Impact of the environment on the number of Tawny Owl (*Strix aluco*) territories in beech forests, Slovakia

Impacto do ambiente no número de territórios de coruja-do-mato (*Strix aluco*) em florestas de faia, Eslováquia

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ABSTRACT

It is important to know the impact of the environmental parameters for the effective conservation of forest owls. This study aims at a better understanding of the relationship between an opportunistic predator - the Tawny Owl (*Strix aluco*) and the environment in typical beech forests in Slovakia. Our study area covers 44 km^2 in the oak-beech forests of the Malé Karpaty mountains, Slovakia. Altogether 11 squares were selected for research in the vicinity of the city of Bratislava. Eight 2x2 km squares Tawny Owl territories were recorded using overnight audio recordings. In three squares owls were counted during night visits with playback. These were recorded during the autumn and spring in 2013-2016. 34 territories were recorded in the samples squares (mean = 3.1 terr./survey square, or 0.77 terr./km^2). The relationship between the environment and the number of territories was examined using the following parameters: old forest cover, length of the watercourses, area of forest loss, elevation and forest management category. Results showed no significant relationships between these selected parameters and the number of Tawny Owl territories. This study supports the idea of Tawny Owl as plastic species with a wide ecological niche, even in typical beech forests in Slovakia.

Keywords: density, forest management, habitat, population, *Strix aluco*

RESUMO

O conhecimento do impacto de parâmetros ambientais é importante para a conservação efetiva de rapinas noturnas florestais. Este estudo pretende compreender a relação entre um predador oportunista – a coruja-do-mato (*Strix aluco*) e o ambiente em florestas de faia típicas da Eslováquia. A área de estudo compreende 44 km^2 de florestas de carvalhos e faia nas montanhas de Malé Karpaty, Eslováquia. Foram registados os territórios de coruja-do-mato em onze quadrículas de 2x2 km através de gravações de áudio noturnas. Em três quadrículas, as corujas foram contadas em visitas noturnas com emissão de vocalizações conspecíficas. A monitorização decorreu no outono e na primavera, entre 2013 e 2016. Foram registados 34 territórios nas quadrículas amostradas (média = 3,1 territórios/quadrícula, ou 0,77 territórios/km^2). A relação entre o ambiente e o número de territórios foi analisada através dos seguintes parâmetros: cobertura de floresta antiga, comprimento de linhas de água, perda de área florestal, altitude e categoria de gestão florestal. Os resultados revelaram que não existem relações significativas entre os parâmetros selecionados e o número de territórios de coruja-do-mato. Este estudo suporta a ideia de que coruja-do-mato é uma espécie plástica com um nicho ecológico amplo, mesmo em florestas de faia típicas da Eslováquia.

Palavras-chave: densidade, gestão florestal, habitat, população, *Strix aluco*

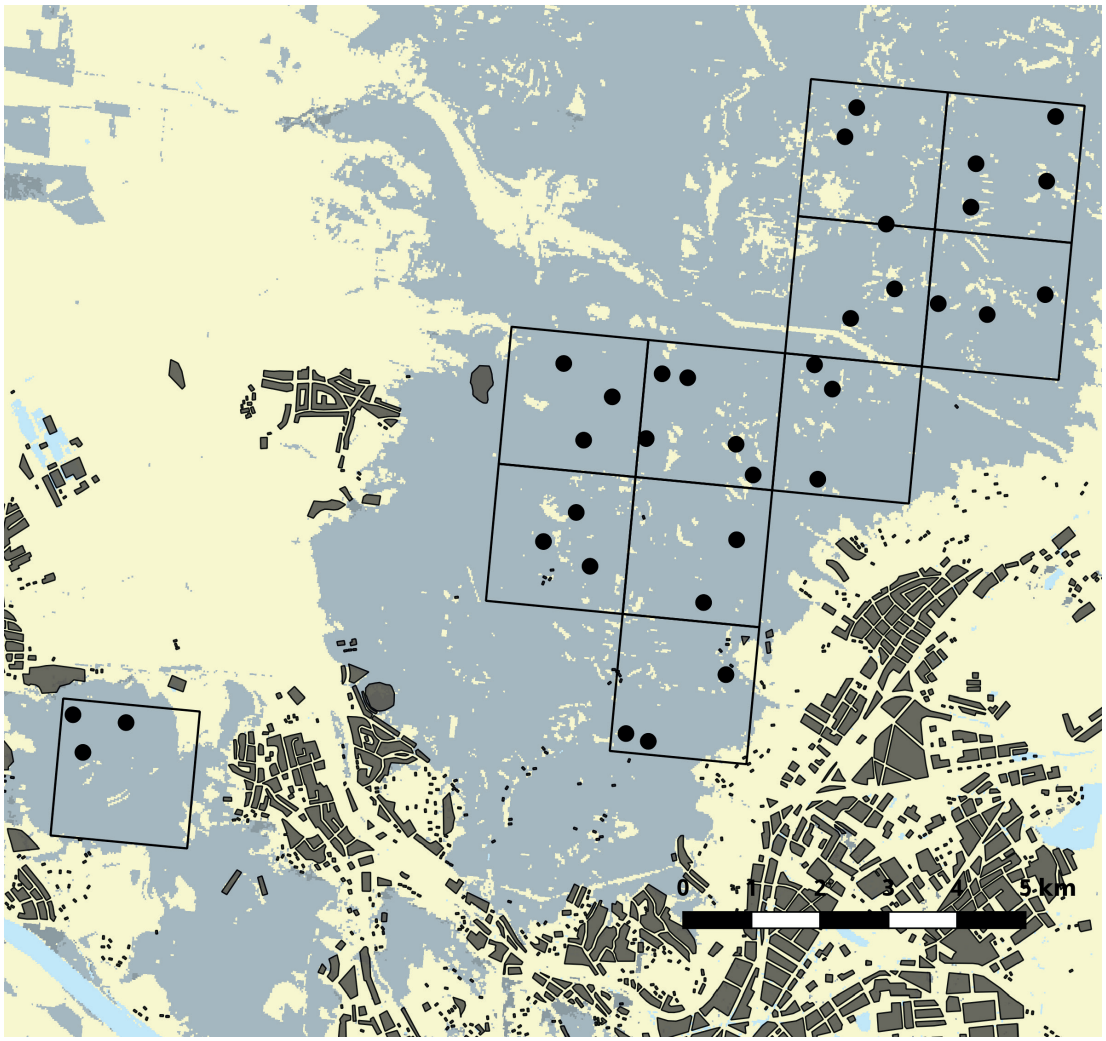
Introduction

Tawny Owl (*Strix aluco*) is a common owl species occupying especially deciduous and mixed forests (Mikkola 1983) and is distributed across most European countries. It is a cavity dweller, but when appropriate cavities are lacking nestboxes and nests of other birds are occupied (Galeotti 2001). One of the key topics of its conservation science is to understand how the species are influenced by the environment (Laurance 2010). Forest species are often related to the parameters like age of the trees (Poulsen 2002), cover of forest (Villard et al. 1999, Bélisle et al. 2001), forest fragmentation (Robinson et al. 1995, Fahrig 2003) or forest management (Martin & Eadie 1999). Since main parts of forests in Europe are managed for wood production (de Rigo et al. 2016), effective conservation measures need to be identified and understood leading to the key environmental parameters for the species.

Although the habitat and forest characteristics inhabited by Tawny Owls were researched in a multitude of studies, there is a lack of information about the influence of the environment within mainly beech forests. This is a dominant type of the forest habitat in Slovakia (Paule 1994). In this study we study the territory density of Tawny Owl in the mixed oak-beech and beech forests in Slovakia and the possible relationship of the number of territories with specific environmental parameters.

Figure 1 - Map of the study area with eleven 2x2 km squares and centres of Tawny Owl (*Strix aluco*) territories (points).

Figura 1 - Mapa da área de estudo com onze quadrículas de 2x2 km e centros dos territórios de coruja-do-mato (*Strix aluco*).



Methods

The study area covers 44 km² (Fig. 1) in Malé Karpaty mountains (Slovakia). These mountains are part of the Carpathian mountain system. A square (2x2 km) from the square network covering the area of Slovakia was defined as a basic unit. Altogether 11 squares were selected for the research in the vicinity of the city of Bratislava. All squares were located in the southern part of the mountains (lat:48.233303, long:17.118257). Habitats of the study area dominantly consisted of beech (*Fagus*), oak (*Quercus*) and hornbeam (*Carpinus*). Human settlements are limited to the edge of the mountains. Part of the study area was affected by the wind calamities in previous years (2004 and 2010). The squares were counted using audio recorders (8 squares) and night visits (3 squares) during the autumn and spring of 2013 - 2016. The owls were recorded from points (recorders -

Table 1 - Descriptive statistics of environmental parameters in the eleven 2x2 km squares beech forest (Slovakia).

Tabela 1 - Estatísticas descritivas dos parâmetros ambientais em onze quadrículas de 2x2 km em floresta de faia (Eslováquia).

CATEGORY	MEAN	SD	MIN	MAX
Length of the watercourses (km)	3.91	1.64	1.08	5.90
Area of the forest loss (ha)	18.41	14.25	0.04	43.43
Area of the economic forest (ha)	94.71	109.11	0.00	367.77
Mean elevation (m)	417.69	60.64	321.72	516.10
Area of the old forest (>100 years) (ha)	100.85	63.27	37.91	212.23

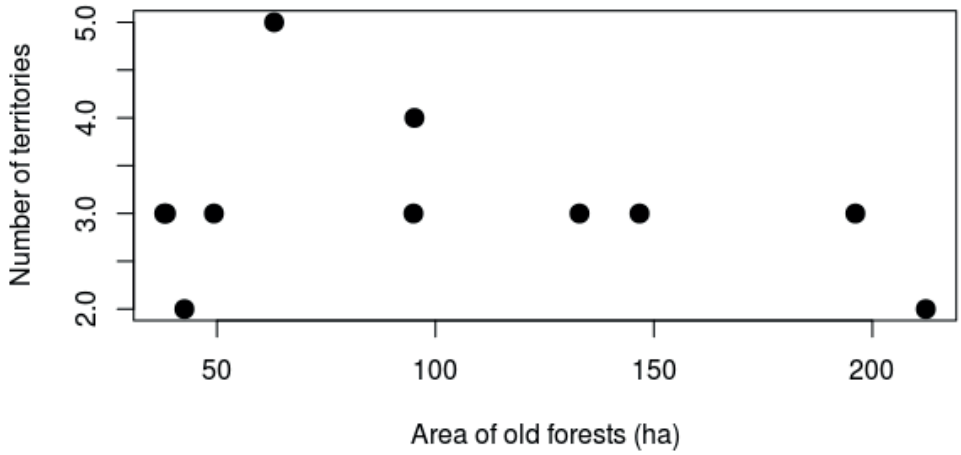
Table 2 - The relationship between environmental parameters and the number of Tawny Owl (*Strix aluco*) territories using GLM (Poisson distribution).

Tabela 2 - Relação entre os parâmetros ambientais e o número de territórios de coruja-do-mato (*Strix aluco*) com base em GLM (distribuição de Poisson).

	DEGREES OF FREEDOM	ESTIMATE	STD. ERROR	Z VALUE	PROBABILITY > Z
Area of the old forests	10	-0.001	0.003	-0.381	0.703
Length of the watercourses	10	0.000	0.000	0.203	0.839
Area of the forest loss	10	0.000	0.000	0.160	0.873
Area of the economic forests	10	-0.001	0.002	-0.545	0.586
Mean elevation	10	0.000	0.003	0.041	0.967

Figure 2 - Relationship between the number of Tawny Owl (*Strix aluco*) territories and the area of old forests using GLM (Poisson distribution).

Figura 2 - Relação entre o número de territórios de coruja-do-mato (*Strix aluco*) e a área de floresta longeva com base em GLM (distribuição de Poisson).



3-4 per square, night visits - 2-3 per square) spread across each square. During the night visits owls were counted during the calm night from points (each point separately for 45 minutes after sunset) with the call imitation (first 5 minutes, repeated after 10 minutes). The count of squares by night visits was repeated three times for more accurate results. Audio recorders recorded two nights from sunset to sunrise. Recordings were converted to spectrograms using the Audacity software program for easier manipulation and exploration. Each owl call position was identified by the strength and direction of the voice of different recordings. Territories were identified based on the current registration of two or more territorial calls and disputes or they were distinguished by the characteristic of the male voice (spectrogram visual analysis).

The area of the economic and old forests was identified by online application (LGIS, 2017). The area of the forest loss (Global Forest Watch, 2014), length of the watercourses and the elevation were analysed in a GIS application (Qgis, GRASS GIS). We used a generalized linear model - GLM (Poisson distribution) for the analysis of the relationship between the number of territories and some environmental parameters. Data were processed and analysed in the statistical programme R (R Development Core Team 2008). The statistical significance was set at $\alpha \leq 0.05$.

Results

Table 1 illustrates the environmental parameters and the number of owl territories.

34 owl territories were recorded (mean = 3.1 +- 0.83 territory/square, range 2-5 terr./square, mean density = 0.77 territory/km^2) in 11 squares. The GLM analysis did not confirm statistical significant influence of the selected parameters on the number of territories (Tab. 2). A high variability of evaluated environmental parameters was recorded. Results show that the environment with the smaller area of old forests can be also occupied by a higher number of owls (Fig 2). Each square contained min. 9 % (max. 53 %) of forest stands older than 100 years, which were distributed unevenly within the study

Figure 3 - Relationship between the number of Tawny Owl (*Strix aluco*) territories and the area of economic forests using GLM (Poisson distribution). Relationship between the number of Tawny Owl (Strix aluco) territories and the area of economic forests using GLM (Poisson distribution).

Figura 3 - Relação entre o número de territórios de coruja-do-mato (*Strix aluco*) e a área de florestas de exploração, com base em GLM (distribuição de Poisson).

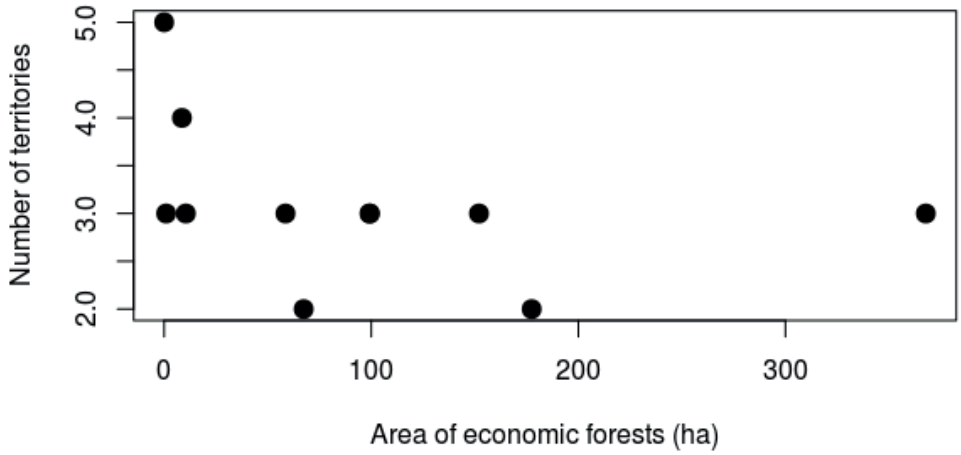


Figure 4 - Relationship between the number of Tawny Owl (*Strix aluco*) territories and the area of the forest loss using GLM (Poisson distribution).

Figura 4 - Relação entre o número de territórios de coruja-do-mato (*Strix aluco*) e a área florestal perdida, com base em GLM (distribuição de Poisson).

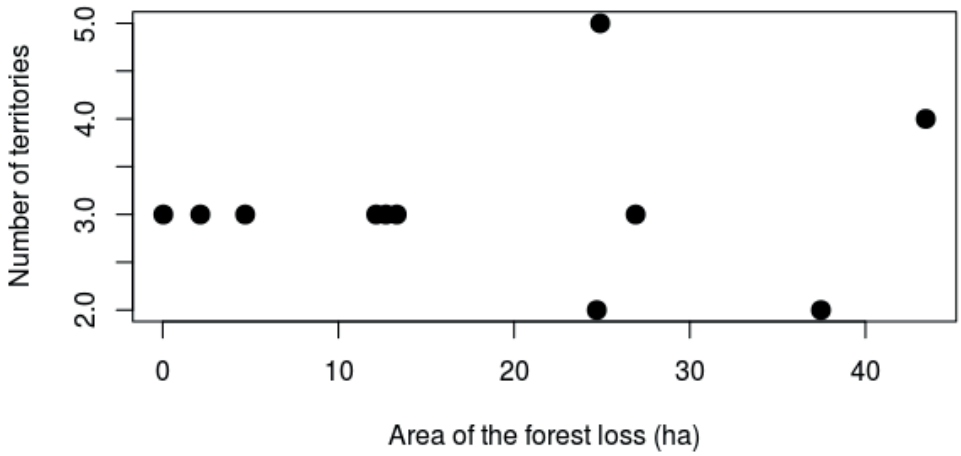


Figure 5 - Relationship between the number of Tawny Owl (*Strix aluco*) territories and the elevation using GLM (Poisson distribution).

Figura 5 - Relação entre o número de territórios de coruja-do-mato (*Strix aluco*) e a altitude, com base em GLM (distribuição de Poisson).

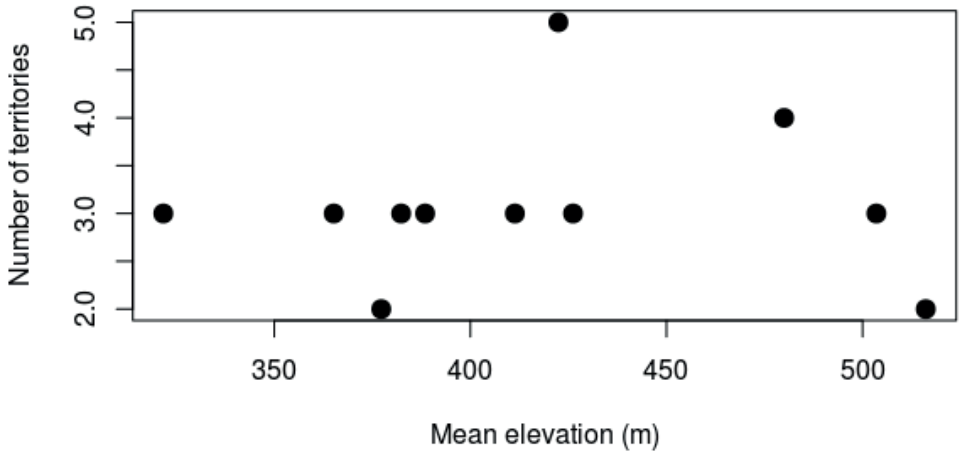
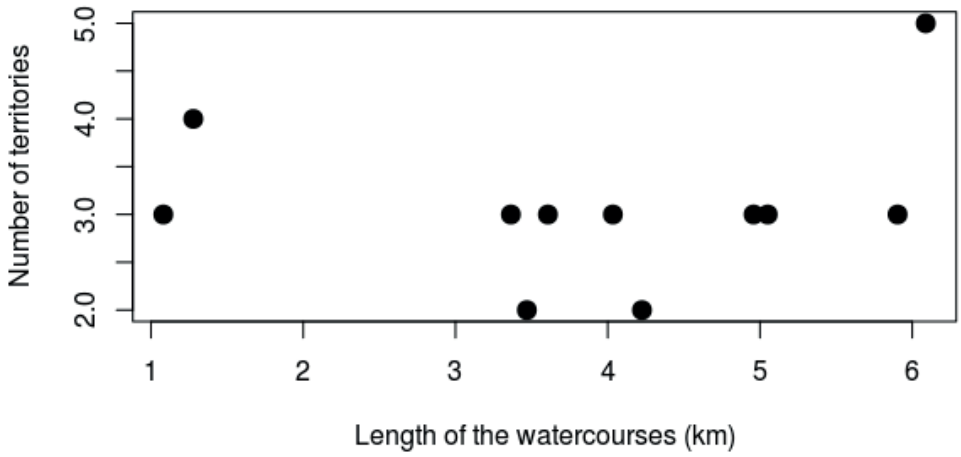


Figure 6 - Relationship between the number of Tawny Owl (*Strix aluco*) territories and the length of the watercourses using GLM (Poisson distribution).

Figura 6 - Relação entre o número de territórios de coruja-do-mato (*Strix aluco*) e o comprimento de cursos de água, com base em GLM (distribuição de Poisson).



area. In each square at least small groups of older stands were present. Squares with higher number of territories (4 and 5 terr.) contained limited or no areas of economic forests (Fig. 3). The area of the forest loss, average elevation and the length of the watercourses was similar in the squares with high or low numbers of territories (Fig. 4, 5, 6).

Discussion

Tawny Owl is a very plastic species that inhabits various environments, mainly forest habitats (Galeotti 2001). Results from the study were compared with areas in neighboring countries and similar habitats. Population density reached similar values as in Poland - 0.7 terr./km^2, where the study area consisted of various forest areas (Matysek et al. 2015). Higher density in alluvial floodplain forests near the Danube (1 terr./km^2) and Morava river (1.6 terr./km^2) is probably related to high quality environments in protected areas (Nagl et al. 2013). In the study from mountains with beech and mixed forests in Slovenia (Vrezec 2003), Tawny Owl density was lower (0.44 terr./km^2), because higher altitudes are occupied especially by the Ural Owl (*Strix uralensis*), a main competitor of Tawny Owls. During our research the presence of the Ural Owl was not confirmed in the area. The highest densities (3.8 - 5.2 terr./km^2) in beech forests were recorded in central Italy (Ranazzi et al. 2001), where territories were located in the higher altitudes - over 1000m asl and with the cover of mature stands. In other areas in Slovakia generally lower values are reported - max. 0.46 terr./km^2 (Danko et al. 2002). These values were obtained during a census where habitats of lower quality also were included. Specialized studies aimed at measuring the density of forest owls from Slovakia are not available today. In Austrian alluvial forests (Nagl 2015) the occurrence of Tawny Owl was positively related to cover of old forest, amount of standing deadwood and the openland. Similar results were confirmed for Romania (Bolboacă et al. 2013) where Tawny Owl showed the highest affinity to old forests compared to other forest age groups. However the influence of the area of old forest on the owls is unclear. No relationship was found between the number of territories and the area of old stands. This study shows that squares with the highest cover of old forests did not contain the highest number of territories, probably because all squares contain relatively high cover of old stands. The importance of open land was shown in studies which analysed the habitat composition in different countries and environments (Nagl 2015, Rumbutis 2017). In Finland, clear-cut areas had a positive impact on the boreal owl nest success (Hakkarainen et al. 1995). Due to the high territory fidelity (Southern 1970, Hirons 1985, Saurola 1987), owls can be negatively influenced by forest management (Newton 1994). Especially intensive forest management reduces old trees with cavities in stands (Lindenmayer et al. 2013, Walankiewicz et al. 2014). They are important for nesting and roosting (Sunde et al. 2003) and as food resource for the prey (Jędrzejewski et al. 1994). As an opportunistic species Tawny Owl can survive in a changing environment, however lower habitat quality can influence reproduction parameters (Rumbutis et al. 2017). Beside the forest management, also natural processes like wind calamities can cause forest loss. However, our results did not show a positive nor negative relationship between forest loss and the number of Tawny Owl territories.

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