Study of the impact of the predator management on the european hare population in great bustard conservation areas

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Abstract: The brown hare is an important component of agro-ecosystems and is also considered a good indicator species for habitat changes or predator-control interventions. Predator management to protect Great bustards can therefore affect this small game species. Our study aimed to assess this impact in an experiment, where we estimated the abundance of the brown hare using spotlight count in three National Park study sites and an independent but similar control habitat and we surveyed the populations of red fox, Eurasian badger and hooded crow between 2021 and 2023. The effectiveness of predator management was characterised by the culling rate. The population size of the brown hare did not change over the years. No correlation was found between predator culling rate and hare population size. The population size of predators also did not vary with changes in the intensity of the culling rate, except for the red fox in the control area. Here, the population size of foxes decreased as a result of more intense predator removal. Overall, the experiment did not provide clear evidence of a positive effect of predator management, as in many other studies, but this may have been due to the small sample size (short period). It is also possible that the habitats are currently able to support this amount of hare and that further habitat development and predator management would be necessary to significantly increase the population size.

Introduction

The hare (*Lepus europaeus*) is a species of special importance from several points of view. It has an important role in the food web, it serves as prey for several predatory species (Goszczyński and Wasilewski 1992, Panek 2013, Reynolds et al. 2010, Kovács et al. 2005), it can also participate in regulating the pattern of vegetation (Katona et al. 2003, Kertész et al. 1993, Mátrai et al. 1998), but it is also an important species as an indicator of the habitat quality.

The predator-prey relationship is two-way, the accessibility of the prey population can regulate the population of predators, but predators can also reduce the populations of their prey. In his study, White (2013) showed that in a natural environment, predators do not control the population of their prey, but the prey animal as a food source, controls the predator population. The herds of herbivorous animals are regulated by the amount of available food sources, which in nature is most strongly influenced by the weather.

At the same time, Jedrzejewska and Jedrzejewski (1998) confirmed with their research that predators are able to exert a more significant effect on prey species when the population density of the prey species is low, so that it is not able to grow quickly despite the improvement of the habitat. Lindström et al. (1994) showed in Sweden between the 1970s and 1980s that when the number of red foxes (*Vulpes vulpes*) fell by 70% due to mange spread throughout the country, the volatility of the vole population was not affected by the decline in the fox population, but the population density of grouse and hares increased by 40–100%. After fox populations recovered by the late 1980s, hare population densities fell back to pre-mange levels or even lower. A similar phenomenon was described by Jensen (2009) in his doctoral thesis. In Denmark, in areas where the population density of foxes decreased due to manage, only the density of hares increased. However, the research also found that predators alone cannot cause the decline of the hare population, since the linear regression set up between the change in the fox harvest and the change in the hare harvest showed only a 14% determination between the two variables.

However, according to Norrdahl and Korpimäki (1995) in Finland, there was no significant correlation between the size of the fox population and the size of the hare population, other factors may also influence the size of the hare population. In his study in Poland, Panek (2013) concluded that predator control and habitat improvement can be used to help preserve the hare population. Based on the comparative study of Biró and Sebők (2024), it appeared that the food diversity of the habitat is an important factor for the behavior of hares, which can increase the time spent feeding and thereby contribute to population growth.

Reynolds et al. (2010), on the other hand, emphasized the importance of predator management based on their experiments in England. As a result of the removal of predators, the population density of hares in the treated area without habitat development increased from 15 individuals/km^2 to 28.5 individuals/km^2 within 3 years. In contrast, Estrada et al. (2015) showed in Spain that, among wildlife management interventions, habitat development and feeding and watering places have a greater impact on the occurrence of birds than fox control.

However, Banks et al. (1998) had a predator removal experiment in Australia, where they examined the effect of a fox population on a population of rabbits (*Oryctolagus cuniculus*), showed results similar to those of Reynolds et al. (2010) later found in England. In two sample areas, the number of foxes was strongly reduced, after 18 months the rabbit population increased by 6.5 times in one place and 12 times in the other, while in the control areas, where culling was not carried out, the population of rabbits barely increased or even decreased.

Based on all of this, it is still questionable how much impact intensive predator reduction can have on the hare population in the agricultural landscape. Therefore, the aim of our research was to examine whether the intensive predator management in the protection sample areas of the great bustard (*Otis tarda*) had a positive effect on the hare population compared to a control area, where the removal of predators was less intense.

Materials and methods

In the cross-border protection of great bustard in Central Europe (LIFE15 NAT/AT/000834) program, the goal is to protect the great bustard population with intensive predator control. A possible indicator of the favorable effect of this intervention is the change in the hare population (Faragó and Náhlik 1997; Panek et al. 2006; Reynolds et al. 2010; Szemethy et al. 2015).
To assess the effectiveness of the treatment, we therefore selected three Natura 2000 areas in the territories of three National Park Administrations (Kiskunsági National Park, Körös-Maros National Park, Bükk National Park) (Upper Kiskunsági salt marshes and Turjánvidék (HUKN10001); Dévaványai plain (HUKM10003); Borsodi plain (HUBN10002)) and Hevesi plain (HUBN10004), within which we have designated 3 treated test areas, as well as a control area far from them (Ladányi Földtulajdonosok Vadásztársaság Egyesület, Püspökladány), which have similar habitat features (Figure 1).

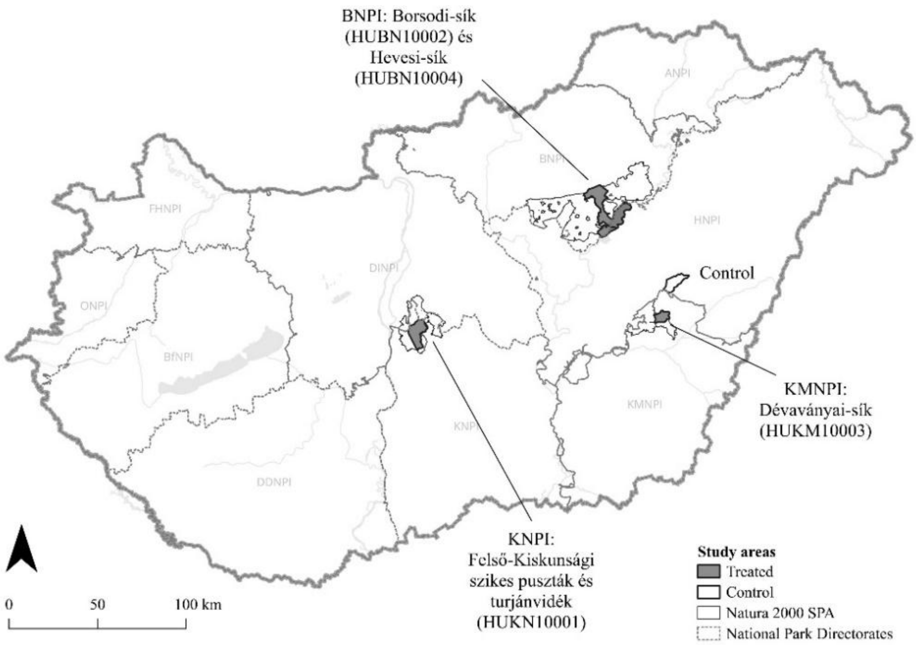

Figure 1. Location of the selected study areas. The mesocarnivore-control sites indicated in dark gray, and the control sites with white and black outline

1. ábra. A kijelölt vizsgálati területek elhelyezkedése. A sötétszürke területek a kezelt részek, míg a fehér terület a kontroll vizsgálatok helyszíne

The test areas are typically covered by large-scale agricultural fields and grasslands. The main cultivated crops are rapeseed, alfalfa, winter wheat, winter barley, spring barley, triticale, corn and sunflower. It is dotted with farms and farmsteads. The roads are bordered by rows of trees and strips of bushes in an irregular distribution. In its overall picture, a landscape typical of the large-scale agricultural areas of the Great Plain can be found everywhere.

The population density of hares was estimated in all study areas using spotlight counts between 2021 and 2023 based on the methodology of Kovács and Heltay (1985), Biró and Szemethy (2010), Majzinger (2017) and Pavliska et al. (2018). Every year in early spring, depending on the weather, we travelled along the predetermined routes (KMNP: 8, KNP: 13, BNP: 9, control: 8 transects). The tests were carried out with 3 overnight repetitions and strip transect estimation was used in the calculations.

To do this, the observers measured the visible distance along the transects each time. The length of each route segment was then multiplied by the distance covered and thus the area actually covered for the given route was obtained. Then we calculated the hare population density (D) separately for the right and left sides for each line using the following formula:

$$\mathrm{D} = \frac{\text{number of observed hares along the line (individuals)}}{\text{the size of the area observed along the line (ha)}}$$

For the left and right sides, we calculated the average population density for each day from the values obtained based on the formula above for all transects. We calculated a total of 6 mean values from the data of the three-night repetitions and the two sides. We calculated the average population density and the error of the estimate (standard error) for the entire area using these values.

Predator hunting was carried out by professional hunters in all areas using firearms and trapping. The effectiveness of this was characterized by the culling rate (the species' annual harvest/estimated population size in a given year) (Heltai et al. 2010), which was examined in the case of three species (fox, badger (*Meles meles*), hooded crow (*Corvus cornix*)). According to Heltai and Szabó (2008), the culling rate of the fox must reach a value of 2 in order to decrease its population. In the case of the badger, this level is 0.7 (Nagy and Heltai 2014).

In the case of the hooded crow, if we count 2.8 reared and fledged chicks per nest (Faragó 2002), then a culling rate of 1.4 is required. Hooded crows usually cause little damage to the hare population, but can have a negative impact on small game, especially in the case of pheasant populations by robbing nests (egg-stealing is a typical behavior of crows: Draycott et al. 2008, Göransson and Loman 1986, Krüger et al. 2018).

As a result of habitat development and predator management, the growing small game population (Reynolds et al. 2010) also has an attractive effect on the hooded crow population (Pringle et al. 2019), which can lead to greater predation pressure, thus their reduction can be beneficial for the small game population of the entire area. In the case of all three species, the estimated population size was determined based on den and nest mapping and this value was used to calculate the culling rate.

Within the study areas, the change in the estimated population size of the hare was checked with a one-way ANOVA after the Shapiro-Wilk test confirmed the normality of the data. The relationship between the culling rate of the predator species and the estimated population density of the hare, as well as between the culling rate and the estimated population of the given predator, was analyzed using linear regression. Each time, the culling rate was compared with the estimated population sizes of the following year, because a stronger effect of the harvest in a given year can be expected on the size of the surviving population in the following year (Heltai et al. 2016). Statistical analyzes were performed using SPSS v20 (IBM Corp.) and Instat v3.05 (GraphPad Software).

Results

The results of the population density estimates of the three years were compared in Figure 2 in our different areas.

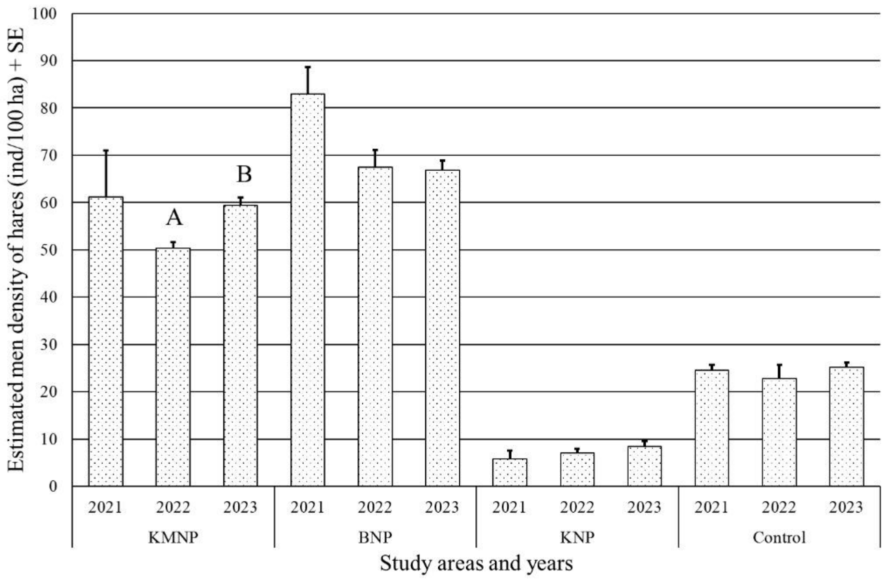

Figure 2. The spring population densities of the European hare in the study areas and in the control site between 2021 and 2023 (mean+SE). The different capital letters show a significant difference between the years inside a study area.

2. ábra. A mintaterületek és a kontroll terület mezei nyúl populációsűrűsége 2021–2023. tavasz (átlag+SE). Az eltérő nagybetűk szignifikáns különbséget jeleznek az évek között egy területen belül.

In the area of KMNP, the hare density estimated for the year 2023 showed a significantly higher value than for the year 2022 (one-way ANOVA with Welch correction: $F_{2,6.145} = 9.41$; $p = 0.013$; Tamhane post-hoc test, $p = 0.004$), however, there was no difference compared to 2021.

Based on the combined examination of the three years, no significant difference could be detected between the BNP estimation results. The result of the analysis of variance ($F_{2,8.488} = 3.45$; $p = 0.08$) did not support the fact that there was a change in the density of the hare population over the years.

According to the results of the one-way ANOVA ($F_{2,15} = 1.057$; $p = 0.372$) in the area of the KNP, there were no significant changes over the years.

Welch's correction of the one-way ANOVA was used in the control area. There was no significant change in the hare population density in this area either ($F_{2,9.204} = 0.312$; $p = 0.739$).

Among the treated areas, in the case of the KMNP, it can be seen that the fox culling rate exceeded the recommended value of 2 every year, and from 2021 it was also higher than this level in the BNP area (Figure 3).

In the case of the badger, the recommended level of 0.7 was also exceeded in these two national park areas, except in 2019 and in 2023 in the case of KMNP (Figure 4). The reduction of the hooded crow was also effective in these two treated areas, although in the case of KMNP the rate remained below the desired level of 1.4 in 2021 (Figure 5).

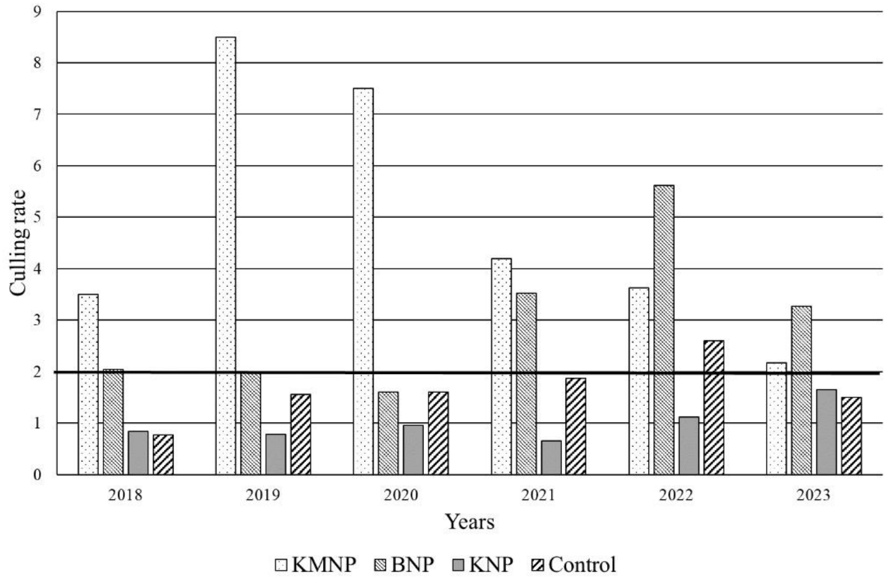

Figure 3. The culling rate of the red fox in the study areas between 2018 and 2023. The thick black line shows the threshold value that is necessary for the effective decreasing of the population.

3. ábra. A róka gyérítési rátája a vizsgálati területeken 2018-2023. között. A vastag fekete vonal a populáció csökkentéséhez szükséges határértéket jelöli.

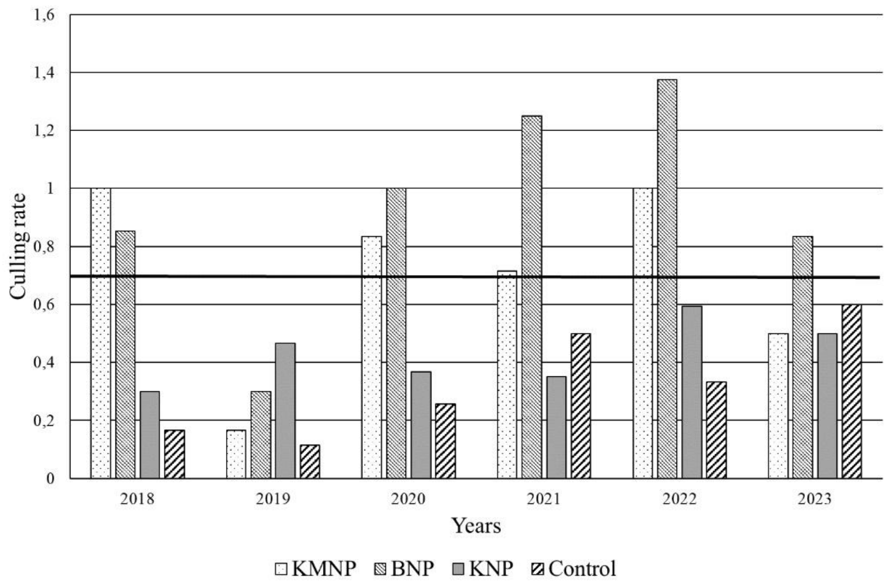

Figure 4. The culling rate of the European badger in the study areas between 2018 and 2023. The thick black line shows the threshold value necessary for the effective reduction of the population.

4. ábra. A borz gyérítési rátája a vizsgálati területeken 2018-2023. között. A vastag fekete vonal a populáció csökkentéséhez szükséges határértéket jelöli.

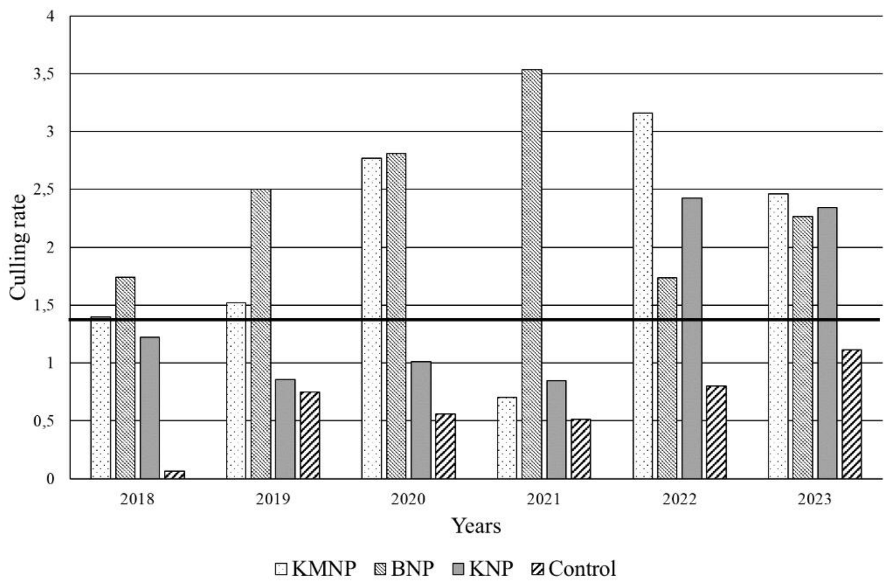

Figure 5. The culling rate of the hooded crow in the study areas between 2018 and 2023. The thick black line shows the threshold value which is necessary for the effective decreasing of the population.

5. ábra. A dolmányos varjú gyérítési rátája a vizsgálati területeken 2018–2023. között. A vastag fekete vonal a populáció csökkentéséhez szükséges határértéket jelöli.

Although the levels necessary to reduce populations were not reached in almost any year in the KNP area, it should be mentioned that in the case of the hooded crow, this was already achieved in 2022 and 2023.

In the control area, only in 2022 did the predator culling rate, which was considered adequate, reach the target level in the case of the fox, but the populations of the badger and the hooded crow continued to be reduced at a low level.

Based on the linear regression, it was not possible to show a clear positive effect between the 2018-2022 values of the culling rates in our study areas and the values of the estimated populations of hares, foxes, badgers and hooded crows in the following years (2019-2023).

Among the correlation studies, only in the KNP area was there a significantly negative relationship between the culling rate and population size of the hooded crow (ANOVA: $F_{1,3} = 31.399$; $p = 0.011$); and between the culling rate and population size of the fox in the control area (Figure 6; ANOVA: $F_{1,3} = 11.365$; $p = 0.043$).

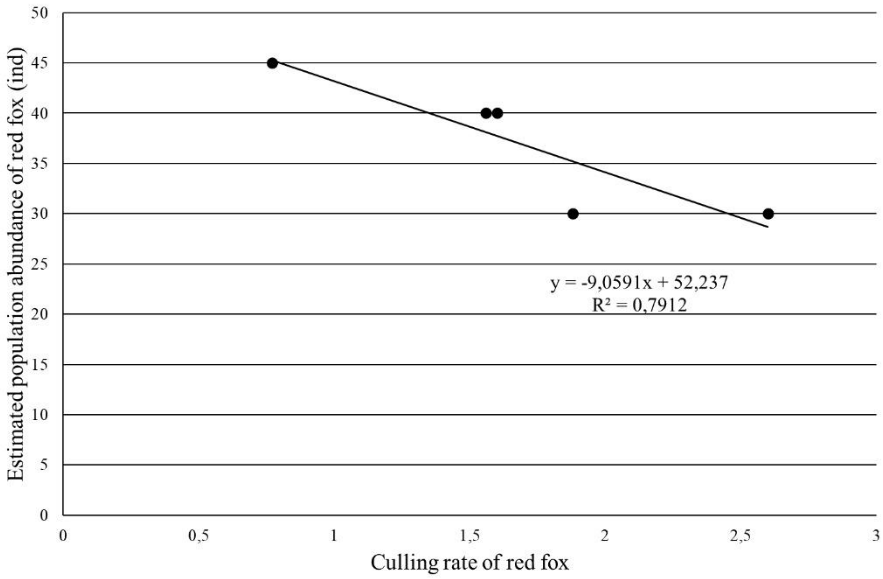

Figure 6. The relationship between the culling rate and the population abundance of red fox in the control site between 2018 and 2023.

6. ábra. A róka gyérítési rátája és populációnagysága közötti összefüggés a kontroll területen 2018–2023 között.

In this case, the decrease in the fox population could have been caused by increasing culling, since the variability of the decrease is explained by $R^2 = 79\%$ of the increase in the culling rate. At the same time, this relationship was even stronger in the case of the hooded crow in the area of the KNP, since there the variability was explained in $R^2=91\%$ by the increase in the culling rate.

Discussion

With an appropriate culling rate of predators, the size of predator populations can be reduced (Heltai 2016) and, in parallel, the growth of small game populations can be promoted (Lindström et al. 1994, Reynolds et al. 2010). However, this cannot be demonstrated in all cases (Jensen 2009, Norrdahl and Korpimäki 1995, Panek 2013).

Although the culling rate recommended by the literature was achieved in several sample areas over the years, the comparison of hare population sizes between years did not show a significant change anywhere. Only in the area of KMNP was there a significant increase from 2022 to 2023, but this was followed by a decrease from 2021 to 2022, and thereafter the hare population rose back to its previous value. It is also possible that under the current habitat conditions, these population sizes are the sustainable quantities under intensive predation control.

It may also be important that until June 30, the desired reduction rate was not reached in the case of the most effective predator species, the fox (not even in the case of the badger and the hooded crow, except for BNP), which may be a problem because the hares were already past their most important pup-rearing period by this time, so the desired reduction did not take place in the period of greatest risk. The larger part of the year-round predator harvest should be reached during the spring, because this is the time when the small game is rearing its offspring, when the predators are able to cause the greatest losses (Heltai et al. 2010).

At the same time, it should be noted that in all cases the number of samples for the analysis is small, so the aggregated analysis of the data of additional years can support demonstrable changes. However, the growth of hare populations does not necessarily depend solely on predator reduction, as explained by Jensen (2009), who found only a weak relationship between the two variables. So, in addition to the uncertainty caused by the low number of samples, it is also conceivable that the effect of predator management cannot be detected in these areas, because the quality of the habitat is limited. Possibly, the hare population could be increased more significantly with further habitat improvements (Marada et al. 2023, Schai-Braun et al. 2020, Weber et al. 2019), but intensive predator management must also be maintained, as habitat improvement alone is not always sufficient (Bro et al. 2004, Reynolds et al. 2010). Together, these interventions can be beneficial for other small game species and the great bustard (Kuijper et al. 2009, Martín et al. 2012, Nelli et al. 2012).

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A ragadozógazdálkodás mezei nyúl populációra gyakorolt hatásának vizsgálata túzokvédelmi területeken

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A mezei nyúl fontos eleme az agrár ökoszisztémáknak, az élőhelyi változások vagy a ragadozógazdálkodási beavatkozások jó indikátor fajának is tartják. A túzok védelme érdekében végzett fokozott ragadozógazdálkodásnak feltehetően lehet hatása ezen apróvadfajra is. A vizsgálatunk célja e hatás felmérése volt. A kutatás során három Nemzeti Park mintaterületein és egy azoktól független, de hasonló kontroll élőhelyen becsültük a mezei nyúl állományát reflektoros létszámbecsléssel és csökkentettük a róka, a borz és a dolmányos varjú populációját 2021–2023 között. A ragadozógazdálkodás hatékonyságát gyérítési rátával jellemeztük. A mezei nyúl állománynagysága nem változott az évek során. A ragadozó fajok gyérítési rátája és a mezei nyúl állomány nagysága között nem találtunk összefüggést. A ragadozók populációnagysága sem változott jelentősen a gyérítési ráta intenzitásának növelésével, kivéve a kontroll területen a róka esetében. Ott a róka populációnagysága csökkent az erőteljesebb ragadozógazdálkodás hatására. Összességében a vizsgálat nem támasztotta alá egyértelműen a ragadozógazdálkodás pozitív hatását, ahogy sok más vizsgálatban sem, de ezt az alacsony mintaszám (rövid időszak) is okozhatta. Valamint az is elképzelhető, hogy az élőhelyek jelenleg ennyi mezei nyulat képesek eltartani és élőhelyfejlesztéssel, valamint a ragadozógazdálkodás további fokozásával lehetne csak növelni az állomány nagyságát.