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MORPHOMETRIC CHARACTERISTICS OF THE GOLDEN JACKAL POPULATIONS IN EASTERN CROATIA AND EASTERN SERBIA

SUMMARY

The aim of the present study was to test whether there are morphological differences between individuals of the golden jackal (*Canis aureus* L.) from two distant populations living in eastern Croatia and eastern Serbia. Measurements of 28 morphometric characters were done on total of 82 male and female individuals, of which 66 from eastern Croatia and 16 from eastern Serbia. Based on performed data analyses it was confirmed that difference in body morphology exists between populations of the golden jackal from eastern Croatia and eastern Serbia. Individuals from eastern Serbian population are characterized in significantly higher values for: total body length, median ear span, lateral ear span, lateral eye span and neck circumference. Individuals from eastern Croatian population are characterized in higher values for: height at withers, ear length, median eye span, front paw length and carpometacarpal length. Head length was significantly longer in males than in females in both studied populations.

Keywords: morphology, golden jackal, population, Croatia, Serbia

INTRODUCTION

The golden jackal (*Canis aureus* Linnaeus, 1758) is a carnivorous mammal which has been a resident wild species in the middle and south-east Europe by the beginning of the 20th century when its population declined and become extinct, mainly caused by habitat disturbances and persecution of mammal predators (Demeter and Spassov 1993). Small and scattered populations survived during the course of last 50 years around the Black Sea region and in Greece, Albania, Montenegro and southern Dalmatia in Croatia (Kryštufek and Tvrtković 1990). In the recent 25 years the golden jackal is in rapid biological expansion across Europe (Arnold et al. 2012).

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New populations have been established in Turkey, Ukraine, Romania, Serbia, eastern Croatia (Bošković *et al.* 2013), Hungary (Szabo *et al.* 2009), Slovenia, Austria (Hoi-Leitner and Kraus 1989) and Italy (Lapini *et al.* 2011), while single individuals were reported from Slovakia (Hell and Raysky 2000) and Czech Republic (Koubek and Červený 2007). Studies on external morphology of the golden jackal residing in Europe were occasional (Kryštufek and Tvrtković 1990, Lapini *et al.* 1993, Giannatos 2004, Krofel and Potočnik 2008, Bošković, 2012) and are still insufficient. Therefore, the main objective of this research was to describe and compare specific morphometric characteristics of the golden jackal originated from two geographically distant populations in eastern Croatia and eastern Serbia.

MATERIAL AND METHODS

Research was carried out on individuals of the golden jackal which were acquired by legal hunt in the period 2008-2011, in selected hunting grounds located in eastern Croatia and eastern Serbia. Morphometric measurements were done on total of 82 male and female individuals, of which 66 from eastern Croatia and 16 from eastern Serbia. Individuals were identified according to sex and age of the animal was estimated on the basis of tooth wear and replacement (Lombaard 1971, Rouichová and Andera 2007). All measurements of total 28 morphometric parameters were done from the right side of the animal by using measuring tape with accuracy ± 1 mm. Following morphometric parameters had been measured, acronyms for which are given in parenthesis:

- 1) Total body length (TBL)
- 2) Head length (HEL)
- 3) Tail length (TAL)
- 4) Trunk length (TRL)
- 5) Height at withers (HEW)
- 6) Length of the cranial part of head (LCH)
- 7) Length of the facial part of the head (LFP)
- 8) Median ear span (MES)
- 9) Lateral ear span (LES)
- 10) Ear length (EAL)
- 11) Median eye span (MEY)
- 12) Lateral eye span (LEY)
- 13) Neck circumference (NEC)
- 14) Chest circumference (CHC)
- 15) Elbow height (ELH)
- 16) Humerus length (HUL)
- 17) Forearm length (FAL)
- 18) Femur height (FEH)
- 19) Hip height (HIH)
- 20) Lower leg length (LLL)
- 21) Front paw length (FPL)

- 22) Front paw width (FPW)
- 23) Carpometacarpal length (CML)
- 24) Carpometacarpal circumference (CMC)
- 25) Hind paw length (HPL)
- 26) Hind paw width (HPW)
- 27) Tarsometatarsal circumference (TMC)
- 28) Hock joint height (HJH).

The differences between group means for morphometric parameters were determined by the analysis of variance (ANOVA) using general linear module (GLM) and Tukey post hoc analysis test.

RESULTS AND DISCUSSION

The results of the measurements done on individuals of the golden jackal from populations in eastern Croatia and east Serbia are presented in Table 1.

Table 1. The mean value (cm) and standard deviation of morphometric measurements of the golden jackal from populations in eastern Croatia and eastern Serbia

Mea- sure	Population				Influence / P		
	Eastern Croatia		Eastern Serbia				
	Male	Female	Male	Female			
	\bar{x} SD				Location (L)	Sex (G)	L x G
TBL	82.96 ^a ± 7.40	80.86 ^a ± 6.82	88.33 ^b ± 3.27	89.85 ^b ± 4.74	<0.0001	0,87	0.33
HEL	19.26 ^a ± 0.84	18.59 ^b ± 0.96	19.77 ^a ± 2.53	17.57 ^b ± 1.71	0.48	<0.0001	0.03
TAL	24.53 ± 1.49	24.17 ± 1.44	24.11 ± 1.61	23.14 ± 1.77	0.09	0.12	0.48
TRL	54.83 ± 6.48	52.44 ^a ± 5.85	58.88 ± 1.96	57.85 ^b ± 1.46	0.003	0,28	0.67
HE W	50.55 ^a ± 2.24	47.82 ^a ± 3.20	47.50 ^b ± 2.66	44.42 ^b ± 2.81	<0.0001	<0.0001	0.82
LCH	10.16 ± 0.59	9.85 ± 0.52	10.96 ^a ± 1.17	9.40 ^b ± 0.96	0.38	<0.0001	0.002
LFP	9.10 ± 0.45	8.74 ± 0.55	8.92 ^a ± 1.60	8.17 ± 0.83	0.07	0.01	0.35
MES	7.58 ^a ± 0.38	7.32 ^a ± 0.73	8.78 ^b ± 1.11	8.17 ^b ± 1.34	<0.0001	0.04	0.40
LES	12.68 ^a ± 1.08	11.85 ^a ± 0.73	14.77 ^b ± 1.78	15.14 ^b ± 1.34	<0.0001	0.46	0.06
EAL	7.97 ± 0.24	7.90 ± 0.29	7.77 ± 0.36	7.65 ± 0.43	0.01	0.27	0,75

Mea- sure	Population				Influence / P		
	Eastern Croatia		Eastern Serbia				
	Male	Female	Male	Female			
	\bar{x} SD				Location (L)	Sex (G)	L x G
MEY	3.82 ^a ± 0.23	3.65 ± 0.30	3.50 ^b ± 0.55	3.50 ± 0.57	0.02	0.39	0.40
LEY	6.72 ^a ± 0.70	6.35 ^a ± 0.57	7.77 ^b ± 0.56	7.28 ^b ± 0.90	<0.0001	0.03	0.74
NEC	31.15 ^a ± 2.37	28.56 ^b ± 2.64	32.55 ± 1.87	30.57 ± 2.43	0.016	0.0015	0.667
CHC	49.50 ± 4.71	47.37 ± 4.71	48.38 ± 2.86	48.14 ± 2.73	0.88	0.34	0.45
ELH	26.88 ± 1.37	25.35 ± 1.62	26.41 ± 1.63	26.64 ± 0.89	0.33	0.12	0,038
HUL	13.93 ± 0.89	13.95 ± 1.31	13.83 ± 1.36	14.00 ± 0.86	0.94	0.77	0.82
FAL	15.30 ± 0.85	15.12 ± 1.32	14.94 ± 1.23	15.50 ± 1.00	0.98	0.55	0.25
FEH	17.62 ± 0.66	17.18 ± 1.37	17.16 ± 1.58	18.28 ± 1.38	0.34	0.31	0.02
HIH	48.78 ^a ± 2.76	47.34 ^b ± 3.34	49.33 ± 2.12	47.28 ± 2.98	0.77	0.041	0.71
LLL	15.33 ^a ± 0.81	14.77 ^b ± 0.94	15.22 ± 1.82	14.28 ± 2.09	0.37	0.028	0.57
FPL	5.52 ± 0.14	5.43 ± 0.25	5.25 ± 0.31	5.57 ± 0.53	0.38	0.14	0.007
FPW	3.51 ± 0.18	3.45 ± 0.19	3.62 ± 0.24	3.51 ± 0.03	0.14	0.13	0.64
CML	7.62 ^a ± 0.48	7.68 ^a ± 0.46	6.71 ^b ± 0.65	6.07 ^b ± 0.53	0.0001	0.04	0.017
CMC	8.45 ± 0.53	8.18 ± 0.53	8.53 ± 0.41	8.25 ± 0.31	0.60	0.06	0.98
HPL	4.99 ± 0.16	4.85 ± 0.33	5.00 ± 0.27	4.88 ± 0.20	0.82	0.08	0.85
HPW	3.25 ± 0.27	3.14 ± 0.20	3.37 ± 0.31	3.40 ± 0.38	0.02	0.57	0.39
TMC	7.92 ± 0.30	7.80 ± 0.43	7.77 ± 0.34	7.61 ± 0.29	0.11	0.18	0.81
HJH	14.08 ^a ± 0.54	13.76 ^b ± 0.73	15.22 ± 1.09	14.68 ± 0.62	0.77	0.04	0.72

P<0.01= 99% significance, P <0.05= 95% significance, letters ^{a,b} indicates statistical significance for the given value

Total body length (TBL) of males was 82.96 cm in eastern Croatian and 88.33 cm in eastern Serbian population. Hadžipavlović (2008) reported 98 cm from Serbia, while Lapini et al. (2009) reported 82 cm from Italy. In females, total body length was 80.86 cm in eastern Croatian and 89.95 cm in eastern Serbian population. We have found that parameter of total body length for female individuals of the golden jackal was significantly ($P<0.01$) higher in eastern Serbian than in eastern Croatian population.

Head length (HEL) was significantly ($P<0.01$) longer in males, related to females, in both studied populations, which corresponds to results reported by Hadžipavlović (2008). Tail length (TAL) in golden jackals from eastern Croatian population was 24.53 cm in males and 24.17 cm in females, while it was 24.11 cm in males and 23.14 cm in females from eastern Serbian population. Statistical significance between studied populations was not confirmed. Previous studies reported the same value of 24 cm from Croatia (Kryštufek and Tvrtković 1990) and Slovenia (Krofel and Potočnik 2008), 20-30 cm from Hungary (Tóth et al 2010), while Demeter and Spassov (1993) reported value of 25 cm.

Trunk length (TRL) in males was longer (58.88 cm) in eastern Serbian population, related to 54.83 cm in eastern Croatian population, but without any statistical significance. A value of 79 cm was reported from Slovenia (Krofel and Potočnik 2008). Females from eastern Serbian population had significantly ($P<0.01$) longer trunk (57.85 cm) related to 52.44 cm in females from eastern Croatian population.

Height at withers (HEW) recorded in the present study was 50.55 cm for males and 47.82 cm for females in eastern Croatian population, and in eastern Serbian population it was 47.50 cm for males and 44.42 cm for females. We have found that parameter of height at withers in both sexes was significantly ($P<0.01$) higher in eastern Croatian, related to eastern Serbian population. Previous studies reported for height at withers in male of the golden jackal values of 48.91 cm in Serbia (Hadžipavlović 2008) and 55 cm in Italy (Lapini et al. 2009), while for female it was reported 45.22 cm in Serbia (Hadžipavlović 2008) and 49 cm in Slovenia (Krofel and Potočnik 2008).

Length of the cranial part of head (LCH) was longer in males than in females from both studied populations of the golden jackal, which was confirmed with higher statistical significance ($P<0.01$). Length of the facial part of the head (LFP) was also significantly longer ($P<0.05$) in males than in females from both populations.

Median ear span (MES) was statistically significantly higher ($P<0.01$) in all individuals from eastern Serbian population related to eastern Croatian population. It was also higher in male than females in both studied populations, but with less statistical significance ($P<0.05$), which corresponds to results reported from Serbia (Hadžipavlović 2008). Lateral ear span (LES) was statistically significantly higher ($P<0.01$) in all individuals from eastern Serbian population than in eastern Croatian population, while the effect of sex on this character was out of importance.

Ear length (EAL) was statistically higher ($P < 0.05$) in all individuals from eastern Croatian than from eastern Serbian population. Relation between sex and ear length was not found. Obtained values for ear length corresponds to results from Serbia (Hadžipavlović 2008), while the value of 8 cm was reported from Slovenia (Krofel and Potočnik 2008) and 9.5 cm from Italy (Lapini et al. 2009).

Median eye span (MEY) was significantly higher ($P < 0.05$) in the golden jackals from eastern Croatian population, related to eastern Serbian population. The sex does not effect on this character. Oppositely, lateral eye span (LEY) was significantly higher ($P < 0.01$) in eastern Serbian population, while it was higher ($P < 0.05$) in males compared to females from both studied populations.

Neck circumference (NEC) was statistically significantly higher ($P < 0.05$) in eastern Serbian than in eastern Croatian population, being highly significant ($P < 0.01$) in males than in females in both populations. Results obtained correspond to values of 35.5 cm in male and 33 cm in female, reported from Serbia (Hadžipavlović 2008). Chest circumference (CHC) was 49.5 cm in males and 47.37 cm in females from eastern Croatian population, while it was 48.38 cm in males and 48.14 cm in females from eastern Serbian population. Previous studies reported 51.33 cm in males from Serbia (Hadžipavlović 2008) and 44.5 cm from Italy (Lapini et al. 2009), and in females, value of 51.5 cm was reported from Serbia (Hadžipavlović 2008) and 51 cm from Slovenia (Krofel and Potočnik 2008). Chest circumference was higher in males than in females from both studied populations but without any statistical difference related to sex.

Values measured for the morphometric parameters: elbow height (ELH), humerus length (HUL), forearm length (FAL) and femur height (FEH) were slightly higher in males than in females from both studied populations, but without any statistical significance. Hip height (HIH) and lower leg length (LLL) were statistically significantly higher ($P < 0.05$) in males than in females from both studied populations.

Front paw length (FPL) was statistically significantly higher ($P < 0.01$) in individuals of both sexes from eastern Croatian population, compared to east Serbian population, being significantly higher ($P < 0.05$) in males than in females.

Values for front paw width (FPW), hind paw length (HPL) and hind paw width (HPW) in males and females were equal in both studied populations of the golden jackal, without any statistically significant differences. Obtained values correspond to those reported from Serbia, Slovenia and Italy (Hadžipavlović 2008, Krofel and Potočnik 2008, Lapini et al. 2009).

Carpometacarpal length (CML) was statistically significantly higher ($P < 0.01$) in males and females from eastern Croatian populations, related to eastern Serbian population. Carpometacarpal circumference (CMC) was slightly higher in males than in female in both studied populations, but without statistical significance between two studied populations.

Tarsometatarsal circumference (TMC) was higher in males than in females in both studied populations, but without any statistical significance.

Hock joint height (HJH) was statistically significantly higher ($P < 0.05$) in males than in females in both studied populations, which corresponds to results from Serbia (Hadžipavlović 2008).

CONCLUSIONS

Morphometric study and comparison of data obtained by measuring 28 morphometric parameters points out certain differences between individuals of the golden jackal from populations in eastern Croatia and eastern Serbia. Individuals from eastern Serbian population are characterized in significantly higher values for: total body length, median ear span, lateral ear span, lateral eye span and neck circumference. Individuals from eastern Croatian population are characterized in higher values for: height at withers, ear length, median eye span, front paw length and carpometacarpal length. Females from eastern Serbian population had significantly longer trunk than females from eastern Croatian population. Head length was significantly longer in males than in females in both studied populations. Low statistical difference was found in morphometric parameters set up for limbs in individuals from both populations. Differences can be attributed to various diet conditions of individuals, food sources availability and habitat suitability in both surveyed areas.

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