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Review Article

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EVALUATION OF REPRODUCTIVE PERFORMANCE, GROWTH, SLAUGHTER TRAITS AND MEAT QUALITY OF BLACK-AND-TAN RABBITS KEPT IN POLAND

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Abstract. Rabbit is a highly adaptable animal, but far-reaching animal improvement, and the use of additives in the form of antibiotics and growth promoters, has resulted in the production of overgrown, often unhealthy individuals. It would be impossible to keep them in a backyard environment or on the increasingly popular organic farms. Hence, less popular rabbit breeds that can provide livestock on farms with extensive production systems are being sought. Literature reports suggest that a breed worthy of consideration is the Tan breed. Scientific studies comparing rearing, fattening and slaughter performance of Black-and-Tan rabbits with New Zealand White rabbits do not indicate that the Black-and-Tan breed is inferior in these traits. The meat obtained from Black-and-Tan rabbits is also of high quality, comparable to that attributed to rabbits of typical meat breeds. In addition, Black-and-Tan rabbits can be a valuable component for commercial crossbreeding, significantly improving the rearing results, slaughter performance and meat quality of the crosses.

Key words: rabbit, Tan breed, meat quality, slaughter performance, reproductive performance.

INTRODUTION

The tradition of eating rabbit meat in European countries dates back to ancient times; more precisely, the first reports of rabbit rearing come from Phoenicia and date back to 1100 BC (Dalle Zotte 2014). Also in modern times, the largest producers of rabbit meat in Europe are the Mediterranean countries such as France, Spain and Italy, where it was from the 1970s onwards that the specialisation and industrialisation of rabbit livestock production began to spread to the rest of the continent (McNitt et al. 2013). World rabbit meat production according to 2018 data was approximately 1.4 million tonnes. The largest contribution of 75.3% is attributed to Asian countries, with China being the main producer of rabbit meat worldwide (Cullere and Dalle Zotte 2018). Such high production places rabbit in 5th place among the top 10 livestock species used for meat production (Bieniek et al. 2012).

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Rabbit meat is characterised by its high dietary value in addition to its appreciated taste. The protein contained in rabbit meat is particularly easily digestible due to its high proportion of essential amino acids, making it suitable for children, the elderly and sick people (Siudak and Pałka 2022). The excessively high content of cholesterol in consumed food is one of the main causes of cardiovascular diseases, while its content in rabbit meat is at the level of 35–50 mg in 100 g of meat, which is twice as low as the content of this lipid in poultry meat (Kowalska 2006). The meat also has a very favourable fatty acid profile, with a high content of linoleic acid, and conjugated linoleic acid (CLA), which has anti-cancer, but also antioxidant, anti-atherosclerotic and anti-diabetic effects. CLA has also been shown to enhance the immune system (Siudak and Pałka 2022).

The high adaptability of rabbits has made it possible to produce breeds reared in a wide variety of environmental conditions, as well as to orientate the animals for the production of specialised raw materials (Bieniek et al. 2012). Widespread breeding, and the improvement of animals to achieve the highest possible production results, as well as the use of additives in the form of antibiotics and growth promoters, has resulted in the production of overbred and often unhealthy individuals. Keeping such animals under backyard conditions or in the increasingly popular organic farms would be impossible (Rebollar et al. 2009; Kalma et al. 2016). Hence, less popular rabbit breeds that can be used as livestock on farms with extensive production systems are being sought. Literature reports indicate that a breed worth considering is the Tan breed.

The breed has its origins in the United Kingdom, where in 1887 in Derbyshire the occurrence of the black-and-tan colour was first observed in the offspring resulting from the crossing of Dutch rabbits with wild European rabbits. The British breeders' task was to preserve the animals' unique colouring, but at the same time retain in the young the temperament and body conformation of domesticated Dutch rabbits. The first representatives of the Tan breed were characterised by a lean, arched build typical for wild animals. Years of selection led to the development of a rabbit with a more stocky and uniform conformation, which is also known today, as well as to the creation of four colour varieties of the tan colouring. In 1908, the Tan rabbit was introduced to the United States and quickly gained popularity there for its elegant exterior, ease of socialisation with other members of the species, and gentle nature, which led to its recognition as a breed by the American Rabbit Breeders Association (ARBA), then known as the National Pet Stock Association (NPSA) (Sandford 1996; Brown and Richardson 2002).

The aim of the study was to collect and compile information on the external appearance, reproductive performance, growth parameters, slaughter performance and meat quality of rabbits of the Tan breed, with a special focus on the black-and-tan colour variety.

BREED SPECIFICATION

The National Centre for Animal Breeding states in the Rabbit Phenotype Evaluation Standard that the Tan (P) rabbit breed occurs in Poland in three colour varieties: Black (Pc), Blue (Pn) and Havana (Ph). The black coat variety is characterised by black guard hairs with orange (flaming) tan hairs. The colours are clearly contrasting and the red-orange highlights occur in the nape area, around the eyes and nostrils, on the ears, jowls, chest, underbelly, inner side of the limbs, and on the tail. In Blue-and-Tan rabbits the colour pattern is similar to that described for the Black-and-Tan, but the colour of the guard hairs is an intense dark blue, while in Havana rabbits the colour of the guard hairs is dark brown (chocolate). The colour of the undercoat hair in the black, blue or brown part of the coat is blue in all colour varieties and orange in the tan part. Black-and-Tan and Blue-and-Tan rabbits have dark brown eyes and claws, while Havana-and-Tan rabbits have brown eyes and dark brown claws. The coat quality of Tan rabbits is of

a high standard. They are characterised by a very dense, springy and silky coat, with a strong sheen and a hair length of 2.5 cm.

According to the National Animal Breeding Centre's Rabbit Phenotype Evaluation Standard (KCHZ 2023b), the body weight of Tan rabbits over 6 months of age should be between 2.5 and 3.3 kg, with the lowest acceptable weight for these rabbits being 2.0 kg and the highest 3.5 kg. These values are considerably lower than those obtained by rabbits of medium-sized breeds, such as the Popielno White, Termond White, New Zealand White or Californian rabbit, which are mainly used for rabbit meat production and have the best fattening and slaughter performance. Fig. 1 shows the body weight of Tan rabbits by months of rearing until the age of six months. The graph also shows the body weights reached by rabbits of typical meat breeds from 3 to 8 months of age.

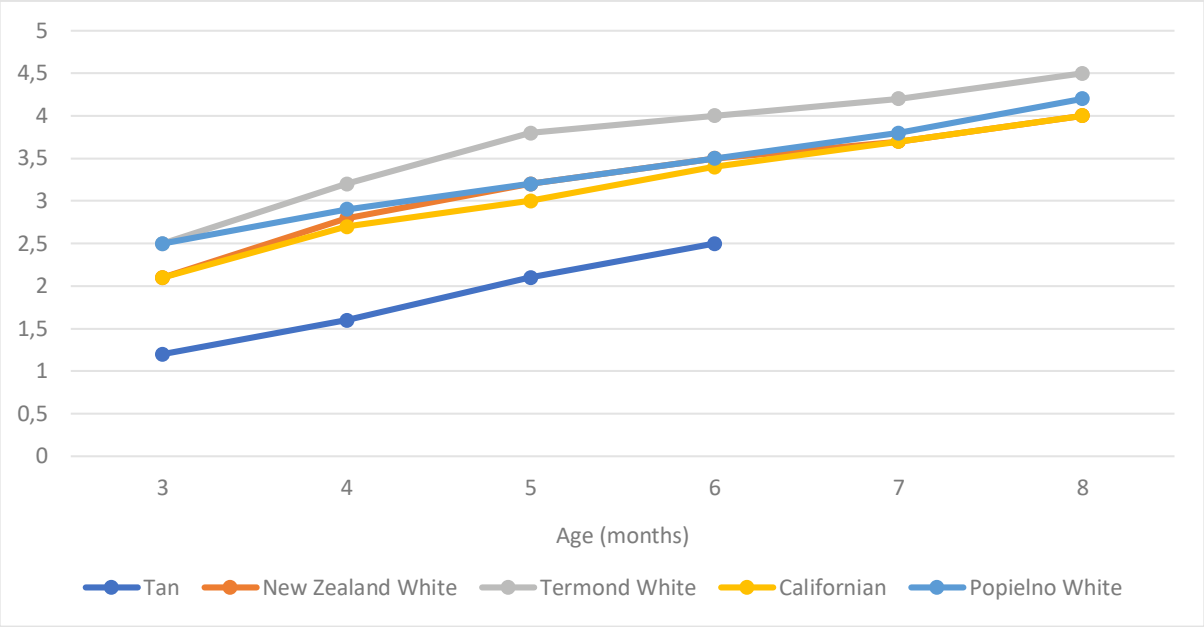

Fig. 1. Body weight of the Tan, New Zealand White, Termond White, Californian and Popielno White rabbits by months of age (KCHZ 2023b)

The Tan breed is characterised by a harmonious conformation, a cylindrical body, a short neck, short limbs, and a short, round head. The ears of animals of this breed are fleshy, hairy, 9–10 cm long. The conformation of females of the Tan breed is noticeably more delicate, and it is an unacceptable defect in them to have jowls.

Other unacceptable defects described in the Rabbit Phenotype Evaluation Standard are: body weight below 2.0 kg or above 3.5 kg, sagging ears, ear length above 12 cm, lack of contrast in tan, lightening of the orange hair, white underside of the tail, clearly visible red or white patches in the coat, large deviation in the colour of the guard and undercoat hairs in relation to the standard for the colour variety. A fault which excludes an animal from further breeding is also a colour of the eyes and claws different from that described in the standard for a particular colour variety.

According to data presented by the National Animal Breeding Centre, between 2012 and 2022, 1–2 herds of Tan rabbits included in the assessment of breeding performance were kept in Poland (Fig. 2). Between 8 and 20 does in the primary herd were maintained over the years (Fig. 3). For overview purposes, the graph shows the population of primary herd does of the New Zealand White, Termond White, Californian and Popielno White rabbits as the most commonly kept rabbit breeds in Poland.

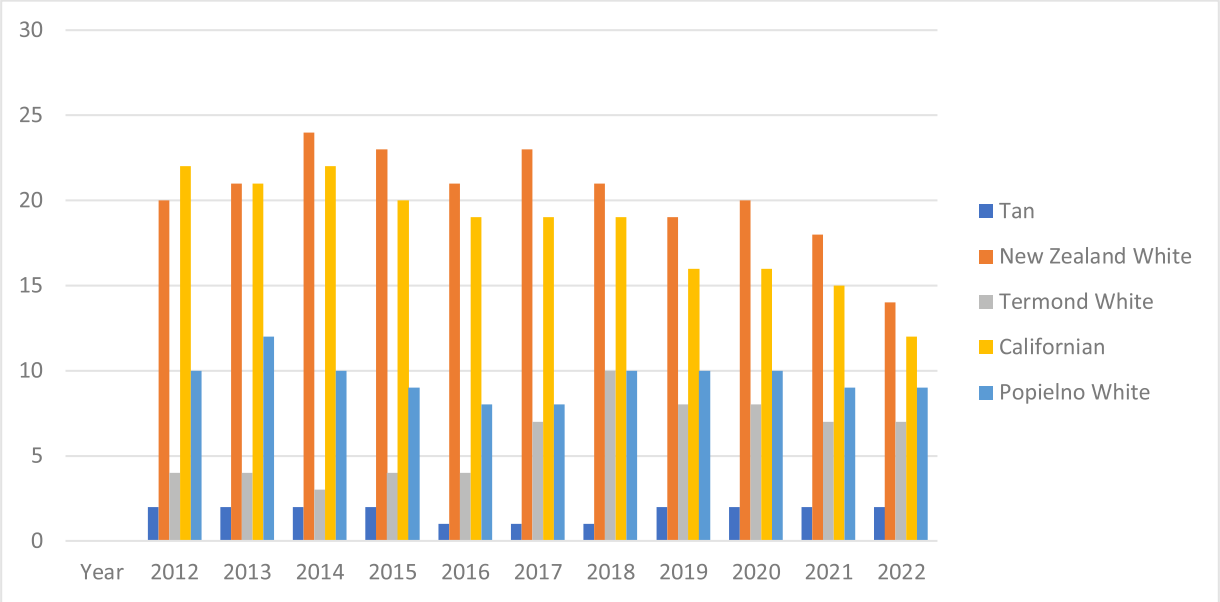

Fig. 2. Number of herds of the Tan, New Zealand White, Termond White, Californian and Popielno White rabbits from 2012 to 2022 (KCHZ 2014, 2016, 2018, 2020, 2022, 2023a)

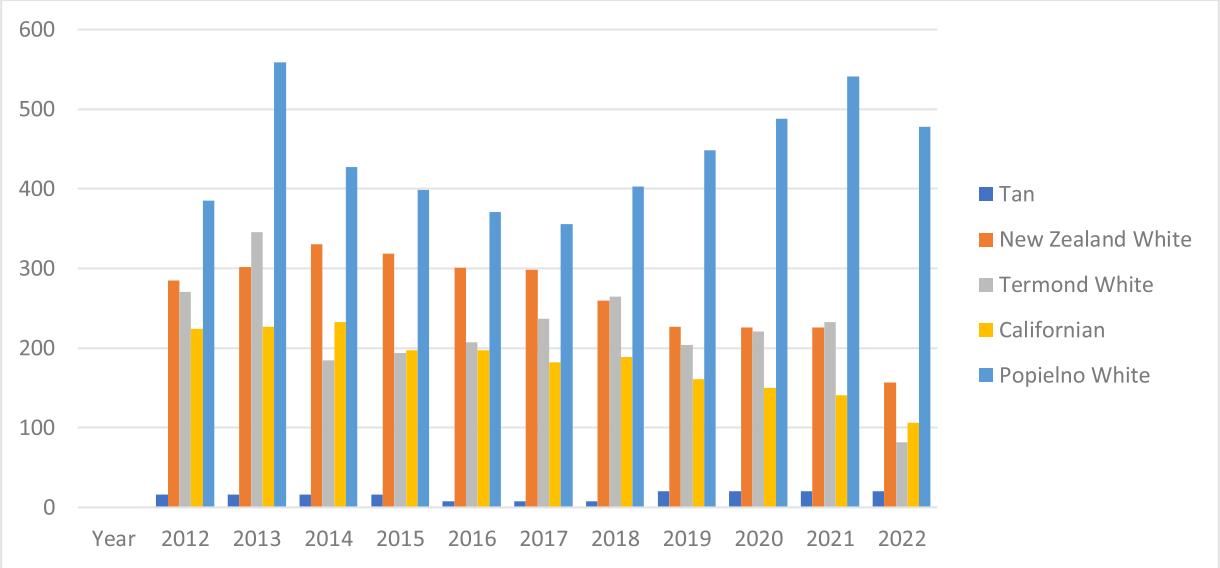

Fig. 3. Number of does in the primary herd of Tan, New Zealand White, Termond White, Californian and Popielno White rabbits from 2012 to 2022 (KCHZ 2014, 2016, 2018, 2020, 2022, 2023a)

The number of litters obtained per female per year averaged 1.36, and there were 5.91 born and 5.12 reared rabbits per litter, which suggests not very high fertility and prolificacy of females of the breed in question (Table 1). The National Animal Breeding Centre reports that in 2022, 21 litters were obtained from Tan rabbits, with 91 live rabbits born and 86 reared. The average number of kits obtained from 1 litter in 2022 was 4.3 born and 4.1 reared rabbits. The percentage of reared kits in the Tan rabbits was 94.5%, which is higher than in the previous year (Table 1). In contrast, 525 New Zealand White rabbits, 2221 Termond White rabbits, 857 Californian rabbits and 7881 Popielno White rabbits were reared in 2022. For the aforementioned breeds, the percentage of reared young rabbits was 86.7%, 69.4%, 84.8%, 86%, respectively.

Table 1. Reproductive performance results of Tan rabbits from 2012 to 2022 (KCHZ 2014, 2016, 2018, 2020, 2022, 2023a)

Year	Number of litters per doe per year	Number of kits born per doe per year	Number of kits raised per doe per year	Percentage of young reared
2012	0.6	3.1	2.9	93.9
2013	1.3	6.1	5.8	94.9
2014	1.2	5.8	5.1	89.0
2015	1.8	8.1	6.7	82.8
2016	1.8	7.3	5.6	77.2
2017	2.5	9.9	8.9	89.9
2018	1	3.5	2.9	85.2
2019	1.1	4.4	4.1	93.1
2020	1.1	5.3	4.4	84.6
2021	1.2	5.6	4.8	85.7

Bieniek (1997), using crossbreeding between Tan-and-Black rabbits and New Zealand White rabbits, has shown that the system where the New Zealand White rabbit is the maternal component and the Tan rabbit is the paternal component has the highest litter size in relation to purebred animals and rabbits whose mothers were Tan-and-Black rabbits and whose fathers were New Zealand White rabbits. In purebred New Zealand White rabbits, the litter size was 6.30, in Tan rabbits it was 6.28, and in the aforementioned crosses it was 6.48. At weaning, there was an average of 5.17 rabbits in a litter of Tan-and-Black rabbits, and thus the average mortality of the young was approximately 17.68%. In comparison, in the crossbred groups, the percentage of deaths was 14.51% in the group where the Black-and-Tan rabbit was used as the paternal component and 9.34% where this breed was used as the maternal component. However, it is noticeable that fertility in Black-and-Tan rabbits has improved significantly over the years. According to Kawińska (1961), the litter of the Tan rabbits was 4.33 kits at the first pregnancy of a doe and 4.75 young at the second pregnancy. Whereas the number of weaned young was 3.60 and 3.70, respectively.

GROWTH, POST-SLAUGHTER TRAITS AND MEAT QUALITY OF TAN RABBITS

Bieniek (1997) described the fattening, slaughter performance traits and meat quality of Tan rabbits of the black colour variety, and compared the values obtained with the New Zealand White breed, which is a commercial breed used worldwide for rabbit meat production. In the mentioned experiment, rabbits of both breeds were reared to 60, 70 or 140 days of age. At individual weeks of rearing, New Zealand White rabbits achieved higher body weights, and higher daily weight gains compared to Black-and-Tan rabbits. They also achieved a higher slaughter weight. However, the values were not significantly different from each other. The same was observed in the case of rearing extended to 140 days. Rabbits of medium-sized breeds are usually slaughtered around 90 days of age; in the experiment carried out by Bieniek, New Zealand White rabbits at 84 days of age reached an average body weight of 1237.4 g, while Black-and-Tan rabbits reached 1057.8 g. Pałka et al. (2018) reported that the slaughter weight recorded between 83 and 90 days of age in Termond White and Popielno White rabbits is 2673.09 g and 2741.48 g, respectively. In a study by Chwastowska-Siwiecka et al. (2011), it was shown that the body weight of Californian rabbits slaughtered at 110 days of age was 2460 g in females and 2470 in males. The slaughter weight of 13-week-old Californian rabbits in the study by Marai et al. (2008) was 1791.1 g. The body weights of medium-sized breeds exceed the weights obtained

by Black-and-Tan rabbits and New Zealand White rabbits used in the Bieniek experiment. All the studies cited were carried out in later years, so the discrepancies that occur may be the result of years of selection, which led to only the best individuals being used for mating in order to perpetuate outstanding traits in the population.

In the experiment, crossbreeding of the above-mentioned breeds was also used, but the mating system of the parents did not show a significant effect on the body weight of the rabbits up to 70 days of age, while in the following weeks of rearing, the differences are noticeable and the Tan rabbit performs worst in comparison with the other groups.

The hot carcass weight obtained from the Black-and-Tan rabbits at 140 days of age averaged 921.3 g, while the chilled carcass weight was 882.8 g. The average carcass meat weight was 717.6 g. The Tan rabbits were characterised by high hot and chilled dressing out percentage, which was determined by four formulas. Depending on the formula used, the hot dressing out percentage was 50.6% or 54.5% and the chilled dressing out percentage was 48.5% or 52.4%. Chwastowska-Siwiecka et al. (2011) report that the hot carcass weight without head and giblets in Californian rabbits was 1166 g in females and 1207 g in males. The chilled carcass weight was 1169 g in females and 1205 g in males. Dressing out percentage hot for Californian rabbits was 48.13% and dressing out percentage chilled was 48.15%. Marai et al. (2008) report that the carcass weight obtained from Californian rabbits was 1511.8 g and the calculated dressing out percentage was 54.7%. Bielański et al. (2000) showed that the carcass weight of Termond White rabbits slaughtered at a slaughter weight of 2600 g was 1155 g and the dressing out percentage was 59.7%. In contrast, Pałka et al. (2018) report that the hot carcass weight of Termond White rabbits was 1435.06 g and the chilled carcass weight was 1390.47 g. Hot and chilled dressing out percentage were calculated for the Termond White breed and were 53.50% and 51.83%, respectively. The authors also used the Popielno White breed in their study, for which the hot carcass weight was 1446.30 g and the chilled carcass weight was 1391.22 g. The dressing out percentage was lower than that of the Termond White rabbits and was 52,81% and 50,81%. Despite the much lower carcass weight, the dressing out percentage (%) obtained by the Black-and-Tan rabbits did not differ significantly from the results recorded for typical meat breeds.

Meat quality analysis included traits such as meat acidity and colour, chemical composition, exudation, water holding capacity and cooking loss. The pH value measured 45 minutes and 24 hours after slaughter on the muscles of the Black-and-Tan rabbits averaged 6.15 and 5.73. The colour lightness was at 26.35 making the meat of the Black-and-Tan rabbits slightly darker than that of the medium breed rabbits. Exudation, water holding capacity and cooking loss in the two breeds studied were at similar levels, with values for the Black-and-Tan rabbits being, respectively: 25.86%, 71.96% and 39.83%.

Siudak et al. (2023) carried out an analysis of meat quality traits such as colour and acidity in 12 week old Termond White, Popielno White and Californian rabbits. The pH measured on *m. longissimus lumborum* after 45 minutes was 6.51, 6.98 and 6.51 in the Termond White, Popielno White and Californian rabbits. After 24 hours, the values in the aforementioned breeds were as follows: 5,95, 5,79 and 5,88. These values do not differ significantly from the results obtained by Bieniek. In the meat colour analysis presented by Bieniek, only the lightness parameter was determined. The experiment by Siudak et al. showed differences in the L coordinate only 45 minutes after slaughter. Statistically brighter meat was obtained from Californian rabbits, but lightness evened out 24 hours after slaughter in all rabbits of medium-sized breeds. The authors noted statistical differences in the parameters a^*_{24} b^*_{24} and C^*_{24}. The lowest values of the aforementioned parameters were characterised by the meat of Popielno White rabbits.

Table 2 shows the content of nutrients such as water, protein and fat in the meat of Black-and-Tan and New Zealand White rabbits. The statistical analysis carried out did not show that these values differed significantly from each other, but it can be seen that meat from Tan rabbits

has a higher protein content and a lower fat content in its composition than meat obtained from New Zealand White rabbits.

Table 2. Percentage of water, protein and fat in meat of New Zealand White and Black-and-Tan rabbits (Bieniek 1997)

Trait	Breed	
	NB	PC
Water content [%]	76.64	76.32
Protein content [%]	20.15	20.49
Fat content [%]	0.90	0.84

NB – New Zealand White breed, PC – Black-and-Tan breed.

TAN RABBIT IN SCIENTIFIC RESEARCH

Letko et al. (2019) set out to use molecular biology methods to identify the mutation in the Black-and-Tan rabbit genotype responsible for its unique colouration. In mice, a 6 kb retroviral insertion located in the hair cycle-specific promoter of the mouse ASIP gene, which encodes the agouti signalling protein, causes the tan phenotype. Three ASIP alleles are thought to exist in rabbits, including the a^t allele, which causes the tan colour, and which resembles the phenotype found in mice. The analysis conducted identified 75 variants associated with the a^t allele, including an 11 kb deletion that is located in the hair cycle-specific ASIP promoter region, a region homologous to the retroviral insertion site in mice. The researchers went on to conclude that the 11 kb deletion is the most likely variant to cause the tan colouration in rabbits.

However, as early as the beginning of the 20th century, scientific papers were being written using rabbits with tan colouration. Castle and Fish (1915) described the relationship between the inheritance of genes responsible for grey, black and black-and-tan colouration. Using cross-breeding, they showed that the coat colour was inherited independently of agouti, but also independently of albino, as the offspring of crosses between the two breeds gave birth to rabbits of all the aforementioned coat colours. The Black-and-Tan rabbits were used by Punnett (1924) to determine the mode of inheritance of the Japanese colour in rabbits and its relation to the presence of the gene responsible for the black-and-tan colour. However, the researcher did not come to a clear conclusion.

In addition to this, female Tan rabbits were used as test material in an experiment carried out by Shaw et al (1974). This experiment was to see what effects a zinc deficiency in the feed ration would have on rabbits. They observed reduced feed intake in rabbits, resulting weight loss, reduced haematocrit, the occurrence of alopecia and skin diseases. The researchers also performed a post-mortem histological analysis of the uteri of the rabbits involved in the experiment and showed that they were pale and physiologically inactive, which was the cause of the reproductive problems that occurred.

Szubartowska and Gromysz-Kałkowska (1986) used the Black-and-Tan breed and the Belgian rabbit in a study on the effects of foschlor on erythrocytes and leucocytes. Application of the pesticide caused a significant decrease in erythrocyte counts, haemoglobin levels and haematocrit values in both breeds studied. In addition, an increase in the average erythrocyte volume and haemoglobin content of the blood cells was observed in Black-and-Tan rabbits. The applied pesticide also caused changes in leucocytes in both breeds, a significant neutrophilic leucocytosis with lymphopenia and eosinopenia was observed. The changes developed in the blood cells indicate that the Belgian breed was more resistant to foschlor poisoning than the Black-and-Tan breed.

CONCLUSION

The Tan rabbit is currently regarded as an amateur breed, not used on a larger scale for meat, skin or fur production. However, scientific studies comparing the rearing, fattening and slaughter performance of Black-and-Tan and New Zealand White rabbits indicate that this breed can be successfully used as livestock on farms with extensive rabbit meat production systems. The quality of meat obtained from Black-and-Tan rabbits is not inferior to that attributed to rabbits of typical meat breeds. In addition, referring to the cited studies Black-and-Tan rabbits can be a valuable component in commercial crossbreeding, significantly increasing the slaughter performance and meat quality of the crosses.

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OCENA UŻYTKOWOŚCI ROZPŁODOWEJ, TUCZNEJ I RZEŹNEJ ORAZ JAKOŚCI MIĘSA KRÓLIKÓW RASY CZARNEJ PODPALANEJ UTRZYMYWANYCH W POLSCE

Streszczenie. Królik jest zwierzęciem o dużych zdolnościach adaptacyjnych, ale daleko posunięte udoskonalanie oraz stosowanie dodatków w postaci antybiotyków i stymulatorów wzrostu doprowadziło do wytworzenia osobników przerasowionych, często cechujących się słabym zdrowiem. Hodow-

la królików w warunkach przydomowych lub w coraz popularniejszych gospodarstwach ekologicznych staje się niemożliwa. Stąd też poszukuje się rzadziej wykorzystywanych ras, które mogą stanowić żywy inwentarz w gospodarstwach o ekstensywnym systemie produkcji. Doniesienia literaturowe sugerują, że warta rozważenia jest rasa podpalana. Badania naukowe porównujące odchów, tucz i wydajność rzeźną królików rasy czarnej podpalanej z królikami rasy nowozelandzkiej białej nie wskazują, aby rasa czarna podpalana była gorsza pod względem badanych cech. Mięso pozyskiwane od królików rasy czarnej podpalanej cechuje się również wysoką jakością, porównywalną z mięsem królików typowych ras mięsnych. Ponadto króliki rasy czarnej podpalanej mogą być cennym komponentem w krzyżowaniu towarowym, znacząco poprawiającym wyniki odchowu, wydajność rzeźną i jakość mięsa mieszańców.

Słowa kluczowe: królik, rasa podpalana, jakość mięsa, użytkowość rzeźna, użytkowość rozpłodowa.