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The influence of the maternal and paternal components and the season and year on the reproduction of female Termond White and Popielno White rabbits

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SUMMARY

The first objective of the study was to compare the reproductive traits of females of two medium rabbit breeds, Termond White and Popielno White. The traits evaluated were litter size at birth, litter size at weaning, and birth weight. The next step was to determine whether the breed of the sire influences the reproductive parameters of the females. As the study covered four seasons and five years, the authors also investigated whether there were differences in the reproductive traits of females depending on the season and year of birth.

The litters for analysis were obtained by crossing female Popielno White (n = 49) and Termond White (n = 108) rabbits with males of the breeds Flemish Giant, California, New Zealand White, Popielno White and Termond White. The females were allowed to mate for the first time at the age of 4.5 months. Four seasons were established: spring (March–May), summer (June–August), autumn (September–November) and winter (December–February). The analysis of the maternal component showed that the Termond White does gave birth to significantly larger litters than the Popielno White rabbits. The weaned litters of Termond White does were also significantly larger than those of Popielno White does. Kits born to Termond White does were significantly heavier than the young of Popielno White does. The breed of the sire had no significant influence on litter size at birth or at weaning or on birth weight. Significant differences between birth years were observed in the case of litter size at birth and weaning and birth weight. Litter size at birth differed between 2019 and 2020. Litter size at weaning differed significantly between the year 2020 and the years 2018 and 2019. Significant differences between seasons were observed for litter size at birth and weaning as well as birth weight.

KEY WORDS: cross-breeding, kits, litters rabbit, rabbit rearing, reproduction.

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INTRODUCTION

Rabbits are polyoestrous mammals, which means they can breed all year round. They reach sexual maturity at about 3–4 months of age – later in large breeds (4–5 months) and at about 3 months in medium breeds. Does are used for breeding for a year or two, depending on the intensity of production. Males remain fertile longer, up to the age of 6 months (de la Fuente and Rosell, 2012). Gestation lasts from 29 to 32 days. The litter is counted 24 hours after kindling and any dead young are removed from the nest (Gacek, 2010). The offspring are weaned after about 35 days (Instytut Zootechniki PIB, 2011). The development of rabbit farming for meat necessitated the selection of breeds that best meet the requirements of breeders. Many years of breeding practice have shown that medium breeds are best suited for the production of meat rabbits, due to their early reproductive maturity, high fertility, and rapid weight gain. Female rabbits of medium breeds begin breeding at 4–4.5 months of age, though some breeders believe it is worth waiting until they are 5 months old. Does starting to breed should weigh more than 3.5 kg, as smaller females give birth to weaker kits. The length of use of does for breeding depends mainly on the frequency of mating. Generally, does are used for three years or longer, but for a shorter period in the case of intensive breeding on large-scale farms. Intensive breeding allows one doe to produce 8 litters per year (about 60 young per year). This can be achieved by mating females at 12–14 days after birth, and therefore during lactation. As numerous scientific studies show, after 9–10 litters does bred intensively have reduced fertilization capacity and produce smaller litters, and therefore must be eliminated from breeding. The elimination rate of females on this type of farm is 80–90% (Zając et al. 1997; Barabasz and Bieniek, 2003).

In Poland, the most popular medium breeds include Termond White and Popielno White (Składanowska-Baryza, 2017). The Termond White breed is distinguished by high fertility. According to the National Animal Breeding Centre, from 2015 to 2020 an average of 3 litters per year was obtained per doe, the average litter size at birth was about 7, and the number of reared animals was about 6 (Krajowe Centrum Hodowli Zwierząt, 2015–2020). The percentage of stillborn animals decreases with each litter (from 5% to 1%). Does of this breed have high milk yield (Pałka et al. 2017b). Males have high-quality sperm and a strong sex drive, resulting in high mating efficiency, with about 80% of matings resulting in fertilization. The Popielno White breed is highly fertile and well adapted to unfavourable climatic conditions (Bielański and Kowalska, 2019). According to the National Animal Breeding Centre, from 2015 to 2020 an average of 2.6 litters per year were obtained per female, the average litter size at birth was about 6, and the number of reared animals was about 5 (Krajowe Centrum Hodowli Zwierząt, 2015–2020).

Popielno White is a Polish breed, included on the list of genetic reserves, and Termond White is a well-known breed. Due to their similar phenotypes, they are often confused by laymen and breeders, who often underestimate their importance in rabbit breeding (due to their white colouring, unattractive appearance, etc.). Intensive rabbit broiler production involves high production costs, and appropriate standards must be maintained in the facilities where the animals are kept. The profitability of this type of breeding is limited by the scale of production. The rabbit breeds analysed in this study, Popielno White and Termond White, are highly resistant to environmental and nutritional conditions, so better production results can be expected than from hybrid lines (which produce good results only under certain conditions). Due to the gradually increasing popularity of these two breeds in small-scale farming, it can be difficult to obtain unrelated individuals, so it made sense to explore various mating options with males of other breeds or of no known breed (which

further reduces maintenance costs). In addition, in this type of system breeders can rebuild the herd using their own animals (Barabasz and Bieniek, 2003). The reproductive traits analysed in this study are important for small-scale production, which is gaining in popularity among breeders without large landholdings.

The first objective of the study was to compare the reproductive traits of females of two medium rabbit breeds, Termond White or Popielno White. The traits evaluated were litter size at birth, litter size at weaning, and birth weight. The next step was to determine whether the breed of the sire influences the reproductive parameters of the females. As the study covered four seasons and five years, the authors also investigated whether there were differences in the reproductive traits of females depending on the season and year of birth.

MATERIAL AND METHODS

The study concerned the breeding use of female rabbits of two breeds: Popielno White (n = 49) and Termond White (n = 108). The data collected, which included the breed of the mother and father and the season and year of kindling, were used to determine the reproductive results of females of both breeds. They came from a single farm (Experimental Station of the Department of Animal Genetics, Breeding and Ethology, University of Agriculture in Krakow), so that the influence of environmental factors on reproduction results was eliminated.

The litters for analysis were obtained by crossing Popielno White and Termond White females with males of the breeds Flemish Giant, California, New Zealand White, Popielno White, and Termond White. The largest number of litters was obtained after crossing with males of the Termond White breed (n = 261), and the fewest using males of the Flemish Giant breed (n = 8). A higher average number of litters was obtained from Termond White females (2.59) than from does of the Popielno White breed (2.16).

The does and offspring used for the experiment were kept in wooden cages, placed in a closed, ventilated building. It was equipped with adequate lighting; a lighting program was used with 14 hours of light and 10 hours of darkness per day. Does were guaranteed unlimited access to feed. They were fed complete commercial pellets, with 15% crude protein, 4.2% crude fat and 17.6% crude fibre. They were given access to water through nipple drinkers.

The females were allowed to mate for the first time at the age of 4.5 months. The young, irrespective of their body weight or condition, were weaned at 35 days of age. Mothers with more than one litter were mated within 7 days of weaning.

Four kindling seasons were established: spring (March–May), summer (June–August), autumn (September–November) and winter (December–February).

Statistical procedures were performed using R software with the PMCMR and DPLYR packages (R Core Team, 2021). All P-values less than 0.05 were considered statistically significant. The effects of birth year and season as well as the breed of the mother and sire on litter size at birth and at weaning and on birth weight were examined. The Shapiro–Wilk normality test (shapiro.test procedure) was used to test this assumption for each trait. All traits failed to meet this criterion, so non-parametric tests (Kruskal–Wallis or Wilcoxon) were used. The effects of birth year and season and the breed of the mother and sire on the three analysed traits were tested separately. The nonparametric Kruskal–Wallis chi-squared test (kruskal.test procedure) with the post-hoc Dunn test (posthoc.kruskal.dunn.test procedure) was used to analyse the effects of birth year and season and

sire breed on the three traits, while the effect of the mother's breed were analysed using the Wilcoxon test (wilcox.test procedure). Four linear models were used:

$Y_{ij} = \mu + BY_i + \varepsilon_{ij}$

$Y_{ij} = \mu + BS_i + \varepsilon_{ij}$

$Y_{ij} = \mu + MB_i + \varepsilon_{ij}$

$Y_{ij} = \mu + SB_i + \varepsilon_{ij}$

where:

Y_{ij} - litter size at birth, litter size at weaning, or birth weight

μ - overall mean

BY_i - fixed effect of *i*-th birth year (i= 1, 2, …, 5)

BS_i - fixed effect of *i*-th season of birth (i = 1, 2, 3, 4)

MB_i - fixed effect of *i*-th mother breed (i = 1, 2)

SB_i - fixed effect of *i*-th sire breed (i = 1, 2, …, 6)

ε_{ij} - residual effect

RESULTS AND DISCUSSION

The analysis of the influence of the maternal component showed that the Termond White does produced significantly larger litters than Popielno White rabbits: 7.52 kits and 6.98 kits, respectively. The litters of Termond White does were also significantly larger at weaning compared to Popielno White does: 7.43 and 6.86 kits, respectively. Kits born to Termond White does were significantly heavier than young born to Popielno White does: 72.53 g and 70.21 g, respectively (Table 1). In a study by Pycha et al. (2020), New Zealand White females produced litters of 6.59 rabbits, which was lower than the values obtained in the present study for the Popielno White and Termond White breeds, while Californian females had litters of 7.71 rabbits, which was similar to the number obtained in the present study for the Termond White breed. Pałka et al. (2017b) showed an average litter size of 7.46 and 7.78 rabbits for female Popielno White and Termond White rabbits, i.e. 0.48 and 0.26 higher than in the present study. The litter size reported by Bielanski et al. (2011) for females of the Popielno White breed was 5.61, which was 1.37 lower than in the present study. Topczewska et al. (2013) obtained an average litter size of 8.49 for the Popielno White breed – a value 1.51 higher than in the present study. According to the National Animal Breeding Centre, the Popielno White breed produced litters of 6.4 rabbits in 2015, 6.3 in 2016–2019, and 6.4 in 2020, while litters of the Termond White breed contained 7.3 rabbits in 2015, 7.2 in 2016–2017, 7.5 in 2018, 7.0 in 2019, and 7.1 in 2020. The results reported by the National Animal Breeding Centre for the Popielno White and Termond White breeds are lower than those obtained in the present study, except in 2018, when the result for the Termond White breed was the same.

The breed of the sire had no significant influence ($P > 0.05$) on litter size, the size of the weaned litter, or the birth weight of the kits (Table 2). Pycha et al. [2020] found that the breed of the sire influenced the total number of litters obtained, in contrast with the result obtained in the present study. According to the authors, New Zealand White females that mated with Flemish Giant males gave birth to fewer (5.85) live kits per litter than did Californian females that mated with Burgundy Fawn males (10.00). Pure-bred litters at weaning were smaller (2.04) than cross-bred ones (5.39 to 10.00).

Table 1

Reproductive traits, by breed of the mother

Breed of mother	Number of litters	Litter size at birth					Litter size at weaning					Birth weight [g]				
		Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median
Popielno White	106	6.98[a]	2.24	2	12	7	6.86[a]	2.27	2	12	7	70.21[a]	16.30	44.5	125.0	67
Termond White	280	7.52[b]	2.45	2	13	8	7.43[b]	2.44	1	13	8	72.53[b]	15.16	45.6	182.5	70

[1)] SD – standard deviation
[a, b] values within a column with different letters differ significantly ($p < 0.05$).

Table 2

Reproductive traits, by breed of the sire

Breed of sire	Number of litters	Litter size at birth					Litter size at weaning					Birth weight [g]				
		Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median
Flemish Giant	8	7.25	2.49	3	10	7.5	7.25	2.49	3	10	7.5	73.98	17.99	47.5	102.0	74.75
California	13	6.92	2.53	2	11	7	6.92	2.53	2	11	7	72.10	9.21	58.0	90.6	70.70
New Zealand White	13	6.85	1.46	3	9	7	6.69	1.49	3	9	7	67.13	11.87	45.6	89.0	69.30
Popielno White	91	7.00	2.32	2	12	7	6.86	2.36	2	12	7	70.99	16.63	44.5	125.0	67.00
Termond White	261	7.54	2.46	2	13	8	7.45	2.45	1	13	8	72.28	15.55	45.6	182.5	70.00

1) SD – standard deviation

Table 3
Reproductive traits, by birth year

Birth year	Number of litters	Litter size at birth					Litter size at weaning					Birth weight [g]				
		Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median	Mean	SD[1)]	Min	Max	Median
2016	51	7.49[ab]	2.57	2	13	8	7.35[a]	2.50	2	12	7	67.84[ab]	9.52	53.3	88.75	66.67
2017	86	7.06[ab]	1.97	2	12	7	7.06[a]	1.97	2	12	7	69.67[ab]	13.37	44.5	115.00	68.75
2018	126	7.50[ab]	2.43	2	13	8	7.50[ab]	2.43	2	13	8	74.82[a]	19.54	45.0	182.50	71.00
2019	75	7.92[a]	2.57	2	13	8	7.81[abc]	2.53	2	13	8	66.58[b]	9.00	46.8	94.00	67.00
2020	48	6.60[b]	2.40	2	11	7	6.10[ad]	2.42	1	10	6	80.64[c]	14.94	53.0	125.00	80.00

[1)] SD – standard deviation

[a, b,c, d] values within a column with different letters differ significantly ($p < 0.05$).

Table 4
Reproductive traits, by season

Season[1)]	Number of litters	Litter size at birth					Litter size at weaning					Birth weight [g]				
		Mean	SD[2)]	Min	Max	Median	Mean	SD[2)]	Min	Max	Median	Mean	SD[2)]	Min	Max	Median
Spring	101	7.86[a]	2.26	2	13	8	7.78[a]	2.21	2	12	8	69.00[a]	12.02	45.6	111.0	67.5
Summer	67	6.59[b]	2.02	3	10	7	6.56[b]	2.04	2	10	7	73.67[ab]	16.47	44.5	121.3	71.6
Autumn	106	6.98[ab]	2.35	2	11	7	6.77[bc]	2.37	1	11	7	76.64[b]	20.41	45.0	182.5	74.0
Winter	112	7.77[a]	2.62	2	13	8	7.72[a]	2.63	2	13	8	68.94[ac]	10.35	46.8	100.0	68.0

[1)] Spring – March to May, Summer – June to August, Autumn – September to November, Winter – December to February; [2)] SD – standard deviation

[a, b,c] values within a column with different letters differ significantly ($p < 0.05$).

CONCLUSIONS

Does of the Termond White breed produce litters of larger size at birth and at weaning in comparison with females of the Popielno White breed. In addition, the birth weight of Termond White rabbits is higher than that of Popielno White rabbits. On the other hand, the breed of the sire did not significantly affect the size of litters at birth or at weaning or the birth weight of rabbits. The analysis confirmed the high productivity of the dams of both breeds, irrespective of the paternal component. The use of Popielno White and Termond White does in small-scale commercial rabbit farming will enable more efficient use of available resources on the farm. The study showed that the year of mating can affect the size of litters at birth and at weaning, as well as the birth weight of rabbits. The season was also shown to significantly influence the number of young born and weaned per litter and the weight of rabbits at birth. It is more beneficial for does to give birth during the winter and spring and rear their kits during the summer.

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