Lifetime reproduction of Karukul ewes as influenced by season of birth, age at first lambing and lambing interval

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Lifetime reproduction of 1 462 eight-year-old Karakul ewes was recorded since 1972. The influence of season of birth, age at first lambing and lambing interval on lifetime reproduction was investigated. Age at first lambing was significantly ($P < 0.01$) affected by month of birth ($R^2 = 36\%$), with spring-born ewes lambing at a younger age than summer- or winter-born ewes. Lifetime reproduction was influenced by both age at first lambing and average lambing interval ($R^2 = 20\%$). However, first lambing interval was unimportant as a predictor of both lifetime reproduction and average interlambing periods, with a non-significant ($P > 0.05$) correlation estimate ($r = 0.05$) between first and average interlambing periods. The inclusion of age at first lambing in a selection programme was recommended.

Leeftydsreproduksie van 1 462 agt-jaar-oud Karakoelooie is vanaf 1972 aangeteken. Die effek van seisoen van geboorte, ouderdom met eerste lamming en laminterval op leeftydsreproduksie is ondersoek. Ouderdom met eerste lamming is betekenisvol ($P < 0.01$) deur maand van geboorte ($R^2 = 36\%$) beïnvloed, met lentegebore lammers wat op 'n vroeër ouderdom as somer- of wintergebore lammers gelam het. Leeftydsreproduksie is deur beide ouderdom met eerste lamming en gemiddelde interlamperiode ($R^2 = 20\%$) beïnvloed. Eerste laminterval is egter 'n onbelangrike voorspeller van beide leeftydsreproduksie en gemiddelde interlamperiodes, met 'n nie-betekenisvolle ($P > 0.05$) korrelasie ($r = 0.05$) tussen eerste en gemiddelde interlamperiodes. Die insluiting van ouderdom met eerste lamming in 'n seleksieprogram word aanbeveel.

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Introduction

Total ewe lifetime reproduction in Karakul production is of both direct economical as well as biological importance. Unlike mutton or woollen sheep breeds, the criteria of ewe productivity and net income in Karakul ewes are to a greater degree dependent on the reproductive rate. The total income of the pelt producer is directly influenced by the number of lambs slaughtered for the pelt market.

Ewe lifetime reproduction, defined as the number of lambs born per ewe over a given period of time per ewe exposed, is dependent on component traits such as fertility, litter size and survival of lambs selected as replacement stock at birth (Fogarty, 1984). Under natural conditions, reproductive rate in Karakul production is limited by a low fecundity as well as a relatively long interlambing period (Nel *et al.*, 1960; Boshoff, 1984). Other factors also influencing ewe lifetime reproduction are the age at first lambing and intervals between lambings, which are affected by the length of the natural breeding season and longevity. There is evidence of considerable within-breed variation in the length of the natural breeding season (Haresign & McLeod, 1985). However, few estimates of heritability or repeatability exist for this trait. According to Baker & Morris (1982), age at puberty, which influences age at first lambing, is moderately heritable and would respond to selection.

Many attempts have been made to predict lifetime reproduction based on early initial reproduction in ewe flocks (Turner, 1966; 1969; Van der Merwe, 1976; Kritzinger *et al.*, 1984; Cloete *et al.*, 1984; Cloete & Heydenrych, 1987; and many others). Results from these studies suggested that lifetime reproduction, despite relatively low repeatabilities of reproductive traits, is positively related to early reproductive performance. However, great differences in subsequent performance compared to initial performance were reported in these studies. Age at first lambing and first interlambing period, however, did not receive much attention as possible initial indicators of subsequent lifetime reproduction.

The objective of this investigation was to assess the contribution of age at first lambing and first interlambing period on ewe lifetime reproduction up to the age of eight years in the most important Karakul stud flock, thereby making a genetic contribution to the whole industry, and to evaluate these factors as possible criteria for inclusion into the selection programme.

Procedure

The data consist of records of 1 462 ewes which completed their lifetime productive period of eight years in the Lovedale Karakul stud flock in Namibia (South West Africa). Lambs which were born and had been selected as replacements between 1972 and 1982 were included in the analysis. From a total of 1 903 ewes, 1 462 completed their lifetime reproductive period of eight years.

Selection in the flock was only applied on pelt quality traits. Replacements were therefore considered as an unselected random sample of the population with regard to both age at first lambing and first interlambing period. However, ewes which failed to lamb in two consecutive years, were culled.

Ewes which were either culled or died before eight years of age were excluded from the analysis, except for the estimation of the repeatability.

Ewes in this flock were normally mated within two fixed mating seasons which ranged from 1 December to 28 February, or to 15 March in some years, and from 15 April to 15 August respectively.

Birth and lambing dates of all lambs and ewes were recorded and age at first lambing and intervals between lambings were derived therefrom. As neither interlambing period nor age at first lambing were continuously distributed (as a result of fixed breeding seasons), both were categorized into three classes. Maiden ewes which first lambed before the age of 16 months were placed in the first class (Early), those which lambed for the first time between 16 and 23 months of age in the second class (Intermediate), and those which lambed for the first time at an age of more than 23 months, in the third class (Late). In addition, ewes were divided into classes according to their first interlambing period (period between first and second lambing). Those with a first interlambing period of less than seven months were in the first class (Short), those with an interlambing period ranging from 7 to 12 months in the second class (Intermediate), and those with longer than 12-month periods in the third class (Long). It also applies to average interlambing periods for each ewe derived from her individual interlambing periods.

Body masses at different ages and seasons were unfortunately not recorded as is normal practice in Karakul flocks.

The Statistical Analysis System (SAS, 1985) was used to analyse the data. For the analysis of both age at first lambing and first interlambing period, year and month of birth as well as age of dam effects were included in the model. The CAT-MOD procedure of linear models for categorical traits was used and the chi-square test was used to compare two categorical traits, e.g. age at first lambing and first interlambing period. Bonferroni's test was applied to test for significant differences (Van Ark, 1981) between a categorical and a continuous trait (e.g. age at first lambing and lifetime reproduction). The repeatability of interlambing period was estimated from the 1903 observations as the interclass correlation coefficient between first and second interlambing periods. A simple correlation coefficient between first interlambing period and the average of all consecutive interlambing periods was also calculated. The first-mentioned was tested with a paired t test (Steel & Torrie, 1981).

Results and Discussion

Results depicting the influence of month of birth of ewes on age at first lambing and average interlambing period are presented in Table 1.

Age at first lambing was significantly ($P < 0,01$) affected by month of birth ($R^2 = 36\%$). Spring-born ewes lambed for the first time at a significantly ($P < 0,01$) younger age than either summer- or winter-born lambs. These results may possibly be attributed to differences in age at attainment of puberty. The results are in agreement with those obtained by Faure et al. (1987a), but are contradictory to those obtained by Le Roux et al. (1975), who found that spring-born Karakul ewe lambs reached puberty at a significantly ($P < 0,01$) higher age than autumn-born ewe lambs. These differences may also be the

Table 1 Average age at first lambing and average inter-lambing period of ewes born in different months of the year (least square means ± SE)

Month of birth of ewes	Number of ewes	Age at first lambing (months)	Average interlambing period (days)
May	19	23,90 ± 0,42[c]	327 ± 12,7[b]
June	302	23,30 ± 0,39[c]	334 ± 3,1[b]
July	209	22,60 ± 0,42[b]	302 ± 4,1[c]
August	132	22,80 ± 0,52[b]	328 ± 6,2[b]
September	413	16,10 ± 0,51[a]	340 ± 10,1[b]
October	213	17,10 ± 0,63[a]	375 ± 12,6[d]
November	38	21,80 ± 0,67[b]	392 ± 16,1[d]
December	87	20,10 ± 0,41[d]	228 ± 4,1[a]
January	49	22,20 ± 0,35[b]	225 ± 6,2[a]
R^2		0,36	0,15

[a-d] Least-square means with a common superscript do not differ significantly ($P \leq 0,05$).

result of the seasonal nature of the natural breeding season (Boshoff et al., 1975). Month of peak fertility in the breeding season is, however, not exactly known under local circumstances. It normally varies with both breed and environment (Lax et al., 1979). Several other authors, viz. Dufour (1975) and Fitzgerald & Butler (1982), also obtained significant season-of-birth effects on age at puberty. Conflicting results may be attributed to an interaction between the nature of the breeding season and nutritional differences, as illustrated by Faure et al. (1987b). They obtained a significant ($P < 0,01$) interaction between season of birth and nutritional system regarding ewe age.

Average interlambing period was also significantly ($P < 0,01$) affected by season of birth ($R^2 = 15\%$) (Table 1). Ewes born during December and January had a significantly ($P < 0,01$) shorter average interlambing period than ewes born during the other months of the year. This tendency may be the result of favourable conditions (semi-desert area with late summer and autumn rainfall) under which these summer-born lambs were reared with a favourable effect on the rest of their reproductive lives.

Age at first lambing also affected first lambing interval significantly ($P \leq 0,01$) (Table 2). Only 1,54% of maiden ewes that lambed for the first time at an early age, also had a short first interlambing period. This low percentage may be a result of physiological stress of the young ewe lambing for the

Table 2 First interlambing period of ewes lambing at different ages

Age at first lambing	Number of observations	First interlambing period (months)			
		Short <7	Intermediate 7—12	Long >12	Total
Early	365	1,54	80,00	18,46	100,00
Intermediate	699	21,92	44,56	33,50	100,00
Late	398	21,66	34,02	43,32	100,00

first time at such an early age. Most of the young ewes which lambed early (80%), had an intermediate (ranging from 7 to 12 months) first interlambing period. Only 18,46% of the ewes which lambed for the first time at an early age, had a long first interlambing period, compared to the 33,50 and 43,32% for the intermediate and late groups respectively. Of the ewes which lambed for the first time at an early age, 81,54% had a first interlambing period of 12 months and less, as compared to 66,48 and 55,68% of the ewes which lambed for the first time at an intermediate or late age respectively. Approximately 43,32% of all ewes which lambed at a late age (>23 months) also had a long (>12 months) first interlambing period. This stresses the importance of lambing for the first time at a young age. Culling of maiden ewes, lambing for the first time at more than 23 months of age, should therefore be considered in this specific flock.

Results of the relationship between age at first lambing and average interlambing period and lifetime reproduction are presented in Table 3.

Table 3 Lifetime reproduction and average interlambing period of ewes lambing at different ages (least square means ± SE)

Age at first lambing	(months)	Number of observations	Average interlambing period (days)	Lifetime reproduction
Early	<16	365	297,50 ±3,82[a]	8,0 ± 0,14[d]
Intermediate	16–23	699	293,60 ± 2,78[a]	7,3 ± 0,100
Late	>23	398	312,50 ± 4,01[b]	6,3 ± 0,13[f]
Mean	20,07	1462	299,16	7,21

[a,b] Least square means with a common superscript do not differ significantly ($P \leq 0,01$).

[d–f] Least square means with different superscripts differ significantly ($P \leq 0,001$).

The average interlambing period of ewes lambing for the first time at an age of more than 23 months, was significantly ($P < 0,01$) longer (17 days) than that of ewes which lambed for the first time at a younger age. This confirms the conclusion drawn from results shown in Table 2.

Results presented in Table 3 also illustrate the significant ($P < 0,01$) ($R^2 = 7,84\%$) effect of age at first lambing on lifetime reproduction. Ewes, lambing for the first time at an age of more than 23 months, produced on average one lamb less than those lambing for the first time between 16 and 23 months of age, over the eight-year reproductive period. Le Roux (1965) also obtained a value of 0,87 offspring per ewe per year over four years for ewes first lambing before 24 months of age, compared to 0,50 per year for ewes lambing for the first time at an age of more than 24 months. Lifetime reproduction was, however, not significantly ($P > 0,05$) influenced by first interlambing period. Age at first lambing therefore seems to be a more reliable predictor of lifetime reproduction than first interlambing period and should be included in a selection programme aimed at improved reproduction of the current flock. The importance of age at first lambing as a selection

criterium was also stressed by Gabina (1989), who obtained a heritability estimate of 0,14 for this characteristic.

When both age at first lambing and average interlambing period were used as predictors of lifetime reproductive performance, a significant ($P < 0,01$) age at first lambing × interlambing period interaction was evident. Both main effects plus the interaction were responsible for 20% of the variation in lifetime reproduction. This interaction is illustrated in Figure 1. The highest reproduction was obtained from ewes either lambing early with an intermediate interlambing period, or ewes with an intermediate age at first lambing and a short interlambing period. The lowest reproductivity was obtained from ewes with a long interlambing period as well as a late age at first lambing.
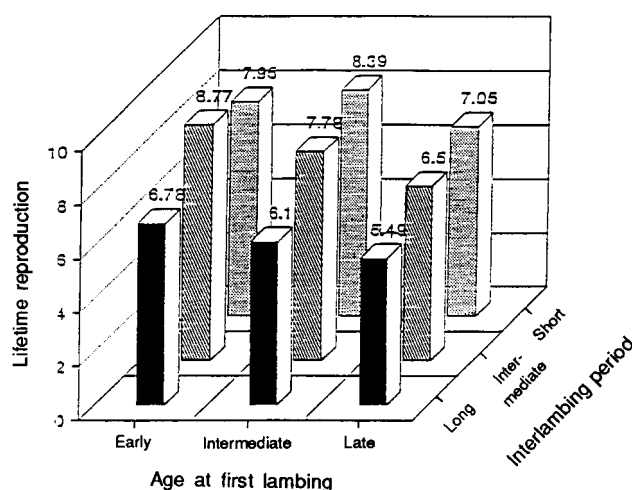
Figure 1 The interaction age at first lambing × average interlambing period on lifetime reproduction.

The estimate of repeatability as calculated from the interclass correlation coefficient between the first and second interlambing periods was not significant ($P > 0,05$) and small ($r = 0,09$). The same applied to the correlation ($r = 0,05$) between the first interlambing period and the average of successive interlambing periods. This confirms the general trend that repeatabilities tend to be low for most reproduction traits (Turner, 1969; Notter, 1981; Dzakuma et al., 1982; Clarke & Hohenboken, 1983; and many others). Gabina (1989) reported significant ($P \leq 0,01$) repeatability estimates ranging from 0,10 to 0,16 for lambing interval in flocks under continuous mating during the unfavourable breeding season and repeatability estimates of close to zero during the favourable breeding season. Results of this study therefore imply that first interlambing period is of limited value as predictor of ewe lifetime reproduction.

Conclusions

In terms of the factors influencing lifetime reproduction considered in this paper, it is clear that age at first lambing seems to be a more reliable predictor than first lambing interval, which is of limited value. Age at first lambing is thus recommended for inclusion in the selection programme for genetic improvement of the current flock.

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