A COMPARISON OF VARIOUS HARDWARE FOR THE MEASUREMENT OF THE CUBITAL INDEX

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Summary

The common availability of hardware offers a possibility of its application in various areas of life, including morphological measurements. The application of appropriate software and commonly available office scanners enables considerable simplification of work.

This study addresses a comparison of the cubital index measured with three methods.

Control measurement of a preparation was carried out in triplicate with the most known method, i.e. by means of a microscope. Next, measurements of three different preparations (each in three repetitions) were performed on two types of monitors and scanners.

The highest value of the cubital index, i.e. 1.92, was obtained in the microscopic measurement, whereas its values obtained from a computer measurement ranged from 1.65 at the resolution of 600 dpi and CRT type monitor to 1.85 at the resolution of 4800dpi and LCD type monitor. It can be concluded, thus, that the value most similar to that obtained in the microscopic measurement is obtained with the latter equipment combination. The statistical analysis of results demonstrated no significant difference between the types of monitors used or statistically significant differences between the applied scanning resolutions. It should be assumed, therefore, that increasing the scanning resolution affects higher accuracy of measurement, whereas the application of a scanner with the resolution of 4800 dpi enables obtaining satisfactory results.

Keywords: bee, cubital index, index values, morphology, office scanner.

INTRODUCTION

To date, measurements of bee bodies performed in order to determine their taxonomy have been carried out with the use of magnifying devices, including most of all magnifying glass, a microscope with a micrometric eyepiece or a reader projecting the magnified picture on a screen.

The most frequently evaluated and commonly recognized trait is the cubital index.

This index, unlike any other, enables precise determination of breed affiliation, and even the linear affiliation, of the bees examined. Hence, it is most often applied in practice.

Unfortunately, labor consumption of morphological measurements (Samborski et al. 2002) as well as the necessity of possessing appropriate devices to be used for that purpose (Prabucki et al. 1978) limit their common application.

The rapid development of computer technology have also led to very considerable advances in that field. Implementation into practice of simple and cost-effective tools enabling determination of values of morphological traits seems to be only a matter of time.

The study was aimed at comparing the accuracy of measurements of the cubital index (ell index) carried out with the use of a computer software on various devices.

MATERIAL AND METHODS

The measurements were performed on preparations obtained from worker bees originating from three different colonies. Three preparations were made, one from each colony. Each preparation contained thirty right wings of the first pair (Ruttner 1992). The prepared wings were protected with scotch tape.

The cubital index was measured with an Mst 131 microscope with a micrometric eyepiece mounted especially for that purpose (Bornus et al. 1966). The method of Ałpatow provides percentage values, whereas that of Goethe provides digital values. Since the values of the cubital index are measured with Ałpatow's method only in Poland and eastern countries, in experimental assumptions we adopted the measurement of the cubital index with the Goetze's method (Ruttner 1992) providing an equivalent of the percentage index acc. to Ałpatow. To determine the accurate value of the cubital index and then to compare it with the results obtained, a microscopic control measurement of the first preparation was carried out in three repetitions.

The preparations were then successively scanned on a glass of flat office scanners.

Table 1

Comparison of computer-aided and microscopic measurement accuracy.

Measurement device	Type	n	Values for the measurement of specimen I		
			range	mean ± (SD)	difference of computer and microscope value
Microscope	MST-131	90	1.49-2.67	1.92 ± 0.22 ab	-
Computer	600dpi CRT	177	1.22-2.22	1.65 ± 0.19 ac	0.27
	600 dpi LCD	179	1.16-2.54	1.67 ± 0.26 bd	0.25
	2400 dpi CRT	180	1.24-2.33	1.75 ± 0.22 ad	0.17
	2400 dpi LCD	180	1.27-2.39	1.77 ± 0.22 bc	0.15
	4800 dpi LCD	90	1.48-2.32	1.85 ± 0.19 cd	0.07

Means followed by the same characters are significantly different at 0.05.

Table 2

Mean values of the cubital index.

Type of hardware used	Specimen			
	I	II	III	$\bar{x}$
600 dpi CRT	1.65	1.81	2.12	**1.87** ab
600 dpi LCD	1.67	1.83	2.13	
2400 dpi CRT	1.75	1.95	2.29	**2.01** ac
2400 dpi LCD	1.77	1.98	2.32	
4800 dpi LCD	1.85	2.07	2.41	**2.11** bc

Means followed by the same characters are significantly different at 0.05.

Table 3

Comparison of different computer hardware.

Type of hardware	Repetition	Specimen									Mean value of the sum of measurements ± SD
		I			II			III			
		Number of wings	Range of meas uremen	$\bar{x}$	Number of wings	Range of meas uremen	$\bar{x}$	Number of wings	Range of meas uremen	$\bar{x}$	
600 dpi CRT	1	59	1.25-2.41	1.68	60	1.26-2.67	1.87	60	1.50-3.25	2.23	
	2	59	1.22-2.22	1.63	60	1.23-2.55	1.82	60	1.54-2.91	2.12	
	3	59	1.22-2.13	1.65	60	1.35-2.55	1.72	60	1.38-3.02	2.03	**1.86 ± 0.33** ac
		177		292.66	180		325.14	180		382.34	
$\bar{x}$		–		–			1.81	–		2.12	
600 dpi LCD	1	60	1.16-2.46	1.66	60	1.50-2.56	1.89	60	1.54-3.09	2.17	
	2	59	1.32-2.51	1.70	59	1.44-2.2	1.81	60	1.60-3.03	2.13	
	3	60	1.25-2.54	1.64	60	1.16-2.41	1.79	60	1.26-2.88	2.09	**1.88 ± 0.33** bd
		179		298.71	179		327.23	180		393.23	
$\bar{x}$		–		1.67	–		1.83	–		2.13	
2400 dpi CRT	1	60	1.24-2.26	1.72	60	1.46-2.47	1.94	60	1.50-2.94	2.31	
	2	60	1.28-2.31	1.76	60	1.57-2.66	1.97	60	1.58-2.98	2.30	
	3	60	1.24-2.33	1.75	60	1.56-2.60	1.95	60	1.56-2.84	2.28	**2.00 ± 0.34** ad
		180		313.41	180		351.84	180		413.06	
$\bar{x}$		–		1.75	–		1.95	–		2.29	
2400 dpi LCD	1	60	1.27-2.39	1.78	60	1.65-2.60	1.98	59	1.62-3.06	2.33	
	2	60	1.27-2.37	1.75	60	1.56-2.59	1.98	60	1.62-3.04	2.33	
	3	60	1.28-2.37	1.78	60	1.60-2.68	2.00	60	1.71-3.04	2.30	**2.02 ± 0.35** bc
		180		318.34	180		356.77	179		415.78	
$\bar{x}$		–		1.77	–		1.98	–		2.32	
4800 dpi LCD	1	30	1.48-2.28	1.84	30	1.74-2.58	2.07	30	1.84-3.05	2.41	
	2	30	1.51-2.32	1.85	30	1.72-2.59	2.08	30	1.87-3.03	2.41	
	3	30	1.50-2.26	1.85	30	1.73-2.56	2.07	30	1.85-3.01	2.41	**2.11 ± 0.19** ab
		90		166.12	90		186.7	90		216.71	
$\bar{x}$		–		1.85	–		2.07	–		2.41	

Means followed by the same characters are significantly different at 0.05.

Use was made of HP scanners – models: 3300C and 3970, and Epson scanner 4990 PHOTO. The picture was scanned with the maximum equipment resolution, i.e. 600dpi (3300C) and 2400dpi (3970) in the case of HP scanners and 4800dpi in the case of Epson scanner.

Projections and measurements of pictures obtained from the HP scanners were performed with two types of monitors. In the first case, it was a 15 inch NEC CRT monitor (MultiSync V520), whereas in the second – a 17 inch Samsung LCD monitor (SyncMaster 740N). Screen resolution on

the first monitor accounted for 1024x768, whereas on the second – for 1280 x 1024.

In the case of the Epson 4990 PHOTO scanner, due to the size of the graphic files obtained, the picture was only analyzed on a computer with a better processor capacity and the second type of monitor, i.e. LCD monitor.

The picture was saved in the *.BMP format in order to avoid quality losses linked with its compression.

The method of determining the cubital index by means of a computer consisted in sending the scanned picture into Flugelindex 2 software, in which measurement points were marked. The results obtained were presented automatically in a digital or graphical form.

In order to determine measurement accuracy, each preparation was measured three times.

RESULTS

The results obtained in a microscopic measurement were different than those obtained with the computer-aided method. The difference observed between them ranges from 0.27 at the measurement with the lower resolution on the CRT monitor to 0.07 at the measurement with the higher resolution on the LCD monitor (Tab. 1). The control measurement (microscope) is characterized by a higher value of the cubital index (1.92) and does not differ significantly from that obtained on the LCD monitor with the highest resolution (Tab. 1).

In analyzing the results obtained at the lower and higher resolution, we may conclude that no significant differences exist between the monitors examined at a significance level of 0.01 at the same resolution (Tab. 2). Significant differences can, in turn, be observed at a significance level of 0.05 between various resolutions used for scanning the preparations (Tab. 2).

The results obtained enable concluding that the highest value of the cubital index in computer-aided measurements was obtained while using a combination of the LCD monitor at an image resolution of 4800 dpi (2.11), whereas the lowest one was obtained from using the CRT monitor at a resolution of 600 dpi (1.86) - Tab. 3.

The values obtained from measurements of pictures scanned with the highest resolution are characterized by higher repeatability of results (Tab. 3).

CONCLUSIONS

1. Results of computer measurements at high resolution (4800 dpi) do not differ significantly from those obtained in microscopic measurements.
2. The application of scanners with a higher resolution enables obtaining satisfactory results.
3. The value of the measurement appeared not to be affected by the type of monitor used.

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PORÓWNANIE PRZYDATNOŚCI RÓŻNEGO SPRZĘTU KOMPUTEROWEGO DO POMIARU INDEKSU KUBITALNEGO

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S t r e s z c z e n i e

Powszechna dostępność sprzętu komputerowego stwarza możliwość stosowania go w różnych dziedzinach życia. Również w pomiarach morfologicznych istnieje taka możliwość. Zastosowanie odpowiedniego oprogramowania i powszechnie dostępnych skanerów biurowych pozwala na znaczne uproszczenie pracy.

W opracowaniu tym porównano pomiary indeksu kubitalnego, trzema sposobami.

Kontrolnie wykonano pomiar preparatu w trzykrotnym powtórzeniu, najbardziej znaną metodą tj. z pomocą mikroskopu. Następnie wykonano pomiary trzech różnych preparatów każdy w trzech powtórzeniach na dwóch typach monitorów i skanerów.

Największą wartością indeksu kubitalnego cechował się pomiar mikroskopowy 1,92, zaś wartości uzyskane z pomiaru komputerowego wahały się w granicach 1,65 dla rozdzielczości 600 dpi i monitora typu CRT, do 1,85 dla rozdzielczości 4800 dpi i monitora typu LCD. Możemy zatem wnioskować, że najbardziej zbliżoną do mikroskopu wartość uzyskujemy za pomocą ostatniej kombinacji sprzętowej. Analiza statystyczna wyników wykazała, że nie ma istotnej różnicy pomiędzy zastosowanymi typami monitorów, natomiast istnieje statystycznie istotna różnica pomiędzy stosowanymi rozdzielczościami skanowania. Przyjąć należy więc, że zwiększanie rozdzielczości skanowania wpływa na zwiększenie dokładności pomiaru, a zastosowanie skanerów z rozdzielczością 4800 dpi pozwala uzyskać zadowalające wyniki.

Słowa kluczowe: pszczoła, indeks kubitalny, wartości indeksu, morfologia, skaner biurowy.