Theriologia Ukrainica, **17**: 80–87 (2019)
http://doi.org/10.15407/pts2019.17.080

IMPACT OF THE PLANT COVER ON PATTERNS OF EUROPEAN ROE DEER (*CAPREOLUS CAPREOLUS*) BED-SITES DISTRIBUTION

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Impact of the plant cover on patterns of European roe deer (*Capreolus capreolus*) bed-sites distribution. — A. Nykonenko. — Research on hoofed mammal species such as the roe deer is of great importance for scientific-based biodiversity conservation actions and population management. Animal ecology studies have fundamental significance for the development of protected areas. The roe deer is a convenient model object for studying population ecology of ungulates by revealing adaptations to the environment and determining the spatial structure of populations. The aim of the present work is to describe the ecological patterns of bed-site selection by the European roe deer in natural forest biotopes located in the Dnipro-Oril Nature Reserve, steppe zone of Ukraine. European roe deer bed-sites were counted during all three autumn months in 2017. Tree and shrub species within a radius of 3.6 m around a bed-site (n = 87) were determined. Duff depth and grass cover height around to the bed-sites were measured. The research was conducted in three different types of ecosystems: pine forest, oak forest, and locust plantations. Shrubs create visual protection of bed-sites in oak forests, while in pine forests visual protection is provided by high grass. Roe deer select places for beds mostly at a distance of 1.5–3.0 m from trees and shrubs, although they may use sites for rest either closer to the plants (20–30 cm) or at a distance more than 3.5–5.0 m. The average distance to the nearest tree exceeds that to shrubs. Duff depth of 1.5–4.5 cm and grass height of 10–75 cm were found right around the bed-sites. We noticed several signs of foraging near the bed-sites, but the tendency of separating places for feeding and rest was demonstrated. Selection of resting sites is influenced by a set of indices of trees and shrubs as well as by grass and other objects providing visual protection. At the same time, the roe deer are prone to have visual control over the surroundings from their bed-sites. The index of environmental protection is calculated as a distance on which the bed-site disappears in an observer's field of view from all four cardinal directions. This index is 3.7 m on average and varies in different biotopes: 4.1 m in pine forest, 2.8 m in oak forest, and 3.6 m in locust plantations. Trees and shrubs have the best protection properties, while grass cover hides the bed-sites at greater distances. Biodiversity conservation managers should be aware of environmental characteristics required for the species' existence. Studying habitat selection patterns of animals allows conservation and creation of favorable ecosystems.

Key words: *Capreolus capreolus*, vegetation, behavioral ecology, habitat selection, Dnipro region.

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Submitted: 02.02.2019. Revised: 15.03.2019. Accepted: 15.05.2019.

Introduction

The European roe deer (*Capreolus capreolus* (Linnaeus, 1758)) is the most widespread member of the deer family (Cervidae), order Cerviformes (Artiodactyla) in Ukraine and throughout Europe. Roe deer spend most of their day feeding (Latham, 1999). However, there is a constant alternation of active periods and repose in their time budgets. The roes create beds (bed-sites) by digging a shallow pit in well-protected sites, where they chew the feed (Chen, 1999). Roe deer usually prefer having the possibility of free view on the terrain but, at the same time, they create the bed-site under visual protection of vegetation and relief (Timofeeva, 1985: 84). This article is focused on vegetation as a factor of bed-sites visual protection.

Nowadays studying animals' adaptations to the constantly changing environment is particularly relevant due to perturbations of their habitat caused by human activity and climate change. The roe deer is an ecologically highly flexible species being able to adapt easily to environmental changes. They often visit agricultural lands and live close to human settlements. People have little influence on the Reserve's territory thus natural behavior of the species can be studied. According to Sokolov,

"studying the behavior of the roe deer facilitates understanding of the social organization of wild mammals that live separately and in small family groups. It also broadens the knowledge about intraspecific adaptations and mechanisms of intrapopulation relations between animals" (Sokolov, 1981: 23).

Material and methods

Field data were collected during autumn months (September–November) in 2017 in the Dnipro-Oril Nature Reserve (Dnipro region, Ukraine). Bed-sites (n = 87) were found following the routes defined in advance. We determined the biotope, where the bed-site was located and measured average vegetation height and duff depth. We evaluated all vegetative characteristics in the radius of 3.6 m (area of 40 m^2) from the center of the bed-site (Cindy, 2001; Gallina, 2010). All shrubs and tree species were identified in this area.

We evaluated environment protection properties: a 40 cm high stick was placed in the center of the bed-site, imitating a laying roe deer. The researcher measured the distance on which the stick was no longer visible in the four cardinal directions. Measurements were taken from a height of 1 m above the ground, simulating a predator (wolf or dog). All four distances were summed and then averaged; the obtained result was called as index of environmental protection *k* ($k = (N + S + W + E) / 4$, where N, S, W and E — distances in the north, south, west and east, respectively, where the bed-site was no longer visible). We also noted the signs of feeding behavior near the bed-sites. We took the photos of all bed-sites, using digital photo camera Nikon D3100. Geographic coordinates were taken by GPS-navigator Garmin eTrex 20. Obtained data were then organized in Microsoft Access 2016 and analyzed by Microsoft Excel 2016 tools. The map with the markings of the bed-sites was built in ArcGIS Online by ESRI (OpenStreetMap) (Fig. 1).

Study area

The Dnipro-Oril Nature Reserve has a status of environmental research institution of national importance since 1990. The Reserve is located on the left-bank floodplain of the Dnipro river, in the center of Dnipro region (48º30' nl, 34º45' el) having an area of 3766.2 ha.

According to geographical zoning, the territory of the Nature Reserve belongs to the Left-Bank-Dnipro-Azov northern-steppe region of the Northern-steppe subzone of the Steppe zone. According to the geobotanical zoning, the vegetation belongs to Pavlograd (Dnipro-Donetsk) area of Azov-Black Sea steppe subprovince of the Black Sea (Pontic) steppe province of the Europe-Asian steppe region.

One of the terraces, where the Reserve is situated, is running along the Dnipro river, reaching 16 km in length and 2 km in width. Another terrace is situated in the central and northern parts of the territory. The relief of the Reserve is hilly-plain, going over the sandy steppe. Sandy deposits of the terrace, influenced by windy processes, have taken the form of mounds. The highest points of the surface in the central part of the Reserve reach 65–70 m. The climate is dry and hot. Average temperature in January is –5.5°C, while in July is +21.5°C. Average annual precipitation is 430 mm.

Flood plain part of the Reserve includes fragments of medium floodplain forests (black poplar (*Populus nigra*), white poplar (*Populus alba*), white willow (*Salix alba*), European oak (*Quercus robur*), European white elm (*Ulmus laevis*), and black alder (*Alnus glutinosa*)), wet and dry meadows, system of lakes with swamps and islands. Sandy steppe, shrub associations of sharp-leaf willow (*Salix acutifolia*), Tatarian maple (*Acer tataricum*), artificial pine plantations (*Pinus sylvestris*) and black locust (*Robinia pseudoacacia*) plantations are located in the arena part of the Reserve.

The vegetation cover of the Reserve is dominated by forests, about 90% of which are of long-flooded type. The largest area is occupied by oak forests (*Quercus robur*); considerable areas also include forests of white willow (*Salix alba*), white poplar (*Populus alba*) and black alder (*Alnus glutinosa*). The intrazonal feature of the Reserve's natural complex creates its uniqueness and plays an important role in biodiversity conservation of the whole region (Chronicle of the Nature of Dnipro-Oril Nature Reserve, 1996–2018. Dnipro, 2018)

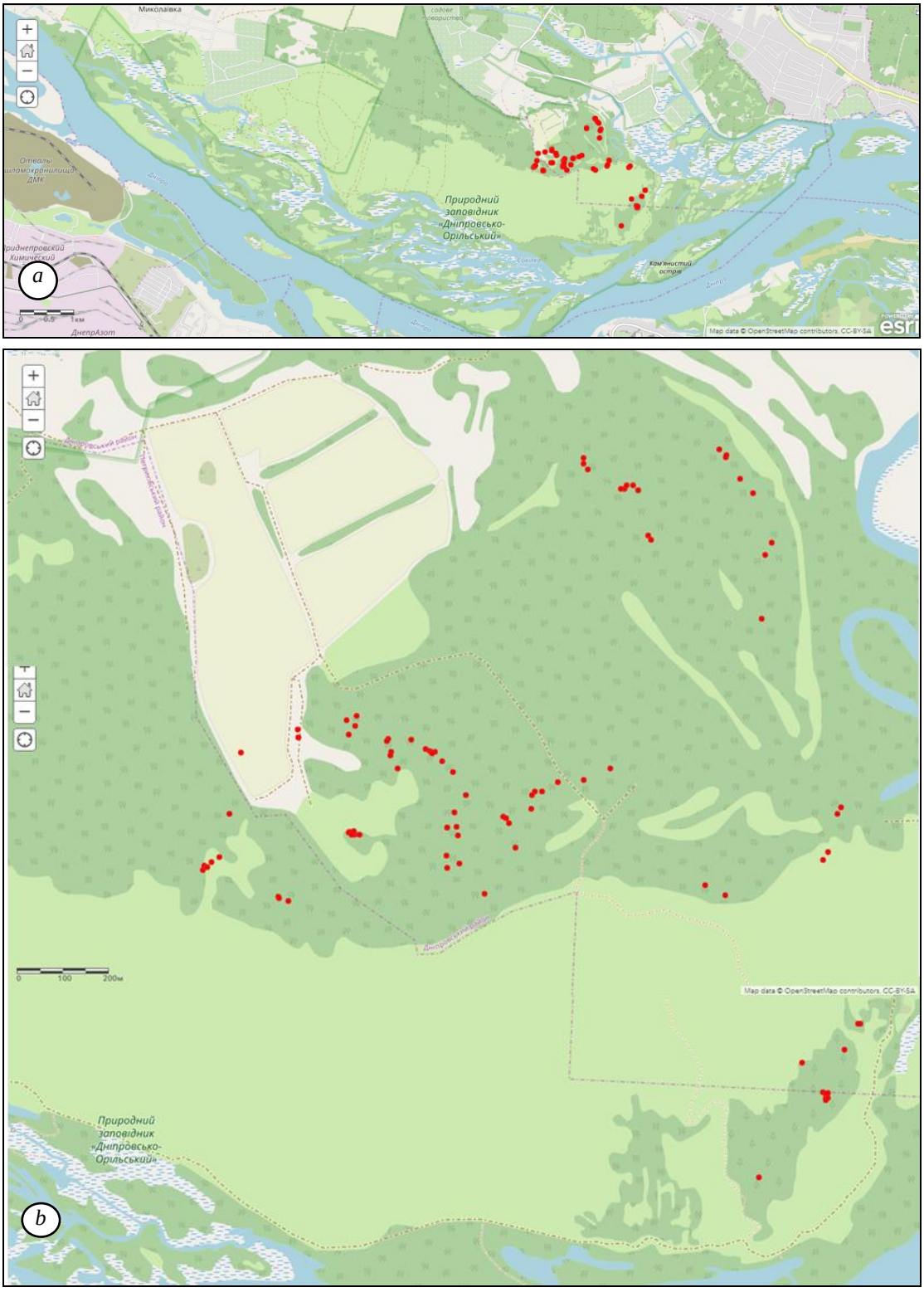

Fig. 1. Map of European roe deer bed-sites in the Dnipro-Oril Nature Reserve: *a* — scale 1 : 25 000; *b* — scale 1 : 6250.

Рис. 1. Карта зі знахідками лежанок сарни на території Дніпровсько-Орільського природного заповідника: *a* — масштаб 1 : 25 000; *b* — масштаб 1 : 6 250.

Results and discussion

Forest types, where bed-sites were found

Roe deer bed-sites were found in different groups of plant associations. They were combined according to steppe forests typology made by A. L. Belgard (1971) into (1) European oak (*Quercus robur*) formation that is included into middle-flooded forests, (2) artificial pine (*Pinus sylvestris*) plantations and (3) plantations of the black locust (*Robinia pseudoacacia*) and honey locust (*Gleditsia triacanthos*). In this paper, these forests are called (1) oak forest, (2) pine and (3) locust plantations for convenience (Fig. 2)

Duff depth and grass height in the areas of bed-sites

Duff depth in different biotopes varies within reliable ranges ($F = 20.10$, $p < 0.01$), and includes deciduous fall in the oak forest (Fig. 3*a*) and coniferous fall in the pine forest (Fig. 3*b*). Grass (motley grass of cereals mixed with dicots) is growing abundantly in the 71.3 % of all bed-sites. It creates additional protection for the bed-site. The height of grass ranges from 0.1 to over 0.75 m in different biotopes ($F = 5.03$, $p < 0.01$).

Duff depth in the oak forest is twice as high as that in the pine forest (4.1 ± 0.3 and 2.5 ± 0.1 cm respectively). Higher grass is noticed in pine plantations compared to the oak forest (27.6 ± 3.0 and 11.0 ± 4.7 cm). However, grass height may reach 1 m in both biotopes due to common yarrow (*Achillea millefolium*), common nettle (*Urtica dioica*), tansy (*Tanacetum vulgare*) and common milkweed (*Asclepias syriaca*). Bed-sites are well-protected by high thickets in these places. More often, the height of cereal forbs is 10-20 cm, although rarely it reaches 40 cm and sometimes 70 cm due to couch grass (*Elymus repens*). In most cases, grass does not grow next to the bed-sites in the oak forest compared with the pine forest (58.3 and 14.8 %). It may be explained by different light in these biotopes: the oak forest is much darker than the pine forest and therefore there is less grass in it. Average indexes of duff depth and grass height are almost equal in the locust plantations and oak forest (3.6 ± 0.6 and 15.3 ± 6.1 cm). Grass does not grow near the bed-sites in one third of all cases.

Jiang et al. (1996) note that high grass grows near most of the beds (91.4%). Other researchers report that roe deer prefer to make bed-sites in thick grass (Timofeeva, 1985). According to the materials by E. Babayev and G. Mirzoev, the number of cereals and grasslands near the bed-sites differs significantly from that in random sites (Babayev, Mirzoev, 2011). According to Linnell (1999), in the forest environments roe deer prefer places with higher vegetation and less visibility for creating the bed. Mysterud (1996) emphasizes the prevalence of abundant grass cover at the beds, although he denies the idea of foraging near the beds, since no herbs of their diet are found near resting sites.

Bites on vegetation near the beds

There were bites on vegetation growing near the beds noticed only in 9 of 87 cases (10.3% of all beds). Only one bite was recorded in the pine plantations on a young elm. Bites were noticed on Tatar maple and cereal plants growing close to the bed in the oak forest. More various bites were noted in the locust plantations: bitten shoots of Tatar maple and elm, eaten bark on a hawthorn, and cereals in the poplar and Tatar maple forests.

Researchers of the location of the beds did not find any bites on the vegetation near the bed-sites, although there were growing species included in the diet of roe deer (Babaev, Mirzoev, 2011). Therefore, the authors assumed that rich grass cover does not perform feeding and thermoregulatory functions, but only serves as additional protection of the bed-site. Mysterud (1996) considers the same. That is, roe deer do not lie in the same place where they feed, but purposefully seek for sheltered places.

Coefficient of environmental protection

The coefficient of environmental protection is calculated according to the measurements on the bed-sites. The lower the index, i.e. the smaller the distance at which the bed is fully concealed from the view, the better protective properties the bed has.

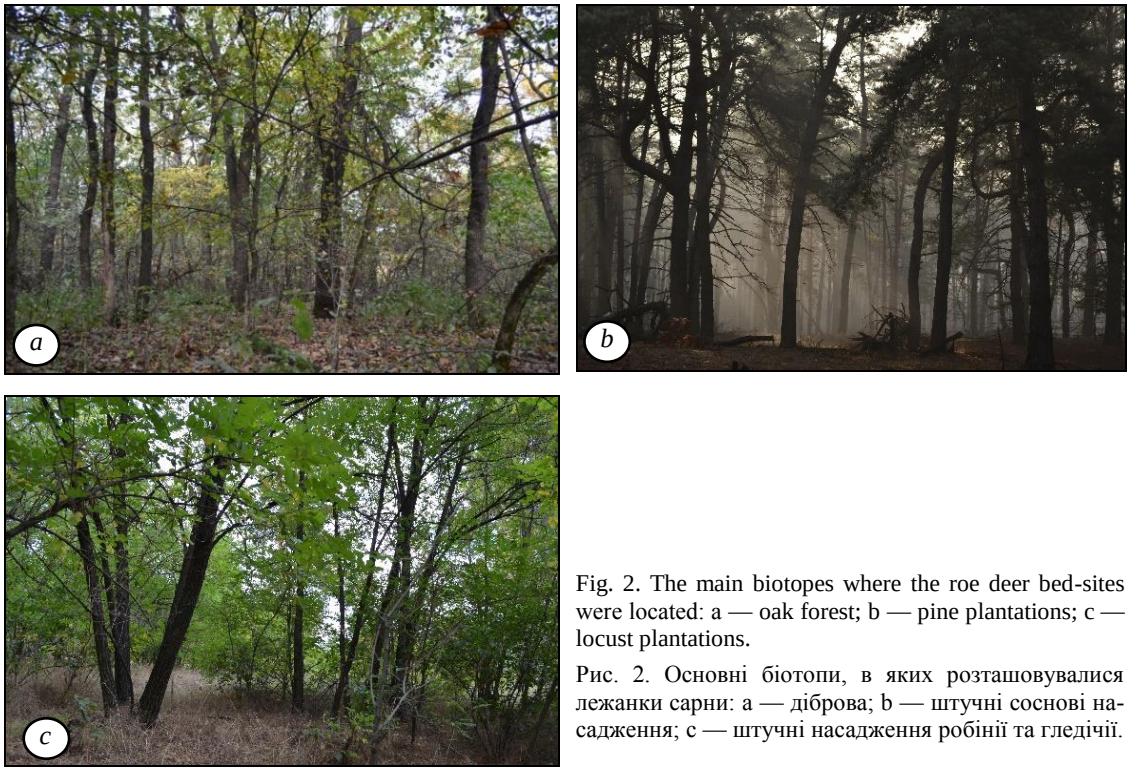

Fig. 2. The main biotopes where the roe deer bed-sites were located: a — oak forest; b — pine plantations; c — locust plantations.

Рис. 2. Основні біотопи, в яких розташовувалися лежанки сарни: a — діброва; b — штучні соснові насадження; c — штучні насадження робінії та гледічії.

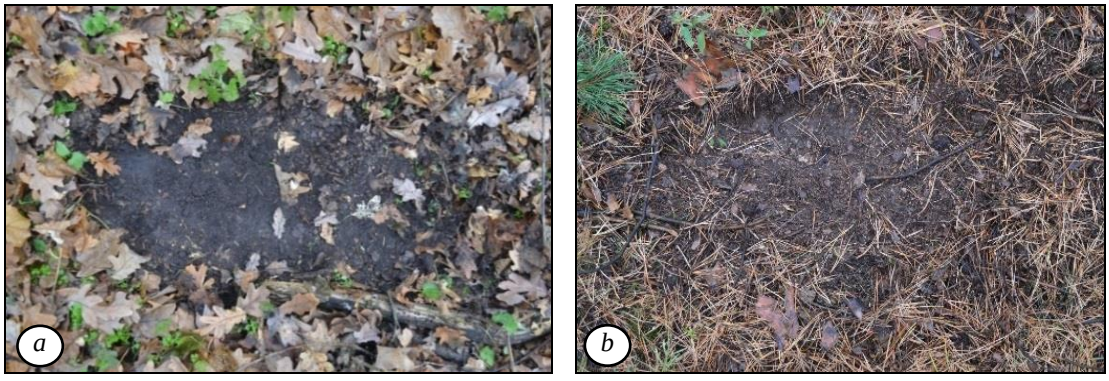

Fig. 3. Roe deer bed-sites: a — in the oak forest; b — in the pine plantations.

Рис. 3. Лежанки сарни: a — у діброві; b — у соснових насадженнях.

The coefficient of environmental protection varies reliably in the different biotopes ($F = 2.22$, $p < 0.05$). On average, the bed-site is concealed at a distance of 3.7 ± 0.2 m from all directions (Table 1). The table shows that bed-sites in the oak forest have the lowest index, and therefore the greatest protection, whereas beds in the pine forest have the highest index and the least protection. This is due to the density of forests and shrubs, which create visual obstacles in the forests, while the pine forest is sparse and therefore easily visible.

Studies by E. Babaev and G. Mirzoev indicate that in the areas with bed-sites, the indexes reflecting the protective properties of the environment are expressed in the horizontal cross-section of the crowns of the woody-shrub storey. These indexes are lower than in random areas meaning that the visibility in the areas where beds are located is worse compared to the random sites, and therefore the protective properties are better (Babaev and Mirzoev, 2011).

Mysterud (1996) indicates that the beds are hidden from view in 12 m on average, and at a distance of 5 m the horizontal cross-section of the crowns is 47 %, and at a distance of 30 m — 98 % against 29 and 90 % respectively in random areas. The author also compared the ratio between the vegetation and the landscape involved in beds' concealment and concluded that the beds are more often protected by vegetation.

Objects of visual protection of the bed-sites

We recorded what exactly were the bed-sites visually concealed by along with the numerical indicators of environmental protection (Table 2). In most cases, bed-sites were protected by trees in all biotopes. The highest percentage of trees being involved in concealing the beds was recorded in the locust plantation and oak forest. Shrubs are the main means of hiding beds in one third of cases in the same biotopes. High grass was protection of the beds more often than trees and shrubs in the pine forest. In the pine and oak forests, dry trees played a significant role in hiding the beds. However, dry branches were used as shelters instead of fallen trees in the locust plantations.

In addition to the fallen trees and branches, bed-sites were protected by the undergrowth (young woody shoots) in the pine and oak forests (honey locust, black locust, Tatar maple in the pine forest, black and white poplar, elm, oak in the oak forest and locust plantations). Roe deer preferred to lay down in the areas, where woodland formed clusters and thickets. In addition, in some cases, in the pine forests bed-sites were protected by the fire trenches, which are located throughout the reserve.

Shrubs concealed the beds at the shortest distance (on average 3 m); the grass had the worst protective properties: it hid the beds from view at 5.7 m (Table 3). The rest of the objects of protection were: fallen trees and branches, trees and undergrowth. They hid the beds at almost equal distances of 3.3–3.5 m. The grass provided protection for the beds at the maximal distance in the pine forest, while the shrubs — at the minimal. The bed-sites were hidden by undergrowth and grass at the greater distance. Fallen trees and undergrowth were absent as protective elements in the pine forest, whereas grass created protection at the greatest distance there (Fig. 4).

Comparing the distances where bed-sites were concealed from the view, we can assume that the trees (including fallen ones) and shrubs are the objects with the best protection properties. However, undergrowth creates the best concealment in the pine forest. Grass has poor protective properties in all biotopes. The findings indicate that roe deer choose beds closer to the trees and shrubs than to the grass. Therefore, well-developed undergrowth is among the important factors that determine the location of beds in certain areas of forest ecosystems.

Table 1. Descriptive statistics of the index of environmental protection in different biotopes

Таблиця 1. Описові статистики індексу захищеності середовища в різних біотопах

Biotopes	n	Mean ± SD	Med	Min	Max	Percentile 2.50	Percentile 97.50
Total	87	3.71 ± 0.21	3.25	1.00	11.50	1.63	9.13
Pine plantations	54	4.14 ± 0.30	3.63	1.50	11.50	1.63	10.13
Oak forests	24	2.78 ± 0.23	2.50	1.00	5.75	1.00	5.75
Locust plantations	9	3.64 ± 0.67	2.50	1.93	7.88	1.93	7.88

Table 2. Percentage ratio of the objects of bed-sites visual protection (% of all bed-sites in each biotope)

Таблиця 2. Співвідношення об'єктів візуального захисту лежанок (% від усіх лежанок по кожному біотопу)

Objects of visual protection	Average	Pine plantations	Oak forest	Locust plantations
Trees	41.38	42.13	46.88	47.22
Shrubs	27.87	18.98	34.38	33.33
Grass	12.64	18.52	3.13	2.78
Fallen trees	12.64	14.81	13.54	–
Fallen branches	2.87	1.39	1.04	16.67
Undergrowth	2.59	4.16	1.04	–

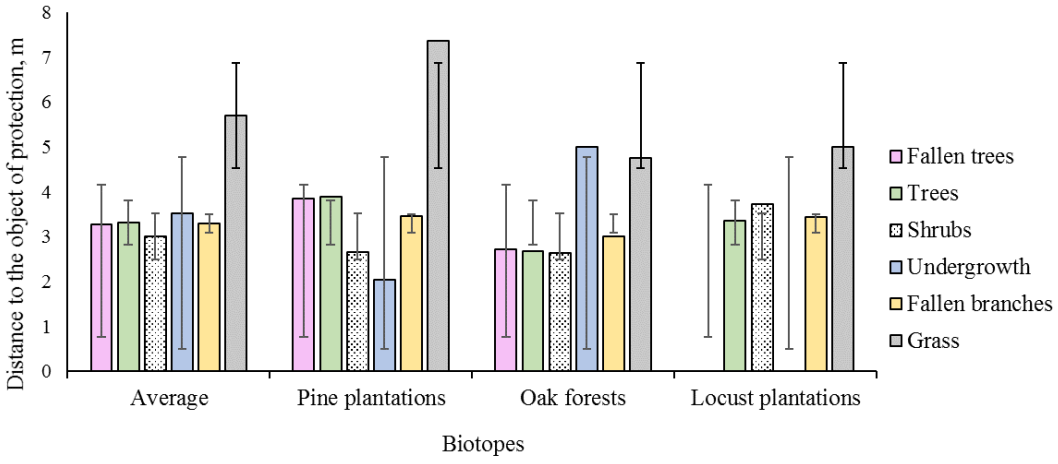

Fig. 4. Diagram of the bed-sites full-concealment distance by different objects.

Рис. 4. Діаграма відстані, на якій лежанка ховається з поля зору за допомогою різних об'єктів.

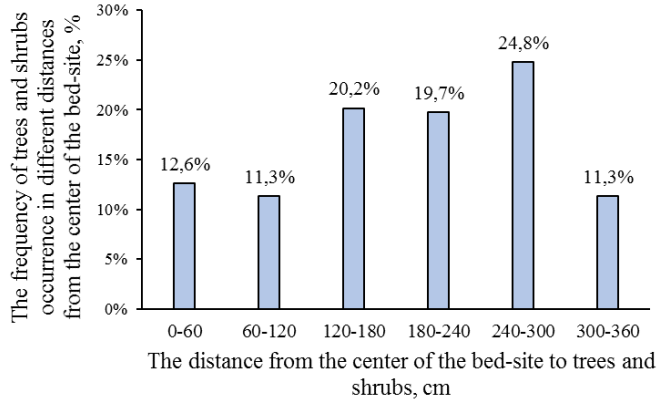

Fig. 5. The frequency of trees and shrubs occurrence in different distances within a radius of 3.6 m from the bed-site.

Рис. 5. Частота зустрічальності деревних та чагарникових рослин на різній відстані від лежанки в межах радіусу 3,6 м від її центру.

It is known that trees-shrubs storey is the most important protective cover in the places of roe deer beds (Babaev, 2011). Our data support this view; however, we also note the high grass that often occurs at the bed-sites as an object of their protection. Mysterud (1996) also notes that bed-sites are better protected with vegetation than random sites. The authors consider trees to be the main objects of protection. It is also known that roe deer prefer to choose bedsies under the protection of trees, but close to open space (in order to have a clear view of danger) (Timofeeva, 1985).

Roe deer selected bed-sites mostly in 1.2–3.0 m distance from trees and shrubs (64.71 % of trees and shrubs within 3.6 m of the center of the beds occur in this distance). Animals could make beds very close to the plants (0-60 cm) and at a distance exceeding 3.6–5.0 m (Fig. 5).

Table 3. Distance (m) of full-concealment of the bed-sites by different objects in the main biotopes

Таблиця 3. Відстань (м), на якій лежанка ховається з поля зору за участі різних об'єктів в основних біотопах

Objects of visual protection	Mean	Pine forest	Oak forest	Locust plantations
Shrubs	3.01	2.65	2.64	3.73
Fallen trees	3.28	3.85	2.71	–
Fallen branches	3.30	3.45	3.00	3.44
Trees	3.31	3.88	2.68	3.36
Undergrowth	3.52	2.03	5.00	–
Grass	5.70	7.36	4.75	5.00

Jiang et al. (1996) obtained the following minimum distance from the beds: 3.7 ± 0.5 m (daytime) and 3.1 ± 0.3 m (nighttime) to the trees and 1.0 ± 0.5 and 1.0 ± 0.1 m to the shrubs. The beds were located closer to the shrubs than to the trees, which coincides with our results. According to another author (Mysterud, 1996), a minimum distance of 112 cm from the bed-site to a tree was found. Roe deer choose bed-sites in different biotopes, next to various trees, and shrubs. Bed-site location is also influenced by a complex of vegetation indexes and other objects that could protect them, as well as by the ability of the roe deer having visual control over environment.

Conclusions

Roe deer create more beds in places with suitable forest floor and grass differing in various biotopes. Duff depth in places suitable for the creation of beds varies from 2.5 to 4.5 cm, whereas the height of grass can be up to 34 cm.

In most cases (90 %), roe deer do not eat grass around the beds. This may be the evidence of entrenched behavior aimed to preserve grass that plays a significant ecological role in creating visual protection of the bed from potential enemies.

In order to create a bed-site, roe deer need specific areas that can create the environment, sufficiently protected from the sight of potential enemies. Herbaceous and shrubby vegetation provide such protection. The index of environmental protection differs significantly in different biotopes, although the bed-site disappears from view at a distance of 3.7 m on average.

The average distance to the trees exceeds the corresponding one to the shrubs. The bed-site is usually hidden at the shortest distance by the shrub (on average of 3 m), whereas the grass has the worst protective properties: it conceals the bed from the view in 5.7 m. Other objects of protection — fallen branches, trees, and undergrowth — hide beds at almost equal distances of 3.3–3.5 m.

Thus, identification of roe deer habitat needs, including the potential conditions for the creation of beds, will allow to introduce science-based measures for conservation of natural ecosystems and, if necessary, restoration of ecosystems on disturbed lands, that are favorable for the existence of ungulates.

Acknowledgments

I would like to express my sincere gratitude to my supervisor V. Y. Gasso for the help and support. I would like to thank my family, as this work would not come into life without their assistance. I also thank S. V. Ermolenko for the inspiration and creating brilliant ideas. I am thankful to research fellow of the Dnipro-Oril Nature Reserve I. S. Maltsev for his constant support in field research and D. S. Ganzha for his help in the identification of plants.

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