# HEART SIZE IN WOOD PIGEON *COLUMBA PALUMBUS* (LINNAEUS, 1758)

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**Abstract.** The morphological studies covered 37 hearts (preserved in 10% formaldehyde) of adult wood pigeons *Columba palumbus* (18 males and 19 females). Mean body weight, total heart weight, and the weights of its parts (anterior wall of right ventricle, left ventricle with interventricular septum, posterior wall of right ventricle, and both atrioventricular valves), as well as the height, width, and girth of the heart, were determined for each sex separately and for the whole sample. No statistically significant differences were found in respective traits between males and females. Besides the absolute parameters, relative indices were also calculated: relative heart weight (as a percentage of body weight), and the proportion of the left and right ventricle in the heart weight. These indices for the wood pigeon are, respectively, 1,24%, 0,26%, and 0,63%. Moreover, an allometric equation was estimated for the relationship between the heart weight (H) and the body weight (B), in the following form: $\log H = 0{,}685 \log B - 1{,}065$. Corresponding data reported by other authors were used in this study for comparisons.

**Keywords:** wood pigeon; *Columba palumbus*, heart parameters, body weight

# KARVELIŲ KERŠULIŲ *COLUMBA PALUMBUS* (LINAEUS, 1758) ŠIRDIES DYDIS

**Santrauka.** Morfologiniai tyrimai buvo atlikti naudojant 37 karvelių keršulių *Columba palumbus* (18 patinų ir 19 patelių) širdis konservuotas 10% formaldehide. Kiekvienai lyčiai atskirai ir bendrai individui buvo nustatytas vidutinis kūno svoris, bendras širdies svoris ir kai kurių jos dalių, kaip priekinės dešinio skilvelio sienos, kairiojo skilvelio su tarpskilveline pertvara, užpakalinės dešinio skilvelio sienos ir abiejų atrioventrikulinių vožtuvų, svoris, bei širdies aukštis, plotis, apimtis. Tarp patinų ir patelių atitinkamų dydžių statistiškai patikimas skirtumas nenustatytas. Be absoliučių matmenų buvo suskaičiuoti santykiniai indeksai: santykinis širdies svoris (kaip kūno masės procentas), ir kairiojo ir dešiniojo skilvelio proporcijos širdies svoriui. Šie indeksai karveliams keršuliams atitinkamai yra: 1,24%, 0.26% ir 0.63%. Be to santykio tarp širdies svorio (H) ir kūno svorio (B) įvertinimui buvo panaudota alometrinė lygtis: $\log H = 0.685 \log B - 1.065$. Palyginimui šiame straipsnyje panaudoti atitinkami kitų autorių duomenys.

**Raktiniai žodžiai**: karvelis keršulis, *Columba palumbus*, širdies matmenys, kūno svoris.

**Introduction.** Early works on avian organs morphometry appeared in the 19th century, dealing mainly with topographic anatomy. This research trend developed with particular intensity in the beginning of the 20th century, and persisted until the 1950s. New tendencies in anatomic studies emerged with the onset of ecology, when the link between the animal's body structure and its habitat was noticed. This enabled drawing new conclusions based on classic works on anatomy (Hartman, 1955; Dobrowolski and Halba, 1970; Schmidt-Nielsen, 1997). In the field of ornithology oriented on anatomical and ecological investigations, a number of interesting works have been published that refer to the size of body and organs of various species in relation to a range of environmental and physiological parameters. Among others, these works deal with brain (Bennett and Harvey, 1985; Iwaniuk and Nelson, 2001), kidneys (Casotti, 2001), stomach (Hume and Biebach, 1996), and heart (Pearson et al., 2000; Bartyzel and Kalisińska, 2000). It was not until the 1980s when such investigations were undertaken in Poland (Borowiec and Wesołowski, 1980; Borowiec and Wanat, 1989).

Data on the size of the elements of an organ, as well as linear measures of body and organs, have not been extensively utilised in ecologically oriented anatomy. With regard to avian heart and its elements (ventricles), such attempts were undertaken by, among others, Drabek (1989; 1997), and Drabek and Tremblay (2000).

This study is a contribution to the knowledge on the heart of the wood pigeon (*C. palumbus*, *Columbiformes*). It should be noted that wood pigeon is listed in Poland as a game species.

**Materials and methods.** The material included 37 adult wood pigeons (18 males and 19 females), obtained from hunters in the vicinity of Szczecin, Poland, in the latter half of August 1998.

1) Introductory examination of material

As soon as the birds were delivered to the laboratory of the Department of Zoology in Szczecin, their taxonomy, age, and sex were determined basing on the differences in morphological (wear and color of feathers) and anatomic structure (differences in the structure of internal sexual organs), according to methods by Madge and Burn (1989), and Gille and Salomon (1999).

The birds were weighed on an electronic scale with precision of 5 g.

2) Heart measurements

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 mm above the

right atrium (*atrium dextrum*) and the left atrium (*atrium sinistrum*), according to a technique proposed by Viscor et al. (1985), Drabek (1989; 1997), and Drabek and Tremblay (2000).

So prepared 37 hearts were preserved in 10% formaldehyde solution. After more than six weeks, the preserved hearts were studied anatomically.

Linear measurements of the hearts included:

-Length (L), measured with slide caliper with accuracy to 0.1 mm between (*apex cordis*) and (*basis cordis*) including the remainings of arterial and venous vessels;

-Width (W), measured with slide caliper with accuracy to 0.1 mm at coronary groove (*sulcus coronarius)* including adipose tissue in horizontal plane;

-Circumference (C), measured with measuring tape with accuracy to 1 mm at (*sulcus coronarius*) including adipose tissue;

Dissections were done with classical anatomic methods. First, both left and right atriums (*atrium dextrum et sinistrum*) were separated from the ventricles. The incision was carried out above (*sulcus coronarius*) beginning at pulmonary trunk (*truncus pulmonalis*). The next incision, which ran from pulmonary trunk through (*vena cava caudalis*) and anterior wall of right ventricle along (*trabeculae carneae*) towards the apex, enabled the dissection of anterior wall of right ventricle.

The hearts were dissected into right ventricle, left ventricle, right atrium and left atrium. Each part, except for the atriums, was separately weighed to 0.01 g after removing blood clots from the cavities. Right ventricle (RV) included its anterior wall only. Intraventricular septum, posterior wall of right ventricle, and both right and left atrioventricular valves (*valvae atrioventriculares dextra et sinistra*) remained with the left ventricle (LV). The anatomical nomenclature used in this study was adopted from Baumel et al. (1993).

Relevant indices were calculated for those of the heart size parameters that were significantly related with each other; also, relative heart weight as a percentage of body weight was calculated, and an allometric equation was estimated for the relationship between the heart weight and body weight, which is commonly applied in such studies (Lasiewski and Calder, 1971; Bennet and Harvey, 1985). Using t-Student test, corresponding mean values of the studied absolute parameters were compared between males and females.

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

**Results.** Body weight data and absolute values of the studied parameters of wood pigeon heart are tabulated in Table 1. Their mean values for males are similar to those for females, therefore further statistical processing was carried out for the entire sample altogether.

Table 1. **Body weight and absolute heart parameters of wood pigeon *C. palubus* (weight expressed in g, linear measures in mm; X – arithmetic mean; SD – standard deviation; V – coefficient of variability;t – t-Student test; ranges shown in brackets)**

| Parameter | ♂ n = 18 | | ♀ n = 19 | | ♂ + ♀ n = 37 | | ♂ vs. ♀ |
|---|---|---|---|---|---|---|---|
| | X ± SD | V | X ± SD | V | X ± SD | V | |
| Body weight, B | 484 ± 52 (403 - 585) | 10.10 | 474 ± 41 (404.5 - 551) | 8.81 | 478 ± 47 (403 - 584) | 9.82 | NS |
| Right ventricle weight, RV | 1.17 ± 0.33 (0.33 - 1.59) | 27.05 | 1.26 ± 0.17 (0.9 - 1.6) | 13.67 | 1.22 ± 0.25 (0.3 - 1.6) | 20.59 | NS |
| Left ventricle weight, LV | 3.71 ± 0.40 (3.0 - 4.92) | 10.81 | 3.72 ± 0.43 (2.69 - 4.55) | 11.52 | 3.7 ± 0.40 (2.69 - 4.55) | 11.02 | NS |
| Heart weight, H | 5.87 ± 0.73 (4.46 - 7.17) | 12.39 | 6.00 ± 0.64 (4.37 - 4.40) | 10.69 | 5.94 ± 0.67 (4.37 - 7.40) | 11.38 | NS |
| Heart length, L | 31.5 ± 2.0 (26.5-35.0) | 6.36 | 31.55 ± 1.78 (28.1 - 34.9) | 5.65 | 31.55 ± 1.86 (26.4 - 35.0) | 5.90 | NS |
| Heart width, W | 20.7 ± 0.9 (18.6 - 22 ) | 4.17 | 21.21 ± 1.92 (16.8 - 26.7) | 9.06 | 20.99 ± 1.51 (16.8 - 26.6) | 7.22 | NS |
| Heart circumference, C | 61± 3.0 (57 - 66 ) | 4.20 | 60 ± 2.22 (53 - 64) | 3.72 | 60 ± 2.50 (53 - 66) | 4.13 | NS |

The coefficients of variability for body weight, heart weight and the weights of its elements rarely exceeded 15%, except for the right ventricle weight, while linear heart parameters showed little variability, the coefficients remaining at the level of 10%.

It was found that the heart weight was significantly correlated with (1) body weight, B ($r = 0.60$; $p \leq 0.0001$), (2) right ventricle weight, RV ($r = 0.60$; $p \leq 0.0001$), and (3) left ventricle weight, LV ($r = 0.86$; $p \leq 0.0001$). Therefore, relevant indices, expressed as a percentage of

body weight (H/B) or a percentage of heart weight (RV/H and LV/H), were established. H/B and LV/H had higher values (respectively 1.24 ± 0.13, 0.63 ± 0.04), whereas RV/H was the lowest (0.26 ± 3.34) of the three indices.

For the relationship between heart weight (H) and body weight (B), an allometric equation was estimated in the following form:

$\log H = 0.685 \log B - 1.065$ ($n = 37$; $s_{xy} = \pm 0.098$)

where $s_{xy}$ denotes an estimation error.

Some authors also apply the heart length to width (L/W) ratio (Drabek, 1989, 1997; Bartyzel and Kalisińska, 1997; Bartyzel and Kalisińska, 2000; Drabek and Tremblay, 2000).

**Discussion.** 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). Other indices that characterize relative size of heart or its parts have been published much less often. For comparison, data on various types of indices with particular consideration to the order *Columbiformes* are presented in Table 2. It has been generally recognized that small size birds have proportionally larger hearts and, consequently, larger relative heart weight, as compared with larger birds (Hartman, 1955; Kalisińska and Dańczak, 1997). However, this general rule does not apply to a number of Columbiform species; the heart of the smallest one (shown in Table 2), i.e. ground dove (*Columbigallina passerini*, present name *Columbina passerina* (Linnaeus, 1758), body weight about 40 g) constitutes 1.22% of the body weight. In heavier birds of this order, i.e. white-necked pigeon (*Columba f. albilinea*, approx. 300 g) and *Oreopelia chiriquensis*, relative heart size is 1.09% and 0.39% respectively (Table 2), while in the largest of all the pigeon species discussed here, wood pigeon (about 480 g), the heart represents 1.24% of the body weight. The highest relative size of the heart (1.80%) was reported by Viscor and Fuster (1987) for the rock dove (*Columba livia*), which has the average body weight of 390 g.

Table 2. **Various indices of relative size of heart and its parts in birds (see Table 1 for symbol explanations)**

| Species | N | H/B (%) | RV/H (%) | L/W | Author |
|---|---|---|---|---|---|
| **Order *Colubiformes*** | | | | | |
| *Columba fasciata albilinea* Bonaparte, 1854 | 7 | 1.09 | - | - | Hartman (1955) |
| *Columbigallina passerini* (Linnaeus, 1758) | 2 | 1.22 | - | - | |
| *Leptotila verreauxi* (Bonaparte, 1855) | 20 | 0.88 | - | - | |
| *Leptotila cassini* (Lawrence, 1867) | 2 | 0.56 | - | - | |
| *Oreopelia chiriquensis* (Linnaeus, 1758) | 8 | 0.39 | - | - | |
| *Zenaida macroura* (Linnaeus, 1758) | 10 | 1.21 | - | - | |
| *Columba livia* J.F. Gmelin, 1789 | 7 | 1.30 | - | - | Viscor et al. (1985) |
| *Columba livia* J.F. Gmelin, 1789 | - | 1.80 | - | - | Viscor and Fuster (1987) |
| *Zenaida macroura* (Linnaeus, 1758) | - | 1.11 | - | - | |
| **Order *Galliformes*** | | | | | |
| *Gallus gallus domesticus* (Linnaeus, 1758) | 8 | 0.28 | - | - | Viscor et al. (1985) |
| **Order *Charadriiformes*** | | | | | |
| *Larus ridibundus* (Linnaeus, 1758) | 7 | 0.95 | - | - | Viscor et al. (1985) |
| **Order *Sphenisciformes*** | | | | | |
| *Aptenodytes forsteri* G.R. Gray, 1844 | 8 | - | 21.26 | 1.31 | Drabek (1989) |
| *Pygoscelis antarctica* (J.R. Forster, 1781) | 8 | 1.07 | 9.3 | 1.12 | |
| *Pygoscelis adeliae* (Hombron et Jacquinot, 1841) | 8 | 0.85 | 10.9 | 1.10 | |
| *Eudyptula minor* (J.R. Forster, 1781) | 27 | 0.86 | 6.7 | 1.22 | Drabek (1997) |
| *Eudyptes chrysocome moseleyi* Mathews et Iredale,1921 | 11 | 1.07 | 15.97 | 1.17 | Drabek and Tremblay (2000) |
| **Order *Anseriformes*** | | | | | |
| *Anser albifrons* (Scopoli, 1769) | 32 | 0.95 | - | 1.38 | Bartyzel and Kalisińska(1997) |
| | 15 | - | - | - | |
| *Anser fabalis* (Linnaeus, 1758) | 54 | 0.94 | - | 1.44 | Bartyzel and Kalisińska (2000) |

It should also be stressed that the domesticated birds that have lost flying ability have relatively smaller hearts than their progenitors (Senglaub, 1959).

Another important problem is the representation of the allometric relationship between the heart and the body weight in birds, as it enables establishing an average, normal heart weight of a bird if its body weight is known. It finds application in all the studies of ecological, phylogenetic, and comparative character, including pathomorphological examinations. Basing on data on a multispecies group of birds (n = 291), Lasiewski and Calder (1971) derived the following equation:

$\log H = 0.911 \log B + 0.913$.

For particular bird species, such equations have been published relatively rarely, for example Kalisińska and Dańczak (1997) reported them for various anseriform birds. No such equation has been estimated for the wood pigeon; it should be also stressed that a statistically properly large data set was used in this study, as compared with those analysed by other authors.

**Conclusions:**

1. Corresponding parameters of body weight, heart weight and heart parts weights did not differ significantly between males and females.

2. Heart weight (H) significantly correlates with body weight (B), right ventricle weight (RV), and left ventricle weight (LV).

3. The established indices (H/B, RV/H, and LV/H) were expressed as percentages and the allometric equation was estimated for the relationship between heart weight and body weight ($\log H = 0.685 \log B - 1.065$).

Both the indices and the equation can be used in comparative studies of ecological, phylogenetic, or pathomorphologic character.

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