: Luca Luiselli.