THE MORPHOMETRY OF MALE ADULTS OF SOUTHERN HAWKER (*AESHNA CYANEA* (MÜLLER, 1764) ODONATA: AESHNIDAE) FROM THE SLOVAK REPUBLIC

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ABSTRACT

The study elaborates the morphometric analysis of 112 male imagoe specimens of Southern Hawker (*Aeshna cyanea*) from 8 localities of Slovakia. 12 morphometric signs for imagoe specimens of Southern Hawker are measured by calliper. The research has confirmed several distortions of normality of data, partly caused by measurement error, e. g. in mm wingspan (WS = average ± SE: 96.66 ± 3.93), body length (BL = average ± SE: 64.86 ± 2.18). This morphometric structure is the most problematic to measure, because of curvature caused by placement in test-tubes with alcohol (97%). We researched there exist correlation between morphometric signs wingspan and the length of body. In addition it has been proved that the correlation of signs is not often linearly correlated. The results are also important, because morphometric signs are used in many determination keys of Odonates. In fact Odonata species are bioindicators of pollution and global warming; measured morphometric structures could be used such as means for monitoring of changing environmental variables in future. We have processed so far the largest data set of morphometric data for Slovakia.

Key words: *Aeshna cyanea*, morphometry, male imagoe specimens, Slovakia.

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INTRODUCTION

The understanding of morphometric characteristics of Dragonflies (*Insecta: Odonata*) is actual in current time. Moreover they have significance for bioindicating of pollution and global warming . They are basic elements for determinating in detetmination keys. The morphometric characteristics could be used for monitoring of weather atributes, e.g. climate changes. According to McNeely (2010) this provides a novel and cost-effective approach.

The amphibious eurytopic species *Aeshna cyanea* (Müller, 1764) Southern Hawker settles various types of lentic habitats. It is characteristic by its adaptability to its changes, it has stable distribution in Europe (Hof, 2010). The morphometric details of imagoe *Aeshna cyanea* have published e.g. Sternberg & Buchwald (2000): the length of the body 6-8 cm (average length ♂ 73,7 mm ♀ 72,2 mm), wingspan ♂ od 100,2 mm, ♀ od 103,7 mm. Askew (1988) presents the length of the body between 67-76 mm, the length of pterostigma does not exceed 3 mm. Kunz (2006) presents the length of the body between 65-72 mm and wingspan 91 – 108 mm. According to Tillyard (1917) the length of hindwing is for ♂ 45-50 mm, for ♀ 48-52 mm, length of abdomen is for ♂ between 54-58 mm, for ♀ 55-58 mm. Hanel & Zelený (2000) mention the length of the body 51- 60 mm for both sex.

By now only morphometric details of larvae *A. cyanea* from Slovakia have been elaborated, (Kubovčík & kol. 2012). Their morphometric analysis was realized for identification of developments stages from chosen ponds of Banská Štiavnica. There is presented average length of the body (24-27,5 mm), length of cercus (3,5-3,90 mm), head width (6,5-6,90 mm), length of right hindwing (5,20-6,10 mm) and length of right anterior tibia (4,4-4,5 mm) for larvae.

MATERIAL AND METHODS

We measured 12 morphometric signs (tab. 1) on 112 imagoe (♂) *Aeshna cyanea* from z 8 Slovak locations. Used abbreviations for measured morphometric signs are by Giacomini & kol. (2008), Goretti & kol. (2001) and Kubovčík (2012).

Tab. 1 Measured morphometric characters of imagoe specimens of Aeshna cyanea

1. WS	wingspan	7. LC	length of cercus
2. BL	length of body	8. HW	head width
3. LLF	length of left forewing	9. LPLF	length of pterostigma on the LF
4. LRF	length of right forewing	10. LPRF	length of pterostigma on the RF
5. LLH	length of left hindwing	11. LPLH	length of pterostigma on the LH
6. LRH	length of right hindwing	12. LPRH	length of pterostigma on the RH

Material for morphometric analysis has been collected from 8 locations from Slovakia during years 1998-2012 (det. et coll. S. David ÚKE SAV, branch-office Nitra): location (L) č. 1- Dlhá nad Oravou (49° 16´ 5.02" s. z. š., 19° 27´ 50" v. z. d., flooded quarry in the inundation river, 480 m n. m., 2008- 2010- 35♂, lgt. K. Janeková. L č. 2 Veličná (19° 15´ 49" s. z. š., 19° 12´ 8,73" v. z. d., oxbow lake, 461 m n. m., 2008-2009- 32♂, lgt. K. Janeková. L č. 3 Istebné (19° 14´ 49" s. z. š., 49° 12´ 12,22" v. z. d., oxbow lake, 457 m n. m., 2008- 2009- 11♂, lgt. K. Janeková. L č. 4 Jurošák (18° 47´ 49" s. z. š., 49° 26´ 32,61" v. z. d., river, 434 m n. m., 2005- 16♂, lgt. K. Matáková. L. č. 5 Čierne-Polesie (18° 52´ 49" s. z. š., 49° 30´ 39,55" v. z. d, gravel pit, 490 m n. m., 2004- 8♂, lgt. S. David. L. č. 6 Oščadnica- CHÚ „Močiar" (18° 50´ 49" s. z. š., 49° 25´ 23,03" v. z. d, swamp, 404 m n. m., 2005- 4♂, lgt. S. David. L č. 7 Lysá nad Dunajcom (20° 21´ 49" s. z. š., 49° 23´ 57,88" v. z. d., swamp, 478 m n. m., 2012- 1♂, lgt. S. David. L. č. 8 Levočské lúky (20° 35´ 49" s. z. š., 49° 2´ 36,32" v. z. d, marsh, 580 m n. m., 1998- 5♂, lgt. J. Schneider.

We measured imagoe species by digital calliper with precision 0,01 mm and we also used binococular loupe. Each size have been measured three times, the average ($\bar{x}$) of it was used for our analysis. We used software StatistikaCz. ver. 7.0 (StatSoft, Inc., 2004) for statistic analysis (descriptive statistics, normality test of data with using Normal Probality Plots and Sapiro-Wilk´s Test for normality and its associated p-value and correlation of chosen morphometric signs).

RESULTS AND DISCUSSION

Descriptive statistics

The results of descriptive statistics of 12 measured morphometric structures of male imagoe species are in tab. 2. Abbreviations of each measured sign are in tab. 1.

Tab. 2 The results of the descriptive statistics of male adult Aeshna cyanea (abbreviations in tab. 1)

	WS	BL	LLF	LRF	LLH	LRH	LC	HW	LPLF	LPRF	LPLH	LPRH
A	96,66	64,86	47,47	47,54	47,06	47,02	5,14	9,49	2,72	2,72	2,70	2,69
SE	0,37	0,21	0,14	0,13	0,14	0,12	0,02	0,03	0,02	0,02	0,02	0,02
M	97,35	64,94	47,56	47,62	47,13	46,94	5,15	9,52	2,72	2,72	2,68	2,68
SD	3,93	2,18	1,46	1,37	1,40	1,31	0,21	0,29	0,24	0,21	0,22	0,21
MI	80,41	57,47	43,05	43,25	43,26	43,15	4,28	7,71	2,20	2,20	2,32	2,26
MA	103,25	71,98	50,47	49,97	50,03	49,53	5,83	9,99	3,64	3,39	3,41	3,44
N	110	111	111	110	108	110	112	112	112	112	112	112
LS	0,74	0,41	0,27	0,26	0,27	0,25	0,04	0,05	0,05	0,04	0,04	0,04

Explanations: A- average, M-median, SE- standard error, M- median, SD- standard deviation, MI- minimum value, MA- maximum value, N- number of observations, LS- level of significance (95,0%).

The high value of scatter (15,45) and standard deviation (3,93) presents extreme values. They can indicate possible error of measuring structures. It could be useful to choose different steps when measuring wingspan. There is an assumption that destructive method of removing and slide-mounting wings provides the most accurate method of measurement because it eliminates error due to wing curvature (Johnson & kol., 2013). Dragonflies measured by us were placed in test-tubes in alcohol (97%).

Normality test of measured data

We used Normal Probability Plots with Shapiro-Wilk´s W test in testing for normality of verification a one-dimensional test. We tested hypothesis: H_0: random selection comes from a set of normal distribution. If $p > p_\alpha$ => we cannot reject H_0 of the statistic significance level 95% (p_α = 0,05). The results of normality distritudion of data are in tab. 3:

Tab. 3 The results of normality test of distribution data (abbreviations in tab. 1)

Znak	Shapiro-Wilks W Test	Znak	Shapiro-Wilks W Test
BL	W= .98404, p= .20894	LC	*W= .96307, p= .00346**
WS	*W= .91870, p= .0000****	HW	*W= .86092, p= .0000****
LLF	*W= .96509, p= .00528***	LPLF	*W= .95730, p= .00124**
LRF	*W= .97246, p= .02221**	LPRF	*W= .96849, p= .00949***
LLH	W= .97653, p= .05290	LPLH	W= .97871, p= .07067
LRH	W= .97895, p= .07913	LPRH	*W= .97129, p= .01623**

The normality of data distribution is distorted in 8 morphometric signs, they are marked by level of test significance (*). Normal distribution of measured signs: *length of the body*, *length of left and right hindwing* and *length of pterostigma on the LH*. Distorted distribution is marked by italics. In fact, one possibility of error normality of data may be caused by inaccuracy measuring. Our measured material was in alcohol (97 %) and sample of males were partly curvatured in test-tubes.

Correlation analysis of morphometric signs of males *Aeshna cyanea*

We tested the correlation of chosen signs that are used in determination keys. We used the selection of categorized 2D scatter-plots and we tested hypothesis H_0: morphometric signs are not correlated. If $p > p_\alpha$ => we cannot reject H_0 of the significance level 95 %. The results of correlation analyse: *BL x WS: r = 0.5003, p = 0.0000***, r^2 = 0.2503; BL x LC: r = 0.2403, p = 0.0111**; r^2 = 0.0577; LLF x LPLF: r = 0.0047; p = 0.9606; r^2 = 0.0000 a LLH x LPLH: r = -0.0634; p = 0.5147; r^2 = 0.0040*. The analysis has confirmed the correlation between length of wings and length of body for males *Aeshna cyanea* and the correlation between length of cercus and length of body (these correlations are marked by italics).

CONCLUSIONS

We have processed first morphometric data of males *Aeshna cyanea* (N = 112) of Slovakia (so far the largest data set of morphometric data for Slovakia). We measured 12 morphological-morphometric structures (e.g. length of body, length of cercus, head width,...). The normality of data for length of body, length of left and right hindwing and length of pterostigma on the LH was statistically accepted. High value of scatter (15,45) and standard deviation (3,93) was confirmend by the sign wingspan; in association with the error normality for mentioned sign, the result presents extreme values. This fact can indicate the error of measuring because imagoe species were stored in test-tubes with alcohol and were partly curvated, what obstructed the technique of measuring. Correlation analysis has proved the correlation between morphometric signs: wingspan and length of body; length of cercus and length of body. These processed morphometric characteristics can be used in preparing of determination tools. They make primary imputs into other analysis, e. g. impact of various habitats and environmental variables on phenotype *Aeshna cyanea* or such as means in future for monitoring of changing environmental variables.

REFERENCES

ASKEW, R. R., 1988: *The Dragonflies of Europe*. Colchester: Harley Books, 291 s.

GIACOMINI, H. C. and DE MARCO, P., 2008: Larvae ecomorphology of 13 Libelluliade (Anisoptera, Odonata) of the Middle Rio Doce Valley, Minas Gerais, Brasil. *Braz. J. Biol*., 68 (1): 211-219.

GORETTI, E., CECCAGNOLI, D, LA PORTA, D. and DI GIOVANNI, M. V., 2001: Larval development of Aeshna cyanea (Müller, 1764) (Odonata: Aeshnidae) in Central Italy. *Hydrobiologia, Kluwer Academic Publishers*, 457:149–154.

HANEL, L. and ZELENÝ, J., 2000: *Vážky (Odonata), výzkum a ochrana*. Vlašim: ČSOP, 240 s.

HOF, CH., 2010: *Species distribution and climate change: current patterns and future scenarios for biodiversity*. Copenhagen. 119 s. Dissertation. Department of Biology, Faculty of Science University of Copenhagen, Supervised by Carsten Rahbek and Miguel B. Araújo. (on line: www.bi.ku.dk/bibliotek/phd/Christian%20Hof.pdf).

JOHNSON, L., MANTLE, B. L., GARDNER, J. L. and BACKWELL, P. R. Y., 2013: Morphometric measurements of dragonfly wings: the accuracy of pinned, scanned and detached measurement methods. *ZooKeys*, 276: 77-84.

KUBOVČÍK, V., GAJDOŠOVÁ, I., ŠULÁKOVÁ, M. and SVITOK, M., 2012: Vážky (Odonata) Malej vodárenskej nádrže a životný cyklus druhu Aeshna cyanea. *Folia Faun. Slov*., 17: 297-303.

KUNZ, B., 2006: Eine biometrische daten von univoltinen Aeshna cyanea. *Mercuriale*, 6: 33-36.

MCNEELY, J., 2010: Monitoring climate change with dragonflies: Foreward. *BioRisk*, 5: 1-2.

StatSoft, Inc. (2004). STATISTICA Cz [Softwarový systém na analýzu dat], verze 7. Www.StatSoft.Cz.

STERNBERG, K. and BUCHWALD, R. (eds.), 2000: *Die Libellen Baden – Wűrttembergs, Bd. 1.: Allgemeiner Teil Kleinlibellen (Zygoptera)*, 468 s., *Bd. 2: Goroβlibellen (Anisoptera)*, Stuttgart: Verlag Eugen Ulmer Gmb H &Co., 712 s. ISBN: 3-8001-3508-6, ISBN: 3- 8001- 35140.

TILLYARD, R. J., 1917: *The Biology of dragonflies (Odonata or Paraneuroptera)*. Cambridge: Cambridge University Press, 396 s.