

MORPHOMETRIC TRAITS OF THE YELLOW HONEYBEE (*APIS MELLIFERA CARNICA*) FROM VOJVODINA (NORTHERN SERBIA)

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Abstract: The morphometric traits of the yellow honeybee from Vojvodina were researched in this study. Samples were collected at seven locations: Banatsko Aranđelovo, Fruška Gora, Vladimirovci, Markovac and Vršac. Each sample contained 50 bees whose body parts were prepared, scanned and measured using computer software. The average values of the measured parameters were: tongue length (6.12 mm), right-wing length (9.07 mm) and width (3.13 mm), number of wing hooks on the rear right-wing (21.44), cubital index (2.40), length (2.04 mm) and width (1.09 mm) of basitarsus of rear right leg, corbicula area (0.79 mm²), length (2.17 mm) and width (4.86 mm) of the third tergite, length (1.31 mm) and width (2.41 mm) of wax plate mirror. The obtained values of the observed parameters were consistent with the values that are characteristic to the Carniolan race of honeybees (*Apis mellifera carnica* Poll).

Key words: Honeybee, morphometric traits, variability

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INTRODUCTION

Morphometric analyses of honeybees are used to investigate the purity of the race. The honeybee, with its 42 studied morphological parameters, has become one of the most researched insects. Ruttner (1988) points out that by using precise morphometric studies, more ecotypes of the Carniolan honeybee races (*Apis mellifera carnica* Poll) may be identified. The first biometric research of honey bee populations in our region was that of Grozdanić (1926), where he identified the yellow form of Banat honey bee as a special group of bees called *Apis mellifera banatica*. Research has been continued by Krunić (1967), Stojanović (1992), Plužnikova (1994), Georgiev (2000), Stevanović (2002), Jeftić (2007), Mladenović and Simeonova (2008) and Nedić (2009).

MATERIAL AND METHODS

In this study, seven samples of yellow honeybee from different locations in Vojvodina (Fruška Gora (FG), Banatsko Aranđelovo (BA), Vladimirovci (U), Markovac (S and B), Vrsac (M, T)) were researched. Selected bee colonies were required to be in good condition, to have a satisfactory health status and to have a pure yellow queen bee and mostly yellow workers. Samples consisted of 50 bees that were drowned in pure alcohol and kept in the same alcohol until the measurement. The body parts of the bees were separated with tweezers, scanned in the resolution of 9600dpi and measured using the computer program AutoCAD. Temporary preparations were made. Measurements were done by standard method (Ruttner et al., 1978). Hooks on the rear wings were counted using a low magnification microscope.

RESULTS

Table 1. Statistical parameters of the observed morphological traits of the examined samples of yellow honey bee from Vojvodina (average ($\bar{x}$), minimum value ($x_{\min}$), maximum value ($x_{\max}$), variance (S^2), standard deviation (S), standard error (S_x), variation coefficient (V)).

Trait	Sample	$\bar{X}$	$X_{\min}$	$X_{\max}$	S^2	S	S_x	V
Tongue length (mm)	T	5,66	4,74	6,46	0,41	0,64	0,09	11,31
	M	6,28	4,48	6,68	0,22	0,47	0,07	7,48
	S	6,23	4,89	6,65	0,17	0,41	0,06	6,58
	B	6,01	4,84	6,68	0,28	0,53	0,07	8,82
	FG	6,37	5,96	6,58	0,03	0,16	0,02	2,51
	U	6,18	5,47	6,51	0,04	0,21	0,03	3,40
	BA	6,10	4,81	6,59	0,20	0,45	0,06	7,38
	Average:	6,12						
Wing length (mm)	T	8,98	8,41	9,37	0,04	0,21	0,03	2,34
	M	9,05	8,62	9,40	0,03	0,18	0,03	1,99
	S	9,30	8,91	9,64	0,03	0,17	0,02	1,83
	B	9,20	8,77	9,47	0,01	0,12	0,02	1,30
	FG	8,98	8,49	9,27	0,03	0,17	0,02	1,89
	U	8,94	8,46	9,33	0,03	0,18	0,03	2,01
	BA	9,01	8,45	9,54	0,05	0,23	0,03	2,55
	Average:	9,07						
Wing width (mm)	T	3,16	3,05	3,31	0,00	0,06	0,01	1,89
	M	3,08	2,89	3,23	0,00	0,07	0,01	2,27
	S	3,24	3,09	3,41	0,00	0,07	0,01	2,16
	B	3,16	3,01	3,24	0,00	0,05	0,01	1,58
	FG	3,07	2,86	3,27	0,01	0,10	0,01	3,26
	U	3,10	2,21	3,32	0,03	0,16	0,02	5,16
	BA	3,11	2,90	3,29	0,01	0,09	0,01	2,89
	Average:	3,13						
Cubital index	T	2,50	1,61	3,21	0,13	0,36	0,05	14,40
	M	2,39	1,82	3,44	0,12	0,35	0,05	14,64
	S	2,49	1,73	3,33	0,12	0,34	0,05	13,65
	B	2,40	1,78	3,20	0,10	0,32	0,05	13,33
	FG	2,28	1,53	3,26	0,12	0,35	0,05	15,35
	U	2,30	1,52	3,52	0,13	0,36	0,05	15,65
	BA	2,44	1,72	3,39	0,08	0,28	0,04	11,47
	Average:	2,40						
Hook number	T	21,72	19,00	24,00	1,44	1,20	0,17	5,52
	M	20,34	17,00	24,00	2,40	1,55	0,22	7,62
	S	22,96	19,00	27,00	3,17	1,78	0,25	7,75
	B	20,30	17,00	24,00	2,92	1,71	0,24	8,42
	FG	22,06	18,00	25,00	2,22	1,49	0,21	6,75
	U	21,50	17,00	26,00	2,96	1,72	0,24	8,00
	BA	21,20	18,00	24,00	1,80	1,34	0,19	6,32
	Average:	21,44						

Table 2. Statistical parameters of the observed morphological traits of the examined samples of yellow honey bee from Vojvodina (average ($\bar{x}$), minimum value ($x_{\min}$), maximum value ($x_{\max}$), variance (S^2), standard deviation (S), standard error (S_x), variation coefficient (V)).

Trait	Sample	$\bar{X}$	$X_{\min}$	$X_{\max}$	S^2	S	S_x	V
Basitarsus length (mm)	T	2,04	1,91	2,20	0,00	0,07	0,01	3,43
	M	1,97	1,72	2,15	0,01	0,09	0,01	4,57
	S	2,05	1,94	2,18	0,00	0,06	0,01	2,93
	B	2,03	1,91	2,15	0,00	0,06	0,01	2,96
	FG	2,07	1,92	2,20	0,00	0,07	0,01	3,38
	U	2,06	1,93	2,17	0,00	0,06	0,01	2,91
	BA	2,02	1,89	2,11	0,00	0,05	0,01	2,47
	Average:	2,04						
Basitarsus width (mm)	T	1,11	0,81	1,27	0,01	0,11	0,02	9,91
	M	1,03	0,73	1,22	0,01	0,12	0,02	11,65
	S	1,10	0,89	1,29	0,01	0,10	0,01	9,09
	B	1,04	0,81	1,26	0,02	0,13	0,02	12,05
	FG	1,11	0,95	1,22	0,00	0,07	0,01	6,31
	U	1,10	0,85	1,21	0,01	0,08	0,01	7,27
	BA	1,11	0,89	1,21	0,00	0,07	0,01	6,31
	Average:	1,09						
Corbicula area (mm ²)	T	0,84	0,48	1,10	0,02	0,13	0,02	15,47
	M	0,80	0,54	1,16	0,02	0,13	0,02	16,25
	S	0,87	0,65	1,15	0,01	0,12	0,02	13,79
	B	0,82	0,60	1,28	0,02	0,14	0,02	17,07
	FG	0,77	0,44	0,97	0,01	0,12	0,02	15,58
	U	0,73	0,55	0,95	0,01	0,11	0,02	15,07
	BA	0,70	0,46	0,96	0,01	0,10	0,01	14,28
	Average:	0,79						
Third tergite length (mm)	T	2,17	2,04	2,32	0,00	0,06	0,01	2,76
	M	2,18	2,03	2,36	0,00	0,07	0,01	3,21
	S	2,21	2,00	2,34	0,00	0,06	0,01	2,71
	B	2,23	2,12	2,34	0,00	0,05	0,01	2,24
	FG	2,14	1,97	2,31	0,01	0,08	0,01	3,74
	U	2,13	2,00	2,25	0,00	0,07	0,01	3,28
	BA	2,15	1,99	2,30	0,00	0,07	0,01	3,25
	Average:	2,17						
Third tergite width (mm)	T	4,89	4,72	5,19	0,01	0,12	0,02	2,45
	M	4,78	4,39	5,46	0,03	0,16	0,02	3,47
	S	4,86	4,56	5,21	0,02	0,14	0,02	2,88
	B	4,95	4,60	5,14	0,01	0,11	0,01	2,22
	FG	4,90	4,56	5,22	0,02	0,15	0,02	3,06
	U	4,80	4,59	5,12	0,01	0,10	0,01	2,08
	BA	4,86	4,59	5,06	0,01	0,12	0,02	2,47
	Average:	4,86						

Table 3. Statistical parameters of the observed morphological traits of the examined samples of yellow honey bee from Vojvodina (average ($\bar{x}$), minimum value ($x_{\min}$), maximum value ($x_{\max}$), variance (S^2), standard deviation (S), standard error (S_x), variation coefficient (V)).

Trait	Sample	$\bar{X}$	$X_{\min}$	$X_{\max}$	S^2	S	S_x	V
Wax plate mirror length (mm)	T	1,33	1,16	1,46	0,00	0,07	0,01	5,26
	M	1,32	1,17	1,44	0,00	0,05	0,01	3,78
	S	1,37	1,19	1,61	0,01	0,08	0,01	5,83
	B	1,33	1,25	1,42	0,00	0,05	0,01	3,75
	FG	1,28	1,13	1,40	0,00	0,05	0,01	3,90
	U	1,29	1,15	1,43	0,00	0,06	0,01	4,65
	BA	1,28	1,15	1,49	0,00	0,06	0,01	4,68
	Average:	1,31						
Wax plate mirror width (mm)	T	2,41	2,13	2,68	0,01	0,09	0,01	3,73
	M	2,42	2,13	2,67	0,01	0,08	0,01	3,30
	S	2,49	2,30	2,74	0,01	0,09	0,01	3,61
	B	2,49	2,26	2,71	0,00	0,07	0,01	2,81
	FG	2,33	2,11	2,48	0,01	0,09	0,01	3,86
	U	2,34	2,13	2,49	0,01	0,08	0,01	3,41
	BA	2,37	2,14	2,78	0,01	0,11	0,02	4,64
	Average:	2,41						

DISCUSSION

Tongue length in the observed samples ranged from 5.66 to 6.37 mm, with an average value of 6.12 mm. The obtained value is slightly lower compared to the results obtained by other authors. Jevtić (2007) stated that the tongue length in 18 experimental colonies from Serbia is 6.41 mm. Georgiev (2007) claimed that the tongue length of the bees from eastern Serbia is 6.34 to 6.50 mm. According to Mladenović and Simeonova (2008), the bees of southern Serbia have an average tongue length of 6.58 mm. Kulinčević et al. (1997) reported a length of 6.4 to 6.8 mm for the bees from Banat. For the yellow bees from Vojvodina and Slavonia, Krunić (1967) reports 6.40 mm as the length of the tongue. In studies of Plužnikov (1994), bees from Bosnia and Herzegovina had an average value of 6.44 mm for this parameter, and the bees from Serbia had a value of 6.39 mm.

The data obtained by descriptive statistics (Table 1) show that there are variations from 8.94 to 9.30 mm in the length of the wings of the observed sam-

ples of yellow honeybee from the territory of Vojvodina. The obtained values for this trait are within the range of values for the Carniolan race. According to Krivcov (1992) the wing length in the Carniolan race ranges from 9.00 to 9.40 mm. Stojanović (1992) in his research on the bees from Sjenica obtained values of 9.42 to 9.53 mm, in the bees from Lazarevac 9.79 mm and in bees from Mariovo 9.32 to 9.55 mm. In the studies of Plužnikov (1994), the bees from Montenegro had an average value for this parameter of 9.73 mm, while the bees from Serbia had a value of 9.66 mm. Jevtić (2007) obtained the value of 9.82 mm for the wing length of bees from Banat. Georgiev (2007) indicates that there is a variation from 9.28 to 9.79 mm in the wing length of bees from eastern Serbia. Bees from southern Serbia, according to research by Mladenović and Simeonova (2008), had a wing length of 8.96 mm. Somewhat different results were obtained by Stevanović (2002), where bees from 30 localities throughout Serbia had a wing length of 6.50 mm. By analyzing the bees from Sudan, El Sarag et al. (1992) state that an average value of wing length was 8.37 mm.

Wing width in the observed samples ranged from 3.07 to 3.24 mm with an average value of 3.13 mm. The data obtained for the wing width in yellow honeybees from Vojvodina have similar values that Krivcov (1992) states for the Carniolan honey bee, where the average value was 3.19 mm, with variation interval from 3.13 to 3.29 mm. In studies of Plužnikov (1994) was indicated that honeybees from Montenegro had an average value of 3.20 mm for this parameter, and the bees from Serbia had a value of 3.12 mm. In the studied colonies from Eastern Serbia, it was determined that the variation interval of the wing width was 3.16 to 3.52 mm (Georgiev, 2006). Similar values for this parameter (3.23 mm) were obtained by Jevtić (2007) in his study of Banat bees. Mladenović and Simeonova (2008) state that an average wing width of bees from southern Serbia is 3.09 mm. Nedić (2009) reports values of 3.34 mm in bees from Vranje and 3.23 mm in bees from Knjaževac.

Variation intervals of the cubital index in yellow honey bees from Vojvodina ranged from 2.28 to 2.50, with an average value of 2.40. The obtained value is within the values presented by other authors for the Carniolan race. In the studies of Vlatković (1957), the value of cubital index for honeybees from the Peštersko-Sjениčki plateau ranges from 2.3 to 3.6. Ruttner (1952) stated that the value of the cubital index is 2.74. Krunić (1967) obtained a cubital index value of 2.96 mm in the population of yellow bees from Vojvodina and Slavonia. In the studied colonies from eastern Serbia, it was shown that the variation interval for cubital index ranges from 2.45 to 2.65 (Georgiev, 2006). Mladenovic et al. (2008) emphasize the value of 2.2 mm in bees from South Serbia.

The average number of hooks on the rear wing in the observed sample was 21.44, while the variation interval ranges from 20.30 to 22.96. The resulting average value coincides with the average value of 21.21 presented by Krunić (1967) in research into the population of yellow bees from Vojvodina and Slavonia. The same author stated that the value for this parameter was 21.25 in the carnica population from mountainous areas. Alpatov (1927) indicates

that the average number of hooks is 21.49 in bees from the territory of Bulgaria. Georgiev (2007) states that the variation interval in bees from eastern Serbia is 20.44 to 21.88.

Basitarsus length ranged from 1.97 to 2.07 mm in the observed samples, the average value was 2.04 mm. The results are consistent with the results of Stojanović (1992), who analyzed honey bees from three regions and obtained values of 1.98 to 2.11 mm. Georgiev (2007) stated that the variation interval for this trait was from 2.03 to 2.34 mm in bees from eastern Serbia. In the research of Stevanović (2002) the basitarsus length in bees from 30 localities in Serbia was 2.09 mm. Jevtić (2007) indicates a length of 2.12 mm in bees from Banat, while Mladenović and Simeonova (2008) give an average value of 1.99 mm for the basitarsus length in bees from the south of Serbia.

Basitarsus width ranged from 1.03 to 1.11 mm in the observed samples, with an average value of 1.09 mm. These results are similar to that of Jevtić (2007) obtained by analyzing the bees from six localities in Serbia, where the greatest basitarsus width was determined in colonies of the Rasina and Banat ecotype (1.16 and 1.14 mm, respectively), and the smallest was in colonies of the Kopaonik ecotype (1.05 mm). Mladenović and Simeonova (2008) have determined a basitarsus width of 1.07 mm in bees from southern Serbia. In the research of Georgiev (2007) it was found that the variation interval for this trait ranged from 1.04 to 1.37 mm in honeybees from eastern Serbia. A similar average value (1.13 mm) was determined by Stevanović (2002).

The corbicula area ranged from 0.70 to 0.87 mm² in the seven samples from the Vojvodina region, with an average value of 0.79 mm². By measuring 387 samples, Milne et al. (1986) found that the tibia area is 1.54 to 2.28 mm². Poklucar (1999) stated that the average tibia area in bees from Slovenia is 2.65 mm².

The length of the third tergite ranged from 2.13 to 2.23 mm in the observed samples, with an average value of 2.17 mm. The obtained data are similar to

data provided by Plužnikov (1994) for this parameter, obtained by examining the bees from Bosnia and Herzegovina (2.17 mm), Montenegro (2.2 mm) and Serbia (2.32 mm). Georgiev (2007) give a variation interval from 1.91 to 2.18 mm for this trait in bees from eastern Serbia. Simeonova (2009), for bees from the north of Kosovo and Metohija (Kosmet), states an average of 2.75 mm and Mladenović and Simeonova (2009) determined a value of 2.62 mm for the length of the third tergite by examining honey bees from central Kosmet.

The width of the third tergite ranged from 4.78 to 4.95 mm, and the average value was 4.86 mm. The obtained data are similar to data provided by Plužnikov (1994) obtained by examining the bees from Bosnia and Herzegovina (4.73 mm), Montenegro (4.70 mm) and Serbia (4.73 mm). Georgiev (2007) stated that the variation interval for this trait is from 4.00 to 4.87 mm in bees from eastern Serbia. Simeonova (2009) stated that for bees from the north of Kosmet, the average value is 5.88 mm and Mladenović and Simeonova (2009a), in their studies of honeybees from central Kosmet, obtained a value of 5.68 mm for this trait.

The wax plate mirror length in the observed samples ranged from 1.28 to 1.37 mm, with an average value of 1.31 mm. The results obtained in the seven examined samples are slightly lower compared to the results that Plužnikov (1994) presented when examining the bees from Serbia (1.44 mm) and Montenegro (1.53 mm). Georgiev (2007) indicates that the variation interval is 1.25 to 1.47 mm for this trait in bees from eastern Serbia. Simeonova (2009) determined an average value of 1.89 mm in bees from the north of Kosmet, and Mladenović and Simeonova (2009a), in examining the honeybees from central Kosmet, obtained the value of 1.94 mm for the length of wax plate mirrors.

The width of the wax plate mirror in the observed samples ranged from 2.33 to 2.49 mm, with an average value of 2.41 mm. The results are in concurrence with the results of Plužnikov (1994) where the width of the wax plate mirrors in bees

from Serbia is 2.45 mm, from Montenegro it is 2.42 mm and from Bosnia and Herzegovina 2.49 mm. Georgiev (2007) indicates a variation interval from 2.06 to 2.15 mm for this trait in bees from eastern Serbia. Simeonova (2009), for bees from northern Kosmet, determined an average value of 3.03 mm, and Mladenović and Simeonova (2009a), in examining the honey bees from central Kosmet, obtained the value of 3.16 mm for the width of the wax plate mirrors.

A detailed taxonomic analysis (from the morphological to molecular level) needs to be carried out on honeybees from the whole Pannonian Plain. Honeybees from Vojvodina and Serbia represent an indigenous gene pool within *A. m. carnica*, with a small number of specific populations created during evolution. Because the territory of the Balkan Peninsula was a refugium for many animal species during the period of the Ice Age in the Pleistocene (Schmitt, 2007), the honeybee haplotypes of Serbia (Nedić et al., 2009) could be regarded as relict groups. For a distinct separation of the areas of dissemination of certain honeybee subspecies and ecotypes, it is necessary to take into account both morphological characteristics and molecular markers.

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