A C T A T H E R I O L O G I C A

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Changes in Haematological Values in Wild Boar During Postnatal Development

[With 1 Table & Figs.]

Examination was made of changes in the blood picture in 6 individuals of *Sus scrofa* L i n n a e u s, 1758 of normal black colour and 11 roan individuals. It was found that Hb content in the blood of black wild boar increases intensively during the first three months of life and that Hct value rises in proportion to this increase, whereas *MCHC* is subject to practically no change. The number of red blood cells increases intensively, and their diameter during this time becomes slightly smaller which, however, causes statistically significant reduction in the average volume of these cells. *MCH* also decreases. Only a slight increase in blood Hb content and Hct value was found in the light-coloured mutation during this period, and the number of *RBC* decreases to a statistically significant extent from the second month of life in these animals. The values of all the above blood indexes are initially greater in the light-coloured animals, but during the second month of life they do not differ from the values characteristic of black individuals. The number of leukocytes in 1 mm^3 of blood was greater in the black wild boar during the whole of the period studied. The ratio of lymphocytes to neutrophils decreases in the black individuals, but remains unchanged in the roan animals.

INTRODUCTION

Studies on the blood picture in the wild boar were undertaken chiefly because there are only very scanty haematological data to be found in literature on the postnatal period of large animals living in a natural habitat.

On the other hand it appeared interesting to make a comparative study of changes in blood index values during the development of normal forms and the light-coloured roan individuals, defined as recessive homozygotes (A n d r z e j e w s k i, 1971), since it has been observed that roan individuals are eliminated from natural wild boar populations usually as early as the first year of their life (A n d r z e j e w s k i, 1971). The values of the leukocyte, and in particular of the erythrocyte indexes, characterizing the respiratory function of the blood and

distinctly reacting to any change in the external habitat, and also to changes in the physiological state of the organism, may form a good complex indicator of the species capacity for adaptation (Kostelecka-Myrcha, 1969). It would therefore seem that a knowledge of the changes in these values during the development of young mutants and their comparison with analogical values in young normal boar should to a certain extent explain part of the complicated physiological mechanism leading to elimination of light-coloured individuals from natural wild boar populations.

MATERIAL AND METHODS

Studies were made on 6 young wild boar of normal black colour, and on 11 light-coloured roan animals. The latter, born in the experimental station of the Institute of Ecology, Polish Academy of Sciences on April 3rd 1971, originated from two 2-year old sows and one 3-year old male caught in 1969 in the Kampinos National Park near Warsaw. The studies began on the 12th day and continued up to the 80th day of life, while those on animals of normal colouring, born on April 12th 1971 in the same station by one 8-year old sow covered by a black male in the experimental station of the Mammals Research Institute at Białowieża, began on the 4th day and continued up to the 71st day of life.

The animals were kept in large forest enclosures 600 m² in area, and were fed *ad libitum* on oats and lucerne (in summer) or root crops (winter). The young individuals were also given the standard mixture for young pigs, in parts of 1 : 3 in relation to the oats fed them.

Blood values were defined in the animals at weekly intervals, obtaining the blood by incising the concha into heparinized test-tubes. Hb g% was measured with a Zeiss haemometer, *RBC* were counted on a Thom grid, and haematorict (Hct %) defined by the micromethod. The diameter of erythrocytes were measured with a Zeiss micrometric eye-piece on dry preparations stained by Pappenheim's method, making 50 measurements for each individual and calculating the average value. The above data were next used as a basis for calculating the heamoglobin content in one red blood cell (*MCH*γγ), the average thickness and volume of erythrocytes and *MCHC* %. Leukocytes were counted on a Bürker grid, and the percentages of the different forms of leukocytes in their total number estimated on stained preparations.

RESULTS

The haemoglobin content in the blood of wild boar of normal black colouring is far lower during the first few days of life than in the case with roan wild boar (Fig. 1, Table 1). Later on this difference diminishes fairly rapidly as Hb content in the blood of black animals increases far more intensively. In both groups Hb content increases distinctly during the first 27 days of life, but far more quickly in the black individuals. As from the second month of life Hb content in the blood of this group of animals continues to increase to a statistically significant degree, although far less intensively than before, while in the roan animals Hb content remains on a practically unchanged level.

Hct value during first month of life also increases fairly abruptly, and less intensively later in the black wild boar, although in this case also the increase continues to be statistically significant (Fig. 2, Table 1). In roan animals, on the other hand, Hct increases relatively negligibly

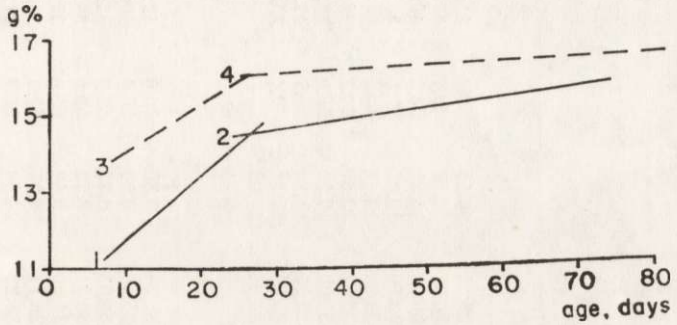

Fig. 1. Changes in haemoglobin content in the biool of wild boar during development.
Solid line — black individuals: 1 — 4—30 days, $y=10.04+0.168x$, $r=0.797$, n=20; 2 — 22—71 days, $y=13.48+0.03x$, $r=0.360$, n=33; broken line — roan individuals: 3 — 12—30 days, $y=12.79+0.123x$, $r=0.668$, n=24; 4 — 24—80 days, $y=15.67+0.015x$, $r=0.030$, n=52.

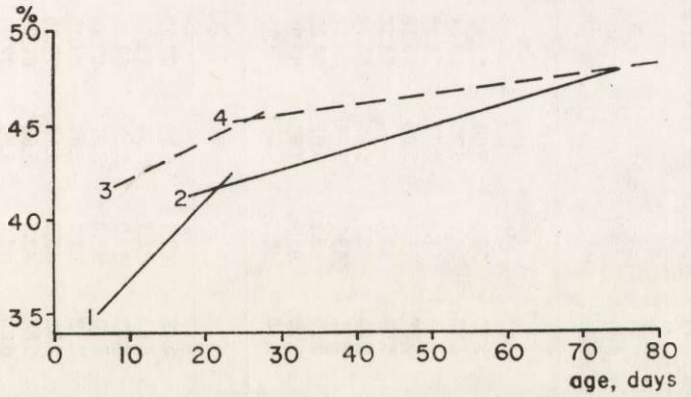

Fig. 2. Changes in haematocrit value during the development of wild boar.
Solid line — black individuals: 1 — 4—30 days, $y=32.80+0.407x$, $r=0.763$, n=16; 2 — 22—71 days, $y=39.35+0.117$, $r=0.512$, n=28; broken line — roan individuals: 3 — 12—30 days, $y=40.12+0.204x$, $r=0.128$, n=21; 4 — 24—80 days, $y=43,83+0.058x$, $r=0.285$, n=50.

and the change is not statistically significant. Like Hb content, Hct value is at first far lower in black individuals but relatively quickly, *i.e.* during approximately the second month of their lives, becomes similar to that characteristic of roan animals.

Table 1

Changes in morphological blood values during postnatal development of wild boar.

Age days	Body wt.,kg	Hb g%	RBC mln/ mm³	Hct %	*RBC* diam. µ	*RBC* vol. µ³	*RBC* thick µ	*MCH* γγ	*MCHC* %	Leukoc. 1000 per mm³	Neutro-phils %	Lym-pho-cytes %	Monoc. %	Eosin. %
						BLACK								
4	1.50	10.10	3.90	33.0	5.88	85.99	3.16	24.44	30.51	18.65	56.0	44.0	0.0	0.0
7—8	2.34	11.50	3.63	35.0	6.35	98.04	3.25	32.22	33.21	7.89	59.7	39.0	1.0	0.3
14—15	3.32	12.67	5.45	41.0	6.27	79.13	2.64	23.31	30.59	8.92	58.2	40.4	1.2	0.2
21—22	4.52	13.90	6.38	44.0	6.03	65.19	2.24	21.84	32.96	10.32	59.8	38.3	1.7	0.2
30	5.35	14.70	6.09	43.2	—	71.22	—	24.16	33.99	13.48	—	—	—	—
36	6.35	15.00	6.99	42.1	6.21	64.98	2.40	21.98	33.93	13.30	51.3	46.7	1.3	0.7
43	7.14	13.80	7.71	44.5	6.46	50.11	—	19.46	31.68	16.20	62.0	36.7	1.0	0.3
49	9.07	15.60	6.15	46.2	6.01	74.02	2.61	25.67	33.99	18.10	54.7	42.3	1.3	1.7
63—64	12.00	16.00	6.76	45.9	5.98	69.06	2.31	24.00	35.04	15.35	74.0	25.2	0.8	0.0
71	11.78	14.80	5.98	48.3	—	80.75	—	24.75	30.64	17.89	—	—	—	—
						LIGHT ROAN								
12—13	2.82	14.10	5.49	43.7	6.24	83.92	2.75	27.25	33.54	8.85	56.0	42.7	1.2	0.0
16—17	3.09	15.10	6.09	42.7	6.33	72.70	2.34	25.64	35.60	6.22	56.9	40.1	2.6	0.4
23—24	3.86	15.60	6.52	44.0	6.13	69.29	2.33	23.93	34.62	6.73	57.0	42.0	1.0	0.0
30—31	4.83	16.50	7.48	47.0	5.91	69.90	2.56	25.35	35.51	8.72	59.6	39.6	0.5	0.3
38	6.02	15.90	7.13	46.3	5.94	65.15	2.36	22.10	34.00	9.40	65.3	33.7	0.7	0.3
51—52	7.89	15.80	5.82	43.9	6.13	77.00	2.74	27.75	36.11	16.04	65.0	33.6	0.7	0.7
59	9.39	17.90	5.88	48.8	5.92	84.78	3.10	30.31	38.23	14.69	56.9	41.3	1.6	0.2
72—73	11.02	17.50	6.33	48.0	5.96	77.06	2.83	28.15	36.77	14.48	60.4	38.6	0.7	0.3
79—80	11.37	16.20	6.31	48.3	—	76.55	—	25.67	33.54	15.18	—	—	—	—

Changes in Hb content in the blood and changes in Hct value thus take parallel courses, although these differ completely in the two groups of animals. The result of the proportionate character of these changes is the relatively constant *MCHC* throughout the whole life period studied of these wild boar (black individuals: $y=31.65+0.051x$, $r=0.378$, n=30, roan individuals: $y=33.65+0.050x$, $r=0.279$, n=53). The tendency observed for *MCHC* to increase may point to the slightly greater intensity of increase in Hb content in the blood than to intensity of the increase in Hct value. Roan individuals maintain a higher *MCHC* during the whole study period than that in black individuals and this difference even increases gradually (Table 1).

The number of erythrocytes in 1 mm³ of blood increases very abruptly during the first month of life in black animals, after which no change occurs in it (Fig. 3, Table 1). In roan animals, however, the slight increase

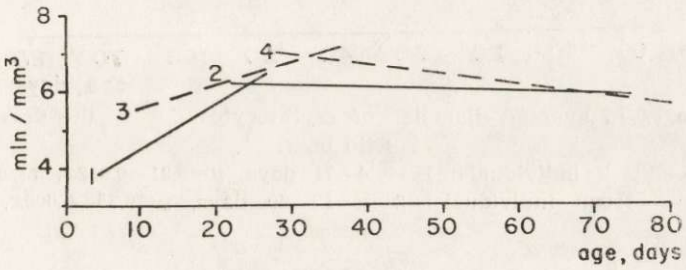

Fig. 3. Changes in number of erythrocytes in 1 mm³ of blood during the development of wild boar.
Solid line — black individuals: 1 — 4—30 days, $y=3.341+0.118x$, $r=0.781$, n=20; 2 — 22—71 days, $y=6.286-0.004x$, $r=-0.057$, n=29; broken line — roan individuals: 3 — 12—30 days, $y=4.96=0.059x$, $r=0.279$, n=24; 4 — 24—80 days, $y=7.74-0.026x$, $r=-0.468$, n=54.

in this value observed up to the 30th day of life is not statistically significant. Later there is statistically significant decrease in the number of *RBC* in these animals. Like Hb content and Hct value, the number of erythrocytes is at first smaller in black animals, but during the second month of life fails to differ from the number of these cells occurring in roan animals.

The diameter of erythrocytes decreases during the development of both group of animals, but this decrease is statistically significant only in roan wild boar (Fig. 4, Table 1), while the thickness of these cells does not undergo any change (black animals: $y=2.38+0.006x$, $r=0.192$, n=22; roan animals: $y=2.33+0.007x$, $r=0.210$, n=51). Their average volume decreases to a statistically significant degree in black individuals (Fig. 5,

Table 1). This decrease is probably the expression of statistically non--significant decrease in erythrocyte diameter which, however, exerts a significant effect on the change in volume of these cells. Only a slight

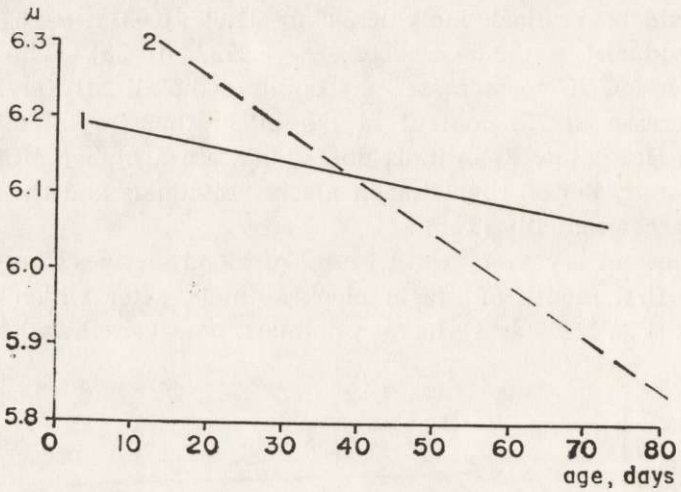

Fig. 4. Changes in average diameter of erythrocytes during the development of wild boar.
Soild line — black individuals: 1 — 4—71 days, $y=6.21—0.002x$, $r=0.140$, n=29; broken line — roan individuals: 2 — 12—80 days, $y=6.35—0.006x$, $r=—0.351$, n=58.

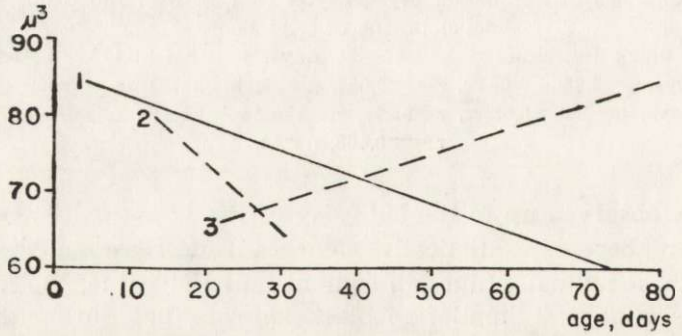

Fig. 5. Changes in average volume of red blood cells during the development of wild boar.
Soild line — black individuals: 1—4—7) days, $y=86.21—0.36x$, $r=—0.474$, n=29; broken line — roan individuals: 2 — 12—30 days, $y=90.2—0.84x$, $r=—0.273$, n=21; 3 — 24—73 days, $y=58.76+0.326x$, $r=0.397$, n=42.

decrease is observed in average volume of *RBC* in roan animals during the first month of life, but at a later period this value increases to a statistically significant degree. This fact is not, however, justified either by

a change in diameter or in thickness of the erythrocytes. The volume of blood cells is calculated on the basis of their number in 1 mm³ of blood and Hct value and it would therefore seem that this is some kind of

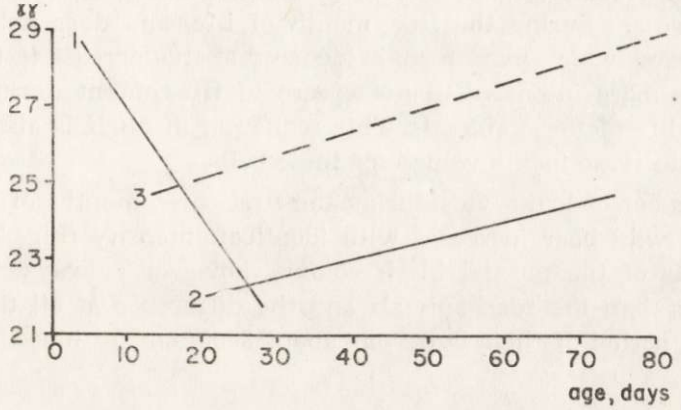

Fig. 6. Changes in mean corpuscular haemoglobin during the development of wild boar.
Solid line — black individuals: 1 — 4—30 days, $y=29.41-0.266x$, $r=-0.521$, n=19; 3 — 12 30 days, $p=5.10+0.10x$, $r=0.348$, $n=19$; 4 — 24—59 days, $y=0.71+0.258x$, $r=0.698$, n=35; 5 — 52—80 days, $y=9.26+0.075x$, $r=0.223$, n=25.

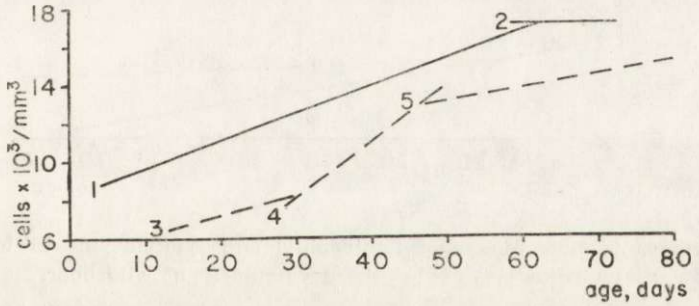

Fig. 7. Changes in number of leukocytes in 1 mm³ of blood during the development of wild boar.
Solid line — black individuals: 1 — 4—63 days, $y=8.17+0.146x$, $r=0.142$, n=27; 2 — 49—71 days, $y=16.99+0.003x$, $r=0.009$, n=10; broken line — roan individuals: 3 — 12—30 days, $y=5.10+0.10x$, $r=0.348$, n=19; 4 — 24—59 days, $y=0.71+0.258x$, $r=0.698$, n=35; 5 — 52—80 days, $y=9.26+0.075x$, $r=0.223$, n=25.

calculation artefact caused by the astonishing phenomenon of the decrease in the number of erythrocytes which begins just after the first month of life in roan wild boar. The decrease in the number of these cells in

1 mm³ of blood is also expressed in the increased Hb content per cell in roan individuals (Fig. 6, Table). In black animals, on the other hand, *MCH* decreases during the first month of life, and does not change at a later period, which may form evidence that the increase in the number of *RBC* is more intensive than increase in Hb content during the first month of life of these animals. This reduction in *MCH* is also connected with the decrease in the volume of these cells.

The number of leukocytes during the first three months of life of both groups of wild boar increases with identical intensity (Fig. 7, Table 1). Individuals of the normal black colour, however, always have more leukocytes than the roan animals and the difference at all times during the study period of their lives was about 3000/mm³ of blood.

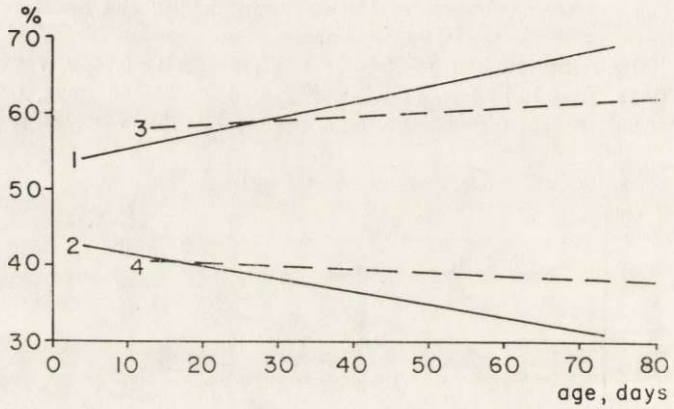

Fig. 8. Changes in percentages of neutrophils and lymphocytes in total number of leukocytes during the development of wild boar.

Solid line — black individuals: 1 — neutrophils, 4—64 days, $y=53.97+0.2x$, $r=0.370$, n=28; 2 — lymphocytes, 4—64 days, $y=43.52-0.17x$, $r=-0.340$, n=28; broken line — roan individuals: 3 — neutrophiles, 13—73 days, $y=56.90+0.06x$, $r=0.145$, n=54; 4 — lymphocytes, 13—73 days, $y=41.03-0.04x$, $r=-0.097$, n=54.

In both groups the percentage of neutrophils also increases and the percentage of lymphocytes decreases in the total number of leukocytes, these changes not being statistically significant in roan individuals, but being very clearly marked in black animals (Fig. 8, Table 1). No significant changes were found in the numbers of monocytes and eosinophils in the animals examined, while no basophils were encountered in any the material examined.

DISCUSSION

The results presented point to the necessity for adopting a different attitude to the changes in blood picture observed in black wild boar and in their roan mutation.

In individuals of normal colour changes in the value of the indexes characterizing the respiratory function of blood from the morphological standpoint to the consistent increase in the oxygen carrying capacity of its unit of volume. Hb content increases intensively in the blood of these animals, and Hct value increases in proportion to this increase, as is shown by the relatively constant *MCHC* value during the whole of the study period. The increase in Hct value is caused by the very intensive increase in the number of erythrocytes in 1 mm^3 of blood in black individuals. The increase in this number must indeed be very intensive, as the thickness of these cells does not alter during this time and their diameter decreases very slightly, but this decrease has a statistically significant effect on the reduction of the average volume of these cells. This abrupt increase in the number of erythrocytes is also the cause of reduction in Hb content per one red blood cell. It may be assumed on the basis of the foregoing facts that the combined area of erythrocytes increases during the development of black wild boar far more intensively than Hb content in their blood. Consequently, there is increasingly less haemoglobin per unit of area of erythrocytes, which faciliates their contact with oxygen and makes more effective functionning possible. Taking into consideration the simultaneous increase in Hb content in 100 ml of blood it may be concluded that the oxygen carrying capacity of a unit of blood volume gradually increases in these animals.

In comparison with domestic pigs (Nordskog *et al.*, 1944, Anderson *et al*, 1969) wild boar have a far higher haemoglobin content in the blood and far higher Hct value, and also slightly more erythrocytes in 1 mm^3 of blood. The justification for this state is to be found in the far higher values of these indexes in even three-month old wild boar than in adult domestic pigs, despite the fact that the process of their increase is not yet completed. During their development the wild boar examined have a higher Hb content in their blood than that of growing domestic piglets (Iwańska, 1963; Miller *et al.*, 1961), and higher Hct value, higher *MCHC* and also larger blood cells containing more haemoglobin. Growing wild boar and domestic piglets differ least in respect of the number of erythrocytes per 1 mm^3 of blood. It would therefore appear that a unit of blood volume in the wild boar has a greater oxygen carrying capacity than the blood of domestic pigs and this difference is

justified in the different level of this function even during the development period of the animals compared.

In roan wild boar both Hb blood content and Hct value increase to a slight degree only. The astonishing fact observed in these animals of the statistically significant reduction in the number of erythrocytes consequently causes a certain increase in Hb content per cell, and also significant increase in the calculated average volume of erythrocytes. If this change in cell volume is considered as an artefact, at variance with the measurements of the diameter of these cells, then no justification can be found for the tendency observed to increase in Hct value, since both the diameter and number of erythrocytes decrease during this time. Regardless, however, of how this phenomenon is viewed, the fact remains that there is only a slight increase in Hb content in the blood of roan wild boar and an accompanying marked decrease in the number of erythrocytes, which forms a sufficient basis for finding gradual deterioration of the capacity of a unit of volume of their blood to carry oxygen.

One-month old mutants have higher values for *RBC* indexes than the black individuals. This fact is most certainly of significance to the viability of young individuals, but further gradual reduction in the value of these indexes, so highly untypical of growing mammals, leads in consequence to considerable limitation of the respiratory function of their blood. Bearing in mind at the same time the far higher cost of thermoregulation found by Myrcha & Jezierski (1972) for roan individuals in comparison with black ones it may be assumed that the winter period is particularly difficult for roan animals, and it would therefore seem likely that under natural conditions the roan mutants generally fail to survive the first winter (Andrzejewski, 1971), whereas they are capable of developing completely normally in captivity.

It is possible that the smaller number of leukocytes in roan animals and the complete absence of changes in the ratio of lymphocytes to neutrophils during their development also result in these animals having poorer chances of surviving in a natural habitat, since it suggests that they may be less resistant to infection than normally coloured wild boar.

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ZMIANY WSKAŹNIKÓW HEMATOLOGICZNYCH DZIKA W ROZWOJU POSTNATALNYM

Streszczenie

Przebadano zmiany obrazu krwi u 6 dzików *Sus scrofa* Linnaeus, 1758 o normalnym, czarnym ubarwieniu i u 11 dzików jasnych, łaciatych, określonych jako recesywne homozygoty (Andrzejewski, 1971). Osobniki czarne badano w okresie od 5 do 71 dnia ich życia, a osobniki jasne od 12 do 80 dnia rozwoju postnatalnego.

Stwierdzono, że zawartość Hb we krwi dzików czarnych intensywnie wzrasta (Fig. 1) i proporcjonalnie do tego wzrostu zwiększa się wartość Hct (Fig. 2), wobec czego *MCHC* nie ulega prawie żadnym zmianom (Tabela 1). Wartość Hct zwiększa się u tych zwierząt dzięki bardzo intensywnemu wzrostowi liczby czerwonych krwinek (Fig. 3), któremu towarzyszy niewielkie zmniejszenie się ich średnicy (Fig. 4) i istotne statystycznie zmniejszenie się przeciętnej objętości tych komórek (Fig. 5). Maleje także *MCH* (Fig. 6). Wyniki te świadczą o znacznym zwiększeniu się zdolności jednostki objętości krwi do transportu tlenu w badanym okresie rozwoju czarnych dzików.

U jasnych, łaciatych osobników stwierdzono natomiast w tym czasie niewielki tylko wzrost ilości Hb we krwi (Fig. 1) i wartości Hct (Fig. 2). Liczba czerwonych krwinek u tych zwierząt od drugiego miesiąca życia istotnie statystycznie maleje (Fig. 3). Zdolność jednostki objętości ich krwi do transportu tlenu ulega więc stopniowemu pogorszeniu.

Wartości wszystkich wyżej wymienionych wskaźników krwi są początkowo wyższe u dzików łaciatych, ale już w drugim miesiącu życia nie różnią się od wartości charakterystycznych dla dzików czarnych, u których obserwuje się stałą dalszą poprawę zdolności jednostki objętości krwi do transportu tlenu. U dzików jasnych natomiast możliwości te stopniowo maleją, utrudniając im adaptację do niekorzystnych warunków środowiska. Dlatego wydaje się prawdopodobne, że okres zimy dla tych zwierząt jest szczególnie trudny. Być może o gorszej przeżywalności łaciatych dzików decyduje również w pewnym stopniu stwierdzona u nich podczas całego badanego okresu niższa niż u czarnych dzików liczba leukocytów (Fig. 7) oraz brak zmiany stosunku limfocytów do neutrofilów (Fig. 8), jakkolwiek intensywność zwiększania się liczby tych krwinek u obu grup zwierząt jest bardzo podobna.