ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 21(3) 2022, 25–36

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2022.21.3.04

ORIGINAL PAPER

Received: 28.05.2022
Accepted: 12.11.2022

THE BIOMETRIC CHARACTERISTIC OF THE TUFTED DUCK *AYTHYA FULIGULA* (LINNAEUS, 1758) FROM WESTERN POMERANIA (POLAND)

Katarzyna Królaczyk[1], Emil Dzierzba[1], Katarzyna Marta Kavetska[1], Daniel Zaborski[2]✉

[1]Department of Animal Anatomy and Zoology, West Pomeranian University of Technology, Janickiego Str. 33, 71-270 Szczecin, Poland
[2]Department of Ruminants Science, West Pomeranian University of Technology, Janickiego Str. 29, 71-270 Szczecin, Poland

ABSTRACT

The purpose of this work was to perform morphometric characteristics of the Tufted Duck *Aythya fuligula* obtained in Western Pomerania, according to their sex and age. The research material consisted of 197 Tufted Ducks obtained in December 2013. The biometric characteristics was performed on the basis of 20 measurements of linear and mass quantities. All internal organs measured and most of the individual body parts of the Tufted Duck were slightly larger in the case of males. Despite the differences in the body size of males and females, the studied birds showed similar variability in both length and mass. The differences between adult and young Tufted Ducks were not so well defined. Adult Tufted Ducks had significantly larger body mass, pectoral muscle mass and lung mass than juveniles. No significant differences were found in the linear values of the examined features.

Key words: Morphometrics, Tufted Duck, Anseriformes, Poland

INTRODUCTION

Water and wetland birds are considered to be bioindicators describing the condition of their habitats [Fernández et al. 2005, Behrouzi-Rad and Ghaemi 2015, Vala Dolatsang and Trivedi 2018]. Observations of these birds have been carried out all over the world for a long time, and their populations have been carefully counted even for many years [Nieoczym et al. 2021]. Determination of bird morphological, biochemical or physiological metrics is used in assessing their condition [Peig and Green 2010, Wilder et al. 2016, Molina-Marin et al. 2022]. The results of such studies also contribute to the assessment of the state of the environment and the population of wild animals in a given habitat [Jiménez-Peñuela et al. 2019]. One of the species of wetland birds whose research could contribute to the assessment of the state of the environment in Poland is the Tufted Duck *Aythya fuligula* (Linnaeus, 1758), the species of diving ducks Aythyini (Delacour et Mayr, 1945) [Nieoczym et al. 2021]. They are omnivorous animals, feeding mainly on seeds and aquatic plants as well as small crustaceans, bivalve molluscs, snails and insect larvae [Sekiya et al. 2000, van Nes et al. 2008, Rose and O'Brien 2020]. These birds obtain their food by foraging mainly in the bottom zone at the depth of up to 6 m [Sokołowski 1977]. Western Pomerania is one of the areas in which the Tufted Duck and other Anseriformes are gathered in large numbers. Due to the presence of freshwater reservoirs and mild winters, it plays a very important role as a wintering area for many species of birds [Królaczyk and Kavetska 2019]. About 33,300 Tufted Ducks were recorded around the outlet stretch of the Odra and the Szczecin Lagoon [Ławicki et al. 2008]. However, for several years, there has been a decrease in the number of Tufted Ducks in Western Pomerania [Królaczyk and Kavetska 2019], which is related to the breeding predation and the decline of the Black-Headed Gull rookery that they willingly accompany [Górski and Mohr 2007, Pöysä et al. 2019].

✉ daniel.zaborski@zut.edu.pl

The ecosystem (aquatic and terrestrial) biological equilibrium is the basis for maintaining species biodiversity [Pham et al. 2020, El Ghizi et al. 2021]. All changes (including climatic ones) influence both the entire ecosystem as well as individual species [Eissa and Zaki 2011, Alfonso et al. 2021]. The birds inhabiting aquatic and marsh environments constitute an integral part of the ecosystems of the West Pomerania Province [Dąbkowski et al. 2017]. The Tufted Duck belongs to the species of least concern (globally) or near threatened (in Europe) [IUCN 2012]; however, due to the decrease in the breeding population size observed for about 40 years in Poland (by approximately 63% between 1980 and 2018 [Chodkiewicz et al. 2019]), it requires special interest. The research on species condition, the threat of heavy metal pollution and helminth fauna, would allow for population monitoring and the observation of changes and their direction [Morado et al. 2017, Jiménez-Peñuela et al. 2019].

Therefore, the purpose of this work was to perform morphometric characteristics of the Tufted Duck obtained in Western Pomerania, taking into account the sex and age of the birds.

MATERIAL AND METHODS

The research hypothesis was that the selected linear and mass measurements differed between the predetermined age groups and both sexes and that a significant interaction between age and sex existed in terms of measurement values. The research material consisted of 197 Tufted Ducks (Anseriformes: Aythyini) which died in fishing nets in December 2013 on Dąbie Lake. It should be emphasized that the study population was quite large. The majority of the studied ducks were males and adult birds (Table 1). Fresh bodies were frozen after delivery to the laboratory and then successively defrozen and measured.

The biometric characteristics of the Tufted Duck was performed on the basis of 20 linear and mass measurements. A total of 13 linear and 7 mass measurements were collected according to the method suggested by Dzubin and Cooch [1992]. The linear measurements were taken using a tape measure (with precision up to 1 mm), an ornithologic ruler (with precision up to 1 mm) and a calliper (with precision up to 0.01 mm). Organ and body mass was measured using an electronic laboratory scale (with precision up to 0.01 and 5 g, respectively).

The linear measurements included: body length (BL), tail length (TL), skull rump length (SRL), beak rump length (BRL), head length (HL), head width (HW), head height (HH), beak length (BKL), head beak length (HBL), tarsometatarsus length (TTL), keel skin length (KSL), keel length (KL), wing length (WL), whereas the mass ones consisted of body mass (BM), pectoralis mass (PM), liver mass (LRM), lung mass (LM), kidneys mass (KM), heart mass (HM) and fat mass (FM).

On the basis of the obtained absolute values, the relative values of all linear measurements were determined in accordance with the following equation:

$$\frac{\text{body part length}}{\text{body length}} \times 100\%$$

and the mass ones in accordance with the following equation:

$$\frac{\text{organ mass}}{\text{body mass}} \times 100\%$$

The variation coefficients were also calculated for both relative and absolute measurements according to the following equation:

$$CV = \frac{s}{\bar{x}} \times 100$$

where:

s – standard deviation,
$\bar{x}$ – arithmetic mean of the sample.

A two-factor multivariate analysis of variance (MANOVA) with interaction was used to determine the relationships between the age and sex of the studied ducks and their morphological features [Aranowska and Rytel 2010]. Two MANOVA models (for absolute and relative measurements) were created [Keppel and Wickens 2004]:

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{ij} + e_{ijk}$$

where:

y_{ijk} – dependent variable vector (absolute or relative measurements depending on the model),
μ – mean value vector,
α_i – main effect vector of the i-th sex level (i = female, male),
β_j – main effect vector of the j-th age level (j = adult, juvenile),
γ_{ij} – interaction vector of the i-th sex level and the j-th age level,
e_{ijk} – random error effect.

The significance of differences in the sex and age subgroups was also determined using Tukey's test for unequal sample sizes following ANOVA. Statistical analysis was performed using Microsoft Office Excel 2010 (Microsoft Inc., Redmont, WA, USA) and Statistica ver. 12 (StatSoft Inc., Tulsa, OK, USA). The value of $P \leq 0.05$ was assumed as the statistical significance level in all analyses.

Table 1. The number of examined ducks by sex and age

Sex/Age	Male		Female	
	Adult	Immature	Adult	Immature
Number	120	16	51	10
Total	136		61	

Table 2. Absolute mass quantities of the Tufted Duck *Aythya fuligula*

Measurement		Species	Adult	Immature	Male	Female
		n = 197	*n* = 171	*n* = 26	*n* = 136	*n* = 61
BM, g	x̄ ±SD	1161.12 ±65.61	1167.89[a] ±60.43	1116.54[b] ±80.86	1184.04[a] ±60.11	1110.00[b] ±45.65
	Range	1015.0–1320.0	1040.0–1320.0	1015.0–1280.0	1040.0–1320.0	1015.0–1220.0
	CV, %	5.65	5.17	7.24	5.08	4.11
PM, g	x̄ ±SD	72.11 ±6.90	72.67[a] ±6.33	68.40[b] ±9.16	72.71[a] ±7.44	70.78[b] ±5.30
	Range	50.20–88.32	54.68–86.33	54.68–88.32	50.20–88.32	54.68–85.95
	CV, %	9.56	8.71	13.40	10.24	7.49
LRM, g	x̄ ±SD	34.61 ±4.64	34.80 ±4.50	33.37 ±5.45	35.19[a] ±4.79	33.31[b] ±4.04
	Range	22.70–47.00	23.78–44.54	22.70–47.00	22.70–47.00	22.70–42.24
	CV, %	13.41	12.93	16.33	13.61	12.13
LM, g	x̄ ±SD	12.86 ±1.71	13.00[a] ±1.68	11.96[b] ±1.65	12.95 ±1.82	12.67 ±1.44
	Range	9.31–17.64	9.31–17.64	9.97–16.18	9.31–17.64	9.68–16.18
	CV, %	13.30	12.93	13.82	14.04	11.33
KM, g	x̄ ±SD	10.73 ±1.38	10.82 ±1.32	10.18 ±1.61	10.79 ±1.42	10.61 ±1.28
	Range	7.40–14.37	7.47–14.37	7.94–14.37	7.40–14.37	7.76–14.37
	CV, %	12.83	12.24	15.81	13.15	12.10
HM, g	x̄ ±SD	11.34 ±1.12	11.37 ±1.15	11.12 ±0.88	11.45 ±1.11	11.09 ±1.12
	Range	8.65–14.62	8.65–14.62	8.79–12.57	8.65–14.62	8.65–14.06
	CV, %	9.91	10.15	7.95	9.69	10.14
FM, g	x̄ ±SD	38.36 ±6.33	38.39 ±6.48	38.17 ±5.39	38.34 ±6.79	38.42 ±5.23
	Range	20.13–56.02	20.13–56.02	27.80–56.02	20.13–56.02	27.39–56.02
	CV, %	16.51	16.87	14.12	17.70	13.61

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); BM – body mass, PM – pectoralis mass, LRM – liver mass, LM – lung mass, KM – kidneys mass, HM – heart mass, FM – fat mass.

RESULTS AND DISCUSSION

As expected, male Tufted Ducks turned out to be larger than females. They were, on average, 7.4 mm longer and 74.0 g heavier (Tables 2 and 3). However, significant differences in the mean values of biometric traits between males and females were found only in the case of three absolute mass (BM, PM and LRM) and five absolute linear (BL, SRL, BRL, KSL, and KL) measurements (Tables 2 and 3). Immature males and females differed significantly in the mean values of one absolute mass (BM), three relative mass (RLM, RKM, and RHM) and two linear (KL and KSL) measurements. Significant differences in the mean values of absolute mass (BM), linear (BL, KL), and relative linear (RTTL) measurements were observed between adult males and females (Tables 6 to 9).

The Tufted Ducks show a clear sexual dimorphism, i.a. in size, that is, males are larger than females [del Hoyo et al. 1992]. Consequently, in order to avoid errors while comparing the sizes of individual body parts of both sexes, the relative values of all linear and mass measurements were also calculated [Labocha and Hayes 2012]. Body length variation for both sexes turned out to be small and amounted to about 2.0%; however, both sexes showed considerable variability in body mass, whose CV was more than twice as high as that for body length and amounted to 5.1% for males and 4.1% for females (Table 2). All internal organs measured (including the pectoral muscle) and most of the individual body parts of the Tufted Duck were slightly larger in males. The exceptions were: BKL and FM, the mean values of which were slightly higher in the case of females (by 0.1 mm and 0.1 g, respectively) but the differences were not statistically significant. Despite the smaller body size, the females had a (relatively) larger head (individual parameters describing the size of the head were about 1.5% higher), internal organs (significant differences found for

Table 3. Absolute linear quantities of the Tufted Duck *Aythya fuligula*

Measurement		Species	Adult	Immature	Male	Female
		n = 197	*n* = 171	*n* = 26	*n* = 136	*n* = 61
BL, cm	x̄ ±SD	45.73 ±0.92	45.75 ±0.91	45.63 ±0.96	45.96[a] ±0.86	45.22[b] ±0.84
	Range	43.20–48.10	43.20–48.10	44.30–47.10	43.20–48.10	43.20–47.20
	CV, %	2.01	2.00	2.11	1.87	1.86
TL, cm	x̄ ± SD	8.90 ±0.10	8.90 ±0.08	8.91 ±0.20	8.91 ±0.12	8.90 ±0.05
	Range	8.40–9.60	8.40–9.30	8.50–9.60	8.40–9.60	8.60–9.10
	CV, %	1.12	0.90	2.24	1.35	0.56
SRL, cm	x̄ ± SD	27.75 ±0.88	27.76 ±0.87	27.68 ±0.93	27.97[a] ±0.81	27.26[b] ±0.83
	Range	25.36–29.89	25.36–29.89	25.59–29.09	25.59–29.89	25.36–29.09
	CV, %	3.17	3.13	3.36	2.90	3.04
BRL, cm	x̄ ± SD	32.87 ±0.90	32.89 ±0.90	32.75 ±0.96	33.09[a] ±0.84	32.37[b] ±0.84
	Range	30.20–35.08	30.20–35.08	30.65–34.11	30.20–35.08	30.20–34.28
	CV, %	2.74	2.74	2.93	2.54	2.59
HL, mm	x̄ ± SD	51.17 ±2.23	51.25 ±2.33	50.66 ±1.41	51.21 ±2.08	51.07 ±2.56
	Range	43.40–58.85	43.40–58.85	49.29–52.48	43.40–58.01	43.40–58.85
	CV, %	4.36	4.54	2.77	4.06	5.02
HW, mm	x̄ ± SD	26.60 ±1.32	26.59 ±1.37	26.67 ±0.91	26.64 ±1.41	26.49 ±1.09
	Range	21.56–28.65	21.56–28.65	26.18–27.70	21.56–28.65	23.50–28.37
	CV, %	4.97	5.17	3.43	5.31	4.10
HH, mm	x̄ ± SD	33.57 ±1.42	33.60 ±1.45	33.40 ±1.18	33.72 ±1.41	33.25 ±1.38
	Range	30.01–36.84	30.01–36.84	32.60–35.84	30.01–36.84	30.01–36.67
	CV, %	4.22	4.31	3.53	4.18	4.16
BKL, mm	x̄ ± SD	39.60 ±1.26	39.59 ±1.27	39.67 ±1.18	39.54 ±1.49	39.56 ±1.25
	Range	35.92–42.44	35.92–42.44	38.37–41.24	30.46–42.44	35.92–42.44
	CV, %	3.17	3.21	2.98	3.76	3.15
HBL, mm	x̄ ± SD	90.77 ±2.55	90.83 ±2.61	90.34 ±2.07	90.76 ±2.50	90.63 ±2.82
	Range	82.16–99.54	82.16–99.54	87.66–93.50	82.16–99.54	82.16–98.15
	CV, %	2.81	2.87	2.29	2.75	3.11
TTL, mm	x̄ ± SD	36.36 ±1.28	36.34 ±1.20	36.51 ±1.71	36.39 ±1.31	36.31 ±1.20
	Range	33.50–39.60	33.50–39.60	34.80–39.60	33.50–39.60	33.92–39.60
	CV, %	3.51	3.31	4.69	3.61	3.30
KSL, mm	x̄ ± SD	91.08 ±3.96	90.93 ±3.79	92.09 ±4.93	91.49[a] ±4.05	90.19[b] ±3.64
	Range	81.30–107.10	81.30–107.10	86.20–99.00	81.3–107.1	81.30–99.00
	CV, %	4.35	4.17	5.35	4.43	4.04
KL, mm	x̄ ± SD	85.27 ±2.95	85.18 ±2.86	85.89 ±3.52	85.67[a] ±2.99	84.38[b] ±2.68
	Range	79.30–93.20	79.20–93.20	82.90–92.60	79.20–93.20	79.30–91.80
	CV, %	3.46	3.35	4.10	3.49	3.18
WL, cm	x̄ ± SD	20.85 ±0.51	20.86 ±0.48	20.78 ±0.65	20.91 ±0.48	20.74 ±0.55
	Range	19.10–23.10	19.10–23.10	20.20–23.10	19.10–23.10	19.10–23.10
	CV, %	2.43	2.31	3.11	2.30	2.67

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); BL – body length, TL – tail length, SRL – skull rump length, BRL – beak rump length, HL – head length, HW – head width, HH – head height, BKL – beak length; HBL – head beak length, TTL – tarsometatarsus length, KSL – keel skin length, KL – keel length, WL – wing length.

RPM, RLM, RKM, RHM, RFM, RTL, RSRL, RBRL, RHBL, and RWL; Tables 4 and 5) and greater visceral fat mass. Only the liver was relatively similar in size (a non-significant difference). It was most likely related to the higher level of oestrogens, which contributed to the growth of adipose tissue deposited both in the abdominal cavity and in internal organs [Siemińska 2007, Coelho et al. 2013]. Contrary to the mean size of individual body parts, their mean differentiation of both sexes was similar and amounted to 6.8% for males and 6.0% for females (Tables 2 and 3). Similar observations were made by other authors who studied the Anseriformes [Działa-Szczepańczyk and Pierko 2010]. Detailed analysis showed that the mass and linear measurements of both sexes also had almost identical mean differentiation, except that the CV values of the mass quantities were several times higher than those of the linear quantities. Despite similar CV values for both sexes, both linear and

Table 4. Relative mass quantities of the Tufted Duck *Aythya fuligula*

Measurement		Species	Adult	Immature	Male	Female
		n = 197	*n* = 171	*n* = 26	*n* = 136	*n* = 61
RPM, %	x̄ ± SD	6.22 ±0.54	6.23 ±0.49	6.14 ±0.82	6.14[a] ±0.54	6.38[b] ±0.52
	Range	4.37–7.49	4.84–7.49	4.96–7.42	4.37–7.19	4.97–7.49
	CV, %	8.74	7.86	13.43	8.79	8.08
RLRM, %	x̄ ± SD	3.01 ±0.55	3.01 ±0.56	2.99 ±0.43	3.01 ±0.61	3.00 ±0.37
	Range	1.89–8.36	1.89–8.36	2.56–4.09	1.89–8.36	2.09–3.83
	CV, %	18.18	18.71	14.49	20.26	12.48
RLM, %	x̄ ± SD	1.11 ±0.15	1.11 ±0.15	1.08 ±0.18	1.09[a] ±0.15	1.14[b] ±0.14
	Range	0.79–1.59	0.79–1.56	0.79–1.59	0.79–1.56	0.88–1.59
	CV, %	13.46	13.01	16.25	13.80	12.32
RKM, %	x̄ ± SD	0.93 ±0.13	0.93 ±0.12	0.92 ±0.18	0.91[a] ±0.12	0.96[b] ±0.13
	Range	0.62–1.40	0.62–1.26	0.63–1.40	0.62–1.26	0.68–1.40
	CV, %	13.59	12.58	19.34	13.44	13.42
RHM, %	x̄ ± SD	0.98 ±0.10	0.97 ±0.09	1.00 ±0.10	0.97[a] ±0.09	1.00[b] ±0.11
	Range	0.70–1.28	0.70–1.28	0.85–1.23	0.70–1.28	0.76–1.28
	CV, %	9.79	9.67	10.42	9.22	10.63
RFM, %	x̄ ± SD	3.31 ±0.55	3.29 ±0.54	3.44 ±0.58	3.24[a] ±0.56	3.47[b] ±0.50
	Range	1.79–5.14	1.79–5.14	2.52–5.14	1.79–5.14	2.45–5.14
	CV, %	16.55	16.47	16.83	17.14	14.40

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); RPM – relative left pectoral muscle mass, RLRM – relative liver mass, RLM – relative lung mass, RKM – relative kidney mass, RHM – relative heart mass, RFM – relative visceral fat mass.

mass measurements showed slightly greater variation in the case of males (Tables 2–5).

The differences between adult and young Tufted Ducks were not well defined. Adult Tufted Ducks had significantly larger BM, PM and LM (Tables 2–5) than juveniles. However, no significant differences were found in the linear values of the examined traits. This may indicate that in the first year of life, ducks quickly reach the size of adult birds, and with age they only increase their muscle mass and accumulate fat tissue. Although in the discussed age ranges, slight differences in the mass (usually not exceeding 5.0%) and linear (about 1.0%) values were noticed; however, the statistical analysis did not confirm their significance (Tables 2–5). Similarly to the mean values of the analysed parameters, their mean differentiation was almost identical in both age groups (Tables 2–5).

The adult males were larger than the young ones in almost every aspect examined. However, significant differences in the mean values of biometric parameters were demonstrated only for one mass (KM, Table 6) and one linear (BL, Table 7) measurement. Particularly large differences were found in the relative head size, which was approximately 11.0% larger in the case of adult males. These discrepancies were best seen in the relative height and width of the head (Table 9). A large variation was also noticed in the fat amount in the two age groups of males. The RFM was 14.3% higher in adult drakes (Table 8). Of all linear and mass measurements (both absolute and relative ones), only the relative liver mass turned out to be almost the same (0.01% higher, on average, in the case of adult males) in both age categories. The CV for adult drakes remained at the level of 6.7%, and was slightly lower for the young ones (6.1%). Among the analysed features, the mass values (mean CV equal to 13.2%) were marked by a much greater variability than the linear ones, whose mean CV value was approximately 3.0%. No major differences in the CV for the mass and linear values were observed; however, they were somewhat greater for several parameters (PM, RPM, WLR, and RFM). The largest discrepancies were found in the amount of visceral fat, for which adult males had almost 10.0% greater variability than the young ones (Table 2).

Among females, the differences in the age subgroups were not so clearly visible (usually a slight variation in size), nor so obvious, because young females often had relatively larger body parts. Although adult females were, on average, 73.0 g heavier, as many as 18 parameters were higher in young ducks (Tables 6–9). Those were mainly the relative sizes of the internal organs. While the differences in organ size were usually small, there were some exceptions, including RKM and RFM, which were higher in young females (Table 8). The mean differentiation of characteristics in individual age groups of females was also larger in the case of juveniles and similarly to males, a much larger variation was found among the mass parameters than the linear ones. The largest (approximately 15.0%) differences in the age sub-

Table 5. Relative linear quantities of the Tufted Duck *Aythya fuligula*

Measurement		Species	Adult	Immature	Male	Female
		n = 197	*n* = 171	*n* = 26	*n* = 136	*n* = 61
RTL, %	x̄ ± SD	20.15 ±0.85	20.19 ±0.82	19.86 ±1.04	20.03[a] ±0.85	20.40[b] ±0.81
	Range	17.28–22.10	17.93–22.10	18.90–21.43	17.28–22.10	17.93–21.83
	CV, %	4.23	4.04	5.25	4.24	3.98
RSRL, %	x̄ ± SD	60.00 ±1.10	59.95 ±1.10	60.34 ±1.05	60.22[a] ±1.06	59.56[b] ±1.14
	Range	57.40–62.79	57.40–62.59	58.66–62.79	57.40–63.46	57.42–62.59
	CV, %	1.83	1.83	1.74	1.76	1.91
RBRL, %	x̄ ± SD	71.19 ±0.95	71.15 ±0.93	71.44 ±1.06	71.36[a] ±0.97	70.85[b] ±0.93
	Range	68.90–73.97	68.90–73.79	70.11–73.97	69.33–75.01	68.90–73.79
	CV, %	1.33	1.31	1.48	1.35	1.31
RHL, %	x̄ ± SD	11.19 ±0.49	11.20 ±0.51	11.11 ±0.32	11.14 ±0.45	11.29 ±0.56
	Range	9.40–12.99	9.40–12.99	10.65–11.69	9.40–12.64	9.62–12.99
	CV, %	4.37	4.55	2.90	4.00	4.99
RHW, %	x̄ ± SD	5.82 ±0.30	5.81 ±0.31	5.85 ±0.21	5.80 ±0.32	5.86 ±0.25
	Range	4.63–6.37	4.63–6.37	5.64–6.25	4.63–6.37	5.16–6.27
	CV, %	5.16	5.36	3.59	5.47	4.34
RHH, %	x̄ ± SD	7.34 ±0.32	7.35 ±0.32	7.32 ±0.25	7.34 ±0.31	7.36 ±0.33
	Range	6.36–8.05	6.36–8.05	7.17–7.92	6.36–8.05	6.36–8.03
	CV, %	4.29	4.42	3.43	4.22	4.49
RBKL, %	x̄ ± SD	8.66 ±0.30	8.66 ±0.30	8.70 ±0.30	8.61 ±0.33	8.75 ±0.32
	Range	7.85–9.49	7.85–9.49	8.29–9.29	6.65–9.49	8.00–9.49
	CV, %	3.47	3.47	3.46	3.83	3.65
RHBL, %	x̄ ± SD	19.85 ±0.58	19.86 ±0.59	19.80 ±0.52	19.75[a] ±0.54	20.04[b] ±0.66
	Range	18.22–21.69	18.22–21.69	18.93–20.90	18.20–21.69	18.22–21.67
	CV, %	2.95	3.00	2.63	2.74	3.30
RTTL, %	x̄ ± SD	7.95 ±0.31	7.95 ±0.30	8.00 ±0.35	7.92 ±0.31	8.03 ±0.28
	Range	7.19–9.00	7.19–9.00	7.65–8.80	7.19–8.84	7.61–9.00
	CV, %	3.84	3.77	4.32	3.91	3.54
RKSL, %	x̄ ± SD	19.92 ±0.87	19.88 ±0.85	20.18 ±0.98	19.91 ±0.85	19.95 ±0.92
	Range	18.07–22.50	18.07–22.50	18.62–22.00	18.07–22.50	18.07–22.50
	CV, %	4.36	4.26	4.85	4.25	4.62
RKL, %	x̄ ± SD	18.65 ±0.67	18.62 ±0.67	18.82 ±0.65	18.64 ±0.65	18.67 ±0.71
	Range	17.35–21.20	17.00–21.20	17.99–20.40	17.00–21.20	17.51–21.20
	CV, %	3.57	3.58	3.46	3.47	3.81
RWL, %	x̄ ± SD	45.60 ±1.23	46.51 ±1.12	45.57 ±1.82	45.49[a] ±1.09	45.87[b] ±1.46
	Range	43.01–52.98	43.01–52.98	43.63–52.98	43.01–52.98	43.30–52.98
	CV, %	2.69	2.45	4.00	2.39	3.19

[a, b] – various lowercase letters within the lines indicate differences statistically significant at the level of $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); RTL – relative tail length, RSRL – relative length from the skull base to the beginning of the croup, RBRL – relative length from the beginning of the beak to the beginning of the croup, RHL – relative head length, RHW – relative head width, RHH – relative head height, RBKL – relative beak length, RHBL – relative head and beak length, RTTL – relative left tarsometatarsus length, RKSL – relative keel–skin length, RKL – relative keel length, RWL – relative left wing length.

groups were found in the amount of fat and the mass of lungs and kidneys (Tables 6 and 7). In each of the above features, young females showed greater differentiation (about 5.0% on average).

The biometric characteristics of the Tufted Duck covered the relative and absolute values of the parameters describing both the body size and internal organs of all the studied birds. According to del Hoyo et al. [1992] the body size of the Tufted Duck varies from 40.0 to 47.0 cm in length and from 1000.0 to 1400.0 g in body mass. The birds collected for the present study corresponded to this description (BL from 43.20 to 48.10 cm, BM from 1015.0 to 1320.0 g). Similar results for the Tufted Duck from Western Pomerania were obtained in 2008, 43.7 cm and 1038.6 g [Działa-Szczepańczyk and Wesołowska 2008]. In general, bird body mass (including the mass of muscles and internal organs) is different in both sexes. It also varies significantly depending on age, nutrition and the distance covered during migration [Austin and Fredrickson 1987, Gammonley and Heitmeyer 1990]. Compared with the mass measurements, linear ones do not fluctuate so much [Freeman and

Table 6. Absolute mass quantities of the Tufted Duck (*Aythya fuligula*) in the age–sex subgroups

Measurement		Immature male	Adult male	Immature female	Adult female
		n = 16	*n* = 120	*n* = 10	*n* = 51
BM, g	x̄ ± SD	1158.75[a] ±72.12	1187.42[a] ±57.85	1049[b] ±35.42	1121.96[b] ±37.22
	Range	1045.00–1280.00	1040.00–1320.00	1015.00–1115.00	1045.00–1220.00
	CV, %	6.22	4.87	3.38	3.32
PM, g	x̄ ± SD	68.67 ±10.68	73.24 ±6.78	67.96 ±6.55	71.33 ±4.91
	Range	50.20–88.32	54.68–86.33	54.68–76.02	62.67–85.95
	CV, %	15.55	9.26	9.63	6.88
LRM, g	x̄ ± SD	34.74 ±5.63	35.25 ±4.69	31.19 ±4.57	33.73 ±3.84
	Range	22.70–47.00	23.78–44.54	22.70–39.73	23.78–42.24
	CV, %	16.21	13.30	14.67	11.37
LM, g	x̄ ± SD	11.65 ±1.51	13.13 ±1.79	12.47 ±1.82	12.71 ±1.37
	Range	9.52–14.82	9.31–17.64	9.68–16.18	9.95–15.39
	CV, %	12.98	13.63	14.61	10.75
KM, g	x̄ ± SD	9.67[a] ±1.29	10.94[b] ±1.37	11.00 ±1.80	10.53 ±1.17
	Range	7.40–12.14	7.47–14.37	8.05–14.37	7.76–13.32
	CV, %	13.33	12.55	16.34	11.07
HM, g	x̄ ± SD	11.08 ±0.67	11.50 ±1.15	11.20 ±1.19	11.07 ±1.12
	Range	10.14–12.35	8.65–14.62	8.79–12.57	8.65–14.06
	CV, %	6.07	9.98	10.60	10.15
FM, g	x̄ ± SD	36.96 ±3.63	38.52 ±7.09	40.11 ±7.21	38.08 ±4.77
	Range	31.59–42.86	20.13–56.02	27.80–56.02	27.39–51.21
	CV, %	9.81	18.41	17.97	12.52

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); BM – body mass, PM – pectoralis mass, LRM – liver mass, LM – lung mass, KM – kidneys mass, HM – heart mass, FM – fat mass.

Jackson 1990, Piersma and Davidson 1991, Badzinski et al. 2009]. For this reason, linear measurements were also used for morphometric characterization, in addition to the most commonly used mass quantities [Freeman and Jackson 1990, Piersma and Davidson 1991, Badzinski et al. 2009]. Consequently, the coefficient of variation for the mass measurements of the Tufted Ducks in the present study was more than three times higher (12.7% on average) than that for the linear ones (3.5% on average).

The body dimensions of the tested ducks did not show great variability; the mean CV value was 6.6%. Particular parts of the body differed mainly in mass, while the variation in their length was much smaller (Tables 2–5). Body mass, averaging 1.161 g, varied more than twice as much as body length, which averaged 45.7 cm (Tables 2 and 3). The other mass values, i.e. PM, LRM, HM, LM, KM and FM, were marked by even higher differentiation (CV > 9.0%). The greatest variability among the examined features was found in the FM and LM (Table 2). The CV of any of the linear parameters did not exceed 6.0%, and the lowest differentiation was found in BL, for which CV was only 2.0% (Table 3).

Of all the internal organs examined, liver mass had the highest CV. These results confirmed the reports of other authors studying the Anseriformes [Kalisińska et al. 1999, Kalisińska et al. 2010]. The relative size of the Tufted Duck liver was also similar (2.5–3.5%) to the values reported by other researchers [Gammonley and Heitmeyer 1990]. The duck kidneys are usually two or three times smaller than the liver, which was also confirmed in the present study (0.9% of the total body mass). According to Kalisińska et al. [1999, 2010], the birds from the Aythyni and Mergini tribes have slightly larger kidneys (RKM = 0.8–1.9%) than the dabbling (non-diving) ducks from the Anatini (0.6–1.4%). It is probably related to the high level of metabolism in the case of flying and well-diving birds, because their kidneys are forced to excrete more metabolites [Kalisińska et al. 2010]. A similar relationship occurs in the case of the heart, which must supply more oxygenated blood to intensively working muscles [Kalisińska and Dańczak 1997, Kalisińska et al. 1999]. The results of our own research partially confirmed this relationship, as the relative heart mass of the studied birds amounted to an average of 1.0% of the total body mass, which was close to the value (0.7–1.1%) reported by the authors examining non-diving ducks from the Anatini tribe [Kalisińska and Dańczak 1997, Bartyzel et al. 2005, Charuta et al. 2005]. The linear sizes of the examined Tufted Duck, as well as the sizes of internal organs, also did not differ from the sizes given by others. Działa-Szczepańczyk and Wesołowska [2008]

Table 7. Absolute linear quantities of the Tufted Duck (*Aythya fuligula*) in the age–sex subgroups

Measurement		Immature male	Adult male	Immature female	Adult female
		n = 16	*n* = 120	*n* = 10	*n* = 51
BL, cm	$\bar{x}$ ± SD	45.96[a] ±0.83	45.96[b] ±0.87	45.09[a] ±0.95	45.25[a] ±0.83
	Range	44.20–47.10	43.20–48.10	43.60–46.60	43.20–47.20
	CV, %	1.81	1.89	2.11	1.82
TL, cm	$\bar{x}$ ± SD	8.92 ±0.26	8.90 ±0.09	8.90 ±0.00	8.90 ±0.05
	Range	8.50–9.60	8.40–9.30	8.90–8.90	8.60–9.10
	CV, %	2.91	1.01	0.00	0.56
SRL, cm	$\bar{x}$ ± SD	27.96 ±0.77	27.97 ±0.82	27.24 ±1.02	27.27 ±0.80
	Range	26.35–29.09	25.59–29.89	25.59–28.63	25.36–29.09
	CV, %	2.75	2.93	3.74	2.93
BRL, cm	$\bar{x}$ ± SD	33.04 ±0.85	32.10 ±0.84	32.28 ±0.99	32.39 ±0.82
	Range	31.22–34.11	30.20–35.08	30.65–33.66	30.20–34.28
	CV, %	2.57	2.62	3.07	2.53
HL, mm	$\bar{x}$ ± SD	50.82 ±1.31	51.27 ±2.16	50.41 ±1.59	51.20 ±2.71
	Range	47.68–52.48	43.40–58.01	46.97–51.80	43.40–58.85
	CV, %	2.58	4.21	3.15	5.29
HW, mm	$\bar{x}$ ± SD	26.56 ±0.81	26.66 ±1.48	26.85 ±1.08	26.42 ±1.09
	Range	24.73–27.60	21.56–28.65	24.40–27.70	23.50–28.37
	CV, %	3.06	5.55	4.02	4.11
HH, mm	$\bar{x}$ ± SD	33.37 ±1.25	33.76 ±1.43	33.44 ±1.11	33.22 ±1.44
	Range	31.00–35.84	30.01–36.84	31.00–35.08	30.01–36.67
	CV, %	3.75	4.23	3.32	4.33
BKL, mm	$\bar{x}$ ± SD	39.54 ±1.49	40.05 ±0.87	39.56 ±1.30	39.56 ±1.25
	Range	30.46–42.44	37.71–41.24	35.92–42.44	35.92–42.44
	CV, %	3.76	2.17	3.29	3.15
HBL, mm	$\bar{x}$ ± SD	90.76 ±2.50	90.87 ±1.42	90.83 ±2.53	90.63 ±2.82
	Range	82.16–99.54	88.19–93.50	82.16–99.54	82.16–98.15
	CV, %	2.75	1.56	2.78	3.11
TTL, mm	$\bar{x}$ ± SD	36.39 ±1.31	36.98 ±1.81	36.31 ±1.22	36.31 ±1.20
	Range	33.50–39.60	34.10–39.60	33.50–39.11	33.92–39.60
	CV, %	3.61	4.90	3.37	3.30
KSL, mm	$\bar{x}$ ± SD	91.49[a] ±4.05	93.84 ±4.22	91.17[b] ±3.94	90.19 ±3.64
	Range	81.30–107.10	86.00–99.00	81.30–107.10	81.30–99.00
	CV, %	4.43	4.50	4.32	4.04
KL, mm	$\bar{x}$ ± SD	85.67[a] ±2.99	87.34 ±3.37	85.45[b] ±2.88	84.38[b] ±2.68
	Range	79.20–93.20	81.80–92.60	79.20–93.20	79.30–91.80
	CV, %	3.49	3.86	3.37	3.18
WL, cm	$\bar{x}$ ± SD	20.91 ±0.48	20.75 ±0.48	20.93 ±0.48	20.74 ±0.55
	Range	19.10–23.10	20.10–21.40	19.10–23.10	19.10–23.10
	CV, %	2.30	2.31	2.29	2.67

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); BL – body length, TL – tail length, SRL – skull rump length, BRL – beak rump length, HL – head length, HW – head width, HH – head height, BKL – beak length; HBL – head beak length, TTL – tarsometatarsus length, KSL – keel skin length, KL – keel length, WL – wing length.

recorded a similar sternum crest length (M = 89.9 and F = 84.5 mm) and tarsometatarsus length (M = 35.2 and F = 34.7 mm) to those presented in our study.

CONCLUSIONS

The biometric characteristics of the Tufted Duck was performed on the basis of 13 linear and seven mass measurements describing the proportions of the size of internal organs and the shape of the body. Mass quantities were characterized by a much higher coefficient of variation than linear measurements. The relative dimensions of individual internal organs of the studied Tufted Ducks corresponded to the average dimensions of these organs studied by other authors and in other free-living waterfowls; hence it was assumed that the studied Tufted Ducks were characterized by good condition. Females had relatively larger internal organs and a higher relative

Table 8. Relative mass measurements in the Tufted Duck (*Aythya fuligula*) in the age–sex subgroups

Measurements		Immature male	Adult male	Immature female	Adult female
		n = 16	*n* = 120	*n* = 10	*n* = 51
RPM, %	x̄ ± SD	5.93 ±0.84	6.17 ±0.48	6.49 ±0.71	6.36 ±0.48
	Range	4.37–7.15	4.84–7.19	5.28–7.42	5.60–7.49
	CV, %	14.17	7.86	10.88	7.48
RLRM, %	x̄ ± SD	3.00 ±0.47	3.01 ±0.63	2.97 ±0.40	3.01 ±0.37
	Range	1.96–4.09	1.89–8.36	2.20–3.56	2.09–3.83
	CV, %	15.56	20.85	13.33	12.43
RLM, %	x̄ ± SD	1.01[a] ±0.12	1.11 ±0.15	1.19[b] ±0.19	1.13 ±0.13
	Range	0.79–1.24	0.79–1.56	0.93–1.59	0.89–1.39
	CV, %	12.24	13.65	16.05	11.39
RKM, %	x̄ ± SD	0.84[a] ±0.11	0.92 ±0.12	1.05[b] ±0.19	0.94[b] ±0.11
	Range	0.63–0.99	0.62–1.26	0.77–1.40	0.68–1.19
	CV, %	13.61	13.08	17.78	11.40
RHM, %	x̄ ± SD	0.96[a] ±0.07	0.97 ±0.09	1.07[b] ±0.12	0.99 ±0.10
	Range	0.85–1.07	0.70–1.28	0.86–1.23	0.76–1.28
	CV, %	6.85	9.49	11.38	10.03
RFM, %	x̄ ± SD	3.21 ±0.40	3.24 ±0.57	3.82 ±0.64	3.40 ±0.44
	Range	2.52–3.79	1.79–5.14	2.69–5.14	2.45–4.66
	CV, %	12.59	17.69	16.64	13.06

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); RPM – relative left pectoral muscle mass, RLRM – relative liver mass, RLM – relative lung mass, RKM – relative kidney mass, RHM – relative heart mass, RFM – relative visceral fat mass.

fat content, however, the coefficient of variation of these characteristics did not differ between males and females. Adults were significantly larger than juveniles only in terms of the mass values; there were no significant differences in the values of the linear parameters.

ACKNOWLEDGEMENTS

No external funding was received or used to support this study.

REFERENCES

Alfonso, B., Hernández, J.C., Sangil, C., Martín, L., Expósito, F.J., Díaz, J.P., Sansón, M. (2021). Fast climatic changes place an endemic Canary Island macroalga at extinction risk. Reg Environ Change, 21, 113. DOI: 10.1007/s10113-021-01828-5.

Aranowska, E., Rytel, J. (2010). Multivariate Analysis of Variance – MANOVA. Psychol. Społ., 5, 117–141.

Austin, J.E., Fredrickson, L.H. (1987). Body and organ weight and body composition of postbreeding female lesser scaup. Auk 104, 694–699.

Badzinski, S.S., Flint, P.L., Gorman, K.B., Petrie, S.A. (2009). Relationships between hepatic trace element concentrations, reproductive status, and body condition of female Greater scaup. Environ. Pollut., 157, 1886–1893. DOI: 10.1016/j.envpol.2009.01.012.

Bartyzel, B., Karbowicz, M., Bartyzel, I. (2005). A comparison of body and heart size between the Mallard and Pekin duck. Vet. Zootech-Lith., 29, 22–25.

Behrouzi-Rad, B., Ghaemi, A. (2015). Changes in the population of wintering waterbirds in Gomishan Wetland at Caspian Sea Coast, Iran. Int. J. Mar. Sci., 5, 1–7. DOI: 10.5376/ijms.2015.05.0012.

Charuta, A., Mańkowska-Pliszka, H., Bartyzel, B.J., Wysocki, J. (2005). Size of heart of the domestic Pekin duck (*Anas platyrhynchos* f. *domestica*) and wild duck (*Anas platyrhynchos*, L. 1758). Acta Sci. Pol., Med. Vet., 4, 11–19.

Chodkiewicz, T., Chylarecki, P., Sikora, A., Wardecki, Ł., Bobrek, R., Neubauer, G., Marchowski, D., Dmoch, A., Kuczyński, L. (2019). Raport z wdrażania art. 12 Dyrektywy Ptasiej w Polsce w latach 2013-2018: stan, zmiany, zagrożenia. Biuletyn Monitoringu Przyrody, 20, 1–80 [in Polish].

Coelho, M., Oliveira, T., Fernandes, R. (2013). State of the art paper: Biochemistry of adipose tissue: an endocrine organ. Arch. Med. Sci., 9, 191–200. DOI: 10.5114/aoms.2013.33181.

Dąbkowski, S.L., Wesołowski, P., Brysiewicz, A., Humiczewski, M. (2017). Międzyodrze: an example of diverse economic and nature-related activities in the part of the Lower Odra Valley. J. Water Land Dev., 34 (VII-IX), 117–129. DOI: 10.1515/jwld-2017-0045.

del Hoyo, J., Elliott, A., Sargatal, J. (1992). Handbook of the Birds of the World. Lynx Edicions, Barcelona.

Działa-Szczepańczyk, E., Pierko, M. (2010). Studium porównawcze cech biometrycznych kaczki krzyżówki (*Anas platyrhynchos*) i jej formy udomowionej (*Anas platyrhynchos* f. *domestica*). [The biometrical analysis of the body in Mallard (*Anas platyrhynchos*) and its *domestica*ted form (*Anas platyrhynchos* f. *domestica*)]. Rocz. Naukowe PTZ, 6, 23–31. [in Polish]

Table 9. Relative linear measurements in the Tufted Duck (*Aythya fuligula*) in the age–sex subgroups

Measurements		Immature male	Adult male	Immature female	Adult female
		n = 16	*n* = 120	*n* = 10	*n* = 51
RTL, %	$\bar{x}$ ± SD	19.61 ±0.97	20.09 ±0.82	20.25 ±1.08	20.43 ±0.76
	Range	17.28–21.43	17.93–22.10	18.06–21.43	17.93–21.83
	CV, %	4.96	4.08	5.33	3.72
RSRL, %	$\bar{x}$ ± SD	60.61 ±0.94	60.14 ±1.03	59.90 ±1.12	59.49 ±1.14
	Range	58.82–62.79	57.40–62.59	58.46–61.44	57.42–62.59
	CV, %	1.55	1.71	1.88	1.91
RBRL, %	$\bar{x}$ ± SD	17.67 ±1.01	71.30 ±0.91	71.08 ±1.07	70.81 ±0.90
	Range	69.69–73.97	69.33–73.79	69.69–72.80	68.90–73.79
	CV, %	1.41	1.27	1.51	1.28
RHL, %	$\bar{x}$ ± SD	11.06 ±0.23	11.16 ±0.47	8.67 ±0.40	11.32 ±0.59
	Range	10.67–11.49	9.40–12.64	8.00–9.29	9.62–12.99
	CV, %	2.09	4.18	4.60	5.19
RHW, %	$\bar{x}$ ± SD	5.78 ±0.16	5.80 ±0.33	5.96 ±0.24	5.84 ±0.25
	Range	5.45–6.13	4.63–6.37	5.42–6.25	5.16–6.27
	CV, %	2.76	5.74	4.05	4.36
RHH, %	$\bar{x}$ ± SD	7.26 ±0.23	7.35 ±0.32	5.96 ±0.24	7.34 ±0.34
	Range	6.89–7.71	6.36–8.05	5.42–6.25	6.36–8.03
	CV, %	3.16	4.33	4.05	4.66
RBKL, %	$\bar{x}$ ± SD	8.72 ±0.23	8.61 ±0.29	8.67 ±0.40	8.77 ±0.30
	Range	8.20–9.17	7.85–9.49	8.00–9.29	8.07–9.49
	CV, %	2.68	3.34	4.60	3.46
RHBL, %	$\bar{x}$ ± SD	19.77 ±0.29	19.76 ±0.55	19.85 ±0.78	20.08 ±0.64
	Range	19.35–20.25	18.22–21.69	18.44–20.90	18.22–21.67
	CV, %	1.47	2.79	3.94	3.18
RTTL, %	$\bar{x}$ ± SD	8.05 ±0.37	7.90[a] ±0.30	7.93 ±0.31	8.05[b] ±0.28
	Range	7.61–8.80	7.19–8.84	7.61–8.69	7.62–9.00
	CV, %	4.57	3.78	3.93	3.45
RKSL, %	$\bar{x}$ ± SD	20.42 ±0.84	19.84 ±0.83	19.81 ±1.10	19.98 ±0.89
	Range	18.70–22.00	18.07–22.50	18.50–21.42	18.07–22.50
	CV, %	4.13	4.17	5.57	4.46
RKL, %	$\bar{x}$ ± SD	19.00 ±0.68	18.59 ±0.63	18.54 ±0.51	18.69 ±0.75
	Range	18.17–20.40	17.00–21.20	17.76–19.55	17.51–21.20
	CV, %	3.57	3.39	2.76	3.99
RWL, %	$\bar{x}$ ± SD	45.15 ±0.88	45.54 ±1.10	46.24 ±2.67	45.80 ±1.12
	Range	43.52–46.22	43.01–52.98	43.63–52.98	43.30–48.01
	CV, %	1.95	2.43	5.77	2.45

[a, b] – various lowercase letters within the lines indicate differences statistically significant at $P \leq 0.05$ (variables for which significant differences were observed are marked in bold); RTL – relative tail length, RSRL – relative length from the skull base to the beginning of the croup, RBRL – relative length from the beginning of the beak to the beginning of the croup, RHL – relative head length, RHW –relative head width, RHH – relative head height, RBKL – relative beak length, RHBL – relative head and beak length, RTTL – relative left tarsometatarsus length, RKSL – relative keel–skin length, RKL – relative keel length, RWL – relative left wing length.

Działa-Szczepańczyk, E., Wesołowska, I. (2008). Morphometric characteristics of esophagus and intestine in Tufted Ducks (*Aythya fuligula*) wintering on the Baltic coastal areas in Northwestern Poland. EJPAU, 11, 1–35.

Dzubin, A., Cooch, E. (1992). Measurements of Geese: General Field Methods. California Waterfowl Association, Sacramento, CA.

Eissa, A.E., Zaki, M.M. (2011). The impact of global climatic changes on the aquatic environment. Procedia Environ. Sci., 4, 251–259. DOI: 10.1016/j.proenv.2011.03.030.

El Ghizi, S., Sadik, M., Hasnaoui, M. (2021). Contribution to the study of the hydro-chemical characteristics of the lake ecosystem Dayet Er-Roumi, Morocco. E3S Web Conf., 314, 07004. DOI: 10.1051/e3sconf/202131407004.

Fernández, J.M., Selma, M.A.E., Aymerich, F.R., Sáez, M.T.P., Fructuoso, M.F.C. (2005). Aquatic birds as bioindicators of trophic changes and ecosystem deterioration in the Mar Menor lagoon (SE Spain). Hydrobiologia, 550, 221–235 DOI: 10.1007/s10750-005-4382-0.

Freeman, S., Jackson, W.M. (1990). Univariate metrics are not adequate to measure avian body size. The Auk, 107, 69–74.

Gammonley, J.H., Heitmeyer, M.E. (1990). Behavior, body condition, and foods of buffleheads and lesser scaups during

spring migration through the Klamath Basin, California. Wilson Bull., 102, 672–683.

Górski, W., Mohr, A. (2007). Czernica *Aythya fuligula*.[The Tufted Duck *Aythya fuligula*] In: Sikora, A., Rohde, Z., Gromadzki, M., Neubauer, G., Chylarecki, P. (red). Atlas rozmieszczenia ptaków lęgowych Polski 1985-2004. [The atlas of breeding birds in Poland 1985-2004]. Bogucki Wydawnictwo Naukowe, Poznań, pp.78-79. [in Polish]

IUCN (2012). International Union for Conservation of Nature and Natural Resources: IUCN Red List Categories and Criteria, Version 3.1, Second edition (2012). Archived (PDF) from the original on 1 March 2019. Retrieved 21 January 2023.

Jiménez-Peñuela, J., Ferraguti, M., Martínez-de la Puente, J., Soriguer, R., Figuerola, J. (2019). Urbanization and blood parasite infections affect the body condition of wild birds. Sci. Total Environ., 651, 3015–3022. DOI: 10.1016/j.scitotenv.2018.10.203.

Kalisińska, E., Budis, H., Podlasińska, J., Lanocha, N., Kavetska, K.M. (2010). Body condition and mercury concentration in apparently healthy goosander (*Mergus merganser*) wintering in the Odra estuary, Poland. Ecotoxicology, 19, 1382–1399. DOI: 10.1007/s10646-010-0524-x.

Kalisińska, E., Dańczak A., Pierko M., Wysocki D. (1999). Relationships between kidney mass and body size in some Anseriformes. Anat. Histol. Embryol., 28, 55–60. DOI: 10.1046/j.1439-0264.1999.00169.x.

Kalisińska, E., Dańczak, A. (1997). Heart size in some anseriform species, in: 11th European Symposium on Waterfowl, Nantes 8-10.09.1997, 8–10.

Keppel, G., Wickens, T.D. (2004). Design and Analysis: A researcher's Handbook 4th Edition. Prentice Hall, New Jersey.

Królaczyk, K., Kavetska, K.M. (2019). Taxonomic structure of cestodofauna of two species of diving ducks *Aythya fuligula* and A. marila (Anseriformes: Aythyini) in north-western Poland. Ann. Parasitol., 65, 341–349.

Labocha, M.K., Hayes, J.P. (2012). Morphometric indices of body condition in birds: a review. J. Ornithol., 153, 1–22. DOI: 10.1007/s10336-011-0706-1.

Ławicki, Ł., Czeraszkiewicz, R., Guentzel, S., Jasiński, M., Kajzer, Z., Kaliciuk, J., Oleksiak, A. (2008). Zimowanie ptaków wodnych na Pomorzu Zachodnim w latach 2002-2008. [Wintering of waterbirds in Western Pomerania in 2002-2008]. Not. Orn., 49, 235–244 [in Polish].

Molina-Marin, D.A., Rodas-Rua, J.C., Lara, C.E., Rivera-Páez, F.A., Fontúrbel, F.E., Castaño-Villa, G.J. (2022). Effects of landscape configuration on the body condition of migratory and resident tropical birds. Divers., 14, 432. DOI: 10.3390/d14060432.

Morado, C.N., Araújo, F.G., Gomes, I.D. (2017). The use of biomarkers for assessing effects of pollutant stress on fish species from a tropical river in Southeastern Brazil. Acta Sci. Biol. Sci., 39, 431–439. DOI: 10.4025/actascibiolsci.v39i4.34293.

Nieoczym, M., Antoń, K., Bednarz, Z., Michalczuk, J., Piechota, D., Stachyra, P., Szewczyk, P. (2021). Population trends of breeding waterbirds on fishponds in south-eastern Poland during 30 years. In: Karpińska, J., Bartoszewicz, M., Sawczuk, R. (red). Modern problems and solutions in environmental protection, Wydawnictwo Uniwerystetu w Białymstoku, Białystok, pp. 12–20.

Peig, J., Green, A.J. (2010). The paradigm of body condition: a critical reappraisal of current methods based on mass and length. Funct. Ecol., 24, 1323–1332. DOI: 10.1111/j.1365-2435.2010.01751.x.

Pham, T.H.Y., Shahrour, I., Aljer, A., Lepretre, A., Pernin, C., Ounaies, S. (2020). Smart monitoring for urban biodiversity preservation. In: Ha-Minh C., Dao D., Benboudjema F., Derrible S., Huynh D., Tang A. (red). CIGOS 2019, Innovation for Sustainable Infrastructure. Lecture Notes in Civil Engineering, vol 54. Springer, Singapore. DOI: 10.1007/978-981-15-0802-8_180.

Piersma, T., Davidson, N.C. (1991). Confusions of mass and size. The Auk 108, 441–443.

Pöysä, H., Lammi, E., Pöysä, S., Väänänen, V.M. (2019). Collapse of a protector species drives secondary endangerment in waterbird communities. Biol. Conserv., 230, 75–81. DOI: 10.1016/j.biocon.2018.12.016.

Rose, P., O'Brien, M. (2020). Welfare assessment for captive Anseriformes: A guide for practitioners and animal keepers. Animals, 10, 1132. DOI: 10.3390/ani10071132.

Sekiya, Y., Hiratsuka J., Yamamuro M., Oka N., Abe M. (2000). Diet selectivity and shift of wintering common pochards and Tufted Ducks in a eutrophic coastal lagoon. J. Mar. Syst., 26, 233–238. DOI: 10.1016/S0924-7963(00)000579.

Siemińska, L. (2007). Adipose tissue. Pathophysiology, distribution, sex differences and the role in inflammation and cancerogenesis. Endokrynol. Pol., 58, 330–343.

Sokołowski, J. (1977). Ptaki; Atlas Polski [Bird; Atlas for Poland]. Wydawnictwo Szkolne i Pedagogiczne, Warszawa [in Polish].

Vala Dolatsang, S., Trivedi, V. (2018). Status of aquatic birds at Aji-1 water reservoir, Rajkot, Gujarat, India. J. Global Bio-Sci., 7, 5375–5384.

van Nes, E.H., Noordhuis, R., Lammens, E.H., Portielje, R., Reeze, B., Peeters, E.T. (2008). Modelling the effects of diving ducks on zebra mussels Dreissena polymorpha in lakes. Ecol. Model., 211, 481–490. DOI: 10.1016/j.ecolmodel.2007.10.001.

Wilder, S.M., Raubenheimer, D., Simpson, S.J. (2016). Moving beyond body condition indices as an estimate of fitness in ecological and evolutionary studies. Funct. Ecol., 30, 108–115. DOI: 10.1111/1365-2435.12460.

Królaczyk, K., Dzierzba, E., Kavetska, K.M., Zaborski, D. (2022). The biometric characteristic of the Tufted Duck *Aythya fuligula* (Linnaeus, 1758) from Western Pomerania (Poland). Acta Sci. Pol. Zootechnica, 21(3), 25–36. DOI: 10.21005/asp.2022.21.3.04

CHARAKTERYSTYKA BIOMETRYCZNA CZERNICY *AYTHYA FULIGULA* (LINNAEUS, 1758) Z POMORZA ZACHODNIEGO (POLSKA)

STRESZCZENIE

Celem niniejszej pracy była charakterystyka morfometryczna czernicy występującej na Pomorzu Zachodnim z uwzględnieniem płci i wieku ptaków. Materiał do badań stanowiło 197 czernic pozyskanych w grudniu 2013 roku. Charakterystyki biometrycznej czernicy dokonano na podstawie 20 pomiarów wielkości liniowych oraz masowych. Wszystkie zmierzone narządy wewnętrzne i większość poszczególnych części ciała czernicy była nieco większa u samców. Pomimo różnic w wielkości ciała samców i samic, badane ptaki wykazywały podobną zmienność zarówno pod względem długości, jak i masy. Różnice między dorosłymi i młodymi czernicami nie były tak dobrze zarysowane. Dorosłe czernice charakteryzowały się znacznie większą masą ciała, masą mięśni piersiowych i masą płuc niż osobniki młodociane. Nie stwierdzono istotnych różnic w wartościach liniowych badanych cech.

Słowa kluczowe: morfometria, czernica, Anseriformes, Polska

Katarzyna Królaczyk https://orcid.org/0000-0002-8980-777X
Katarzyna Marta Kavetska https://orcid.org/0000-0002-7739-1586
Daniel Zaborski https://orcid.org/0000-0003-3590-3229