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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Ovulation rate and prolificacy in Booroola × Olkuska crossbred ewes

Józef Klewiec[1], Elżbieta Martyniuk[2]
Mirosław Gabryszuk[1], Antoni Baranowski[1]

[1] Polish Academy of Sciences Institute of Genetics and Animal Breeding, Jastrzębiec, 05-552 Wólka Kosowska, Poland

[2] Department of Genetics and Animal Breeding, Warsaw Agricultural University, Ciszewskiego 8, 02-786 Warsaw, Poland

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The study presents a comparison of ovulation rate (CL number) and litter size between pure Booroola (BB) and their reciprocal crosses (F_1 and F_2) with Olkuska sheep. As these breeds express a high reproduction potential and in the same time differ significantly in other performance traits affecting lamb production, it was assumed that their crosses might combine beneficial characteristics of both. When the total numbers of CL were analysed the ovulation rate in BB appeared by 0.6 higher ($P \leq 0.002$) than in crossbred ewes (F_1 and F_2 pooled). However, no such difference was ascertained when analysing the maximum CL numbers. Ovulation rate and litter size did not differ between F_1 and F_2 crossbred ewes.

KEY WORDS: Booroola / crossing / Olkuska sheep / litter size / ovulation rate / sheep

Booroola rams when used in a two-step commercial crossing with low-prolific maternal local sheep breeds significantly increase (by about 60%) litter size in their F1 daughters. However, distribution of litter size is unfavourable as the share of litters with three and more lambs reaches as much as 24% [Klewiec and Gabryszuk 1996] accompanied by lamb mortality up to 22% [Klewiec and Baranowski 1999]. The high litter size in Booroola is determined by a single gene $FecB^B$ of a major effect, increasing ovulation rate [Davis *et al*. 2002].

Body weight in the prime lambs sharing the Booroola genotype is by 15-18% lower than in Polish Merino lambs. Lower is also their dressing percentage but higher overall fat content of carcass. Lower body weight in Booroola crosses results from a low body weight of pure Booroola adults. The negative impact of Booroola on meat production traits in crossbred lambs is reduced only when crosses share 50% of Suffolk genes [Janiuk *et al*. 1998].

Another advantage of using Booroolas in commercial crossing of sheep is their non-seasonality of reproduction.

The other highly prolific breed used in the two-step commercial crossing is the Polish native Olkuska sheep that reaches maturity at the age of 9-10 months. A single gene of a major effect on ovulation rate in Olkuska sheep is different from that revealed in Booroola [Martyniuk and Radomska 1991, Martyniuk 1996]. Olkuska sheep kept in small private flocks are extremely well adapted to roughage and show high milk yield that supports rearing of multiple litters. The mature ewes reach body weight of 63 kg [Martyniuk 1996]. However, Olkuska sheep do not feel well in large flocks, exhibits a marked breeding seasonality and is quite susceptible to respiratory tract diseases.

Considering the above, Booroola × Olkuska crossing seemed reasonable, to combine valuable traits of both breeds. It was expected that Booroola × Olkuska rams will transfer the major prolificacy gene to their progeny either from Booroola or Olkuska breed, and that the resulting crossbred lambs will exhibit higher growth rate and better meat performance than pure Booroola lambs.

Material and methods

The investigation was carried out in the years 1995-2001 on the sheep farm belonging to the Institute of Genetics and Animal Breeding, Jastrzębiec. The Booroola flock was established there through importation of Booroola embryos from New Zealand in 1988 [Klewiec *et al*. 1991]. Olkuska sheep were purchased at the age of 4-7 years from highly prolific flocks belonging to small farmers in the Olkusz region, taking into account their high lifetime prolificacy and encouraging pedigree information.

The F_1 Booroola × Olkuska ewes were obtained from reciprocal crossing of 30 Booroola ewes with two Olkuska rams and 12 Olkuska ewes with six Booroola rams. The Booroola ewes had ovulation rate recorded in their first breeding season at the age of 18 months. The F_2 generation was obtained by *inter se* mating of F_1 crosses.

This study was based on analysis of ovulation rate and litter size records of 46 pure Booroola ewes and 73 Booroola × Olkuska crosses including the comparison of 22 F_1 and 40 F_2 contemporaries.

Pure Booroola and F_1 and F_2 ewes were mated first time in the August-September, at the age of 18 months. The laparoscopy was conducted within 6-10 days after appearing of first oestrus. The lambs were weaned at the age of 8 weeks. All sheep were fed traditional diet, with daily pasturing during the grazing season with constant access to mineral supplements.

The number of laparoscopies in single female depended on the number of *corpora lutea* (CL), and never exceeded three. If in a given female five or more CL were observed at the first recording, the ewe was not recorded again. In case of ewes that expressed ovulation rate lower than 5 the recording was repeated in the next two oestrus cycles. The analyses were carried out based on either the total number of CL observed in all recordings (approach I) or the maximum CL observed in each ewe (approach II). For example, if the ewe had 2, 3 and 3 CL recorded in consecutive cycles, the analysis according to approach II was based on her maximum ovulation rate, *i.e.* 3.

The litter size was analysed to evaluate the difference between Booroolas and F_1 crosses as well as between crosses F_1 and F_2.

Results and discussion

Table 1 presents the comparison of ovulation rate between pure Booroola and Booroola × Olkuska ewes (F_1 and F_2 pooled). The ovulation rate based on all CL records (approach I) was highly significantly higher in pure Booroola than in Booroola × Olkuska ewes, with the mean difference of 0.6 CL. The mean ovulation rate in Booroola ewes was in agreement with the initial report from this flock [Klewiec and Gabryszuk 1998] where the mean ovulation rate in ewes born from 1989 to 1995 was 4.25 with standard deviation of 1.23, and the maximum CL number of 8. A single ovulation was

Table 1. Ovulation rate in Booroola and Booroola × Olkuska crossbred ewes as evaluated on total vs maximum CL numbers

Effect	Total CL number (approach I)			Maximum CL number (approach II)		
	N^1	LSM	SE	N^2	LSM	SE
Genotype		$P \le 0.002$			$P \le 0.055$	
BB	56	4.49	0.16	46	4.77	0.18
BO	127	3.87	0.13	73	4.33	0.17
Year		$P \le 0.002$			$P \le 0.031$	
1	8	4.13	0.41	5	4.84	0.52
2	15	5.11	0.30	13	5.26	0.32
3	9	4.67	0.39	6	5.02	0.48
4	20	3.95	0.26	12	4.44	0.33
5	35	3.93	0.20	25	4.18	0.23
6	47	3.62	0.18	27	4.09	0.23
7	41	3.83	0.17	31	4.03	0.21

N^1 – number of recorded cycles; N^2 – number of ewes.
BB – pure Booroola ewes.
BO – Booroola × Olkuska ewes (F_1 and F_2 pooled).

never observed in pure Booroola either in present, or the earlier study. It is interesting, that the differences between genotypes when compared on the basis of maximum ovulation rate in each ewe (approach II) appeared only on the border of significance. However, the mean CL count in Booroolas never reached 5, what means that some of Booroola ewes have not met criteria of homozygous genotype. The same was reported by Klewiec and Gabryszuk [1998] where nine out of 28 Booroola ewes did not express ovulation rate of 5 or more. However, the share of homozygous Booroola ewes could be higher than homozygous Olkuska ewes, what may explain the lower ovulation rate in crossbred ewes in comparison with pure Booroolas.

The year effect on ovulation rate was found highly significant or significant, both in Booroola and crossbred ewes. The mean CL number varied between years from 3.6 to 5.1 for all records and from 4.03 to 5.26 for maximum CL recorded (approach I and II, respectively).

Figure 1 and 2 illustrate the distribution of CL number in Booroola and Booroola × Olkuska ewes. When analysed on the basis of a total CL number (approach I, Fig. 1) the share of low ovulation rates (2 and 3) in Booroolas appeared low – 2 and 20%, respectively. The share of low ovulation rates was even lower when evaluated based on maximum CL numbers (approach II, Fig. 2) where no double and less than 10% of triple ovulations appeared. In the crosses, double or triple ovulation shares were found much higher – 17 and 35% according to a total CL (Fig. 1) and 8 and 27% according to a maximum CL numbers (Fig. 2) analysed, respectively.

It is worth to notice that in some crossbred ewes a very high ovulation rates – up to 8 CL – were recorded, what suggested that they might be carriers of two different major genes. While localization and structure of Booroola major effect gene is already

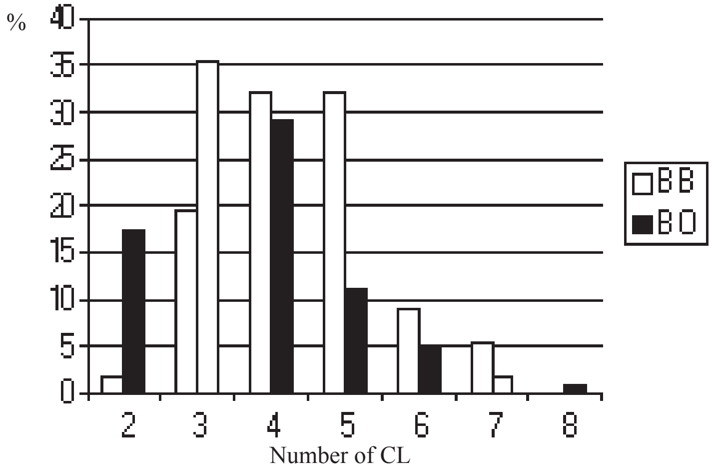

Fig. 1. Distribution of a total CL numbers in pure Booroola and Booroola × Olkuska crosses (approach

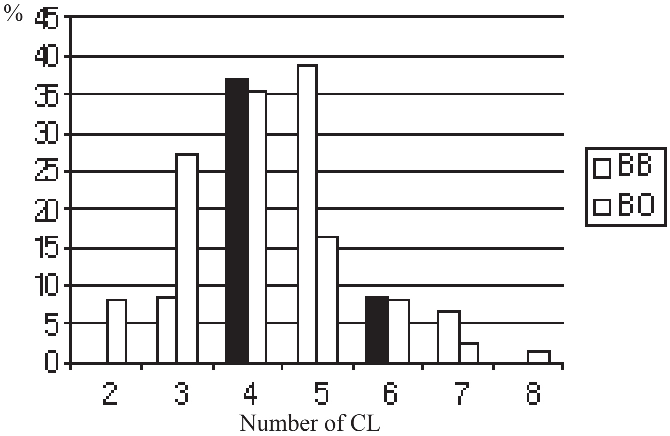

Fig. 2. Distribution of maximum CL numbers in pure Booroola and Booroola × Olkuska crosses (approach II).

known [Wilson *et al*. 2001], the identification of the Olkuska gene is still pending. It was already proved that the mutation in the latter must be different from *FecB*^{B} [Davis *et al*. 2002].

As expected, the differences between F_1 and F_2 crosses were not found significant either with approach I or II (Tab. 2). The latter approach, based on maximum ovulation reached by each ewe, showed the mean CL number just below 4 what means that potential reproductive performance of Booroola × Olkuska crosses exceeds the level commonly used to classify heterozygous Booroola carriers. Although it was proved that high prolificacy in Olkuska sheep is not related to *FecB*^{B}, there is sufficient data supporting the hypothesis of the presence of a major gene in the former (Martyniuk, unpublished data). The present study shows that in Booroola × Olkuska ewes ovulation rate potential exceeds that determined by a single *FecB*^{B} inherited from Booroola.

The effect of year of recording was not statistically ascertained, the maximum difference in the CL number between years was 0.62 and 0.49 according to analytical approach I and II, respectively.

The surprising result appeared from comparison of Booroola with crossbred ewes relating to prolificacy (Tab. 3). In spite of ovulation rate being higher by 0.62 in Booroolas, their mean litter size was lower by 0.26 total lambs born ($P \leq 0.08$). The possible explanation may be related to the fact that Booroola flock was small and maintained without any external genetic influences since 1989. Moreover, all embryos originally imported from New Zealand descended from two sires and eight dams only [Klewiec *et al*. 1991]. In spite of using very narrow polygamy ratio (four to six ewes per ram), the inbreeding level in the flock continuously increased.

In sheep, an embryo survival decreases with the increased ovulation rate [Hanra-

Table 2. Ovulation rate in Booroola × Olkuska crossbred ewes in generations F_1 and F_2 as evaluated on total *vs* maximum CL numbers

Effect	Total CL number (approach I)			Maximum CL number (approach II)		
	N^1	LSM	SE	N^2	LSM	SE
Generation		$P \leq 0.479$			$P \leq 0.719$	
F_1	43	3.43	0.18	22	3.83	0.29
F_2	63	3.61	0.18	40	3.98	0.25
Year		$P \leq 0.300$			$P \leq 0.841$	
1	12	3.81	0.35	8	4.18	0.48
2	23	3.69	0.25	15	4.01	0.33
3	36	3.17	0.20	19	3.69	0.32
4	35	3.41	0.22	20	3.74	0.33

N^1 – number of recorded cycles; N^2 – number of ewes.

Table 3. Litter size in Booroola and Booroola × Olkuska crossbred ewes

Effect	N	LSM	SE
Genotype		$P \leq 0.078$	
BB	77	2.33	0.12
BO	119	2.59	0.10
Lambing		$P \leq 0.439$	
1	72	2.27	0.12
2	67	2.47	0.12
3	33	2.53	0.17
4	24	2.58	0.20

BB – pure Booroola ewes.
BO – Booroola × Olkuska ewes (F_1 and F_1 pooled).

han 1982, Hanrahan and Quirke 1985]. In the present study the ovulation rate of 5 and more was recorded in 54% cycles of Booroolas while in only 29% cycles of crossbreds (Fig. 1 and 2).

It should also be noticed that Olkuska sheep because of its bigger frame and higher body weight may provide a better maternal environment for developing embryos. Klewiec *et al*. [2002] reported that the mean body weight before mating season reaches 43 kg in adult Booroola ewes, 55 kg in F_1 (Booroola dam × Olkuska sire), 58 kg in F_1

(Olkuska dam × Booroola sire) and 63 kg in pure Olkuska ewes. Possible heterosis effect, both maternal and individual, could also positively contribute to increased embryo survival in crossbred ewes.

As it is shown in Table 3, the litter size in crosses increased from 2.3 in primiparas to 2.6 in ewes lambing for the fourth time.

Table 4 presents a comparison of a litter size in F_1 and F_2 crosses in their first, second and third lambing season. The mean litter size in F_1 and F_2 ewes was exactly the same, the number of lambs born increasing in consecutive lambings. However, probably due to the low sample size the differences between lambings were not statistically ascertained.

Table 4. Litter size in Booroola × Olkuska crossbreds in successive lambings

Effect	N	LSM	SE
Generation		$P \leq 0.984$	
F1	72	2.57	0.12
F2	35	2.57	0.18
Lambing		$P \leq 0.595$	
1	45	2.47	0.15
2	43	2.51	0.15
3	19	2.74	0.23

Distribution of litter size was more beneficial in Booroola × Olkuska crossbreds than in pure Booroolas because of the lower share of single births in the former (Fig. 3).

Concluding, Booroola × Olkuska crossbred ewes in spite of their lower ovulation rate showed the litter size significantly higher than that in pure Booroolas. The crosses better utilized their reproduction potential and exhibited higher prolificacy. Their better overall reproduction results could be assigned to higher body weight reported in

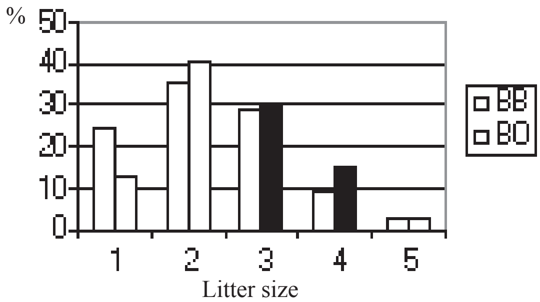

Fig. 3. Distribution of litter size in pure Booroola and Booroola × Olkuska crosses.

earlier studies, as well as possible decreased losses in early pregnancy resulting from lower ovulation rate and also eventual heterosis. Comparison of F_1 with F_2 generation of crossbred ewes showed stable level both of ovulation rate and litter size.

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Józef Klewiec, Elżbieta Martyniuk,
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Poziom owulacji i plenności maciorek mieszańców owcy booroola z owcą olkuską

S t r e s z c z e n i e

Mieszańce F_1 owcy booroola (BB) z owcą olkuską (O) – BO – uzyskano z obukierunkowego krzyżowania 30 maciorek BB z dwoma trykami O i 12 maciorek O z sześcioma trykami BB. Pokolenie F_2 pochodziło z kojarzenia $F_1 \times F_2$. Analizowano poziom owulacji i plenność 46 maciorek BB i 73 maciorek BO, uwzględniając 22 maciorki F_1 i 40 maciorek F_2. Łączna liczba ciałek żółtych maciorek BB była wyższa o 0,6 ($P \leq 0{,}002$) niż stwierdzona u mieszańców F_1 i F_2. Natomiast nie udowodniono różnicy w maksymalnej liczbie ciałek żółtych. Plenność maciorek BB i BO była na jednakowym poziomie. Nie stwierdzono różnic w poziomie owulacji i plenności między maciorkami F_1 a F_2.