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The synthetic WROBER line – effect of the mating system on reproductive parameters and production of slaughter lambs

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The aim of the study was to compare two mating systems and their impact on reproductive parameters in sheep of the synthetic WROBER line and to evaluate the profitability of lamb meat production. Sheep were raised at the Agricultural Experimental Station in Żelazna (Warsaw University of Life Sciences) in a traditional system with mating once a year and at the Werbkowice Experimental Farm (Institute of Soil Science and Plant Cultivation – National Research Institute) in an intensified system with a shortened lambing interval. The study confirmed the suitability of the WROBER line for intensive production of slaughter lambs. In this system, 0.5 more lambs were obtained per ewe (in all seasons) than in the traditional system. Due to the increased number of lambs produced, the WROBER line can become more profitable.

KEY WORDS: WROBER line, reproductive parameters, prolificacy, sheep

Reproduction parameters significantly affect profitability in sheep production, especially with when there is a large decrease in the sheep population (Niżnikowski et al., 2017). A minor increase in the sheep population was not observed until recent years (Polish Union of Sheep Farmers PZOw, 2018). The lack of meat breeds in the domestic sheep population in Poland necessitated improvement of native breeds to meet the needs of the changing market (Niżnikowski et al., 2002). In the past, many attempts were made to create breeds and lines of sheep that would have high prolificacy and good meat characteristics. Examples include the Polish Whiteheaded Mutton and the synthetic BCP and SCP lines, which

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have become permanently established in Polish sheep breeding (Gut, 1994; Gruszecki et al., 2008), as well as the BWP/75 line (Pompa-Roborzyński, 2004). In addition to prolific meat sheep, typical prolific lines and breeds were created that were meant to provide large numbers of lambs, e.g. Merinofin (Borys and Osikowski, 2002) or Koluda sheep (Jarzynowska and Korman, 2010). In some European Union countries (e.g. France and Ireland), a significant proportion of sheep are kept in LFA (less-favoured areas) to reduce the cost of maintaining the flock (Nowakowski, 2017). To this end the WROBER line was created, which is predisposed for use in such areas (Junkuszew et al., 2015; Niżnikowski et al., 2017), is able to give birth to numerous offspring, and has meat characteristics that satisfy the needs of consumers. Thus the WROBER line fills the gap arising from the lack of a sheep with a genotype adapted to the conditions of central Poland (Niżnikowski et al., 2017).

The aim of the study was to compare two mating systems and their effect on reproductive parameters in sheep of the synthetic WROBER line and to evaluate the profitability of meat lamb production.

Material and methods

WROBER line ewes from the Agricultural Experimental Station in Żelazna

Data on three lambings of ewes of the synthetic WROBER line From the Agricultural Experimental Station in Żelazna, belonging to the Warsaw University of Life Sciences (SGGW), were collected in 2016-2018. On this farm, sheep were kept in the pasture during the summer and spent the night in livestock buildings. In the winter they were kept in the fold at all times. Mating was carried out in a traditional system, in which the ewe lambs once a year (Table 1).

Table 1
Number of ewes and lambs of the WROBER line in Żelazna, broken down by generation and gender of lambs

Year of lambing		WROBER line ewes			Offspring of WROBER line ewes		
		F_1	F_2	F_1+F_2	male	female	male + female
2016	n	12	16	28	b.d.	b.d.	39
2017	n	10	25	35	19	27	46
2018	n	3	30	33	30	23	53

n – number of mated ewes; b.d. – no data

WROBER line ewes from the Agricultural Experimental Station in Werbkowice

The WROBER line in Werbkowice was created using Heath Sheep ewes from Żelazna and Berrichon du Cher rams from the flock in Żydowo (Niżnikowski et al., 2017). Pedigrees were used to analyse reproduction results for four lambings, broken down by generations of WROBER ewes. The number of lambing sheep broken down by generation is shown in Table 2. The data concerned the period from February 2016 to April 2018. Sheep in Werbkowice remained in pastures around the clock during the growing season and in livestock buildings in the winter. Rapid change of generations in the flock was a priority, in order to reach the final genotype as quickly as possible. Lambing took place at various times, with a frequency greater than once a year.

The data collected for all WROBER line sheep were used to calculate the mean fertility index, mean number of lambs born per litter, mean number of live lambs on day 7, mean number of weaned lambs, and mean number of lambs born per ewe in all seasons for each flock. For the flock of sheep in Werbkowice, the average lambing interval (days) was calculated as well. Reproductive traits were assessed using multifactorial analysis of variance within flocks, taking into account the effect of the season and generation (F_1 and F_2), as well as flock x generation interactions (which did not prove significant and were not included in the tables). The last part of the results presents reproductive parameters for both flocks, taking into account the generation of sheep (F_1 and F_2). When the season and generation were found to significantly influence the parameters, the differences between pairs of treatments were assessed using the Duncan test (Ruszczyc, 1981). In addition, both flocks were compared in terms of reproductive parameters during the study period, calculated per year (flock in Werbkowice). This enabled assessment of breeding effectiveness and the effect of the flock on

Table 2

Number of ewes and lambs of the WROBER line in Werbkowice, broken down by generation and gender of lambs

Lambing date		WROBER line ewes			Offspring of WROBER line ewes		
		F_1	F_2	F_1+F_2	male	female	male + female
II 2016	n	35	8	43	22	32	54
XII 2016	n	34	8	42	32	26	58
III-IX 2017	n	10	20	30	16	20	36
III-IV 2018	n	–	31	31	19	19	38

n – number of mated ewes

the parameters tested. Calculations were made using the IBM SPSS Statistics package 26.0 (2020). The results are presented as the average of the features obtained by the least squares means (LSM) method and the standard errors (SE).

Results and discussion

Flock at the Agricultural Experimental Station in Żelazna

The reproductive parameters of all sheep kept at the Agricultural Experimental Station in Żelazna are shown in Table 3. Sheep in Żelazna had a fertility rate of 100% in all years. The highest mean number of lambs born per ewe was noted in 2018 (1.78), and the lowest in 2017 (1.35). In 2016, the value of this parameter was intermediate between the other years, without significantly differing from them. In 2018, significantly higher values were found for the mean number of lambs born, the mean number of live lambs on day 7, and the mean number of lambs reared in each season compared to previous years.

Table 3
Reproductive parameters of ewes of the synthetic WROBER line kept in Żelazna in the years 2016-2018

Parameter		Year		
		2016	2017	2018
Mean fertility rate	LSM	1.00	1.00	1.00
	SE	0.00	0.00	0.00
Mean number of lambs born per litter	LSM	1.40^{c}	1.42^{c}	1.78^{ab}
	SE	0.09	0.09	0.14
Mean number of live lambs on d 7	LSM	1.40	1.42	1.73
	SE	0.10	0.09	0.15
Mean number of reared lambs	LSM	1.40^{cb}	1.35^{c}	1.73^{b}
	SE	0.09	0.09	0.15
Mean number of lambs born per ewe in all seasons	LSM	1.40^{cb}	1.35^{c}	1.73^{b}
	SE	0.09	0.09	0.15

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly: a ... c – $P \leq 0.05$

Analysis of the reproduction results of the WROBER synthetic line by generation F_1 or F_2 (Table 4) revealed significantly higher reproduction parameters for the F_1 generation. In this generation, the number of lambs reared exceeded the economic break-even point reported in other works (Milewski, 2010), determined to be 1.5 lambs reared per ewe. In 2016 and 2017, the F_2 generation achieved a lower number of weaned lambs than the break-even point reported by Milewski (2010), while in 2018 the number of reared lambs was close to this indicator.

Flock at the Agricultural Experimental Station in Werbkowice

The reproductive parameters of sheep kept at the Agricultural Experimental Station in Werbkowice are shown in Table 5. The season, genotype and interaction between them (not shown in the tables) had a highly significant or significant effect on the reproduction parameters in this herd. The only exception was the effect of the season on the mean number of lambs born per litter. The lowest values for all features were noted in December 2016,

Table 4
Reproductive parameters of ewes of the synthetic WROBER line kept in Żelazna, broken down by generations F_1 and F_2

Parameter		F_1			F_2		
		2016	2017	2018	2016	2017	2018
Mean fertility rate	LSM	1.00	1.00	1.00	1.00	1.00	1.00
	SE	0.00	0.00	0.00	0.00	0.00	0.00
Mean number of lambs born per litter	LSM	1.67	1.60	2.00	1.13^{C}	1.24^{C}	1.57^{AB}
	SE	0.14	0.15	0.28	0.12	0.10	0.09
Mean number of live lambs on d 7	LSM	1.67	1.60	2.00	1.13^{b}	1.24^{ab}	1.47^{a}
	SE	0.15	0.16	0.29	0.13	0.10	0.09
Mean number of reared lambs	LSM	1.67	1.50	2.00	1.13^{c}	1.20^{c}	1.47^{ab}
	SE	0.14	0.16	0.29	0.13	0.10	0.09
Mean number of lambs born per ewe during the breeding season	LSM	1.67	1.50	2.00	1.13^{c}	1.20^{c}	1.47^{ab}
	SE	0.14	0.16	0.29	0.13	0.10	0.09

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly:
A…C – $P \leq 0.01$; a ... c – $P \leq 0.05$

Table 5
Reproductive parameters of ewes of the synthetic WROBER line kept in Werbkowice

Parameter		2016 February	2016 December	2017	2018
Mean fertility rate	LSM	1.00^{B}	0.88^{A}	1.00^{B}	1.00^{B}
	SE	0.02	0.02	0.02	0.02
Mean number of lambs born per litter	LSM	1.30	1.20	1.30	1.23
	SE	0.09	0.09	0.09	0.08
Mean number of live lambs on d 7	LSM	1.30^{b}	0.99^{a}	1.30^{b}	1.19^{ab}
	SE	0.09	0.09	0.09	0.08
Mean number of reared lambs	LSM	1.30^{b}	0.99^{a}	1.30^{b}	1.19^{ab}
	SE	0.09	0.09	0.09	0.08
Mean number of lambs born per ewe in all seasons	LSM	1.30^{b}	0.99^{a}	1.30^{b}	1.19^{ab}
	SE	0.09	0.09	0.09	0.08

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly:
A…C – $P \leq 0.01$; a ... c – $P \leq 0.05$

compared to other study periods. Achieving the goal of aseasonality in the reproductive cycles of the WROBER line requires further work, especially given that good reproduction results were obtained in the remaining months of the calendar year.

The reproduction results of the WROBER synthetic line ewes by generation (F_1 and F_2) are shown in Table 6. The fertility rate of all ewes was high. Only in December 2016 did ewes of the F_2 generation show a lower fertility rate (90%) than the F_1 generation, for which it was 100% in the same period. The highest average number of lambs born was noted for F_1 ewes in 2017, with an average of 1.60 lambs born per ewe, while the lowest average (0.70) was recorded in the F_2 generation in December 2016. In this lambing, the low fertility of F_2 ewes contributed to a low average number of lambs. F_2 ewes had the highest fertility rates (1.0) in February 2016 and in the years 2017 and 2018, and the lowest in December 2016, with the lowest average number of weaned lambs obtained in this group. F_1 ewes accounted for 81% of the flock in February and December 2016 but only 31% in 2017, and in 2018 there were none. F_2 generation sheep participated in all four lambings. In the first and second they accounted for 19% of the flock, but in 2017 the share of F_2 sheep had increased to 63%, and in 2018 it was 94%.

An attempt was made to shorten the lambing interval for production of meat lambs (Table 7). The first lambing interval was shortened by two months and the second by three

Table 6

Reproductive parameters of ewes of the synthetic WROBER line kept in Werbkowice, broken down by generations F_1 and F_2

Parameter		F_1			F_2			
		2016 February	2016 December	2017	2016 February	2016 December	2017	2018
Mean fertility rate	LSM	1.00	1.00	1.00	1.00	0.90	1.00	1.00
	SE	0.02	0.02	0.03	0.04	0.04	0.02	0.02
Mean number of lambs born per litter	LSM	1.23^{B}	1.53^{Ab}	1.60^{Aa}	1.38^{Ba}	0.70^{Ac}	1.00^{b}	1.23^{Ba}
	SE	0.08	0.08	0.15	0.16	0.16	0.10	0.08
Mean number of live lambs on d 7	LSM	1.23^{a}	1.35^{ab}	1.60^{b}	1.38^{Bc}	0.50^{A}	1.00^{aB}	1.19^{B}
	SE	0.08	0.08	0.14	0.16	0.16	0.10	0.08
Mean number of reared lambs	LSM	1.23^{a}	1.35^{ab}	1.60^{b}	1.38^{Ba}	0.50^{A}	1.00^{bB}	1.19^{B}
	SE	0.08	0.08	0.14	0.16	0.16	0.10	0.08
Mean number of lambs born per ewe during the breeding season	LSM	1.23^{a}	1.35^{ab}	1.60^{b}	1.38^{Bc}	0.50^{A}	1.00^{aB}	1.19^{Bb}
	SE	0.08	0.08	0.14	0.16	0.16	0.10	0.08

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly: A…C – $P \leq 0.01$; a ... c – $P \leq 0.05$

months relative to the traditional interval, whereby lambing takes place every 365 days. The final lambing interval was 360 days, which was close to the number of days in the traditional lambing system.

The average lambing interval for all lambings was two months shorter than in the traditional system, so it can be concluded that lamb production was intensified. Such intensified breeding is consistent with the reproductive traits of the WROBER line progenitors (Niżnikowski, 2002). A shorter lambing interval in WROBER ewes was the intended result (Niżnikowski et al., 2015).

Comparison of results from the Agricultural Experimental Stations in Żelazna and Werbkowice

Table 8 compares reproductive parameters in the flocks in Żelazna and Werbkowice. Analysis of the lambing results in both flocks indicates that all ewes had high fertility.

Table 7
Lambing intervals in the flock in Werbkowice

Dependent variable	Season			
	February 2016 – December 2016	December 2016 – 2017	2017 – 2018	Mean
LSM (days)	296^{A}	255^{B}	360^{C}	304
SE (days)	1.49	3.06	2.22	1.35

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly: A…C – $P \leq 0.01$

Table 8
Comparison of reproductive parameters of ewes of the WROBER line in Werbkowice and Żelazna

Parameter		Flock	
		Werbkowice	Żelazna
Mean fertility rate	LSM	0.98	1.00
	SE	0.01	0.01
Mean number of lambs born per litter	LSM	1.30^{a}	1.53^{b}
	SE	0.04	0.05
Mean number of live lambs on d 7	LSM	1.23^{a}	1.50^{b}
	SE	0.05	0.05
Mean number of reared lambs	LSM	1.23^{a}	1.49^{b}
	SE	0.04	0.05
Mean number of lambs born per ewe in all seasons	LSM	1.20^{a}	1.49^{b}
	SE	0.05	0.05

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly: a ... c – $P \leq 0.05$

The ewes were young, with no sterility. The high fertility of the WROBER ewes indicates that the new line has acquired a high level of fertility from Heath Sheep (Niżnikowski, 2002).

On average, more lambs per ewe in each lambing were obtained for the entire flock in Żelazna than in Werbkowice (Table 8). The average numbers of live lambs on day 7, of weaned lambs, and of lambs obtained in all litters were also higher in Żelazna. The number of reared lambs in WROBER sheep is higher than in the mass population of Heath sheep (Niżnikowski, 2002) and at the same time lower than for Heath sheep in Żelazna (PZOw, 2018). All reproductive parameters for WROBER ewes described in this paper are higher than those reported by Niżnikowski et al. (2015).

In both flocks, ewes of the F_1 generation achieved higher prolificacy than the F_2 generations (Table 9). Ewes from the flock in Żelazna, of both the F_1 and F_2 generations, reared more lambs on average (by 0.34 and 0.13, respectively) than those in Werbkowice.

Another issue to be considered in comparing the flocks in Żelazna and Werbkowice is the overall production of lambs over two years. Table 10 compares reproductive parameters calculated per year. A significantly higher fertility rate was demonstrated for ewes from Werbkowice, due to the intensified breeding system on this farm. The last parameter, i.e. the average number of lambs born per ewe in all seasons, best illustrates how many lambs were born in Werbkowice as a result of shortening the lambing

Table 9

Comparison of reproductive parameters of ewes of the WROBER line in Werbkowice and Żelazna, broken down by generation of ewes, F_1 and F_2

Parameter		Flock			
		Werbkowice		Żelazna	
		F_1	F_2	F_1	F_2
Mean fertility rate	LSM	0.99	0.96	1.00	1.00
	SE	0.01	0.01	0.02	0.01
Mean number of lambs born per litter	LSM	1.41	1.18	1.70	1.37
	SE	0.06	0.06	0.08	0.06
Mean number of live lambs on d 7	LSM	1.33	1.13	1.68	1.32
	SE	0.07	0.06	0.08	0.07
Mean number of reared lambs	LSM	1.33	1.13	1.67	1.30
	SE	0.07	0.06	0.08	0.07
Mean number of lambs born per ewe in all seasons	LSM	1.31	1.08	1.67	1.30
	SE	0.07	0.06	0.08	0.07

Table 10
Comparison of reproductive parameters (per year) of the flocks from Werbkowice and Żelazna

Parameter		Flock	
		Werbkowice	Żelazna
Mean fertility rate	LSM	1.45[a]	1.00[b]
	SE	0.02	0.01
Mean number of lambs born per litter	LSM	1.40	1.50
	SE	0.14	0.06
Mean number of live lambs on d 7	LSM	1.37	1.47
	SE	0.14	0.06
Mean number of reared lambs	LSM	1.37	1.45
	SE	0.14	0.06
Mean number of lambs born per ewe in all seasons	LSM	1.95[a]	1.45[b]
	SE	0.14	0.06

Numerical values in the same row for individual groups with the same superscript letters do not differ significantly: a ... c – $P \leq 0.05$

interval. The result for Werbkowice is on average 0.5 lambs higher than for Żelazna. This suggests that WROBER line sheep in this breeding system are able to match or even surpass the breeding parameters of highly prolific breeds, such as the Koluda sheep (Jarzynowska and Korman, 2010) or the 08 prolific meat sheep (PZOw, 2018).

Profitability of production

Ewes from the WROBER line were kept in two flocks in which different mating systems were used. At the Agricultural Experimental Stations in Żelazna, mating took place once a year. If the break-even point for sheep production is taken to be 1.5 lambs per ewe per year (Milewski, 2010), then it can be concluded that this line borders on economic profitability on this farm. However, comparison of generations shows that ewes from the F_1 generation achieved better results than F_2 ewes.

In the second flock, at the Agricultural Experimental Stations in Werbkowice, sheep were mated in an intensified system, in which the lambing interval was reduced. Reproductive parameters, such as the average number of lambs born and reared in each lambing, were lower than those obtained in Żelazna. However, when the values for the traits were calculated per year, the average number of lambs born per year was shown to surpass

the break-even point for sheep breeding (Milewski, 2010). Therefore, the results confirmed that the WROBER line is useful in the shortened lambing interval system for intensive acquisition of slaughter lambs.

Conclusions

The following conclusions were drawn from the research:

– In the traditional system, breeding of WROBER sheep may not be profitable due to the insufficient level of lamb production.

– The shortened lambing intervals in sheep of the WROBER line led to a profitable level of production of slaughter lambs.

– WROBER ewes, as well as their progenitor, the Heath sheep, are suitable for the production of lambs for fattening in an extended season of sexual activity during the year. This can be exploited by producers to ensure a continuous supply of meat lambs to the market, irrespective of the season.

– Keeping sheep of the WROBER line in the pasture throughout the growing season showed that they are fully adapted to LFA conditions. This is an important factor that may increase interest in the WROBER line among Polish sheep breeders, especially in areas that are currently excluded from agricultural production.

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