

**Bartłomiej Kaproń \*, Bożena Nowakowicz-Dębek\*\*, Wioletta Wnuk\*\*,  
Justyna Martyna\*\*, Leon Saba\*\*, Paweł Różański\*\***

**EFFECT OF LIVING CONDITIONS ON HEAVY METAL CONTENTS  
IN POLISH KONIK HORSES COAT HAIR AND BLOOD SERUM**

**WPŁYW WARUNKÓW BYTOWANIA NA ZAWARTOŚĆ METALI  
CIĘŻKICH W SIERŚCI I SUROWICY KRWI KONIKA POLSKIEGO**

**Key words:** horse, heavy metal, soil, feed, hair, blood.

**Słowa kluczowe:** konie, metale ciężkie, gleba, pasza, sierść, krew.

*Celem przeprowadzonych badań było określenie zawartości metali ciężkich we krwi i sierści koników polskich, przy uwzględnieniu biogeochemicznych warunków bytowania. Badania przeprowadzono w Ośrodku Hodowli Stajennej Konika Polskiego w Roztoczańskim Parku Narodowym w pełni sezonu wegetacyjnego (od maja do sierpnia). Ogółem wykonano pięć serii badawczych (pobrań) na 19 klaczach i 33 ogierach. W badaniach uwzględniono poszczególne ogniwa układu troficznego (próbki gleb, pasz, krew, sierść).*

*Poziom badanych elementów mineralnych w paszach był na ogół odzwierciedleniem składu mineralnego gleb, a koncentracja Cu, Zn i Pb w sierści badanych koni kształtowała się na niskich lub bardzo niskich poziomach i była trudna do interpretacji, ze względu na niewielką liczbę badań w tym zakresie. W pewnej części prób surowicy krwi badanych koni nie stwierdzono obecności ołowiu, w pozostałych próbach natomiast ołów występował w stężeniach bliskich błędowi pomiarowego aparatury analitycznej.*

*Uzyskane wyniki mogą być przydatne do ustalenia profilu metabolicznego badanych koni oraz do określenia niedoborów mineralnych w środowisku ich bytowania i opracowania dostosowanych recepturowo mieszanek mineralnych.*

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\* *Dr inż. Bartłomiej Kaproń – Roztoczański Park Narodowy, ul. Plażowa 2, 22-470 Zwierzyniec; tel.: 604 102 122.*

\*\* *Dr hab. – prof. nadzw. Bożena Nowakowicz-Dębek, dr Wioletta Wnuk, dr Justyna Martyna, prof. dr hab. Leon Saba, dr Paweł Różański – Katedra Higieny Zwierząt i Środowiska, Uniwersytet Przyrodniczy w Lublinie, ul. Akademicka 13, 20-950 Lublin; e-mail: leon.saba@up.lublin.pl*

## 1. INTRODUCTION

The Polish Konik horses has been long regarded as the only endemic breed of horses maintained in Poland, unlike Hucul horses whose breeding region comprises a few countries. The pony is a primitive horse breed that is only some different from its prehistoric descendant - the tarpan (*Equus caballus* Gmelini var. *silvestris*) which lived in the Vistula River-basin. Breed diversity hinders any comparison between metabolic values of the studied index and those of Shire breed horse and Falabella horse miniature breed. A vital component of the diagnostic procedure proves to be appropriate recognition of the biogeochemical conditions of the animal habitat. Soil micro- and macroelement availability is directly translated into quality of produced feedstuffs and thus, influences the supply of the bioelements essential for animal growth and development. Analysis of the soil-plant-animal trophic system allows for determination of potential deficiencies of particular component in the environment as well as its compensation by appropriate supplementation of feed rations [Krumrych et al. 1995; Sasimowski and Budzyński 1987; Stachurska et al. 2009].

Habitat of Polish Konik horses in the Roztocze National Park seems to be theoretically clean. However, a metallurgy-sulfur railway line located there became a major contributor of pollutants that accumulate in the environment, so the analysis of animal metabolic profile including biogeochemical conditions was much needed. Therefore, the research objective was to assess heavy metal contents in blood and coat hair of Polish Konik horses at the background of their living conditions.

## 2. MATERIAL AND METHODS

The studies were carried out in the Centre for Farm Breeding of Polish Konik horse in the Roztocze National Park (RPN) on the predominant sandy podzolic soils. The researches were conducted at high vegetative season (from May to August). A total of five research series (samplings) were performed. The investigations involved 19 mares and 33 stallions of Polish pony breed managed in a stable satisfying the welfare requirements for this animal species.

During the vegetative season, the horses stayed out at pasture most of the day and were stabled at night. Horses had free access to water both, at the stable (automatic drinkers) and pasture as well at paddock (water trough). Throughout the autumn-winter period, the Polish Konik horses diet was supplemented by salt blocks. The horses' nutrition plan was based on local feedstuffs, i.e. green forage from pasture with additional hay portions at night and supplementary oats for working horses, carriage and saddle ones. The horses were fed according to the Feeding Standards for Animals [National Research Council 1989, Sasimowski and Budzyński 1987].

Soil samples were collected once at the height of each vegetative season from meadows and pastures where horses stayed, using Egner stick to take samples from the 0–20 cm humus layer with mixed method sampling. The samples of provided feedstuffs were collected from green pasture forage, hay and oats.

Coat hair for analysis was taken after Brochart method [Brochart 1978]. Blood for examination was collected from the external jugular vein. A content of Cu, Zn and Pb in soil samples, feedstuff administered, hair and blood serum was determined by atomic absorption spectrometry (AAS) with Unicam 939 apparatus. The obtained results were analyzed using the SAS statistic software.

### 3. RESULTS

The soil samples collected from the pastures where the investigated horses stayed, showed a mean level of Cu – 3.33 mg/kg d.m. in the RPN (tab. 1). These findings categorize the studied soils as extremely poor in copper.

Feeds eaten by the studied horses were clearly copper – deficient and its mean levels reached 2.50 mg Cu/kg d.m. in green pasture forage and 2.67 mg/kg in hay (tab. 1).

**Table 1.** Content Cu in soils, each feedstuff and coat hair of studied horses

**Tabela 1.** Zawartość Cu w glebach, poszczególnych paszach i sierści badanych koni

Horse breed - sampling site		Soils mg·kg <sup>-1</sup> d.m.	Feedstuff type mg·kg <sup>-1</sup> d.m.			Hair mg·kg <sup>-1</sup> d.m.
			Green forage	Hay	Oats	
Polish Konik horses RPN	$\bar{x}$	3.33	2.50	2.67	6.43	2.98
	SD	0.17	0.14	0.49	0.19	0.31

In Polish konik horses hair, there was stated mean Cu concentration – 2.98 mg·kg<sup>-1</sup> d.m. (tab. 1), while 9.38 μmol·l<sup>-1</sup> in blood serum (tab. 4). No sex impact on a copper content in horses' blood serum was recorded.

A Zn level in the soil samples under study was 97.75 mg·kg<sup>-1</sup> d.m. in the RPN. Mean zinc concentration in the investigated feeds ranged between 25.45 mg·kg<sup>-1</sup> d.m. (oats) and 37.30 mg·kg<sup>-1</sup> d.m. (green forage) (tab. 2).

Mean Zn content in hair was 35.03 mg·kg<sup>-1</sup> d.m., (tab. 2) whereas in blood serum – 18.66 μmol·l<sup>-1</sup> (tab. 4). Among the Polish konik horses, only young mares (0–3 years old) showed statistically significant ( $P \leq 0.05$ ) higher concentration of this bioelement in serum compared to stallions of the same age.

**Table 2.** Content Zn in soils, each feedstuff and coat hair of studied horses**Tabela 2.** Zawartość Zn w glebach, poszczególnych paszach i sierści badanych koni

Horse breed - sampling site		Soils mg·kg <sup>-1</sup> d.m.	Feedstuff type mg·kg <sup>-1</sup> d.m.			Hair mg·kg <sup>-1</sup> d.m.
			Green forage	Hay	Oats	
Polish Konik horses RPN	$\bar{x}$	97.75	37.30	30.15	25.45	35.03
	SD	1.10	2.58	5.55	0.88	6.17

**Table 3.** Content Pb in soils, each feedstuff and coat hair of studied horses**Tabela 3.** Zawartość Pb w glebach, poszczególnych paszach i sierści badanych koni

Horse breed - sampling site		Soils mg·kg <sup>-1</sup> d.m.	Feedstuff type mg·kg <sup>-1</sup> d.m.			Hair mg·kg <sup>-1</sup> d.m.
			Green forage	Hay	Oats	
Polish Konik horses RPN	$\bar{x}$	0.10	0.106	0.11	0.01	0.22
	SD	0.00	0.008	0.008	0.00	0.15

**Table 4.** Content of copper, zinc and lead in blood serum [ $\mu\text{mol}\cdot\text{l}^{-1}$ ] subject to horse sex**Tabela 4.** Zawartość miedzi, cynku i ołowiu w surowicy [ $\mu\text{mol/l}$ ] w zależności od płci badanych koni

Horse breed - sampling site	Sex	Cu $\mu\text{mol}\cdot\text{l}^{-1}$		Zn $\mu\text{mol}\cdot\text{l}^{-1}$		Pb $\mu\text{mol}\cdot\text{l}^{-1}$	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Polish Konik horses RPN	Mares	9.23	0.188	18.83a	0.457	0.003	0.001
	Stallions	9.53	0.158	18.49a	0.386	0.002	0.001
	All	9.38	0.145	18.66	0.354	0.0025	0.001

**Denotation – table 1, 2, 3, 4:**  $\bar{x}$  – arithmetic mean, SD – standard deviation, a.b – means denoted with the same letters differ significantly at  $P \leq 0.05$ .

In the investigated centre for horse breeding, a lead level in the soil samples averaged  $0.10 \text{ mg}\cdot\text{kg}^{-1} \text{ d.m.}$  (tab. 3). In hay and green forage, this element concentration maintained at a similar level, while a Pb content in oats grain appeared to be about ten-fold lower (tab. 3). Lead concentration in ponies' hair was found to be  $0.22 \text{ mg}\cdot\text{kg}^{-1} \text{ d.m.}$  (tab. 3). In some parts of serum samples from the examined horses, no lead presence was recorded, while in the others the values noted were close to the measurement error of the analytic device (tab. 4).

#### 4. DISCUSSION

Copper is a nutrient essential for every living organism. Its concentration in soils in Poland ranges from  $1\text{--}100 \text{ mg Cu}$  in  $1 \text{ kg}$  soil and it is usually lower in light soils. The organic and peat soils, despite a total copper content, may be poor in available forms of copper. It is a consequence of a fact that organic acids occurring in such soils bind copper strongly

to produce complex compounds inaccessible for plants. That in turn, decreases yield and a copper level in feedstuffs [Trąba and Wolański 2004].

Copper concentration in a soil from pastures in the RPN and feedstuffs was similar or lower compared to the Waclawek's studies in northern Poland [Waclawek 1997] that indicates good availability of Cu from the feeds given to the investigated horses, in spite of the element deficiency. Cu content measurements in horses' hair appeared to be substantially lower than those obtained by the other authors for purebred English, Wielkopolski or Małopolski horses [Cieśla and Janiszewska 2000, Janiszewska and Betlejewska-Kadela 1993].

Data illustrating a copper level in blood serum and available in literature, most often refers to noble horses maintained in the state breeding centers studs and herds of stallions. For various horse breeds, many authors reported different research findings that do not allow for the explicit interpretation of a Cu level dependence in blood serum and coat hair [Cieśla and Janiszewska 2000, Janiszewska and Betlejewska-Kadela 1993, National Research Council 1989].

Whereas Krumrych et al [1995] observed higher Cu values in blood serum of Polish Konik horses ( $13.39 - 13.73 \mu\text{mol}\cdot\text{l}^{-1}$ ) from the farm breeding at different seasons. Cu concentration in serum from the studied horses was higher than those stated by Waclawek [Waclawek 1997] in fiording breed horse managed in the Central Pomerania.

Soils in Poland, irrespective of a class, do not show Zn deficit [National Research Council 1989]. The Zn values in soil were considerably lower than those noted by Waclawek [1997] in the Central Pomerania region ( $250 \text{ mg}\cdot\text{kg}^{-1} \text{ d.m.}$ ). The blood serum Zn levels obtained in the present research were 2-fold higher compared to those presented by Krumrych et al. [1995] in the Polish Konik horses from three greatest breeding centres. The feed analysis revealed higher zinc concentration in green pasture forage as against its content in oats and hay.

The major lead source in soils and feeds prove to be among others, herbicides, mineral fertilizers, sewage and transportation. A mean Pb level in soil in the investigated horse farm breeding ( $0.10 \text{ mg}\cdot\text{kg}^{-1} \text{ d.m.}$ ) was 2-fold lower than average Pb concentration recorded in soils of the Lublin Province [Janiszewska and Betlejewska-Kadela 1993]. Such a low content may be ascribed to a fact that the present researches were made in the nature protection area far from the industrial centers and enveloped by extensive forest complexes.

Hair makes quite simple and the least invasive analytic material that reflects the mineral status of animal, however it can not be applied as the only indicator but combined with another biological material – blood, liver, kidneys, etc [West et al. 2004].

Stachurska et al. [2009] who examined hair and hoofs of Polish Konik horses from the farm breeding and reservations, reported that Mn concentration is closely correlated with age. Similar observations were made about hoofs, hence a suggestion concerning the Cu supplementation in both systems of horse management.

Asano et al. [2002] in their studies did not find any significant differences for As, Al, Pb, Cd, Hg, Se, Si, P, Na, K, Ca, Mg, Fe, Cu, Zn, Mn, Cr, Ni in the hair of race horses (mares

and stallions) aged 2–5 years. A correlation analysis confirmed a relationship between Cd and animal age. The authors indicate a possibility of using mineral contents in race horses' hair for the assessment of animal body condition and feeding control.

Concentration of elements studied in animal body should be considered at the background of their environment (soil, feedstuffs) as well as their absorption capability and availability. Both, deficiency and excess of any chemical element may develop different metabolic disorders of utility animals.

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