Correlation of morphological parameters of donkey from Austria

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Abstract

The donkey, as a work animal, is gradually losing its value. Agriculture industrialization, mechanization of many processes on mountain and valley farms have lead to a reduction of donkey livestock. This reduction gives cause for concern, and is good reason to study all aspects of these domestic animals in order to revive its role, to restart livestock growth in its familiar habitats, and to introduce it into new environments. This study focuses on these aspects. The domestic donkey (*Equus asinus*) originated from Africa, and there are two kinds of African donkeys: Nubian and Somali. Their enormous, almost mystical, endurance is well known. There is no place in the world where a donkey is not able to perform the most difficult work, above all in transporting goods. A donkey has an amazing capability of stable movement through the most difficult places. For study sample consisted of 44 donkeys (28 males and 16 females) from Austria. The following morphometric parameters were analysed: height at the withers, height at the back, height of the croup, body length, chest depth, chest width, chest circumference anterior, chest circumference posterior, shin circumference, head length, skull length, face length, skull width, face width, length of ears. Measurements were performed using a ruler, tape measure and vernier callipers. The average height at the withers of males was 116.40 cm, ranging from 99.60 to 140.60 cm, while for females, the average was 102.38 cm, ranging from 90.50 to 125.70 cm. Body length of males was on average 121.85 cm with a standard deviation of 11.79, while the mean body length for females is 115.80 cm, with a range of 101.00 to 131.00 cm. Male head length ranged from 48.00 to 71.00 cm, with an average of 55.60 cm, while in females, head length was on average 50.06 cm, ranging from 43.00 to 56.00 cm. Using the Pearson correlation, a very significant or significant positive statistical correlation was observed between almost all parameters of males, while for females, Pearson correlation values had slightly different values than for males. There was no statistically significant correlation between chest width and anterior chest circumference with nearly any other parameters. For females, a negative correlation between the skull width and all other parameters was also observed.

Key words: *donkey; morphometry; correlation*

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Introduction

The donkey, as a labour animal, is gradually losing its value. Agriculture industrialization, mechanization of many processes on mountain and valley farms have led to reductions in donkey livestock, which is cause for concern. This is good reason to study all the aspects of these domestic animals in order to revive their role, to restart its livestock growth in familiar habitats, and to introduce them into new environments. This study focuses on the aspects above.

The domestic donkey (*Equus asinus*) comes from Africa, and there are two kinds of African donkeys: Nubian and Somali. Their enormous, almost mystical endurance, is well known. There is no place in the world where a donkey is not able to perform the most difficult work, above all in the transportation of goods. The donkey has an amazing capability of stable movement through the most difficult places.

To date, examination of exterior traits has been performed on multiple populations in several countries. In Italy, the basic morphological parameters of the Amiata donkey breed in Tuscany province were (Orlandi et al., 1997; Casini et al., 2007). There is also research on the morphological characteristics of donkeys in the Turkish region of Igdir (Yilmaz and Ertugrul, 2011). On the Adriatic islands, the donkey was a basic working animal. The morphological characteristics of donkeys on the island of Mljet were studied almost 60 years ago (Essert, 1959). The Baroque donkey is one of the rarest donkey races in the world. The first study on the morphological characteristics of this breed was published in 2019 (Urosevic et al., 2019). The external characteristics of donkeys in the Kabylie area of Algeria are reported in a 2019 study (Ayad et al., 2019). Ebangi and Vall (2005) report the basic morphological parameters of donkeys in Cameroon, in the Sudan-Sahel region. Donkey body conformation tests were also performed in northwestern and central Ethiopia (Tsega and Lemma, 2015). In Turkey, studies were conducted on several donkey populations. The populations in western Turkey (Urosevic et al., 2016), and in southern and southeastern Turkey (Yilmaz and Trevor Wilson, 2013) have been examined. The structure of the Primorsko-Dinaric donkey has been well researched in Croatia (Ivanković et al., 2000).

The morphometric characteristics of donkeys in northwestern Nigeria were studied by John et al. (2017). In Spain, the population of Catalan donkeys was examined (Polch and Jordana, 1997). Đermanović et al. (2013) studied the morphometry of young donkeys, up to two years old, in southern Serbia. The exterior traits of domestic donkey in southeastern Serbia were reported by Trailović et al. (2011). Extensive research has been done by Vlaeva et al. (2016) on the morphological traits of donkeys in Bulgaria. The relationship of head length with ridge height was studied in Romania, Northern Macedonia and Turkey by Urosevic et al. (2015). The morphological characteristics of donkeys in the Czech Republic are reported by Kostukova et al. (2015). The group of great donkeys includes donkeys of the Italian Romagnolo breed, which were studied by Beretti et al. (2005). The morphological features of Hasavi donkeys, an indigenous breed in the eastern province of Saudi Arabia were reported by Shawaf et al. (2016).

Materials and methods

The study sample consisted of 44 donkeys (28 males and 16 females) from Austria. The following morphometric traits were analysed: height at the withers (WH), height at the back (BH), height of the croup (CH), body length (BL), chest

depth (CD), chest width (CW), chest circumference anterior (CCA), chest circumference posterior (CCP), shin circumference (SC), head length (HL), skull length (SL), face length (FL), skull width (SW), face width (FW), length of ears (EL). All measurements were performed using a ruler, tape measure and vernier callipers.

The data were first processed by descriptive statistics by gender, and Pearson's correlation method was used to determine the dependence among the measured parameters. The data collected were processed using Statistical Package for the Social Sciences (SPSS) software for Windows Release 17.0.0.

Results

The results of descriptive statistics for males (Table 1) show that the average height at the withers is 116.40 cm, with a range from 99.60 to 140.60 cm. The back height averages 113.25 cm with a standard deviation of 11.52. The croup is taller than the height of the withers, with a minimum height of 100.20 cm, and maximum height of 144.10 cm, and an average height of 118.02 cm. The body length of males is on average 121.85 cm with a standard deviation of 11.79. Chest depth varies from 45.00 to 63.00 cm with an average value of 51.44 cm, and chest width averages 29.08 cm. The anterior circumference of the chest varies from 106.00 to 161.00 cm, while the posterior circumference of the chest varies from 118.00 to 194.00 cm. The circumference of the shin averages 15.07 cm with a standard deviation of 1.98 cm. The length of the head is from 48.00 to 71.00 cm, with an average value of 55.60 cm. The mean length of the face is 29.78 cm, and mean length of the cranial part is 25.82 cm. The width of the cranial part is from 21.00 to 26.00 cm, and the width of the face varies from 10.00 to 17.00 cm. The mean length of the ears is 25.96 cm.

In females, the height of the withers varies between 90.50 and 125.70 cm, with an average height of 102.38 cm, with a standard deviation of 8.28 and a standard error of 2.07. The height of the back is

Table 1. Descriptive Statistics – Males

Parameter	N	Minimum	Maximum	Mean		Std. Deviation
		(cm)	(cm)	(cm)	Std. Error	(cm)
WH	28	99.60	140.60	116.40	2.22	11.75
BH	28	96.40	139.50	113.25	2.18	11.53
CH	28	100.20	144.10	118.02	2.28	12.08
BL	28	103.00	146.00	121.85	2.23	11.80
CD	27	45.00	63.00	51.44	1.03	5.35
CW	27	20.00	38.70	29.08	0.99	5.13
CCA	25	106.00	161.00	126.52	2.90	14.51
CCP	28	118.00	194.00	147.75	3.28	17.35
SC	28	12.00	20.00	15.07	0.37	1.98
HL	28	48.00	71.00	55.61	1.04	5.49
SL	28	23.00	30.00	25.82	0.35	1.87
FL	28	23.00	42.00	29.79	0.83	4.37
SW	28	21.00	26.00	22.93	0.29	1.51
FW	28	10.00	17.00	13.11	0.38	1.99
EL	28	20.00	31.00	25.96	0.56	2.94

Table 2. Descriptive Statistics – Females

Parameter	N	Minimum	Maximum	Mean		Std. Deviation
		(cm)	(cm)	(cm)	Std. Error	(cm)
WH	16	90.50	125.70	102.38	2.07	8.29
BH	16	91.20	121.50	99.68	1.84	7.37
CH	16	94.70	128.80	106.27	1.99	7.97
BL	16	101.00	131.00	115.80	2.01	8.03
CD	16	41.00	59.30	47.40	1.41	5.63
CW	16	20.10	40.80	28.21	1.46	5.84
CCA	16	101.00	145.00	119.94	2.92	11.68
CCP	10	127.00	165.00	149.40	3.26	10.31
SC	16	12.00	17.00	13.28	0.33	1.32
HL	16	43.00	56.00	50.06	0.81	3.23
SL	16	22.00	26.00	23.93	0.35	1.39
FL	16	21.00	31.00	26.12	0.63	2.53
SW	16	20.00	25.00	22.31	0.37	1.49
FW	16	8.00	16.00	11.84	0.43	1.71
EL	16	21.00	31.00	24.09	0.60	2.42

99.68 cm on average, with a standard deviation of 7.37. The height of the croup in females is from 94.70 cm to 128.80 cm. Body length is from 101.00 to 131.00 cm, with a mean length of 115.80 cm. The mean chest depth is 47.40 cm, and average width is 28.21 cm. The anterior chest circumference varies from 101.00 to 145.00 cm, and the posterior chest circumference is from 127.00 to 165.00 cm. The mean circumference of the shin is 13.28 cm with a standard deviation of 1.31 cm. The length of the head in females varies from 43.00 to 56.00 cm, with an average head length of 50.06 cm and standard deviation of 3.23. The mean length of the cranial part is 23.93 cm, and mean length of the facial part is 26.12 cm. The width of the skull ranges from 20.00 to 25.00 cm, and the width of the facial part ranges from 8.00 to 16.00 cm. The length of ears in females ranges from 21.00 to 31.00 cm.

Using the Pearson correlation, a very significant or significant positive statistical correlation was observed between almost all parameters in males (Table 3). However, no statistically significant correlation was observed between cranial width and withers height, back height, croup height, body length, chest depth, anterior chest circumference, cranial length of the head, ear length.

For females, Pearson correlation values have slightly different values than for males (Table 4). There was no statistically significant correlation between chest width and anterior chest circumference with other parameters. For chest width and anterior chest circumference, a significant statistical correlation was only observed with body length, anterior and posterior chest circumference, and chest depth. In females, a negative correlation was observed between the width of the cranial part and all other parameters. However, this negative correlation was not statistically significant, except for the ratio of the width of the cranial part and the posterior circumference of the chest. Among all other parameters in females, a very significant or significant statistical value of the positive correlation of the measured parameters was recorded.

Table 3. Pearson correlation values in males

		WH	BH	CH	BL	CD	CW	CCA	CCP	SC	HL	SL	FL	SW	FW	EL
WH	Pearson Correlation	1	0.98**	0.96**	0.88**	0.87**	0.49**	0.59**	0.76**	0.83**	0.86**	0.60**	0.82**	0.63**	0.26	0.84**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.010	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.183	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
BH	Pearson Correlation	0.98**	1	0.97**	0.84**	0.87**	0.47*	0.56**	0.77**	0.82**	0.84**	0.63**	0.78**	0.61**	0.27	0.82**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.012	0.003	0.000	0.000	0.000	0.000	0.000	0.001	0.168	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
CH	Pearson Correlation	0.96**	0.97**	1	0.83**	0.87**	0.48*	0.57**	0.82**	0.82**	0.86**	0.65**	0.80**	0.59**	0.29	0.81**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.012	0.003	0.000	0.000	0.000	0.000	0.000	0.001	0.138	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
BL	Pearson Correlation	0.88**	0.84**	0.83**	1	0.88**	0.52**	0.59**	0.72**	0.75**	0.81**	0.57**	0.77**	0.64**	0.20	0.76**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.005	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.325	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
CD	Pearson Correlation	0.87**	0.87**	0.87**	0.88**	1	0.71**	0.57**	0.86**	0.80**	0.86**	0.64**	0.81**	0.61**	0.35	0.76**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.001	0.070	0.000
	N	27	27	27	27	27	27	24	27	27	27	27	27	27	27	27
CW	Pearson Correlation	0.49**	0.47*	0.48*	0.52**	0.71**	1	0.27	0.62**	0.59**	0.56**	0.34	0.57**	0.39*	0.46*	0.46*
	Sig. (2-tailed)	0.010	0.012	0.012	0.005	0 .000		0.210	0.001	0.001	0.002	0.081	0.003	0.044	0.016	0.016
	N	27	27	27	27	27	27	24	27	27	27	27	27	27	27	27
CCA	Pearson Correlation	0.59**	0.56**	0.57**	0.59**	0.57**	0.27	1	0.60**	0.61**	0.61**	0.60**	0.51**	0.45*	0.35	0.41*
	Sig. (2-tailed)	0.002	0.003	0.003	0.002	0.003	0.210		0.002	0.001	0.001	0.002	0.009	0.024	0.087	0.040
	N	25	25	25	25	24	24	25	25	25	25	25	25	25	25	25
CCP	Pearson Correlation	0.76**	0.77**	0.82**	0.72**	0.86**	0.62**	0.60**	1	0.76**	0.80**	0.62**	0.73**	0.51**	0.42*	0.68**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.001	0.002		0.000	0.000	0.000	0.000	0.005	0.025	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28

Table 3. Pearson correlation values in males (suffix)

		WH	BH	CH	BL	CD	CW	CCA	CCP	SC	HL	SL	FL	SW	FW	EL
SC	Pearson Correlation	0.83**	0.82**	0.82**	0.75**	0.80**	0.59**	0.61**	0.76**	1	0.86**	0.72**	0.77**	0.48**	0.52**	0.57**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000		0.000	0.000	0.000	0.009	0.005	0.002
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
HL	Pearson Correlation	0.86**	0.84**	0.86**	0.81**	0.86**	0.56**	0.61**	0.80**	0.86**	1	0.71**	0.95**	0.47*	0.48*	0.67**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000		0.000	0.000	0.013	0.010	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
SL	Pearson Correlation	0.60**	0.63**	0.65**	0.57**	0.64**	0.34	0.60**	0.62**	0.72**	0.71**	1	0.46*	0.45*	0.28	0.48*
	Sig. (2-tailed)	0.001	0.000	0.000	0.001	0.000	0.081	0.002	0.000	0.000	0.000		0.014	0.015	0.142	0.010
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
FL	Pearson Correlation	0.82**	0.78**	0.80**	0.77**	0.81**	0.56**	0.51**	0.73**	0.77**	0.95**	0.46*	1	0.39*	0.48*	0.64**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.003	0.009	0.000	0.000	0.000	0.014		0.041	0.011	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
SW	Pearson Correlation	0.63**	0.61**	0.59**	0.64**	0.61**	0.39*	0.45*	0.51**	0.48**	0.47*	0.45*	0.39*	1	0.14	0.71**
	Sig. (2-tailed)	0.000	0.001	0.001	0.000	0.001	0.044	0.024	0.005	0.009	0.013	0.015	0.041		0.484	0.000
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
FW	Pearson Correlation	0.26	0.27	0.29	0.19	0.35	0.46*	0.35	0.42*	0.52**	0.48*	0.29	0.47*	0.14	1	0.09
	Sig. (2-tailed)	0.18	0.17	0.14	0.33	0.07	0.02	0.09	0.03	0.01	0.01	0.14	0.01	0.48		0.65
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28
EL	Pearson Correlation	0.84**	0.82**	0.81**	0.76**	0.76**	0.46*	0.41*	0.68**	0.57**	0.67**	0.48*	0.64**	0.71**	0.09	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.016	0.040	0.000	0.002	0.000	0.010	0.000	0.000	0.651	
	N	28	28	28	28	27	27	25	28	28	28	28	28	28	28	28

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 4. Pearson correlation values in females

		WH	BH	CH	BL	CD	CW	CCA	CCP	SC	HL	SL	FL	SW	FW	EL
WH	Pearson Correlation	1	0.96**	0.97**	0.75**	0.67**	0.40	0.47	0.67*	0.83**	0.81**	0.49	0.76**	0.65**	-0.07	0.79**
	Sig. (2-tailed)		0.000	0.000	0.001	0.005	0.123	0.065	0.033	0.000	0.000	0.053	0.001	0.006	0.789	0.000
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
BH	Pearson Correlation	0.96**	1	0.95**	0.65**	0.62*	0.25	0.45	0.66*	0.78**	0.81**	0.54*	0.73**	0.69**	-0.10	0.724ž**
	Sig. (2-tailed)	0.000		0.000	0.006	0.011	0.359	0.079	0.037	0.000	0.000	0.031	0.001	0.003	0.704	0.002
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
CH	Pearson Correlation	0.97**	0.95**	1	0.79**	0.62*	0.38	0.45	0.73*	0.76**	0.87**	0.55*	0.81**	0.69**	-0.12	0.78**
	Sig. (2-tailed)	0.000	0.000		0.000	0.010	0.144	0.078	0.017	0.001	0.000	0.029	0.000	0.003	0.653	0.000
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
BL	Pearson Correlation	0.75**	0.65**	0.79**	1	0.76**	0.67**	0.66**	0.81**	0.55*	0.75**	0.54*	0.67**	0.68**	-0.43	0.61*
	Sig. (2-tailed)	0.001	0.006	0.000		0.001	0.005	0.005	0.004	0.027	0.001	0.033	0.005	0.004	0.099	0.011
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
CD	Pearson Correlation	0.67**	0.62*	0.62*	0.76**	1	0.71**	0.59*	0.58	0.56*	0.52*	0.50*	0.39	0.46	-0.30	0.61*
	Sig. (2-tailed)	0.005	0.011	0.010	0.001		0.002	0.016	0.078	0.024	0.040	0.049	0.139	0.070	0.267	0.012
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
CW	Pearson Correlation	0.40	0.25	0.38	0.67**	0.71**	1	0.42	0.54	0.15	0.29	0.10	0.32	0.17	-0.28	0.48
	Sig. (2-tailed)	0.123	0.359	0.144	0.005	0.002		0.102	0.106	0.590	0.274	0.700	0.234	0.534	0.291	0.060
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
CCA	Pearson Correlation	0.47	0.45	0.45	0.67**	0.59*	0.42	1	0.85**	0.46	0.256	0.201	0.217	0.338	-0.485	0.456
	Sig. (2-tailed)	0.065	0.079	0.078	0.005	0.016	0.102		0.002	0.074	0.338	0.455	0.419	0.201	0.057	0.076
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
CCP	Pearson Correlation	0.67*	0.66*	0.73*	0.81**	0.58	0.54	0.85**	1	0.24	0.78**	0.59	0.64*	0.63*	-0.75*	0.56
	Sig. (2-tailed)	0.033	0.037	0.017	0.004	0.078	0.106	0.002		0.509	0.007	0.075	0.045	0.049	0.013	0.092
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 4. Pearson correlation values in females (suffix)

		WH	BH	CH	BL	CD	CW	CCA	CCP	SC	HL	SL	FL	SW	FW	EL
SC	Pearson Correlation	0.83**	0.78**	0.76**	0.55*	0.56*	0.15	0.46	0.24	1	0.58*	0.32	0.57*	0.51*	0.11	0.76**
	Sig. (2-tailed)	0.000	0.000	0.001	0.027	0.024	0.590	0.074	0.509		0.018	0.227	0.021	0.043	0.686	0.001
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
HL	Pearson Correlation	0.81**	0.81**	0.87**	0.75**	0.52*	0.29	0.26	0.78**	0.58*	1	0.67**	0.91**	0.77**	-0.32	0.57*
	Sig. (2-tailed)	0.000	0.000	0.000	0.001	0.040	0.274	0.338	0.007	0.018		0.005	0.000	0.001	0.222	0.022
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
SL	Pearson Correlation	0.49	0.54*	0.55*	0.54*	0.50*	0.10	0.20	0.59	0.32	0.67**	1	0.31	0.56*	-0.37	0.16
	Sig. (2-tailed)	0.053	0.031	0.029	0.033	0.049	0.700	0.455	0.075	0.227	0.005		0.249	0.025	0.159	0.552
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
FL	Pearson Correlation	0.76**	0.73**	0.81**	0.67**	0.39	0.32	0.22	0.64*	0.57*	0.91**	0.31	1	0.68**	-0.21	0.64**
	Sig. (2-tailed)	0.001	0.001	0.000	0.005	0.139	0.234	0.419	0.045	0.021	0.000	0.249		0.004	0.432	0.008
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
SW	Pearson Correlation	0.65**	0.69**	0.69**	0.68**	0.46	0.17	0.39	0.63*	0.51*	0.77**	0.56*	0.68**	1	-0.42	0.43
	Sig. (2-tailed)	0.006	0.003	0.003	0.004	0.070	0.534	0.201	0.049	0.043	0.001	0.025	0.004		0.102	0.100
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
FW	Pearson Correlation	-0.07	-0.10	-0.12	-0.43	-0.30	-0.28	-0.49	-0.75*	0.11	-0.32	-0.37	-0.21	-.042	1	-0.04
	Sig. (2-tailed)	0.79	0.70	0.65	0.10	0.27	0.29	0.06	0.01	0.67	0.22	0.16	0.43	0.10		0.89
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16
EL	Pearson Correlation	0.78**	0.72**	0.78**	0.61*	0.61*	0.48	0.46	0.56	0.76**	0.57*	0.16	0.64**	0.43	-0.04	1
	Sig. (2-tailed)	0.000	0.002	0.000	0.011	0.012	0.060	0.076	0.092	0.001	0.022	0.552	0.008	0.100	0.893	
	N	16	16	16	16	16	16	16	10	16	16	16	16	16	16	16

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Discussion

Studying the basic morphological parameters of donkey Amiati in the Italian province of Tuscany, Orlandi et al. (1997) found that the average withers height of males was 135.5 cm and females 130.00 cm. The height of the male donkey croup was, on average, 135.8 cm and the females 131.3 cm. Regarding the height of the back, the average value in males was 132.6 cm and in females 126.8 cm. The Romanesque breed is a large breed of Italian donkey in the big donkey group. The morphological characteristics of donkeys of this breed were studied by Beretti et al. (2005). The average height of the withers was 132.2 cm with a minimum of 117.0 cm and a maximum of 145.0 cm. Chest circumference, on average, was 149.3 cm. A rather wide variation interval from 119.0 cm to 178.0 cm was determined. Shin circumference had an average value of 17.0 cm, minimum 14.0 cm and maximum 21.0 cm. The big donkey group includes another Italian breed, Amiata. Casini et al. (2007) report that the average height of the withers of male Amiata donkeys is 125.82 ± 5.25 cm and females 125.15 ± 5.21 cm. Regarding the height of the croup, the average value for males was 129.80 ± 26.30 cm and for females 129.89 ± 36 cm. The circumference of the chest had an average value of 146.72 ± 7.68 cm in male and 145.84 ± 7.37 cm in females. The average body length of the males was 130.45 ± 8.89 cm and females 128.62 ± 6.29 cm. Regarding head length, the average value was found in males, 57.90 ± 2.81 cm and in females 55.82 ± 2.42 cm. The average value of the circumference of the shin in male was 17.40 ± 0.70 cm and in females 16.07 ± 0.82 cm. Compared to the sample of individuals in Austria, it is noticeable that the values of donkey parameters in Tuscany and other Italian breeds are larger than in Austria donkeys.

The morphological characteristics of donkeys in Turkey, the Igdir region, are reported by Yilmaz and Ertugrul (2011). The average height of the withers is 99.10 cm. Average height of the withers of males was 99.70 cm and females 98.60 cm, and average croup height was 102.30 cm in males and 100.90 cm in females, and 101.00 cm for the whole population. Body length, on average, was 103.00 cm. In males, the average body length was 103.40 cm and in females 102.20 cm. The chest circumference was, on average, 111.50 cm. In males, this value averaged 112.80 cm and in females 111.60 cm. The authors found that the average chest depth in the observed population was 45.40 cm. The average chest depth of males was 45.60 cm and females 45.50 cm. As for the chest width, a mean value of 29.10 cm was obtained. In males, the chest width had an average value of 29.40 cm and in females 28.70 cm. The study showed that the average length of the head was 48.40 cm. Males had an average head length of 48.80 cm and females 48.00 cm. The total mean value of the shin circumference was 13.4 cm, and in males 13.5 cm and females 13.10 cm. Studying donkeys in western Turkey, Urosevic et al. (2016) found that the average height of the withers, in the observed population, in males was 104.2 ± 3.7 cm with a minimum of 101.5 cm and a maximum of 108.5 cm. In female, the average height of the withers was 103.1 ± 2.2 cm with a range from 100.7 to 106.0 cm. The same authors found that the average height of the donkey male in Northern Macedonia was 106.1 ± 2.2 with a range from 103.4 cm to 109.0 cm. In females, the average height of the withers is 99.7 ± 2.7 cm with a minimum of 96.0 cm and a maximum of 103.5 cm. Studying donkeys in Romania, the same authors found that the average height of the withers in male was 100.8 in male 1.1 cm, with a minimum height of 100.00 cm and a maximum of 101.6 cm. In females, the average height of the withers

was 101.2 in male 8.6 cm with an interval variation from 81.0 cm to 111.6 cm. The population of donkeys in southern and southeastern Turkey was studied by Yilmaz and Trevor Wilson (2013). The average withers height of male was 102 ± 66 cm and females 99.7 ± 0.58 cm. The height of the back of males was 105.3 ± 0.62 cm and females 102.4 ± 0.56 cm. The male body length was 105.2 ± 0.74 cm and the females 103.1 ± 0.65 cm. As for the circumference of the chest, the authors found a mean value of 113.3 ± 0.60 cm in males and 111.7 ± 0.76 cm in females. Regarding head length, the average value was determined for male 49.0 ± 0.27 cm and females 47.5 ± 0.32 cm. Regarding the volume of shin circumference, a mean value of 13.6 ± 0.09 cm for males and 13.3 ± 0.10 cm for females was established. The values presented in this study show that both male and female donkeys in Austria are taller than donkeys in Turkey, and the mean croup height of males and females was higher than donkeys in Turkey. The average donkey body length in Austria is greater than of individuals measured in Turkey.

On the Adriatic islands, the donkey was a basic working animal. The morphological characteristics of donkeys on the island of Mljet were studied by Essert in 1959. The average donkey height was 100.65 cm and the donkey 99.48 cm, with a total mean of 100.23 cm. Regarding back height, the average was 102.77 cm, while in males, the average height of the back was 102.95 cm and in females 102.26 cm. Average croup height was 103.37 cm, with averaged croup height of 102.86 cm in males and 103.26 cm in females. The total average body length was 100.81 cm. In males, this value was 100.11 cm and in females 100.93 cm. Chest circumference, on average, was 107.82 cm for males and 108.80 cm for females with a total average value of 108.83 cm. The mean value of the circumference of the shin was 12.23 cm with 12.60 cm in male and 12.16 cm in female individuals. The population of donkeys in the Adriatic islands is shorter than donkeys in Austria. Also interesting is the donkey body size on the Adriatic islands, which is square, while the population in Austria has a rectangular body format.

In the first study on the baroque donkey, Urosevic et al. (2019) report that the average withers height of males is 115.5 cm with a range from 108.4 cm to 120.3 cm. In females, the average height of the withers is 112.2 cm with a range from 104.2 cm to 122.2 cm. The average back height of females is 109.3 cm with a range from 102.0 cm to 118.7 cm. In males, the average back height is 112.8 cm with a minimum value of 102.1 cm and a maximum of 119.1 cm. The height of the croup, on average, in males was 118.3 cm and with an interval of variation from 111.1 cm to 125.1 cm. In females, the average croup height is 115.0 cm with a minimum of 108.2 cm and a maximum of 126.5 cm. Average female body length is 120.7 cm with a minimum of 108.9 cm and a maximum of 133.0 cm. In males, the average body length is 119.2 cm, the minimum is 112.0 cm and the maximum is 127.0 cm. Average chest depth of males is 49.2 cm, minimum 48.0 cm and maximum 52.0 cm. In females, the chest had an average depth of 52.2 cm, the minimum was 48.0 cm and the maximum was 55.0 cm. The average anterior circumference of the chest of females is 124.5 cm with an interval of 110.0 cm to 135.0 cm. In males, the mean value for this parameter was 118.6 cm with a minimum of 110.0 cm and maximum 130.0 cm. The average head length in males was 55.0 cm with a skull length of 24.8 cm. In females, the average head length is 54.5 cm and skull length of the skull is 25.0 cm. The females, on average, had a shin circumference of 13.0 cm with an interval of variation from 12.9 cm to 14.0 cm. In males, the average value of the circumference of the shin is 14.0 cm with an interval of 13.0 cm to

16.0 cm. The studied donkey population presented here has similar values, with smaller oscillations in some parameters, as Baroque donkeys. However, the variation intervals are higher in this population than in the Baroque donkey. Approximately the same parameter values can be explained that both populations share the same distribution range of origin and where they live today. In the Baroque donkey, the variation intervals are likely to be smaller due to controlled breeding and more stringent criteria for breeding individuals over the last few centuries.

The external characteristics of donkeys in the Kabylie area of Algeria are reported by Ayad et al. (2019). They found that the average withers height of individuals younger than 5 years was 106 ± 6.3 cm. The average height of the withers was 105.3 ± 4.8 cm, in individuals from 6 to 10 years old, and 103.2 ± 5.2 cm in those older than 11 years. The height of the croup, on average, in young individuals was 110.2 ± 5.8 cm, in adults 108.7 ± 5.3 cm and over the age of 11 years 107.2 ± 3.7 cm. When it comes to body length, the authors found that the average body length of the young individuals was 107.3 ± 8.7 cm, in adults up to 10 years of age, the body length averaged 109.6 ± 3. 5 cm and 108.4 ± 6.4 cm in those older than 11 years. Circumference of the shin, the average value in young individuals was 14.5 ± 1.3 cm, in those between 6 and 10 years 14.8 ± 0.6 and for individuals older than 11 years this value was 14.7 ± 0.9 cm. Algerian donkeys have a slightly lower withers height than the studied population in Austria.

Ebangi and Vall (2005) reported the basic morphological parameters of donkeys in the Sudan-Sahel region of Cameroon. The average height of the withers is 98.05 cm with a range of 90.00 to 110.00 cm. The average body length was 137.26 cm with a minimum value of 115.00 cm and a maximum of 173.00 cm. The circumference of the chest, measured behind the elbow joint, is 107.53 cm with an interval of variation from 97.00 to 125.00 cm. This donkey population is significantly shorter than the population in Austria. The size of the donkey body in Cameroon is very interesting as it is very rectangular. The body length and body size of the donkey population in Cameroon is significantly higher than the population in Austria.

Tsega and Lemma (2015) studied the bodily form of donkeys in northwestern and central Ethiopia, where the largest donkeys in Ethiopia are found. For working individuals, the average height of the withers was 118 ± 5.54 cm with an interval of variation from 102.00 to 140.00 cm. The chest circumference averaged 124.4 ± 2.2 cm with variations from 103.00 to 156.00 cm. Ethiopia's population is slightly taller than donkeys in Austria.

Ivankovic et al. (2000) reported that in the Littoral Dinaric donkey, the average height of the withers was 96.93 cm, the circumference of the chest was 112.75 cm and the circumference of the shin was 12.82 cm. In the North Adriatic donkey, the average height of the withers is 115.28 cm, the circumference of the chest is 131.80 cm and the circumference of the shin is 14.85 cm. The Istrian donkey has an average ridge height of 124.07 cm, a chest circumference of 144.01 cm and a shin circumference of 16.30 cm. The average croup height for the Littoral Dinaric donkey is 99.85 cm, for the North Adriatic donkey 119.21 cm and for the Istrian donkey 128.29 cm. The average body length of the Littoral Dinaric donkey is 102.62 cm, in the North Adriatic 121.11 cm and in the Istrian Donkey 131.30 cm. The population of donkeys in Austria is most similar to the northern donkey in terms of parameters.

The morphometric characteristics of donkeys in northwestern Nigeria were examined by John et al. (2017). In the observed population, average head length

was 39.9 cm, average chest circumference was 94.3 cm, and body length 92.0 cm. The average height of the withers is 92.8 cm. Compared to this study, donkeys in Austria are significantly taller.

The Catalan donkey also belongs to the group of tall donkeys. Polch and Jordana (1997) reported that the average height of males is 142.20 cm with an interval of variation from 129.0 cm to 156.0 cm. In females, the average height of the withers is 136.29 cm, a minimum of 123.0 cm and a maximum of 148.0 cm. The average back height of males was 137.44 cm with a minimum of 126.0 cm and a maximum of 152.0 cm. The average back height of females is 132.68 cm with a minimum value of 120.0 cm and a maximum of 144.0 cm. Males have an average croup height of 143.0 cm with a range from 127.0 to 157.0 cm. In females this average value is 139.59 cm with a range from 127.0 cm to 150.0 cm. Chest circumference, on average, in males was 157.00 cm with a minimum value of 146.0 cm and a maximum of 170.0 cm. In female, the average chest circumference is 154.70 cm with an interval from 140.0 cm to 169.0 cm. When it comes to the head, the authors determined that males, on average, have a head 61.24 cm long, with a minimum length of 55.0 cm and a maximum of 68.0 cm. Comparing the values obtained in our study, the population in Austria has lower values in all parameters compared to Catalan donkeys.

Đermanović et al. (2013) studied the morphometry of young donkeys, up to two years old, in the area of southern Serbia. They determined that the average height at the withers of females was 100.5 cm, body length was 101.30 cm, chest circumference was 105.45 cm, and shin circumference was 11.80 cm. In males, the average value of the height at the withers was 100.27 cm, body length was 101.27 cm, chest circumference was 105.64 cm, and shin circumference was 11.82 cm. Studying the exterior traits of domestic donkey in southeastern Serbia, Trailović et al. (2011) found that the average height at the withers is 105.72 cm, body length 112.06 cm, chest circumference 114.44 cm and shin circumference 12.67 cm. The population of donkeys in Southern Serbia is significantly shorter and with a shorter body compared to the population in Austria.

When it comes to the morphological characteristics of donkeys in Bulgaria, extensive research was done by Vlaeva et al. (2016). Studying donkeys in three regions in Bulgaria, the authors found that the average withers height was 119.80 ± 8.09 cm with an interval of variation from 99.0 cm to 148.0 cm. The average body length was 124.64 ± 9.28 cm with a minimum value of 102.0 cm and a maximum of 154.0 cm. Chest circumference had an average value of 136.69 ± 9.94 cm with a minimum of 115.0 cm and a maximum of 160.0 cm. The donkeys of these populations are quite strong, since the average shin circumference is 16.01 ± 1.35 cm, with a minimum of 13.0 cm and maximum of 20.0 cm. The donkey population in Bulgaria is larger and stronger in relation to the population in Austria.

The connection between head length and the withers height was studied in Romania, Northern Macedonia and Turkey by Urošević et al. (2015). The minimum head length for females in Romania was 44.0 cm and the maximum 54.0 cm. The average value was 49.1 cm. In Northern Macedonia, the minimum head length of females was 48.0 cm and a maximum of 56.0 cm was determined, and the average head length of female donkeys was 50.4 cm. When it comes to Turkey, the minimum value of the length of the head was 48.0 cm with a maximum of 51.0 cm, and the average value was 50.0 cm. No statistically significant differences in head length were observed within the observed groups. In the donkey

population in Austria, the average head length is almost the same as the average head length in individuals in the populations in these three countries.

The morphological characteristics of donkeys in the Czech Republic are reported by Kostukova et al. (2015). Considerable variability was found in the height of the withers. The minimum value of withers height was 98.0 cm, and the maximum was 131.0 cm. the average value was 107.5 cm. The average back height was 105.5 cm, with a minimum value of 91.5 cm and a maximum of 130.0 cm. For croup height, the average value was 110.7 cm, the minimum 95.0 cm, and the maximum value of the height of the croup 139.0 cm. Donkeys in the observed population had an average head length of 44.4 cm, minimum head length of 37.5 cm and maximum of 54.0 cm. Chest circumference averaged 129.5 cm with a range from 111.0 cm to 155.0 cm. The studied population in Austria has a similar interval of variation while the average value is significantly higher.

The morphological characteristics of the Hasavi donkeys, an indigenous breed of donkeys in the eastern province of Saudi Arabia were reported by the Shawaf et al. (2016). The donkeys of this race belong to the group of large donkeys. The average height of the males is 130.5 ± 1.3 cm and females 126.3 ± 1.1 cm. When it comes to back height, the average height was 127.2 ± 1.2 cm for of males, and 123.3 ± 1.1 cm for females. Croup height was greater than the height of the withers, and was 133.8 ± 1.1 cm in males and 129.4 ± 1.0 cm in females. The average body length for males was 185.8 ± 2.8 cm and 178.8 ± 1.3 cm for females. Shin circumference in males was 16.8 ± 0.4 cm and in females 15.5 ± 0.2 cm. Donkeys of this breed have significantly higher parameter values in relation to the studied population in Austria.

Considering the three donkey populations in Turkey, Northern Macedonia and Romania, Urošević et al. (2019) found that donkeys in this region are smaller in size. Average withers height of males was 104.9 ± 3.1 cm with a minimum value of 100.0 cm and a maximum of 109.0 cm. In females, the average height of the withers was 101.5 ± 3.9 cm with a minimum of 95.1 cm and a maximum of 107.5 cm. Average back height of males is 102.8 ± 3.5 cm, minimum 97.4 cm and maximum 108.0 cm. In females, the backs are on average 99.3 ± 3.1 cm high. The minimum is 94.5 cm and the maximum 104.3 cm. Average croup height was 106.6 ± 3.2 cm in males with a minimum value of 102.3 cm and a maximum value of 114.5 cm. In females, croup height was on average 105.7 ± 3.5 cm with a range from 100.3 cm to 112.1 cm. In males, body length ranged from 97.0 cm to 123.0 cm with an average value of 113.4 ± 7.2 cm. Females had an average body length of 113.6 ± 10.5 cm with a range of 100.0 cm to 138.0 cm. These observed populations in three different countries had lower values than the studied donkey population in Austria.

Conclusions

In relation to the sample of individuals of the population in Austria, it is noticeable that the values of the stated parameters of donkeys in Tuscany and other Italian breeds are higher in relation to the same parameters of donkeys in Austria. The values obtained in our study show that donkeys in Austria, both males and females, are taller than donkeys in Turkey, with a higher croup height. The average body length of donkeys in Austria is greater than the body length of individuals measured in Turkey. The body shape of donkeys on the Adriatic islands is square, while the population in Austria has a rectangular body shape. The body length and body size of the donkey population in Cameroon is

significantly larger than the population in Austria. The observed populations in three different countries had lower values compared to the studied donkey population in Austria.

The Pearson correlation showed a very significant or significant positive statistical correlation between almost all parameters in males. No statistically significant correlation was observed between the skull width and height at the withers, height of the back, croup height, body length, chest depth, anterior circumference of the chest, skull length, or length of the ears. In females, Pearson correlation values had slightly different values than males. There was no statistically significant correlation between chest width and anterior chest circumference with almost all other parameters. In females, a negative correlation was observed between the width of the cranial part and all other parameters.

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Povezanost morfoloških parametara magaradi u Austriji

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Posljednjih desetljeća polako, ali stalno, magarac gubi mjesto kao svugdje prisutna radna snaga. Industrijalizacija poljoprivrede, mehanizacija mnogih poslova u brdskim i planinskim predjelima prouzročili su smanjenje broja magaradi. Intenzitet smanjenja prešao je granicu alarmantnosti. Da bi se uspješno vodila akcija revitalizacije magaradi u njihovim uobičajenim, a i novim arealima neophodno je ovu domaću životinju upoznati s različitih aspekata. U tom je smislu obavljeno i ovo istraživanje. Domaći magarac (*Equus asinus*) potječe iz Afrike. Razlikuju se nubijski i somalijski magarci. Poznata je velika radna izdržljivost magaradi, koja je pomalo i mistična. Ne postoje geografski predjeli gdje magarad ne obavljaju najteže oblike rada, prije svega transporta. Za svako čuđenje je njihova mogućnost kretanja i stabilnost po nepristupačnim terenima. Za potrebe ovog rada korištena je ukupno 44 magaradi (28 mužjaka i 16 ženki). Proučavane jedinke su s područja Republike Austrije. Analizirani su sljedeći morfometrijski parametri: visina grebena, visina leđa, visina križa, dužina trupa, dubina prsa, širina prsa, obujam prsa prednji, obujam prsa zadnji, obujam cjevanice, dužina glave, dužina lubanje, dužina facijalnog dijela, širina lubanje, širina facijalnog dijela, dužina ušiju. Mjerenje je obavljeno pomoću Litinovog štapa, pantljike i pomičnog mjerila s nonijusem. Prosječna visina grebena iznosila je 116,40 cm, a interval variranja od 99,60 cm do 140,60 cm. Visina grebena ženki varira od 90.50 cm do 125.70 cm. U prosjeku ženke su visoke 102,38 cm sa standardnom devijacijom od 8,28 i standardnom grješkom od 2,07. Dužina trupa u mužjaka u prosjeku je iznosila 121,85 cm sa standardnom devijacijom od 11,79. Dužina trupa ženki iznosila je od 101,00 cm do 131,00 cm. Srednja vrijednost dužine trupa u ženki bila je 115,80 cm. Dužina glave mužjaka bila je od 48,00 do 71,00 cm, s prosječnom vrjednošću od 55,60 cm. Dužina glave u ženskih jedinki varira od 43,00 do 56,00 cm. Glava je prosječno bila duga 50,06 cm sa standardnom devijacijom od 3,23. Primjenom Personove korelacije zabilježena je vrlo značajna ili značajna pozitivna statistička korelacija između gotovo svih parametara u mužjaka. U ženki vrijednosti Personove korelacije imaju nešto drugačije vrijednosti nego u mužjaka. Između širine prsa i prednjeg obujma prsa nije bilo statistički značajne korelacije s gotovo svim ostalim parametrima. Za ove parametre jedino je pozitivna vrlo značajna statistička korelacija zabilježena između dužine trupa i širine prsa, kao i prednjeg obujma prsa; zatim između prednjeg i zadnjeg obujma prsa i dubine prsa ova dva parametra. U ženki je zabilježena i negativna korelacija između širine lubanjskog dijela i svih ostalih parametra.

Ključne riječi: *magarac, morfometrija, korelacija*