Thesis of Doctoral (PhD) Dissertation

EXAMINATION OF PARAMETERS AND FACTORS AFFECTING AND INFLUENCING POPULATION DYNAMICS OF EUROPEAN BROWN HARES (*LEPUS EUROPAEUS*, P. 1778)

Péter Farkas

Ph.D. candidate

Dissertation supervisors:

Dr. Szilvia Kusza, Ph.D. Senior Research Fellow

Dr. István Majzinger, Ph.D

UNIVERSITY OF DEBRECEN

Doctoral School of Animal Science

Debrecen, 2021

1. BACKGROUND AND GOALS OF THE THESIS

The brown hare (*Lepus europaeus*, P. 1778) is an important species of the Hungarian fauna, both from an ecological point of view and for wildlife management as well. A decreasing tendency in the populations of the species can be observed in the whole of Europe from the mid-1960s to the present day. The estimated population has shrunk over the past nearly sixty years from 1,200,000+ to less than 400,000 in Hungary (CSÁNYI, 2016). Its use has also dropped to one-sixth of its former levels, taking 1960 as the base year. In the 2018/19 hunting season in Hungary, a total of 81 541 brown hares were harvested, 30.55% of which was captured and 69.45% hunted down. The number of brown hares brought to the day's shot per hunter has been 1 or 2 over the past decade, compared to 25 to 30 per hunter in the 1960s (MAJZINGER and CSÁNYI, 2017). Based on the estimates, the largest brown hare populations in Hungary are found in Békés, Jász-Nagykun-Szolnok and Bács-Kiskun counties. Apart from the counties mentioned, brown hares live in Csongrád-Csanád, Hajdú-Bihar and Szabolcs-Szatmár-Bereg counties in large numbers. The decline in the number of individuals is cyclical, therefore the trend is not directly observable. According to the literature, the variability of survival between birth and reproductive age may also contribute to cyclical population change (KOVÁCS, 1986). Its main causes include, in particular, the human impact on the environment (primarily the loss of various habitats, pollution, overuse of chemicals, and rapid development in field crop technologies), climate change, the proliferation of certain predator species and the negative effects of diseases and parasites on the population. As for game management, the drastic decline in wildlife population is significantly exacerbated by frequent mistakes in game management. Common mistakes on the part of game management include using a constant harvesting, the long period between estimation and harvest, multiple utilization of a given hunting site. Additional difficulty of population declines of brown hares increasing the number of sports and professional hunters. Key factors in the future use of Hungarian brown hare populations are applying management practices based on monitoring of the given site and year, and a coordinated "regional small game management" between neighbouring hunting sites. For practical wildlife management it is helpful to be aware of the population dynamics of the brown hare. Population dynamics describes the temporal and spatial changes in the relations of populations and in the number of individuals, which are essentially determined by the number of offspring, survival and migration, and influenced by various factors (e.g. age structure and the proportion of the sexes of the population, weight and condition of individuals), probably to a varying extent from year to year (I1). While managing the species, wildlife management can help the well-founded utilization of the population by conducting regular surveys. The extent of utilization is determined by the population density in the given area, the indicators of reproduction, the proportion of the sexes in the fall, and the age composition of the population. I demonstrate the factors influencing the population density of the hare, based on CASWELL, 1989 cit. WINCENTZ (2009)'s data, in Figure 1. The upper row shows the outside factors influencing hare population density, the middle row the life cycle of the species and the survival rate between life stages (S_l, S_j, S_a). Reproduction rate applies to older females, the arrows indicate the direction of the interactions, the positive and negative signs the possible effect of the interaction.

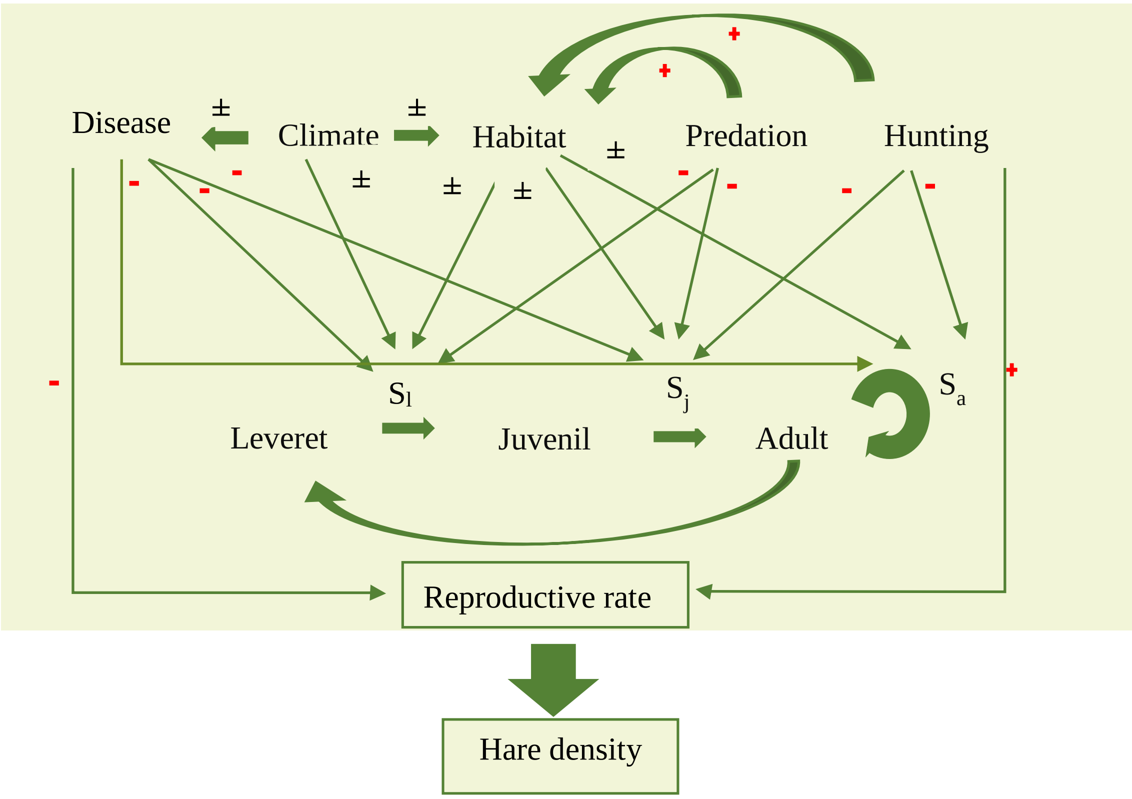

Figure 1. **The theoretical model of the factors influencing the abundance of the European brown hare** (Source: by CASWELL, 1989 cit. WINCENTZ (2009))

In summary in my dissertation I examined the parameters and factors which affecting and influencing population dynamics of European brown hares.

In light of above, I have pursued the following objectives in my thesis:

- Collection and comparative evaluation of accurate data on individual animals and on the population as a whole (with particular emphasis on the reproductive performance of the species as one of the possible internal causes of population decline) at two hunting sites in the Great Hungarian Plain, Túrkeve and Békéscsaba, where the brown hare is still found in significant numbers – although the characteristics of these two sites differ in several respects.
- Comparison of individual and population-specific parameters in a given year across sites and at a given site across years.
- Demonstrating interrelations between population-specific parameters and harvesting, examining relationships that may be useful for practical game management as well.

In analysing the data, I sought answers to the following questions:

1. Do the studied brown hare populations differ in characteristics presumably influencing reproductive performance (age, body weight, physical condition)?
2. Do individual characteristics (especially placental scar count, age, and physical condition) show higher variability by year and area, or within area?
3. Is there a causal relationship between the placental scar count and individual characteristics (age, body weight, kidney fat index)?
4. Does the age of the animal affect its physical condition?
5. Is there a difference in the fecundity of populations at the hunting site by age group?
6. Within the age group, are infertile young females younger than fertile young females?
7. Within the age group, are infertile elderly females older than fertile elderly females?
8. To what extent does age structure change in relation to hunts (will be more young or adult)?
9. Do age groups that make up the stock contribute evenly to the productivity of the population?
10. Does the hunting site and the hunting year influence the number of offspring?
11. Do hare populations at the hunting site differ in survival rates by age group?
12. Does the annual population-level reproductive performance and age composition differ significantly due to hunts?

2. MATERIAL AND METHOD

My research was conducted at two hunting sites in the Great Hungarian Plain, Túrkeve and Békéscsaba. When selecting the sampling sites, I was looking for a site where living conditions for small game are outstanding, and where brown hare occurs in significant numbers. I also tried to make sure that the sites are different in various respects. I thought it important that the game management staff should be dedicated, conscientious and meticulous. The recurring tasks of the research work, which lasted for three years between 2014 and 2016, consisted of field observations (population estimates in spring and autumn), sample collection, collecting game management data, as well as laboratory tests and computerized statistical data processing. The sampling was carried out in accordance with Decree No 79/2004. (V.4.) FVM of the Ministry of Agriculture and Rural Development between 1 October and 31 December, concurrently with the hunting season for the species. In three years, including trial hunts, organ samples and data were collected from 378 animals at the two sites, of which 20 to 25 specimens per year and site were obtained from the day's kill at test hunts (*Table 1*). Hunts took place at the beginning, middle and end of the hunting season each year, at both sites. At the beginning of each season (in the first week of October), we conducted hare walking with the help of 4 or 5 hunters, the same number of huntsmen, and 3 or 4 hounds, considered a trial hunt. The hunts took place over the entire area and can therefore be considered representative. Surround hunts in the middle and at the end of the season, providing most of the samples, were conducted with the participation of 25-30 hunters, the same number of huntsmen, and 4 or 5 hounds. Comparing the two hunting sites examined, the one at Túrkeve is a large and relatively undisturbed, highly rated site, while the one at Békéscsaba is a small site with plenty of disturbance due to the proximity of a city, a busy road network, and a number of farms, but with great hare population density.

2. 1. Collecting individual and population data

In the course of my research, I collected and evaluated individual and population-specific data for each year and site. The following individual data were recorded for the animals in each day's kill: sex, age (based on the dry weight of the eye lens), body weight, left kidney weight, kidney fat mass surrounding the left kidney, kidney fat index, and placental scar count. As for population data, I estimated spring and autumn population densities (individual/100 hectare) and sizes, sex ratios, and young-old ratios in autumn by hunting year and site.

From the placental scar count I determined fecundity rates, estimated the total offspring number and reproductive loss per year. With the written permission of the game management, I retrieved game management data from the National Game Management Database.

Table 1.

Number of shot brown hares in hunting bags by area

Year	Area*	∑ juv.	∑ ad.	juv. ♀	juv. ♂	ad. ♀	ad. ♂
2014	1	49	42	22	27	26	16
	2	53	34	32	21	26	8
2015	1	25	24	8	17	20	4
	2	31	38	18	13	20	18
2016	1	13	26	6	7	20	6
	2	12	31	8	4	21	10
Total	-	183	195	94	89	133	62

*1=Túrkeve, 2=Békéscsaba juv.=juvenil, ad.=adult

2.2. Headcount

I made estimates of the population size by conducting nocturnal surveys with a spotlight counting method (KOVÁCS, 1986; ZELLWEGER et al., 2011) in one-tenth of the area of the hunting sites in all three autumns and subsequent springs. Estimates were made on rainless days in late January-February and November. The observations were made mainly around the feeding areas of the animals, near rapeseed and alfalfa fields and meadows, for three consecutive nights. I averaged the results obtained. Headcounts were done from a vehicle moving at a speed of 8-10 km/h during the night feeding period with a headlamp a voice recorder, with the participation of professional hunters. The length of the area covered ranged from 30 to 60 km on each occasion. The total headcount was derived from the estimated data based on the following formula:

$$N = \frac{n}{t} * T$$

Where: N = total headcount; n = derived number of brown hares in the sample area; T = total area size, t = sample area size (KOVÁCS, 1986).

I calculated standard deviation and relative standard deviation from the data of the estimates.

2.3. Reproductive numbers

When examining the day's kill, I determined the sex and measured the body weight. Sex was determined by visual inspection of the external genitalia while holding the animal. To collect data on reproduction, I prepared the individuals for autopsy and extracted the female internal genital organs (ovaries, fallopian tubes, uterus, cervix) from females and placed them in a freezer in individually identifiable sealable bags for further examination.

2.4. Age estimates

The samples were examined at the laboratory of the University of Szeged Faculty of Agriculture. I removed the ocular lenses from the eyeball through an incision at the border of the sclera and cornea, then fixed them in a 4% formaldehyde solution till the examinations with unique identifiers. CABOŃ-RACZYŃSKA and RACZYŃSKI (1972) recommends removing the ocular 1-2 hours after the kill. For practical reasons – adapting to the field circumstances – he does this by removing the whole eyeball. This is similar to KOVÁCS and HELTAY (1985)'s study, where the ocular was fixed with the eyeball, without preparation, in a 4% formaldehyde solution. The literature mentions fixation in a 10% formaldehyde solution for 3 days and slower drying at 37 °C for 72 hours ŠELMIĆ et al. (1999). Drying to constant weight at 103 °C was performed in a Memmert oven and desiccator for 210 minutes. To determine lens weights to the nearest mg, I used a PRL A 13 type analytical scale. In order to prove the achievement of constant weight, we performed trial drying on some samples, and performed monitoring measurements after resting the samples in a desiccator for 180, 195, 210 and 225 minutes. We experienced only minimal difference between 195 and 210 minutes. The body weights were practically the same after desiccation for 210 and 225 minutes. Based on the measured dried lens weights, the animals were classified either as young (lens weight <280 mg) or old (lens weight> 280 mg) (KOVÁCS et HELTAY, 1985). I then further divided the groups according to the categories given by SUCHENTRUNK et al. (1991) (*Table 2. and 3*).

Table 2.

Estimated age of brown hares based on the weight of dried eye lens

Weight of dried eye lens	Estimated age (month)	Estimated age (year)
280>	2-9	1>
281-340	14-23	1-2
341-360	26-35	2-3
361<	38-47<	3-4<

Source: SUCHENTRUNK et al. (1991)

Leverets were divided into eight further subgroups based on the method described by SUCHENTRUNK et al. (1991).

Table 3.

Estimated age of young hares (1> year) based on the weight of dried eye lens

Weight of dried eye lens (mg)	Estimated age (month)
25-100	1>
101-125	1-2
126-150	2-3
151-175	3-4
176-200	4-6
201-225	6-7
226-250	7-9
251-280	9-10

Source: SUCHENTRUNK et al. (1991)

2.5. Physical condition estimation and kidney fat index

I used the left kidney and the kidney fat surrounding it to assess physical condition. After evisceration, the organ samples were stored in sealable plastic bags with unique identifiers, frozen at -20 °C. When processing the samples, I measured the dissected kidney and kidney fat on a digital kitchen scale to the nearest gram, then entered the data in a sampling log.

I used the method developed by SUGÁR (2000) for estimating physical condition. I divided the sum of the weight of the left kidney and the fat around it by the weight of the left kidney (reduced KFI).

$$KFI = \frac{weight\ of\ left\ kidney\ and\ fat\ around\ left\ kidney(g)}{weight\ of\ left\ kidney\ (g)}$$

SUGÁR (2000)

The same method is recommended by STOTT and HARRIS (2006) as the left kidney was measured to be significantly larger. Taking into account kidney fat index values, the animals were classified as in poor condition if between 0.000-0.600, in average condition if between 0.601-1.400, in good condition if between 1.401-2,000, and in excellent condition if above 2.001, according to MAJZINGER et CSÁNYI (2017) 's classification. Body weight was measured with a digital scale before evisceration during examining the day's kill. The individual data obtained were recorded in a sampling log.

2.6. Laboratory tests

2.6.1. Examining female internal genital organs and placental scar count

As per the literature, placental scar count is not always properly visible due to the migration of endometrial macrophages. This may increase the error rate in estimates (GÁL, 2006). BRAY et al. (2003) recommends freezing after having the uterus rested for at least 6 hours, otherwise the high water content of the tissues may impair the visibility of placental scars. The counting of placental scar can be performed immediately after rinsing with water, using a stereomicroscope (BENSINGER et al., 2000). The collected samples were stored frozen at -20 °C after the required rest. During the experiments, the uterine horns of the slowly thawed samples were opened longitudinally with a scalpel and the placental scars were counted, without a staining procedure, using an Olympus SZ51 type binokular stereomicroscope.

2.7. Method of statistical data processing

I evaluated the data within the given sites across years and across the sites for each year (*Figure 2.*). Statistical data were recorded and processed in Excel and in the IBM SPSS Statistics 22 software package. By examining the outliers, I deliberately filtered out and, where necessary, excluded from further examinations any presumably outlier body weight, lens weight, placental scar count and kidney fat index values. I performed descriptive statistics for individual characteristics by site and year. I tested for normality (Kolmogorov-Szmirnov test) as a prerequisite for the subsequent variance test. In addition to the basic statistics, I examined homogeneity with the Levene test, and the difference between sample means with a two-sample t-test. One-way analysis of variance was used to examine the annual differences between the sites. To examine homogeneity (Levene-test), I used the Bonferroni or Tukey tests for homogeneous variance and the Tamhane test for non-homogeneous variance. To compare all examined variables within a given area per year, I used multivariate analysis of variance after testing for homogeneity. Tests were also performed for all individuals and for all individuals by sex and area. The age distributions of the stocks were evaluated by chi-square tests within both sites across years and within the same year across both sites. I used the general linear model (GLM) and regression analysis to test the unique and combined effects of one or more factors influencing individual parameters. I tested for normality and homogeneity for all variables. In the GLM model, I used placental scar count in fertile individuals as the dependent variable. Site, year, and age were included as categorizing factors. I used kidney fat index and body weight as covariates to examine which factors, and whether alone or in combination, result in the greatest variability in the studied variable.

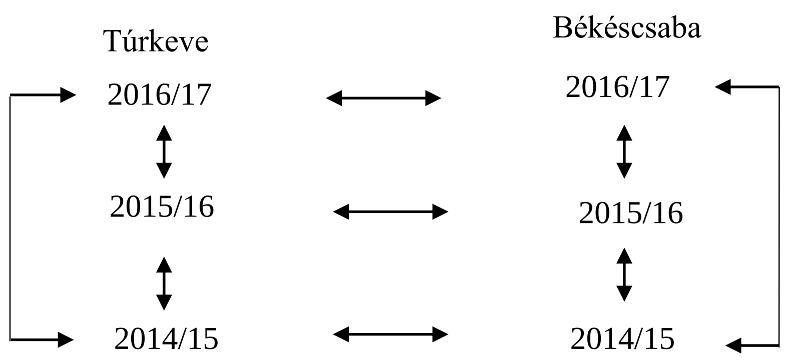

Figure 2. **Process figure of statistical evaluation**

3. RESULTS

The differences within the areas I summed up in Table 4. I found that the two most varied individual characteristics at the area were body weight [4/6] and kidney fat index [5/6], while the least varied was fertility rate [1/6] count. By variability I mean the ratio of cases with significant differences per number of cases overall. The number of placental scars showed no variability in Túrkeve [0/3] and only in two years in Békéscsaba [2/3]. The reason could be that every year, in the fall population the age composition of females showed bigger differences in the Békéscsaba area than in Túrkeve.

Table 4.

Differences in significance level of individual characteristics and population-wide data by areas (*: p <0,001; *: p<0,05)**

Area	Years	Weight ♀	KFI♀	Fertility rate	Pl.scare
Túrkeve	2014-2015	0,001*	0,096	0,124	0,371
	2014-2016	0,921	0,000***	0,045*	0,731
	2015-2016	0,027*	0,000***	0,627	0,334
Békéscsaba	2014-2015	0,000***	0,000***	0,363	0,033*
	2014-2016	0,154	0,000***	0,143	0,384*
	2015-2016	0,000***	0,000***	0,509	0,017*
Variability	S/N_s	4/6	5/6	1/6	2/6

KFI=kidney fat index, Pl. scare=Placental scars

When comparing sites, only body weight showed variability among individual characteristics, while in population data there was a difference in age composition of females and in sex ratios (Table 5.). Data across sites showed no difference in female kidney fat index, fecundity rates, and placental scar count. Regarding the individual characteristics, the only difference between the two areas in the same year occurred in body weight, in 2014 (Table 5.). Population characteristics showed no differences except for age composition in 2014 and 2015. The statistical results obtained show that differences are typically significant between specific years within the same area and not so much between areas in the same year, so in further studies we combined data from the two areas and compared different years. The age composition of populations in the same area regarding all the individuals did not differ in the study period in the two areas. Analyzing age differences in the same year by area, it was only in one year (2014) that I found a significant difference. There was no difference in age composition between the areas in 2015 and 2016, despite the fact that in 2016 the number of individuals under 1 year of age dropped significantly in both areas. However, the age composition of females in the two areas showed variability in two years [2/3].

Table 5.

Differences of individual characteristics and population-wide data between areas

	Years	**Sex ratio* (1:)**		**Age structure***		**Weight ♀**	**KFI♀**	**Fertility rate**	**Pl.scare**
		1	**2**	**1**	**2**				
	2014	1,11	2,00	0,85	1,23	0,000	0,716	0,722	0,583
	2015	1,33	1,22	0,40	0,90	0,052	0,105	0,303	0,220
	2016	2,00	2,07	0,30	0,38	0,432	0,214	0,395	0,921
Variability	**S/N$_s$**	0/3		2/3		1/3	0/3	0/3	0/3

* 1:Túrkeve, 2: Békéscsaba, P <0,05

Leverets and yearlings made up the majority of the samples at both study sites which is favourable from the point of view of game management (Figure 3.). The age group older than these two groups accounted for 4.1-18.6% of the abundance.

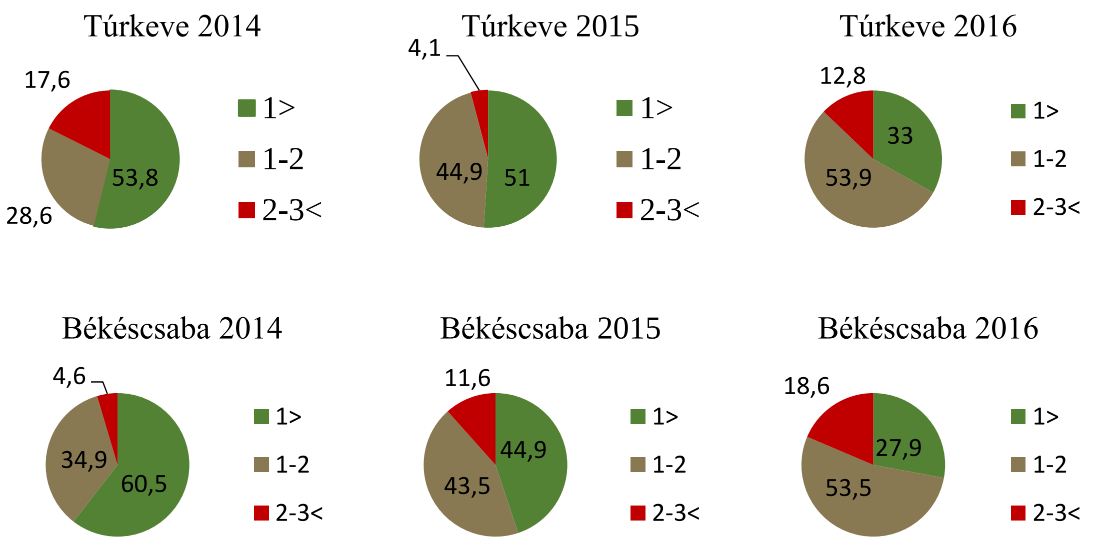

Figure 3. **The age structure by areas and years between 2014 and 2016**

Regarding the yearly age distribution, in all three years the majority of the population was maximum 1-2 years of age. The age distribution was similar in the two areas in the same year. The minimum proportion of the age group under 1 year in a given territory in a given year was 27.9%, its maximum proportion 60.5%. In the hunting bag, minimum 28.6%, maximum 53.9% of individuals were 1-2 years of age. At the time of hunting, nearly half of the individuals under 1 year of age were 4-7 months old, which is the time of dispersion of individuals.

Based on survival probability data, in the time period and areas studied, age-specific survival probability had a slight correlation with the individual's sex and age group. Comparing the survival patterns of age groups in the two areas I found that the survival rate of the age group over 1 year was more balanced. I also found a difference between the two areas regarding the survival rate by age group. The survival rate of the age group under 1 year was [Φ=0.39-0.59], that of the age group of 1-2 years or older was over [Φ=0.71] in the areas examined. Overall, the age-specific survival probability of males is more balanced over the years.

In my paper I used the following formula to estimate the contribution of each age group to the reproduction of the population:

$$\mathrm{AHkcs} = \frac{\mathrm{Nkcs} * \mathrm{Vkcs} * \mathrm{Pkcs}}{\sum \mathrm{SZkcs}} * 100$$

Where N_{kcs}=number of samples in the age group, V_{kcs}=pregnancy rate of the age group, P_{kcs}=average number of placental scars in the age group, $\sum$=Sz_{kcs}=the number of all offspring in the given year per age group.

$$\mathrm{RHkcs} = \frac{\mathrm{Vkcs} * \mathrm{Pkcs}}{\sum \mathrm{Vkcs} * \mathrm{Pkcs}} * 100$$

Where: V_{kcs}=pregnancy rate of the age group, P_{kcs}= average number of placental scars in the age group.

When studying the contribution of each age group to the reproductive performance of the population, I established that the most absolute reproduction is provided by individuals of 1-2 and 2-3 years of age (Figure 4.). Individuals of the age group 2-3 years and above are the most valuable in terms of relative reproduction performance (Figure 5.), but as there are fewer of them, their absolute contribution is lower than that of individuals of 1-2 years. The age groups under 1 year and 1-2 years provide higher absolute contribution, in spite of their lower relative contribution, due to their higher proportion in the population.

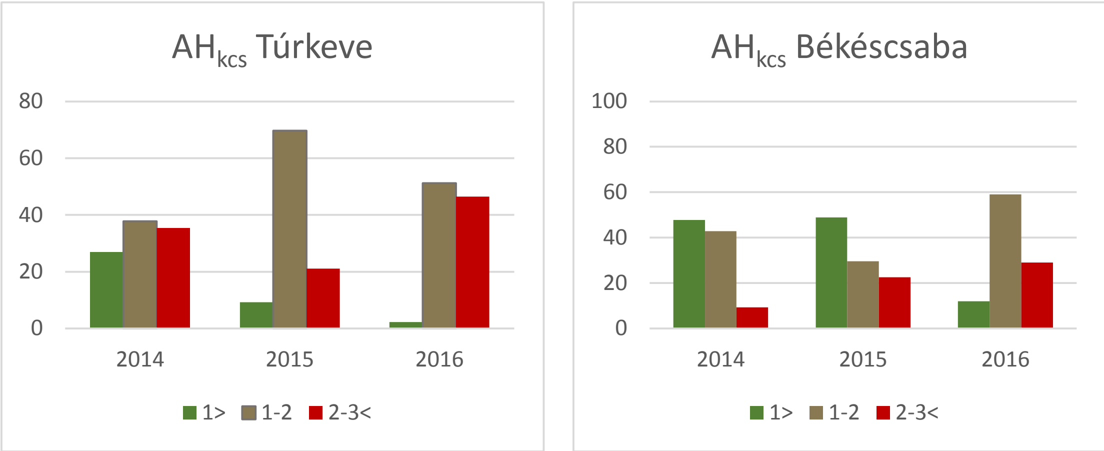

Figure 4. **Absolute contribution to reproductive performence of population by age groups**

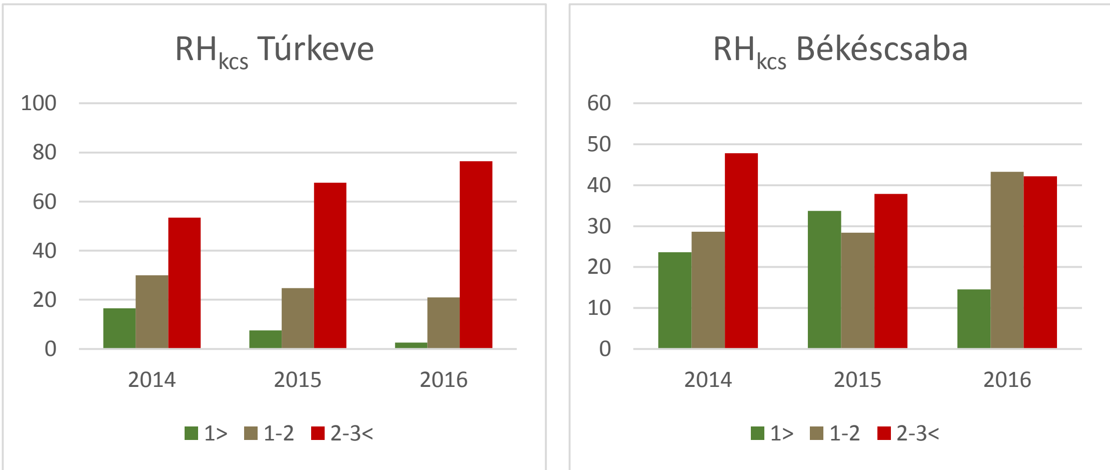

Figure 5. **Relative contribution to reproductive performence of population by age groups**

The pregnancy rate by age group was lowest in the age group under 1 year, [71%], and highest in the age group 2-3 years, [87%]. The pregnancy rate of individuals under 1 year was higher than that provided in literature (Figure 6.). Given their high proportion in the overall kill, these individuals provided 20-30% of the absolute number of offspring on the average in these three years. From the three age groups, the number of placental scars was lowest in the age group under 1 year: [3.71 scars/mother] (Figure 7.). Even though the oldest age group, between 2 and 3 years of age, accounted for 14% of the total abundance, they contributed significantly [22,9%] to the reproductive performance of the population.

What can be ascertained is that in each of the three years and at both sites, the fecundity of individuals older than one year appeared to be constant.

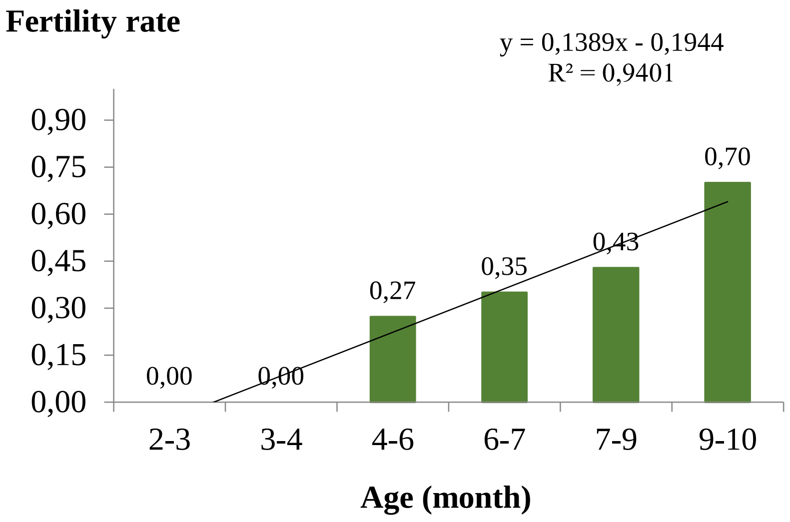

Figure 6. **The number of fertility rate by age groups under 1 years**

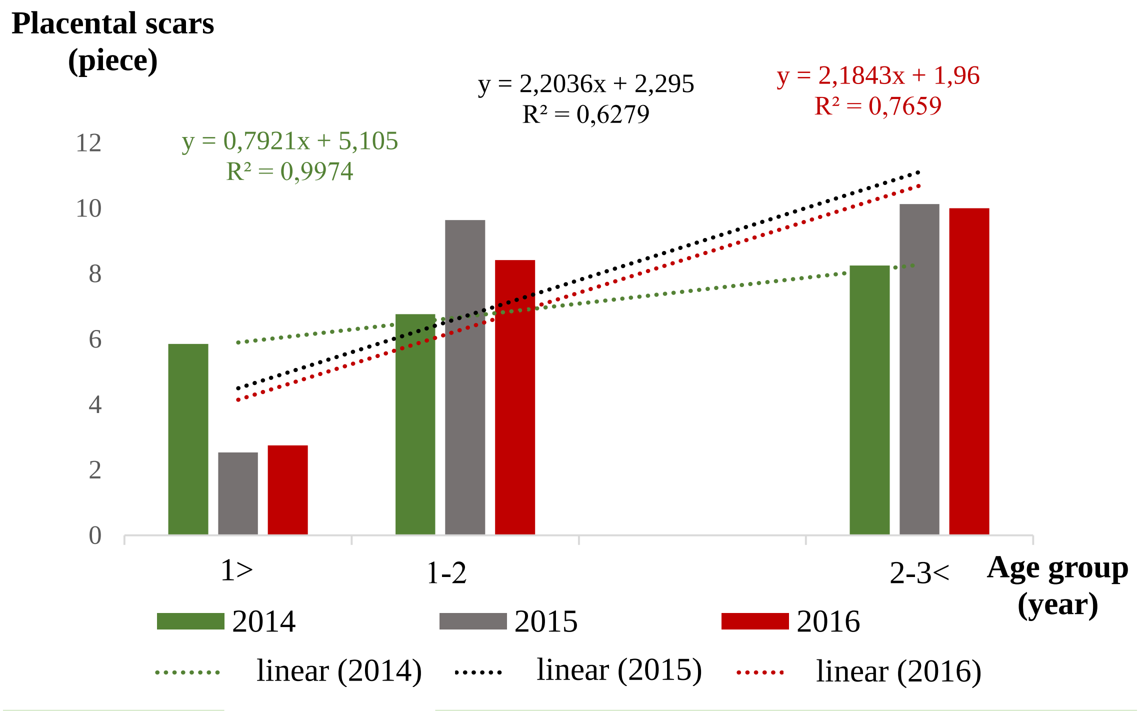

Figure 7. **The number of placental scars by age groups and years**

Based on the GLM models used to examine unique and combined effects of one or more factors in individual parameters, placental scar count in fertile females was most affected by the interaction between hunting year, age, site*age, and site*year*age [$R^2 = 0.393$]. Although body weight did not significantly affect placental scar count in the GLM model, regression analysis shows that female body weight [R^2 = 0.167], apart from age [R^2 = 0.087], also influences placental scar count. Examining the condition of all animals, we can establish the exclusive effect of the hunting year [R^2 = 0.369], where weather presumably plays a prominent role. Infertile and fertile young females differed significantly in their age within a given age group. Females showing no fertility were significantly younger than females showing fertility. Based on the data, the age threshold for reproduction in females is around 6 months. The dry weight of the eye lens in infertile and fertile elderly females also differed significantly within each age group. The dry weight of eye lens in older females showing no fertility (placental scar count = 0) was significantly lower than that of older females showing fertility (placental scar count > 0), despite the individuals being in the same category (1–2 years) as classified by SUCHENTRUNK et al. (1991). This may mean that in case of older females, infertility could be due to true infertility, or possibly a temporary lack of reproduction in a given reproductive cycle, since these individuals are of a potentially reproductive age. Fecundity in the droves inhabiting the sites was higher in the disturbed site. From the reproductive indices of the species in the study sites we can conclude that the main reason behind the decrease in the number of individuals is not the potential decrease in reproductive performance.

Data analysis provided the following answers to the questions formulated in the objective:

1. **Do the studied brown hare populations differ in characteristics presumably influencing reproductive performance (age, body weight, physical condition)?** The age distribution of the female animals differed at the two sites, which may be significantly influenced by harvesting. The two individual traits with the highest variability within a given site were kidney fat index and body weight. Body weights at the two sites did not differ significantly by sex during the three years, with differences showing the highest variability in the youngest age group. Body weight was more balanced at the Túrkeve site. The individual parameter with the highest variability was kidney fat index for both sexes; however, there was no difference between the sites for a given sex in either year. By FLIS és RATAJ (2019 b) the high KFI has a significantly better effect on the reproduction, survival rates and stabilize the population.

2. Do individual characteristics (especially placental scar count, age, and physical condition) show higher variability by year and area, or within area? Both placental scar count and kidney fat index values are more balanced across sites in a given year than at a given site across years. The body weight variable in the same year only differed in one year between the two areas and only in females; there was no difference in kidney fat values. Comparing the kidney fat values of all the females over the years, I found that they differed each year. The biggest influence on kidney fat values was the hunting year, which is probably related to the weather, food resources and utilization in the given year. FLIS and RATAJ (2019 a) claim that based on the reproductive potential of the species, the growth of the population is possible if the individuals are in a good condition, there is a higher proportion of females and young individuals, and the population density is minimum 3 individuals/100 hectare. The number of placental scars did not differ between the two areas in the same year; there was no difference in the number of placental scars over the years at all in Túrkeve and only in two years in Békéscsaba, which may be explained with the better age composition of females in Túrkeve. The age distribution of the two populations considering all the individuals did not differ in the time period studied. Comparing the age composition between the two areas by year considering all the individuals, I found a difference in only one year. The age composition of females differed between the two areas in 2/3 of the years studied, which was probably strongly influenced by utilization. In Túrkeve, there was one year when the age composition of both females and the whole population in general showed a significant difference, but not the age composition of males. In Békéscsaba, there were two years when the age composition of males and the whole population showed a difference, and one year when the age composition of females did. In the third year studied, the proportion of individuals under 1 year of age in the two areas decreased significantly to [33% and 27.9% respectively, which according to BEUKOVIĆ et al. (2017) is extremely low. In my opinion, in the next year utilization (but trapping definitely) should have been practically suspended in both areas. Calculated with the formula used by SLAMEČKA et al. (1997) cit. POPOVIĆ et al. (2008), the growth of the population in 2016 was [4.48%] in the Túrkeve area and [-2.91] in the Békéscsaba area.

3. Is there a causal relationship between the placental scar count and individual characteristics (age, body weight, kidney fat index)? Placental scar count did not vary in Túrkeve but did vary in Békéscsaba in two years. Placental scar count in fertile females was influenced by the year, age, site*age interaction, and site*year*age interaction according to the GLM model. Overall, placental scar counts across the two sites did not differ in any given year. However, the age of females had a significant effect on placental scar count. BEUKOVIĆ et al. (2013 b) describes a statistically verifiable relationship between body weight and placental scar count (R^2=0, 1296), as well as between body mass index and fecundity rate. My research showed a relationship between the effect of age ($p < 0.0001$; $F = 33.154$; $R^2 = 0.087$) and body weight ($F = 33.154$, $p < 0.0001$; $R^2 = 0.167$) on placental scar count, according to the multivariate regression model. Of the two variables, body weight had a greater effect on placental scar count. 16.7% of its variance was accounted for by body weight, while age accounted for 8.7%. There was no correlation between kidney fat index and the placental scar count ($F = 0.000$; $p = 0.987$; $R^2 = 0.000$). As per the results of the regression analysis, the variables with the highest standard regression coefficient and the strongest effect on placental scar count were body weight and age. BENSINGER et al. (2000) found 84% of adult females, but only 1% of juvenile females, fertile. I found that the uterus of 30–70% of the leverets showed at least one placental scar, while the same stands for 77% of yearlings.

4. Does the age of the animal affect its physical condition? The tests showed that kidney fat indices did not differ across age groups in other words the physical condition is therefore not influenced by age. Within a given age group, the greatest variability was found in yearlings. Across years, the biggest difference was found in the physical condition of leverets. Kidney fat index was influenced primarily by the hunting year ($F = 49.663$; $p = 0.000$; $R^2 = 0.357$), which is likely to be related to the weather and food sources of the given year. Examining the physical condition of mature individuals, STOTT AND HARRIS (2006) found that digestive fat reserves are most intensively developed in lactating females.

5. Is there a difference in the fecundity of populations at the hunting site by age group? The pregnancy rate of all the females over the years only differed in one case. In one area the pregnancy rate of age groups showed a difference, in the other area it did not. At one of the sites, fecundity differed across age groups, but there was no such effect at the other site. The fecundity of all females not differed between age groups [$chi^2=3.581$ és $p=0.167$ df=2]. From the data I deduce that most of the individuals under 1 year of age were potentially in a reproductive age and the age composition of the population was relatively favorable in terms of reproductive performance.

6. Within the age group, are infertile young females younger than fertile young females? Eye lens weight in leverets ranged from 180 to 260 mg. Infertile young females within the age group were younger than fertile young females, corresponding to individuals of about 4 months of age based on their average lens weight [176 mg]. According to lens weight, females can mature as early as at 6 months of age, 1-2 months earlier than mentioned by MACDONALD et BARETT (1993).

7. Within the age group, are infertile elderly females older than fertile elderly females? Infertile elderly females belonged to the same age group as fertile adult females. Elderly females not showing fertility have an estimated average age of 1-2 years based on dried eye lens weight [307mg], as do fertile elderly females [324mg]. This may mean that in case of older females, infertility could be due to true infertility, or possibly a temporary lack of reproduction in a given reproductive cycle, since these individuals are of a potentially reproductive age. NIKODÉMUSZ et al. (1985) found pathological abnormalities in 39.5% of female genital samples examined. Less than 60% of individuals older than 5 years participated in reproduction.

8. To what extent does age structure change in relation to hunts (will be more young or adult)? Annual harvesting can transform age structure. In the examined population, leverets and yearlings accounted for a higher proportion of the stock in all three years, which is favourable from the point of view of game management. Among all animals, leverets made up 48.3% of the samples, yearlings 40.3%, while individuals older than 2 years made up only 11.4% of the samples. Overall, we can conclude that at both site and across all three years more than 80% of the samples constituted of leverets and yearlings, while the proportion of individuals older than 2 years was 10.1-12.8% in the day's kills. My results are similar to those of BEUKOVIĆ et al. (2011) in Serbia, who found that about 50-75% of the autumn hare population are leverets and 25-50% are yearlings. In other countries, the proportion of juveniles in autumn hare populations was much lower. In central Poland, WASIŁEWSKI (1991) found that the proportion of leverets in the autumn population was 20–40%, PINTUR et al. (2006) in Croatia found it at 50%, while BENSINGER et al. (2000) found it at 41% in Germany and HANSEN (1992) in Denmark found it at 31.8-41.3%.

9. Do age groups that make up the stock contribute evenly to the productivity of the population? Age groups that make up the stock contribute to the productivity of the population in varying degrees. Most of the actual offspring number (AH_{kcs}) was produced by yearlings and adults [2/3]. Individuals between 2 and 3 years of age also contributed significantly as compared to their numbers, but their proportion in the samples was only slightly more than 14%. The RH_{kcs} value of 48% is high for this age group, as they have the potential to significantly increase the headcount. The extent of this is greatly influenced by the proportion of the age group within the population. The RH_{kcs} value was the greatest by age group 2-3 years and then the age group 1-2 years. The lowest placental scar count was found in leverets, averaging 3.71 per doe, but their fecundity rate was high [71%] and their significant proportion in the population [above 40%] resulted in more than 30% of the total population reproductive performance. The most "valuable" age group for the population are yearlings, as they have high fecundity rates, placental scar counts, and proportion in the samples.

10. Does the hunting site and the hunting year influence the number of offspring? The year influenced the number of offspring more than the area did. Based on our results, the differences between specific years in a given area are bigger than those between areas in the same year. Statistically, the pregnancy rate did not differ between the two areas. The average number of placental scars calculated for the three years was the same in the two areas. MACDONALD and BARRETT (1993) claims that the hunting area does not significantly influence the pregnancy rate of reproductive-age females. Their study has demonstrated that in Europe (regardless of hunting area) we can calculate with 3 births per mother, with 1-4 offspring each birth. The number of offspring born was more influenced by hunting year. As PAP and SZRNKA (2004) also mentions, this is probably due to the weather, as a rainy spring or an early summer leads to deteriorated conditions and thus fewer offspring. In SHAI-BRAUN et al. (2020)'s study, the size of fallow area within the hunting area has a positive effect on the population density in spring, on population growth, the proportion of young individuals, the survival rate of young individuals and the size of the kill in the fall. In Serbia between 2000 and 2009, POPOVIĆ et al. (2012) established an average population density of 8.17-9.10 individuals/100 hectare. The national average population size decreased by 0.43%, while in the Vojvodina region there was a 10.09% growth, with a population density of 12.62-15.16 individuals/100 hectare. Based on their experiences, they consider the exact determination of population size in spring, on the first hunting week, to be of vital importance. Their recommendations for the future include the ongoing training of professional hunters, the development of habitats, game feeding and the temporary suspension of hunting for 2-3 years in certain areas with a population under 5 individuals/100hectare. BUTTERWORTH et al. (2017) established that in England and Wales, high utilization in February (69%) led to a decreasing tendency in population size for several years, whereas in Scotland, the same extent of utilization but distributed proportionately over the months resulted in population growth. The cause of the difference is the number of orphaned young, which was 7.6% of the spring population in the first case and only 0.3% in the second. In POPOVIĆ et al. (2013)'s research the area as an influencing factor has a smaller effect on age distribution.

11. Do hare populations at the hunting site differ in survival rates by age group? The survival pattern of leverets at the two sites in any given year was not the most even of any age group. Survival patterns of males and females differed during the research period. There was also a difference in survival rate within the same sex per year and age group for both sexes. Overall, the survival pattern for males can be considered more balanced over the three years, similarly to the findings of MARBOUTIN et HANSEN (1998), who estimated the annual survival rate of animals based on winter temperature, sex, and body weight. They found that surviving the winter was more probable in animals over 3 kg of body weight than in young animals, and males survive the winter more successfully than females.

12. Does the annual population-level reproductive performance and age composition differ significantly due to hunts? Due to the unfavourable age composition at the Békéscsaba site, the effective contribution of potentially more productive age groups to the reproductive performance of the population was lower than at the Túrkeve site, especially in the first two years. This highlights the importance of conserving the core population in terms of higher reproduction rates and more abundant harvests. GÖRITZ et al. (2001) found no difference in the reproductive performance of droves at the examined hunting sites in Germany. VOLOKH (2014) in the south of Ukraine found an increase in the population of hares in years where the proportion of juveniles in the November stock was at least 62.7%. BEUKOVIĆ et al. (2012) experienced a significant correlation between the extent of utilization, the population density in the fall and the next year's population size in Vojvodina. Due to rational wildlife management (individual management recommendations based on age determination from samples), the Vojvodina population became stable over the 15 years studied (estimated population size 262 042 individuals, average hare density 13.2 individuals/100 hectare, average proportion of young individuals in the fall 56%). In Lithuania, PĖTELIS and BRAZAITIS (2009) experienced huge differences (3-39%) in the annual utilization rate between areas.

4. NEW SCIENTIFIC RESULTS OF THE THESIS

- In the hunting areas I examined, the most variable characteristics were body weight and kidney fat index, the least variable was pregnancy rate. I demonstrated that in both areas, the majority of the population was composed of the age groups under 1 year and between 1-2 years. I established that based on the yearly age distribution, a larger part of the population belonged to these age groups, but in some years, hunting upset the age composition.
- Based on my studies, the rate of survival from one year to the next was higher in both areas in the age group of 1-2 years than among individuals under 1 year of age.
- I established a causal relation between the factors influencing the number of placental scars and individual characteristics. The factors influencing the number of placental scars to the highest extent were hunting year, the individual's age and body weight, as well as year*age and area*year*age interactions. The condition of individuals did not affect the number of offspring.
- I demonstrated that in both areas and in all the three years the fertility of individuals over 1 year of age can be considered constant on the basis of calculated values. In the case of young females, "infertility" is likely not to mean true infertility but a condition before sexual maturity. I mentioned that the threshold age for the reproduction of females is around 6 months, as individuals of this age already had placental scars. I established that adult females without signs of fertility belong to the same age group as fertile aged females, so in their case barrenness is due to lack of reproduction or pathological reasons.
- On the basis of trial hunts, over 60% of young individuals are estimated to have been born between (mid)-April and (mid)-September, which coincides with the dispersion of individuals after birth.
- I calculated the absolute (AHkcs) and relative contribution (RHkcs) to population-level reproductive performance for each age group. I have found that individuals of the age group 2-3 and above are the most valuable in terms of relative reproduction performance, but as there are fewer of them, their absolute contribution is lower. The age groups under 1 year and 1-2 years provide higher absolute contribution, in spite of their lower relative contribution, due to their higher proportion in the population.
- Over the years there is a difference between areas in terms of the effective contribution of potentially more productive age groups to the reproductive performance of the

population, the reason of which is the unfavorable age composition in one of the areas. This also highlights the importance of protecting the core population in order to ensure a higher reproduction rate and a larger utilizable population.

5. PRACTICAL APPLICABILITY OF THE RESULTS

1. I managed to collect data about several hundred Hungarian hares especially regarding age and reproductivity indices. In the possession of this data, I could assess the age composition of the populations and the absolute and relative contribution of each age group to the reproductive performance of the species, which reinforces the necessity of utilization based on data and potentially the allocation of utilizable quantities based on age assessment from mandatory kill samples. Naturally, this should be done using up-to-date technical equipment (e.g., thermal imaging) and performing and monitoring well-timed estimates.
2. I managed to demonstrate that individual differences are typically not found between areas but within the same area over the years, whereas population characteristics (especially the age composition and pregnancy rate of females) differ between areas; this reinforces the planning of utilizable quantities per year in the given areas. I obtained important information regarding the age of individuals under 1 year (at the time of hunting, a large proportion of them is 4-7 months old), which coincides with the dispersion time of the species.
3. I managed to demonstrate cause-effect relationships between certain individual characteristics and the number of average placental scars in fertile females.
4. I collected data to explore the survival rate by age group, and I found that the survival rate of the young age group to be lower, whereas that of males higher. I demonstrated that the survival rate of age groups over the years may differ according to area, so wildlife management can improve the survival rate of young hares by developing their habitat (increasing fallow area, well-managed predator control).
5. From the collected data I estimated the threshold reproductive age for females (six months) and that young individuals participate in reproduction to a higher extent but with fewer offspring than suggested by literature. The research reinforced that due to pregnancy rate depending on age and the annual changes in age composition, yearly population-level reproductive performance may differ by year and area as well.
6. I established that the result of trial hunts can be considered representative with the sample size I used (n_{trial}=141 and n_{all}=378).

6. REFERENCES

1. BENSINGER, S. - KUGELSCHAFTER, K. - ESKENS, U. - SOBIRAJ, A. - SOBIRAJ, G. (2000): Untersuchungen zur jährlichen Reproduktionsleistung von weiblichen Feldhasen (*Lepus europaeus* Pallas 1778) in Deutschland. Zeitschrift für Jagdwissenschaft. 46, 73-83.
2. BEUKOVIĆ, M. - ĐORĐEVIĆ, N. - POPOVIĆ, Z.- BEUKOVIĆ, D. - ĐORĐEVIĆ, M. (2011): Nutrition specificity of brown hare *(Lepus europaeus)* as a cause of decreased number of population. Contemporary Agriculture. 60, 403-413.
3. BEUKOVIĆ, M. - POPOVIĆ, Z. - ĐORĐEVIĆ, N. (2012): The management analysis of hare population in Vojvodina for the period 1997-2011. In: Modern aspects of sustainable management of game population. International Symposium on Hunting. 22-24. June 2012. Zemun-Belgrade. Szerk. POPOVIĆ, Z., BEUKOVIĆ, M., MILUTINOVI, M., BEUKOVIĆ, D. 2012. University of Novi Sad, 9-15.
4. BEUKOVIĆ, M. - STANIC, I. - BOZIC, A.- BEUKOVIĆ, D. - DJAN, M. - VELICKOVIC, N. (2013 b): Correlation of hunting mass with reproductive potential of female hare (*Lepus europaeus* P.) In: Modern aspects of sustainable management of game population. International Symposium on Hunting. 2. 17-20 October 2013. Novi Sad. Szerk. BEUKOVIĆ, M., POPOVIĆ, Z., ĐORĐEVIĆ, N., ĐORĐEVIĆ, M., DAN, M., BEUKOVIĆ, D., LAVADINOVIĆ, V. 2013. University of Novi Sad, 73-78.
5. BEUKOVIĆ, M. - POPOVIĆ, Z.- BEUKOVIĆ, D (2017): Age determination of brown hare in province of Vojvodina for seasone 2016, trends of juvenile in population In: Proceedings International Symposium on Animal Science (ISAS). 5-10. June. 2017. Herceg Novi, Montenegro. Szerk. TRIVUNOVIĆ, S. 2017. University of Novi Sad, Faculty of Agriculture, 347-353.
6. BRAY, Y. - MARBOUTIN, E. - PEROUX, R. - FERRON, J. (2003): Reliability of stained placentalscar counts in European hares. Wildlife Society Bulletin. 31, (1), 237-246.
7. BUTTERWORTH, A. –TURNER, K. M. –JENNINGS, N. (2017): Minimising orphaning in the brown hare *Lepus europaeus* in England and Wales: should a close season be introduced? Wildlife Biology. 2017 (4), 00279.
8. CABOŃ-RACZYŃSKA, K. – RACZYŃSKI, J. (1972): Methods for Determination of Age in the European Hare. Acta Theriologica. 17, (7): 75-86.

9. CASWELL, H. (1989): Matrix Population Models: Construction, Analysis and Interpretation. Sinauer Assiciates, 1-328. In: WINCENTZ, T. (2009): Identifying causes for population decline of the brown hare (*Lepus europaeus*) in agricultural landscapes in Denmark. PhD thesis. Aarhus University, Denmark.

10. CSÁNYI S., (Szerk.) (2016): Vadgazdálkodási Adattár 1960-2016. Országos Vadgazdálkodási Adattár, Gödöllő. 48.

11. CSÁNYI S. - MÁRTON M. - KÖTELES P. - LAKATOS E. - SCHALLY G. (szerk.) (2019): Vadgazdálkodási Adattár - 2018/2019. vadászati év. Országos Vadgazdálkodási Adattár, Gödöllő. 66.

12. FLIS, M.-RATAJ, B. (2019 a): Characteristics of population indicators of Brown hare (*Lepus europaeus*, Pall.) obtained during group hunting in the region with the highest density in western part of the Lubin region in Poland. Applied Ecology and Enviromental Research 17 (6), 13701-13711.

13. FLIS, M.-RATAJ, B. (2019 b): Weight of body, carcass and internal organs as well as paranephric fat index (KFI) as the individual condition indices of the brown hare (*Lepus europaeus*) in eastern Poland. Annals of Warsaw University of Life Sciences-SGGW Animal Science 58 (2), 133-141.

14. GÁL J. (2006): A Lajta-Hanság mezei nyúl állományának vizsgálata különös tekintettel annak egészségügyi helyzetére. PhD értekezés, Sopron.

15. GÖRITZ, F. - FAßBENDER, M. - BROICH, A. - QUEST, M. - BLOTTNER, S. A. - GILLES, M. - LENGWINAT, T. - SPITTLER, H. - HILDEBRANDT, T. B. (2001): Untersuchungen zur reproduktiven Fitness lebender weiblicher Feldhasen aus unterschiedlichen Habitaten. Zeitschrift für Jagdwissenschaft. 47, 92-99.

16. HANSEN, K. (1992): Reproduction in European hare in a Danish farmland. Acta Theriologica. 37 (1-2), 27-40.

17. (I1): https://hu.wikipedia.org/wiki/Popul%C3%A1ci%C3%B3dinamika Utolsó hozzáférés: 2020.10.28.

18. KOVÁCS GY. (1986): Létszámbecslési módszer gyakorló vadgazdáknak. A mezei nyúl állománysűrűségének becslése reflektorral. Vadbiológia. 1, 73-79.

19. KOVÁCS GY. - HELTAY I. (1985): A mezei nyúl. Ökológia, gazdálkodás, vadászat. Mezőgazdaság Kiadó, Budapest. 176.

20. MACDONALD, D.- BARETT, P. (1993): Mammals of Britain and Europe. Harper Collins Publishers, 1-312.

21. MAJZINGER I. - CSÁNYI S. (2017): Útmutató az adatokon alapuló mezei nyúl-gazdálkodáshoz. Szent István Egyetemi kiadó, Gödöllő. 70.

22. MARBOUTIN, E.- HANSEN, K. (1998): Survival rates in non harvested brown hare population. The Journal of Wildlife Managment. 62, 772-779.

23. PAP T.- SZRNKA T. (2004): A mezei nyúl gazdálkodási modellek vizsgálata. Nimród. 6, 4-7.

24. NIKODEMUSZ E. - KOVÁCS G. - VETÉSI F. (1985): On the pathology of the female reproductive tract in the European hare. In: XVIIth Congress of the International Union of Game Biologist. 17-21 September 1985. Brussels. Szerk. CROMBRUGGE, S. A., 1985. Brussels, 773-775.

25. PĖTELIS, K. –BRAZAITIS, G. (2009): The European hare (*Lepus europaeus* Pallas) population in Lithuania: the status and causes of abundance change. Acta Biologica Universitatis Daugavpiliensis. 9 (1), 115-120.

26. PINTUR, K. - POPOVIĆ, N. - ALEGRO, A. - SEVERIN, K. - SLAVICA, A. - KOLIĆ, E. (2006): Selected indicators of Brown hare (*Lepus europaeus* Pallas, 1778) population dynamics in northwestern Croatia. Veterinarski Arhiv. 76, 199-209.

27. POPOVIĆ, Z. - BEUKOVIĆ, M. - ĐORĐEVIĆ, N. (2012): Management brown hare (*Lepus europaeus* Pall) population in Serbia. 1997-2011. In: Modern aspects of sustainable management of game population. International Symposium on Hunting. 22-24. June 2012. Zemun-Belgrade. Szerk. POPOVIĆ, Z., BEUKOVIĆ, M., MILUTINOVI, M., BEUKOVIĆ, D. 2012. University of Novi Sad, 1-6.

28. POPOVIĆ, Z. - BEUKOVIĆ, M. - MILOŠEVIĆ, G. (2013): Analysis of the state of hare population in the hunting grounds of central Serbia. In: Modern aspects of sustainable management of game population. 2nd International Symposium on Hunting. 17-20. October, 2013. Novi-Sad. Szerk. POPOVIĆ, Z., ĐORĐEVIĆ, N., ĐORĐEVIĆ, M., ĐAN, M., BEUKOVIĆ, D., LAVADINOVIĆ, V. 2013. University of Novi Sad, 39-47.

29. ŠELMIĆ, V. - ĐAKOVIĆ, D. - NOVKOV, M. (1999): Istraživanja realnog prirasta zečijih populacija i micropopulacija u Vojvodini, Godišnji izveštaj o naučnoistraživačkom radu u organizaciji, Novi Sad. 127-134.

30. SHAI-BRAUN, S. C.- RUF, T. –KLASNEK, E. –ARNOLD, W. –HACKLÄNDER, K. (2020): Positive effects of set-asides on European hare (*Lepus europaeus*) populations: Leverets benefit from an enhanced survival rate. Biological Conservation. 244, 108518.

31. SLAMEČKA, J.– HELL, P. - JURČÍK, R. (1997): Brown hare in the Westslovak Lowland. Acta Sc. Nat. Brno 31 (3–4), 21–28, 100–103. In: POPOVIĆ, N. - PINTUR, K.

- ALEGRO, A. – SLAVICA, A. – LACKOVIĆ, M. – SERTIĆ, D. (2008): Themporal changes in the status of the European hare (*Lepus europaeus* Pallas, 1778) populations of Međimurje, Croatia. Natura Croatica 17 (4), 247-257.

32. STOTT, P. - HARRIS, S. (2006): Demographics of the European hare (*Lepus europaeus*) in the Mediterranean climate zone of Australia. Mammalian Biology. 71, (4), 214-226.
33. SUCHENTRUNCK, F. - WILLING, F. - HARTL, GB. (1991): On eye lens weights and other age criteria of the brown hare (*Lepus europaeus* Pallas, 1778). Zeitschrift für Säugetierkunde. 56, 365-374.
34. SUGÁR L. (szerk.) (2000): Vadbetegségek. Mezőgazda Kiadó, Budapest. 147.
35. VOLOKH, A. (2014): Dynamics of the European hare populations (*Lepus europaeus* Pallas, 1778) in the steppe zone of Ukraine. Beiträge zur Jagd- und Wildforschung. 39, 369-379.
36. WASIŁEWSKI, M. (1991): Population dynamics of the European hare *Lepus europaeus Pallas, 1778* in Central Poland. Acta Theriologica. 36, (3-4), 267-274.
37. ZELLWEGER-FISCHER, J.- KÉRY, M.- PASINELLI, G. (2011): Population trends of brown hares in Switzerland: the role of land-use and ecological comensation areas. Biological Conservation. 144, 1364-1373.

7. PUBLICATIONS

UNIVERSITY of DEBRECEN

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

Registry number: DEENK/30/2021.PL
Subject: PhD Publication List

Candidate: Péter Farkas
Doctoral School: Doctoral School of Animal Husbandry
MTMT ID: 10054521

List of publications related to the dissertation

Hungarian scientific articles in Hungarian journals (3)

1. **Farkas, P.**, Kusza, S., Majzinger, I.: A predátor fajok jelentősége a mezei nyúl (Lepus europaeus Pallas, 1778) állományok alakulásában: Szakirodalmi áttekintés. *Agrártud. Közl. 73*, 43-49, 2017. ISSN: 1587-1282.
2. **Farkas, P.**, Kusza, S., Barta, T., Majzinger, I.: Koreloszlás-vizsgálat és életkorbecslési módszerek összehasonlítása alföldi mezei nyúl állományokon. *Vadbiológia. 19*, 47-53, 2017. ISSN: 0237-5710.
3. **Farkas, P.**, Majzinger, I., Kusza, S.: A mezei nyúl (Lepus europaeus, Pallas 1758) fontosabb populációs paramétereinek összehasonlítása két alföldi területen. *Agrártud. Közl. 69*, 69-74, 2016. ISSN: 1587-1282.

Foreign language scientific articles in Hungarian journals (1)

4. **Farkas, P.**, Majzinger, I.: Comparative Analysis of body weight and condition in two brown hare populations. *Rev. Agric. Rural Dev. 6* (1-2), 176-181, 2017. ISSN: 2063-4803.

Foreign language scientific articles in international journals (2)

5. **Farkas, P.**, Kusza, S., Balogh, P., Majzinger, I.: Examination of fertility indicators of European brown hares (Lepus europaeus) in Eastern Hungary. *J. Anim. Plant Sci. 30* (3), 634-641, 2020. ISSN: 1018-7081. DOI: http://dx.doi.org/https://doi.org/10.36899/JAPS.2020.3.0075 IF: 0.481 (2019)
6. **Farkas, P.**, Kusza, S., Majzinger, I.: Analysis of some population parameters of the Brown hare (Lepus Europaeus Pallas,1758.) in two hunting areas on the Hungarian Great Plain. *Lucrări ştiinţifice, Serie 1. Management Agricol. 18* (1), 71-74, 2016. ISSN: 1453-1410.

UNIVERSITY of DEBRECEN

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

Hungarian conference proceedings (1)

7. **Farkas, P.**: A mezei nyúl (Lepus europaeus, Pallas, 1758.) populációdinamikáját befolyásoló tényezők vizsgálata.
In: Helyi termék - hagyomány, hálózat avagy fiatal kutatók vidéken - konferencia publikációs kiadványa. Szerk.: Kozma Gábor János, Seregi János, Dávidházy Gábor, Paszternák Ferenc, Barancsi Ágnes, Gazsó Tibor, Gál Ferenc Főiskola, Mezőtúr, 21-29, 2015. ISBN: 9786155256172

Foreign language abstracts (3)

8. **Farkas, P.**, Kusza, S., Majzinger, I.: Estimation population density of European brown hare populations in two different hunting areas in Hungary.
In: Modern Aspects of Sustainable Management of Game Populations : 6th International Wildlife and Game Management Symposium: Book of Abstracts, University of Forestry, Szófia, 62, 2018.
9. **Farkas, P.**: The experiments of live capture of the European brown hare in Hungarian Great Plain.
In: 15th Wellmann International Scientific Conference : book of abstracts: Towards sustainable agriculture: an interdisciplinary approach. Szerk.: Monostori, Tamás, Szegedi Tudományegyetem, Mezőgazdasági Kar, Hódmezővásárhely, 38, 2017. ISBN: 9789633065303
10. **Farkas, P.**, Kusza, S., Majzinger, I.: Survey of the age structure in two European brown hare populations based on periosteal jaw segment examination.
In: 5th International Hunting and Game Management Symposium : Book of Abstracts and Proceedings. Ed.: Kusza Szilvia, Jávor András, University of Debrecen, Debrecen, 48, 2016. ISBN: 9786155403101

Total IF of journals (all publications): 0,481
Total IF of journals (publications related to the dissertation): 0,481

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

25 January, 2021