DOI: 10.21005/AAPZ2024.69.1.10

FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2024, 370(69)1, 114–134

Received 27 Jul 2023
Revised 19 Nov 2023
Accepted 24 Nov 2023

Stanisław SOCHA, Dorota Elżbieta WEREMCZUK, Dorota KOŁODZIEJCZYK

ANALYSIS OF VARIABILITY IN CONFORMATION TRAITS AND THE EFFECTIVENESS OF BREEDING WORK IN RABBITS OF THE TERMOND WHITE AND POPIELNO WHITE BREEDS

Institute of Zootechnics and Fisheries, University of Siedlce, Siedlce, Poland

Abstract. The aim of the study was to assess and analyze conformation characteristics and the effectiveness of breeding work in TB and PB rabbits over 10 years. The study determined the variability of conformation traits in two animal herds, as well as their heritability. Additionally, phenotypic trends in conformation traits were estimated. The analysis of variance of conformation traits showed that the year of license had a statistically highly significant impact on: body weight (expressed in grams and points), body structure, breed type, coat color and specific breed characteristics. Gender and race had a statistically significant impact on body weight (g) and coat color. Moreover, race also showed a statistically significant effect on body weight in the scoring. In turn, the farm had a statistically significant impact on: body weight (g), body structure, breed type, coat color and specific breed characteristics. The analysis of conformation characteristics showed that 97.9% of rabbits received positive marks, and 2.1% were disqualified. Only individuals intended for herd improvement were subjected to evaluation. Summarizing the results of the conformation traits analysis, it can be concluded that the rabbits kept on the examined farms underwent proper selection. The animals had very good conformation features. Based on our own research, it was found that rabbit breeding in both of the studied farms was conducted correctly, and the obtained results are satisfactory, both in terms of reproductive and conformatin traits.

Key words: rabbit, Termond white, Popielno white, conformation traits, variability, heritability, breeding efficiency.

INTRODUCTION

The domestic rabbit is a species of farm animals. It originates from the wild rabbit. whose original habitat was the western part of the Mediterranean Sea coast (Nowak 1971). The domestic rabbit is a versatile species of animals. Its most popular use is for meat production. Rabbit meat is valuable in terms of nutritional content and dietary qualities.

According to Kowalska et al. (2016). rabbit meat consumption in our country increased from 0.6 kg per person in 2010 to 1.2 kg per person in 2015.

Corresponding author: Stanisław Socha, Institute of Zootechnics and Fisheries, University of Siedlce, Bolesława Prusa 14, 08-110 Siedlce, e-mail: stanislaw.socha@uws.edu.pl.

Achieving satisfactory production results depends on the selection of appropriate genetic material. Properly conducted selection has allowed for the development of highly meaty lines characterized by a high meat content in the carcass (Maj 2005). To popular breeds of rabbits kept for meat include: Popielno white and Termond white. Both of these breeds are known for their snowy white fur and red eyes (Bielański et al. 2011; Kowalska 2016; Weremczuk 2017).

According to Bielański et al. (2011). Popielno white rabbits can be kept in amateur breeding conditions and – due to the fact that the quality of the carcass is not much different from the popular New Zealand White rabbits – they also work well in large-scale breeding.

When selecting individuals for further breeding, the decisive aspect is the utility and breeding value of the animals. Through to the conducted evaluation of traits, we are able to select from among the whole herd only those individuals that are characterized by the highest indicators.

When evaluating the differences that occur between breeds or lines, genetic parameters are used. One of them is the coefficient of heritability (h^2), whose values range from 0 to 1. With the knowledge of this indicator for a given trait, the breeder is able to apply the appropriate breeding method.

The structure of rabbit breeding is based on performance-controlled herds and large-scale farms focused on meat production. The development of rabbit breeding is dictated primarily by the existence of pedigree and reproduction farms, which are important in rabbit production. The main task of both breeding and reproductive farms is to obtain the best possible individuals and supply breeding farms. One breed of rabbits has been bred in Poland – Popielno white rabbits, which are covered by the Farm Animal Genetic Resources Protection Program, and work has been carried out on preserving the rabbit population of this breed since 1989 (Bielański and Kowalska 2010; Kowalska and Bielański 2011).

The goal of the program is to maintain the breed pattern, breed specific traits (high fertility and prolificacy, fast growth rate, low feed consumption), as well as to preserve genetic variability. In the breeding of rabbits on large-scale farms, we have to deal with the evaluation of lifetime and post-slaughter traits, as well as a whole range of activities related to breeding work, including selection.

Determination of the value of measurable traits that are economically important and determine the utility of a given individual is the utility value. When estimating it, the following are taken into account: live traits, post-slaughter traits, and meat quality (Niedźwiadek 1981). In other words, the decisive influence on the utility value of rabbits is: health, fertility and prolificacy, size and conformation of the rabbit, condition and muscularity, as well as fur quality.

The aim of the study was to evaluate and analyze conformation traits and breeding efficiency in Popielno White and Termond White rabbits. In the study, the variability of traits in herds of animals was determined, as well as the heritability of conformation traits. Phenotypic trends of conformation traits over ten years in the farms included in the analysis were estimated.

MATERIAL AND METHODS

The research material for the evaluation of conformation traits came from two breeding farms. The first of them (farm A) is located in the south-eastern part of Poland in the Podkarpackie Voivodship. This farm specializes in the production of rabbit meat, primarily based on breeding the Popielno White (PB) and Termond White (TB) rabbit breeds. The second farm (referred to as Farm B in this study) is situated in the Opole voivodeship. Several rabbit breeds, including

the Termond White rabbits, are raised there. The rabbits were fed with pelleted, nutritionally balanced feeds that met all the dietary requirements for the animals (Gugołek 2011).

Breeding records on the farms were kept very meticulously and all activities related to the breeding and use of the rabbits were recorded. The publication is based on the results of the evaluation of conformation traits carried out between 2009 and 2018. During this time, 3136 rabbits. belonging to two breeds, were evaluated. A positive evaluation was obtained by 97.9% of the rabbits and 2.1% were disqualified. Most rabbits of the TB breed were assessed, as rabbits of this breed were found on both Farm A and Farm B.

During the study period, the Patterns of Conformation Evaluation according to the National Centre for Animal Breeding (Patterns 2000 and 2016) were in force. The Patterns of Conformation Evaluation (Patterns 2000 and 2016) include six traits expressed in points: body weight, body conformation, breed type, coat quality, coat colour and breed specific traits, as well as total points. A total of 3073 rabbits were assessed including: 2694 females and 379 males. The study included two breeds of rabbits that were used in the farms included in the performance evaluation: the Thermond White (TB) and the Popielno White (PB).

Each of the rabbit conformation traits studied and analysed was subjected to detailed statistical analysis, including multivariate analysis of variance. Statistical analyses were performed using the SAS computer package and STATISTICA.

The GLM (General Linear Models) procedure was used to assess the impact of individual effects on the level of the traits analysed. Multivariate analyses of variance were carried out using the model:

$$Y_{ijklmn} = \mu + R_i + P_j + R_k + F_l + E_{ijklm}$$

Y – traits analysed: body weight in grams, body weight in points, body build, breed type, coat quality, coat colour, breed specificity**,** total points.
μ – mean of the traits,
R_i – fixed effect of year,
P_j – fixed effect of sex,
R_k – fixed influence of breed,
F_l – fixed influence of farm,
E_{ijklm} – residual unexplained by experiment – error.

The significance of differences between the means for the fixed effects was determined by the Tukey test and the LSMean test at a significance level of $\alpha = 0.0$.

RESULTS AND DISCUSSION

Statistical analysis of rabbit conformation traits

The analysis of variance shows that body weight (g) was statistically highly significant ($P \leq 0.01$) influenced by all variables included in the model, namely year of animal evaluation, sex, breed and farm.

The TB breed rabbits in 2012 had the highest average body weight, at 5120 g, while the PB breed animals had the lowest, at 3850.5 g (Table 1). Throughout the study period, the TB breed achieved a higher average body weight compared to rabbits of the PB breed. The latter achieved the highest mean value for this trait in 2009 – 4260.71 g and it was 859.3 g lower than such a value for the TB breed (Table 1). Also in the study by Kmiecik et al. (2016). rabbits of this breed were characterised by a significantly higher body weight compared to

rabbits of the Californian and PB breeds. Comparing the results obtained in rabbits of the TB breed in both farms, it should be noted that the animals from farm B were statistically characterised by a higher average body weight (Table 1).

Table 1. Statistical description of body weight (g)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	4438.80	514.206	11.58
		PB	28	4260.71	229.878	5.40
2010	A	TB	97	4140.21	454.757	10.98
		PB	30	4096.67	554.905	13.55
	B	TB	22	4890.91	265.310	5.43
2011	A	TB	224	4351.79	501.474	11.52
		PB	72	4005.56	402.768	10.06
	B	TB	60	4846.67	442.821	9.14
2012	A	TB	114	4270.18	561.119	13.14
		PB	127	3971.65	503.937	12.69
	B	TB	50	5120.00	337.458	6.59
2013	A	TB	231	4431.60	536.897	12.12
		PB	245	4005.30	501.813	12.53
	B	TB	29	5096.55	400.431	7.86
2014	A	TB	102	4367.65	468.019	10.72
		PB	162	4137.04	461.551	11.16
	B	TB	12	5100.00	351.620	6.90
2015	A	TB	83	4515.66	493.490	10.93
		PB	101	4215.84	435.369	10.33
	B	TB	28	4885.71	393.196	8.05
2016	A	TB	139	4637.41	453.373	9.78
		PB	215	4230.70	491.695	11.62
	B	TB	49	4744.90	396.895	8.37
2017	A	TB	116	3998.10	439.913	11.00
		PB	147	3850.48	557.486	14.48
	B	TB	38	4765.79	463.405	9.72
2018	A	TB	79	4056.96	284.958	7.02
		PB	110	4085.46	280.182	6.86
	B	TB	46	4893.48	423.426	8.65
Total			3073	4301.79	555.488	12.91

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

On farm B less variability (V) can be observed compared to farm A, which may be due to the different numbers of animals assessed on one and the other farm (Table 1).

Considering the sex of the animals, the higher average body weight, assessed both in grams and points, was characterised by females (Table 2).

Table 2. Statistical description of the analyzed traits with respect to the sex of the rabbits

Trait	sex	n	$\bar{x}$	SD	V
Body weight (g)	male	379	4158.84	564.979	13.59
	female	2694	4321.90	551.279	12.76
Body weight (points)	male	379	9.19	0.829	9.02
	female	2694	9.49	0.748	7.88
Body build (points)	male	379	18.20	0.566	3.11
	female	2694	18.12	0.580	3.20
Breed type (points)	male	379	18.18	0.648	3.56
	female	2694	18.19	0.607	3.34
Coat quality (points)	male	379	18.33	0.565	3.08
	female	2694	18.18	0.550	3.03
Coat colour (points)	male	379	9.26	0.670	7.56
	female	2694	9.41	0.718	7.63
Specific breed charakteristics (points)	male	379	19.98	0.135	0.68
	female	2694	19.97	0.172	0.86
Total points (points)	male	379	93.13	1.780	1.91
	female	2694	93.34	1.559	1.67

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

For body weight expressed in points, in addition to sex, factors such as year of evaluation and breed had a statistically highly significant ($P \leq 0.01$) effect on this conformation trait. Farm in this case was not statistically significant.

On farm A, rabbits of the TB breed received the lowest mean score for body weight in 2017 – 9.07 points, while the highest and also maximum mean score was recorded in 2018 – 10 points. The PB breed received the lowest average score in 2014 – 8.87 points, while the highest was recorded in 2018 – 10 points. On farm B, where only TB breed rabbits were kept, the lowest average score for body weight was recorded in 2016 – 9.90 points, while the highest and at the same time maximum score of 10 points was observed during several years of evaluation, namely: in 2010, 2011, 2012, 2014 and 2015 (Table 3).

Considering the breed, it has to be said that TB rabbits performed better compared to PB. The exception was the penultimate year of the evaluation, in which, on farm A, the mean for body weight in points was lower in TB rabbits than in PB rabbits (Table 3). In the study by Kołodziejczyk et al. (2018), the TB breed also performed more favourably compared to PB. On farm A for the TB breed, SD scored zero in 2018, which clearly represents the lowest score for both this breed and PB rabbits. In contrast, the highest SD for TB breed rabbits was recorded in 2014 – 0.782. The PB breed had the lowest SD in 2018 – 0.00, while the highest was in 2012 – 0.875.

Table 3. Statistical description of body weight (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	9.64	0.635	6.59
		PB	28	9.54	0.637	6.68
2010	A	TB	97	9.42	0.719	7.63
		PB	30	9.27	0.740	7.98
	B	TB	22	10.00	0.000	0.00
2011	A	TB	224	9.77	0.576	5.90
		PB	72	9.26	0.840	9.06
	B	TB	60	10.00	0.000	0.00
2012	A	TB	114	9.64	0.742	7.70
		PB	127	9.34	0.875	9.37
	B	TB	50	10.00	0.000	0.00
2013	A	TB	231	9.55	0.683	7.15
		PB	245	8.98	1.040	11.59
	B	TB	29	9.93	0.258	2.60
2014	A	TB	102	9.23	0.782	8.48
		PB	162	8.87	0.765	8.63
	B	TB	12	10.00	0.000	0.00
2015	A	TB	83	9.39	0.660	7.03
		PB	101	8.98	0.754	8.41
	B	TB	28	10.00	0.000	0.00
2016	A	TB	139	9.57	0.637	6.66
		PB	215	9.01	0.752	8.35
	B	TB	49	9.90	0.306	3.09
2017	A	TB	116	9.07	0.615	6.78
		PB	147	9.36	0.662	7.07
	B	TB	38	9.95	0.226	2.28
2018	A	TB	79	10.00	0.000	0.00
		PB	110	10.00	0.000	0.00
	B	TB	46	9.98	0.147	1.48
Total			3073	9.45	0.764	8.09

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

Another of the traits evaluated was body conformation, the scoring of which, according to the Patterns of Conformation Evaluation (Patterns, 2000 and 2016), ranges between 16 and 20 points. When assessing this trait, the harmoniousness of the body conformation, the line of the back, as well as the presence of admissible defects in terms of: the shape of the head and ears, their length, and the visible jowls are taken into account. All the rabbits evaluated had similar values for the body conformation score, yet the year of evaluation, breed and farm had a statistically highly significant ($P \leq 0.01$) effect on this trait. In contrast, gender had no statistically significant effect on body conformation (Table 2).

The TB rabbits on farm B, in the second year of evaluation, had the highest mean body conformation. This was the highest score throughout the study period and was 18.77 points. The lowest mean for body conformation, of 17.87 points, was obtained by PB rabbits (Table 4). The statistical analysis shows that rabbits from farm B scored slightly higher than animals

from farm A in terms of body conformation. This relationship was present for most of the study period (Table 4).

The highest variability, V (4.23), was observed in PB rabbits in 2017. While the lowest (1.46) was in the first year of the evaluation (Table 3). In contrast, V on farm A for TB was lowest in 2011 at 2.03, while it was highest in 2017 at 3.59.

Table 4. Statistical description of body build (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	18.03	0.539	2.99
		PB	28	17.93	0.262	1.46
2010	A	TB	97	17.91	0.614	3.43
		PB	30	17.87	0.629	3.52
	B	TB	22	18.77	0.685	3.65
2011	A	TB	224	18.02	0.366	2.03
		PB	72	18.07	0.454	2.51
	B	TB	60	18.62	0.585	3.14
2012	A	TB	114	18.17	0.419	2.31
		PB	127	18.06	0.484	2.68
	B	TB	50	18.54	0.613	3.31
2013	A	TB	231	17.98	0.484	2.69
		PB	245	18.18	0.453	2.49
	B	TB	29	18.48	0.575	3.11
2014	A	TB	102	17.89	0.628	3.51
		PB	162	17.94	0.582	3.24
	B	TB	12	18.17	0.577	3.18
2015	A	TB	83	18.23	0.502	2.75
		PB	101	18.21	0.516	2.83
	B	TB	28	18.36	0.488	2.66
2016	A	TB	139	18.53	0.594	3.21
		PB	215	18.38	0.558	3.04
	B	TB	49	18.10	0.549	3.04
2017	A	TB	116	17.95	0.644	3.59
		PB	147	18.07	0.765	4.23
	B	TB	38	18.42	0.395	2.14
2018	A	TB	79	18.00	0.599	3.33
		PB	110	18.03	0.748	4.15
	B	TB	46	18.38	0.353	1.92
Total			3073	18.13	0.579	3.19

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

Analysis of variance for breed type showed that year of evaluation and farm were the most significant of the variables ($P \leq 0.01$). Gender and breed of rabbits had no statistically significant effect on this trait.

The mean values of the breed type score over the nine years of the study took on values of 17.69–19.14 points. The highest mean for breed type was obtained by TB rabbits on farm B in 2010, while the lowest mean over the entire study period occurred two years later, in 2012, in PB animals on farm A. The TB breed, kept on the same farm, obtained the lowest average number of points for breed type in 2013 – 17.93 points (Table 5).

In 2014, all TB breed animals evaluated on farm B scored the same average number of points for breed type. During the entire study period, this was the only year in which there was no variability. In the other years, the coefficients of variation were between 1.21 and 4.82 (Table 5).

Table 5. Statistical description of breed type (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	17.99	0.506	2.81
		PB	28	18.11	0.629	3.47
2010	A	TB	97	18.40	0.786	4.27
		PB	30	18.10	0.759	4.19
	B	TB	22	19.14	0.351	1.84
2011	A	TB	224	18.26	0.666	3.65
		PB	72	18.06	0.870	4.82
	B	TB	60	19.05	0.467	2.45
2012	A	TB	114	17.96	0.245	1.36
		PB	127	17.69	0.499	2.82
	B	TB	50	19.00	0.286	1.50
2013	A	TB	231	17.93	0.278	1.55
		PB	245	17.74	0.476	2.68
	B	TB	29	19.04	0.186	0.98
2014	A	TB	102	18.18	0.496	2.73
		PB	162	18.03	0.743	4.12
	B	TB	12	19.00	0.000	0.00
2015	A	TB	83	18.34	0.501	2.73
		PB	101	18.15	0.517	2.85
	B	TB	28	18.75	0.441	2.35
2016	A	TB	139	18.47	0.501	2.71
		PB	215	18.36	0.537	2.92
	B	TB	49	18.84	0.373	1.98
2017	A	TB	116	18.04	0.371	2.06
		PB	147	18.25	0.432	2.37
	B	TB	38	18.91	0.228	1.21
2018	A	TB	79	18.13	0.435	2.40
		PB	110	18.29	0.456	2.45
	B	TB	46	18.78	0.292	1.55
Total			3073	18.19	0.611	0.36

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

Coat quality is another trait in the phenotypic evaluation of rabbits, for which 17 to 20 points are awarded. In the evaluation of this trait, the density of the predominantly undercoat hairs, the length of the cover hairs and the silkiness and springiness of the coat are taken into account. Defects in hair coat elasticity and density are also allowed in this category.

Analysis of variance showed that all factors included in the model had no statistically significant effect on this trait. In the study by Kołodziejczyk et al. (2018), coat quality was statistically significantly influenced by the year of evaluation.

Table 6 shows the statistical characteristics of hair coat quality. On farm A, the TB breed received the lowest mean score for this trait in 2018 – 17.98 points, while the highest mean score was recorded in 2010 – 18.52 points. The PB breed received the lowest average score in 2009 – 17.89 points, while the highest was recorded in 2010 – 18.33 points. Farm B kept rabbits of the TB breed only, for which the lowest mean score for coat quality was 18.12 points and the highest was 19.17 points (Table 6).

Table 6. Statistical description of coat quality (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	18.26	0.618	3.39
		PB	28	17.89	0.737	4.12
2010	A	TB	97	18.52	0.597	3.23
		PB	30	18.33	0.480	2.62
	B	TB	22	19.00	0.617	3.25
2011	A	TB	224	18.29	0.493	2.70
		PB	72	18.15	0.362	2.00
	B	TB	60	19.17	0.493	2.57
2012	A	TB	114	18.35	0.479	2.61
		PB	127	18.29	0.473	2.59
	B	TB	50	18.92	0.445	2.35
2013	A	TB	231	17.99	0.586	3.26
		PB	245	18.10	0.337	1.86
	B	TB	29	18.79	0.491	2.61
2014	A	TB	102	18.08	0.305	1.69
		PB	162	18.12	0.376	2.08
	B	TB	12	18.83	0.389	2.07
2015	A	TB	83	18.04	0.551	3.06
		PB	101	17.94	0.614	3.42
	B	TB	28	18.46	0.508	2.75
2016	A	TB	139	18.08	0.435	2.41
		PB	215	18.04	0.528	2.93
	B	TB	49	18.12	0.564	3.11
2017	A	TB	116	18.01	0.447	2.48
		PB	147	18.12	0.490	2.70
	B	TB	38	18.43	0.522	2.83
2018	A	TB	79	17.98	0.452	2.52
		PB	110	18.08	0.491	2.71
	B	TB	46	18.41	0.451	2.45
Total			3073	18.20	0.554	3.04

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

The lowest variability of the trait, coat quality, was observed in TB rabbits kept on farm A, with a V-value of 1.69, while on farm B, the V-value for this breed fluctuated around 3.39. The V coefficient was at the level of 1.69. Higher variability was recorded in 2009, when the V value reached 3.39. On the other hand, on farm B, the V coefficient for this breed ranged from 2.07 to 3.25. For the PB breed, the lowest coefficient of variation at the level of 1.86 occurred in 2013, while the highest – 4.12 – was recorded in 2009 (Table 6). The results

obtained are similar to those obtained by Kołodziejczyk et al. (2013) in a study conducted on New Zealand White rabbits, also belonging to the medium breed group.

When analysing the next conformation trait – coat colour – it can be concluded that the statistically highly significant influence on this trait was exerted by all factors included in the model, i.e. year of performance control, sex, breed and farm.

The rabbits of the PB breed, in the first year of the study, were characterised by the highest mean coat colour (Table 7). At that time, all the animals of this breed evaluated obtained the maximum number of points, i.e. 10. Therefore, the coefficient v was 0.00 in that year. Also in 2014, there was no variability, as all the TB rabbits from farm B evaluated obtained 9 points each for coat colour (Table 7). The highest average score of 9.94 was obtained in 2016, while the lowest average score of 8.96 was recorded in 2010. On farm A, the breed scored the lowest mean score for this trait in 2016 – 8.35 points, while the highest, at 9.91 points, was in 2009 (Table 7). In Otulakowski's (2011) study, on the other hand, the TB breed turned out to be better, with the highest percentage of rabbits with an exemplary assessment of coat colour.

Table 7. Statistical description of coat colour (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	9.91	0.284	2.87
		PB	28	10.00	0.000	0.00
2010	A	TB	97	9.66	0.476	4.93
		PB	30	9.50	0.509	5.35
	B	TB	22	8.96	0.213	2.38
2011	A	TB	224	9.72	0.496	5.10
		PB	72	9.92	0.278	2.81
	B	TB	60	9.05	0.287	3.17
2012	A	TB	114	9.73	0.447	4.59
		PB	127	9.75	0.436	4.47
	B	TB	50	8.98	0.141	1.58
2013	A	TB	231	9.81	0.408	4.16
		PB	245	9.85	0.355	3.60
	B	TB	29	8.97	0.186	2.07
2014	A	TB	102	9.89	0.312	3.15
		PB	162	9.86	0.350	3.55
	B	TB	12	9.00	0.000	0.00
2015	A	TB	83	8.42	0.544	6.46
		PB	101	8.54	0.521	6.10
	B	TB	28	9.75	0.441	4.52
2016	A	TB	139	8.35	0.477	5.72
		PB	215	8.41	0.502	5.98
	B	TB	49	9.94	0.242	2.44
2017	A	TB	116	8.66	0.559	6.45
		PB	147	9.18	0.593	6.47
	B	TB	38	9.09	0.646	7.10
2018	A	TB	79	8.67	0.499	5.76
		PB	110	9.25	0.578	6.25
	B	TB	46	9.65	0.314	3.25
Total			3073	9.39	0.717	7.64

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

The anaysis of variance for breed-specific traits shows that the year of evaluation and the farm had a statistically highly significant (P ≤ 0.01)effect on this trait. On the other hand, breed and sex were found to be statistically insignificant for this trait. On farm A, all rabbits of both breeds (TB and PB) evaluated scored the maximum score for this trait – 20.00, so the coefficient of variation for the ten years of evaluation was 0.00 (Table 8). The maximum score for breed specific traits was obtained by both breeds. The benchmark score in TB rabbits was obtained by more than 95% of the evaluated individuals. The PB breed, on the other hand, proved to be a 100% reference breed, as all individuals received the maximum score (Table 8).

Table 8. Statistical description of specific racial traits (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	20.00	0.000	0.00
		PB	28	20.00	0.000	0.00
2010	A	TB	97	20.00	0.000	0.00
		PB	30	20.00	0.000	0.00
	B	TB	22	19.00	0.000	0.00
2011	A	TB	224	20.00	0.000	0.00
		PB	72	20.00	0.000	0.00
	B	TB	60	19.00	0.184	0.97
2012	A	TB	114	20.00	0.000	0.00
		PB	127	20.00	0.000	0.00
	B	TB	50	20.00	0.000	0.00
2013	A	TB	231	20.00	0.000	0.00
		PB	245	20.00	0.000	0.00
	B	TB	29	19.97	0.186	0.93
2014	A	TB	102	20.00	0.000	0.00
		PB	162	20.00	0.000	0.00
	B	TB	12	20.00	0.000	0.00
2015	A	TB	83	20.00	0.000	0.00
		PB	101	20.00	0.000	0.00
	B	TB	28	20.00	0.000	0.00
2016	A	TB	139	20.00	0.000	0.00
		PB	215	20.00	0.000	0.00
	B	TB	49	20.00	0.000	0.00
2017	A	TB	116	20.00	0.000	0.00
		PB	147	20.00	0.000	0.00
	B	TB	38	19.87	0.322	1.62
2018	A	TB	79	20.00	0.000	0.00
		PB	110	20.00	0.000	0.00
	B	TB	46	20.00	0.000	0.00
Total			3073	19.97	0.168	0.84

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

The trait to which breeders attach the greatest importance is the total score for all the traits assessed. In the case of rabbits, this amounts to a maximum of 100 points. The analysis of variance for this trait showed no statistically significant influence of any of the factors

included in the model. In the analysed farms, the obtained averages for the sum of points in the individual assessment years were at the level of 91.70–95.48 (Table 9), i.e. they did not deviate too much from the standard. The highest average total points were obtained by white Thermondz rabbits kept on farm B. The averages for animals of the same breed but from farm A ranged from 91.72–94.05 points. The lowest average total score was characterised by rabbits of the PB breed in 2015 (Table 9).

Table 9. Statistical description of of the total score (points)

Evaluation year	Farm	Breed	n	$\bar{x}$	SD	V
2009	A	TB	317	93.85	1.259	1.34
		PB	28	93.46	1.319	1.41
2010	A	TB	97	93.85	1.474	1.57
		PB	30	93.00	1.762	1.89
	B	TB	22	94.82	1.053	1.11
2011	A	TB	224	94.05	1.159	1.23
		PB	72	93.46	1.210	1.29
	B	TB	60	94.90	0.838	0.88
2012	A	TB	114	93.79	1.148	1.22
		PB	127	93.08	1.264	1.36
	B	TB	50	95.48	0.614	0.64
2013	A	TB	231	93.26	1.178	1.26
		PB	245	92.80	1.200	1.29
	B	TB	29	95.17	0.602	0.63
2014	A	TB	102	93.27	1.522	1.63
		PB	162	92.81	1.377	1.48
	B	TB	12	95.00	0.739	0.78
2015	A	TB	83	92.42	1.317	1.43
		PB	101	91.70	1.775	1.94
	B	TB	28	95.32	0.670	0.70
2016	A	TB	139	92.99	1.657	1.78
		PB	215	92.17	1.642	1.78
	B	TB	49	94.90	0.797	0.84
2017	A	TB	116	91.72	1.759	1.92
		PB	147	92.97	1.508	1.62
	B	TB	38	94.66	0.901	0.95
2018	A	TB	79	92.77	1.260	1.36
		PB	110	93.66	1.145	1.22
	B	TB	46	95.16	0.675	0.71
Total			3073	93.31	1.589	1.70

n – abundance; $\bar{x}$ – arithmetic mean; SD – standard deviation; V – coefficient of variation.

The results obtained are consistent with those of Kowalska (2016) and Zawiślak et al. (2016). In Kowalska's (2016) study of PB rabbits, animals of this breed obtained an average conformation score of 93.6–93.9 points, i.e. they were characterised by good and very good grades. Zawiślak et al. (2016) showed that the majority of rabbits received good and very good scores (93–95 points); their percentage share reached up to 70.1%.

There was less variability in the mean total score for TB rabbits on both farm A and B. On farm A for the TB breed, the SD was lowest in 2012 – 1.148, while the highest was in 2017 – 1.759. Rabbits of the PB breed obtained the lowest standard deviation in 2018 – 1.145. The animals under evaluation were very equal in terms of the evaluated traits. The coefficient of variation for total scores ranged from 0.64% to 1.94%.

Based on the results of the rabbit conformation evaluation, it can be concluded that the animals kept in both analysed farms in the period 2009–2018, which were subjected to conformation evaluation, were characterised by very good coat parameters. Slightly higher parameters were characterised by the TB breed. Similar results were obtained in her study by Weremczuk (2017).

Genetic and breeding analysis of evaluated traits in rabbits

The contribution of the genotype to the formation of a given trait is measured by the heritability coefficient (h^2), which takes values in the range from 0 to 1. The values of the heritability coefficient (h^2) of traits related to the conformation of rabbits are shown in Table 10. The highest value of this parameter was characterised by body weight of 0.28, which affects the body weight score (Table 10). Rabbits in the studies by Nowicki (2014) and Otulakowski (2011) had a similar heritability of this trait (0.29). According to Bieniek et al. (2016), heritability coefficients for body weight in rabbits ranged from 0.2 to 0.4, e.g. New Zealand White rabbits achieved a heritability of 0.36–0.38 (Bieniek et al. 2016).

Table 10. Heritability coefficients of conformation traits in rabbits

Trait	h^2
Body weight (in points)	0.28
Body build	0.15
Breed type	0.20
Coat quality	0.25
Coat colour	0.26
Breed specificity	0.15
Total score	0.18

The heritability of coat colour in rabbits obtained in this study was at the level of 0.26 (Table 10). Almost twice the heritability coefficient (at the level of 0.44) of this trait in rabbits was characterised by individuals in the studies of Otulakowski (2011) and Nowicki (2014). Other fur-bearing animal species such as mink and chinchillas are characterised by heritability of this trait at the level of 0.33–0.36 (Kołodziejczyk 2010). In polar foxes, on the other hand, the heritability coefficient for coat colour purity ranges from 0.18 (Nowicki 2014) to 0.60 (Filistowicz et al. 2000). Knowledge of the heritability of a given trait forms the basis for selecting an appropriate breeding method (Pałka 2015).

The coefficient of heritability of coat quality was 0.25. The coefficients of heritability of this trait in the studies by Nowicki (2014) and Otulakowski (2011) were at a similar level (0.24).

The quality of the coat is influenced by the density, length and silkiness and elasticity of the hair. These parameters are lowly heritable and thus not very susceptible to selection. These coefficients take on varying values, due to the way they are estimated and the influence of various factors.

A trait with a similar level of heritability coefficient as the above was breed type. The value of this parameter obtained in this study was 0.20. More than twice as high heritability of racial type – 0.49 was obtained in their study by Nowicki (2014) and Otulakowski (2011).

The lowest heritability coefficient of 0.15 was obtained by such conformation traits as breed specific traits and body conformation. Almost twice as high value of heritability coefficient of body conformation (0.29) is presented by Nowicki (2014) and Otulakowski (2011).

The heritability of the total score for all evaluated traits oscillated at 0.18 and was slightly higher than the value of the coefficient for this trait obtained by Otulakowski (2011) and Nowicki (2014). In contrast, Socha (2004), as well as Filistowicz et al. (2000), showed a significantly higher value for this parameter.

In this study, phenotypic correlations of rabbit conformation traits were estimated (Table 11). The correlations between the sum of points and the remaining traits turned out to be positive and relatively high, with the exception of the correlation between the sum of points and breed specific traits, as this value is negative and amounts to −0.16. For the remaining traits: body weight, body conformation, breed type, coat quality, the phenotypic correlations are respectively: 0,61; 0,48; 0,48; 0,52, 0,32.

Negative and very low correlations were found when analysing the relationship between different traits. Correlations between breed-specific traits and body weight and body conformation were −0.14, between body conformation and coat colour −0.17, while between breed type and coat colour and breed-specific traits, respectively: −0.19 and −0.23. A negative and low correlation (−0.25) occurred between coat quality and breed specific traits.

Table 11. Phenotypic correlation coefficients

	Body type	Breed type	Coat quality	Coat colour	Specific breed traits	Total points
Body weight	0.21	0.13	0.06	0.02	−0.14	0.61
Body type	–	0.16	0.19	−0.17	−0.14	0.48
Breed type	–	–	0.21	−0.19	−0.23	0.48
Coat quality	–	–	–	0.05	−0.25	0.52
Coat colour	–	–	–	–	0.13	0.32
Specific breed traits	–	–	–	–	–	−0.16

In the study by Kołodziejczyk et al. (2018), correlation values varied, namely between total score and other traits ranging from 0.077 to 0.444, while negative values occurred between body weight (g) and coat quality and between body weight (score) and breed type and hair colour quality. These ranged from −0,076 to −0.052.

The study also estimated phenotypic trends of the analysed conformation traits (Fig. 1– 8). The magnitudes of the trends express changes per unit of time, which in this study was one year.

The conformation traits for both breeds were characterised by a large variation in the values obtained over the study period (Fig. 1–8), and the phenotypic trends for the traits: body weight (g), coat quality, coat colour and total points showed a decreasing trend (Fig. 1–8).

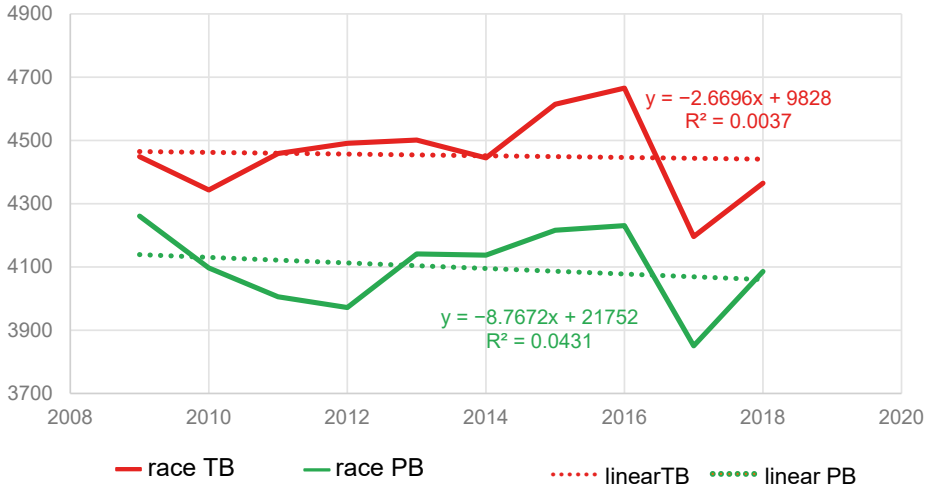

Fig. 1. Phenotypic trends in body weight in successive years of the study with respect to rabbit breed

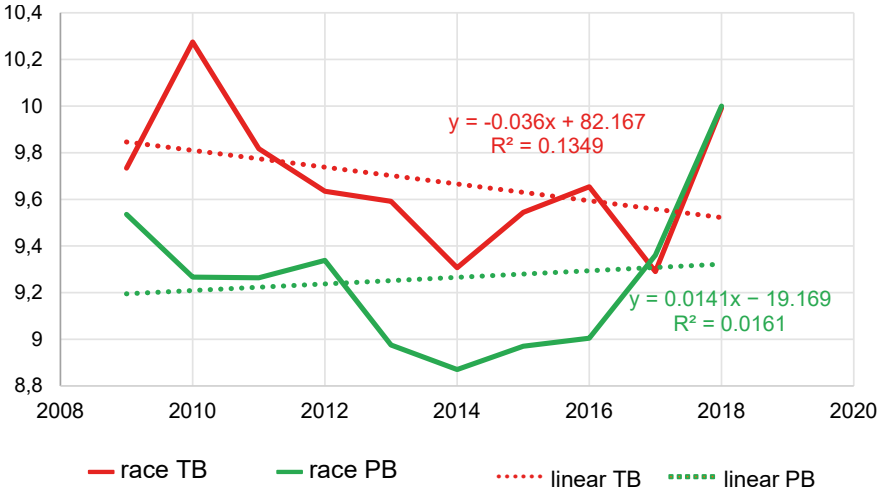

Fig. 2. Phenotypic trends of body weight scoring in successive years of the study with respect to rabbit breed

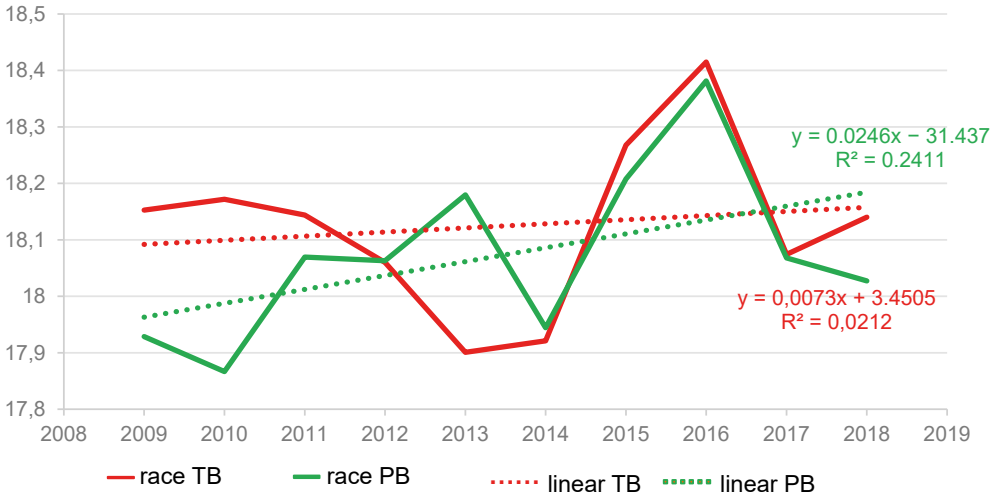

Fig. 3. Phenotypic trends in body conformation in successive years of the study with respect to rabbit breed

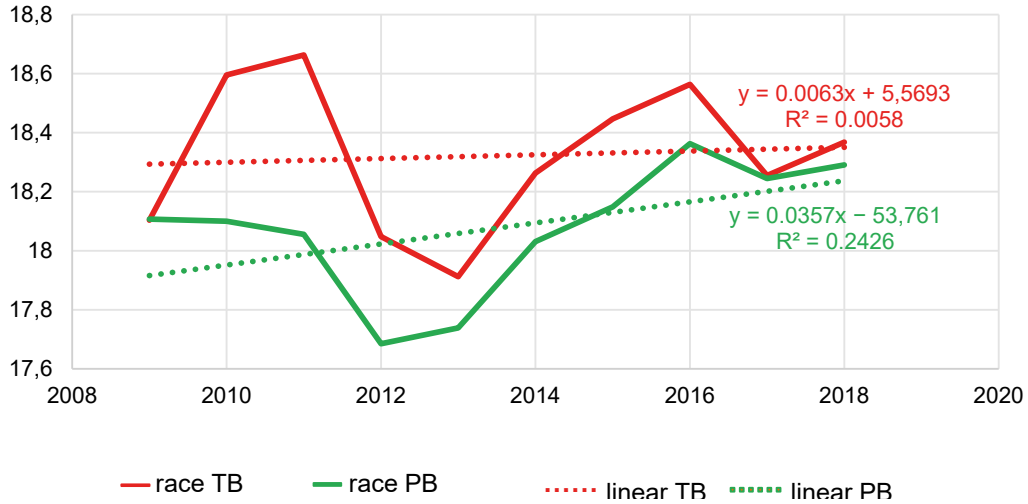

Fig. 4. Phenotypic trends for the trait: breed type in successive years of the study by rabbit breed

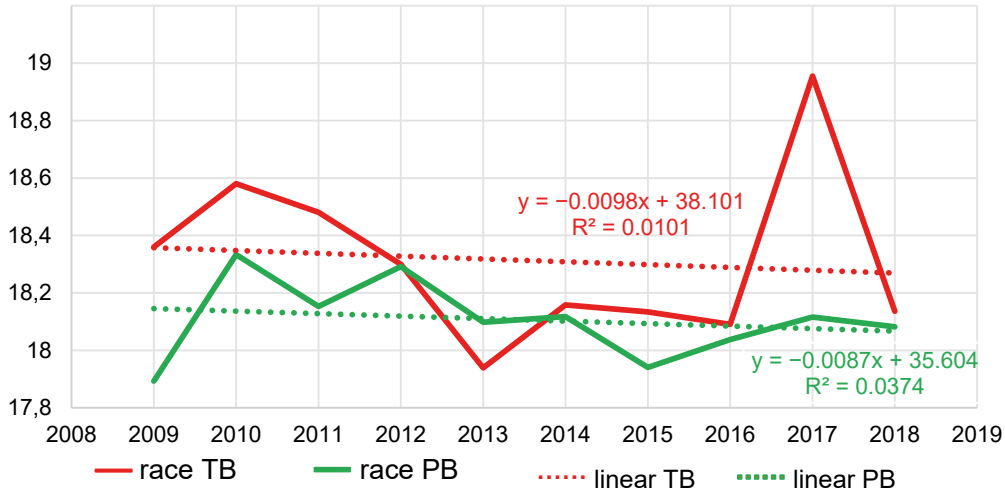

Fig. 5. Phenotypic trends of hair coat quality in successive years of the study with respect to rabbit breed

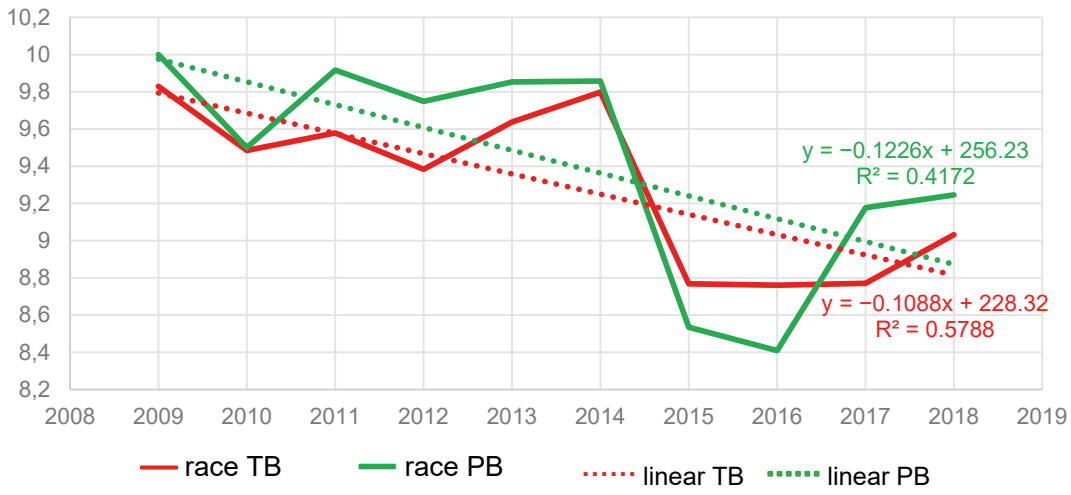

Fig. 6. Phenotypic trends in coat colour in successive years of the study with respect to rabbit breed

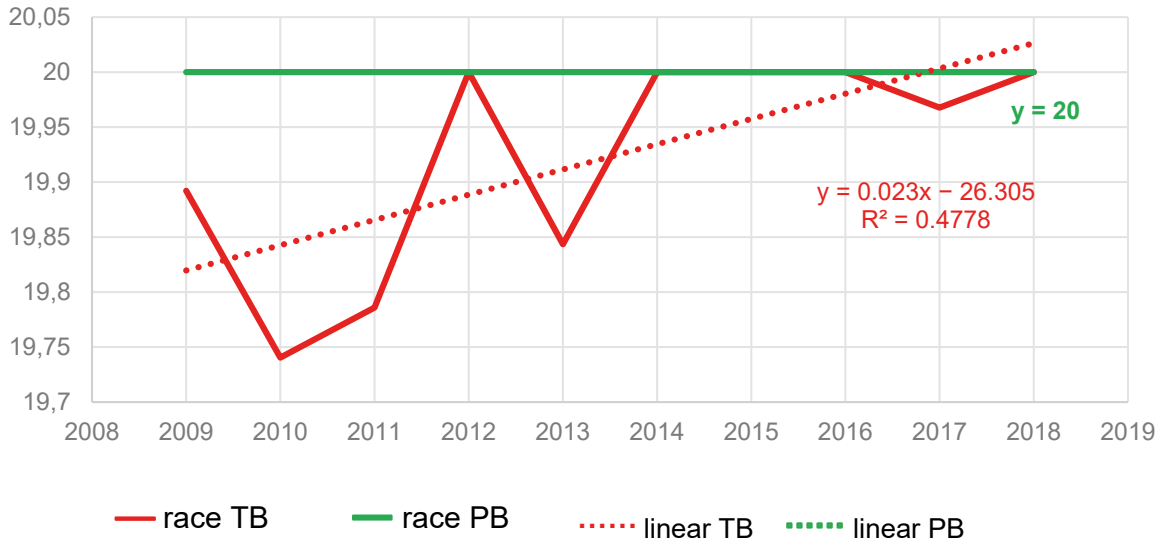

Fig. 7. Phenotypic trends for breed-specific traits in successive years of the study by breed

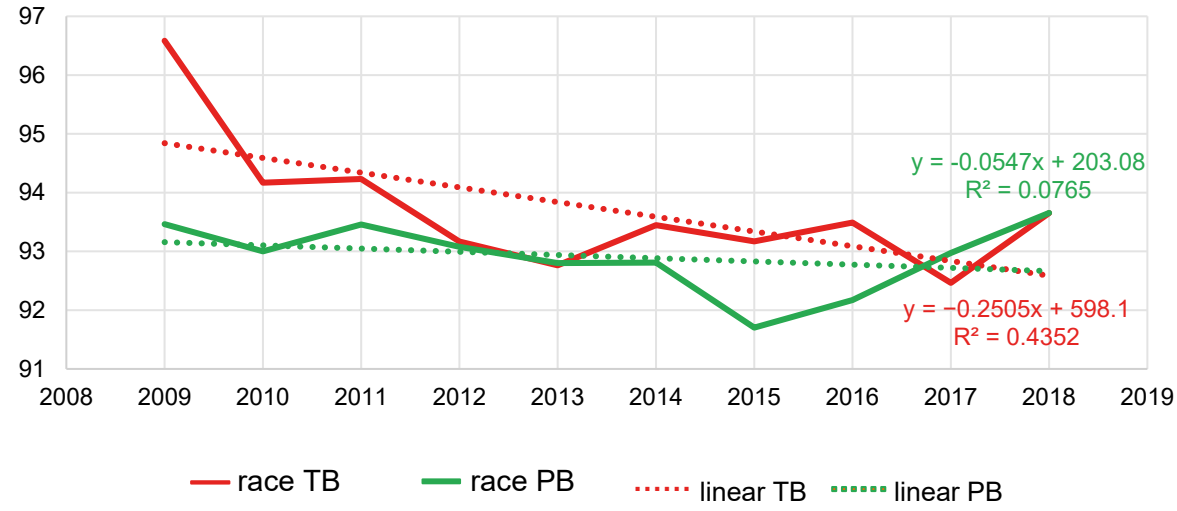

Fig. 8. Phenotypic trends of total scores in successive years of the study by breed

In the scoring of body weight, a difference can be seen between the breeds analysed. Both breeds showed variations in the points awarded regarding this trait, but TB rabbits showed higher scores (Table 3).

Analysis of body weight in points over ten years showed that the phenotypic trend of this trait had an increasing trend for the PB breed and a decreasing trend for TB rabbits (Fig. 1).

The phenotypic trend lines for body conformation and breed type in rabbits of both breeds showed an increasing trend (Fig. 1–2). For PB rabbits, the trend line for breed-specific traits also had an increasing trend, while TB rabbits received the maximum score of 20 points for this trait in each evaluation year analysed (Fig. 7).

Taking into account the sex of the individuals studied, it can be seen that in both males and females there was a slight improvement in breed specific traits and breed type with the following year of analysis. There are differences for the other traits. Body conformation improved in females, while body weight scores improved in males. A significant difference between the sexes of the rabbits occurred in the body weight score in grams.

Table 12. Linear regression coefficients of analysed characteristics (y) by sex

Characteristic to be analysed (outcome variable y)	Regression coefficient value (b)	
	sex	
	1 (♂)	2 (♀)
Body weight (g)	−0.78	−19.84
Body mass (points)	0.03	−0.02
Body build (points)	−0.02	0.02
Breed type (points)	0.02	0.03
Coat quality (points)	−0.07	−0.03
Coat colour (points)	−0.12	−0.13
Breed specificity (points)	0.01	0.01
Total points (points)	−0.16	−0.12

The independent variable (x) is the year of assessment.

Table 12 shows the regression coefficients of the traits, taking the year of animal evaluation (x) as the independent variable. The regression indices obtained are varied. The negative indices obtained, for example, for body weight indicate a decrease in values between years. Thus, for males, it is by 0.78 g and for females by 19.84 g.

It should be noted that the regression index for total score was also negative. In males it was −0.16 and in females −0.12.The regression indices are characterised by very small values. Although they are negative, it can be assumed that the (mean) values of the hair coat quality traits and body weight were maintained at similar levels in the farms included in the performance check.

CONCLUSIONS

The results obtained in this study allow the following summary and conclusions to be formulated:

1. Analysis of variance for conformation traits showed that licence year had a statistically highly significant effect on: body weight, body conformation, breed type, coat colour and breed specific traits. Sex and breed had statistically highly significant effects on: body weight (in grams) and coat colour. In addition, breed also showed a statistically significant effect on body weight in points. On the other hand, the farm had a statistically highly significant effect on: body weight (in grams), body conformation, breed type, coat colour and breed-specific traits.

2. The analysis of conformation traits showed that positive conformation scores were obtained by 97.9% of rabbits, while 2.1% were disqualified. Only specimens intended for herd renovation were evaluated. Summarising the results of the analysis of the conformation traits, it should be stated that the rabbits kept on the farms studied were subjected to correct selection. The animals were characterised by very good conformation traits.

3. In the above study, low heritability coefficients (h^2) were obtained, where the highest value of this parameter was characterised by body weight of 0.28, coat colour of 0.26 and coat quality of 0.25, breed type obtained a heritability coefficient of 0.20. The lowest heritability coefficient of 0.15 was characterised by specific breed traits and body conformation. In contrast, the heritability of the total score for all evaluated traits was 0.18.

4. The conformation traits for the two breeds analysed showed a wide variation in the trait values obtained over the study period, and the phenotypic trends for body weight (g), coat quality, coat colour and total points showed a slightly decreasing trend.

5. The regression indices obtained are diverse. The negative coefficients obtained, for example, for body weight indicate a decrease in values between years. Thus, in males it is by 0.78 g and in females by 19.84 g. It should be noted that the regression index for the total score was also negative. In males it was −0.16 and in females −0.12. The regression indices are characterised by very small values. Although they are negative, it can be assumed that the (mean) values of the hair coat quality traits and body weight were maintained at similar levels in the farms included in the performance check.

REFERENCES

Bielański P., Kowalska D. 2010. Królik popielniański biały − jedyna zachowana rodzima rasa królików [Popielno White rabbit – the only surviving native rabbit breed]. Prz. Hod. 9, 28–31 [in Polish].

Bielański P., Kowalska D., Wrzecionowska M. 2011. Wykorzystanie rodzimej rasy królików popielniańskich białych i ich mieszańców do produkcji mięsa [Utilisation of the native Popielno White rabbit breed and its hybrids for meat production]. Rocz. Nauk. PTZ 3, 67–73 [in Polish].

Bieniek J., Maj D., Pałka S. 2016. Odziedziczalność cech przyżyciowych, poubojowych i jakości mięsa królików [Heritability of lifetime, post-slaughter traits and meat quality of rabbits]. Prz. Hod. 2, 25–27 [in Polish].

CSHZ. 2000. Wzorzec oceny pokroju królików [Standard for the evaluation of the conformation of rabbits]. Warszawa: Centralna Stacja Hodowli Zwierząt [in Polish].

Filistowicz A., Przysiecki P., Tokarska M., Wierzbicki H. 2000. Genetic determination of coat colour in golden fox (*Vulpes vulpes* L.). J. Appl. Genet. 41(4), 259–265.

Gugołek A. (ed.) 2011. Zalecenia żywieniowe i wartość pokarmowa pasz. Zwierzęta futerkowe [Nutritional recommendations and feed value. Fur animals]. Jabłonna: Instytut Fizjologii i Żywienia Zwierząt PAN [in Polish].

KCHZ. 2016. Wzorzec oceny fenotypu królików [Standard for the evaluation of the conformation of rabbits]. Warszawa: Krajowe Centrum Hodowli Zwierząt [in Polish].

Kmiecik M., Pałka S., Kozioł K., Otwinowska-Mindur A., Migdał Ł., Bieniek J. 2016. Porównanie przyrostów dziennych i masy ciała samic i samców królików ras średnich [Comparison of daily growth and body weight of female and male rabbits of medium breeds]. Rocz. Nauk. Zoot. 43(2), 183–189 [in Polish].

Kołodziejczyk D. 2010. Analiza skuteczności pracy hodowlanej na cechy funkcjonalne i pokroju u wybranych odmian barwnych norek (Mustela vision Schreber) [Analysis of the effectiveness of breeding work on functional and conformation traits in selected colour varieties of mink (Mustela vision Schreber)]. Doctoral dissertation. Siedlce: AP in Siedlce [in Polish].

Kołodziejczyk D., Gontarz A., Socha S. 2013. Analysis of conformation traits of New Zealand White rabbits on a breeding farm. Acta Sci. Pol., Zootech. 12(4), 17–28.

Kołodziejczyk D., Weremczuk D.E., Paskudska A., Socik M., Socha S. 2018. Analysis of conformation breeding value of Blanc de Termonde and Popielno White rabbits on a reproductive farm. Acta Sci. Pol., Zootech. 17(4) 2018, 13–20.

Kowalska D. 2016. Króliki popielniańskie białe – stan hodowli w Polsce [Popielno white rabbits – state of breeding in Poland]. Wiad. Zootech. 54(2), 96–105 [in Polish].

Kowalska D., Bielański P. 2011. Study on the possibility of using the native Popielno White rabbit breed in commercial farming. A. Anim. Sci. 11(2), 307–320.

Kowalska D., Gugołek A., Strychalski J. 2016. Zastosowanie pasz rzepakowych w żywieniu królików [Application of rapeseed feed in rabbit nutrition]. Scientific publication of the Institute of Zootechnique PIB in Balice k/Krakow [in Polish].

Maj D. 2005. Wpływ krzyżowania przemiennego królików rasy białej nowozelandzkiej i kalifornijskiej na użytkowość mięsną [The effect of alternate crossbreeding between New Zealand White and California White rabbits on meat performance]. Doctoral thesis. Kraków: UR in Kraków [in Polish].

Niedźwiadek S. 1981. Zasady hodowli królików [Principles of rabbit breeding]. Warsaw: PWRiL [in Polish].

Nowak E. 1971. O rozprzestrzenianiu się zwierząt i jego przyczynach [On the spread of animals and its causes]. Zesz. Nauk. Inst. Ekolog. PAN 3, 1–255 [in Polish].

Nowicki S. 2014. Ocena przydatności aukcyjnej wartości skór w doskonaleniu pokroju lisów pospoltych i polarnych [Evaluation of the usefulness of the auction value of pelts in the improvement of the conformation of common and polar foxes]. Scientific dissertation 470. Poznań: Uniwersytet Przyrodniczy w Poznaniu [in Polish].

Otulakowski G. 2011. Analiza genetyczna i fenotypowa cech pokroju i wskaźników rozrodu wybranych ras królików [Genetic and phenotypic analysis of conformation traits and reproductive indices of selected rabbit breeds]. Doctoral dissertation. Wrocław: Uniwersytet Przyrodniczy we Wrocławiu [in Polish].

Pałka S. 2015. Analiza użutkowości I parametry genetyczne cech jakości mięsa u królików [Performance analysis and genetic parameters of meat quality traits in rabbits]. Doctoral thesis. Kraków: Uniwersytet Rolniczy w Krakowie.

Socha S. 2004. Genetic parameters of size and fur quality in a mink population (*Mustela vision* Sch.). Scientifur 28, 251–253.

Weremczuk D. 2017. Analiza hodowlana cech pokroju królików w fermach reprodukcyjnych [Breeding analysis of conformation traits of rabbits in a reproductive farm]. Master's thesis. Siedlce: UPH in Siedlce.

Zawiślak J., Święcicka N., Bernacka H. 2016. Results of the conformation evaluation of fur-bearing animals bred on Polish farms included in the evaluation of functional and breeding value in the years 2010–2014. Wiad. Zootech., R. LIV, 2, 16–22.

ANALIZA ZMIENNOŚCI CECH POKROJU I SKUTECZNOŚCI PRACY HODOWLANEJ U KRÓLIKÓW RAS TERMONDZKI BIAŁY I POPIELNIAŃSKI BIAŁY

Streszczenie. Celem pracy była ocena i analiza cech pokrojowych oraz efektywności pracy hodowlanej u królików TB i PB na przestrzeni 10 lat. W pracy określona została zmienność cech pokroju w dwóch stadach zwierząt, a także ich odziedziczalność. Ponadto oszacowano trendy fenotypowe cech pokrojowych. Analiza wariancji cech pokroju wykazała, że rok licencji miał statystycznie wysoko istotny wpływ na: masę ciała (wyrażoną w g i pkt.), budowę ciała, typ rasowy, barwę okrywy włosowej i specyficzne cechy rasowe. Płeć i rasa miały statystycznie wysoko istotny wpływ na masę ciała (g) i barwę okrywy włosowej. Ponadto rasa wykazała statystycznie istotny wpływ także na masę ciała w ocenie punktowej. Z kolei ferma statystycznie wysoko istotnie wpływała na: masę ciała (g), budowę ciała, typ rasowy, barwę okrywy włosowej oraz specyficzne cechy rasowe. Analiza cech pokroju wykazała, że pozytywne

oceny uzyskało 97,9% królików, a zdyskwalifikowano 2,1%. Ocenie poddawano wyłącznie osobniki przeznaczone na remont stada. Podsumowując wyniki analizy cech pokroju, należy stwierdzić, że króliki, które utrzymywane były na badanych fermach, poddane zostały prawidłowej selekcji. Zwierzęta charakteryzowały się bardzo dobrymi cechami pokroju. W świetle badań własnych stwierdzono, że hodowla królików w obu badanych fermach, prowadzona była w sposób prawidłowy, a uzyskane wyniki są zadowalające, zarówno pod względem cech reprodukcyjnych, jak i pokrojowych.

Słowa kluczowe: królik, termondzki biały, popielniański biały, cechy pokroju, zmienność, odziedziczalność, efektywność hodowli.