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Predicting the expected impact of climate change on the reproductive success of roe deer and wild boar

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Abstract: We have identified weather factors that may influence the reproductive characteristics of roe deer and wild boar, and thus the harvest rates in the future. By exploring the weather and other factors affecting reproductive success, considering the likely scenarios of climate change, we hope to predict future changes in reproductive capacity and, in the light of these, estimate the necessary changes in harvest rates to maintain reasonable numbers of animals.

Keywords: climate scenarios, wildlife reproduction, population control, corpora lutea, foetuses

1. Introduction

In Hungary, annual temperatures have risen by 1.2°C–1.8°C over the past 30 years, and the frequency of extreme droughts has increased [1, 2]. Climate change is particularly threatening the xeric limits of temperate continental forests. Predictions of expected changes in major site factors predict dramatic future droughts, and, consequently, a significant shift in forest climate classes is expected, especially at low elevations [3]. Population sizes of the big game species with the greatest impact on forest habitats have shown a significant increase in recent decades, not only in Hungary but also across Europe [4, 5]. This is mainly due to underharvest, but habitat factors that facilitate reproduction are also important in this respect. Most notably, climate warming facilitates reproductive survival. These changes inevitably have and will continue to have an impact on the reproductive capacity of native big game species and the tree species composition of forests, and through this on the future extent of forest damage [6].

The aim of this research is to identify the weather and reproductive characteristics and their interrelationships that may influence the population dynamics of roe deer and wild boar and, through this, the harvest rates in the future. By exploring the weather and other factors affecting reproductive performance, considering the likely scenarios of climate change, we hope to predict future changes in reproductive performance and, in the light of these, estimate the necessary changes in harvest rates to maintain reasonable population levels.

2. Materials and methods

The study was carried out in Zala County, Hungary (*Figure 1*). First, we analysed the population dynamics of the two big game species of Zala County, using the 28-year data set of the National Game Management Database (OVA).

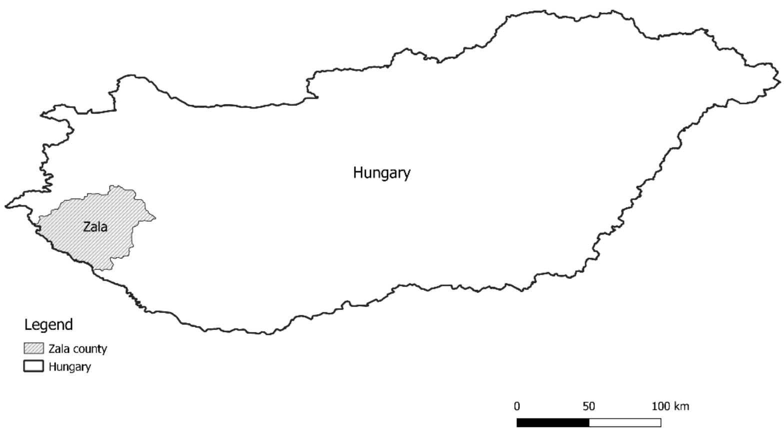


Figure 1. Location of the study area: Zala County, Hungary

Subsequently, we explored the factors influencing population dynamics using our own historical data and international literature. Our previous reproductive biology studies [7]–[9], which determined the reproductive characteristics of big game species, were extended over time and to species that had not been studied before. For this purpose, we determined the number of embryos (foetuses) of females hunted during the hunting season. After removing the reproductive organs, we examined the ovary, counted the number of corpora lutea, dissected the uterus, counted the number of embryos, and recorded their sex according to the methodology used in former wildlife reproduction studies [9–11].

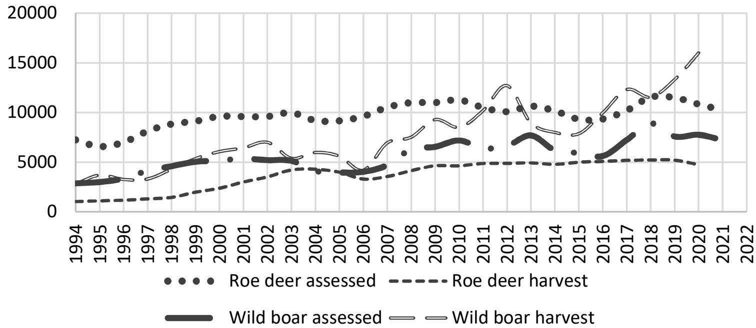
In the phase of early gestation, we counted only the number of corpora lutea, as it is not possible to determine the characteristics of the embryos accurately due to their undeveloped nature. The number of corpora lutea is a good approximation of the number of offspring that will be born later. For the big game species studied (roe deer and wild boar), maternal body condition was determined by kidney fat index analysis [12]. The age estimation was first performed based on tooth wear, followed by counting the cementum layers of the M1 tooth for a more accurate estimation of age [13–15]. We investigated whether the age and body condition of females influenced the presence, number, and sex of the foetus and then examined the variation of body condition with age.

In addition to recording individual-specific features, we continuously estimated the population's reproductive success. The number of breeding females and their respective reproductive success was counted in the observed big game groups; so, the offspring per female was continuously monitored. In the case of big game species, the results were processed to look for correlations between meteorological characteristics (amount of precipitation and monthly mean temperature) and the rate of pregnancy and the number of embryos. The effect of weather data on the survival of new-borns (fawns, piglets) was investigated. We examined the period of the year when the reproduction of each big game species was most exposed to risk of mortality. We looked for general trends in mortality throughout the year and modelled the effect of weather. We studied the relationship between weather characteristics and the reproductive success.

The differences between the number of corpora lutea and the number of foetuses were tested using Wilcoxon's test. To test the correlations and determine the strength of relationships between different sets of data, Spearman's rank correlations were calculated. Statistical analyses were carried out using STATISTICA version 13.5.0.17 (TIBCO 2022) and Microsoft Excel.

3. Results and discussions

For both big game species, estimation and shooting numbers increased steadily over the studied period with small or major peaks and troughs (*Source:* OVA [17] *Figure 2*). The increase was driven by more favourable conditions for reproductive survival, but the main reason for this phenomenon across Europe is that the densities of these species exceeded the level where the regulating effect of hunting (and, where relevant, predator) can operate [5, 9, 16]. The main cause of this relies on stagnant or declining hunting pressure [5]. Estimation and harvest data for big game species follow a similar trend, which is not possible, as increased shooting should lead to a decline in the following year's population. For this reason and because of high harvest numbers relative to estimates, population extinctions should occur in the longer term, so we concluded that the estimate numbers are highly unreliable. This is because in the absence of adequate estimation methods, hunters give their estimation numbers by guesswork ("guesstimation"), relying heavily on shooting data and/or considering their management objectives. Accordingly, during population trend analyses, only the shooting data were taken into account, and it was found that the population of both species clearly increased during our study period, with an explosive increase in the case of wild boar.



Source: OVA [17]

Figure 2. Trends in big game estimation and harvest data in Zala County, Hungary

In order to model future changes in the required level of harvest, we need to look at species-specific factors influencing population trends, such as birth and mortality characteristics, and the weather effects on these.

In the analysis of the reproductive biology of roe deer, the pregnancy rate was 95.6% for all individuals examined [9]. We examined the number of corpora lutea per doe for pregnant individuals, as this allows us to determine the reproductive rate per doe with a high degree of certainty in the early stages of pregnancy. The difference between the number of corpora lutea and the number of foetuses was not significant ($T = 42.5$; $p = 0.107$, $n = 93$), but we found a strong, positive, and significant correlation between these features ($r = 0.717$; $p < 0.05$, $n = 93$). The number of corpora lutea per doe in the studied period was 1.6 ± 0.7. The effect of the meteorological data for May–July was analysed, but the evolution of the number of corpora lutea was not influenced by the monthly mean temperature ($r = -0.43$; $p = 0.247$, $n = 9$) or by the amount of precipitation ($r = 0.159$; $p = 0.683$, $n = 9$). No effect of these weather factors could be detected for pregnancy rate (temperature: $r = -0.282$; $p > 0.05$, $n = 9$; rainfall: $r = 0.463$; $p > 0.05$, $n = 9$).

In addition to abiotic factors, the effects of body weight, body condition, and age on reproduction were analysed. We found no statistically significant difference in the number of corpora lutea per doe for age ($r = 0.15$, $p = 0.699$, $n = 9$). There was no effect of increasing body condition on the change in the proportion of non-pregnant does ($r = -0.142$, $p > 0.056$, $n = 9$).

Furthermore, we examined the effect of autumn and winter condition on the development of the number of corpora lutea and foetuses of the current and the following year. Only autumn body condition had significant effect on the number of foetuses in the following year. A strong positive correlation was found between dressed body mass and the number of corpora lutea ($r = 0.933$, $p = 0.000$, $n = 9$), where the number of corpora lutea increased with increasing body weight. When pregnant does were examined, 44% of cases had 1 foetus, 52% had 2 foetuses, and 4% had 3 foetuses.

Once the survival rate of fawns was established, we examined the factors that might have influenced it. In the case of postnatal mortality (identified based on June monitoring data), we examined temperature and precipitation conditions in May. In contrast to temperature, which showed no detectable relationship ($r = -0.36$, $p = 0.329$, $n = 9$), rainfall showed a positive correlation with fawn survival ($r = 0.685$; $p = 0.04$, $n = 9$) (*Figure 3*).

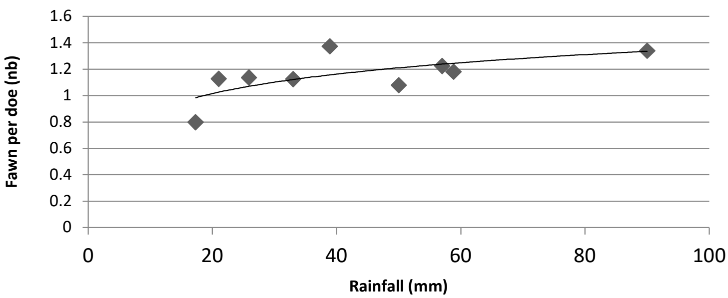


Figure 3. Evolution of fawn survival in relation with precipitation in May

For the summer survival of fawns (based on September monitoring data), we examined mean monthly temperature ($r = 0.188$, $p = 0.627$, $n = 9$) and precipitation ($r = -0.056$; $p = 0.886$, $n = 8$) for July–August but found no statistically significant relationships. For winter survival (based on April monitoring data), no statistically confirmed effect of temperature was found ($r = -0.583$; $p = 0.129$, $n = 8$). The intrauterine sex ratio was 1:0.8, skewed in favour of the males. The prenatal (intrauterine) mortality rate was 5.1% during the study period. Neonatal mortality was 23.3%, summer mortality was 2%, winter mortality of surviving individuals was 24%, and, overall, 49.3% of the born fawns died by the end of winter.

The birth rate in the wild boar study was 6.7 ± 2.1 ($n = 51$) [8]. No significant differences were found between the pregnancy rates of the study years ($p > 0.05$). The foetal sex ratio was 1:1.2 (♂:♀), the standard deviation of the number of female and male foetuses did not differ among study years ($F = 1.6063$), and the t-test showed no statistically significant difference from 1:1 ($t = -1.464$, $p > 0.05$; $n = 49$). The number of foetuses (FN) increased with age (FN = 0.5134*age + 4.7579; $p < 0.01$; $n = 36$), and age explained 25% of the variance in the number of foetuses ($r = 0.5$). A correlation was found between the number of foetuses and the number of corpora lutea (CLN) (FN = 0.7374*CLN + 0.7316; $F = 62.56$; $p = 0.000$; $n = 51$). The number of corpora lutea explained 55% of the variance in the number of foetuses ($r = 0.74$). In late gestation, the number of foetuses vs. corpora lutea ratio was 0.83 ± 0.15. No correlation was found between pregnancy rate and sows' height at withers, chest girth, or neck circumference. However, a strong correlation was found between sows' body weight (BW) and the number of foetuses (FN = 3.7457*Ln(BW) - 10.075; $F = 20.14$; $r = 0.5648$; $p = 0.000$; $n = 41$) (*Figure 4*).

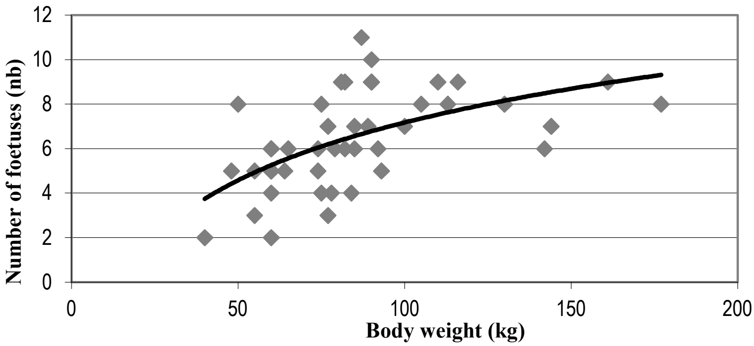


Figure 4. Changes in the number of foetuses as a function of sow's body weight

Our estimates showed relatively high mortality rates in early life stages. The estimated new-born mortality rate was 55.1% (3.75 piglets/sow) in the first year of the study and 60.9% (4.04 piglets/sow) in the second year. Summer mortality was 6.2% (0.19 piglets/sow) in the first year and 9.3% (0.24 piglets/sow) in the second year. As a consequence of mortality, the average number of piglets after early life was 3.05 ± 1.64 ($n = 124$) in the first year and 2.59 ± 1.33 ($n = 63$) in the second year, the difference not being significant ($p > 0.05$). There was no statistically proven difference ($p > 0.05$) between the recruitment up to the end of September in the two studied years (2.86 ± 1.54; $n = 83$ and 2.35 ± 1.41; $n = 63$). No statistical correlation was found for weather effects; however, based on a European survey with a larger sample size, it was clear that some extreme weather effects (long and cold winter, high snow cover, wet spring) have a strong influence on the recruitment [5].

4. Conclusions

Based on the results, we found that the future population number of the species under study will be influenced primarily by harvest rate. At the same time, changes in climatic conditions may affect the body condition of individuals and the survival rate of offspring, which will influence harvest rate. An increase in the frequency of extreme weather events in a given year may have an impact on the longer-term dynamics.

Based on our study results and literature data processing, the body condition of the wild boar and roe deer populations is expected to increase over the coming period. In the case of roe deer, this is due to an increase in average winter temperature as an influencing factor on snow cover [16]. In the case of wild boar, mean annual temperature is also an influencing factor. For this species, not only a change in body condition is predicted [18], but an increase in the survival of juveniles is even more plausible [19]. The study of the reproductive performance of the roe deer showed that neonatal mortality (currently 23.3%) will decrease with the decrease in May precipitation [9]. These changes and processes and their magnitude should be considered when planning future harvest rate.

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