

Heritability of some productive traits in animals from Ile de France sheep breed

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Abstract

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The purpose of the present study was to determine the heritability of some productive traits in sheep of Ile de France breed. The study was conducted with 369 ewes and 473 lambs of Ile de France breed for the period 2016–2020, bred at the Experimental Base of the Institute of Animal Science – Kostinbrod. Biological fecundity was determined as the ratio of the litter size, stillbirths and aborted lambs to the number of lambing ewes. Live weights were measured at birth, at 10 days, at 30 days and at 70 days, with a deviation of ± 2 days. The information was processed using the methods of variational statistics. A variance analysis was performed using ANOVA model, significance of the effect of the factor was determined by the values of Fisher's F-criterion, and the significance of the differences between the studied groups – by the Student's t-test, with the statistical software Data Analysis, Excel 2021, Microsoft. The coefficients of the heritability of the studied productive traits were estimated. A significant effect of the year of lambing $F = 2.725^*$ on biological fecundity and the year of birth on the live weight at birth $F = 5.721^{***}$, at 10 days $F = 23.875^{***}$, at 30 days $F = 14.363^{***}$ and at 70 days of age $F = 44.715^{***}$ was found. The average fecundity of the ewes was 154%. There were statistically significant differences for the average live weight of lambs at different stages of development depending on the year of birth. Estimated heritability values for biological fecundity $h^2 = 0.03^*$ and live weight at birth $h^2 = 0.05^{***}$, at 10 days $h^2 = 0.18^{***}$, at 30 days $h^2 = 0.12^{***}$, and at 70 days of age $h^2 = 0.30^{***}$ were from low to average.

Keywords: Ile de France sheep breed; fecundity; live weight; heritability

Introduction

Ile de France sheep breed is directed to meat and wool production. The process of its creation began at the beginning of the 30s of the 19th century in France, by crossing ewes of the French Rambouillet breed with Dikley-Leisster rams imported from England. The purpose of the targeted selection was to obtain offspring with good meat yield and fine wool. The good adaptive capability of animals of this breed, as well as the good combination of their biological qualities with economic efficiency, makes Ile de France one of the most widespread sheep breeds in the world. In 1968 for

the very first time were imported 94 sheep and 21 rams in Bulgaria. The Breeding Association for Ile de France breed in Bulgaria reported that for 2022, total number of controlled animals were 8149 sheep and 323 rams bred in 58 farms.

A significant number of Bulgarian authors studied the characteristics of Ile de France sheep breed productive traits and the possibilities of its crossing with other Bulgarian breeds (Achkanova et al., 2019; Ivanova et al., 2015, 2017, 2018; Laleva et al., 2006, 2007, 2021; Raicheva et al. al., 2005, 2010; Slavov, 2007, 2008). Increasing the productivity of animals is essential for every branch of animal husbandry. Live weight is an important parameter for all

types of productivity direction. It is directly related to the main reproductive indicator fecundity. Fecundity not only determines productivity in sheep breeding, but is also a major factor related to economic efficiency regardless of the productive direction. The individual fecundity of animals is determined by litter size, and this factor is influenced both by the effect of the environment and by the genetic potential of the animals. The factors influencing the phenotypic traits in sheep are of hereditary, non-hereditary (external environment) nature, and they usually act simultaneously, and it is difficult to determine the degree of influence of each of them. Establishing the genetic structure of animals and the dynamics of the heritability of their productive characteristics would allow more effective management of the selection (Márquez et al., 2012; Stratz et al., 2018).

The aim of the present study was to establish the heritability of some productive traits in sheep of Ile de France breed.

Materials and Methods

The present study was conducted with 369 ewes and 473 lambs of the Ile de France breed for the period 2016–2020, bred at the Experimental Base of the Institute of Animal Science – Kostinbrod. Main productive traits – biological fecundity and live weight at different stages of development of lambs to 70 day after birth were established depending on the year of lambing of ewes and the year of birth of lambs. Biological fecundity was determined as the ratio of the number of live births, stillbirths and aborted lambs to the number of lambed ewes. Live weights were measured at birth, at 10 days, at 30 days and at 70 days, with a deviation of ± 2 days.

The data was processed using the methods of variational statistics. A variance analysis was performed using the ANOVA model, the significance of the effect of the factor was determined by the values of Fisher's F-criterion, and the significance of the differences between the studied groups – by the Student's t-test, with the statistical software Data Analysis, Excel 2021, Microsoft. The coefficients of the heritability of the studied productive traits were estimated.

Results and Discussion

A characterization of biological fecundity was made for five consecutive years of lambing (Table 1). The average fecundity of ewes was 154%, and it varied between 138% and 164%, with a high coefficient of variation (39.28%).

It was found a statistically significant effect of year of lambing ($F = 2.725^*$) on the biological fecundity in the studied ewes.

Table 1. Biological fecundity of Ile de France sheep

№	Year of lambing	Biological fecundity (lambs per ewes)			
		n	x	SE	CV%
1	2016	67	1.64	0.073	36.27
2	2017	80	1.60	0.068	37.99
3	2018	58	1.64	0.080	37.41
4	2019	76	1.53	0.081	45.98
5	2020	88	1.38	0.052	35.41
Total		369	1.54	0.032	39.28
F		2.725 *			
Significance		5 < 1**, 5 < 2**, 5 < 3 **			

Note: Significance ** – $P \leq 0.01$; * – $P \leq 0.05$

The results in the present study were in similar range of those reported by Metodiev & Raicheva (2008) for fecundity variation (between 134.61% – 188.46%) in their study on the effect of age in purebred Ile de France sheep. Laleva et al. (2007) and Kleeman & Walker (2005) announced for similar data in meat sheep breeds.

Metodiev et al. (2010) conducted a study on the fecundity and the sex cycle activity in sheep from the herd of Ile de France sheep from the Institute of Animal Science-Kostinbrod. The results were similar to the present study (fecundity was 156%). The same author reported 166.66% fecundity for the same herd with early insemination (Metodiev, 2015). In other study of Metodiev (2021) on the effect of the year on fecundity, the author found values between 110% – 182.35%.

The year of birth had a highly significant effect ($P \leq 0.001$) on the live weight at birth, at 10 days, at 30 days and at 70 days of age (Table 2).

The results for the live weight of the lambs of different ages during the five consecutive years were analyzed (Table 2). The birth weight was found to be significantly lower in 2018 compared to 2016, 2017, and 2020 ($P \leq 0.01$, $P \leq 0.001$), as well as significantly higher live weight in 2016 compared to 2019 ($P \leq 0.05$).

Live weight of lambs at 10 days of age was significantly higher in 2017 ($P \leq 0.01$, $P \leq 0.001$) and significantly lower in 2018 ($P \leq 0.01$, $P \leq 0.001$). In 2020, ten-day-old lambs significantly outweighed those born in 2016 ($P \leq 0.001$) (Table 2).

Results of the live weight at 30 days of age showed that lambs born in 2016 and 2017 were found to be lighter than those born in 2018, 2019 and 2020 ($P \leq 0.01$, $P \leq 0.001$) (Table 2).

The live weight of lambs at 70 days of age, which was also the live weight at weaning for Ile de France breed in the studied flock, was significantly lower in 2016 and 2017 ($P \leq 0.001$) (Table 2).

In a publication by Ivanova and Raicheva (2015), including information for the period 2004–2008 of animals from

Table 2. Live weight of Ile de France sheep, kg

№	Year of birth	Live weight at birth				Live weight at 10 days				Live weight at 30 days				Live weight at 70 days			
		n	x	SE	CV%	n	x	SE	CV%	n	x	SE	CV%	n	x	SE	CV%
1	2016	110	4.566	0.079	18.08	107	6.459	0.095	15.26	107	11.110	0.118	11.01	107	21.905	0.139	6.58
2	2017	127	4.548	0.080	19.90	120	7.280	0.100	15.00	117	11.357	0.188	17.89	97	22.949	0.145	6.22
3	2018	93	4.113	0.078	18.39	87	6.097	0.077	11.82	84	12.245	0.154	11.56	83	24.787	0.272	10.01
4	2019	22	4.168	0.049	5.56	21	6.600	0.119	8.23	21	12.771	0.501	17.99	21	24.710	0.619	11.49
5	2020	121	4.431	0.068	16.94	115	6.872	0.081	12.59	112	12.270	0.095	8.15	111	24.379	0.129	5.59
Total		473	4.419	0.037	18.44	450	6.720	0.048	15.10	441	11.766	0.077	13.77	419	23.514	0.103	8.93
F		5.721***				23.875***				14.363***				44.715***			
Sig-nificance		1 > 3***; 1 > 4*; 2 > 3***; 5 > 3**				2 > 1***; 1 > 3**; 5 > 1***; 2 > 3***; 2 > 4**; 2 > 5***; 4 > 3**; 5 > 3***				3 > 1***; 4 > 1***; 5 > 1***; 3 > 2***; 4 > 2**; 5 > 2***				2 > 1***; 3 > 1***; 4 > 1***; 5 > 1***; 3 > 2***; 4 > 2***; 5 > 2***			

Note: Significance *** – $P \leq 0.001$; ** – $P \leq 0.01$; * – $P \leq 0.05$

the studied flock, female lambs had an average live weight as follows: 4.58 kg – 5.28 kg at birth, at 10 days of age – 7.29 kg – 8.41 kg, on the 30th day – between 12.26 kg and 14.92 kg, at 70 days of age – 22.19 kg – 27.57 kg. For male lambs, the values of the average live weight were: at birth – from 4.65 kg to 5.29 kg, on the 10th day – between 7.08 kg and 8.67 kg, at 30 days of age – 11.6 kg – 15.15 kg, at weaning (at 70th day) – 22.16 kg – 28.8 kg.

At the next stage of the herd's development (2009-2015), the live weight of female lambs was within the limits: at 10 days of age – 6.87 kg – 8.20 kg, on the 30th day of lambing – between 11.26 kg and 14.13 kg, at 70th day (at weaning) – 21.22 kg – 24.75 kg, (Ivanova & Raicheva, 2018). The live weight of male lambs was: 7.45 kg – 8.71 kg on the 10th day, on the 30th day – between 11.77 kg and 14.41 kg, at 70 days of age – from 21.47 kg to 25.49 kg.

The results for the period 2011–2015 of the study of the live weight of female lambs raised in Agricultural Institute – Stara Zagora, reported by Laleva et al. (2020), were: at birth – 3.802 kg, on the 10th day – 6.996 kg, on the 30th day 11.515 kg, on the 70th day – 22.199 kg.

During period 2008–2016 in a study of Ile de France sheep controlled by the Ile de France Breeding Association in Bulgaria, Achkakanova & Staykova (2019) reported lamb weight values as follows: 4.564 kg live weight at birth, 15.049 kg – at 30 days of age and 24.137 kg – at 70 days of age. The authors concluded that, according to the obtained data, the breed had been successfully adapted and, under good conditions of feeding and growing, could realize its full productive potential in the conditions of Bulgaria.

Heritability values for the studied productive indicators were presented on Table 3. For the studied period, a low value for the heritability of the biological fecundity was found ($h^2 = 0.03^*$). Laleva et al. (2021) found higher h^2 values for fecundity in two Ile de France herds, 0.20 and 0.29, respec-

tively. Baelden et al. (2005), based on data from the French National performance recording scheme (French National database), determined the fecundity h^2 values in herds of the same breed reared in France reported values for fecundity heritability of first, second and third lambing 0.10, 0.08 and 0.09 respectively.

Table 3. Heritability (h^2) of productive traits of Ile de France sheep

Trait	n	h^2
Biological fecundity	369	0.03*
Live weight		
at birth	473	0.05***
at 10 days	450	0.18***
at 30 days	441	0.12***
at 70 days	419	0.30***

Note: Significance *** – $P \leq 0.001$; ** – $P \leq 0.01$; * – $P \leq 0.05$

Regarding the heritability of the live weight, statistically significant values were found with low h^2 at birth, at 10 days and at 30 days of age ($h^2 = 0.05$; $h^2 = 0.18$ and $h^2 = 0.12$) and at 70 days of age ($h^2 = 0.30$) (Table 3). The results in the present study were comparable to those of Boikovski et al. (2001), Cobo et al. (2021), Laleva et al. (2021), Slavov et al. (2008), Stancheva (2013) and Stancheva et al. (2005). According to Stancheva (2013), the low heritability could be associated with the conservatism of the studied traits, the intensive selection carried out before the first mating and the predominant influence of environmental conditions. A similar conclusion was stated by Laleva et al. (2021). The authors indicated that they observe statistically non significant and low values of heritability, repeatability and genetic correlations of the analyzed fecundity and live weight. According to them, this was an indicator of low genetic variation and a more significant influence of environmental factors, which suggests a low efficiency of mass selection by phenotype.

Conclusions

The following conclusions could be drawn by the current study.

A statistically significant effect of the year of lambing $F = 2.725^*$ on the biological fecundity and the year of birth on the live weight at birth $F = 5.721^{***}$, at 10 days $F = 23.875^{***}$, at 30 days $F = 14.363^{***}$ and at 70 days of age $F = 44.715^{***}$ was found ($P \leq 0.001$).

The average fecundity of the ewes was 154%.

There were statistically significant differences ($P \leq 0.001$; $P \leq 0.01$; $P \leq 0.05$) for the average live weight of lambs at birth, at 10 days, at 30 days and at 70 days of age depending on the year of birth.

Estimated heritability values for biological fecundity $h^2 = 0.03^*$ and live weight at birth $h^2 = 0.05^{***}$, at 10 days $h^2 = 0.18^{***}$, at 30 days $h^2 = 0.12^{***}$, and at 70 days of age $h^2 = 0.30^{***}$ were from low to average ($P \leq 0.001$; $P \leq 0.05$).

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