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Craniometric features of European hare (*Lepus europaeus* Pall.) from North-west Croatia and the island of Vir

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ABSTRACT

The family of hares (*Leporidae*) expresses significant variation of morphological features under the influence of environment and diet. The aim of this research was the craniometric analysis of hares from two different habitat types, in order to confirm the presence of different ecotypes of this species in Croatia. The hares were sampled in the area of the island of Vir (Mediterranean habitat) and north-west Croatia (continental habitat). Craniometric measurements were conducted on 27 adult skulls, 12 female and 15 male skulls. 12 skulls originated from the island of Vir and 15 skulls were from north-west Croatia. 25 skull measurements were made, of which 6 were on the mandible for each skull. The results of the research showed significant variations in skull measurements between hares sampled on the island of Vir and in continental north-west Croatia. Of 19 cranium measurements, 10 measurements indicated statistical differences at $P<0.01$, 3 measurements indicated statistical differences at $P<0.05$, and of the 6 analysed mandible measurements, 5 indicated statistical differences at $P<0.01$. Cranium measurements that varied significantly were greater for hares from north-west Croatia by 5.11 to 12.84%, and mandible measurements also tended to be greater by 7.18 to 16.70%. Variations in craniometric measurements according to sex were not significant for both sites. The results indicate the presence of different ecotypes of European hare in Mediterranean and continental habitats.

Key words: European hare, craniometric analysis, habitat, the island of Vir, North-west Croatia

Introduction

The European hare (*Lepus europaeus* Pall.) is a widespread indigenous game species in Croatia and Europe. Apart from the continental region of Croatia, European hare also

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inhabits all the large Croatian islands (JANICKI et al., 2007). Since the hare is highly prized as a game animal, it is often introduced into areas beyond its natural ranges. Due to the recorded trend of population decline of European hares across Europe over the last 40 years (EDWARDS et al., 2000), relocation of hares was conducted and hunting grounds populated with individuals from other regions with abundant populations. For instance, continental, coastal and island hunting grounds in Croatia were populated with hares from northern Europe. According to zoological taxonomy, the European hare is classified in the taxonomic order Lagomorpha, family Leporidae, genus *Lepus*. The leporids express significant variations of morphological features under the influence of environment and diet (YOM-TOV and GEFFEN, 2006). Due to great variations within genera, some authors assume that the phylogenesis and systematics of hares has not been completely clarified (FLUX, 1983; CHAPMAN and FLUX, 1990; PIERPAOLI et al., 2003; BEN SLIMEN et al., 2008). For instance, CHAPMAN and FLUX (1990) suggest 30 subspecies and HOFFMAN and SMITH (2005) 15 subspecies of *Lepus europaeus*. Historically, subspecies of hares were classified based on the morphological features of the skull and teeth (SUCHENTRUNK et al., 2003; PALACIOS et al., 2008). Besides morphometrics, application of molecular methods over the last years contributed also in elucidating the systematics and distribution of subspecies. XIN (2003) suggests that analysis of skull development between different animal species exposed to different selection pressure can contribute to understanding of geographical variations of particular populations, as well as life history strategies and evolutionary change. Craniometric analysis, in the determination of species and subspecies within the genus *Lepus*, in research into geographic variations of this genus respectively, was applied in Europe by CABON-RACZYNSKA (1964), PALACIOS (1996), SLAMEČKA et al. (1997), RIGA et al. (2001), SHEVCHENKO and PESKOV (2005), PALACIOS et al. (2008), in Asia by HIRAKAVA et al. (1992), XIN (2003), YOM-TOV and GEFFEN (2006), and in North America by BAKER et al. (1978) and NAGORSEN (1985).

In Croatia there are no comprehensive data on the general craniometric features of hares. In the area of the town of Đakovo biometric research into hares was conducted by ROMIĆ (1965), but it did not include comprehensive morphology of the skulls. PINTUR et al. (2006, 2010) and POPOVIĆ et al. (2008) recorded hare body mass in the north-west Croatia region and on the islands of Vir and Brač as part of population research, but they also did not apply the craniometric method.

The aim of this research was to determine the general craniometric features of hare populations in the north-west region of Croatia and the island of Vir, to determine the correlation of these features regarding sex and habitat type, respectively. Accordingly, the aim was to determine the presence of different geographic variations of this species in Croatia. The recorded results were compared with the available craniometric values collected from other populations in the genus *Lepus* in Europe.

Materials and methods

Samples for analysis were collected in the area of the island Vir and in two sites of continental Croatia, Sveta Nedjelja and Zlatar. The island of Vir is Mediterranean habitat, between 0 and 112 metres above sea level. According to the Köppen classification, the climate is classified as *Csa* climate, Mediterranean climate with hot summers (FILIPČIĆ, 1998). Vegetation on the island of Vir consists predominantly of dry Mediterranean grasslands, abandoned agricultural land and various degradation stages of Mediterranean *Quercus ilex* forest and *Pinus halepensis* (TRINAJSTIĆ, 2008). The study areas Sveta Nedjelja and Zlatar are continental habitats, between 120 and 500 metres above sea level. According to the Köppen classification, the climate is classified as *Cfb* climate, mild and humid with warm summers (FILIPČIĆ, 1998). These areas are dominated by agriculture and consist of a mosaic of small field parcels. Arable areas are interspersed by areas of grassland meadow. Hares were sampled during the 2006 and 2007 hunting seasons. Each animal was sexed and aged. Hares were aged by the dry weight of the eye lens (ŠELMIĆ, 1984, PINTUR et al., 2006). Craniometric analysis was conducted on 27 skulls in total, belonging to adults more than 1 year old. Twelve analysed skulls were collected from the area of the island of Vir (6 males and 6 females) and 15 skulls were from the north-west Croatia region (9 males and 6 females).

Following treatment of the skulls and mandibles, craniometric measurements were taken with digital callipers (in millimetres) with two decimals accuracy. Measurements applicable to the genus *Lepus* were used according to VON DEN DRIESCH (1976). On each skull 25 measurements were made (Fig. 1), 19 cranium measurements and 6 mandible measurements. All mandible measurements were taken on the left mandible. Craniometric measures were statistically analysed between the sexes within the same habitat type and between habitat types using the t-test for equality of means. The statistical software program SPSS 17.0 was used to analyse the obtained results.

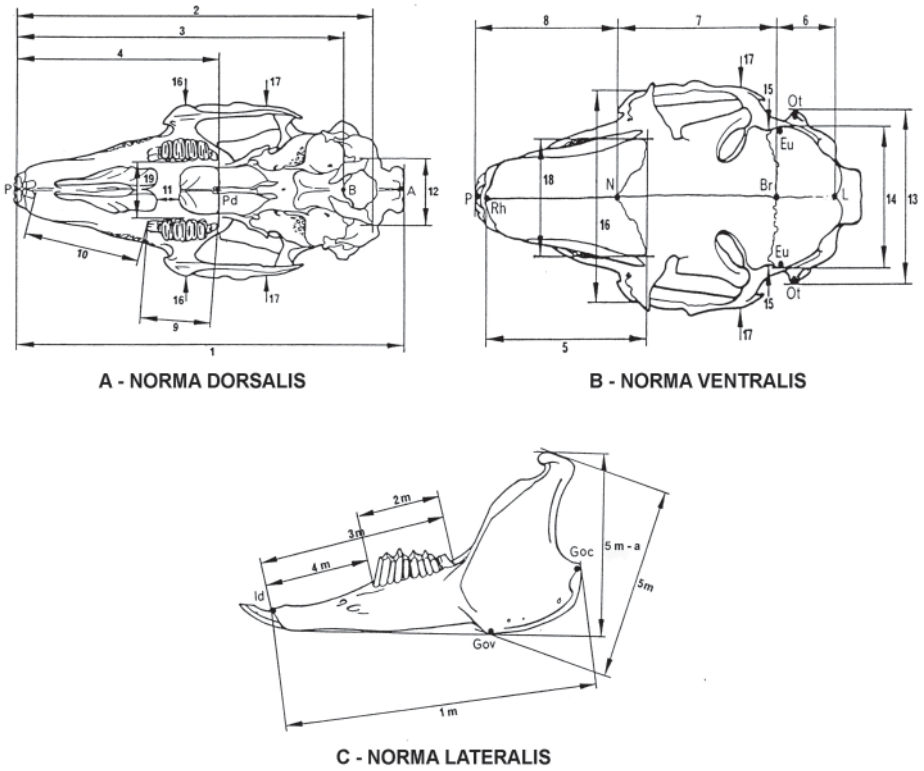

Fig. 1. Measurements of the skull of European hares (VON DEN DRIESCH, 1976)

1. Total skull length; 2. Condylobasal length; 3. Basal length; 4. Dental length; 5. Greatest length of the nasals; 6. Parietal length; 7. Frontal length; 8. Viscerocranium length; 9. Length of the cheektooth; 10. Length of the diastema; 11. Palatal length; 12. Greatest width of the occipital condyles; 13. Greatest width across the openings of the external acoustic meatus; 14. Greatest neurocranium width; 15. Width of skull; 16. Oral zygomatic width; 17. Aboral zygomatic width; 18. Greatest width of the nasals; 19. Palatal width

Mandible measures: 1m. Length from angle to tip (excluding incisors); 2m. Length of the cheektooth row; 3m. Length: aboral border of the alveolus of M3-Infradentale to tip (excluding incisors); 4m. Length of the diastema; 5m. Height of the vertical ramus; 5m-a Height of the vertical ramus.

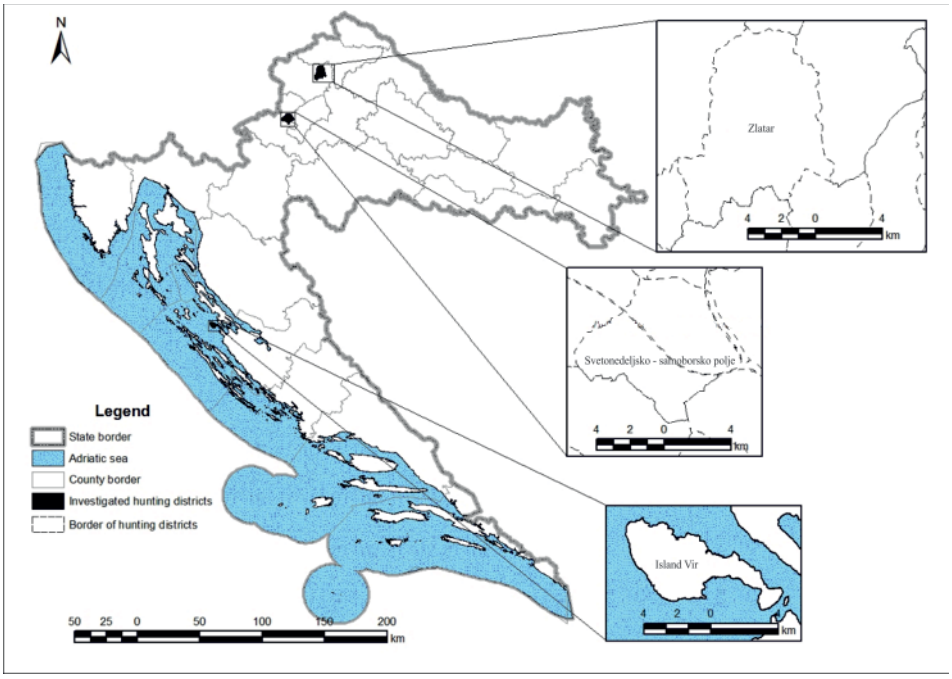

Fig. 2. The habitat locations of the hare populations included in the study

Results

Craniometric analysis of the cranium and mandibles of the hares sampled in the area of north-west Croatia is shown in Table 1, and for the hares sampled in the area of the island of Vir, in Table 2. In these tables for each measurement, according to sex, the following values are shown: minimum, maximum, mean, standard error, standard deviation and p value obtained by *t*-test indicating statistical differences between sexes at $P<0.05$. In Table 3 the mean values of cranium and mandible measurements (for both sexes) are shown according to habitat (north-west Croatia, island of Vir). Each measure, according to site, tends to be greater for hares from north-west Croatia region.

The variations in craniometric measurements according to sex were not significant for both sites. However, the results showed significant variations in skull measurements between hares sampled on the island of Vir and in continental north-west Croatia. Of 19 cranium measurements, 10 measurements indicated statistical differences at $P<0.01$ and 3 measurements indicated statistical differences at $P<0.05$. Of the 6 mandible measurements analysed, 5 indicated statistical differences at $P<0.01$. Cranium measurements that varied

significantly were greater for hares from north-west Croatia by 5.11 to 12.84%, as well as mandible measurements, tending to be greater by 7.18 to 16.70%.

Table 1. Descriptive statistics for the skull measurements of adult European hare from northwest Croatia (results of *t*-test (P))

Measure (mm)	Sex	Mean ± SD	Std. Error	P	Min - Max
1	M	100.9736 ± 2.95160	0.88994	0.985	95.81-105.49
	F	100.9425 ± 1.98398	0.99199		98.32-102.85
2	M	88.6627 ± 2.76206	0.83279	0.690	84.30-92.53
	F	89.2700 ± 1.63567	0.81783		87.41-91.23
3	M	81.1591 ± 2.62641	0.79189	0.949	76.96-84.69
	F	81.0675 ± 1.48399	0.74199		79.20-82.32
4	M	49.6036 ± 1.61966	0.48834	0.568	46.90-52.07
	F	50.1625 ± 1.67444	0.83722		48.17-51.72
5	M	44.3727 ± 2.43128	0.73306	0.611	40.51-47.63
	F	45.0375 ± 0.99027	0.49513		43.81-46.09
6	M	22.0700 ± 2.08683	0.62920	0.753	19.53-24.94
	F	22.4625 ± 2.09182	1.04591		20.56-24.65
7	M	39.7427 ± 3.41255	1.02892	0.275	33.49-43.65
	F	41.8450 ± 2.09604	1.04802		40.00-44.72
8	M	35.0655 ± 2.56696	0.77397	0.250	31.70-40.69
	F	33.3050 ± 2.29151	1.14576		30.87-36.13
9	M	17.3955 ± 0.59942	0.18073	0.999	16.19-18.23
	F	17.3950 ± 0.67323	0.33661		16.73-18.11
10	M	29.8555 ± 0.88310	0.26626	0.387	28.57-30.99
	F	29.3925 ± 0.89656	0.44828		28.47-30.62
11	M	6.3564 ± 0.69916	0.21080	0.925	5.24-7.27
	F	6.3925 ± 0.39970	0.19985		5.81-6.71
12	M	17.2827 ± 0.89389	0.26952	0.566	15.48-18.42
	F	16.9900 ± 0.69618	0.34809		16.36-17.88
13	M	37.1891 ± 1.16439	0.35108	0.708	34.80-38.92
	F	36.9125 ± 1.45225	0.72612		35.29-38.56
14	M	30.8655 ± 1.06868	0.32222	0.806	29.54-32.70
	F	30.6850 ± 1.67080	0.83540		28.54-32.60
15	M	29.0591 ± 1.25355	0.37796	0.478	26.95-30.66
	F	29.5725 ± 1.01536	0.50768		28.43-30.89
16	M	43.6500 ± 1.14383	0.34488	0.152	42.35-45.73
	F	44.7050 ± 1.31769	0.65884		42.73-45.40

Table 1. Descriptive statistics for the skull measurements of adult European hare from northwest Croatia (results of *t*-test (P)) (continued)

Measure (mm)	Sex	Mean ± SD	Std. Error	P	Min. - Max
17	M	46.8682 ± 0.74376	0.22425	0.795	45.42-48.11
	F	46.7550 ± 0.68840	0.34420		45.99-47.63
18	M	21.6082 ± 1.40038	0.42223	0.846	19.45-23.77
	F	21.7550 ± 0.68821	0.34411		20.95-22.44
19	M	14.2073 ± 0.44109	0.13299	0.260	13.50-15.15
	F	13.8825 ± 0.56228	0.28114		13.46-14.71
1m	M	69.7773 ± 2.05081	0.61834	0.409	66.99-74.17
	F	68.8075 ± 1.56327	0.78164		66.48-69.85
2m	M	18.0627 ± 0.89469	0.26976	0.969	16.39-19.57
	F	18.0425 ± 0.83851	0.41925		17.22-19.16
3m	M	41.7191 ± 1.30861	0.39456	0.958	39.65-43.82
	F	41.6775 ± 1.40453	0.70226		39.84-43.04
4m	M	25.4909 ± 6.13183	1.84882	0.563	22.75-43.84
	F	23.6250 ± 0.90142	0.45071		22.29-24.24
5m	M	43.7345 ± 1.37231	0.41377	0.867	41.66-46.74
	F	43.6075 ± 0.92330	0.46165		42.94-44.96
5m-a	M	41.0382 ± 1.59539	0.48103	0.793	38.79-43.74
	F	40.7950 ± 1.44503	0.72251		39.24-42.72

*- 05; **- P<0.01; *- significantly differs (P<0.05), ** - significantly differs (P<0.01)

Table 2. Descriptive statistics for the skull measurements of adult European hare from the island of Vir (results of *t*-test (P))

Measure (mm)	Sex	Mean ± Std. Deviation	Std. Error	P	Min. - Max.
1	M	92.7333 ± 4.14402	2.39255	0.792	88.80-97.06
	F	93.4167 ± 0.66890	0.38619		92.71-94.04
2	M	79.7567 ± 2.94123	1.69812	0.470	77.24-82.99
	F	78.1267 ± 1.97437	1.13990		76.70-80.38
3	M	73.2467 ± 2.56198	1.47916	0.871	70.90-75.98
	F	72.9900 ± 0.20075	0.11590		72.80-73.20
4	M	45.1100 ± 1.47367	0.85082	0.938	43.52-46.43
	F	45.2133 ± 1.60032	0.92395		43.44-46.55
5	M	39.4367 ± 2.44044	1.40899	0.644	37.89-42.25
	F	38.6400 ± 1.29317	0.74661		37.53-40.06
6	M	19.6533 ± 0.05033	0.02906	0.035	19.60-19.70
	F	21.0567 ± 0.77520	0.44756		20.45-21.93

Table 2. Descriptive statistics for the skull measurements of adult European hare from the island of Vir (results of *t*-test (P)) (continued)

Measure (mm)	Sex	Mean ± SD	Std. Error	P	Min. - Max
7	M	39.8033 ± 5.50397	3.17772	0.311	35.45-45.99
	F	36.0700 ± 0.94715	0.54684		35.28-37.12
8	M	31.3000 ± 1.73491	1.00165	0.117	29.37-32.73
	F	33.5167 ± 0.83128	0.47994		32.66-34.32
9	M	16.1100 ± 0.37749	0.21794	0.573	15.71-16.46
	F	15.9333 ± 0.32655	0.18853		15.59-16.24
10	M	26.7033 ± 1.26001	0.72747	0.916	25.44-27.96
	F	26.6067 ± 0.79198	0.45725		26.11-27.52
11	M	5.9000 ± 0.33061	0.19088	0.096	5.61-6.26
	F	5.1967 ± 0.45457	0.26245		4.90-5.72
12	M	16.7967 ± 0.95133	0.54925	0.596	16.00-17.85
	F	16.2700 ± 1.26645	0.73119		14.97-17.50
13	M	35.8333 ± 1.94202	1.12122	0.343	34.49-38.06
	F	34.6033 ± 0.40004	0.23096		34.20-35.00
14	M	31.1700 ± 1.29047	0.74505	0.763	29.69-32.06
	F	30.7533 ± 1.83053	1.05686		28.72-32.27
15	M	29.7533 ± 1.71039	0.98749	0.454	27.78-30.81
	F	28.7600 ± 1.17478	0.67826		27.45-29.72
16	M	39.9700 ± 1.75291	1.01204	0.791	38.03-41.44
	F	39.5000 ± 2.26960	1.31036		36.89-41.01
17	M	44.6800 ± 2.29776	1.32661	0.480	42.45-47.04
	F	43.2833 ± 2.09510	1.20961		41.40-45.54
18	M	20.1900 ± 0.64211	0.37072	0.593	19.65-20.90
	F	19.1433 ± 3.05474	1.76365		15.62-21.05
19	M	13.2533 ± 0.52013	0.30030	0.830	12.74-13.78
	F	13.4133 ± 1.08868	0.62855		12.21-14.33
1m	M	61.7267 ± 1.92251	1.10996	0.884	59.75-63.59
	F	61.9067 ± 0.55940	0.32297		61.48-62.54
2m	M	16.6567 ± 1.07677	0.62167	0.781	16.03-17.90
	F	16.8667 ± 0.57951	0.33458		16.25-17.40
3m	M	37.6400 ± 2.09516	1.20964	0.909	35.25-39.16
	F	37.4800 ± 0.87710	0.50639		36.91-38.49
4m	M	20.8133 ± 1.48042	0.85472	0.943	19.11-21.79
	F	20.7300 ± 1.20403	0.69515		19.36-21.62
5m	M	33.0567 ± 9.83466	5.67805	0.306	21.72-39.30
	F	39.7500 ± 0.98423	0.56824		39.08-40.88

Table 2. Descriptive statistics for the skull measurements of adult European hare from the island of Vir (results of *t*-test (P)) (continued)

Measure (mm)	Sex	Mean ± SD	Std. Error	P	Min. - Max
5m-a	M	36.5900 ± 1.05674	0.61011	0.534	35.50-37.61
	F	37.4633 ± 1.95618	1.12940		36.25-39.72

*- significantly differs (P<0.05), ** - significantly differs (P<0.01)

Table 3. Comparison of mean skull measurements for adult European hares from north-west Croatia and the island of Vir (results of *t*-test (P))

Measure (mm)	Location	N	Mean ± SD	Std. Error	P	Region difference (%)
1	VIR	12	93.0750 ± 2.68109	1.09455	930.000**	7.81%
	NWC	15	100.9653 ± 2.65828	0.68637		
2	VIR	12	78.9417 ± 2.41177	0.98460	0.000**	11.13%
	NWC	15	88.8247 ± 2.46979	0.63770		
3	VIR	12	73.1183 ± 1.63137	0.66601	0.000**	9.88%
	NWC	15	81.1347 ± 2.32397	0.60005		
4	VIR	12	45.1617 ± 1.37706	0.56218	0.000**	9.23%
	NWC	15	49.7527 ± 1.59374	0.41150		
5	VIR	12	39.0383 ± 1.80045	0.73503	0.000**	12.37%
	NWC	15	44.5500 ± 2.12719	0.54924		
6	VIR	12	20.3550 ± 0.91224	0.37242	0.050	8.21%
	NWC	15	22.1747 ± 2.02003	0.52157		
7	VIR	12	37.9367 ± 4.08138	1.66622	0.172	5.87%
	NWC	15	40.3033 ± 3.19150	0.82404		
8	VIR	12	32.4083 ± 1.71885	0.70172	0.070	6.32%
	NWC	15	34.5960 ± 2.54583	0.65733		
9	VIR	12	16.0217 ± 0.33018	0.13479	0.000**	7.90%
	NWC	15	17.3953 ± 0.59479	0.15357		
10	VIR	12	26.6550 ± 0.94274	0.38487	0.000**	10.35%
	NWC	15	29.7320 ± 0.87989	0.22719		
11	VIR	12	5.5483 ± 0.52419	0.21400	0.010*	12.84%
	NWC	15	6.3660 ± 0.61941	0.15993		
12	VIR	12	16.5333 ± 1.04249	0.42560	0.136	3.90%
	NWC	15	17.2047 ± 0.83220	0.21487		
13	VIR	12	35.2183 ± 1.42354	0.58116	0.006**	5.11%
	NWC	15	37.1153 ± 1.19850	0.30945		
14	VIR	12	30.9617 ± 1.43476	0.58574	0.815	-0.47%
	NWC	15	30.8173 ± 1.19197	0.30777		

Table 3. Comparison of mean skull measurements for adult European hares from north-west Croatia and the island of Vir (results of *t*-test (P)) (continued)

Measure (mm)	Location	N	Mean ± SD	Std. Error	P	Region difference (%)
15	VIR	12	29.2567 ± 1.42064	0.57998	0.921	-0.21%
	NWC	15	29.1960 ± 1.18261	0.30535		
16	VIR	12	39.7350 ± 1.83188	0.74786	0.000**	9.55%
	NWC	15	43.9313 ± 1.24089	0.32040		
17	VIR	12	43.9817 ± 2.11018	0.86148	0.000**	6.10%
	NWC	15	46.8380 ± 0.70665	0.18246		
18	VIR	12	19.6667 ± 2.05576	0.83926	0.013*	9.15%
	NWC	15	21.6473 ± 1.22750	0.31694		
19	VIR	12	13.3333 ± 0.76811	0.31358	0.010*	5.58%
	NWC	15	14.1207 ± 0.47835	0.12351		
1m	VIR	12	61.8167 ± 1.27016	0.51854	0.000**	11.08%
	NWC	15	69.5187 ± 1.93000	0.49832		
2m	VIR	12	16.7617 ± 0.78188	0.31920	0.004**	7.18%
	NWC	15	18.0573 ± 0.85000	0.21947		
3m	VIR	12	37.5600 ± 1.43919	0.58755	0.000**	9.95%
	NWC	15	41.7080 ± 1.28307	0.33129		
4m	VIR	12	20.7717 ± 1.20773	0.49305	0.071	16.89%
	NWC	15	24.9933 ± 5.26880	1.36040		
5m	VIR	12	36.4033 ± 7.24679	2.95849	0.001**	16.70%
	NWC	15	43.7007 ± 1.23743	0.31950		
5m-a	VIR	12	37.0267 ± 1.48531	0.60638	0.000**	9.63%

Explanatory notes: NWC - North-west Croatia (Sveta Nedelja, Zlatar); VIR - the Island of Vir, *- significantly differs (P<0.05), ** - significantly differs (P<0.01)

Discussion

The European hare is a widespread species in Croatia. Besides the northern regions of the country it also inhabits the southern regions, where it is also recorded on Adriatic islands.

Population studies of European hare in Croatia by PINTUR et al. (2006, 2010), within the study areas on the island of Vir and the region of north-west Croatia, demonstrated that hare body mass was greater in the region of north-west Croatia. PINTUR et al. (2010) recorded that the mean body mass of adult males in the island of Vir was 2.87 kg and of adult females 3.09 kg, while mean hare body mass was significantly greater in the region of north-west Croatia, with values of 3.84 kg for adult males and 3.66 for females (PINTUR et al., 2006).

Led by these data, in this paper, the craniometric features of European hare (*Lepus europaeus*) from the same study areas were analysed, with the aim of confirming the presence of different morphological variations in Croatia.

Craniometric analysis is a frequently used method in research of different species within a genus *Lepus* (PALACIOS, 1996; RIGA et al., 2001; SUCHENTRUNK et al., 2007), as well as in research of morphological variations within a species. Morphological variation was confirmed by HIRAKAWA et al. (1992) for the *Lepus brachyurus* in Japan, by BAKER et al. (1978) for the *Lepus arcticus* in North America, by ANGERBJÖRN and FLUX (1995) for the *Lepus timidus* in Scandinavia and Russia, by SLAMEČKA et al. (1997) for the *Lepus europaeus* in Slovakia, and by SHEVCHENKO and PESKOV (2005) in Ukraine respectively.

Data do not exist on morphological variations of the European hare (*Lepus europaeus*) in Croatia and they are also scarce for Europe. The results of this research showed significant variations in skull measurements between hares sampled on the island of Vir and in continental north-west Croatia, tending to be greater for hares from the north-west Croatia region. Ten measurements indicated statistical differences at $P<0.01$ and 3 measurements indicated statistical differences at $P<0.05$. Of the 6 mandible measurements analysed, 5 indicated statistical differences at $P<0.01$ (Table 3). Four measurements: condylobasal length, greatest length of the nasals, length of the diastema and palatal length, were greater for hares from north-west Croatia by more than 10% (Table 3). The values of only two measurements, greatest neurocranium width and width of skull, were slightly greater for hares from the island of Vir, but these variations were not significant. Mandible measurements were greater by 7.18 to 16.7% for hares from the north-west Croatia region (Table 3). Compared to some basic craniometric measurements recorded in Slovakia (east Slovakia in particular) by SLAMEČKA et al. (1997), values from the north-west Croatia region are very similar, while greater than the values recorded on the island of Vir. For instance, the recorded total length in eastern Slovakia was 101.14 mm, in north-west Croatia 100.96 mm, and on the island of Vir 93.07 mm. The recorded value of aboral zygomatic breadth for eastern Slovakia hares was 46.50 mm, for hares from north-west Croatia 46.83 mm and on the island of Vir 43.98 mm. Similarity between hares in Slovakia and north-west Croatia may be explained by the similar climate and habitat conditions. TEZ et al. (2012) determined craniometric features of the *Lepus europaeus* from the Asian part of Turkey. The observed total length in Turkey (78.76 mm) was significantly smaller than the total length recorded on the island of Vir, while observed values of aboral zygomatic breadth (43.78 mm) were very similar to the recorded value for hares from the island of Vir.

SHEVCHENKO and PESKOV (2005) conducted craniometric analysis of the hares from Ukraine. The basic craniometric measurement of total length was 99.00 mm for the hares from Ukraine and aboral zygomatic width varied from 45.25 to 47.25 mm. These values

are similar to those recorded for hares from the north-west Croatia region. PALACIOS (1996) determined a mean value of the total length of the *Lepus europaeus* from Italy of 97.67 mm and an aboral zygomatic width of 45.50 mm, which are smaller than the values recorded for hares from the north-west Croatia region, but greater than those recorded for hares from the island of Vir. These results suggest that craniometric measurement values decrease with latitude, from north to south of the European continent.

The results of the craniometric analysis conducted also indicated that the sex of the hares could not be distinguished by this method, which was also recorded by previous authors (SLAMEČKA et al., 1997; RIGA et al., 2001).

Variations of morphological features might reflect genetic variations, but considering habitat type, we suggest that variations of morphological features are caused by species adaptation to climatic conditions and habitat type. The observed patterns of morphological variation in hares is described here by Bergmann's rule, which has been reported by BAKER et al. (1978) and YOM-TOV and GEFFEN (2006). The demonstrated results confirm the exceptional adaptability of the *Lepus europaeus* to ecological conditions in its habitat.

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PINTUR, K., N. DANČEVIĆ, I. ŠTEDUL, N. POPOVIĆ, V. SLIJEPČEVIĆ: Kraniometrijske značajke zeca običnog (*Lepus europaeus* Pall.) s područja sjeverozapadne Hrvatske i otoka Vira. Vet. arhiv 84, 387-400, 2014.

SAŽETAK

Porodica zečeva (*Leporidae*) sposobna je pod utjecajem okoliša i načina prehrane očitovati znatne razlike morfoloških obilježja. Cilj ovoga istraživanja je kraniometrijska analiza zečeva (*Lepus europaeus* Pall.) s dva različita tipa staništa, kako bi se potvrdilo postojanje različitih morfoloških varijacija (ekotipova) ove vrste u Hrvatskoj. Zečevi su uzorkovani na području otoka Vira (mediteransko stanište) i sjeverozapadne Hrvatske (kontinentalno stanište). Kraniometrijska mjerenja su provedena na 27 lubanja odraslih zečeva, 12 ženskog i 15 muškog spola. Dvanaest lubanja potječe s područja otoka Vira, a 15 s područja sjeverozapadne Hrvatske. Na svakoj lubanji je izmjereno 25 mjera, od čega 6 na donjoj čeljusti. Rezultati istraživanja pokazali su statistički značajne razlike između veličine lubanja zečeva koji žive na otoku Viru i onih koji potječu s kontinentalnog dijela sjeverozapadne Hrvatske. Od 19 mjera lubanje, 10 mjera pokazalo je razliku na razini značajnosti $P<0,01$, 3 mjere pokazale su razliku na razini značajnosti $P<0,05$, a od 6 analiziranih mjera mandibule, 5 ih je bilo na razini značajnosti $P<0,01$. Mjere lubanje koje su pokazale statistički značajnu razliku bile su veće na području sjeverozapadne Hrvatske od onih s područja otoka Vira od 5,11 - 12,84%, dok su mjere donje čeljusti bile veće na području sjeverozapadne Hrvatske 7,18 - 16,70 %. Nije utvrđena statistički značajna razlika između kraniometrijskih karakteristika među spolovima unutar istog staništa. Rezultati istraživanja govore da na otoku Viru obitava drugačiji ekotip zeca od onog na kontinentu.

Ključne riječi: zec obični, kraniometrija, stanište, otok Vir, sjeverozapadna Hrvatska