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Heavy Metals in the Organs of Anseriform Birds

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Abstract

The anseriform birds studied in the present work were taken from Słońsk Reserve, the Baltic Seacoast and from a breeding farm in Kołuda Wielka.

The contents of metals (lead Pb, cadmium Cd, zinc Zn, copper Cu) in the livers and kidneys of male and female ducks (*Anas platyrhynchos*, mallard; *Clangula hyemalis*, long-tailed duck) and geese (*Anser anser*, greylag goose; *A.anser f.domestica*, domestic goose) were compared.

The highest Cd level was found in the kidneys of mallards from the Słońsk Reserve, the lowest in the kidneys of domestic geese. Moreover, the highest levels of Pb, Zn and Cu were recorded in mallards.

Analyzing the contents of metals in the livers of tested birds, the highest levels of Pb, Cd and Zn were also found in mallards and geese from Słońsk.

The highest Cu level was found in the livers of domestic geese. The levels of all studied metals, except copper, was higher in the livers of females.

Keywords: anseriform birds, heavy metals, kidneys, liver

Introduction

Heavy metals present in the natural environment influence the level of these elements in various organs, which could be risky for human and animal health. This has determined studies of monitoring character to have been taken up.

Rapid progress of civilization in the last half-century caused by the development of knowledge and industry using new, complex technologies with their unpredictable effects, has acted on nature. Antropogenic transformations of landscape undoubtedly have shaken the biological balance in biotops. Devastation of flora has resulted in the decrease of animal food amount and is responsible for a drop in animal numbers and many a time for the impoverishment of species. These phenomena influence the existence of people being in direct danger [2, 6, 8, 9, 15, 20].

Environmental control could be multidirectional but one of the most essential criterion of analysis are observations carried out on animals [8, 10, 13]. Long-term investigations have confirmed that birds should be included among the most important bioindicators in the animal world. The present paper discusses data resulting from studies on anseriforms.

Material and Methods

Four species of anseriform were studied. Mallards *Anas platyrhynchos* (10 males, 4 females) and greylag geese *Anser anser* (3 males, 6 females) were taken from Słońsk Reserve, situated in the Warta and Odra flood waters. Long-tailed ducks *Clangula hyemalis* (14 males, 14 females) came from Pomeranian Bay, near Wolin National Park. Domestic geese *Anser anser f.domestica* (8 males, 8 females), were taken from Kołuda Wielka (Bydgoszcz province).

Livers and kidneys of the birds were mineralized in a mixture of nitric and perchloric acids and then contents of Pb, Cd, Zn, Cu were determined using the ICP method (JOBIN-YVON JY-24 ICP-EAS). The obtained values were then prevalued for 1 g of fresh tissue. The results were statistically analyzed. Coefficient of variation and standard deviation were estimated by variance analysis and Duncan's test within sexes of particular species.

Results and Discussion

The contents of Pb in 1 g of a fresh kidney tissue of birds are shown in Table 1. The lowest level of lead was

Table 1. Lead content (μg/g of wet tissue) in kidneys and liver and statistical analysis of data.

Species	Kidneys				Liver			
	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv
Domestic goose								
M, n=8	0.9	0.10 (0.00-0.27)	0.08	80.7	0.03	0.05 (0.00-0.19)	0.06	123.2
F, n=8	0.13	0.13 (0.03-0.26)	0.08	60.3	0.06	0.07 (0.00-0.18)	0.05	78.2
Greylag goose								
M, n=3	0.19	0.30 (0.14-0.55)	0.22	74.8	0.08	0.09 (0.07-0.12)	0.03	28.6
F, n=6	0.14	0.50 (0.08-1.85)	0.70	140.6	0.07	0.12 (0.04-0.27)	0.10	87.1
Mallard								
M, n=10	0.08	9.16 (0.00-102.8)	29.50	322.0	0.15	0.65 (0.00-2.09)	0.84	129.5
F, n=4	0.19	0.25 (0.00-0.81)	0.33	132.5	0.05	0.05 (0.00-011)	0.06	116.2
Long-tailed duck								
M, n=14	0.11	0.11 (0.04-0.27)	0.56	49.7	0.15	0.16 (0.03-0.30)	0.07	47.9
F, n=14	0.8	0.09 (0.04-0.20)	0.05	55.5	0.19	0.18 (0.05-0.36)	0.09	47.4

Me – median, $\bar{x}$ – average, x_{min} – minimum, x_{max} – maximum, s – standard deviation, cv – coefficient of variation (%), M – males, F – females.

Table 2. Cadmium (μg/g of wet tissue) in kidneys and liver and statistical analysis of data.

Species	Kidneys				Liver			
	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv
Domestic goose								
M, n=8	0.60	0.61** (0.38-0.88)	0.14	23.5	0.10	0.15** (0.04-0.38)	0.13	86.8
F, n=8	1.52	0.67 (0.68-3.07)	0.70	42.0	0.49	0.51 (0.23-0.71)	0.22	42.7
Greylag goose								
M, n=3	2.49	3.41 (1.04-6.69)	2.94	86.2	0.39	0.52 (0.32-0.86)	0.30	56.5
F, n=6	4.38	6.24 (0.74-13.7)	6.26	100.2	0.75	1.37 (0.22-3.10)	1.37	99.5
Mallard								
M, n=10	12.1	14.2 (0.02-43.9)	14.4	101.8	1.46	1.55 (0.00-4.35)	1.24	80.1
F, n=4	11.3	20.0 (0.16-76.1)	31.9	160.0	0.50	1.71 (0.04-5.78)	2.75	161.3
Long-tailed duck								
M, n=14	4.17	4.22 (1.29-6.91)	1.75	41.6	1.26	1.30 (0.51-2.40)	0.56	43.5
F, n=14	5.25	5.26 (2.11-10.60)	2.26	43.0	1.35	1.40 (0.50-2.29)	0.53	37.9

Me – median, $\bar{x}$ – average, x_{min} – minimum, x_{max} – maximum, s – standard deviation, cv – coefficient of variation (%), M – males, F – females.
** – values statistically significant at $P \leq 0.01$.

found in long-tailed ducks and domestic geese. High variation coefficients stated in both sexes indicate a considerable diversification in the level of lead in males and females, despite the lack of statistically significant differences.

Lead content differed between species. It was higher in female geese while in ducks its concentrations were greater in males, which had already been stated by Szefer and Falandysz [9] and Falandysz [10] in their studies on various species of birds.

Analyzing Pb concentration in livers it should be noted that the results obtained in case of male mallards differed significantly from all the other Pb values observed, just as it was with Pb levels in kidneys. It is worth mentioning that in spite of the equally high variation among particular birds higher Pb content, though statistically unconfirmed, was found in females.

Similar relations were noticed by Clausen and Wolstrup [5] in mallards, and by Blus et al. [1] in tundra swan *Cygnus columbianus*. This was not explicitly certified by Falandysz [9] in his studies on mute swan *Cygnus olor,* in which the above mentioned dependence was found only in young birds.

When comparing Pb levels in the liver of long-tailed duck observed in our own studies with the results obtained by Szefer and Falandysz [17], it should be said that in birds from the Gdańsk Bay the Pb amount was lower and the differences within sexes minimal.

Cadmium, provoking first of all kidney and cardiovascular diseases, is a potential teratogenic agent.

In Table 2 the Cd level in kidneys of discussed species is shown. Relatively high variation coefficients within both sexes were found. Apart from the domestic goose ($P \leq 0.05$) no statistically significant differences between sexes were discovered. The Cd content in kidney of domestic goose was the lowest. The highest Cd level, similar to Pb content, was found in other wild and domestic animals [5, 8, 9, 14].

Though the Cd level in the livers of waterfowl (Table 2) was lower than in kidneys, differences between males and females, in which the Cd concentration was considerably higher, remained. In the case of domestic geese they were statistically significant ($P \leq 0.05$).

The level of metals indispensable for proper organism functions (provided their amounts are rather small) were examined. One of the most important is zinc, a component of metal enzymes activating functions of other enzymes, a growth agent, an element taking part in the functioning of skin tissues.

Zinc excess is rather rare but when it does occur it results in the inhibition of growth, loss of appetite, arthritis and internal bleeding. It also reduces the ability to assimilate Cu and Fe; young animals are particularly sensitive.

In Table 3 the level of Zn in the kidneys and livers of studied birds is shown. Analyzing the zinc concentration in kidneys, a lower variation was noticed, especially in males,

Table 3. Zinc content (µg/g of wet tissue) in kidneys and liver and statistical analysis of data.

Species	Kidneys				Liver			
	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv
Domestic goose								
M, n=8	21.9	21.8 (18.6-23.6)	1.5	7.0	29.1	36.3* (25.9-63.5)	14.6	40.4
F, n=8	23.2	23.1 (18.9-26.4)	2.7	11.8	51.4	49.6 (39.5-57.8)	7.7	15.5
Greylag goose								
M, n=3	21.9	20.8 (19.6-22.3)	1.4	6.7	40.0	45.0 (37.2-57.9)	11.2	24.9
F, n=6	17.8	19.4 (14.7-25.7)	5.0	25.7	44.9	45.5 (32.1-68.8)	13.6	29.9
Mallard								
M, n=10	25.7	26.0 (20.4-32.3)	4.1	15.9	44.6	43.6* (37.0-50.3)	4.8	11.0
F, n=4	27.9	29.2 (24.7-35.4)	4.5	15.3	55.0	53.9 (44.5-61.1)	7.0	13.0
Long-tailed duck								
M, n=14	23.5	22.6 (16.7-22.1)	2.8	12.4	25.2	24.0 (8.20-28.3)	4.9	20.2
F, n=14	23.0	22.9 (19.3-27.2)	2.3	10.1	26.8	27.2 (23.4-34.4)	2.9	10.8

Me – median, $\bar{x}$ – average, x_{min} – minimum, x_{max} – maximum, s – standard deviation, cv – coefficient of variation (%), M – males, F – females.

* – values statistically significant at $P \leq 0.05$

** – values statistically significant at $P \leq 0.01$.

Table 4. Copper content (µg/g of wet tissue) in kidneys and liver and statistical analysis of data.

Species	Kidneys				Liver			
	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv	Me	$\bar{x}$ (x_{min} - x_{max})	s	cv
Domestic goose								
M, n=8	3.33	3.56 (2.64-5.13)	0.87	24.4	51.2	126.0 (12.9-448.0)	150.0	118.9
F, n=8	2.69	2.78 (2.19-3.96)	0.58	21.0	53.1	66.9 (16.4-134.0)	46.9	70.1
Greylag goose								
M, n=3	3.16	2.98 (2.39-3.39)	0.53	17.7	31.1	31.3 (27.1-35.6)	4.2	13.5
F, n=6	2.96	2.94 (2.00-4.22)	0.79	26.7	27.0	25.5 (13.5-34.1)	7.4	29.2
Mallard								
M, n=10	4.33	4.43* (2.21-6.52)	1.33	30.0	30.5	29.7 (11.6-61.9)	13.5	45.4
F, n=4	5.58	6.35 (3.76-9.46)	2.19	34.6	22.2	18.6 (5.16-25.0)	9.2	49.3
Long-tailed duck								
M, n=14	3.51	3.69 (3.01-4.68)	0.41	11.2	6.9	7.4 (3.83-14.6)	2.3	31.4
F, n=14	3.78	3.92 (3.19-5.10)	0.52	13.2	7.3	7.8 (4.89-14.3)	2.3	29.9

Me – median, $\bar{x}$ – average, x_{min} – minimum, x_{max} – maximum, s – standard deviation, cv – coefficient of variation (%), M – males, F – females.

* – values statistically significant at $P \leq 0.05$.

but the Zn content in kidneys of both males and females was alike. A similar Zn level in the kidneys of scaup duck *Aythya marila* was found only by Szefer and Falandysz [18]. In the investigations of all other previously cited authors the level of zinc in kidneys was considerably higher. In the studies by Osborn et al. [16], the Zn level was even dozens of times higher, which could suggest a reduced level of the element in all species studied in the present work.

A higher level of zinc, when compared with that found in long-tailed ducks, was observed in the livers of the remaining 3 species (Table 3), variability being considerably low. Statistically significant differences within sexes were stated in domestic geese ($P \leq 0.05$) and in mallard ducks ($P \leq 0.01$), with a higher concentration in males. The values obtained, however, are lower when compared with literature data, which could indicate Zn deficiency.

Studies by Cerklewski and Forbes [3] showing interactions between some metals could help explain this phenomenon. Zinc and lead have a similar gastrointestinal absorption mechanism and alike intracellular metabolism, in which metal enzymes containing Zn are involved. In their experiments on dogs and lead-poisoned rats, Victery et al. [19] observed increased zinc excretion and lead concentration in urine. Lead is suggested to damage renal tubules, resulting in increased excretion of other elements with urine. Cadmium levels (considerably increased in our studies on birds) and zinc excretion are also interrelated – Brzozowska [2].

Copper – the regulator of growth processes, present in oxidising enzymes and fundamental for hematopoietic processes – is the second element that belongs to the group of metals indispensable for proper organism functioning, found in connection with poisonous elements. Liver is the indicator here. Copper can also be dangerous in both deficiency and excess. Hemoglobinemia, hemoglobinuria, icterus and liver injury are the symptoms of intoxication by copper.

Table 4 shows the average copper levels both in kidneys and livers. Absolute values of Cu level in all species were similar and except for mallards no particular differences in both sexes were found. Statistically significant differences ($P \leq 0.05$) were noticed in mallards only.

Copper levels obtained in our investigations were considerably lower than those given by Falandysz [9], Szefer and Falandysz [17], Clausen and Wolstrup [4], Elvestad et al. [7], Honda et al. [11, 12]. The level of Cu in particular species was distinctly differentiated and oscillated from a few milligrams in the long-tailed ducks to over 126 in the female domestic goose. In long-tailed ducks Cu levels in both organs was very low when compared with the levels observed by other authors.

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