

Factors affecting reproduction in Merino ewes of the Tygerhoek flock

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Factors affecting reproduction in Merino ewes were investigated using data of 7 917 matings of 2 258 ewes in the Tygerhoek flock during the lambing seasons of 1971 to 1984. The ewes were run in a selection trial to evaluate selection procedures for wool yield (selection for clean fleece mass as such or for S/P ratio) against a control group. The data were analysed by least squares procedures within and across ewe age groups. Reproduction traits investigated were ewes conceived/ewe mated (Ec/Em), lambs born/ewe conceived (Lb/Ec), lambs born/ewe mated (Lb/Em), and lambs weaned/ewe mated (Lw/Em). Age trends in reproduction were in agreement with literature cited. Selection for clean fleece mass and S/P ratio did not reduce reproduction, but tended to affect it advantageously. This tendency could not be related to diverging time trends when compared to the control group. Multiple-born ewes reproduced better than singles. Mating mass and Ec/Em were linearly and positively related in 2-year-old ewes, but virtually unrelated at older ages. The relationship of mating mass with Lb/Ec and Lb/Em was linear and positive throughout. The effect of mating mass on Lb/Em was partially transmitted to Lw/Em. Multiple-born ewes tended to be more responsive in terms of Lb/Ec and Lb/Em to mating mass increases than singles. *S. Afr. J. Anim. Sci.* 1986, 16: 36–42

Faktore wat reproduksie in Merino-ooie beïnvloed is ondersoek met data van 7 917 parings op 2 258 ooie van die Tygerhoekkudde in die periode van 1971 tot en met 1984. Die ooie is in 'n seleksieproef gebruik om twee seleksiemetodes vir hoër wolproduksie (seleksie vir skoonwolmassa as sulks of vir S/P-verhouding) teen 'n kontrolegroep te evalueer. Die data is oor en binne ooi-ouderdomsgroepe met kleinste kwadrate-metodes geanaliseer. Reproduksiekenmerke wat ondersoek is, is ooie beset/ooi gepaar (Ok/Op), lammers gebore/ooi beset (Lb/Ok), lammers gebore/ooi gepaar (Lb/Op) en lammers gespeen/ooi gepaar (Ls/Op). Reproduksieneigings met toenemende ouderdom was in ooreenstemming met aangehaalde literatuur. Seleksie vir skoonwolmassa en S/P-verhouding het nie reproduksie benadeel nie, maar het geneig om dit te bevoordeel. Hierdie neiging kon nie aan uiteenlopende tendense in vergelyking met die kontrolegroep toegeskryf word nie. Meerlingooie was meer produktief as enkelinge. Die verwantskap van paarmassa met Ok/Op was reglynig en positief by ooie van 2 jaar, maar afwesig in ouer ouderdomsgroepe. Die verwantskappe van paarmassa met Lb/Ok en Lb/Op was deurgaans reglynig en positief. Die invloed van paarmassa op Lb/Op is in 'n mate oorgedra na Ls/Op. Lammers gebore/ooi beset en Lb/Op het by meerlinge geneig om met 'n toename in paarmassa teen 'n skerper helling toe te neem as by enkelinge. *S.-Afr. Tydskr. Veek.* 1986, 16: 36–42

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Introduction

Reproduction is generally defined as the number of lambs weaned per ewe mated (Turner, 1969). Reproduction rate is therefore a composite trait, consisting of conception rate, multiple births, and lamb survival. It is therefore evident that reproduction can be affected by numerous factors. Barlow (1974) did not obtain any significant divergence in overall reproduction rate in flocks selected for or against clean fleece mass. A significantly higher weaning percentage in young ewes of the fleece minus flock, and a significantly higher lifetime twinning rate in the fleece plus flock were, however, reported. Genetic correlations between wool yield and reproduction rate reviewed by Turner (1972) are variable in sign, whereas Clarke (1972) reported a slight negative response in hogget fleece mass after selection for reproduction rate.

The age structure of ewes in a breeding flock has a marked effect on productivity and genetic progress (Turner & Young, 1969). The effect of age on reproduction in ewes of different breeds and in different environments is well documented in the literature. In general, twinning rate and conception rate increased with age, followed by a decline in reproductive performance after approximately five lambing opportunities (Turner & Dolling, 1965; Atkins, 1980; Olivier, 1982; Fourie & Heydenrych, 1983).

Reproduction in ewes is also affected by birth type. Multiple born ewes tend to be superior to singles (Turner, 1969; Van der Westhuysen, 1973; Kritzing, Stindt & Van der Westhuysen, 1984). Contradictory results were, however, reported by Wallace (1964) and Atkins (1980). There is also some evidence of different reproductive patterns with ageing in multiple and single born ewes (Piper & McGuirk, 1976; Baharin & Beilharz, 1977).

Mating mass appears to be positively related to reproduction (Coop, 1962; McLaughlin, 1970; Adalsteinson, 1979; Donnelly, Morley & McKinney, 1982; Langlands, Donald & Paull, 1984), particularly because of an increased ovulation rate (Morley, White, Kenney & Davis, 1978; Kelly & Johnstone, 1982). Contradictory findings were reported by Van der Merwe (1976) and Geisler & Fenlon (1979).

Seen against this background, an investigation into these factors were undertaken with data of the Tygerhoek Merino flock.

Materials and Methods

The selection procedures implemented in the Tygerhoek Merino flock were discussed by Heydenrych (1975), Heydenrych, Vosloo & Meissenheimer (1977) and Heydenrych, Du Plessis & Cloete (1984). The flock originally consisted of four

selection groups and a control group. Based on preliminary findings (Heydenrych, 1975; Heydenrych, *et al.*, 1977) ewes belonging to the original Groups 1 and 3 (rams selected for clean fleece mass) and Groups 2 and 4 (rams selected for S/P ratio) were pooled for the present analyses. Group 5 was maintained as a genetically stable control. The data included 2 258 ewes born from 1968 to 1982, totalling 7 917 matings and 6 550 lambings in the lambing years 1971 to 1984 inclusively. Ewes available for mating were referred to as mated, whereas known abortions were treated as still-births. Individual ewes were treated as separate individuals with every lambing opportunity. The LSML76 computer program (Harvey, 1977) was used in most analyses. The program accommodates unequal subclass frequencies, and is suitable for the analysis of discrete data by least squares (Harvey, 1982). Ewes conceived/ewe mated (Ec/Em), lambs born/ewe conceived (Lb/Ec), lambs born/ewe mated (Lb/Em), and lambs weaned/ewe mated (Lw/Em) were analysed according to two basic fixed linear models. The first model included the discrete independent variables and relevant interactions. For the overall analysis across age groups, this model included lambing years, selection groups, ewe age and birth type as independent variables. The lambing years \times selection groups and ewe age \times birth type interactions were included as sources of variation. The data were also analysed within age groups. For 2-year-old ewes the sources of variation included lambing years, selection groups, dam age, birth type, and the lambing years \times selection groups interaction. The same analysis was carried out on the data of the other age groups, but dam age was excluded after preliminary runs.

The second model corresponded to the first in all the analyses, but excluded the two-factor interactions, and included the average weighted regressions of Ec/Em, Lb/Ec, Lb/Em and Lw/Em on mating mass (a continuous independent variable). Individual regressions for the lambing year, selection group, ewe age, and birth type classes were also fitted in the overall analysis. The interactions of selection groups and dam age (in the 2-year-old ewes) with mating mass were unimportant and were excluded from the final runs within age groups. Means for the discrete independent variables were adjusted for mating mass differences throughout (Harvey, 1977).

Least squares means for the discrete independent variables (analysed according to the first model) are presented and discussed. Class means for lambing years were not tested for significant differences, but were regressed on lambing year to investigate time trends. Differences in class means for selection groups, age groups and birth type groups were tested by the Bonferoni method (Van Ark, 1981). The average regressions of Ec/Em, Lb/Ec, Lb/Em and Lw/Em on mating mass are presented graphically.

Results and Discussion

The proportion of the total variance accounted for by the investigated independent variables was relatively low and ranged from 3,2 to 12,6% in the respective analyses. This finding is consistent with other reports in the literature where discrete data were analysed, and is related to the 'all or none' nature of the data (De Haas & Dunlop, 1969; Mullaney & Brown, 1969). Analyses of this nature are, however, considered to be valid if sufficient observations are included (Harvey, 1982).

Lambing year

Differences between years were relatively large and no time trends were evident for Ec/Em, Lb/Ec and Lb/Em. Regres-

sion equations indicated virtually no trend in Ec/Em, whilst slight increases in Lb/Ec and Lb/Em were obtained. The variation accounted for by these equations was less than 10%. Weaning rate showed a drop in all the selection groups after 1979. This trend could not be related conclusively to any known environmental or managerial factor, and will be subjected to further investigations.

Age

Conception rate improved from 0,73 Ec/Em in the 2-year-old ewes to approximately 0,86 in the older ewes ($P \leq 0,01$). Lambs born/ewe conceived increased from 1,14 in 2-year-old ewes to 1,40 in the 6-year-old ewes, most of the differences between age groups being significant ($P \leq 0,01$). Lambs born/ewe mated and Lw/Em increased significantly ($P \leq 0,01$) from respectively 0,83 and 0,65 at 2 years of age to reach 1,14 and 0,94 at 4 years of age. Lambs born/ewe mated subsequently tended to increase to 1,20 at 6 years whereas almost no further increase was obtained in Lw/Em. These results are in general agreement with the literature (Turner & Dolling, 1965; De Haas & Dunlop, 1969; McGloughlin & Curran, 1969; Coop, 1973; Heydenrych, 1975; Gregory, Roberts & James, 1977; Arnold & Charlick, 1980; Atkins 1980; Olivier, 1982; Fourie & Heydenrych, 1983). It must be stressed that most of the authors cited investigated more age groups than the present study. The only really contradictory results were reported by Mullaney & Brown (1969) who reported a steady decrease in the lambing rate of Merino ewes with increasing age. The results of other breeds reported by Mullaney & Brown (1969) agreed with the present findings.

Adjustment for mating mass resulted in reduced mean squares for age groups, possibly owing to age trends in mating mass (Coop 1973; Heydenrych 1975). Coop (1962) and McGloughlin & Curran (1969) contended that differences in reproduction between 2-year-old ewes and older ewes can be ascribed almost entirely to differences in mating mass. In the present work, the variation in reproductive performance associated with ewe age was not eliminated by adjustment for mating mass. It is comparable to reports of McLaughlin (1970, for Corriedale ewes) and Coop (1973), where age itself, or repeated pregnancies, was considered to contribute to differences between age groups.

Selection groups

Age-specific and overall least square means for selection and control group ewes are presented in Table 1. Lambs born/ewe conceived in Group 1 (clean fleece mass) was significantly ($P \leq 0,01$) higher than in the other two groups in the overall analysis. This tendency is also noteworthy in the age-specific means. Group 1 ewes differed significantly from Group 2 in 2, 3, 4 and 5-year-old ewes, and from Group 5 in the 2-year-old ewes. The difference in Lb/Ec between Group 1 and the control also approached significance ($P=0,07$) in the 6-year-old ewes. It is interesting to note that Ec/Em tended to be higher in Group 2 in 2, 4 and 6-year-old ewes. The only significant ($P \leq 0,05$) differences for Ec/Em, however, were between Group 2 and Group 5 ewes at 2 years of age, and between the selection groups and the control in the overall analysis. The difference between Group 1 and the control also approached significance ($P=0,09$) in 3-year-old ewes. The tendency towards a higher conception rate in Group 2 ewes reduced the difference in Lb/Em between Group 1 and 2 ewes. The only significant ($P \leq 0,05$) difference between these groups was obtained in the 3-year-old ewes. Lambs born/ewe mated tended to be lower in Group 5 (control) than in the

Table 1 The age-specific and overall least square means for the reproduction traits investigated in Groups 1, 2 and 5

Age and selection group	Number of ewes		Dependent variables			
	mated	lambled	Ec/Em	Lb/Ec	Lb/Em	Lw/Em
2 years						
Group 1	703	516	0,74 ^{a,b}	1,18 ^a	0,87 ^a	0,67
2	693	529	0,78 ^a	1,12 ^b	0,87 ^a	0,69
5	593	412	0,70 ^b	1,12 ^b	0,78 ^b	0,62
3 years						
Group 1	697	605	0,87	1,24 ^a	1,09 ^a	0,88
2	697	600	0,86	1,17 ^b	1,01 ^b	0,85
5	581	478	0,83	1,20 ^{a,b}	0,99 ^b	0,84
4 years						
Group 1	579	499	0,86	1,36 ^a	1,17	0,96
2	582	516	0,89	1,29 ^b	1,16	0,96
5	507	437	0,87	1,29 ^{a,b}	1,12	0,92
5 years						
Group 1	460	406	0,87	1,40 ^a	1,22	0,94
2	446	392	0,87	1,29 ^b	1,13	0,95
5	425	352	0,83	1,35 ^{a,b}	1,12	0,90
6 years						
Group 1	320	273	0,85	1,46	1,24	0,95
2	310	274	0,89	1,39	1,24	0,99
5	324	262	0,82	1,36	1,12	0,90
Overall						
Group 1	2 758	2 298	0,84 ¹	1,32 ¹	1,12 ¹	0,89 ¹
2	2 728	2 311	0,86 ¹	1,26 ²	1,08 ¹	0,88 ¹
5	2 431	1 941	0,81 ²	1,26 ²	1,03 ²	0,84 ²

^{a,b}Denote significance ($P \leq 0,05$) within columns

^{1,2}Denote significance ($P \leq 0,05$) within columns

selection groups. Differences in Lb/Em between Group 1 and Group 5 ewes were significant in the age groups of 2 and 3 years ($P \leq 0,05$) and in the overall analysis ($P \leq 0,01$), and approached significance ($P \leq 0,05$) in 5 and 6-year-old ewes. Corresponding differences between Group 2 and Group 5 ewes were significant in the 2-year-old ewes ($P \leq 0,05$) and the overall analysis ($P \leq 0,01$) and approached significance ($P \leq 0,05$) in the 6-year-old ewes. The weaning rate of selection group ewes tended to be higher than in control group ewes, being statistically significant ($P \leq 0,01$) only in the overall analysis.

These results can be compared to those reported by Barlow (1974), noting the rather similar increase in lifetime twinning rate of his fleece plus ewes. It was attempted to relate differences in the overall reproduction of the respective groups to time trends within groups, but no real consistent trends could be distinguished.

Reasons for the differences in reproduction rate between the selection groups and the control group can only be speculated upon. The proportion of rams per breeding ewe in the control flock was higher than in the selection groups (Heydenrych, *et al.*, 1984). Differences in Ec/Em may have been caused by the fact that a wider spectrum of rams, which may incidentally have included rams with a lower fertilizing ability, was used in the control flock. Selection for clean fleece mass resulted in a correlated increase in livemass (Heydenrych, *et al.*, 1984) which could possibly be related to the higher twinning rate in Group 1 ewes (see the section on mating mass). It does, however, not seem to be appropriate to make final conclusions regarding correlated responses at this stage.

Future results regarding genetic correlations between wool traits and reproduction may help to clarify the obtained results.

Dam age

Differences between the respective dam age classes were relatively small and nonsignificant in the 2-year-old ewes. Van der Merwe (1976) reported a lower average litter size of multiple born 2-year-old Dorset ewes born to 2-year-old dams, when compared to contemporary singles. Multiple born ewes of older dams were superior to contemporary singles. The dam age \times birth type interaction was not significant in preliminary runs, and was excluded. Multiple born ewes tended to reproduce better than singles irrespective of the age of their dams. McCall & Hight (1981) reported a dam age effect on the hogget reproduction of Romneys, indicating that this effect may be of importance in ewes mated at a very young age.

Birth type

The age-specific and overall least square means of single and multiple born ewes are presented in Table 2. The reproduction of multiple born ewes was consistently higher than in singles. Differences in Lb/Ec and Lb/Em were significant ($P \leq 0,05$) for the age groups of 5 years and younger. Significant differences were also obtained for Ec/Em in the age groups of 3 and 4 years, and for Lw/Em in the age groups of 3–5 years. No significant differences between birth type groups existed in the 6-year-old ewes. In the overall analysis, multiple born ewes were superior to singles in all reproduction traits ($P \leq 0,01$). These results are in general agreement with the majority of published results (Vakil, Botkin & Roehrkasse, 1968; Turner, 1969; Van der Westhuysen, 1973; Kritzing, *et al.*, 1984). Age trends in multiple and single ewes are in general agreement with those reported for Dorset ewes (Van der Merwe, 1976) and for the Trangie Merino flock (Piper

Table 2 The age-specific and overall least square means for the reproduction traits in single and multiple born ewes

Age and birth type	Number of ewes		Dependent variables			
	mated	lambled	Ec/Em	Lb/Ec	Lb/Em	Lw/Em
2 years						
Single	1 323	955	0,72	1,12 ^a	0,81 ^a	0,63
Multiple	666	502	0,75	1,16 ^b	0,87 ^b	0,68
3 years						
Single	1 270	1 063	0,84 ^a	1,18 ¹	0,99 ¹	0,81 ¹
Multiple	705	620	0,87 ^b	1,23 ²	1,08 ²	0,91 ²
4 years						
Single	1 086	926	0,85 ^a	1,28 ¹	1,09 ¹	0,90 ¹
Multiple	582	526	0,90 ^b	1,36 ²	1,22 ²	1,00 ²
5 years						
Single	856	728	0,85	1,30 ¹	1,10 ¹	0,90 ^a
Multiple	475	422	0,87	1,39 ²	1,22 ²	0,97 ^b
6 years						
Single	633	530	0,84	1,38	1,17	0,94
Multiple	321	279	0,86	1,43	1,24	0,95
Overall						
Single	5 168	4 202	0,82 ¹	1,25 ¹	1,03 ¹	0,84 ¹
Multiple	2 794	2 348	0,85 ²	1,31 ²	1,12 ²	0,92 ²

^{a,b}Denote significance ($P \leq 0,05$) within columns

^{1,2}Denote significance ($P \leq 0,01$) within columns

& McGuirk, 1976). However, it does not agree with results on the Cunnamulla Merino flock reported by the latter authors, where twin born ewes tended to be inferior to singles up to an age of 3 years. It is interesting to note that the

superiority of multiple born ewes tended to decrease from 5 to 6 years of age. A rather similar finding was reported by Baharin & Beilharz (1977), only at an earlier age. These findings may possibly be related to differences in the longevity

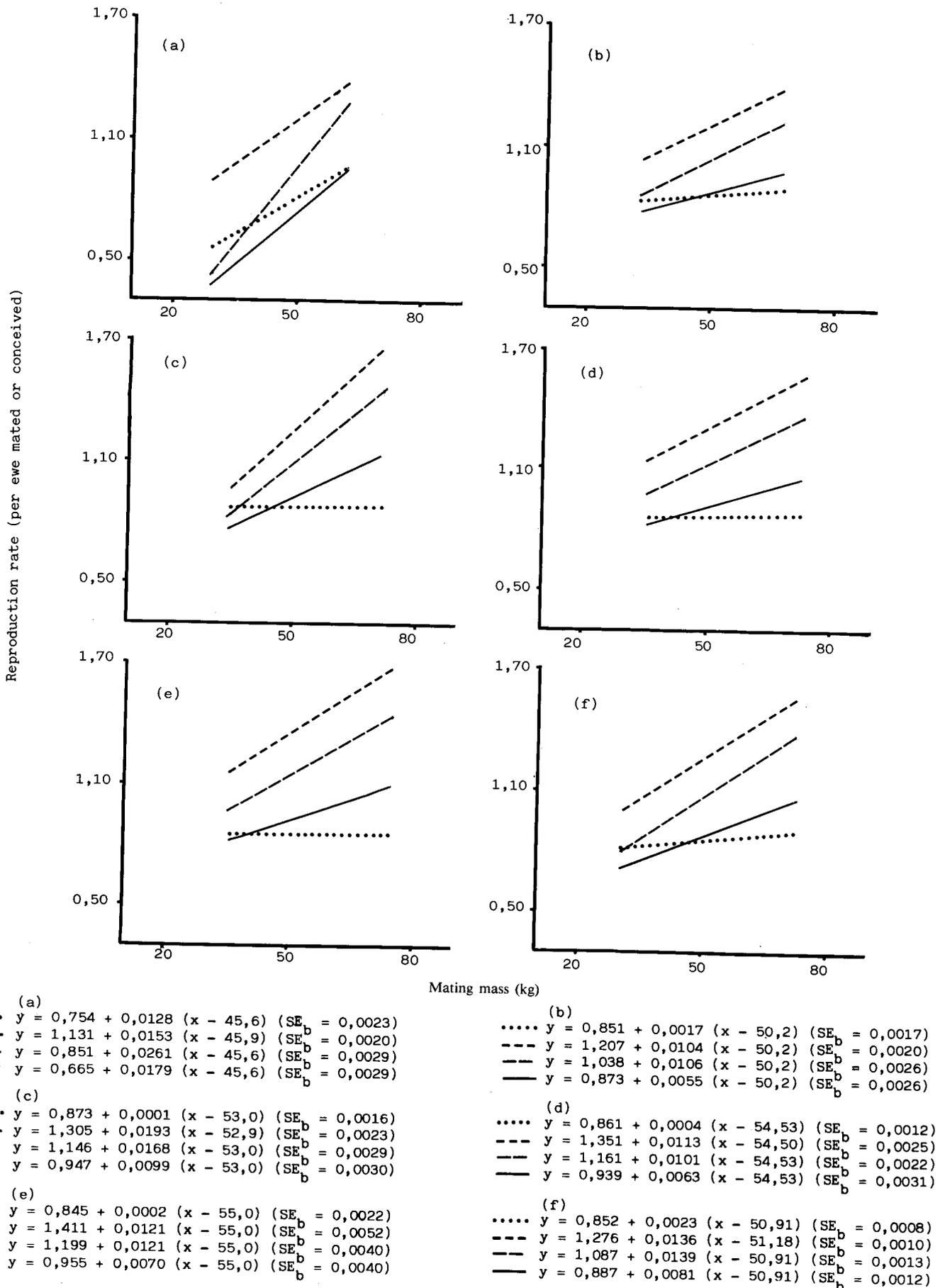


Figure 1 The regressions of ewes conceived/ewe mated (.....), lambs born/ewe conceived (-----), lambs born/ewe mated (———) and lambs weaned/ewe mated (——) on mating mass in ewes at ages of two (a), three (b), four (c), five (d), six (e) years and for the overall analyses (f).

of the two birth type groups, an aspect which has not yet been investigated.

The present results disagree with those reported by Wallace (1964), Thrift & Dutt (1976), Baharin & Beilharz (1977) and Atkins (1980), which led Cloete, Heydenrych & Du Plessis (1984) to propose the existence of a birth type \times locality interaction, with a smaller effect of birth type caused by poor growth of multiples (Wallace, 1964). It must, however, be stressed that Kritzinger, *et al.* (1984) reported a relatively large difference in reproduction between single and twin born Elsenburg S.A. Mutton Merino ewes, whereas only a small difference existed in Elsenburg Dormer ewes. The underlying mechanisms may be more complicated, as was suggested by the pasture \times birth type interaction reported by Ch'ang (1963). Selection for birth type as a means of improving reproductive performance of Tygerhoek ewes appears to be validated.

Mating mass

The within age group and overall regressions of Ec/Em, Lb/Ec, Lb/Em and Lw/Em on mating mass are presented in Figure 1. An increase of 1 kg in mating mass was associated with an increase of 0,0128 Ec/Em in the 2-year-old ewes. This relationship may be related to the relationship of livemass with sexual maturity in young sheep (Dýrmundsson, 1973; McCall & Hight, 1981). In older ewes, virtually no relationship existed between these variables. These results are consistent with reports in the literature where differences in the effect of livemass on conception rate of two-tooth and older ewes were investigated (Coop, 1962; Vosloo, 1967; Allison, Thompson & Davis, 1974). The overall regression coefficient of 0,0023 Ec/Em per kg mating mass is comparable to values of 0,0029 (De Haas & Dunlop, 1969), 0,0074 (Lindsay, Knight, Smith & Oldham, 1975) and 0,0052 (Atkins, 1980). It is somewhat smaller than values of 0,011 (McLaughlin, 1970, for Merino data) and 0,012 (Bichard, Younis, Forrest & Cumberland, 1974, for Clun Forest lambs). The latter regression coefficient should, however, be compared to the regression of 0,0128 obtained for the age group of 2 years. No significant quadratic tendencies that could not be related to the interactions of mating mass with the discrete independent variables were obtained in any of the age groups. These results are in agreement with those reported by Donnelly, *et al.* (1982). McLaughlin (1970), Suiter & Fels (1971) and Hight & Jury (1973) reported nonlinear tendencies in Ec/Em with an increase in mating mass.

The regressions of Lb/Ec on mating mass were consistent for ewe age groups and ranged from 0,0104 to 0,0193 Lb/Ec for an increase of 1 kg in mating mass. These regressions are in agreement with the majority of published results (Coop, 1962; Coop & Hayman, 1962; Purser, 1965; Vosloo, 1967; De Haas & Dunlop, 1969; McLaughlin, 1970; Suiter & Fels, 1971; Hight & Jury, 1973; Drew, Barry, Duncan & Kleim, 1973; Bichard, *et al.*, 1974; Lindsay, *et al.*, 1975; Adalsteinson, 1979; Atkins, 1980; Langlands, *et al.*, 1984). Seven comparable regressions reported by these authors for 2-year-old ewes averaged $0,0156 \pm 0,0032$, whereas 19 corresponding regressions for ewes of mixed age groups averaged $0,0131 \pm 0,0056$. It therefore appears that the regression of Lb/Ec on mating mass is fairly consistent over age groups, and likely to occur in most sheep breeds and environments. Some authors did, however, not obtain any significant relationship between twinning rate and mating mass in adult ewes (Van der Merwe, 1976; Geisler & Fenlon, 1979), and in 2-year-old ewes (Allison, *et al.*, 1974).

Conception rate was independent of mating mass in ewes older than 2 years (Figure 1). The regressions of Lb/Em on mating mass were therefore closely related to the effect of Lb/Ec in these age groups. The steeper slope of 0,0261 Lb/Em for an increase of 1 kg in mating mass in 2-year-old ewes is related to the linear effect of mating mass on Ec/Em in this age group. Corresponding regression coefficients for the other age groups ranged from 0,0101 to 0,0168. These results are in general agreement with results in the literature (Lax & Brown, 1968; Suiter & Fels, 1971; Lindsay, *et al.*, 1975; Egan, Thompson & McIntyre, 1977; Atkins, 1980; Donnelly, *et al.*, 1982).

The effect of mating mass on Lb/Em was partially expressed in Lw/Em. The regression on mating mass was 0,0179 Lw/Em for an increase of 1 kg in mating mass in 2-year-old ewes, and ranged from 0,0055 to 0,0099 for older age groups. All these regression coefficients were significant ($P \leq 0,05$) except the coefficient for 6-year-old ewes. Comparable regression coefficients in the literature ranged from 0,0006 to 0,0223 in 2-year-old ewes and from 0,0059 to 0,0171 in older ewes (Hight & Jury, 1973). Langlands, *et al.* (1984) correspondingly reported a regression coefficient of 0,0231.

Livemass thus appears to be phenotypically related to reproduction rate. The genetic correlation between these traits must, however, be considered before final recommendations can be made. According to results reviewed by Turner (1972) this correlation is likely to be positive.

Individual regressions for birth type classes

Most of the individual class regressions obtained were not considered to be of practical importance. The interactions of mating mass with birth type were significant or approached significance in some of the analyses within and across age groups. Multiple born ewes tended to be more responsive to mating mass increases than singles, the differences between regression coefficients being significant ($P \leq 0,05$) for Lb/Ec and Lb/Em in the overall analysis. Obtained regression coefficients for single and multiple born ewes were respectively $0,0118 \pm 0,0011$ and $0,0155 \pm 0,0014$ Lb/Ec and $0,0115 \pm 0,0014$ and $0,0163 \pm 0,0018$ Lb/Em in association with an increase of 1 kg in mating mass. The tendency towards a greater response in the reproductive performance of multiple born ewes with an increase in mating mass is in general agreement with previous findings (Cloete, *et al.*, 1984). The feasibility of differential feeding for these ewes prior to mating is a managerial aspect that could possibly be considered.

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