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**Metabolic Rate during the Postnatal Development of Wild Boars \***

[With 1 Table &amp; 4 Figs.]

Examination was made of changes of metabolic rate during the postnatal development of wild boars of the normal black colour, and light roan colour. The phase of intensive increase was found to occur nearly 10 days earlier in black boars and was followed by a decrease in metabolic rate. After 30 days of life the metabolic rate of the two groups of animals changes in proportion to changes in their body weight. The value of the respiration coefficient increases from 0.70—0.75 during the first month of life to an average of 0.90—0.95 at the age of four months. The RQ of roan boars is usually slightly lower than that of black individuals. The range of the thermoneutral zone of roan animals aged 11 months examined in winter is narrower than that in animals of normal colouring. At temperatures over 15°C no differences were found in the metabolic level of the two groups, but at lower temperatures a higher metabolic rate was observed in black than in light-coloured animals. Considerable differences were found in the metabolic level of growing wild boars and domestic pigs.

## I. INTRODUCTION

Studies were made of changes of metabolic rate during the postnatal development of *Sus scrofa* Linnaeus, 1758. Studies on this species, which plays an important role in the functioning of forest associations, have so far been made on an insufficiently extensive scale. Definition of bioenergetic indices, including the value of energy losses during metabolic processes, is essential when endeavouring to estimate the participation of these animals in the energy balance of forest ecosystems.

Studies so far made on changes of the metabolic rate during the early period of mammals' development have been limited almost entirely to laboratory animals (Barić, 1953; Kleiber, 1961; Taylor,

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1960; Rožaja & Maslennikova, 1968) and domestic animals (Alexander, 1961; Holub *et al.*, 1957; Mount, 1968; Roy *et al.*, 1957). Data on wild species of large animals, are very few in number (Makarova, 1968; Slonim, 1962).

It would appear that comparison of the character of changes of metabolic rate during the postnatal development of wild boar and domestic pigs, that is, animals very closely related but living under completely different habitat conditions, may prove interesting from the comparative point of view. A knowledge of the course taken by this process in wild boar of normal black colouring, and those individuals characterized by light roan colouring, would form an important contribution to a knowledge of the physiological properties of this recessive mutation constantly occurring in the natural populations of these animals (Andrzejewski, 1971).

## II. MATERIAL AND METHODS

Studies on changes of the metabolic rate during the postnatal development of wild boar were carried out on 6 animals of the normal black colour and on 11 light-coloured roan animals. The latter individuals, born in captivity in the Institute of Ecology, Polish Academy of Sciences on April 3rd 1971, were the progeny of two 2-year old sows and one 3-year old boar, all of which were caught in the Kampinos National Park near Warsaw. Studies on these animals were initiated on the 14th day of life. Wild boars of normal colour, born on April 12th 1971 in the same Institute, were the progeny of an 8-year old sow covered by a black boar in the Mammals Research Institute, Polish Academy of Sciences, at Białowieża, and in the case of this group of animals studies were begun on the 4th day of their life.

The animals were kept in large forest enclosures 600 m<sup>2</sup> in area. They were fed *ad libitum* with oats, lucerne (in summer) or root crops (in winter). The young wild boars were also fed the standard mixture for piglets, in proportions of 1:3 in relation to the oats fed.

Oxygen consumption and carbon dioxide production were measured by means of a flow respirometer, the Kipp and Zonen diaphragmometer. Short 2-hour periods of respiratory tests for growing wild boars were always carried out at the same time of day, between 9 and 15, at a temperature of 22–23°C, in chamber in which the individuals could move about freely. The animals remained under constant observation, unnoticed by them, throughout the whole measurement period. Animals which lay quietly in the chamber, or in some cases even slept, were considered inactive. Wild boars which moved about the chamber, frequently lying down and getting up, but not manifesting visible signs of unrest, were considered as averagely active, while those which throughout the whole period of respiratory measurements exhibited intensified excitability, frequently making attempts at escaping from the chamber, were considered as very active.

During the first two and a half months of life the two groups of animals were examined weekly, then three times at monthly intervals. In addition examination was made for the same animals, at the age of 11 months, in Fe-



bruary 1972, of the effect of ambient temperature on their metabolic rate. Before beginning the respiration measurements proper the animals were acclimatised to the given ambient temperature for 3—4 hours.

III. RESULTS

Changes of metabolic level during postnatal development of wild boar of the normal black colouring are given in Table 1. The amount of oxygen consumption per unit of body weight during a unit of time

Table 1

Variations in metabolic rate during postnatal development of normally coloured and light-coloured roan wild boar. Temperature 22—23°C.

Age, days	Body wt., kg	RQ	Inactive			Averagely active		Very active	
			l O <sub>2</sub> /kg hr	kcal/animal per 24 hr	0.75 kcal/kg 24 hr	l O <sub>2</sub> /kg hr	kcal/animal per 24 hr	l O <sub>2</sub> /kg hr	kcal/animal per 24 hr
Black									
4—5	1.61	0.73	0.99	180.7	126.2	1.32	270.8	—	—
8—9	2.27	0.74	1.21	326.5	172.5	1.30	385.9	1.95	489.3
15—16	3.32	0.72	1.54	566.6	233.2	1.84	755.3	2.84	1174.2
22—23	4.53	0.73	0.87	477.4	147.5	1.35	687.0	1.76	884.6
31	5.50	0.72	0.71	449.3	121.2	1.11	682.3	—	—
37	6.35	0.78	0.73	519.9	131.9	0.92	751.5	—	—
44	7.42	0.88	0.63	542.3	121.6	1.04	937.4	1.41	1301.1
50	8.82	0.84	0.68	646.5	133.9	0.89	956.5	1.27	1320.0
64—65	11.00	0.87	0.61	792.0	129.9	0.82	992.7	0.89	1195.8
72	11.78	0.87	0.55	698.8	114.4	—	—	0.98	1438.4
100	18.20	0.89	0.70	1437.8	168.0	1.15	2629.0	—	—
127	25.98	0.96	0.51	1596.8	139.0	—	—	—	—
155	28.44	0.84	0.42	1353.7	113.1	—	—	0.94	3387.2
Light roan									
13—14	2.70	0.72	0.59	169.3	86.7	1.24	315.5	1.37	375.1
17—18	3.08	0.72	0.87	297.7	129.7	1.36	466.3	2.24	885.2
24—25	3.86	0.71	1.39	605.6	220.1	2.17	921.5	2.57	1126.8
31—32	4.78	0.72	0.89	436.1	138.1	1.54	878.8	2.48	1414.5
39	6.02	0.76	0.74	501.3	132.4	1.49	1143.4	2.34	1692.9
52—53	8.87	0.78	0.79	702.5	152.7	1.04	909.2	1.43	1497.5
59—60	9.39	0.85	0.59	638.8	117.5	—	—	2.18	2493.5
73—74	11.03	0.85	0.59	668.3	118.3	0.95	1252.7	1.76	2248.5
80—81	11.38	0.89	0.58	785.5	126.6	0.80	1093.7	0.93	1332.7
109—110	16.69	0.90	0.56	1172.4	138.2	1.11	1951.8	1.97	3724.8
137—138	24.05	0.96	0.53	1350.3	125.0	—	—	0.98	2878.2
168	26.56	0.90	0.48	1489.8	126.9	—	—	0.82	2326.4

by inactive animals, measured at a temperature of 22—23°C, while at first relatively low, increases abruptly and attains a maximum at the time the animal completes its second week of life. From this time on there is an initial, very intensive, decrease in oxygen consumption,

lasting to about the 30th day of the animal's life, followed by a very slow decrease in the value of this index observed up to the end of the measurements made.

The character of the variations in the amount of oxygen consumed during postnatal development of inactive roan boars is analogical to that observed in animals of normal colour (Table 1). There is, however, about two weeks shift in time of the period abrupt increase and decrease in the value of this index between these two groups of animals. Roan wild boars aged two weeks are still characterized by very low oxygen consumption, which attains its maximum level in these animals when they are about four weeks old.

In both groups of wild boar examined very intensive and very similar changes in the value of the respiration coefficient can be observed (Table 1, Fig. 1). During the first month of life the  $RQ$  value in wild boar is relatively low, varying from .70 to .75, after which

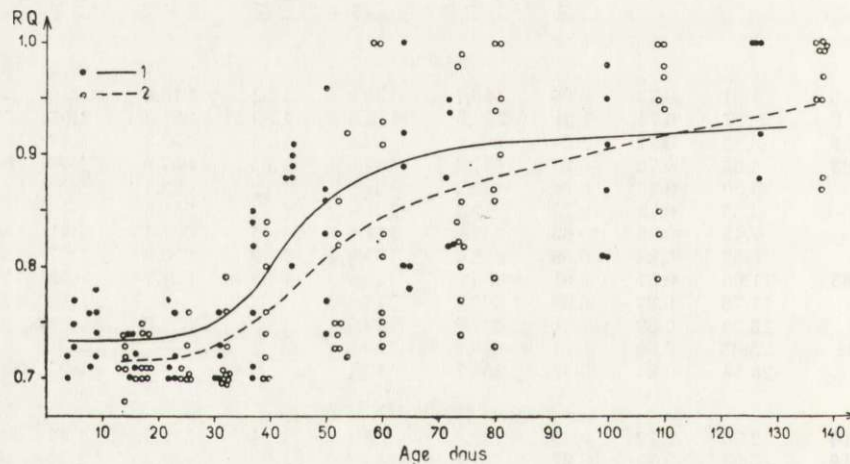


Fig. 1. Changes in value of the respiration coefficient ( $RQ$ ) during postnatal development of black wild boars (1) roan wild boars (2).

there is a distinct increase in the value of the respiration coefficient lasting up to the third month of the animal's life. From this time onwards the  $RQ$  values are more or less stable on a level of .90—.95. The value of the respiration coefficient in roan wild boars, from the time that the changes described above come to an end, are established on a slightly lower level than the  $RQ$  values for wild boars of normal colour.

Taking the amounts of oxygen consumed and respiration coefficient values as a basis, calculation was made of the metabolic rate of these

animals in energy units, *i. e.*, in kcal/kg hr (Fig. 2) and kcal/animal 24 hr and kcal/kg<sup>0.75</sup> 24 hr (Table 1). They follow the same course as the changes described above in the amount of oxygen consumed by these animals.

The differences observed in values of metabolic level, converted to metabolic unit of body weight (kg<sup>0.75</sup>), suggest that over the age of 1

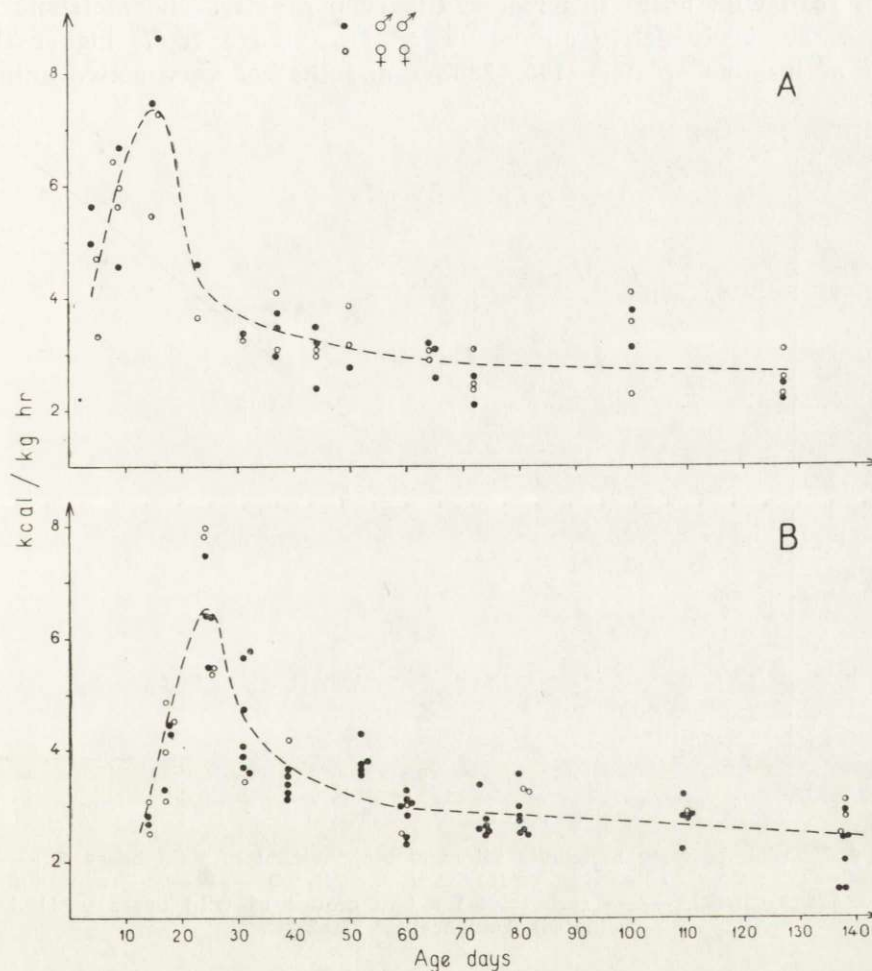


Fig. 2. Variations in metabolic rate during postnatal development of normally coloured (A) and roan (B) wild boars. Temperature 22—23°C.

month changes in the metabolic rate of wild boars are directly dependent on changes in their body weight (Fig. 3).

No differences connected with sex were found in the course taken by changes of any of the above indices in either of the groups of



wild boars examined. Considerable differences in metabolic rate, connected with differences in the animals' activity, were found in both normally coloured and roan wild boars (Table 1). On an average the metabolic rate of averagely active black wild boars increases in comparison with inactive animals by 150% (120—180%), and of very active animals by 190% (150—240%).

In roan wild boars this increase is even greater. The metabolic level of averagely active animals is on an average 180% higher than that of inactive animals (130—230%), and that of very active animals

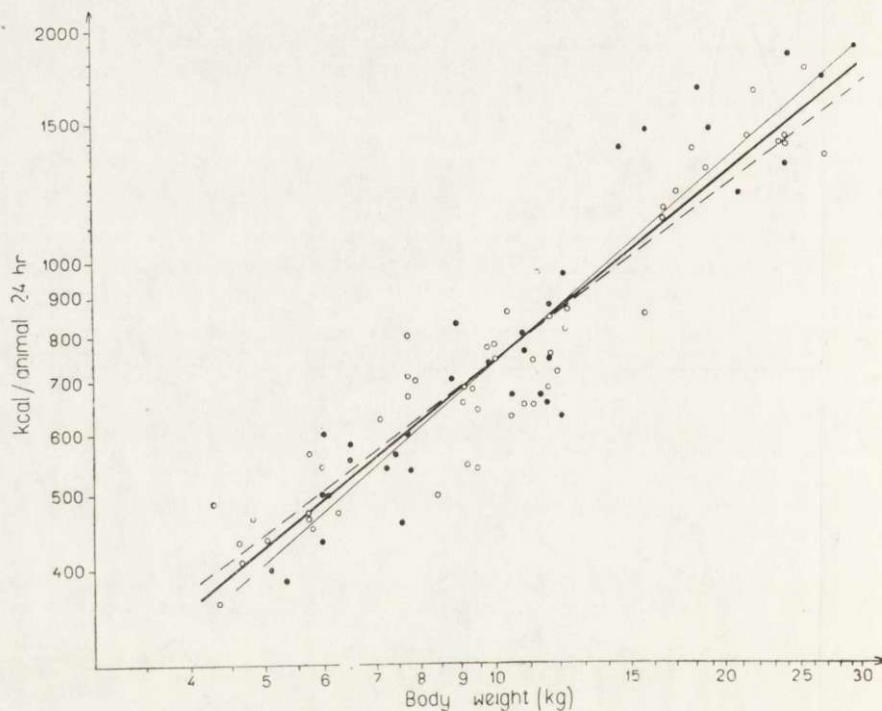


Fig. 3. Relation between metabolic rate and body weight of wild boars ● ———, animals of normal colouring  $y=101.6x^{0.86}$  ( $n=34$ ), ○ ——— roan animals  $y=132.5x^{0.74}$  ( $n=52$ ), ——— sum total for two groups of wild boars  $y=119.1x^{0.79}$  ( $n=86$ ). Temperature 22—23°C.

280% higher (180—390%). The differences are not dependent on the age or sex of the animals (Table 1).

The metabolic rate of wild boars at the age of 11 months, examined in February, changes very intensively with a change in the ambient temperature (Fig. 4). In the case of roan animals lying quietly in the respiration compartment metabolic rate is lowest within the temperature range of approx.  $-3^{\circ}\text{C}$  —  $+3^{\circ}\text{C}$ . At temperatures both above and

below this range, which may be considered as a thermoneutral zone, the metabolic rate of roan wild boars increases intensively. The thermoneutral zone of the normally coloured wild boars simultaneously examined is probably far wider, but it proved impossible to define its range accurately, in particular the lower critical temperature, during the course of these studies. Ambient temperatures of  $-3^{\circ}\text{C}$ — $-6^{\circ}\text{C}$ , which are physiologically low temperatures for roan animals, are still neutral temperatures for black wild boars.

Within the range of ambient temperatures above  $15^{\circ}\text{C}$  no differences were in principle found in the amount of heat produced by animals

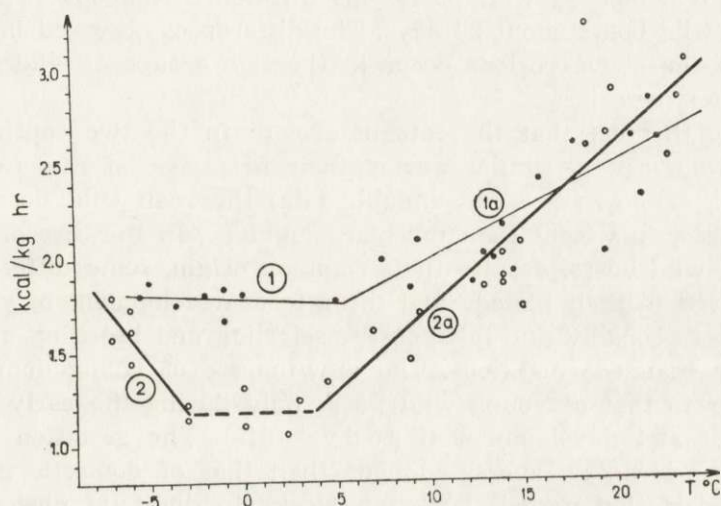


Fig. 4. Relation between metabolic rate of 11-month old wild-boars and ambient temperature.

● — normally coloured animals: 1— $y=1.78-0.007x$  ( $n=8$ ), 1a— $y=1.48+0.05x$  ( $n=16$ ), ○ — roan animals: 2— $y=0.802-0.13x$  ( $n=7$ ), 2a— $y=0.853+0.087x$  ( $n=19$ ).

belonging to the two study groups, but at lower ambient temperatures the metabolic rate of normally coloured wild boars is far higher than that of roan animals. Within the range of neutral temperatures for the two groups of animals this difference is about 50%.

#### IV. DISCUSSION

The course taken by changes of metabolic rate during the initial period of postnatal development of wild boars differs from the results given by many authors for domestic pigs. Holub *et al.* (1957) and Mount (1958, 1959) found that at  $23^{\circ}\text{C}$ , that is, at a temperature si-



milar to that at which the wild boars were examined, the maximum level of oxygen consumed, calculated per unit of body weight, was found in piglets 2—4 days old. A similar result was obtained by Mount & Rowell (1960, who carried out their measurements at a temperature of 30°C. In addition Mount (1968) found that with an ambient temperature of 10°C—40°C one-day old piglets have a lower metabolic rate than piglets from 2—6 days old.

The above data are evidence of the considerable difference in time between the periods in which rapid increase and decrease of metabolic rate takes place in growing wild boars and domestic pigs. In the case of normally coloured wild boars this difference is about 10 days, and for roan wild boars about 20 days. The differences observed in the time at which the above periods occur in the two groups of wild boars are also interesting.

Despite the fact that the rate of growth in the two captive groups of *S. scrofa* is very similar during their first year of life (Andrzejewski & Jezierski, unpubl. data) the roan wild boars are always lighter in weight than the black animals. In the case of domestic pigs and wild boars, despite their common origin, some differences can be observed in their biology and the rate of development of young animals, most probably due to intensive selection and breeding under considerably changed conditions. The growth rate of young domestic pigs is similar to that of young wild boars only during the early period of their postnatal development (Brody, 1945). The gestation period in wild boars is on an average longer than that of domestic pigs, as is also the lactation period, lasting 8 weeks in domestic pigs and 2.5—3.5 months in wild boars, although here the young wild boars begin to consume natural food, in addition to their mother's milk, as early as the second or third week of life (Sych, 1964; Mount, 1968). All the above data show that there are probably considerable differences in the rate of physiological development of the two groups of wild boars and domestic pigs at the time of birth and during the first phase of postnatal development.

There is also a phase of intensive increase, then a decrease, in the amount of oxygen consumed by animals during the course of changes of metabolic rate during postnatal development of other mammals, followed by a period of slow changes in this index correlated with changes in body weight. The above phase is observed at different times from the moment of the animals' birth in different species. In the case of elk these changes occur on the 1—3 day of life (Makarova, 1968), in rats they occur during the first 40 days after birth (Kleiber, 1961; Taylor, 1960), and in hamsters they end about the 20th



day of life (Rožaja & Maslennikova, 1968). In humans, on the other hand, maximum values of metabolic rate, calculated for metabolic unit of body weight, occur at the age of about 1 year (Benedict & Talbot, 1921—cited after Kleiber 1961).

As already stated above, the metabolic rate of wild boars changes after the 30th day of life proportionally to body weight. Exponents of regression equation  $y=ax^b$  (Fig. 4) are very similar to the power of  $3/4$  of body weight calculated by Kleiber (1961) and accepted as the metabolic unit of mammals body weight. Coefficients  $a$  of these equations are slightly higher than the value calculated by Kleiber (1961) in comparisons between species of mammals. The difference is probably caused by the fact that despite the metabolic level of inactive wild boars only being taken into consideration in the present calculations, the animals were not fasting and in addition it is not known whether a temperature of 22—23°C is a neutral temperature for them. The value of this coefficient is even higher, from 135—140, for growing, fattened domestic pigs weighing 20—60 kg (Mount, 1968).

It can be seen from the data presented (Fig. 4) that the zone of physiologically neutral temperatures for 11-months old wild boars weighing from 55—60 kg, occurs at far lower ambient temperature than is the case with domestic pigs. The lower critical temperature for newborn piglets is approximately 31°C, and for pigs weighing 50 kg approximately 21°C (Mount, 1968).

The differences observed in the resting metabolic rate of normally coloured and roan wild boars and in intensity of heat production in thermoregulation processes (Fig. 4) suggest that roan wild boars are probably worse adapted to life under winter conditions than normally coloured animals. This assumption, and the suggestions presented above as to the inequality in the physiological development of the two groups of animals during the early postnatal period, confirm the opinion held by Andrzejewski (1971) that roan wild boars are fairly frequently born under natural conditions, but are weaker physiologically than black individuals and die during the first year of life.

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ZMIANY TEMPA METABOLIZMU W ROZWOJU POSTNATALNYM DZIKÓW

#### Streszczenie

Zbadano zmiany tempa metabolizmu w rozwoju postnatalnym dzików o ubarwieniu normalnym, czarnym i jasnych, laciowych. U dzików czarnych stwierdzono wcześniejsze o około 10 dni wystąpienie fazy intensywnego wzrostu, a potem spadku poziomu metabolizmu (Tabela 1, Fig. 2). Po 30 dniu życia tempo metabolizmu obu grup dzików zmienia się proporcjonalnie do zmian ich ciężaru ciała (Fig. 3). Wartość współczynnika oddechowego wzrasta od 0.70—0.75 w pierw-



szym miesiącu życia do średnio 0.90—0.95 w wieku czterech miesięcy. RQ dzików łaciatych jest na ogół nieco niższe w porównaniu ze zwierzętami czarnymi (Fig. 1). Zakres strefy termoneutralnej 11 miesięcznych dzików łaciatych badanych zimą jest węższy niż dzików ubarwionych normalnie. W temperaturach powyżej 15°C w poziomie metabolizmu obu grup nie stwierdzono różnic, natomiast w temperaturach niższych zaobserwowano wyższe tempo metabolizmu u dzików czarnych w porównaniu z jasnymi (Fig. 4). Stwierdzono znaczne różnice w poziomie metabolizmu rosnących dzików i świń domowych.