MORPHOLOGY OF HEART AND SOME PARAMETERS OF BODIES OF THE BLACK SCOTER *(MELANITTA NIGRA LINNAEUS, 1758)*

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Summary. Comprehension on the subject of heart structure remains imperfect in relation to many bird species. Adjustment of cardio-vascular system for definite models of bird's lives i.e. for plunge is mostly attractive. Description of chosen anatomical parameter of body was the main intention of the research at the Black scoter *Melanitta nigra*, with scrupulous deliberation of heart structure as well as it size. Determination of execute measurements of heart parameters as well as their relative value performed on 30 adult persons of this sort of bird (16 males and 14 females). Animals earned from fishing net, they bogged to which during feeding and they died most often. Material gained from fishing bases of polish coasts of Baltic Sea, between 1995 and 2002 year. It performed following designation of body parameters: weight of body, length of body, length of tarsometatarsus, length of sternum as well as measurement of the following heart parameters: weight, height, width, girth, weight of right and left ventricle. Existence of statistically important difference exert in range of largeness of body and hearts among birds of opposite sex. Drakes characterized greater absolute dimension of body and all-out mass, owned too larger and heavier heart. However, did not ascertain statistically important difference in case of all linear parameters of heart as well as it relative weight.

Key words: heart, birds, black scoter, morphometry.

JUODOSIOS ANTIES (*MELANITTA NIGRA LINNAEUS, 1758*) ŠIRDIES IR KAI KURIŲ KŪNO PARAMETRŲ TYRIMAI

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Santrauka. Daugelio paukščių rūšių širdies struktūra ir kūno masė nėra iki galo ištyrinėta. Skirtingų paukščių rūšių kraujo apytakos organai skiriasi priklausomai nuo gyvenimo būdo. Vienas pagrindinių tyrimo tikslų – apibūdinti juodosios anties (*Melanitta nigra* L.) širdies ir kūno santykį. Tyrimai atlikti su 30 suaugusių šios rūšies paukščių (16 gaigalų ir 14 ančių). Medžiaga surinkta 1995–2002 metais Baltijos jūros pakrantėse (Lenkijos teritorijoje, žvejybos bazėse). Tyrimo metu tirti paukščių kūno parametrai – svoris, ilgis, pastaibio ilgis, krūtinkaulio ilgis, atlikti širdies tyrimai: svoris, aukštis, plotis, dešiniojo ir kairiojo skilvelių svoris. Atlikus statistinę paukščių kūno ir širdies parametrų analizę nustatyta, kad juodosios anties gaigalų kūno ir širdies ilgis bei svoris buvo didesnis negu patelių.

Raktažodžiai: širdis, paukščiai, juodoji antis, morfometrija.

Introduction. In the midst of near 9200 sorts of birds on the Earth, lamellirostres order *Anseriformes* includes 150 sorts, majority at that huge (97%) it belongs to suborder *Anseres*, the family Anatidae *Anatidae* (del Hoyo et al., 1992).

It is possible to divide them, from ecological point of view, on three groups of bird: phytophagous, omnivorous and plunderers. Gooses belong to phytophagous birds prominently. Proper ducks are representatives of omnivorous birds, among them the mallard *Anas platyrhynchos* who represents tribe *Anatini*. Many lamellirostres birds are predators, so they plunge on considerable depth in search nourishment, on which fishes or invertebrates consist. Representatives of tribe *Mergini*, Long-tailed duck *Clangula hyemalis* and Black scoter *Melanitta nigra*, represents this ecological group of

bird mainly (del Hoyo et al., 1992; Ferens and Wasilewski, 1977).

Many others researchers dealt with adaptation of cardio-vascular system for specific models of bird lives (Noren et al., 2001; Green et al., 2001; Yoda et al., 2001). The object of analysis undertakes in these work in determined majority was investigate influence of external environment on physiological modifications in cardio-vascular system of bird. Senglaub (1959) and Potemkowska (1975) between other dealt with largeness of bird's heart too. Elaborations of valid questions of anatomical structures face each other with ecological aspects considerably more rarely. In these elaborations are taken advantage parameters which defining largeness of body and heart as well their part.

The purpose of that work was morphological description of chosen linear parameter of body and heart as well as their individual part at Black scoter.

Material and methods. Black scoter nest on inland waters of tundra numerously (del Hoyo et al., 1992). It flies by in area of Baltic Sea coast periodically and spends there the winter usually. The birds of that sort overcome in the course of migration from 500 for 7000 km. Coast of Baltic Sea is a place to winter almost 800 thousand birds of that sort (Durinck et al., 1994; Hagemeijer and Blair, 1997). Black scoter belongs to plunderers group of birds and it plunges in search of food for 15 m of depth (del Hoyo i in., 1992).

Material used to analyses gained during autumn and wintry months between 1995 and 2002 year from fishing bases in neighborhoods of Dziwnów, Świnoujście, Międzyzdroje, Międzywodzie and Wisełka at polish coasts of Baltic Sea as well as in neighborhoods of Stepnica, Wolin and Kamień Pomorski at lagoon of Szczecin. Birds earned from fishing net, they bogged to which throughout feeding and subsequently they died most often.

In the present work we accepted bird's anatomical nomenclature according to elaboration Baumel et al. (1993). We determined taxonomy, age and sex of the birds as soon as delivered them to the laboratory. These analyses based on morphological and anatomical differences in some structures (i.e. dependent on feathers coloration as well as the degree of their wasted; conditioned by the differences in the structure of *Bursa Fabricii* as well as internal genital organs) accordingly to methods by Madge and Burn (1989) and Gille with Salomon (1999). Subsequently ducks were weighed (B) on Pesola balance with precision to 50 g. Then, were fulfilled measurements of the external body parameters accordingly to methods by Dzubin and Cooch (1992). The absolute body length (D) was measured by yardstick with precision to 5 mm from the end of the rostrum bridge to the end of the rump. The measure of the length of sternum (S) was done by slide caliper with 0,1 mm accuracy from the process of sternal crest to the end of middle sternal trabecula. Similarly, measure of the tarsometatarsus length (J) was made by slide caliper with precision to 0,1 mm from the proximal epiphysis of the bones talus – metatarsal to the trochlea of talus.

After that, the hearts dissected, rinsed off the blood and dried on blotting paper. The pericardium was removed and then the main blood vessels were cut accordingly to the methods by Drabek, Tremblay and Viscor (Drabek and Tremblay, 2000; Drabek, 1997, 1989; Viscor et al., 1985). Afterwards, 30 hearts prepared just like that were fixed in 10% formaldehyde solution. The preserved hearts were studied anatomically as well as morphologically more than six weeks later. The heart height (L) as well as heart width (W) were measured by slide caliper with precision to 0,1 millimeter. The height was measured from the apex to the base of heart including the rest of main blood vessels while the width was measured in horizontal plane at the level of coronary groove with adipose tissue. The girth of heart (C) was measured in horizontal plane at the level of coronary groove too, by yardstick with precision to 1 mm.

It performed anatomical preparation of heart structures accordingly to classical methods, separating ventricles from atriums. First cut, which exhibited front wall of the right ventricle, was led above the coronary groove from the opening of pulmonary trunk throughout caudal vena cava. Afterwards, second cut was carried toward the apex of heart through the wall next to the trabeculae carneae. Accordingly to distribution taken into consideration in the present work (Szostakiewicz-Sawicka, 1967), external wall of the arterial cone and part included between right and front border of interventricular septum presented front wall of the right ventricle; back wall of the right ventricle stretched from right for back border of interventricular septum.

It divides ventricles of heart on the following parts: right ventricle (RV), left ventricle (LV). Every part of heart, after removal blood, were weighed separately, with accuracy for 0,01 g. Right ventricle (RV) included front wall only whereas left ventricle (LV) included interventricular septum, back wall, and both of atrioventricular valves.

All gotten results subjected to statistical analysis. There were calculated mean values, standard deviation and coefficient of variability for all absolute parameters of body and heart. Indices, characterizing relative size of heart have been established also (Drabek and Tremblay, 2000; Drabek, 1997, 1989; Viscor et al., 1985; Hartman, 1955). We marked relative indexes of heart, heart height to it width (L/W); participation of front wall of right ventricle in relation to heart weight (RV/H %) as well as relation of mass of front wall of right ventricle to weight of left ventricle (RV/LV %). During nomination RV/LV index, we were taking into consideration interventricular septum, back wall, and both of atrioventricular valves. We established also relative mass of heart as a percent of body weight (H/B %).

Using t-Student test, corresponding mean values of absolute heart size as well as it relative largeness were submitted intraspecies comparison between both sexes (dimorphic relationship). Moreover were done intraspecies assessment among young and old persons (ontogenetic relationship). However, for grasping differences between species in largeness of relative

parameters characterizing heart and it parts has been employed Tukey test.

Base for installation proper algometric equation presented statistically important correlations among parameters of bodies and hearts (Schmidt-Nielsen, 1994; von Bertalanffy, 1984; Gould, 1966). General formula of the equation introduce in the following way: logY = b logX + A, where: Y – dependent variable (most often there is a mass of organ or it parts); X – independent variable (most often there is a body size parameter like it weight or length); b and A – constant of equation (A = log a).

All statistical computations were done using Statistica software package (StatSoft, Inc. 2000).

Table 1. **Characteristic of the absolute body and heart size of the Black scoter adult males and females**

Parameters	♂		♀		♂ *vs.* ♀
	X ± SD	V	X ± SD	V	
	n = 16		n = 14		
Parameters of body					
B (g) body weight	1373 ± 84 (1250 - 1590)	6,12	1203 ± 75 (1090 - 1350)	6,26	t = 5,78 p ≤ 0,01
D (mm) body length	433 ± 13 (410 - 460)	3,00	417 ± 26 (380 - 490)	6,23	t = 2,11 p ≤ 0,05
S (mm) sternum length	99,2 ± 6,1 (89,0 - 110,0)	6,18	94,6 ± 4,6 (89,0 - 103,0)	4,83	t = 2,10 p ≤ 0,05
J (mm) tarsometatarsus length	44,9 ± 1,4 (43,0 - 48,2)	3,10	43,5± 1,8 (41,0 - 47,2)	4,11	t = 2,37 p ≤ 0,05
Parameters of heart					
H (g) heart weight	10,11 ± 0,93 (8,56 - 11,55)	9,20	8,89 ± 1,18 (7,37 - 11,78)	13,27	t = 3,16 p ≤ 0,01
L (mm) heart height	44,4 ± 2,3 (41,8 - 49,0)	5,18	43,5 ± 2,7 (39,2 - 48,0)	6,20	NS
W (mm) heart width	30,0 ± 3,2 (24,5 - 35,9)	10,67	29,3 ± 2,4 (26,0 - 34,4)	8,19	NS
C (mm) heart girth	77,6 ± 5,5 (68,0 - 88,0)	7,08	75,3 ± 4,32 (70,0 - 82,0)	5,73	NS
RL* (g)	8,54 ± 0,63 (7,45 - 9,44)	7,37	7,40 ± 0,88 (6,22 - 9,36)	11,89	t = 4,08 p ≤ 0,01
RV** (g)	1,97 ± 0,21 (1,63 - 2,32)	10,66	1,72 ± 0,19 (1,42 - 2,18)	11,05	t = 3,46 p ≤ 0,05
LV*** (g)	6,56 ± 0,49 (5,78 - 7,29)	7,46	5,68 ± 0,73 (4,71 - 7,18)	12,85	t = 3,91 p ≤ 0,01

X, mean values; SD, standard deviation; V, coefficient of variability; n, number of observations; RL*, mass of right and left ventricles, interventricular septum and both of atrioventricular valves; RV**, mass of front wall of right ventricle; LV***, mass of left ventricle with consideration interventricular septum, back wall, and both of atrioventricular valves; range of variation in parentheses

Discussion. Absolute largeness of heart as well as it mass are factorial differentiated at lamellirostres birds. In the midst of researched sorts of hunting birds living in the area of Poland heaviest hearts has the biggest one from they i.e. Bean goose and White-winged scoter (Bartyzel, 2002). Among researched ducks most light heart characterizes the smallest one – Long-tailed duck. However, Mallard, Greater scaup as well as Black scoter characterized similar mass of heart, which locates these sorts of birds in the middle of discussed over.

Available scientific literature among indices characterizing relative largeness of heart faces each other in relative mass of heart most often, which is expressed as a percent of body mass. These dependences represent as well proper algometric equations. Viscor and Fuster (1987) as well as Hartman (1955) have collect most of all from this range of data. It belongs to underline, that usually it establish these indices in foothold about data for several, anywhere from ten to twenty birds more rarely. In the present elaboration for this purpose it takes advantage data from tens of persons even. In general it takes for granted, that small birds (weighing about 100 g) have greater relative mass of heart than big birds (weighing over 1000 g). In the first group of birds value of this index is included in partition from 1,15 for 1,39%, however, in second group fluctuates around 0,85% (Kalisińska et al., 1999; Kalisińska and Dańczak, 1997; Brush, 1966; Hartman, 1955). Geographic as well as climatic factors

project on value of relative mass of heart also e.g. latitude. Activity and intensity of bird's life are indissolubly related with these factors (Drabek and Tremblay, 2000; Viscor and Fuster, 1987; Hartman, 1955).

Table 2. **Indexes of linear correlation between body and heart parameters of Black scoter adult males and females**

Parameter	D	S	J	H	L	W	C	RL	RV	LV
B	0,40 p≤ 0,05	0,40 p≤ 0,05	0,44 p≤ 0,01	0,72 ≤ 0,01	NS	NS	NS	0,73 p≤ 0,01	0,60 p≤ 0,01	0,73 p≤ 0,01
D		0,51 p≤ 0,01	0,63 p≤ 0,01	0,62 ≤ 0,01	NS	NS	NS	0,63 p≤ 0,01	0,40 p≤ 0,05	0,67 p≤ 0,01
S			0,43 p≤ 0,01	0,46 p≤ 0,05	NS	NS	NS	0,56 p≤ 0,01	0,55 p≤ 0,01	0,53 p≤ 0,01
J				0,49 p≤ 0,01	NS	NS	NS	0,48 p≤ 0,01	NS	0,53 p≤ 0,01
H					0,45 p≤ 0,05	NS	0,54 p≤ 0,01	0,96 p≤ 0,01	0,79 p≤ 0,01	0,95 p≤ 0,01
L						NS	NS	0,43 p≤ 0,05	0,52 p≤ 0,01	0,38 p≤ 0,05
W							0,74 p≤ 0,01	NS	NS	NS
C								0,40 p≤ 0,05	0,38 p≤ 0,05	0,39 p≤ 0,05
RL									0,85 p≤ 0,01	0,99 p≤ 0,01
RV										0,76 p≤ 0,01

B, body weight; D, body length; S, sternum length; J, tarsometatarsus length; H, heart weight; L, heart height; W, heart width; C, heart girth; RL, mass of right and left ventricles, interventricular septum and both of atrioventricular valves; RV, mass of front wall of right ventricle; LV, mass of left ventricle with consideration interventricular septum, back wall, and both of atrioventricular valves; p, significance level; NS, differences not significant

Table 3. **Characteristic of the relative heart size of Black scoter adult males and females**

Index	♂		♀		♀ + ♂		♂ vs. ♀
	X ± SD	V	X ± SD	V	X ± SD	V	
	n = 16		n = 14		n = 30		
H/B (%)	0,74 ± 0,06 (0,66 - 0,87)	8,11	0,74 ± 0,08 (0,62 – 0,92)	10,81	0,74 ± 0,06 (0,62 - 0,92)	8,00	NS
L/W	1,49 ± 0,16 (1,26 - 1,84)	10,74	1,50 ± 0,17 (1,17 - 1,84)	11,33	1,50 ± 0,16 (1,17 - 1,84)	10,70	NS
RV/H (%)	19,58 ± 1,75 (17,05 - 23,48)	8,94	19,47 ± 1,50 (17,15 - 22,47)	7,70	19,53 ± 1,61 (17,05 - 23,48)	8,24	NS
RV/LV (%)	30,13 ± 2,78 (26,42 - 35,48)	9,22	30,48 ± 2,64 (26,54 - 35,61)	8,66	30,30 ± 2,67 (26,42 - 35,61)	8,81	NS

X, mean values; SD, standard deviation; V, coefficient of variability; n, number of observations; B, body weight; H, heart weight; L, heart height; W, heart width; RL, mass of right and left ventricles, interventricular septum and both of atrioventricular valves; RV, mass of front wall of right ventricle; LV, mass of left ventricle with consideration interventricular septum, back wall, and both of atrioventricular valves; range of variation in parentheses

In table collated detailed information concerning representatives of lamellirostres order *Anseriformes*, equal wild, as well as domesticated (table 4). On base of personal observation and available scientific literature data it analyzes absolute masses of bodies as well as absolute masses of hearts freshly collected and solidified

in formaldehyde. These analyses subjects also relative indices of heart mass. Comparing relative masses of hearts fresh and solidified in formaldehyde, it is possible to ascertain, that certain are noted in this range, sometimes considerable differences. In general relative mass of heart (H/B) solidified in formaldehyde is smaller than proper value for fresh heart. Phenomenon ascertain it in such case of sort as Bean goose *Anser fabalis* (Bartyzel et al., 2004), Black scoter *Melanitta fusca*, Greater scaup *Aythya marila*, Long-tailed duck *Clangula hyemalis* (Bartyzel, 2002). Differences reach in some cases 35% even. Observed differences can result from different manners of preparing heart (accuracy of empting heart from blood, places of cutting blood vessels) as well as influence of solidification process.

In general at lamellirostres birds relative mass of fresh heart is close 1% of body weight. An exception present data quoted by Viskor and Fuster (1987) for Greylag goose *Anser anser* and mallard *Anas platyrhynchos*. According to the above mentioned authors this index is equal for both of birds sorts (0,80%). However, these information have been based on single cases. They distinctly wander away from the value served by other researchers too. One of biggest flying bird from lamellirostres order, weighing over 14 kg even, Mute swan *Cygnus olor*, characterized relative mass of heart over 1% (1,03% - Viscor and Fuster, 1987).

In our research biggest relative mass of fresh heart ascertain at Long-tailed duck *Clangula hyemalis* (H/B = 1,26% - data not published), ducks most perfectly adapted for plunge and from among analyzed simultaneously smallest (Kalisińska and Dańczak, 1997). Hartman (1955) serves approximated relative mass of heart (1,30%) for small, weighing near 360-400 g, Masked duck *Oxyura dominica*. Relatively big mass of heart of lamellirostres birds can result from one part from none too big body weight of certain sort (e.g. *Clangula hyemalis*, *Oxyura dominica*), but from other part from considerable request for oxygen and necessity of property of match of efficient cardio-vascular system, because both of mentioned ducks plunge very well (Drabek, 1989; Lasiewski and Calder, 1971; Brush, 1966).

In order to convict, if consistent correspondence between established real masses of hearts (Hr) with certain general model, calculated theoretical masses of hearts (Ho) for birds about definite body weight taking advantage equation of Lasiewski and Calder (1971) - table 2. Considerable real conformity ascertains at several sorts of the researched birds, but the differences did not surpass 5%. In the midst of males there were - Mallard (Bartyzel et al., 2005), Long-tailed duck and Greater scaup (Bartyzel, 2002); whereas among females - White-winged scoter and Greater scaup (Bartyzel, 2002). Greater differences (over 5%) have taken a stand at Bean goose *Anser fabalis*, equal males as well as females (Bartyzel et al., 2004), Black scoter *Melanitta nigra* (Bartyzel, 2002) and Mallard *Anas platyrhynchos*, only at females (Bartyzel et al., 2005). At Bean goose real mass of heart (Hr) is greater about several percent from calculated (Ho), however, at two sorts remaining, Long-tailed duck and Mallard - at females only, Hr have turned out distinctly smaller than Ho, about 8 and 14% respectively - table 5.

Table 4. **Absolute and relative largeness of heart of adult wild bird from Anseriformes order**

Species	n	B(g)	H(g)	H/B(%)	Author
Melanitta nigra	30	1100-1510	9,50	0,74	Present work [(1)]
Melanitta fusca	26	1030-1740	15,18	0,80	Bartyzel, 2002 [(1)]
Aythya marila	35	1020-1650	10,12	0,79	Bartyzel, 2002 [(1)]
Anas platyrhynchos	28	1100-1740	8,86	0,74	Bartyzel et al., 2005 [(1)]
Anser fabalis	63	2200-3600	24,41	0,88	Bartyzel et al., 2004 [(1)]
Clangula hyemalis	16	972	7,98	0,82	Bartyzel, 2002 [(1)]
Anser anser	6	3480	33,30	0,96	Bartyzel, Kalisińska, (unpublished data) [(2)]
Anser anser	1	3065	-	0,80	Viscor, Fuster, 1987 [(2)]
Anser fabalis	44	3080	30,29	0,99	Kalisińska, Dańczak, 1997 [(2)]
Anser fabalis	31	3227	26,19	0,93	Bartyzel, Kalisińska, 1997 [(2)]
Anser albifrons	33	2360	23,31	0,99	Kalisińska, Dańczak, 1997 [(2)]
Anser albifrons	15	2313	20,56	0,97	Bartyzel, Kalisińska, 1997 [(2)]
Anas platyrhynchos	13	1120	10,50	0,95	Kalisińska, Dańczak, 1997 [(2)]
Anas platyrhynchos	1	1105		0,80	Viscor, Fuster, 1987 [(2)]
Anas platyrhynchos	11	1087	11,91	1,09	Senglaub, 1959 [(2)]
Anas platyrhynchos (captivity)	13	747	6,87	0,92	
Anas platyrhynchos	4	1034	9,72	0,94	Hartman, 1955 [(2)]
Melanitta fusca	26	1760	18,95	1,09	Kalisińska, Dańczak, 1997 [(2)]
Aythya marila	30	1120	12,19	0,97	
Clangula hyemalis	8	1080	13,16	1,26	

n, number of observations; H, heart weight; B, body weight; H/B%, relative heart weight as a percent of body weight, [(1)], material fixed in 10% formaldehyde; [(2)], material fresh

Table 5. **Real and calculated heart weight of researched lamellirostres birds**

Species	♂n	♀n	B (g)		H_r (g)		H_o (g)		H_r / H_o	
			♂	♀	♂	♀	♂	♀	♂	♀
Anser fabalis	31	32	2970	2610	25,72	23,11	22,08	19,63	1,16	1,18
Anas platyrhynchos	16	12	1320	1250	10,02	8,62	10,56	10,05	0,95	0,86
Clangula hyemalis	16	-	972	-	7,89	-	7,99	-	0,99	-
Melanitta nigra	16	14	1373	1203	10,11	8,89	10,94	9,7	0,92	0,92
Melanitta fusca	14	12	2016	1776	16,38	13,99	15,52	13,83	1,06	1,01
Aythya marila	18	17	1338	1247	10,32	9,92	10,69	10,02	0,97	0,99

B, body weight; H_r, real heart weight; H_o, calculated heart weight on base algometric equation by Lasiewski and Calder (1971): $\log H_o = 0{,}911 \log B + 0{,}913$; n, number of observations

Table 6. **Interspecies comparison of indexes characterizing heart of the researched sorts of goose and ducks with penguins**

Species	G (m)	n	Index				Author
			H/B (%)	L/W (%)	RV/H (%)	RV/LV (%)	
Lamellirostres birds (Pb)							
Anser fabalis	-	63	0,88	1,43	20,34	31,64	Bartyzel et al., 2004
Anas platyrhynchos	-	55	0,74	1,44	18,50	28,03	Bartyzel et al., 2005
Clangula hyemalis	60[1)]	16	0,82	1,34	18,10	27,16	Bartyzel, 2002
Melanitta nigra	15[1)]	30	0,74	1,49	19,53	30,30	Present work
Melanitta fusca	30[1)]	26	0,80	1,38	19,25	29,29	Bartyzel, 2002
Aythya marila	5[1)]	35	0,79	1,33	18,95	28,26	Bartyzel, 2002
Lamellirostres together		X	0,79	1,42	19,14	29,28	
		±SD	±0,06	±0,06	±0,08	±1,78	
		V	7,59	4,22	0,41	6,07	
Penguins (P)							
Pygoscelis antarctica	121[2)]	8	1,07	1,12	9,3	15,8	Drabek, 1989
Pygoscelis adeliae	175[3)]	8	0,85	1,10	10,9	18,9	
Aptenodytes forsteri	534[4)]	8	-	1,31	21,26	37,36	
Eudyptula minor	69[5)]	27	0,86	1,22	6,7	17,9	Drabek, 1997
Eudyptes chrysocome moseleyi	168[6)]	11	1,07	1,17	15,97	33,52	Drabek, Tremblay, 2000
Penguins together		X	0,96	1,18	12,83	24,70	
		±SD	±0,10	±0,08	±5,80	±9,96	
		V	10,41	6,79	45,20	40,00	
Pb vs. P			t= -5,64 $p \leq 0{,}01$	t= 4,22 $p \leq 0{,}01$	NS	NS	

G, maximum depth of plunge; X, mean values; SD, standard deviation; V, coefficient of variability; t, t-Student test; p, level of significance; NS, statistically not significant; [1)] del Hoyo et al., (1992); [2)] Bengtson et al., (1993); [3)] Whitehead, (1989); [4)] Koyman and Kooyman, (1995); [5)] Drabek, Tremblay, (2000)

It is possible to accept on above-mentioned base of analysis, that lamellirostres birds grant general model of dependence between body weight and heart weight processed by Lasiewski and Calder (1971), accidentally only. In order to have greater certitude in valuation of heart mass, when body weight is known only, it belongs

to establish for small groups of birds (e.g. families or tribes), for single sorts even, algometric equations. For three sorts of goose Bean goose, Greater white-fronted goose and domestic goose such equation has processed Kalisińska and Dańczak (1994).

In group of researched lamellirostres birds (without distribution on sex) relation of heart height (L) for its width (W), or L/W index, ranged from 1,33 to 1,50. Smallest values of these indices recorded at Greater scaup and Long-tailed duck, 1,33 and 1,34 respectively, but biggest at Black scoter(1,50). There is no relationship between heart shape and body largeness rather, neither systematic membership (table 5).

Participation of right ventricle in all-out heart mass (RV/H index) has changed at individual sort of birds in range from 18,10 to 20,34%. Smallest value of the RV/H index ascertain at Long-tailed duck, whereas biggest at Bean goose (table 5). These differences between both of sorts surpasses 2,2%. Next index expressing percent of right ventricle to left room RV/LV included in partition from 27,16 to 31,64%. Biggest value of the index ascertain at heaviest bird from researched sorts bean goose, whereas smallest at most light – Long-tailed duck. However, differ in mass and taxonomy between these birds is not only. There are also many important distinctions in behavior. Otherwise, they fly differently from each other, besides, Long-tailed duck is perfectly plunging bird also, however, Bean goose does not plunge. There was recorded a lot of differences between Long-tailed duck and Black scoter (H/B, L/W, RV/H and RV/LV), though both of sorts belong to the same tribe *Mergini*. Black scoter distinguish differ from Great scaup by two indices (L/W and RV/LV) as well as from White-winged scoter (H/B and L/W). Black scoter and White-winged scoter represents the same kind *Melanitta*. The Mallard from *Anatini* tribe differ from each other sort of duck (*Mergini* and *Aythyini* tribes) by RV/H index. There is assumption, that ecological as well as behavioral factors project on so considerable differences in largeness of RV/H index exactly. These differences reach over 4,6% in case of males Bean goose and Long-tailed duck.

It is possible to regard Drabek for a pioneer of the research over adaptation of bird for different environments and manners of lives, taking into consideration morphology of heart. In year 1989, he as first has put forward suggestion, that structure and shape of heart at penguins can play important role in their abilities for plunge (Drabek and Tremblay, 2000).

As all indices concerning heart of lamellirostres birds are relatively aligned (table 6), but values of coefficient of variability (V) do not surpass 8%. In case of penguins, it writes down a lot greater ratios of variability surpassing even 40% (exception V for L/W). In the midst of penguins there are statistically different values of two indices; H/B - relative mass of heart and L/W - relation of heart height to its width ($p \leq 0,01$). Compared to lamellirostres penguins have greater H/B index, but smaller L/W index. Remaining indices RV/H and RV/LV are greater at lamellirostres birds about 33 and 15% respectively, but these differences have not been confirmed statistically. Reasons of these facts at penguins it belongs to look in big sweep of values of discussed index as well as small number of observations in compared group.

Among penguins, Drabek and Tramblay (2000) found statistically certified differences in following indexes concerning heart: H/B, RV/LV and RV/H. Many differences found within lamellirostres birds also, which discussed earlier already. Reasons of these differences emerged probably in different individual accommodation of sorts as well as their groups. Between penguins, about approximated body weight even (e.g. Chinstrap penguin *Pygoscelis antarctica* and Adelie penguin *Pygoscelis adeliae*, weigh near 4 kg each other) recorded distinct differences in relative mass of heart and RV/H index (Drabek and Tramblay, 2000). Researchers of penguins suggest, that differences in heart anatomy can be coherent with parameters of plunge e.g. depth as well as time of plunging. At deeply plunging Moseley's penguin (weight of body 2,3 kg), on 168 meters even, ascertain greater value of RV/H index (weight of right ventricle in relation to whole mass of heart) than at other heavier penguins (*Pygoscelis antarctica* and *Pygoscelis adeliae*). Greater quota of right ventricle relatively to absolute mass of heart can resulted from increase of lung perfusion at birds staying on surface as well as minimization of time of this stay (Drabek and Tramblay, 2000).

Above-mentioned considerations have causal character only, because until now modest part of information concerning about proportion of linear dimensions of heart as well as participation of its ventricles into absolute mass of the organ has been placed in scientific literature merely. In principle, these considerations recorded representatives of two row *Sphenisciformes* and *Anseriformes* merely. Premises exist behind saying that birds take advantage different parameters of cardio-vascular system during different kind of locomotion which project on largeness of heart also (Froget et al., 2001; Ancel et al., 2000; Viskor and Fuster, 1987).

Conclusions

1. Within the confines of intraspecies comparison, with reference to researched wild birds, exerted that in general is noted distinctly genital dimorphism in parameters characterizing absolute largeness of body and hearts;
2. Relative largeness of heart at Long-tailed duck was similar between males and females;
3. The largest part of differences in morphology of heart discovered between ducks and Bean goose;
4. Differences within ducks concerned four indices even. Maximally it’s observed between Long-tailed duck and Black scoter though both of them belong to the same tribe *Mergini* (H/B, L/W, RV/H and RV/LV). As it happens, the ducks from the same order also *Melanitta,* Black scoter and White-winged scoter, displayed differences in largeness of two indices (H/B and L/W). Mallard is distinguished from remaining sorts of ducks one, but not always the same index;
5. On base personal data as well as performed from

scientific literature valuing of similarity and differences of relative indices describing largeness of bird's heart. In general analyzed indices have small value of coefficient of variability in group of lamellirostres birds, but big over 40% even in group of penguins. Distinct differences between these groups of birds recorded for two indices, H/B and L/W. Next two indices, RV/H and RV/LV, differed also, but these differences have not been confirmed statistically.

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