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[1]Uniwersytet Przyrodniczy w Lublinie, Katedra Hodowli i Użytkowania Koni
ul. Akademicka 13, 20–950 Lublin
e-mail: michal.pluta@up.lublin.pl
[2] Ośrodek Hodowli Zachowawczej w Roztoczańskim Parku Narodowym w Zwierzyńcu

MICHAŁ PLUTA[1], RYSZARD KOLSTRUNG[1], JAN SŁOMIANY[2]

The effect of age and some environmental agents on physiological parameters of Polish Konik horses during the harrowing

Wpływ wieku oraz wybranych czynników środowiskowych na parametry fizjologiczne u koników polskich podczas bronowania

Summary. The research paper aimed to determine the effect of horse age and weather conditions on physiological parameters (heart rate – HR), body temperature, respiratory rate (RR) of each animal from the treatment groups during the spring harrowing operation. The studies were carried out in the farm Florianka Roztocze National Park (7.5 ha area) in Zwierzyniec over the years 2005–2010. For working purposes, 15 Polish Konik breed horses (9 stallions, 2 mares and 4 geldings) were grouped in pairs, i.e. 19 pairs during the six-year research period. In 2006, 2008 and 2009, 3 horse pairs harrowed the field, while in the other years – 2 pairs did. Out of 15 horses, 11 animals worked twice or more times. The working time length of each horse team determined by the horse owner depended mainly on the animal age, training advance level and gender. In order to establish the influence of age on physiological indices, all the working horses were allocated into five age groups: group I – including 3-year-olds (11 animals), group II – 4-year-olds (8), group III – 5 to 8-year-olds (6), group IV – 9 to 11-year-olds (6) and group V – aged ≥ 12 years (7). The maximum average HR 137.29 beats per minute (bpm) was measured in group I (3-year-olds) to decrease in the successive age groups until it reached 123.29 bpm in group V. Similar relations of the gradually declining means depending on animal age and training advance level were observed for the difference in the number of breaths measured before and after the exercise (group I 25.27 b/m, group V 19.86 b/m). There occurred significant and highly significant statistical differences between the average HR rates of the age groups. As for the differences in body temperatures taken before and after work, such significances were not noted. To determine the impact of weather conditions on physiological parameters, the next division into two treatment groups was made, i.e. horses aged < 5 years (19 animals) and horses ≥ 5 years (19). The obtained simple correlation coefficient showed moderate relations between the air temperature and the physiological parameters in the horses under the age of 5 years (from 0.41 to 0.69) and thus, confirmed the occurring mutual interactions. The combined effect of weather elements (multiple

correlations), and predominantly air temperature, also had a substantial effect on the organisms of the working animals. In the majority of horses from all the groups, the changes noted in the studied physiological parameters were considered normal and found within the reference range. Therefore, it can be concluded that the organisms of Polish Konik horses can do well in small-scale agricultural, agritourism and ecological ones farms.

Key words: Polish Konik, exercise, farm tool, physiological parameters

INTRODUCTION

Polish Konik horses are maintained all over Poland in the stabled and reserve breeding system. Recently, a large number of private breeders have established stud farms to breed and utilize horses of this breed. These horses do quite well as riding, draft ponies or can perform a wide variety of tasks, e.g. after appropriate training, in on-farm transportation or in driving harness [Kownacki 1984, Łukomski 1997]. Individuals of this breed are regularly evaluated in terms of their utility and riding or driving value [Program… 2007]. The use of working horses in modern agriculture seems to be anachronic [Kendell 2005], yet as horse power is much cheaper than tractor power, its use is an economical option, justified and advisable especially in small-scale farming (farms of 10–12 ha arable land) or in ecological and agritourist farms [Herold 2008, Kolstrung *et al*. 2009, Matyka 2008]. However, under the influence of work environment, various responses in animal organism can be triggered. The objective of the paper was to determine the effect of animal age and some weather conditions on heart rate, body temperature and respiratory rate in the working Polish Konik horses. Besides, the physiological indices ranges within which the animals can work were studied.

MATERIAL AND METHODS

The research material presented in Table 1 comprised 15 Polish Konik horses (9 stallions, 2 mares, 4 geldings) bred, maintained and used in the Roztocze National Park area, in Zwierzyniec. Horse work was observed and recorded during routine spring pre-sowing harrowing on arable land in Florianka. The cultivated land of 10 ha area is divided into four equal plots of 2,5 ha each. Every autumn, winter wheat is sown into one of four plots (alternately), so the area for spring harrowing is 7,5 ha. The studies were conducted for six successive years, 2005 through 2010. The Table gives the dates of work performed. In 2005 and 2007, harrowing operation lasted for two days due to organizational issues. Considering changeability of weather conditions that were likely to affect the work performed by horses and the state of animal organisms, each day was treated as a separate whole. Hence, there were distinguished eight observation days out of the six-year study period. Traditional light tooth harrows pulled by a two-horse team were used to perform the operation. The table columns contain the successive numbers of horse pairs; a total of 19 teams were recorded to harrow the field during six years of study. Owing to organizational reasons, in 2006, 2008 and 2009 three horse pairs harrowed the field at the same time, whereas two pairs in the other years. It is noteworthy,

tab. 1

Table 1.Characteristics of horses and comparison of each horse pair employed in harrowing
Tabela 1. Charakterystyka koni oraz zestawienie poszczególnych par pracujących w bronach

Lp.	Horse name Nazwa konia	Sex Płeć	Birth year Rok ur.	Date of work Data pracy							
				07.04.2005	13.04.2005	20.04.2006	16.04.2007	23.04.2007	10.04.2008	07.04.2009	13.04.2010
1.	Trzmiel	s./og.	1987	1 (18)							
2.	Toksja	m./kl.	1991			5 (15)					
3.	Hart	s./og.	1995			6 (11)	8 (12)	10 (12)	12 (13		)
4.	Hektor	s./og.	1997	2 (8)	3 (8)	6 (9)	9 (10)	11 (10)	13 (11)	15 (12)	18 (13)
5.	Hańczor	s./og.	2000		4 (5)					16 (9)	
6.	Mop	g./w.	2002	1 (3)	4 (3)	7 (4)					
7.	Traper	s./og.	2002	2 (3)	3 (3)						
8.	Morelka	m./kl.	2002			5 (4)					
9.	Taner	s./og.	2003			7 (3)	9 (4)	11 (4)			
10.	Top	g./w.	2003						14 (5)	17 (6)	19 (7)
11.	Halogen	s./og.	2004				8 (3)	10 (3)	13 (4)		
12.	Huragan	g./w.	2005						12 (3)	16 (4)	
13.	Natan	g./w.	2005						14 (3)	17 (4)	
14.	Tors	s./og.	2006							15 (3)	19 (4)
15.	Nap	s./og.	2007								18 (3)
Total – Razem				4	4	6	4	4	6	6	4

1, 2, 3,… numbers in coolumns refer to the horse ordinal numbers – liczby w kolumnach oznaczają numery par koni.
(3), (4),… numbers in parentheses refer to the age of particular horses – liczby w nawiasach oznaczają wiek koni.
s – stallion, m. – mare, g. – gelding.
og. – ogier, kl. – klacz, w. – wałach.

that the studied group of older animals (> 4 years), apart from spring harrowing, is used for driving work and under saddle. The work organizer paired the horses so that a younger animal aged 3–4 years could learn from older one. Young horses are trained earlier and harrowing, especially with an older horse (pair 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19) can be treated as one more form of driving practice. As for the horses under investigation, Hektor proved to be the most efficient "teacher" (Tab. 1, No 4) that worked together in driving teams (in pairs) with six stallions (pair 2, 6, 9, 13, 15, 18). Throughout the six-year research period, 11 horses worked twice or a couple of times (Tab. 1).

Beside the number of each horse pair, the age of a horse working at given date is given in brackets (Tab. 1). The oldest horses: stallion Trzmiel (aged 18 years) and mare Toksja (15 yrs) worked only once. At that season of the year (spring), mares do not work as a rule because they are in late pregnancy or nurse their foals. Therefore, using a mare pair Toksja and Morelka in 2006 was an exceptional case. The first one gave birth to colt Tors on February 9 and the foal was left in the stable with other mothers when Toksja worked, while the other 4-year old mare was not in foal at that time.

Table 2.Working time (t) of horses on each harrowing day
Tabela 2. Czas pracy (t) koni w poszczególnych dniach bronowania

Lp.	Date of work Data pracy	No of horse pair Nr par koni	Average working time Średni czas pracy		S	min	max
			(min)	(h)	(min)	(min)	(min)
1.	07.04.05	2	146.17	2.26	17.32	133.92	158.42
2.	13.04.05	2	77.17	1.17	1.41	76.17	78.17
3.	20.04.06	3	162.58	2.43	37.95	124.75	200.67
4.	16.04.07	2	158.17	2.38	7.66	152.75	163.58
5.	23.04.07	2	75.38	1.15	0.65	74.92	75.83
6.	10.04.08	3	125.33	2.05	1.34	124.25	126.83
7.	07.04.09	3	137.53	2.18	14.97	120.75	149.50
8.	13.04.10	2	162.25	2.42	0.0	162.25	162.25
Total/Razem		19	132.34	2.12	35.55	74.92	200.07

Daily working time (t) of horses summarized in Table 2 was dependent on the work organization as stipulated by a breeder. It ranged from 76 minutes (for stallions Hektor and Traper on 13.04.2005) to over 200 minutes (for stallions Hart and Hektor on 20.04.2006). The harrowing time for most pairs was over 2 hours (average 132,34' – Tab. 2). The number of breaks from work was from one (e.g. Hart and Halogen pair 23.04.2007) up to four breaks (e.g. Trzmiel and Mop 07.04.2005; Top and Natan 10.04.2008) and chiefly depended on harrowing time length and horse endurance. The length of break when the animals returned to resting heart and respiratory rate averaged 8,01 minutes (min – 3', max – 15').

Taking into account that horse work can be affected by changeable weather conditions, they were recorded every day and their characteristics presented in Table 3. Air temperature is given in degrees Celsius (^{o}C), relative humidity in %, air speed in m/s and cloudiness in the eight parts into which the space is divided, namely octants [Kossowska-Cezak *et al.* 2000].

Table 3.Weather conditions on each working day of horses
Tabela 3. Warunki pogodowe w poszczególnych dniach pracy koni

Lp.	Date of work Data pracy	Air temperature Temperatura powietrza (°C)	Relative humidity Wilgotność względna pow. (%)	Air motion Ruch powietrza (m/s)	Cloudiness (octant) Zachmurzenie (oktanty)
1.	07.04.05	16.0	54	4.0	1/8
2.	13.04.05	14.0	72	2.0	6/8
3.	20.04.06	13.2	79	1.0	7/8
4.	16.04.07	14.5	67	3.0	2/8
5.	23.04.07	14.0	60	1.5	5/8
6.	10.04.08	16.0	76	4.0	4/8
7.	07.04.09	18.0	58	3.5	1/8
8.	13.04.10	14.5	61	2.5	2/8

Performing the work, the horse HR was recorded continuously (bpm) by a Polar Accurex Plus monitor. Animal body temperature (°C) was measured five minutes before the work star along with breathing rate. The measurements were repeated immediately after the work completion.

In order to determine the influence of animal age on some regularities occurring in the obtained physiological data, all the horses working during the 6-year study period were divided into five age groups: 3-year-olds (11 animals), 4-year-olds (8), 5–8-year-olds (6), 9–11-year-olds (6) and horses ≥ 12 yrs (7).

Bearing in mind that variability of the studied physiological parameters in horses can be invoked by the weather conditions, two horse groups were formed considering the work on each day. The analysis involved the following age groups: horses < 5 years (19) and aged 5 years and ≥ 5 years (19). Mutual dependences were studied using the coefficient of simple correlations (r) and multiple (R) [Oktaba 1972].

The obtained material illustrating the course of heart rate variability during harrowing and differences in body temperature and respiratory rate before and after exercise was analyzed statistically. For each horse group, there were calculated arithmetic means (x), extreme values – minimum (min) and maximum (max), standard deviations (SD) [Oktaba 1972]. Within each trait, there was determined significance of differences (Microsoft Excel XP) between the age groups and each working day.

RESULTS AND DISCUSSION

Table 4 presents statistical characteristics of heart rate of each horse age group. The highest mean values of this trait (137,07) were obtained in the 3-year-olds (group I). In the successive groups, this parameter was reported to decline to reach the lowest mean value 123,29 in the group of the oldest horses (group V). Highly significant statistical differences were reported between the means for group I and the others. One more such difference was noted between the animals from group II (4-year-olds) and V (horses ≥ 12 yrs). In the other relations between the groups, significant differences were observed

Table 4. Statistical characteristics of HR (bpm) of horses employed in harrowing
Tabela 4. Statystyczna charakterystyka tętna koni (ud./min) pracujących w bronach

Group Grupa	Horses Konie	n	x	S	Min	Max
I	3-year-olds 3-letnie	11	137.07 ^{ABCD}	20.69	54	222
II	4-year-olds 4-letnie	8	130.33 ^{AeF}	21.29	56	207
III	5–8-year-olds 5–8-letnie	6	128.97 ^{Bgh}	17.21	62	196
IV	9–11-year-olds 9–11-letnie	6	123.80 ^{Ceg}	15.06	61	199
V	12 ≤	7	123.29 ^{DFh}	16.11	42	190
Total – Razem		38	129.42	28.48	42	222

Values denoted by the same letters differ significantly: small letters a,b...– at $P \leq 0.05$, capital letters A, B… – at $P \leq 0.01$.
Wartości oznaczone tymi samymi literami różnią się istotnie: małymi a, b… – przy $P \leq 0,05$, wielkimi A, B… – przy $P \leq 0,01$.

or did not occur. A decrease of average pulse rate on the grounds of animal age seems to be justified as with increasing age, horse organism under training adjust to working conditions, which is consistent with other authors' opinions [Aguirre i Orihuela 2000, Strzelec 2001, Szarska 1998].The best example to illustrate that are the means for horses obtained during the next working years and summarized in Figure 1. There were chosen only those horses that worked (harrowing) three times at least. Stallion Hektor (worked each study year, the mean from 125,10 – 2nd working day up to 113,78 bpm – the last 8th day), stallion Taner (3 successive working years, the mean from 127,78 through 117,95 to 117,21) gelding Top (3 working years, from 144,22 through 135,74 to 125,58) and stallion Halogen (from 148,41 through 140,89 to 127,88). The organisms of other horses responded differently to the exercise, e.g. the course of mean consecutive values for stallion Hart that harrowed the field four times was as follows: 131,06 – 140,51 – 125,42 –125,33. During the first two years, the values show an upward trend to decline and reach ca 125 level in the next years. Average working time of horses was 132,34' (Tab. 2) and induced muscle energy expenditure, which as Szarska reports [2000], can be covered completely by aerobic processes. The highest average HR values were recorded in gelding Huragan which was used twice for harrowing, that is 164,64 and 161,59 bpm. This young animal (3–4-year old when working) was closely observed after over 2-hour work and it manifested the apparent signs of severe fatigue, including all over body sweating, the arm muscles tremor. While, the mean pulse rates recorded for stallion Hektor indicated appropriate response of its organism to harrowing effort and as a rule, the horse paired up to another animal had lower parameters of the studied trait. The only exception was a driving team with stallion Taner (23.04.07) when the higher parameters were recorded. Importantly, highly statistically significant differences (at $P \leq 0,01$) between all the mean values were determined within each working pair and this fact highlights individual responses of organisms of the studied animals to the working conditions.

fig. 1.

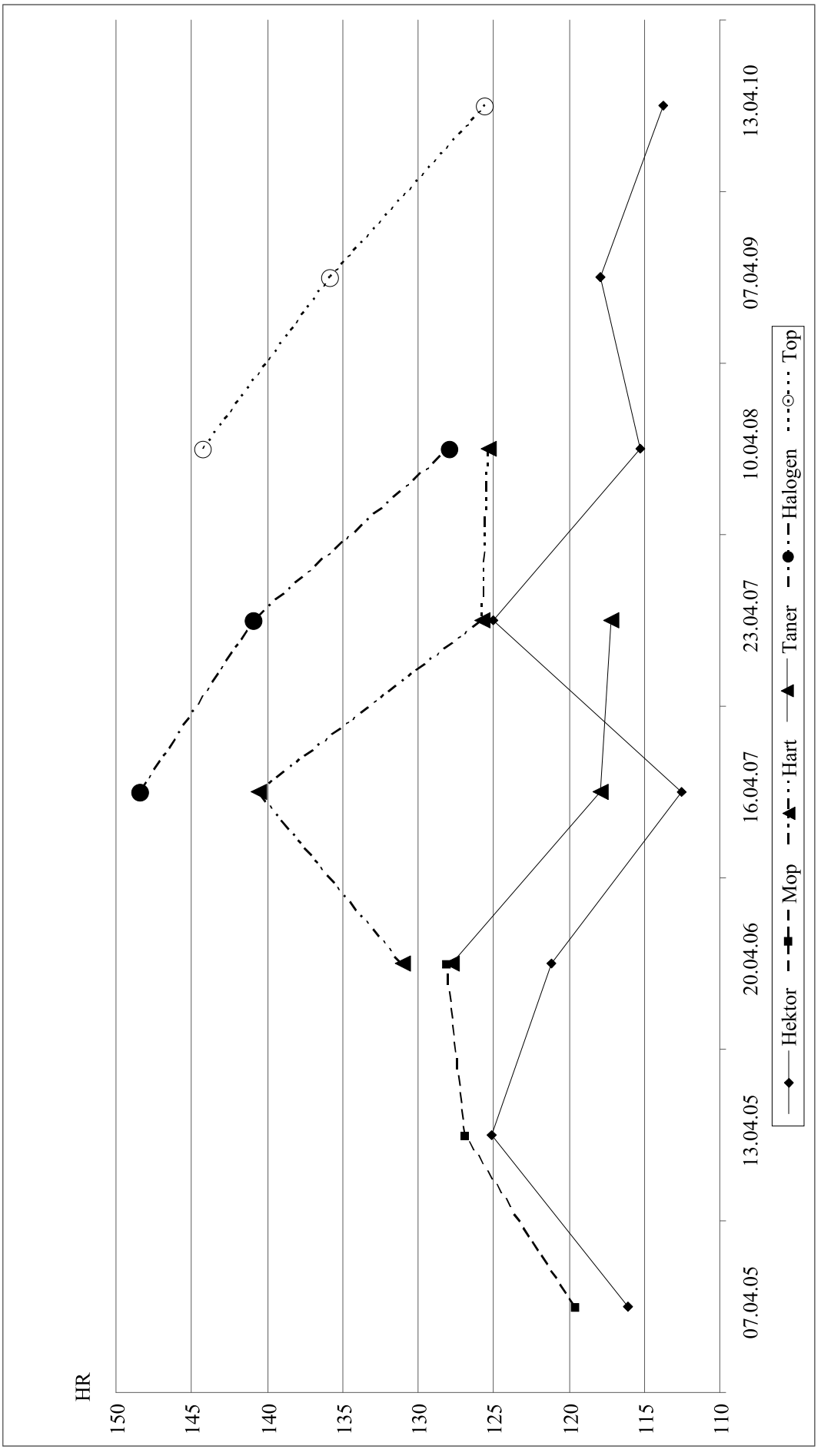

Fig. 1. Average heart rate of chosen horses on each working day
Rys. 1. Średnie tętna wybranych koni w poszczególnych dniach pracy

While monitoring the horses performing the work, the behavioral patterns they displayed were observed. Undoubtedly, the horse character and temperament contribute to increasing and persistent higher level of pulse rate, as Aguirre and Orihuela reported [Aguirre and Orihuela 2000]. In the case of young and older individuals (e.g. Hart, Hektor, Taner, Top), it was short duration growth and regarding the length of horse working time, not sufficiently persistent to affect the means.

Table 5. Statistical characteristics of body temperature difference in horses before and after harrowing work
Tabela 5. Statystyczna charakterystyka różnicy temperatur ciała koni przed pracą i po pracy w bronach

Group Grupa	Horses Konie	n	Temperature difference Różnica temperatur (^oC)				Body temperature Temperatura ciała (^oC)			
							before work przed pracą		after work po pracy	
			x	S	min	max	min	max	min	max
I	3-year-olds 3-letnie	11	0.64	0.24	0.3	1.1	37.6	38.5	38.2	39.2
II	4-year-olds 4-letnie	8	0.71	0.44	0.3	1.7	37.7	38.4	38.3	40.1
III	5–8-year-olds 5–8-letnie	6	0.72	0.21	0.5	1.0	37.4	38.0	38.2	38.8
IV	9–11-year-olds 9–11-letnie	6	0.82	0.29	0.5	1.1	37.5	38.1	38.2	38.8
V	12 ≤	7	0.80	0.26	0.4	1.2	37.4	38.0	38.2	38.9
Total – Razem		38	0.72	0.29	0.3	1.7	37.4	38.5	38.2	40.1

Table 6. Statistical characteristics of RR difference in horses before and after harrowing work
Tabela 6. Statystyczna charakterystyka różnicy liczby oddechów u koni przed pracą i po pracy w bronach

Group Grupa	Horses Konie	n	Difference in RR (b/m) Różnica liczby oddechów (od./min)				Liczba oddechów			
							before work przed pracą		after work po pracy	
			x	S	min	max	min	max	min	max
I	3-year-olds 3-letnie	11	25.27^{AbC}	5.97	18	34	12	20	32	50
II	4-year-olds 4-letnie	8	21.50^{A}	5.83	12	30	14	18	26	46
III	5–8-year-olds 5–8-letnie	6	22.67	4.50	14	26	12	16	26	42
IV	9–11-year-olds 9–11-letnie	6	21.33^{b}	6.53	12	30	12	16	24	46
V	12 ≤	7	19.86^{C}	5.67	14	28	10	16	28	42
Total – Razem		38	22.45	5.82	12	34	10	20	24	50

Values denoted by the same letters differ significantly: small letters a, b… – at $P \leq 0.05$, capital letters A, B... – at $P \leq 0.01$
Wartości oznaczone tymi samymi literami różnią się istotnie: małymi a, b… – przy $P \leq 0,05$, wielkimi A, B – przy $P \leq 0,01$

Table 5 and 6 present body temperature and respiratory rate taken before and after work for each age group. There are also summarized the differences in these measurements. According to Zwoliński [1980], normal resting temperature of a healthy horse ranges between 37,5 and 38,5 and the breathing rate 8–14 per min. These indices were found to be increased in all the studied animals performing harrowing. It is natural, as Szarska [1998] indicates, that working muscles as a consequence of their contraction produce heat (body temperature increase) which is lost through elevated respiratory frequency and sweating. The horses from two younger groups (3- and 4-year-olds) showed higher body temperatures before and after the exercise. The highest temperature after the work 40,1^{o}C was measured in gelding Huragan from group II, already mentioned above. It was the horse which on that day was noted to have the highest difference in this parameter 1,7^{o}C. No significant statistical differences were reported between the average body temperature values of each horse group.

Alike in the studies by Jasiński and Jaworski [1988], in 3-year-old stallions Taner and Tors higher resting RR rates were determined (19–20). Tors had the highest value of the parameter after work 50 b/m (Tab. 6). However, the greatest difference between the initial and final RR was recorded in a 3-year-old gelding Natan 34 b/m. The breaths number measured in some horses after work was found to increase 2-or even 3-fold and that applied to the individuals from the first two age groups. Significant statistical differences occurred in two comparisons of average RR between group I and II and then V, whereas significant differences between the individuals from group I and IV.

Table 7 gives statistical characteristics of physiological parameters for all and two age groups of horses below 5 yrs, 5-year-olds and older, considering a working day. Each day, the same number of younger animals (group I) and older (group II) was employed in harrowing. The obtained mean heartbeat rates in the horses under 5 yrs were generally higher than those recorded in older ones from group II. Within each working day, significant and highly significant statistical differences were noted between the means for group I. Most differences were observed between two days, i.e. 6 and 7 and the rest. In the group of 5-year-old horses and older, no statistical differences were reported within the days but there were noted significant differences between the parameters measured on 6 and 7 day between these two age groups. Mean heart rate in the group of older horses as "total" was lower by 9,28 bpm than the mean for the younger group.

Differences in body temperatures measured before and after the work allowed to highlight some variability between the days for a given group and both groups of horses (Tab. **7**) within which no significant statistical differences were reported (alike Tab. 5). While in the RR parameter, significant and highly significant differences were found, within both age groups, between each study day. A parameter of horse body temperature, as compared to others, turned out to be the least changeable through eight working days.

Data concerning weather conditions (Tab. 3) and characteristics of physiological parameters (Tab. 7) facilitated the calculation and determination of mutual dependences, which were presented in Table 8. Simple correlations (r) between the means of all the physiological parameters and air temperature for horses below 5 yrs reached moderate dependences, from 0,41 (difference in respiratory rate) to 0,69 (heart rate). Dependence between pulse rate and air temperature turned out to be significant. Moderate dependence (0,51) between HR and air motion was also noted for this horse group. In the other cases, weak, low and even negative correlations were observed. For group II ($5 \leq$ horses), significant dependence occurred comparing difference in body temperatures and sky cloudiness. The results of single correlations together with multiple correlations (R) allowed to

Table 7.Statistical characteristics of physiological parameters for horse groups on each working day
Tabela 7. Statystyczna charakterystyka wskaźników fizjologicznych dla grup koni w poszczególnych dniach pracy

Day Dzień	Date of work Data pracy	Horses < 5 year/Konie < 5 lat					Horses ≥ 5 years/Konie ≥ 5 lat				Total horses/Razem konie				
		n	x	S	min	max	x	S	min	max	n	x	S	min	max
		Heart rate of horse/Tętno koni													
1.	07.04.05	2	122.12^{ab}	12.49	54	172	117.12	11.91	53	167	4	119.62^{abCD}	12.45	53	172
2.	13.04.05	2	128.99^{cd}	14.91	62	177	126.11	14.83	69	189	4	127.55^{aEF}	14.94	62	189
3.	20.04.06	3	124.03^{EF}	14.50	59	176	125.60	15.20	62	199	6	124.89^{GH}	14.84	59	199
4.	16.04.07	2	132.64	24.90	58	222	126.05	20.65	61	190	4	129.35^{bij}	23.11	58	222
5.	23.04.07	2	129.08^{gh}	20.10	56	198	125.20	13.65	62	173	4	127.14^{KL}	17.29	56	198
6.	10.04.08	3	148.49^{acEgi} □	22.56	77	220	128.22□	16.76	73	194	6	138.36^{CEGiKM}	22.31	73	220
7.	07.04.09	3	148.46^{bdFhj} □	19.09	62	207	129.58□	16.87	42	196	6	139.02^{DFHjLN}	20.34	42	207
8.	13.04.10	2	130.17^{ij}	15.11	62	189	119.68	12.66	60	164	4	124.96^{MN}	14.89	60	189
Total – Ogółem		19	134.27	21.23	54	222	124.99	16.19	42	199	38	129.42	28.48	42	222
		Body temperature difference in horses/Różnica temperatur ciała koni													
1.	07.04.05	2	0.70	0.14	0.6	0.8	0.60	0.00	0.6	0.6	4	0.65	0.10	0.6	0.8
2.	13.04.05	2	0.45	0.21	0.3	0.6	0.95	0.07	0.9	1.0	4	0.70	0.32	0.3	1.0
3.	20.04.06	3	0.53	0.21	0.3	0.7	1.03	0.06	1.0	1.1	6	0.78	0.31	0.3	1.1
4.	16.04.07	2	0.80	0.14	0.7	0.9	0.65	0.21	0.5	0.8	4	0.73	0.17	0.5	0.9
5.	23.04.07	2	0.80	0.42	0.5	1.1	1.15	0.07	1.1	1.2	4	0.98	0.32	0.5	1.2
6.	10.04.08	3	0.50	0.20	0.3	0.7	0.57	0.12	0.5	0.7	6	0.53	0.15	0.3	0.7
7.	07.04.09	3	1.03	0.61	0.5	1.7	0.8	0.10	0.7	0.9	6	0.92	0.41	0.5	1.7
8.	13.04.10	2	0.50	0.14	0.4	0.6	0.45	0.07	0.4	0.5	4	0.48	0.10	0.4	0.6
Total – Ogółem		19	0.67	0.33	0.3	1.7	0.78	0.24	0.4	1.2	38	0.72	0.29	0.3	1.7
		Respiratory rate difference in horses/Różnica liczby oddechów koni													
1.	07.04.05	2	22.00^{a}	5.66	18	26	14.00^{aBcD}	0.00	14	14	4	18.00^{AbC}	5.66	14	26
2.	13.04.05	2	31.50^{Bcd}	2.12	30	33	25.00^{a}	1.41	24	26	4	28.25^{ADEFgH}	4.03	24	33
3.	20.04.06	3	19.00^{BeFg} □	1.00	18	20	24.67^{Bef} □	2.31	22	26	6	21.83^{DIJ}	3.49	18	26
4.	16.04.07	2	15.00^{chIj}	4.24	12	18	17.50^{eg}	2.12	16	19	4	16.25^{EIKLm}	3.10	12	19
5.	23.04.07	2	22.00^{k}	5.66	18	26	16.00^{fh}	5.66	12	20	4	19.00^{FnO}	5.77	12	26
6.	10.04.08	3	25.33^{eh}	7.57	20	34	21.33^{ci}	5.03	16	26	6	23.33^{bgKnP}	6.15	16	34
7.	07.04.09	3	29.33^{aFIkl}	1.15	28	30	27.33^{Dghij}	3.06	24	30	6	28.33^{CJLOPR}	2.34	24	30
8.	13.04.10	2	24.00^{dgjl}	0.00	24	24	18.00^{j}	5.66	14	22	4	21.00^{HmR}	4.76	14	24
Total – Ogółem		19	23.68	6,05	12	34	21.11	5.44	12	30	38	22.39	5.83	12	34

Values in columns within one trait denoted by the same letters differ significantly: small letters a, b... – at P ≤ 0.05, capital letters A, B...– at P ≤ 0.01. Values in lines, between groups significant at □P ≤ 0.0.5/Wartości w kolumnach w obrębie danej cechy oznaczone tymi samymi literami różnią się istotnie: małymi a, b… – przy P ≤ 0,05, wielkimi A, B… – przy P ≤ 0,01. Wartości w wierszach, pomiędzy grupami, istotne przy: □P ≤ 0.05.

establish the mutual influence of weather conditions on horse physiological parameters (Tab. 7). Combined effect of climate factors on average heart rate of both horse groups, considered separately or together, reached substantive (high, above 0,8) values of multiple correlation coefficient. It is displayed by occurring statistically significant dependences in two values of the coefficient. Taking into account four weather variables, it should be noted that air temperature had the greatest influence on average HR parameters, while sky cloudiness – the slightest. Alike, all the weather conditions were found to have considerable (over 0,77) impact on the difference in horse body temperature, while in comparison with the older animals group, a very high and significant dependence was noted. In this correlation, there was calculated the probability of nearly equal effect of all the climate conditions on the obtained mean differences in body temperatures. Mean differences in the number of breaths of the animals from group I were greatly affected by the weather conditions and the influence appeared to be really sound (0,923) and highly significant. Out of four weather elements chosen, air temperature and motion were found to exert vital impact. A multiple correlation coefficient for the group of older animals at this level of comparison, assumed moderate dependences (under 0,7).

Table 8. Simple (r) and multiple (R) correlations and coefficient of determination (R^2) between mean physiological parameters in horses and weather conditions
Tabela 8. Korelacje proste (r) i wielokrotne (R) oraz współczynnik determinacji (R^2) między średnimi wskaźników fizjologicznych u koni a warunkami pogodowymi

Group Grupa	Weather conditions – Warunki pogodowe					
	temperature temperatura	relative humidity wilgotność	motion ruch	cloudiness zachmurzenie	total feather conditions warunki pogodowe razem	
	air – powietrza					
	R				R	R^2
	HR of horses (bpm) – Tętno koni (ud./min)					
Horses < 5 years Konie < 5 lat	0.69*	0.09	0.51	-0.31	0.864*	0.746
Horses ≥ 5 years Konie ≥ 5 lat	0.19	0.49	-0.09	0.26	0.828	0.686
Total horses Razem konie	0.59	0.22	0.36	-0.15	0.856*	0.733
	Temperature body difference – Różnica temperatur ciała (^oC)					
Horses < 5 years Konie < 5 lat	0.59	-0.61	0.25	-0.59	0.812	0.660
Horses ≥ 5 years Konie ≥ 5 lat	-0.40	0.22	-0.73	0.67 *	0.913 *	0.834
Total horses Razem konie	0.06	-0.21	-0.38	0.13	0.777	0.603
	Difference in RR (b/m) – Różnica liczby oddechów (od./min)					
Horses < 5 years Konie < 5 lat	0.41	-0.07	0.15	0.01	0.923**	0.853
Horses ≥ 5 years Konie ≥ 5 lat	0.15	0.49	-0.19	0.29	0.692	0.479
Total horses Razem konie	0.35	0.22	-0.01	0.16	0.792	0.627

Indices significant at: *P ≤ 0.05, **P ≤ 0.01 – Współczynniki istotne przy: *P ≤ 0,05, **P ≤ 0,01.

CONCLUSIONS

The research results of the six-year-study allow to draw the following conclusions:

1. In the Polish Konik horses allocated into five age groups and employed in harrowing, pronounced age-related effect on three physiological parameters was determined. The effect was most noticeable in characteristics of mean HR, which was highest in 3-year-olds (group I) – 137,07 bpm to decrease gradually in the next age groups and reached the lowest value of 123,29 bpm in the oldest animals. Similar dependences applied to the RR measured before and after the work. The characteristics of the aforementioned parameters pointed to significant and highly significant statistical differences between the groups as regards mean HR and RR values. Such significances were not established for differences in body temperature. It is noteworthy that the obtained values of physiological parameters fell within the norms and did not cause any adverse consequences in horse organism and, thus make guidance for the Polish Konik horse users indicating, e.g. the working heart safe range for the animals.

2. It was found that mean physiological parameters of two age groups of working horses (group I < 5 years, II ≥ 5 years) are also affected by the weather conditions. It is supported by the results of simple correlation coefficient that reached moderate dependences between air temperature and physiological parameters in horses under 5 years. Combined operation of weather elements, predominantly air temperature, have prominent influence on working animal organism.

3. The obtained research results have confirmed the Polish Konik horse predisposition, developed as the end result of centuries of working in draft horse teams, for prolonged stressful effort and thus, suitability for driving. The character, endurance and organism adaptability make this horse breed fit well into farming system and its traction power favors the small sustainable farm, agritourist and ecological as well.

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Streszczenie. Celem opracowania było określenie wpływu wieku koni i warunków pogodowych na parametry fizjologiczne (tętno, temperatura ciała, liczba oddechów) poszczególnych grup osobników podczas bronowania wiosennego. Badania prowadzono od 2005 do 2010 r. na polach (7,5 ha) gospodarstwa Florianka RPN w Zwierzyńcu. 15 koników polskich pracowało w parach (9 ogierów, 2 klacze i 4 wałachy), których na przestrzeni sześciu lat było 19. W roku 2006, 2008 i 2009 pole bronowały 3 pary. W pozostałych latach – 2 pary koni. Spośród 15 koni 11 brało udział w pracy dwa lub kilka razy. Czas pracy poszczególnych par, ustalany przez właściciela koni, zależał głównie od wieku, wytrenowania oraz płci osobników. W celu określenia wpływu wieku na parametry fizjologiczne konie podzielono na pięć grup: I – 3-letnie (11 osobników), II – 4-letnie (8), III – 5–8-letnie (6), IV – 9–11-letnie (6) i V – ≥ 12 lat (7). Najwyższy wskaźnik średniego tętna, 137,29 ud./min, wystąpił w I grupie (trzylatki), następnie u kolejnych grup wiekowych stopniowo obniżał się aż do 123,29 ud./min u osobników z V grupy. Podobne zależności stopniowego obniżania się średniej, zależnie od wieku oraz wytrenowania, wystąpiły odnośnie do różnicy liczby oddechów mierzonej przed i po pracy (I grupa 25,27 od./min, V grupa 19,86 od./min). Pomiędzy średnimi parametrami tętna dla grup wiekowych wystąpiły istotne i wysoko istotne różnice statystyczne. Dla różnic temperatury ciała mierzonej przed i po pracy takich istotności nie było. W celu określenia wpływu warunków pogodowych w danym dniu na parametry fizjologiczne, dokonano kolejnego podziału na dwie grupy: konie młodsze niż 5 lat (19 osobników) oraz konie 5-letnie i starsze (19 osobników). Uzyskane wyniki wskaźnika korelacji prostej osiągnęły umiarkowane zależności pomiędzy temperaturą powietrza a parametrami fizjologicznymi koni poniżej 5 roku życia (od 0,41 do 0,69) i mogą być potwierdzeniem wzajemnych interakcji. Wspólne działanie czynników pogodowych (korelacje wielokrotne), głównie temperatury powietrza, również miało znaczący wpływ na organizmy pracujących zwierząt. U większości koni zanotowano prawidłowe i mieszczące się w normie zmiany w trzech badanych parametrach fizjologicznych. Pozwala to stwierdzić, że organizmy koników polskich mogą dobrze sprawdzać się w nieduży gospodarstwach rolnych, agroturystycznych i ekologicznych.

Słowa kluczowe: konik polski, praca, narzędzia polowe, parametry fizjologiczne