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SELECTION FOR SUPERIOR GROWTH ADVANCES THE ONSET OF PUBERTY IN MERINO EWES

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SUMMARY
The present study evaluated the impact of selection for high muscle and high growth on puberty. One hundred and thirty six Merino ewe lambs with Australian Sheep Breeding Values (ASBVs) at post-weaning age for liveweight (PWT) and depth of eye muscle (PEMD) and fat (PFAT) were used. Analyses were completed to determine how these production traits were related with the onset of puberty during the teasing period. Overall, 89% of lambs reached puberty when lambs weighed (±SEM) 40 ± 0.5 kg and were 222 ± 3.5 days old (179-248 days) at their first oestrus. Puberty was accelerated by PWT, PEMD and PFAT, but the effects of PEMD and PFAT were due to correlated changes in PWT. We concluded that genetic selection for high growth will accelerate the onset of puberty in Merino ewes.

INTRODUCTION
The age at which ewe lambs attain puberty is the result of a dynamic interaction between genetic and environmental factors (Dýrmundsson 1981). As puberty approaches, the concentrations of Luteinizing Hormone and Follicle Stimulating Hormone gradually increase, stimulating the growth and maturation of ovarian follicles, and eliciting the cascade of endocrine events that leads to ovulation (Foster *et al.* 1985). At this stage, the female is considered to have reached physiological sexual maturity. Ewe lambs generally achieve physiological sexual maturity when they have reached between 50 and 70% of mature liveweight (Hafez 1952; Dýrmundsson 1973) so, if growth is restricted, the pre-pubertal anovulatory condition persists (Foster *et al.* 1985). Therefore, whilst age is often seen as a factor in sexual maturation, it is not as important as liveweight.

Achieving puberty is closely associated with liveweight, so, it is logical that rapidly-growing ewe lambs will achieve puberty earlier than slower-growing lambs (Boulanouar *et al*. 1995). Moreover, because accelerated growth involves enhanced muscle development, sheep that have been selected for higher muscle size also show higher rates of growth independently of their level of nutrition (Lewis *et al*. 2002; Hegarty *et al.* 2006). Enhanced muscle development has been shown to be positively correlated with fecundity in mature ewes (Ferguson *et al.* 2007), but it is not known whether differences in muscling would affect the achievement of physiological sexual maturity in ewe lambs. We therefore tested whether ewe lambs selected for higher growth and muscling reach puberty at an earlier age than those selected for lower growth and muscling.

MATERIAL AND METHODS
Location and animals. The experiment was conducted at Medina Research Station (32.2° S, 115.8° E), from February to May 2010 with 136 Merino ewe lambs. Lambs were born in August–September 2009 from ewes that had been sourced from two Western Australian stud flocks (Merinotech WA and Moojepin) and that had been mated to sires with a wide range in breeding values for muscle and growth. Liveweight was recorded weekly and at 164 ± 1.0 days of age

Ultrasonography was used to measure the depth of the *longissimus dorsi* muscle and subcutaneous fat depth at a point 45mm from the midline over the 12th rib. The data were used to generate Australian Sheep Breeding Values (ASBVs) at post-weaning age for weight (PWT; range 0 to 8 kg), depth of eye muscle (PEMD; range 0 to 2.6 mm) and fat (PFAT; range 0 to 1.2 mm) by MERINOSELECT (Brown *et al.* 2007).

First oestrus – age and liveweight at puberty. Four Merino wethers bearing harnesses (MatingMark®; Hamilton, NZ) were introduced to detect the onset of oestrus when the ewe lambs were aged (±SEM) 179 ± 1.0 days and weighed 37 ± 0.4 kg. The wethers received a 2 mL subcutaneous injection of testosterone enanthate (Ropel®, Jurox, NSW) every week, beginning one week before they were placed with the ewe lambs. Crayons on the harnesses were changed every week. The animals were all run together in a 20 x 60 m paddock where they had *ad libitum* access to clean water and commercial sheep pellets (11.5 MJ of metabolisable energy, 15% protein; Macco Feeds Australia). The wether teasers were removed when the ewe lambs were on average 248 ± 1.1 days old. Oestrus was assessed three times per week by observation and interpretation of crayon marks. Date of first oestrus was determined by the date the first crayon mark was recorded and liveweight and age at this point were considered as liveweight and age at puberty.

Data analysis. The independent variables included in all analyses were dam source, dam age and lamb birth type; co-variates that were included in the model were PWT, PEMD, and PFAT. Their effects on puberty (marked or not by the wethers) were analyzed using the generalized linear mixed model procedure (PROC GLIMMIX) with a binomial distribution and logit link function (SAS/STAT software; 2008). Their effects on liveweight at first oestrus and age at first oestrus were analyzed using linear mixed model procedures (PROC MIXED) (SAS/STAT software; 2008). For these reproductive traits, dam age and birth type were fitted as fixed effects. All two-way interactions among the fixed effects were included in the model and non-significant (P > 0.05) interactions were removed from the final model. The data are presented as logit values and back-transformed percentages.

RESULTS

First oestrus – age and liveweight at puberty. Of the 136 lambs in the flock, 122 (89%) displayed oestrus during the pre-mating period when they weighed (±SEM) 40 ± 0.5 kg and were 222 ± 3.5 days old (179-248 days). A greater proportion of lambs with higher PWT (P< 0.001), PEMD (P< 0.05) or PFAT (P<0.01) reached puberty during teasing than those with lower PWT, PEMD or PFAT (figures 1 and 2). However, it seems that the effects of PEMD and PFAT were due to correlated changes in PWT.

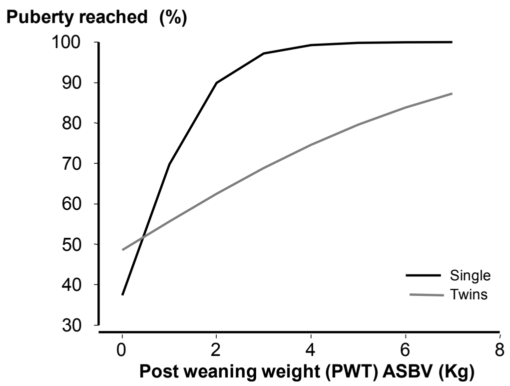

Figure 1. Relationships between Australian Sheep Breeding Values for post-weaning weight (PWT; P < 0.001) and birth type (PWT*BT; P < 0.05) and the proportion of Merino ewe lambs that achieved puberty between 179 and 248 days old.

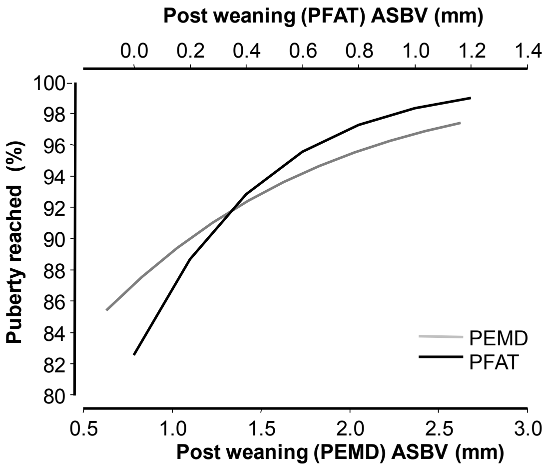

Figure 2. Relationships between Australian Sheep Breeding Values for post-weaning fat (PFAT; P < 0.01) and eye muscle depth (PEMD; P < 0.05) and the proportion of Merino ewe lambs that achieved puberty between 179 and 248 days old. PWT was not included in the model.

When PWT was added to the PEMD or PFAT model these effects were no longer evident indicating that the effects of PEMD and PFAT traits are linked to liveweight. The effects of PWT on the onset of puberty was influenced by lamb birth type and more single born lambs reached puberty by day 248 than twin born lambs (P<0.001).

Liveweight at first oestrus was influenced by dam source (P < 0.001) and PWT (P < 0.001), but not by birth type, PEMD or PFAT (P > 0.05). Liveweight at first oestrus increased about 1 kg per kg increase in PWT and on average twin-born lambs were 0.8 kg lighter that single lambs at their first oestrus (39.7 vs 40.5 kg). Age at first oestrus differed between dam sources (P < 0.001). Lambs with a higher PWT were younger at their first oestrus (P < 0.05; Figure 3). Birth type, PEMD and PFAT did not affect age at first oestrus (P > 0.05).

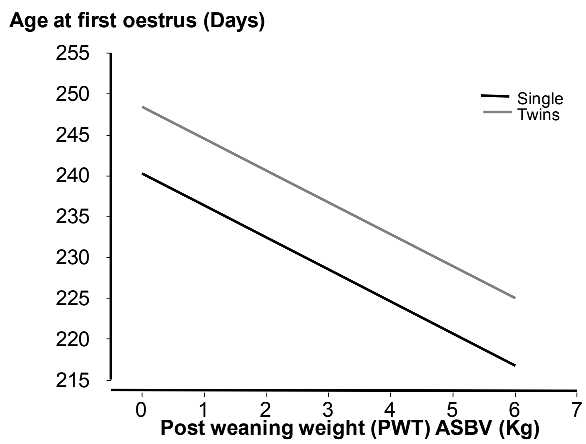

Figure 3. Relationships between Australian Sheep Breeding Values for post-weaning weight (PWT) and birth type and age at first oestrus ($P < 0.05$) in Merino ewe lambs.

DISCUSSION

Merino ewe lambs with higher PWT reached puberty at an early age than those with lower PWT, so, our hypothesis is partially supported. The effects of PWT are consistent with Barlow and Hodges (1976) who reported a positive genetic correlation between weaning weight and reproductive performance in Merino ewe lambs and with Alkass *et al*. (1994) who reported that genetic selection for enhanced growth advanced puberty. Interestingly, in our work PEMD and PFAT were also related to puberty, but when PWT was added to the model these effects were no longer evident indicating that the effects of PEMD and PFAT traits are linked to liveweight.

The average liveweight of the lambs that reached puberty during the teasing period was about 40 kg which is equivalent to about 63% of their mature weight (Ferguson unpublished data). This is within the range of 50-70% of mature weight that needs to be achieved in conjunction with certain interactions between genetic and environmental factors in order to reach puberty (Hafez 1952; Dýrmundsson 1973, 1981). The ability to reach puberty and conceive at lower liveweights would have major implications for the cost-effectiveness of feeding strategies to improve reproductive performance from Merino ewe lambs.

Ewe lambs born and raised as singles reached puberty at a younger age and a heavier weight than ewes born as twins. The effect of birth type on the timing of puberty is supported by previous studies (Southam *et al*. 1971). It seems that the rapid onset of puberty in single-born lambs is related to weight gain and better growth compared to twin-born lambs. Therefore, selection for high growth will have greater impact on reproductive performance in twin-born lambs.

CONCLUSION

It is possible that genetic selection using ASBVs for high growth will accelerate the onset of puberty in Merino ewes. Further research is necessary to determine whether the impact of muscle and fat on onset of puberty occurs independently of growth.

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