MORPHOLOGY AND MORPHOMETRY OF THE ANTEBRACHIAL SKELETON AND BONES OF HAND OF THE DOMESTIC PEKIN DUCK

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Summary. The aim of the present study was to study the feature and to analyse the morphometry of the antebrachial skeleton and bones of hand of the domestic pekin duck (*Anas platyrhynchos f. domestica*). The morphological studies covered 84 immature ducks (42 females, 42 males) and 40 adult ducks (34 females, 6 males). Mean body weight and absolute parameters of all bones were determined separately for each sex of ducks and for the total sample. There were found statistically significant differences ($p<0,05$) in the respective bones traits between males and females - quality of dimorphism and between immature and adult ducks – ontogenetic nature. The obtained results can be used in the breeding research and in the definition of remains of bones of the fossil birds during excavation.

Keywords: duck, bones, morphology, morphometry.

NAMINĖS PEKINO ANTIES DILBIO IR PLAŠTAKOS KAULŲ MORFOLOGIJA IR MORFOMETRIJA

Santrauka. Nėra tikslių duomenų apie laukinių ir naminių paukščių ir jų formų skeleto morfometriją. Šių tyrimų tikslas – atlikti naminės Pekino anties (*Anas platyrhynchos f. domestica*) dilbio ir plaštakos kaulų analizę. Tyrimams gauta 84 nesubrendusių paukščių (42 patelės ir 42 patinai) ir 40 suaugusių individų (6 patelės ir 34 patinai) iš naminių paukščių fermos Międzyrzec Podlaski. Kaulų struktūroms ištirti parinkti ontogenetinis ir dimorfinis metodai.

Laboratorijoje antys į grupes suskirstytos pagal lytį ir amžių. Prieš kiekvieną tyrimo etapą paukščiai buvo sveriami elektroninėmis svarstyklėmis 0,1 kg tikslumu. Laikantis klasikinės anatominės metodikos kaulai buvo preparuojami. Gauta kaulinė medžiaga buvo verdama 3% $NaHCO_3$ tirpale ir balinama 3% H_2O_2 tirpalu. Tada kaulai buvo džiovinami patalpoje 16–20 ^oC temperatūroje ir išmatuoti slankmačiu 0,1 mm tikslumu.

Tyrimų rezultatai rodo, kad egzistuoja dimorfiniai sparnų kaulų pločio ir ilgio skirtumai tarp nesuaugusių ir suaugusių ančių. Šie skirtumai statistiškai reikšmingi, ypač tarp suaugusių ančių.

Raktažodžiai: antis, kaulai, morfologija, morfometrija.

Introduction. In the previous anatomical elaboration the skeleton structure of the wild birds and their domestic form were included only occasionally (Dobrowolski and Halba, 1970). There are also not many papers concerning the skeleton structure of the birds with regard to a range of environmental parameters and various mode of life (Bannasch, 1986). Generally these anatomical elaborations refer only to bones of particular body parts of the domestic birds. One of the elder studies describes bones of the thoracic limb of domestic ducks breeding in Germany (Timman, 1919). Furthermore this elaboration demonstrates as much more small size of German farming birds as in the rest of World. Highly extensive reports relating to skeleton morphology of the domestic ducks with regard to domestic goose (Dobrowolski and Halba, 1970; Ede, 1996). Much more precise osteometrical study among gallinaceous birds was performed also in German (Schweizer, 1961).

The main currently trend of delve are structural and mechanical quality of the skeletal system of different bird species (Ede, 1996; Kaczanowska-Taraszkiewicz, 2001; de Margerie et al., 2004). However, the most of the similar studies was conducted among wild and domestic mammals (Ferretti et al., 1993; Sasaki, et al., 1999) as well fossil animals (Hu, 2005). There are freshly delved in farm chicken (Zweers et al., 1987; Applegate and Lilburn, 2002; Kowalik et al., 2004) which was prelude to undertake similar attempt amongst other bird species (Burke and Henry, 1999; Kaczanowska-Taraszkiewicz, 2001). Among others, the mechanical and geometrical parameters of the mallard skeleton were the aim of the study concerned by Kowalik et al. (2004).

The aim of the present study was to elaborate morphological and morphometrical analyses of the antebrachial skeleton and bones of hand of the domestic pekin duck. There were supposed to define measurement of the respective bones, as overriding point of the study as adequate to the age and sex. Therefore, there were conducted ontogenetic and dimorphic manner of delve of mentioned bone's structures. Moreover, the results constitute valuable origin to comparative inter specific studies (Bartyzel et al., 2003) and to the define remains of fossil birds bones during archaeological researches (Driesch, 1976; Tomek, 1984; Bocheński et al., 1997; Tomek and Bocheński, 2000).

Material and methods. The morphological studies was conducted using 84 skeletons of antebrachial and bones of hands of the immature, 4-8 week old persons (42 females, 42 males) and 40 skeletons of the adult domestic pekin ducks (34 females, 6 males). All of the birds came

from fowl farm in Międzyrzec Podlaski. In the laboratory each duck was defined separately to proper age and sex group based on anatomical structure of the external and internal sex organs and then was weighted with accuracy to 0,1 kg. Mean body weight of the adult individual was between 3,0 and 4,1 kg, whereas in the immature birds was between 1,9 and 3,2 kg. After slaughter the osseous material was fixed in accordance with classical anatomical preparative method (Kim et al., 2004). Subsequently, the skeletons were prepared and boiled in 3% solution of $NaHCO_3$, whereby the bones were steeped with water stream and after cleaning were bleached with 3% H_20_2 solution. Finally, the bones were dried in room temperature (16-20^{O}C). There were took careful notice in the anatomical description with regard to peculiarity species features of the duck as well to age and sex manner. The measurements of the thoracic limb bones were made by means of a slider with nonius accurately within 0,1 mm (Driesch, 1976). The absolute parameters of the appropriate bones was estimated for males, females and for all individuals separately based only on the left side skeletons of the antebrachial and bones of hand. There were calculated mean values ($\bar{x}$), standard deviation (SD) and coefficient of variability (CV). The obtained results were submitted to statistics procedure using t-Student test. The statistically significant differences was accepted at the level $p<0,05$.

Results.

Antebrachial skeleton.

Radius (radius). The maximum length of the mentioned bone in the adult male ducks (94,9 mm) was greater almost 4 mm than in adult females ($p>0,05$). The minimum width of the shaft of radius (4 mm) was also similar for both sex groups of the ducks. The width of the cranial and caudal end of radius was respectively significantly greater in the adult males than in females (tab. 1).

Table 1. **Parameters of radius. Explanations: mean values in the same line marked: A, B – differences extremely significant – p<0,01; a, b – significant differences – p<0,05; a, a – insignificant differences – p>0,05; m. – males; f. – females; im. – immature; ad. - adult**

Parameters (mm)		m. im.	f. im.	m. ad.	f. ad.
Maximum length of shaft	$\overline{x}$	$85,8^{a}$	$87,8^{a}$	$94,9^{a}$	$91,0^{a}$
	SD	7,3	4,2	2,1	13,59
	CV	8,5	4,8	2,2	14,93
Minimum width of shaft	$\overline{x}$	$3,6^{a}$	$3,6^{a}$	$4,4^{a}$	$4,0^{a}$
	SD	0,5	0,6	1,1	0,3
	CV	13,4	16,5	24,5	7,9
Maximum width of cranial end	$\overline{x}$	$5,9^{B}$	$5,0^{A}$	$6,9^{B}$	$6,0^{A}$
	SD	0,3	0,5	0,5	0,4
	CV	4,7	10,3	7,4	7,5
Maximum width of caudal end	$\overline{x}$	$7,7^{a}$	$7,8^{a}$	$9,4^{b}$	$9,0^{a}$
	SD	0,8	0,7	0,6	0,3
	CV	10,4	9,0	6,3	3,1

In the immature males the maximum length of radius was 2 mm smaller in size than in females. The minimum width of the shaft of mentioned bone was average 3,6 mm in both sex group of the immature ducks. Also the width of the caudal end of radius was similar between the immature males – 7,7 mm and females – 7,8 mm. Only the width of the cranial end of radius was statistically significant greater in the immature males than females (tab. 1).

Specific character of radius in the group of immature ducks was practically the same width along the length of the shaft. All of the osseous structures of the caudal end of the adult ducks radius were not developed yet in the immature individuals.

Ulna (ulna). In the domestic ducks these are the bones in the shape of a bow insignificantly longer and much thicker than radius. The maximum length of the mentioned bone in the adult males and females was respectively 102,4 and 100,1 mm and the difference was not significant ($p>0,05$). The maximum width of the shaft (7,3 mm) as well width of the caudal end of ulna (11,3 mm) was also insignificantly greater for group of the males duck. On the other hand the maximum width of the cranial end of ulna was significantly greater in the adult males than in females (tab. 2).

There was statistically significant difference in the length of ulna between immature and adult males which was estimated as 14,1 mm. The length of mentioned bone in immature males was also shorter than in females of that age group (90,7 mm). The minimum width of the shaft (6,1 mm) as well as width of the caudal end of ulna (10,1 mm) was insignificantly greater in immature males while the width of the cranial end of mentioned bone was greater in immature females (tab. 2).

In the immature ducks olecranon as well as placed in the caudal end of ulna anconeal process and their structures were hardly visible.

Bones of hand.

Hand (manus). In the domestic ducks the hand is longer than ante brachial and are composed of three parts: carpals (ossa carpi), metacarpals (ossa metacarpalia) and phalanges bones (ossa digitorum manus).

Carpal bones (carpus). These bones in the domestic ducks consisted of two bones: radial (os carpii radiale) and ulnar (os carpi ulnare).

Radial carpal bone (os carpii radiale). The maximum length of the mentioned bone in the adult male ducks (9,8

mm) was significantly greater than in females (9,7 mm). In the group of immature ducks maximum length of radial carpal bone (8 mm) was pretty similar for males and females ($p>0,05$) but to the adult ducks was near 2 mm smaller (tab. 3, 4).

Table 2. **Parameters of ulna, explanations in tab. 1**

Parameters (mm)		m. im.	f. im.	m. ad.	f. ad.
Maximum length of shaft	$\overline{x}$	$88,3^{a}$	$90,7^{a}$	$102,4^{a}$	$100,1^{a}$
	SD	8,2	5,3	2,1	3,0
	CV	9,2	5,8	2,1	3,0
Minimum width of shaft	$\overline{x}$	$6,1^{a}$	$5,9^{a}$	$7,3^{a}$	$7,0^{a}$
	SD	2,0	0,5	1,3	1,6
	CV	32,3	9,0	17,5	23,1
Maximum width of cranial end	$\overline{x}$	$11,2^{a}$	$11,5^{a}$	$15,0^{B}$	$14,0^{A}$
	SD	1,5	1,3	0,9	0,5
	CV	13,7	11,4	6,2	3,4
Maximum width of caudal end	$\overline{x}$	$10,1^{a}$	$9,9^{a}$	$11,3^{a}$	$11,0^{a}$
	SD	1,6	1,0	1,0	1,2
	CV	16,4	10,3	8,4	11,0

Table 3. **Parameters of bones of hand in the adult ducks, explanations in tab. 1**

Designation of bone		Parameters (mm)	m. ad.			f. ad.		
			$\overline{x}$	SD	CV	$\overline{x}$	SD	CV
Radial carpal bone		Maximum length	$9,8^{B}$	0,1	1,0	$9,7^{A}$	0,1	1,0
Ulnar carpal bone		Maximum length	$9,0^{a}$	0,1	1,6	$8,8^{a}$	0,4	1,4
Metacarpals bones		Maximum length	$75,0^{a}$	1,7	2,3	$73,3^{a}$	2,0	2,7
		Width of cranial end	$19,4^{b}$	1,3	6,5	$18,2^{a}$	1,0	5,5
		Width of caudal end	$10,9^{b}$	1,1	9,7	$9,9^{a}$	0,9	9,0
Phalanx II	Proximal phalanx	Maximum length	$30,23^{B}$	0,3	1,7	$28,3^{A}$	0,1	0,3
		Width of cranial end	$8,7^{B}$	0,1	1,7	$6,9^{A}$	0,1	1,7
	Distal phalanx	Maximum length	$2,0^{b}$	0,2	11,7	$1,8^{a}$	0,1	3,8
		Width of cranial end	$1,1^{B}$	0,1	10,9	$1,0^{A}$	0,1	9,4
Phalanx III	Proximal phalanx	Maximum length	$34,7^{B}$	0,9	2,7	$31,5^{A}$	0,3	1,1
		Width of cranial end	$8,9^{B}$	0,2	2,5	$7,9^{A}$	0,1	0,9
	Distal phalanx	Maximum length	$27,4^{B}$	0,5	1,8	$25,1^{A}$	0,2	0,7
		Width of cranial end	$5,9^{a}$	0,2	3,8	$5,8^{a}$	0,2	3,6
Phalanx IV	Proximal phalanx	Maximum length	$29,5^{B}$	0,5	1,6	$26,6^{A}$	0,4	1,5
		Width of cranial end	$6,2^{a}$	0,1	1,9	$5,9^{a}$	0,9	15,6

Table 4. **Parameters of bones of hand in the immature ducks, explanations in tab. 1**

Designation of bone		Parameters (mm)	m. im.			f. im.		
			$\overline{x}$	SD	CV	$\overline{x}$	SD	CV
Radial carpal bone		Maximum length	$8,1^{a}$	1,0	14,3	$7,9^{a}$	0,8	11,7
Ulnar carpal bone		Maximum length	$7,0^{B}$	0,5	7,8	$6,5^{A}$	0,7	12,5
Metacarpals bones		Maximum length	$68,6^{a}$	4,8	7,0	$67,9^{a}$	2,4	3,6
		Width of cranial end	$15,2^{a}$	2,2	14,7	$16,4^{a}$	1,2	6,1
		Width of caudal end	$8,2^{a}$	1,8	21,9	$7,5^{a}$	1,8	24,9
Phalanx II	Proximal phalanx	Maximum length	$23,0^{a}$	1,6	7,1	$23,2^{a}$	1,9	8,2
		Width of cranial end	$3,9^{B}$	0,4	9,2	$4,5^{A}$	0,6	14,0
	Distal phalanx	Maximum length	$1,5^{b}$	0,1	7,2	$1,5^{a}$	0,0	3,4
		Width of cranial end	$1,3^{B}$	0,2	12,9	$1,0^{A}$	0,1	12,2
Phalanx III	Proximal phalanx	Maximum length	$27,3^{B}$	2,7	9,9	$25,7^{A}$	2,1	8,3
		Width of cranial end	$7,2^{B}$	0,7	9,7	$6,5^{A}$	0,7	11,1
	Distal phalanx	Maximum length	$20,9^{B}$	1,6	7,5	$22,0^{A}$	1,3	6,0
		Width of cranial end	$4,5^{a}$	0,4	10,5	$4,4^{a}$	0,3	6,9
Phalanx IV	Proximal phalanx	Maximum length	$24,8^{B}$	0,3	1,2	$25,2^{A}$	0,6	2,5
		Width of cranial end	$5,2^{B}$	0,1	2,3	$4,5^{A}$	0,3	6,2

Ulnar carpal bone (os carpi ulnare). The maximum length of ulnar carpal bone in the adult males and females was pretty similar. In the immature males the maximum length of mentioned bone (7,0 mm) was significantly greater than immature females however to the adult males of ducks was almost 2 mm smaller (tab. 3, 4).

Metacarpals bones (ossa metacarpalia). The second and third metacarpal bones (ossa metacarpalia II and III) are joint each other. Between both of them run only subtle groove of metacarpal bones (fissura metacarpalia). The thicker part of that bone - second metacarpal bone is situated on the side of radial carpal bone. On the other hand, the thinner one is third metacarpal bone which is placed on the surface of ulnar carpal bone. Next to the proximal end of second metacarpal bone is located tuberosity of second metacarpal bone which is the remainder of first metacarpal bone (os metacarpale I). There is juxtaposing of that osseous structure with backward first finger.

The maximum length of the metacarpals bones in the adult male ducks was 75,0 mm and nearly 2 mm greater than in females. The width of the cranial end of mentioned bones (19,4 mm) as well as width of the caudal end (10,9 mm) was significantly greater in adult male ducks than in females - 18,2 and 9,9 mm, respectively(tab. 3, 4).

In the immature males the maximum length of that bones was 6,4 mm smaller than in the adult one. Among the immature ducks of both sexes the length of mentioned bones was practically equal. Also the width of cranial and caudal end of metacarpals bones was nearly similar between immature males and females (tab. 3, 4).

There was specific phenomenon of the structures of metacarpal bones in the immature ducks. Each of the osseous structures of mentioned bones as muscular flexor superficial tubercle were not developed yet suchlike in the adult individuals. From 84 analyzed thoracic limb skeletons of the immature ducks there were 36 cases with completely dissociation of the metacarpals bones.

Phalanges (digiti manus). There are three fingers - II, III and IV (digiti manus II, III et IV) of the duck's hand. The second and third fingers are always compound of proximal and distal phalanx. The distal phalanxes of second and third fingers have respective structures, unguis and apex. The fourth finger consists just of proximal phalanx with flexor process.

Proximal phalanx of digit II (phalanx proximalis digiti II). The maximum length of that bone in the adult males (30,2 mm) was significantly longer than in females (28,3 mm). The maximum width of cranial end in the mature males was 0,8 mm greater than in the mature females (tab. 3).

However, in the both sex group of immature ducks the maximum length of proximal phalanx digit II was practically identical and was estimated approximate to 23 mm. In turn the width of cranial end of that phalanx was significantly greater in females than in males (tab. 4).

Distal phalanx of digit II (phalanx distalis digiti II). The maximum length of that bone in the adult males and females was respectively 2,0 and 1,8 mm and that difference was statistically significance. Similarly the width of cranial end of that bone was significantly greater in mature males (tab. 3).

In the immature ducks of both sex the length of mentioned bone was approximately 1,5 mm (tab. 4). On the other hand the width of cranial end of distal phalanx digit II in immature birds was greater than in the adults and was estimated respectively 1,3 mm in males and 1,0 mm in females (tab. 3, 4).

Proximal phalanx of digit III (phalanx proximalis digiti III). The maximum length of that bone in the adult males (34,7 mm) was 3,2 mm significantly longer than in females (31,5 mm). There were also statistically significant greater values of the maximum width of cranial end in the mature males (tab. 3).

There were also significantly greater values of both parameters of proximal phalanx of digit III in the immature group of male ducks (tab. 4). On the other hand the maximum length as well as width of cranial end of that bone was respectively 7,4 and 1,7 mm smaller in immature males than the adults (tab. 3, 4).

Distal phalanx of digit III (phalanx distalis digiti III). The maximum length of mentioned bone in the adult males was significantly 2,3 mm greater than in females. In turn the width of cranial end of that bone was pretty similar in both groups of mature birds (tab. 3).

In the immature female ducks the maximum length of distal phalanx of digit III was significantly 1,1 mm greater than in males. On the other hand the width of cranial end of that bone was pretty similar in immature birds, males and females (tab. 4).

Proximal phalanx of digit IV (phalanx proximalis digiti IV). The maximum length of mentioned bone in the adult males and females was respectively, 29,5 mm and 32,4 mm. The maximum width of cranial end was just slightly greater in the mature males (tab. 3).

In the immature female ducks the maximum length of distal phalanx of digit IV was insignificantly greater than in males (tab. 4). The respective values of that bone in the adult males (28,2 mm) and females (27,8 mm) was about 3 mm greater (tab. 3, 4). The maximum width of cranial end of mentioned bone (5,2 mm) was significantly greater in immature male birds (tab. 4).

Discussion. The morphological and morphometrical analyses of the antebrachial skeleton and bones of hand in the domestic pekin ducks (Anas platyrhynchos f. domestica) let us the fresh view on anatomical characteristic of respective osseous structures. There were found distinct sex dimorphism in maximum length and width of particular bones of thoracic limb of the immature ducks as well as the adults. The dimorphism was especially evident in the mature birds.

The above considerations constitute only broad views of the anatomical researches of wild and domestic birds. There are just few papers contributing to recognition of the respective parts of bird's skeleton (Timman, 1919). It is necessary to conduct such as morphometrical and an archaeological investigation of bird's bones to further explanation of many environmental and ecological adaptations in varies species of bird. There are some data for confirmation to use by a bird which lives in opposite conditions the different manner of biomechanical parameters of their skeleton (Bannasch, 1986; Ede, 1996; Applegate and Lilburn, 2002; Kowalik et al., 2004; de Margerie et al.,

2004). There are also some implications of that to size of respective osseous structures of bird's skeletons.

The mean values of maximum length of radius was practically equal for immature and adult analyzed domestic ducks, respectively 86,8 and 92,9 mm. Parallel values of that bone in the research of Timman (1919) was slightly lower and the mean value in immature and adult ducks was respectively 80,0 and 91,5 mm.

The mean values of maximum length of ulna shaft in both analyzed age group of domestic ducks was in like manner. There were estimated, for mature and immature birds, respective quality of ulna length, 101,2 and 89,5 mm. On the other hand the respective values in the mentioned elaboration was 86,2 mm for immature ducks and 100,4 mm for adult birds.

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