

## A COMPARISON OF BODY AND HEART SIZE BETWEEN THE MALLARD AND PEKIN DUCK

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**Summary.** The aim of performed study was to evaluate morphological changes in the wild ducks connected with domestication effect. Sixteen males and 12 females of the adult mallard ducks *Anas platyrhynchos* (Linnaeus, 1758) were analyzed and compared to 20 domestic pekin ducks *Anas platyrhynchos f. domestica* (10 males, 10 females). The body size (total body weight, body length) and the absolute heart weight were determined for each bird. There were statistically significant differences in respective traits between wild and domestic ducks and between males and females of each species ( $p < 0,05$ ). In addition, the absolute heart parameter of the weight, relative heart weight was calculated as a percentage of body weight. The relative heart index was statistically significantly higher compared to the mallard duck. The performed study between wild ducks have shown significant domesticated differences in body and heart size. This was in agreement with corresponding data reported by other authors.

**Keywords:** bird, duck, body, heart, morphometry, domestication.

## DIDŽIOSIOS ANTIES IR PEKINO ANTIES ŠIRDIES IR KŪNO DYDŽIŲ PALYGINIMAS

**Santrauka.** Tyrimo tikslas buvo palyginti laukinių ančių morfologinius pokyčius, kuriuos galėjo paveikti prijauginimo procesas. Šešiolikos suaugusių didžiosios anties patinų ir 12 suaugusių patelių *Anas platyrhynchos* (Linnaeus, 1758) duomenys buvo lyginami su 20 naminių pekino ančių *Anas platyrhynchos f. domestica* (10 patinų, 10 patelių). Išmatuoti visi ančių kūno dydžiai (kūno svoris, kūno ilgis) bei absoliutus širdies svoris. Gauti skirtingų individų grupių duomenys: naminių ir laukinių gyvūnų bei patinų ir patelių buvo statistiškai patikimi ( $p < 0,05$ ). Absoliutus širdies svorio parametras bei santykinis širdies svoris buvo apskaičiuotas kaip kūno svorio procentas. Santykinis didžiosios anties širdies indeksas buvo statistiškai patikimesnis. Laukinių ančių kūno ir širdies dydžių skirtumų tyrimas parodė statistiškai reikšmingus prijauginimo skirtumus. Šie rezultatai sutapo su atitinkamais kitų tyrėjų duomenimis.

**Raktažodžiai:** didžioji antis, kūnas, širdis, morfometrija, prijauginimas.

**Introduction.** From the midst of 9200 bird's species, Lamellirostral order (*Anseriformes*) contains more than 150 species. Almost all of them (98%) belongs to Anseres suborder (*Anseres*) and to the family of Anatidae (del Hoyo et al., 1992).

Most of the data about bird's heart size were accumulated by Hartman (1955) as well as Viscor and Fuster (1987). A lot of the newest elaborations were occupied on the adaptation of the bird's vascular system to varies habitat (Yahav et al., 1997; Noren et al., 2001; Green et al., 2001; Yoda et al., 2001). Most of them were dedicated to analyses of environmental and ecological influences on the physiological modification of the bird's vascular system. Especially, changes of the body size and the structure of internal organs related to bird's domestication had considerably interest among farmers (Senglaub, 1959; Potemkowska, 1975).

There are only few elaborations concentrated to the anatomical structure of the birds with regard to the parameters of body size as well as size of heart and its parts in relation to the ecological aspects. The most important investigations of that character contributed to the onset of a number of interesting works concerned with the size of heart and its elements – ventricles of various birds species in relation to a range of environmental and

physiological parameters, such attempts were undertaken by, among others, Drabek (1989, 1997) as well as Drabek and Tremblay (2000). First time there were collected data about absolute and relative heart size parameters of the penguins (Drabek, 1989). It was not until the 1980's when such investigations were undertaken in Poland (Borowiec and Wesolowski, 1980; Borowiec and Wanat, 1989).

There are considerable differences in the bird's rate of metabolism connected to varies environmental and habitat conditions as well as different methods of moving and feeding. Johnston and Williamson (1960) indicated the influences of environmental factors on the heart size and its structure as well as the metabolism rate. That kind of dependence of bird's vascular system efficiency upon the metabolism rate were conducted by, among others, Brush (1966), Berger et al. (1970), Bevan et al. (1995), Schaub and Prinzing (1999), Duncker (2000), Konarzewski et al. (2000), Froget et al. (2001). Authors in these elaborations showed the effects of varies ecological factors on the body size and its structure.

That kind of researches will broaden our knowledge about heart structure and the morphometry of its elements as well as efficiency of bird's vascular system in the range of environmental conditions. These studies will constitute also comparative material to the other bird's species

particularly wild and domestic birds of Lamellirostral order. The aim of the present study was to contribute the knowledge of domestication effect on the body and heart size of the wild mallard duck. In the near future all of these papers will compose as the whole monographic elaboration.

**Materials and methods.** The material of examination included 28 adult mallard ducks (16 males, 12 females) obtained from hunters (in the middle of hunting season, between September and October, 1995-1999) in the neighborhood of Szczecin, Poland and 20 adult pekin ducks (10 males, 10 females) obtained from duck farm in September 1998.

As soon as the birds were delivered to the laboratory, their taxonomy, age and sex were determined basing on the differences in morphological and anatomical structures accordingly to methods by Madge and Burn (1989) as well as by Gille and Salomon (1999). Subsequently the ducks were weighed on an electronic scale with precision to 5 g. Then absolute body length were estimated using measuring tape with accuracy to 1 mm.

The hearts were dissected, rinsed off the blood and dried on blotting paper. The pericardium was removed, and the main blood vessels were cut at one millimeter above right and left atrium (*atrium dextrum et sinistrum*), accordingly to technique proposed by Viscor et al. (1985), Drabek (1989, 1997) as well as by Drabek and Tremblay (2000). Afterwards, the hearts prepared just like that were

fixed in 10% formaldehyde solution. The preserved hearts were studied anatomically more than six weeks later. Subsequently the hearts were weighed on an electronic scale with precision to 5 g; also relative heart weight as a percentage of body weight was calculated.

Using t-Student test, corresponding mean values of the studied absolute parameters were compared between wild and domestic ducks and between males and females of each species separately. All statistical computations were done using Statistica software package (StatSoft Inc., 2000).

**Results.** Body size data and absolute values of the heart parameters of the mallard and pekin ducks are tabulated in Table 1. Almost all of the mean values obtained for males are not statistically significant differ in relation to those for females (Table 1). There were statistically significant differences of body and heart size between wild and domestic ducks, which manifested by larger total values of all parameters for pekin duck (Table 2). Both males and females of the mallard was distinctly smaller than respective sex of the pekin duck. The weight and length of the body was respectively, 38 and 73% of the domestic duck body size values (Table 3). Moreover, the heart of the mallard was hardly 45% of the weight of the domestic duck heart (Table 3). On the other hand the relative rate of the heart weight was greater in the mallard males as well as females than in pekin duck of the respective sex (Table 2).

Table 1. Absolute body and heart size parameters of the adult mallard duck *Anas platyrhynchos* and the adult pekin duck *Anas platyrhynchos f. domestica* (X, mean values; SD, standard deviation; V, coefficient of variability; t, value of t-Student test; p, significance level; NS, differences not significant; range of variation in the parentheses, B - body weight, D - body length, H - absolute heart weight)

| Adult form of wild mallard duck   | males n=16              |      | females n=12            |      | males vs. females |
|-----------------------------------|-------------------------|------|-------------------------|------|-------------------|
| Parameter                         | X±SD                    | V    | X±SD                    | V    |                   |
| B (g)                             | 1320±100<br>(1100-1740) | 7,6  | 1250±145<br>(1030-1470) | 11,6 | NS                |
| D (mm)                            | 519±18<br>(480-545)     | 3,5  | 483±15<br>(460-510)     | 3,1  | t=5,46<br>p≤0,01  |
| H (g)                             | 10,0±1,0<br>(8,2-11,9)  | 10,4 | 8,6±1,1<br>(7,0-10,5)   | 12,8 | t=3,42<br>p≤0,01  |
| Adult form of domestic pekin duck | males n=10              |      | females n=10            |      | males vs. females |
| Parameter                         | X±SD                    | V    | X±SD                    | V    |                   |
| B (g)                             | 3138±185<br>(2800-3400) | 5,9  | 3143±262<br>(2650-3450) | 8,3  | NS                |
| D (mm)                            | 706±18<br>(680-730)     | 2,5  | 630±29<br>(620-701)     | 4,6  | t=4,77<br>p≤0,01  |
| H (g)                             | 19,5±1,4<br>(18,0-21,9) | 7,3  | 18,9±1,1<br>(17,1-20,7) | 6,0  | NS                |

**Discussion.** There are two species, the greylag goose *Anser anser* and the mallard duck *Anas platyrhynchos* in the midst of wild representatives of Lamellirostral birds which domesticated form are commonly breeding in Europe. Also, these are the ancestral species for the domestic goose *Anser anser f. domestica* and the domestic duck *Anas platyrhynchos f. domestica*.

The body size as well as different feathers are the fundamental morphological differences between wild and domestic animals. There are observed distinct greater parameters of body size amongst domesticated birds as well as domestic form of mammals (Stahl, 1965; Bartyzel

and Kalisińska, 2000). There are also much more frequent white coat form in the midst of the domestic birds than the wild form of Aves (Bogolubski, 1968; Nowicki et al., 1995). There are also noticed such like differences in the size or weight of the most of internal organs, among others, length of gut duct, weight of encephalon and heart size (Senglaub, 1959; Bogolubski, 1968; Kalisińska et al., 1997; Kalisińska and Dańczak, 1997; Bartyzel and Kalisińska, 2000; Szczepańczyk et al., 2000; Iwaniuk and Nelson, 2001). The literature on the heart size provides numerous data on the relative heart weight expressed as a percentage of body weight (Hartman, 1955; Senglaub,

1959; Viscor and Fuster, 1987; Kalisińska and Dańczak, 1997; Bartyzel and Kalisińska, 2000). Other indices that characterize relative size of heart or its parts have been published much less often. It has been generally recognized that small size birds have proportionally larger heart and, consequently, larger relative heart weight, as compared with bigger birds (Hartman, 1955; Kalisińska and Dańczak, 1997; Bartyzel and Kalisińska, 2000). That kind of researches which characterizes and compares size of heart and its parts between wild and domestic birds have not been published much often. In Table 4 are tabulated absolute and relative values of heart weight of the domestic geese as well as domestic ducks. The

relative heart weight of the domestic goose constitutes from 0,62% to 0,80% of the body weight. On the other hand that value in the wild form of goose - greylag goose is approximate 0,96%. The heart weight of the domestic pekin duck constitutes from 0,62% to 0,86% of the body weight (average 0,76%). In the wild form of duck - mallard duck that value is approximate 0,91% - from 0,74% to 1,09%. Thus the relative indices of heart weight for the domestic goose and duck were respectively 0,25% and 0,15% lower than for the wild form of goose and duck. It should also be stressed that the wild mallard ducks which have lost flying ability have relatively smaller hearts than their progenitors (Senglaub, 1959).

Table 2. Domestication effect on the absolute body size and on the absolute and relative heart size parameters. Comparison between adult males and females of the mallard *Anas platyrhynchos* (Ap) and the domestic pekin ducks *Anas platyrhynchos f. domestica* (Apfd); n – number of observations, t - value of t-Student test, p - significance level, B - body weight, D - body length, H - absolute heart weight, H/B - relative heart weight.

| Parameter | Adult males<br><i>Ap</i> (n=16) vs. <i>Apfd</i> (n=10) | Adult females<br><i>Ap</i> (n=12) vs. <i>Apfd</i> (n=10) |
|-----------|--|--|
| B         | t = -23,24<br>p ≤ 0,01                                 | t = -21,40<br>p ≤ 0,01                                   |
| D         | t = -25,15<br>p ≤ 0,01                                 | t = -17,56<br>p ≤ 0,01                                   |
| H         | t = -19,62<br>p ≤ 0,01                                 | t = -21,52<br>p ≤ 0,01                                   |
| H/B       | t = 4,66<br>p ≤ 0,01                                   | t = 2,74<br>p ≤ 0,05                                     |

Table 3. Comparison of the absolute body and heart size parameters between the adult mallard *Anas platyrhynchos* (Ap) and the domestic pekin ducks *Anas platyrhynchos f. domestica* (Apfd).

| <i>Ap</i> / <i>Apfd</i> x 100% | Value (%) |
|--------------------------------|-----------|
| Body weight                    | 38        |
| Body length                    | 73        |
| Heart weight                   | 45        |

Table 4. Heart size parameters of the adult wild and domestic birds of Lamellirostral order (n - number of observations, B - body weight, H - absolute heart weight, H/B - relative heart weight)

| Species of domestic birds             | n  | B (g) | H (g) | H/B (%) | Author                       |
|---------------------------------------|----|-------|-------|---------|------------------------------|
| <i>Anser anser f. dom.</i>            | 16 | 5800  | 35,8  | 0,62    | Kalisińska and Dańczak, 1994 |
| <i>Anser anser f. dom.</i>            | -  | 4405  | 35,24 | 0,80    | Sturky, 1970                 |
| <i>Anser anser f. dom.</i>            | -  | -     | -     | 0,80    | Salomon, 1993                |
| <i>Anas platyrhynchos f. dom.</i>     | 20 | 3140  | 19,19 | 0,62    | Present study                |
| <i>Anas platyrhynchos f. dom.</i>     | 12 | 2844  | 24,7  | 0,89    | Hughes et al., 1995          |
| <i>Anas platyrhynchos f. dom.</i>     | -  | -     | -     | 0,80    | Salomon, 1993                |
| <i>Anas platyrhynchos f. dom.</i>     | -  | 1685  | 12,54 | 0,74    | Sturky, 1970                 |
| <i>Anas platyrhynchos f. dom.</i>     | 6  | 2094  | 15,70 | 0,75    | Senglaub, 1959               |
| <b>Species of wild birds</b>          |    |       |       |         |                              |
| <i>Anas platyrhynchos</i>             | 13 | 1120  | 10,50 | 0,95    | Kalisińska and Dańczak, 1997 |
| <i>Anas platyrhynchos</i>             | 1  | 1105  | -     | 0,80    | Viscor and Fuster, 1987      |
| <i>Anas platyrhynchos</i>             | 11 | 1087  | 11,91 | 1,09    | Senglaub, 1959               |
| <i>Anas platyrhynchos</i> (captivity) | 13 | 747   | 6,87  | 0,92    | Senglaub, 1959               |
| <i>Anas platyrhynchos</i>             | 4  | 1034  | 9,72  | 0,94    | Hartman, 1955                |

These distinctly lower relative indices of heart weight for domesticated form of geese as well as ducks in relation to their ancestors are connected with greater body size of that birds and flying loss ability (Bogolubski, 1968; Nowicki et al., 1995; Kalisińska et al., 1997, Kalisińska and Dańczak, 1997; Bartyzel and Kalisińska, 2000).

**Conclusions.** Corresponding parameters of body weight, heart weight and the weights of its parts were significantly differ between males and females and between wild mallard ducks and domestic pekin ducks. Relevant absolute body and heart size parameters were greater for males and for domestic pekin ducks. Heart weight significantly correlates with body weight. The established relative indices of heart size were greater for wild mallard ducks. All of these parameters could be used in comparative anatomical analysis of phylogenetic, pathomorphologic and ecologic as well as domestic character.

**Acknowledgments.** The authors thanks Mrs. E. Kalisińska and Mr. P. Mysłek for their constructive help. This work was supported by Grant DZ 5/98 of Agricultural University of Szczecin.

#### References.

- Bartyzel B., Kalisińska E.: Wielkość serca gęsi zbożowej *Anser fabalis* i gęsi białoczelnej *Anser albifrons*. *Folia Univ. Agr. Stet.* 2000. Vol. 210. P. 17-23.
- Berger M., Hart J.S., Roy O.Z.: Respiration, oxygen consumption and heart rate in some birds during rest and flight. *Z. Vergl. Physiologie.* 1970. Vol. 66 P. 201-214.
- Bevan R., Boyd I.I., Butler P., Reid K., Woakes A., Croxall J.: Heart rates and abdominal temperatures of free-ranging South Georgian shags, *Phalacrocorax georgianus*. *J. Exp. Biol.* 1997. Vol. 200 P. 661-675.
- Bogolubski S.: Pochodzenie i ewolucja zwierząt domowych. PWRiL, Warszawa. 1968.
- Borowiec M., Wanat A.: Polska bibliografia ornitologiczna III, lata 1971 – 1980. *Acta Orn.* 1989. Vol. 25 P. 108-221.
- Borowiec M., Wesolowski T.: Polska bibliografia ornitologiczna II, lata 1961 – 1970. *Acta Orn.* 1980. Vol. 18. P. 7-140.
- Brush A.H.: Avian heart size and cardiovascular performance. *Auk.* 1966. Vol. 83. P. 266-273.
- Drabek C.M.: Heart and ventricle weights of Antarctic penquins. *Can. J. Zool.* 1989. Vol. 67. P. 2602-2604.
- Drabek C.M.: Heart and ventricle weights of the Little penguin *Eudyptula minor*. *Emu.* 1997. Vol. 97. P. 258-261.
- Drabek C.M., Tremblay Y.: Morphological aspects of the heart of the northern rockhopper penguin (*Eudyptes chrysocome moseleyi*): possible implication in diving behavior and ecology? *Polar Biol.* 2000. Vol. 23. P. 812-816.
- Duncker H.R.: Der Atemapparat der Vögel und ihre lokomotorische und metabolische Leistungsfähigkeit. *J. Ornithol.* 2000. Vol. 141. P. 1-67.
- Froget G., Butler P.J., Handrich Y., Woakes A.J.: Heart rate as an indicator of oxygen consumption: influence of body condition in the king penguin. *J. Exp. Biol.* 2001. Vol. 204. P. 2133-2144.
- Gille U., Salomon F.V.: Wachstum von Bursa Cloacalis (Fabricii) und Milz bei Enten. *Anat. Histol. Embryol.* 1999. Vol. 28. P. 229-233.
- Green J.A., Butler P.J., Woakes A.J., Boyd I.L., Holder R.L.: Heart rate and rate of oxygen consumption of exercising macaroni penguins. *J. Exp. Biol.* 2001. Vol. 204. P. 673-684.
- Hartman F.A.: Heart weight in birds. *Condor.* 1955. Vol. 57. P. 221-238.
- del Hoyo J., Elliott A., Sargatal J.: Handbook of the Birds of the World. 1992. Vol. 1. Ostrich to Ducks, Lynx Editions, Barcelona.
- Iwaniuk A.N., Nelson J.E.: A comparative analysis of relative brain size in waterfowl (*Anseriformes*). *Brain Behav. Evol.* 2001. Vol. 57. P. 87-97.
- Johnston D.W., Williamson F.S.L.: Heart weights of North American crows and ravens. *Wilson Bull.* 1960. Vol. 72. P. 248-252.
- Kalisińska E., Dańczak A.: Heart size in some anseriform species. 11th European Symposium on Waterfowl, Nantes 8 – 10.09.1997. P. 392-396.
- Kalisińska E., Jackowski A., Bartyzel B.: Morfometria żołądków gęsi zbożowej *Anser fabalis*. *Przeł. Hod. Zesz. Nauk.* 1997. Vol. 32. P. 51-59.
- Konarzewski M., Gavin A., McDevitt R., Wallis I.R.: Metabolic and organ mass responses to selection for high growth rates in the domestic chicken (*Gallus domesticus*). *Physiol. Biochem. Zool.* 2000. Vol. 73. P. 237-248.
- Madge S., Burn H.: Wildfowl. An identification guide to the ducks, geese and swans of the world. Christophertelm, London. 1989.
- Noren S.R., Williams T.M., Pabst D.A., McLellan W.A., Dearolf J.L.: The development of diving in marine endotherms: preparing the skeletal muscles of dolphins, penguins, and seals for activity during submerge. *J. Comp. Physiol.* 2001. Vol. 171. P. 127-134.
- Nowicki B., Jasek S., Maciejowski J., Nowakowski P., Pawlina E.: Atlas ras zwierząt gospodarskich. Wyd. Nauk. PWN, Warszawa. 1995.
- Potemkowska E.: Drobiarstwo. PWRiL, Warszawa. 1975.
- Schaub R., Prinzinger R.: Long-term telemetry of heart rates and energy metabolic rate during the diurnal cycle in normothermic and torpid African blue-naped mousebirds (*Urocolius macrourus*). *Comp. Biochem. Physiol. A Mol. Integr. Physiol.* 1999. Vol. 124, (4). P. 439-45.
- Senglaub K.: Vergleichende metrische und morphologische Untersuchungen an Organen und am Kleinhirn von Wild-, Gefangenschafts- und Hausenten. *Morph. Jb.* 1959. Vol. 213. P. 18-23.
- Stahl W.R.: Organ weights in primates and other mammals. *Science.* 1965. Vol. 150. P. 1039-1042.
- StatSoft Inc. STATISTICA for Windows, Computer program manual. 2000. StatSoft, Inc., 2300 East 14th Street, Tulsa.
- Szczepańczyk E., Kalisińska E., Ligocki M., Bartyzel B.: Morphometry of esophagus and gut in bean Goose *Anser fabalis*. *Zool. Poloniae.* 2000. Vol. 45. P. 37-46.
- Viscor G., Fuster J.F.: Relationships between morphological parameters in birds with different flying habits. *J. Com. Biochem. Physiol.* 1987. Vol. 87. P. 231-249.
- Viscor G., Marques M.S., Palomeque J.: Cardiovascular and organ weight adaptations as related to flight activity in birds. *J. Comp. Biochem. Physiol.* 1985. Vol. 82. P. 597-599.
- Yahav S., Straschnow A., Plavnik I., Hurwitz S.: Blood system response of chickens to changes in environmental temperature. *Poult Sci.* 1997. Vol. 76. P. 627-633.
- Yoda K., Naito Y., Sato K., Takahashi A., Nishikawa J., Ropert-Coudert Y., Kurita M., Le Maho Y.J.: A new technique for monitoring the behaviour of free-ranging Adelie penguins. *J. Exp. Biol.* 2001. Vol. 204. P. 685-690.