

## Factors affecting prolificacy and lambs rearing results in Olkuska sheep population

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**Abstract:** *Factors affecting prolificacy and lambs rearing results in Olkuska sheep population.* The aim of this study was to evaluate reproductive performance of the growing Olkuska sheep population and to analyse impact of a number of factors on lamb rearing results as well as the length of ewes' utilisation in the flock. Although reproductive performance of Olkuska sheep is still at a relatively high level, recently a decrease of average prolificacy and the continuously low percentage of lambs reared have been observed. This might be related to the rapid growth of the population in the recent years and rather short flock-life of ewes, on average 3.17 years. The results of this study confirm that the size of the litter had the highest impact on lamb rearing results. Substantial differences in reproductive performance depending on the age of the dam were also observed. Despite of poor rearing of lambs born in large litters, no significant correlation between the average prolificacy of ewes in the flock and the percentage of lambs being reared was observed. The results indicate that a major influence on lamb rearing performance depends upon individual characteristics of a dam, as well as husbandry conditions in the flock and skills of the breeder.

*Key words:* Olkuska sheep, litter size, lamb rearing

### INTRODUCTION

Olkuska sheep, developed in the early 20<sup>th</sup> century in the Olkusz region, is a native Polish longwool sheep breed.

The breakdown of the sheep sector in the period of 1980s and 1990s resulted in the rapid decrease of the Olkuska sheep population size, down to 100 breeding ewes only. Since 2000, as result of the coordinated efforts undertaken within the genetic resources conservation programme, and especially enhanced financial support to maintain endangered local sheep breeds provided through the Rural Development Programme 2004–2006, the Olkuska sheep population systematically increased and the number of flocks is growing (Sikora 2010).

At present, the population of Olkuska sheep is developing steadily. In 2013, 1550 purebred ewes were registered in the flock books (PZO 2013). Of these, 952 breeding ewes (kept in 50 flocks) have been included in the genetic resources conservation programme (IZ-PIB 2005).

Olkuska sheep are characterised by exceptionally high prolificacy and good maternal abilities. With single lambing per year, the mean litter size of two and over two years old ewes is at least two (IZ-PIB 2005). Such high prolificacy is genetically determined by a single gene of a major effect increasing ovulation rate in carriers (Martyniuk 2009). Recent research has shown that in the

Olkuska sheep population, a novel mutation *FecX<sup>O</sup>* in *BMP15* gene on X chromosome, is segregating (Kaczor 2011; Demars et al. 2013). Contrary to six other known mutations in *BMP15* gene, in Olkuska sheep, the homozygous carriers are fertile and hyperprolific. The litter size in Olkuska sheep ranges from one to seven.

Rearing lambs from large litters puts substantial demands on breeders' time and investment. As a result of the rapid development of Olkuska sheep population and high number of newly established flocks, more farmers, without adequate experience are becoming involved in Olkuska sheep breeding. Given this trend, better understanding of the specific characteristics of reproductive performance of Olkuska sheep is needed to enhance management and further develop the breed.

The aim of this paper was to analyse selected traits of reproductive performance of the breed in the last several years. Due to substantial lamb mortality observed within some flocks, it was also important to evaluate the impacts of various factors on lamb rearing results, and the length of ewes' utilisation within the flock to be able to conduct informed discussion with Olkuska sheep breeders participating in the genetic resources conservation programme.

## MATERIAL AND METHODS

The material used in this study included data on lambings of 1718 Olkuska ewes participating in the reproduction in years 1996–2012. Based on data availability and quality, the lamb rearing results were

analysed only in the years 2003–2012. Two reproductive traits were considered in this study at the flock level:

- Prolificacy, defined as the percentage of all lambs born (alive and dead) of all ewes lambing in the flock;
- Lamb rearing, defined as the percentage of lambs reared out of all lambs being born (alive and dead).

Similarly, reproductive traits analyzed for individual ewes included litter size and percentage of lambs reared.

Data for this study were obtained from various sources: lambing reports since 2007 provided by regional branches of the Polish Union of Sheep-Farmers of Nowy Targ, Opole, Lublin, Warszawa, Malbork, and Poznań; lambing databases of the National Research Institute of Animal Production (since 2002) and breeding documentation obtained directly from Olkuska flocks (Imbramowice and Żelazna since 1996).

The study on relationship between the length of utilisation and the reproductive performance of ewes was conducted on 399 ewes that completed their flock-life and had at least three lambings. In total, 1937 lambing results of 399 ewes were analysed. Out of 399 ewes, 124 ewes had three litters only, 99 four litters, 56 five and 120 six or more litters. A separate analysis was conducted for sheep kept at Warsaw University of Life Sciences – SGGW flock in Żelazna (77 out of 399 ewes).

In order to identify factors having a significant impact on lamb rearing results, data on 10 676 lambs born by 1718 dams were analyzed. Due to the gaps in data, 25 dams from the initial group were eliminated, leaving 1693 ewes for the final analysis. For each

lamb the following data were recorded: year of birth, type of birth (range from 1 to 6 and more), age of dam (range from 1 to 8 and older), herd ID, dam ID, and survival up to 56 days (values 0 or 1).

The reproductive performance of Olkuska ewes belonging to different age classes was analyzed for 1693 ewes. Age categories were determined according to similar age-related reproductive potential of ewes, what reduced data loss to minimum. Litters of ewes older than 7 years accounted for only 5.3% of the data and therefore older ewes were grouped in one category (7–12). The age structure of ewes participating in the lambings was analyzed for 1058 ewes participating in year 2012 reproductive season. Age distribution in 2012 was representative for the last few years.

The relationship between lamb rearing results and mean prolificacy of the dam in individual flocks was estimated

using the sample of flocks (44) with available relevant data for the years 2008–2012.

The Spearman rank correlation test (cor.test, method="Spearman"), linear Pearson correlation test (cor.test, method="Pearson") and the test for equality of proportions based on chi-square statistics (prop.test and pairwise.prop.test with Bonfferoni correction) in R environment (R Development Core Team 2008) were used in statistical analysis.

## RESULTS

The average prolificacy of Olkuska sheep in 2012, was 207% (N = 1058) with lamb rearing at the level of 74.01%. In the period studied, the lamb rearing was in the range of 72.3% (in 2004) to 84.7% (in 2007), while the mean prolificacy was in the range of 208% (2012) to 221% (in 2004) as shown on Figure 1.

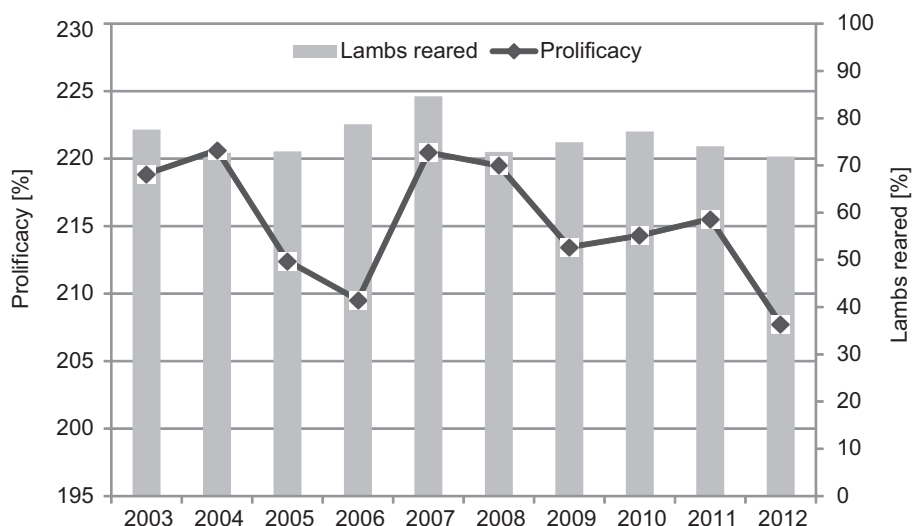


FIGURE 1. Average prolificacy and lambs' rearing percentage in Olkuska sheep flocks in years 2003–2012

The mean reproductive performance in Olkuska ewes increased with age, having the highest values in 4–6 years old ewes (Table 1). The substantially higher prolificacy was observed in 2 or 3 years old ewes (217%) in comparison with 1 year old ones (185%). The increase of average prolificacy in older ewes was mainly due to a higher share of large lit-

ters in this age group. For instance, triplets constituted over 20% of litters in 2 or 3 years old ewes, while in 1 year old ewes, their share was 8.3% only.

Lamb rearing percentage was the highest in ewes between 2 and 6 years old, on average 76% (Table 1). A substantial decline was observed in 7 or more years old ewes, down to 70.5%.

TABLE 1. Mean prolificacy, litter size distribution and lamb rearing results in years 2003–2012 in ewes of different age (N = 1693)

Age of dam [years]	Average prolificacy [%]	Litter size	Litters			Average share of lambs reared [%]
			Number	Share in the flock [%]	Share of lambs reared [%]	
1	185	1	175	25.9	86.9	73.6
		2	438	64.8	74.1	
		3	56	8.3	59.5	
		4	6	0.9	66.7	
		5	1	0.1	40.0	
2–3	217	1	401	16.0	86.3	76.0
		2	1447	57.9	80.4	
		3	532	21.3	71.6	
		4	93	3.7	62.9	
		5	20	0.8	54.0	
		6	5	0.2	16.7	
		7	3	0.1	38.1	
4–6	227	1	209	13.9	90.0	76.0
		2	836	55.4	80.5	
		3	361	23.9	70.4	
		4	70	4.6	70.4	
		5	22	1.5	78.2	
		6	6	0.4	25.0	
		7	4	0.3	35.7	
7–12	228	1	47	18.0	70.2	70.5
		2	128	49.0	77.7	
		3	61	23.4	63.9	
		4	17	6.5	57.4	
		5	7	2.7	82.9	
		6	0	0	0	
		7	1	0.4	42.9	

The age of the dam had significant effect on lamb rearing results, both in case of large litters and in twins and singles. Significant differences were observed:

- in twins and singles ( $p < 0.05$ )
  - between 1, 2–3 and 4–6 years old ewes;
- in litters of three lambs and more ( $p < 0.05$ ) – between 1 and 4–6 years old ewes.

A highly significant relationship (propability test;  $p < 0.01$ ) was observed between the litter size and the number of lambs reared (Table 2). The lamb rearing was rather low in triplets and litters consisting of four or five lambs (69%). The most difficult to rear were lambs born in litters of six or seven, only 28% of them were weaned.

The mean prolificacy and percentage of lambs reared in 44 selected flocks in years 2008–2012 are presented at Figure 2. The average prolificacy in examined flocks ranged between 170 and 312%, while the average percentage of lambs reared was between 33.3 and 92.1%. No significant phenotypic correlation was observed between these two traits ( $+0.039$ ,  $p = 0.703$ ). Among the 44 flocks included in the analysis, there were flocks of relatively low prolificacy for Olkuska breed (192%) and poor rear-

ing results (50.7% only), as well as flocks with outstanding reproduction results (225 and 91.8% respectively) – Figure 2.

The average length of ewe utilisation in the flock estimated on the basis of a sample of 399 ewes was rather short, with a high standard deviation, indicating substantial differences between individual dams ( $3.17 \pm 1.64$ ). It has to be underlined that a high share of young ewes was observed in the examined flocks.

The age structure of ewes participating in the lambing in 2012 ( $N = 1058$ ) is presented at Figure 3. Due to the early maturity of Olkuska breed and good husbandry conditions, some flocks used to practice an early lambing, therefore a small share (10.9%) of 1 year old ewes was observed in lambing in 2012. The highest contribution to 2012 lambing had ewes 2, 3 and 4 years old (20.0, 18.5 and 20.6% respectively), while only 28.1% of all litters were born by older ewes.

A significant relationship between mean litter size and a maximum litter size of ewes and the length of their utilisation in a flock was observed for the whole population of the Olkuska sheep (Table 3). However, such relationship was not significant for the Żelazna flock, probably due to the small sample size. In opposition to the rest of the population,

TABLE 2. Lamb rearing results in litters of 1–7 lambs

Specification	Litter size							Total
	1	2	3	4	5	6	7	
Number of lambs born	832	5 698	3 030	744	250	66	56	10 676
Number of lambs reared	719	4 520	2 121	486	171	14	21	8 052
Share of lambs reared [%]	86.4 <sup>A</sup>	79.3 <sup>B</sup>	70.0 <sup>C</sup>	65.3 <sup>C</sup>	68.4 <sup>C</sup>	21.2 <sup>D</sup>	37.5 <sup>D</sup>	75.4

Groups with different letters (A, B, C, D) have highly significant differences in the percentage of lambs reared.

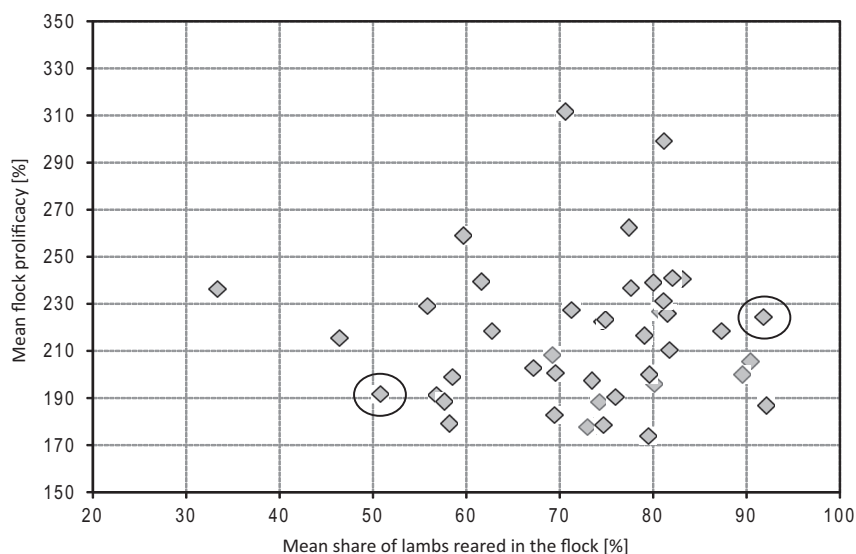


FIGURE 2. Mean prolificacy and % of lambs reared in selected 44 flocks of Olkuska sheep. Circles represent flocks, in which rearing of lambs is very high or very low despite their similar prolificacy level

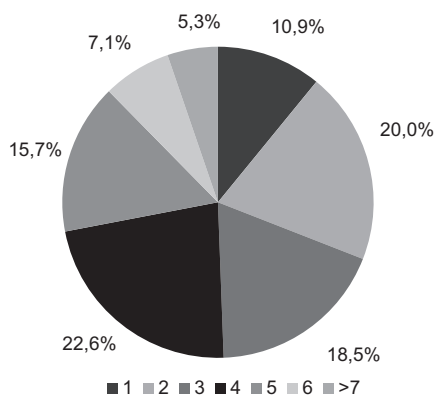


FIGURE 3. The age structure of ewes participating in the lambing in 2012 (N = 1058)

TABLE 3. The Spearman rank correlation coefficient between length of ewe utilisation on the flock and mean and maximum litters size and mean lamb rearing

Specification	Correlation coefficient		
	Population (N = 322)	RZD Żelazna (N = 77)	Total (N = 399)
A length of ewe utilisation in the flock and mean litter size	+0.134 <sup>a</sup>	+0.218	+0.149 <sup>b</sup>
maximum litter size	+0.347 <sup>b</sup>	+0.193	+0.317 <sup>b</sup>
mean share of lambs reared [%]	+0.006	+0.315 <sup>b</sup>	+0.068

<sup>a</sup> Significant (<0.05), <sup>b</sup> highly significant correlation (<0.01).

positive correlation between lamb rearing results and the length of ewes' utilisation was observed in Żelazna flock (+0.315;  $p < 0.01$ ).

## DISCUSSION

Olkuska sheep is a breed of high reproductive potential and good maternal abilities, which combined with breeders' experience and knowledge, enable rearing lambs from numerous litters. The average prolificacy of Olkuska ewes in the analyzed period of 2003–2012 was significantly higher than the minimum level, set in the breed standard. However, in recent years, a slight decrease in the average litter size was observed. High variation in prolificacy levels between years and the clear downward trend was also reported by Piwczyński et al. (2013). In 2012, the average prolificacy of Olkuska ewes was the lowest of all analyzed years, amounting to 208%; also a percentage of lambs reared remained at a relatively low level. These results may be associated with a high proportion of primiparous ewes in the population (30.9% in 2012; Fig. 3), as well as a higher share in the recent years of breeding rams that were not carriers of the *FecX<sup>O</sup>* gene. A frequency of the *FecX<sup>O</sup>* gene in the population, regional distribution of the gene carriers, as well as its effect on litter size and other reproductive traits, requires further research.

The significant correlation between the average prolificacy and maximum litter size of ewes and the length of their utilization in the flock could indicate that breeders prefer to keep more prolific ewes longer in the flock. However, it should be also noted that the age related physiological increase of the litter size

could have contributed to this relationship. In Żelazna flock, in the opposition to the rest of the population the length of ewes' flock-life was most affected by their performance in lambs' rearing. This trend is in line with flock management strategy, to cull dams that have poor lamb rearing results.

The relationships between litter size and survival of lambs were studied in a number of prolific sheep breeds (Fogarty et al. 2000; Kleemann and Walker 2005; Gootwine et al. 2008). In studies conducted by Gootwine et al. (2008) lamb survival at birth in Awassi and Asaf breeds was 98, 92, 86, 78 and 65% for litters consisting of respectively of a single lamb, twins, triplets, quadruplets and quintuplets. Also, in previous studies on Olkuska sheep, a high mortality at birth and poor lamb rearing were observed in litters consisting of many lambs. In Drozdy flock (Klewiec and Baranowski 1999), 7% of still born lambs were observed in twins, 14% in litters of triplets and 25% in quadruplets. High lamb losses were also reported during the rearing period. On average, in this flock, 1.4 lambs and were weaned from twin litters and 1.1 lambs from triplet litters at the age of 56 days.

Rearing results in Olkuska sheep is also influenced by the age of dams, however, the impact of this factor is much smaller than the litter size. It should be underlined, that poor rearing results observed in this study can be attributed to a large share of primiparous in the current population of Olkuska sheep. The average length of utilisation of ewes in the flock, only a little over 3 years, is shorter than recommended. The average flock-life, about 5 years, would be most beneficial to farmers. The present low

flock-life may be associated with the dynamic development of the Olkuska sheep population, a large number of newly established flocks and resulting exchange of adult females between farmers. The number of flocks participating in the sheep genetic resources conservation programme has increased from 10 to 50 in the period 2005–2013.

Analysis conducted in the selected 44 flocks indicated high differences both in the level of prolificacy, as well as the percentage of lambs reared among flocks. Despite the high effect of litter size on the success of lambs' rearing, and thus the strong relationship between dam prolificacy and lamb rearing results, no significant correlation was observed between the average prolificacy of ewes in the flock, and the percentage of lambs being reared. This result indicates the importance of individual maternal abilities of the ewes and quality of husbandry conditions provided individual flocks. The flock effect is a combination of a number of factors, such as the overall husbandry conditions, nutrition and animal welfare; and most of all engagement, experience and the skills of a breeder. Management of a flock of such a high prolificacy, as observed in the case of Olkuska breed, requires greater efforts than in the case of the majority of Polish sheep breeds which have an average litter size not exceeding 1.50. It is recommended that beginner breeders, start from a lower level of flock prolificacy, and with increased knowledge and experience, select their flocks towards reaching the full potential of fecundity offered by Olkuska sheep breed (Smętek and Korczyński 2010).

In light of the establishment of a large number of new flocks and the high differences in performance among individual flocks, it becomes particularly important to ensure that breeders have access to the most complete information about the breeding material. Genotyping of all rams available for sale to make sure if they are carrying the *FecX<sup>O</sup>* gene would greatly facilitate a choice of appropriate rams and enable better management of flock prolificacy. The genotype information would assist in the selection of breeding pairs for mating to control reproduction level as well as inbreeding in the flock. At present, the increasing genetic relationship between ewes and rams impose a significant management problem in the Olkuska sheep population (Martyniuk 2011; Drobik 2014).

## CONCLUSIONS

Olkuska sheep is a highly prolific breed therefore maintaining its overall reproductive performances is of a major importance. Although, as expected, the impact of litter size on lamb mortality is substantial, also other factors, such as age of dam and flock effect, play an important role. At the current rate of population growth there is a high risk of further decrease in reproductive performance. The flock effect and the length of ewe utilisation in the flock are factors which improvement is possible through a better husbandry and could lead to a higher reproductive performance of Olkuska sheep in Poland. It is very important to discuss this issue with breeders and facilitate sharing experience of lamb rearing techniques and overall flock manage-



ment to improve flocks' outputs and the breed performance. Monitoring and analysing performance results of the Olkuska population, especially flocks that are participating in sheep genetic resources conservation programme, and communicate it to breeders is essential for the future of the breed, as many farmers experiencing difficulties in lamb rearing are getting disappointed with the breed.

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**Streszczenie:** *Analiza czynników wpływających na plenność oraz odchów jagniąt w populacji owiec rasy olkuskiej.* Celem niniejszej pracy było scharakteryzowanie populacji owiec olkuskich pod względem użytkowości reprodukcyjnej na przestrzeni ostatnich lat oraz analiza wpływu wybranych czynników na wyniki odchowu jagniąt oraz długość użytkowania matek w stadzie. Użytkowość reprodukcyjna owiec olkuskich kształtuje się na stosunkowo wysokim poziomie, w ostatnich latach obserwuje się jednak obniżenie poziomu plenności oraz utrzymujący się dość niski poziom odchowu jagniąt. Może to być związane z dynamicznym rozwojem populacji oraz krótkim

okresem użytkowania matek w stadach wynoszącym średnio jedynie 3,17 lat. Czynnikiem, który ma największy wpływ na odchów jagniąt u owiec rasy olkuskiej, jest wielkość miotu. Obserwuje się również wyraźne zmiany w użytkowości reprodukcyjnej w zależności od wieku matki. Pomimo słabszych wyników odchowu w przypadku licznych miotów nie obserwuje się istotnej korelacji między średnią plennością matek w stadzie a poziomem odchowu jagniąt. Wskazuje to na fakt, że decydujący wpływ na odchów mają indywidualne predyspozycje matki, warunki utrzymania zwierząt oraz umiejętności hodowcy.

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