Modern Environmental Science and Engineering (ISSN 2333-2581)
January 2020, Volume 6, No. 1, pp. 59-71
Doi: 10.15341/mese(2333-2581)/01.06.2020/005
Academic Star Publishing Company, 2020
www.academicstar.us

Morphological Characteristics of the European Hare (*Lepus europaeus* Pallas, 1778) in the Steppe Zone of Ukraine

Volokh Anatoliy

Department of Geoecology and Land Management, Tavricheskiy State Agrotechnological University, Melitopol, Ukraine

Abstract: Our studies did not reveal any significant differences in the exterior between males and females of the European hare (*Lepus europaeus transivanicus Mattshi*, 1901) The most changeable was tail length, varying in males within 75.0% between minimum and maximum values, and in females within 74.2%. The same applies to ear length (48.4% in males and 75.0% in females). Nowadays, in the steppe zone of Ukraine, individuals with body mass amounting to 3.0-4.5 kg dominate (88.9 % of males and 86.7 % of females). In the steppe zone of Ukraine, where the reproduction processes start earlier than in the central or northern parts of the range, the increase of body mass in relation to body length is much more impetuous in females than in males. The linear regression confidence interval with a probability threshold of $P = 0.05$; $t = 4.3$ in animals of both sexes lies within the values of 52.5 and 55.5 cm. Thus, the correlation between the body mass and body length is closer in females ($r = 0.89$) than in males ($r = 0.67$). A closer relationship between these important characteristics during the reproduction process in females surely exists in other populations as well. It can be interpreted as an adaptive reaction of an organism of the European hare to the influence of different ecological factors in the most responsible period of the species life cycle. Despite the considerable changes in the agrarian sector of the country, occurred during 1966-2018, which dramatically deteriorated habitats of field game, minimal, maximum and average values of exterior and craniological parameters of the European hare remain surprisingly stable.

Key words: European hare, area, Steppe Zone, Ukraine, population, dynamics, structure, biotopes, hunting

1. Introduction

All the wild animals can inhabit the area only if local ecological conditions meet their biological requirements. This principle of unity of an organism and its environment is supported by morpho-physiological adaptations that are relatively constant over a certain period of time. However, some species turned out to be incapable to provide an adequate evolutionary response to the rapid changes in the environment, being a characteristic feature of our time. It has caused a sharp decline in their numbers and even led to the extinction. At the same time, other species were able to adapt to the new ecological situation and began to live successfully in many anthropogenic biotopes. One of them is the hare (*Lepus europaeus* Pallas, 1778), which number in the steppe zone of Ukraine in 1970 was equal to 725,900, and in 2015 — 654,100 [1]. We found it interesting to examine the exterior and craniometry of this species under the climate warming and the dominance of the anthropogenic landscape, since nowadays 76.34% of the steppe zone of the country is covered by agricultural areas and 64.20% — by arable lands [2].

2. Material and Methods

Over the period 1967-2018, during hunting in Zaporizhzhia, Dnipropetrovsk, Donetsk, Mykolaiv, Odesa and Kherson regions of Ukraine (12.10-31.01), a total of 668 hares (341♀; 327♂) were measured and

Corresponding author: Anatoly Volokh, Ph.D., Professor; research areas/interests: auto- and synecology, mammal populationsmanagement, hunting and conservation. E-mail: volokh50@ukr.net.

weighted. Especially valuable data on body mass (n = 263) from the hares, captured in 1970-1974 for their further introduction to other areas, were submitted by Dr. L. S. Shevchenko (Institute of Zoology of the Academy of Sciences of Ukraine). The following external morphological parameters were used: 1) body length; 2) tail length; 3) ear length; 4) foot length; 5) body mass. Despite a specific form of the ear, its length was measured by an auricle profile, similar to the majority of other terrestrial mammals (Fig. 1). All the measurements were taken with the help of a flexible metal measuring tape.

All the hares collected were divided into adults and juveniles based on the availability of a tubercle, typical for young individuals and located at the distal end of the ulnar bone, according to Stroh's method [3]. The age of adults was identified by weighting crystalline lens [4], dried in a thermostat (t = 60-80°C) as well as by agglutination lines in a periosteal zone of the lower mandible [5].

When necessary, the morphological material was treated using regression and correlation analyses with a CSS software package (Microsoft-Corpiring). In most cases, when the animals were compared by a set of parameters, 95% confidence level was applied (P = 0.05).

3. Discussion

The hare is regarded as an animal with reversed sexual dimorphism (females being larger than males) [6, 7]. The differentiation of ecological niches, increased competition for food resources, more efficient reproduction of larger females and inheritance of certain morphological traits by descendants are mentioned among possible causes of this phenomenon [8]. However, our studies did not confirm any sexual dimorphism in the European hare at the southern limit of the subspecies distribution range (*Lepus europaeus transivanicus Mattshi*, 1901) (Table 1). We revealed no significant differences for the whole set of analysed parameters. Interestingly, tail length was found to be quite changeable, varying in males within 75.0% between minimum and maximum values, and in females within 74.2%. The same applies to ear length (48.4% in males and 75.0% in females) that has a crucial ecological value under significant variations in air temperature and a long and hot summer.

Table 1 Exterior of adult hares (12 October – 31 January).

Measurements	*n*	M±m	Min	Max	CV, %
Males					
Body mass, kg	147	4.2±0.03	3.3	5.2	8.08
Body length, cm	122	58.4±0.40	47.0	68.5	7.49
Tail length, cm	103	9.6±0.10	7.4	12.3	10.20
Length of hind leg, cm	122	15.3±0.07	13.4	17.2	4.91
Length of ear, cm	120	10.5±0.07	9.3	13.8	7.07
Females					
Body mass, kg	127	4.2±0.03	3.1	5.0	7.33
Body length, cm	113	58.1±0.32	51.0	67.5	5.85
Tail length, cm	98	9.7±0.12	7.2	12.9	11.75
Length of hind leg, cm	112	15.4±0.09	11.5	18.0	5.97
Length of ear, cm	110	10.7±0.09	8.0	14.0	9.04

The highest coefficient of variation (CV, %) was recorded in the European hare in the south of Ukraine for tail length, and the lowest — for foot length in representatives of both sexes. This is largely due to the fact that the category of "adults" includes animals which linear growth still continues while the body masses of most of them have almost reached their maximum. However, the above-mentioned parameters

also indicate a high plasticity of limbs, which among all exterior parameters are the most capable to dynamic response to the changes in the ecological situation.

Leverets grow rather quickly, and by the start of hunting season they are almost identical to adult individuals (Table 2). Especially it relates to the animals which was born in February-March. In the end of winter, juveniles become mature, turning into adults, which also affect their exterior parameters. Since the hare has several litters during the year, the difference between the minimum and maximum values in young animals is larger than in adults. For the same reason, the coefficient of variation is rather high for all indicators, but especially for body mass, tail and ear length. All exterior differences between males and females in young hares are statistically insignificant.

Examination of young hares *(n* = 688), collected in 53 points of Czech Republic, also did not reveal differences between males and females in body mass. Interestingly, characteristics of hare habitats (characteristics of plant vegetation and soil mineralization) have insignificant impact on the growth of leverets, whereas in the regions with high industrial pollution the retardation of the growth rate is recorded along with the increase in the average body mass [9].

Table 2 Exterior of juvenile hares (12 October – 31 January).

Measurements	*n*	M±m	Min	Max	CV, %
Males					
Body mass, kg	254	3.4±0.03	2.0	4.3	12.32
Body length, cm	220	55.7±0.30	44.5	67.1	6.91
Tail length, cm	179	9.0±0.09	6.1	11.7	13.09
Length of hind leg, cm	220	14.7±0.07	12.0	17.6	7.28
Length of ear, cm	222	10.6±0.07	7.0	14.3	9.83
Females					
Body mass, kg	142	3.4±0.04	2.2	4.3	12.42
Body length, cm	114	55.9±0.37	38.5	67.0	7.12
Tail length, cm	111	9.3±0.14	6.0	13.0	15.30
Length of hind leg, cm	119	14.8±0.10	10.0	17.2	7.65
Length of ear, cm	117	10.4±0.12	6.9	14.0	12.79

However, somewhat different picture can be observed for development stages of the populations with a noticeable dynamics of age-sex structure. During the periods of the number depression these populations are usually characterized by the increase in heterozygosity and genotype diversity [10]. It increases the tolerance of animals and allows supporting the maximum valuable productivity in the unfavourable environmental conditions [11]. In the steppe zone of Ukraine, in rape and sunflower fields, where the leveret mortality is especially high, a major part of the population consists of adults, usually dominated by females. Contrary to males, they are sedentary and rarely undertake even small migrations. In addition, mortality of young males in mammals is usually higher than in females which is especially obvious in case of food shortage [12]. Therefore, only a severe deterioration of habitat conditions, mainly due to the prolonged ice-slick and deep snow, forces the animals leave their natal areas and move to more comfortable regions. It is known that during severe winters, which were quite frequent in the 1920s, the hare was recorded in great numbers at the Azov Sea coast almost annually after 20 December.

In the years with peak numbers (1982-1984), when warm and almost snowless winters occurred in a major part of South-Eastern Europe, the survival of young animals sharply increased. At the same time, mean and extreme values of exterior morphological parameters decreased (Table 3), due to the increase in the

proportion of juveniles in the population. However, the revealed differences were not significant since young hares after 8-9 months have exterior parameters similar to older age groups. The only exception was body mass as adult females are significantly weightier than young ones (t = 4.2). The most rapid increase in body mass of the European hare is observed in juveniles and then it slows down, though continuing to grow insignificantly during subsequent years.

Table 3 Exterior of the European hare for different abundance.

Measurements	Maximum			Depression			t
	M±m	Min	Max	M±m	Min	Max	
Males (n = 267)							
Body mass, kg	3.6±0.08	3.0	4.5	3.7±0.06	2.9	4.9	2.0
Body length, cm	57.5±0.58	52.0	61.0	57.2±0.43	50.0	62.0	1.3
Tail length, cm	9.3±0.23	7.5	11.2	8.8±0.16	6.5	11.0	0.9
Length of hind leg, cm	16.1±0.19	13.7	18.0	15.1±0.17	12.2	16.8	2.9
Length of ear, cm	10.9±0.11	9.5	12.0	10.2±0.16	7.0	11.6	1.7
Females (n = 266)							
Body mass, kg	3.5±0.09	2.5	4.6	3.8±0.08	3.0	4.9	4.2
Body length, cm	57.0±0.83	50.0	62.0	56.8±0.46	47.0	65.0	0.2
Tail length, cm	9.5±0.34	6.0	12.4	9.5±0.24	6.5	15.0	0
Length of hind leg, cm	15.3±0.19	13.1	17.0	15.2±0.12	12.0	16.2	0.5
Length of ear, cm	10.7±0.17	9.5	12.4	10.5±0.15	7.5	14.0	0.9

Therefore, locally, in the depressed years, when adult animals dominate in groupings, females may be significantly weightier than males, and have longer ears and feet. This phenomenon is caused by different age of the animals compared. Thus, females are mostly represented by individuals of a senior age group (1 year 6-8 months – 2 years 6-8 months), while males are dominated by comparatively young hares (8-9 months – 1 year 8-9 months). It is a consequence of the age cross, and the revealed discrepancies are quite natural, since the growth of the European hare continues for the whole life, though with slower rate. It should be noted that our colleagues [13], studied geographical variations and morphological differentiation of the European hare in Ukraine, have revealed that females are significantly longer than males in the forest zone (t = 3.46; $P < 0.01$) and weightier than males — in the forest steppe zone. At the same time, in the latter case, males had longer ears and tails. Despite the fact that the mentioned authors have weighted and measured quite a high number of animals from the forest zone of our country (~500), they did not record any noticeable differences in the external morphology of males and females.

To avoid possible errors, connected with the hunting selectivity, we used the data on animals (n = 49), bagged within an area of ~800 ha per 1 hunting season (Table 4). It was found out that in this sample males (n = 22) were weightier than females (n = 27) and had higher values of body, foot and ear lengths. However, these differences turned out to be statistically insignificant. In that year, hunters quite often shot small individuals of both sexes which indicated high survival rate of animals from the last litter.

The study of the relationship between the mass dynamics and body length is of great importance, and its results were quite interesting for the hares, inhabiting the steppe zone of Ukraine. The increase of body mass in relation to body length in animals of the southern populations, where the reproduction processes start earlier than in the central or northern part of the range, is much more impetuous in females than in males (Fig. 1).

Table 4 Hare exterior in case of high abundance of the animals (28.11– 26.12.1982).

Measurements	Sex	M±m	Min	Max	*t*
Body mass,	♀	3.5±0.07	2.8	4.3	
kg	♂	3.6±0.73	3.0	4.5	0.25
Body length,	♀	56.6±0.83	51.0	63.2	
cm	♂	57.7±0.51	52.0	61.1	1.19
Tail length,	♀	9.4±0.32	6.0	12.0	0.34
cm	♂	9.3±0.21	7.5	11.2	
Length of hind leg,	♀	15.3±0.17	13.2	17.0	
cm	♂	15.9±0.18	13.7	18.0	2.61
Length of ear,	♀	10.6±0.18	9.5	13.0	
cm	♂	10.9±0.95	9.5	12.0	0.32

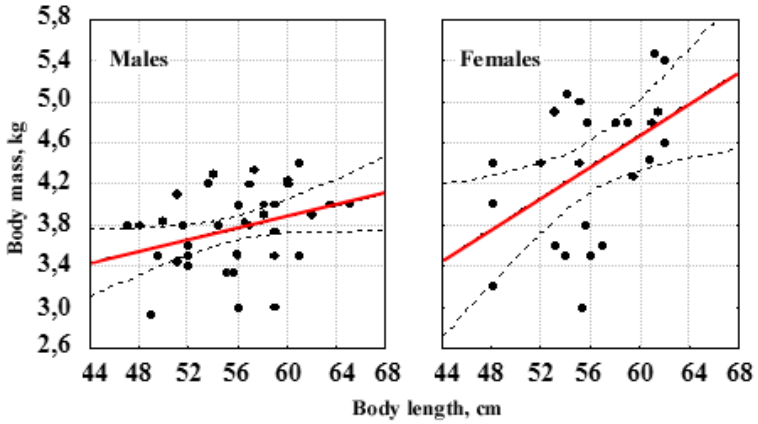

Fig. 1 The dependence of hare body mass on the length of the body in February-August.

The linear regression confidence interval with a probability threshold of $P = 0.05$; $t = 4.3$ in animals of both sexes lies within the values of 52.5 and 55.5 cm. Thus, the correlation between the body mass and body length is closer in females ($r = 0.89$) than in males ($r = 0.67$). A closer relationship between these important characteristics during the reproduction process exactly in females surely exist in other populations as well. It can be interpreted as an adaptive reaction of an organism of the European hare to the influence of different ecological factors in the most responsible period of life and can be of hereditary nature.

It is quite understandable that in the temperate zone of the Northern Hemisphere, the increase of body mass in relation to body length in the European hare occurs in the spring-summer season, associating with the highest concentration of forage, which has an important biological meaning: owing to a high amount of proteins, consumed by animals with forage, the growth and the increase in body mass both in future parents and embryos are accelerated.

The reduction of body mass in animals of both sexes occurs gradually and coincides with the end of the vegetation period of many fodder plants and with the start of a depressive phase of oogenesis and spermatogenesis. It is natural that during the pregnancy (February-July) and breastfeeding of leverets, females are weightier than males (Table 5). In the mentioned period this parameter in females constituted 4.4±0.13 kg, and in males — only 3.8±0.06; the frequency of animal records with body mass exceeding 4.0 kg amounted to 54.2% in females, and 34.2% in males.

In summer, the largest males weighted 4.4 kg, while maximum body mass of pregnant females reached 5.5

kg. According to all other exterior parameters, males were similar to females the same as it is recorded in many European countries [14-16].

In the steppe zone of Ukraine, individuals with body mass amounting to 3.0-4.5 kg dominate (88.9% of males and 86.7% of females). Despite the unequal distribution of this index in animals of different sexes, the peaks of its curve in males and females almost completely coincide (Fig. 2). In 1967-2018, out of the great number of the females examined (n = 354), only two weighted 5.0, and one – 5.2 kg. Among males (n = 328), two hares had a weight of 4.8 and five of 4.9 kg, though some animals of both sexes reached an age of 4+ years. At this, variability of this parameter between years was quite low, thereby indicating a significant stability of this index.

Table 5 The hare exterior (n = 263) in the breeding period (February-July 1970-1995).

Measurements	Sex	M±m	Min	Max	t
Body mass,	♀	4.4±0.13	3.2	5.5	4.3
kg	♂	3.8±0.06	2.9	4.4	
Body length,	♀	55.4±1.12	38.0	62.0	
cm	♂	55.5±0.72	47.0	65.0	0.1
Tail length,	♀	9.4±0.27	6.5	11.0	
cm	♂	9.6±0.16	8.0	11.5	0.7
Length of hind leg,	♀	14.6±0.18	11.5	16.0	
cm	♂	14.9±0.09	13.5	16.0	1.5
Length of ear,	♀	10.3±0.17	6.9	13.5	
cm	♂	10.4±0.12	8.5	13.0	0.5

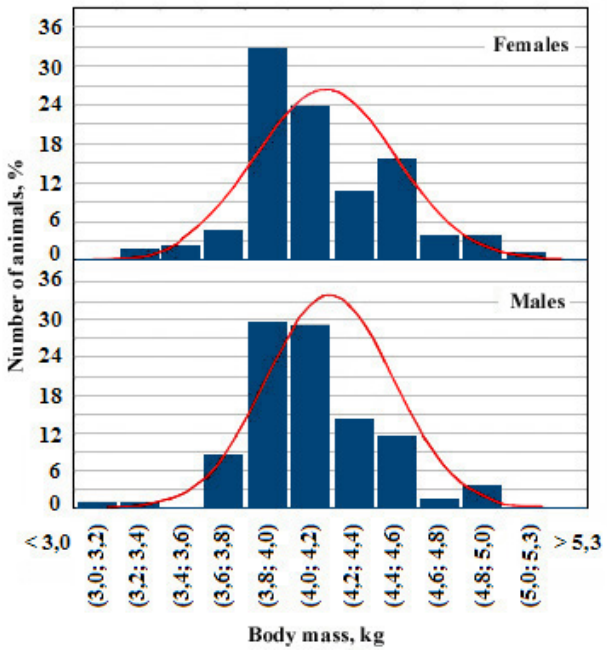

Fig. 2 Distribution of hares (12.10-31.01) by body mass (n = 668).

The least mean values of body mass were observed in the years with comparatively high local numbers when the population contained a lot of juveniles, whereas the highest values were recorded in the depression years when many individuals belonged to senior age groups. The largest hares (5.0-5.3 kg) were bagged in different areas of the steppe zone. Currently, their average body mass is low everywhere. By the way, in flat regions of Bulgaria, inhabited with the same subspecies as in the south of Ukraine, in the 1960s the adult males weighted 3.72, and females — 3.93 kg; juveniles had a weight of 3.26 and 3.2 kg, respectively [17]. These parameters are close to our data.

Despite the fact that we weighted rather a great number of animals, bagged in different years, many hunters believe that in the areas of their residence the hares are much weightier that in the areas of our hunting. This is a misperception, since hunters rarely weigh the game in our country. Over 40 years of the research and a huge number of weighted hares (n = 738), their body mass never exceeded 5.3 kg (Table 6). It should be noted that the variation coefficient of this parameter, considered for a long period of time, is significant since the species is characterised by the

birth of several litters during the year. However, it varies in very narrow limits — from 11.16 to 20.44%. It shows quite a high tolerance of an organism of the European hare to regular and rather intensive human pressure. Slightly higher body masses was revealed in hares *(n* = 2519) from Western Slovakia, where males weighted 4.21±0.35 (2.8-5.6), and females — 4.31±0.35 (3.0-5.7) kg. Zoologists explain this by the fact that the animals, inhabiting the country, belong to the subspecies *L. e. hybridus* which representatives are larger than our *L. e. transilvanicus* [18].

Table 6 Distribution of hares per body mass (kg) during hunting (30.10-31.01).

Years	*n*	M±m	Min	Max	CV, %
1976-1980	28	3.5±0.13	2.1	4.9	19.25
1981-1985	83	3.7±0.05	2.5	5.0	13.52
1986-1990	104	4.0±0.05	2.0	4.9	13.27
1991-1995	127	3.5±0.04	2.5	4.9	11.25
1996-2000	69	3.6±0.05	2.5	4.3	11.16
2001-2005	108	3.8±0.05	2.0	4.9	14.10
2006-2010	54	3.9±0.07	2.7	4.6	13.00
2011-2015	77	4.0±0.08	1.9	5.3	17.61
2016-2018	23	4.1±0.09	3.4	5.0	10.15
Total:	*670*	*3.8±0.02*	*1.9*	*5.3*	*14.53*

Averagely, if not dividing into age groups, body length of most females (79.3 %) and males (83.6 %) in the steppe zone of Ukraine ranged between 50-60 cm; only in 4 females this parameter comprised 68.0-68.5 cm, and in 2 males — 67.0-67.5. Generally, it corresponds to the data on variations in body length obtained by our colleagues [13].

Body mass of the European hare shows a great dependence on the population density. When the population density is low, body mass is usually higher and vice versa. In general, it is a common phenomenon in many countries of the world, described by an allometric equation: $D = aW^b$ [19], where D is the population density*;* a – proportionality ratio; W – body mass; b – allometric index. An implementation mechanism of the mentioned relationship is very simple:

a) the density growth is almost always determined by the increase in the percentage of juveniles, which are less weighty than adults;

b) as a result of trophic competition because of shortage of exchange energy, the mammals cannot reach a normal condition in the period of maximum growth and development;

c) the mortality level among the mammals of southern groupings, experiencing favourable climate conditions and better food supply due to the dominance of agrocoenoses, is much lower than that in the northern areas. It is a precondition for the development of higher population density.

When comparing animals of the same age in the periods of number depression, a slight increase in body mass of adults and young hares can be observed [7]. Thus, for example, in fields of the Netherlands, where the hare population density was high, their average body mass was 3.4 kg, and in the fields with low density — 3.6 kg [20]. It is quite natural, since with few exceptions, the increase in density usually happens at the expense of better survival of juveniles which are less weighty and have other exterior parameters than those in adults (A.V.).

Comparative analysis of material from different natural zones of Ukraine (Table 7), made by our colleagues [13], has revealed some population

differences in exterior morphology of the European hare. They are as follows:

- females of the European hare from the forest zone are much longer than those from the forest-steppe (t = 4.53; P = 0.01) and steppe zones (t = 6.29);
- males from the forest-steppe zone are much longer than those from the steppe zone (t = 3.15) and slightly weightier (t = 2.21);
- large specimens, exceeding 5.5. kg, which were once numerous in northern populations, have disappeared from the forest and forest-steppe zones. This phenomenon was also recorded in Poland, where body mass of adult animals in the end of the year ranged within 4.47-4.62, and juveniles — from 3.94 to 4.09 kg. At this, females were much weightier than males [7]. Interestingly, that when raising together in a Ukrainian farm, the animals from the forest zone, starting from their birthday to 3 years, were 16.3±0.84 % weightier than their steppe age-mates. Among adult females this difference was not valid (t = 1.4), but in males it reached significant values (t = 4.0) [21].

Table 7 Geographical variations in the exterior of the European hare.

Measurements	Sex	Population								
		Steppe (n = 475)			Forest-steppe (n = 149)			Forest (n = 64)		
		M±m	Min	Max	M±m	Min	Max	M±m	Min	Max
Body mass, kg	♂	3.9±0.08	2.0	4.9	4.2±0.11	2.2	5.8	3.8±0.21	2.3	5.0
	♀	4.2±0.13	2.2	6.0	4.5±0.22	2.1	6.5	4.2±0.23	2.6	5.5
Body length, cm	♂	55.6±0.69	44.5	67.5	59.3±0.95	48.0	70.0	58.9±1.71	49.0	72.5
	♀	55.6±0.81	47.0	67.0	57.9±1.20	45.4	70.0	61.7±1.64	53.5	75.0
Tail length, cm	♂	9.3±0.21	5.5	13.5	9.7±0.15	8.0	11.0	9.5±0.38	7.0	10.8
	♀	9.7±0.24	6.0	15.5	9.1±0.22	7.5	10.7	9.9±0.52	8.0	11.0
Length of hind leg, cm	♂	15.1±0.14	11.5	18.0	15.5±0.30	11.0	17.0	16.0±0.16	15.0	16.8
	♀	14.8±0.17	11.7	17.2	15.2±0.41	10.0	17.0	15.9±0.30	14.5	17.0
Length of ear, cm	♂	10.4±0.15	7.0	14.5	10.8±0.24	8.7	14.0	10.4±0.28	9.3	11.5
	♀	10.3±0.20	6.9	14.0	10.1±0.33	6.3	11.3	10.7±0.31	9.5	12.0

The above-mentioned materials indicate that a dramatic anthropogenic transformation of the environment in the 20th century has induced certain changes in external morphology of the European hare. The largest forms of the species were reported from the southernmost region of the European part of the former USSR (*L. e. tesquorum* Ognev, 1924) as well as for its northern and central parts (*L. e. hybridus* Pallas, 1811) [22]. It is known that the largest Ukrainian specimens were earlier recorded in the forest and forest-steppe zones, inhabited, correspondingly, by representatives of the mentioned subspecies. In these areas, in the 1960s, the average mass of females constituted 4.51, and males — 4.47 kg; the largest animals were 6.0-6.4 kg. Among collected hares (n = 220), 64.5% had body mass from 4 to 5 kg; 15.4% — from 5 to 6 kg, while the specimens of 3.0-4.5 kg, being the most numerous in the steppe zone, were quite rare (16.8%). In those years, the representatives of northern and central areas of Ukraine had quite significant body length, ranging between 50.0-69.0 cm in females, and 51.0-71.6 cm in males [23]. Nowadays, these morphological discrepancies became undistinguished.

Comparison of the data on the exterior of the European hare in the steppe zone of Ukraine, collected by us in 1980-2014, with those, collected mostly in 1966-1976 [13], showed no significant changes occurred for such a long period of time (Table 8).

Despite temporal difference and crucial changes in agricultural indiustry, which has lead to dramatic

deterioration in habitats of the field game, the minimum, maximum and average values of exterior parameters of the European hare show a surprising similarity. A significant dominance of the females, studied by our colleagues in 1966-1976 [13], over the females measured by us, is not quite understandable. Moreover, they estimate the maximum body mass of females at 6.00 kg. Probably, these scientists have included in their calculations the materials collected outside the hunting season, when nursing and probably pregnant females were bagged. Anyway, among the quite large number of hares (n = 670), weighted by us in the period from the third decade of November to 31 January in 1980-2018, the largest males were of 5.3, and females — 5.0 kg. Nevertheless, similar to humans and other animals, extremely large individuals can be found occasionally, not typical for the species. Thus, 8 November 2015, near Zaporizhzhia City, a hunter bagged the European hare with a body mass of 6.9 kg! To compare, at the northernmost limit of the species distribution range, in Karelia, the average body mass of the European hare was 4-5, and maximum — 7 kg with a body length of 55-68 cm [24]. In the north-east of the natural range, in Tataria, the average body mass of the animals constituted 4.71, ranging from 3.77 and 7.40 kg, and body length was 58 (54-62) cm [25].

Table 8 Temporal variations in the exterior of the European hare.

Measurements	Sex	1966-1976* ♂/♀ (n = 233/241)			1980-2018** ♂/♀ (n = 327/341)			t
		M±m	Min	Max	M±m	Min	Max	
Body mass, kg	♂	3.9±0.08	2.0	4.9	3.8±0.03	2.0	5.3	1.17
	♀	4.2±0.13	2.2	6.0	3.7±0.03	2.0	5.0	3.75
Body length, cm	♂	55.6±0.69	44.5	67.5	57.2±0.22	47.9	67.6	1.89
	♀	55.6±0.81	47.0	67.0	57.1±0.26	46.0	68.5	1.76
Tail length, cm	♂	9.3±0.21	5.5	13.5	9.3±0.09	6.0	12.9	0
	♀	9.7±0.24	6.0	15.5	9.3±0.08	5.1	12.4	1.58
Length of hind leg, cm	♂	15.1±0.14	11.5	18.0	15.1±0.07	11.5	18.0	0
	♀	14.8±0.17	11.7	17.2	14.9±0.06	11.7	17.2	0.56
Length of ear, cm	♂	10.4±0.15	7.0	14.5	10.7±0.07	7.0	14.3	1.81
	♀	10.3±0.20	6.9	14.0	10.4±0.07	6.9	14.0	0.47

Although mammal limbs are known to be important ectosomatic organs, using to reduce extra physiological heat, and their parameters are controlled by natural selection [26], no significant prevalence over the representatives of northern populations was found [15]. Moreover, males from the forest zone have longer tails that those from the forest-steppe (t = 2.25; P = 0.05) and steppe zones (t = 2.29). Hares from the forest zone have also longer feet (3.43/2.54) than steppe hares (t = ♂/♀), which smooths the interpopulation differences, recorded in the 1950s. In general, the study of quite voluminous data shows that nowadays the European hares from northern populations have no peculiar differences from those inhabiting the south of Ukraine.

Interestingly, in the areas of their acclimatization the European hares have small body weight. Thus, in New Zealand, with the dominance of marine climate, it comprised 3.15 kg in adult males, and 3.30 kg in females in the end of the 20th century [25]. In Argentina, where animals mainly inhabit a transformed pampa with temperate climate, adult males averagely weighted 3.6, and females — 3.9 kg [26]. In Ukraine, similar body mass is recorded in hares from the steppe Crimea. And although the morphological material for the Crimean population is limited, none of the hares examined by us (n = 9) or our colleagues (n = 8) [13] exceeded 4 kg. Apart from the small size, Crimean hares are characterized by peculiar hair-covering which even in extremely severe winters have chestnut-red

colouration. To compare, the specimens from the Ukrainian part of the Azov Sea region have a high number of white guiding stripes on their shoulders, backside, hips and rump. In combination with reddish-black top hair they provide grey colouration of the coat on backside and flanks, whitish — on the rump and totally white — on the belly (Fig. 3).

Skull sizes are regarded as important morphological parameters. Previously, craniological studies rarely took into account the age of examined animals that resulted in groundless and sometimes even erroneous distinguishing of taxa at the level of subspecies or even higher. To-date, an accompanying determination of the age is a must for these works.

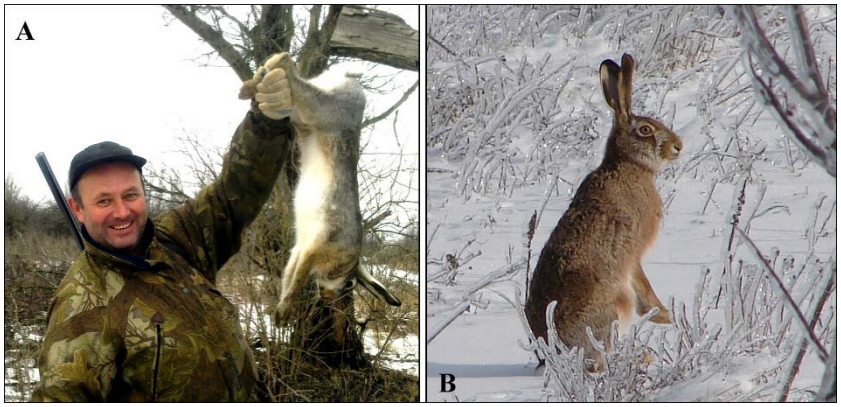

Fig. 3 A hunter with the European hare, bagged 10.01.2010 near Zaporizhzhia (A) and European hare in the Crimea, 27.01.2010 (B).

A skull of the European hare is completely formed during the first life year. However, our results have shown (Table 9) that the growth of some skull elements still continues after this period. When comparing individuals of junior (under 1 year) and middle (1-2 year) adult groups, it turned out that the latter have significantly higher maximum (t = 2.59; P = 0.01) and condilo-basal (t = 3.44) skull lengths than yearlings. It also relates to the length of nasal bones (t = 3.49), width of brain capsule (t = 2.74; P < 0.01), diastema length of the upper jaw (t = 2.98; P = 0.04), length of the lower jaw (t = 2.10; P = 0.04), and length of the lower tooth row (t = 2.21; P = 0.03).

Unproportional or allometric skull growth [27] of the European hare still continues in subsequent years. Its lengthening is especially noticeable. When comparing specimens from the middle and senior age groups it turned out that the latter have significantly higher maximum (t = 6.70) and condilo-basal (t = 4.90) skull lengths than the previous ones. It also relates to the length of nasal bones (t = 4.36), length of the upper tooth row (t = 2.33; P = 0.02), and diastema length of the upper jaw (t = 4.31). At the same time, statistically significant differences in parameters, characterizing the skull width growth, are absent in many cases and their values may even overlap or be quite close in all the age groups.

Simultaneously with the allometric skull growth in the European hare, a cranial suture close is observed as well as thickening and enlargement of some bone elements. It is, for instance, occipital protuberance and supraorbital protuberances of frontal bones, which size and form allow a clear division of animals into juvenile, middle-aged and old.

When investigating variations in craniometrical parameters of animals of the steppe population to establish the significance of their age changes (Table 10), the following peculiarities are noteworthy:

- in most cases, irrespectively of age, there are no craniological differences between sexes; the only exception is the length of lower row of molars (t = 2.35; P = 0.03) in one-year-old females, and the length of nasal bones (t = 2.58; P = 0.02) in old males which are significantly longer than in females of the same age;

Table 9 Age variations in craniometrical parameters (mm) in the European hare.

Cranial measure	Sex	Age								
		< 1 Year (n = 45)			1-2 Years (n = 41)			> 2 Year (n = 29)		
		M±m	Min	Max	M±m	Min	Max	M±m	Min	Max
Total cranial length	♂	96.0±0.71	87.2	99.9	97.3±0.60	93.2	102.2	102.0±0.62	97.5	106.8
	♀	95.0±1.07	81.1	99.8	97.8±0.93	90.0	101.4	101.5±0.47	97.5	106.6
Condilobasal length	♂	83.6±0.78	77.2	88.0	86.0±0.55	82.2	90.1	89.9±1.03	85.2	97.9
	♀	82.9±1.08	71.4	88.8	86.1±0.87	78.5	89.8	89.1±0.61	85.2	92.4
Zygomatic breadth	♂	45.0±0.80	36.1	49.3	45.6±0.39	41.8	48.7	45.0±0.85	42.0	48.9
	♀	45.5±0.71	35.9	49.2	46.5±0.50	41.4	49.3	46.4±0.84	41.4	49.3
Length of the nasal	♂	39.3±1.05	32.2	49.0	43.0±0.41	40.4	46.8	46.8±0.65	41.3	49.9
	♀	39.6±1.01	32.6	47.5	42.4±1.05	35.3	47.1	44.6±0.55	41.2	47.9
Interorbital constriction	♂	13.6±0.43	11.2	14.9	13.9±0.19	12.6	15.2	14.7±0.37	13.3	16.9
	♀	13.9±0.35	11.6	15.2	14.6±0.34	13.1	17.5	14.3±0.26	12.9	15.8
Brain capsule width	♂	32.0±0.29	30.2	33.5	32.6±0.28	30.8	35.5	33.4±0.50	31.2	35.5
	♀	31.9±0.41	29.3	34.4	33.0±0.34	30.6	35.2	33.0±0.25	31.8	34.8
Length of upper tooth row	♂	17.3±0.28	13.2	19.3	17.5±0.26	15.9	20.5	17.9±0.32	16.0	20.5
	♀	17.2±0.29	15.1	18.9	17.7±0.16	16.1	18.9	18.3±0.35	16.4	20.5
Diastema of the maxillary	♂	28.1±0.37	25.2	31.2	29.1±0.28	26.8	31.3	30.9±0.27	28.1	31.8
	♀	27.7±0.52	20.9	30.5	28.9±0.39	25.6	30.4	30.3±0.31	28.9	32.4
Mandibule length	♂	69.5±0.78	63.7	75.0	70.6±0.56	69.0	75.1	71.8±0.67	69.0	75.8
	♀	68.5±1.32	56.2	75.6	71.6±0.61	69.3	74.2	70.8±0.79	67.3	74.1
Length of lower tooth row	♂	18.8±0.26	16.5	20.0	19.3±0.29	17.8	20.8	20.1±0.29	18.0	22.0
	♀	18.7±0.46	15.0	21.0	20.1±0.24	19.1	21.5	19.6±0.36	18.5	21.8
Diastema of the mandible length	♂	22.4±0.39	19.6	24.7	22.4±0.45	19.2	24.5	23.1±0.31	21.0	24.4
	♀	23.0±0.82	18.0	30.0	24.0±0.98	21.2	28.9	24.1±0.58	21.8	28.8

Table 10 Variations in craniometrical parameters of the European hare and significance of their age differences.

Cranial measure	Sex	< 1 Year (n = 45)		1-2 Years (n = 41)		> 2 Year (n = 29)	
		CV, %	t	CV, %	t	CV, %	t
Total cranial length	♂	3.47	1.61	2.67		2.26	0.67
	♀	5.04		3.56	0.53	1.91	
Condilobasal length	♂	4.26	0.48	2.77		3.95	0.69
	♀	5.66		3.77	0.16	2.35	
Zygomatic breadth	♂	8.36	0.46	4.11		5.37	
	♀	7.45		4.57	1.49	5.75	1.21
Length of the nasal	♂	12.47	0.22	4.40	0.64	4.97	2.58
	♀	11.39		9.29		4.75	
Interorbital constriction	♂	10.01		6.40		7.86	1.03
	♀	8.67	0.58	9.11	1.80	6.46	
Brain capsule width	♂	2.84	0.25	3.77		4.77	0.76
	♀	4.21		3.90	0.93	2.55	
Length of upper tooth row	♂	7.45	0.24	7.01		6.46	
	♀	7.51		3.76	0.66	6.57	0.88
Diastema of the maxillary	♂	6.06	0.60	4.57	0.25	3.22	0.06
	♀	8.44		5.33		3.57	
Mandibule length	♂	4.62	0.64	2.75		3.35	0.98
	♀	7.49		2.54	1.28	3.51	
Length of lower tooth row	♂	5.74	0.17	5.22		5.20	0.99
	♀	9.43		3.54	2.09	5.82	
Diastema of the mandible length	♂	7.19		6.89		4.78	
	♀	13.85	0.64	12.28	1.65	7.58	1.62

- each age group of the European hare has slight variations in craniological parameters;
- coefficient of variation (CV, %) shows the highest average values and amplitude of variability in juveniles (7.35±0.62, limit = 2.84-13.85), somewhat lower values – in middle-aged (5.10±0.53, limit = 0.68-4.07), and the lowest values (4.68±0.37, limit = 1.91-7.86) in old hares that indicate retardation in the rate of craniological changes.

Comparison of animals from the forest and forest-steppe zones by craniological parameters has revealed their certain phenotype diversity. In addition, it has been established that statistically significant differences, found between these populations, did not depend on the sex and age of animals. Interestingly, sex dimorphism of skull proportions was found between males and females of the Crimean population of the European hare. Apart from this, the females showed higher similarity with the representatives of the steppe (Euclidean distance: 2.25) and the forest-steppe zones (Euclidean distance: 2.25), while the males (Euclidean distance: 2.39) — with the representatives of the forest zone. Generally, the results of a complex research of exterior and craniological parameters [13] have shown that the animals from the Crimea are considerably distanced from those from the Carpathians, forest and forest-steppe zones. Perhaps, peculiar characteristics of the Crimean hares are explained by an insular nature of the population which is developing under a partial geographical isolation and the limited influence of continental population waves.

References

[1] A. M. Volokh, *Mammals Hunted in Steppe Ukraine*, Kherson: Grinn D. S., B. 2, 2016, pp. 1-572 (russ.).

[2] A. Volokh, *Dynamics of the European Hare Populations (Lepus europaeus Pallas, 1778) in the Steppe Zone of Ukraine*, Beiträge zur Jagd & Wild forschung, Bd. 39, GmbH, 2014, pp. 369-379.

[3] G. Stroh, *Zwei siechere Altersmerkmale beim Hase. Tierärtztliche Wochenschr*, Berlin, N 12, 1931, pp. 180-181.

[4] I. Semizorová, The weight of the dried eye lenses is an indicator of the brown hares age (Lepus europaeus Pall.), *Lesnittvi* 21 (1975) (6) 553-560 (slov.).

[5] G. A. Klevezal, *Recording Structures of Mammals: Determination of Age and Reconstruction of Life History*, Rotterdam: Balkema A.A., 1996, pp. 1-274.

[6] J. E. Flux, Reproduction and body weights of the hare Lepus europaeus Pallas in New Zealand, in: *Proc., N. Z. Ecol. Soc.* 10 (1967) (2) 357-401.

[7] K. Caboń-Raczyńska, Variability of the body weight of European Hares, *Acta theriol.* 19 (1974) (1-13) 69-80.

[8] K. Ralls, Mammals in which females are larger than males, *Quart. Rev. Biol.* 51 (1976) (2) 245-276.

[9] E. Novakova, J. Dusek and J. Sole, Die Wachstumgeschwindigkeit bei Junghasen in der Kulturlandschaft. Ecol. and manag, Europ. Hare populations, Warszawa: Panstv. w-wo roln. i lesne, 1976, pp. 85-92.

[10] Yu. P. Altukhov, *Genetic problems in populations*, Moscow: Science, 1983, pp. 1-279 (russ.).

[11] F. I. Ayala, Genetic differentiation during the speciation process, *Evol. Biol.* (1975) (8) 1-78.

[12] J. A. Miller, Survival: sizing up the sexes, *Sci. News.* 127 (1985) (3) 40.

[13] L. S. Shevchenko and V. N. Peskov, Geographical variability and morphological differentiation of the brown hare (Lepus europaeus) on the territory of Ukraine, *Archives of the Zoological Museum* (2005) (37) 121-133 (russ.).

[14] F. Abildbard, J. Andersen and O. Barndorff-Nielsen, The Hare population (Lepus europaeus Pallas) of illumo island, Denmark a report on the analysis of the data from 1957-1970, *Ann. Rev. Game Biol.* 6 (1972) (5) 1-32.

[15] B. Frylestam, Structure, size and dynamic of three European hare populations in Soutern Sweden, *Acta Theriol.* 24 (1979) (32-38) 449-464.

[16] H. Spitler, Zur Ursache des sptunghatten Streckenrückganges beim Feldhasen (Lepus europaeus Pallas, 1778) in den Jahren 1978 und 1979, *Z. Jagdwiss* 33 (1987) (3) 175-184.

[17] P. Petrov, Weight fluctuations of the brown hare (Lepus europaeus Pallas) in Bulgaria, *Gorskop. Science* 1 (1964) (4) 73-81 (bulg.).

[18] J. Slamečka, P. Hell and R. Jurčik, Brown hare in the Westslovak Lowland. Acta scientiarum naturalium Academia scientiarum Bohemicae, *Brno* 31 (1997) (3-4) 1-115.

[19] R. H. Peters and J. V. Raelson, Relations between individual size and mammalian population density, *Amer. Natur.* 124 (1984) 498-517.

[20] S. Broekhuizen, Survival in adult European Hares, *Acta Theriol.* 24 (1979) (32-38) 465-474.

[21] V. A. Arhipchuk, Features of postnatal growth of the Brown hare (Lepus europaeus Pallas, 1778). Morphological features of vertebrates of Ukraine, scientific articles, Kyiv: Institute of Zoology, 1983, pp. 5-11 (russ.).

[22] Catalog of mammals of the USSR, *Pliocene-present*, Zoological Institute of the Academy of Sciences of the USSR. Edited by I. M. Gromov, G. I. Baranova, Leningrad: Science, 1981, pp. 1-456 (russ.).

[23] O. P. Korneev, *Brown Hare in Ukraine*, Kyiv: Kyiv State University, 1960, pp. 1-108 (ukr.).

[24] P. I. Danilov, *Hunting Animals of Karelia: Ecology, Resources, Management, Protection*, Moscow: Science, 2005, 1-340 (russ.).

[25] Yu K. Popov, *Mammals of the Volga-Kama Region*, Kazan branch of the USSR Academy of Sciences, 1960, pp. 1-468 (russ.).

[26] K. Smidt-Nielsen, *Animal Physioligy: Adaptation and Environment*, Cambridge University Press, B. 1, 1979, pp. 1-416.