

Development of Generic Animal Unit Ratings for Sheep and Goats

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Executive summary

- In recent years there have been advancements in the defining and applying of animal units
- Animal units can be applied with varying levels of complexity, including;
 - generic tables by animal class and age, with no weights and production estimates required,
 - tables to look up animal units for various weights and corresponding production levels (weight gains or reproduction),
 - multivariate models which calculate animal unit ratings based on multiple variables (age, sex, liveweight, growth, reproduction etc.).
- This work has developed generic animal unit ratings for sheep and goats in extensive grazing operations in Queensland and the rangelands.
- The animal unit ratings are derived from the metabolisable energy demand of animals relative to that of the standard animals. The energy demand is calculated using the feeding standards (CSIRO, 2007).
- The standard animals used are:
 - Animal (or Adult) Equivalent (AE): a 2.25 yo 450kg bos Taurus steer with zero liveweight gain walking 7km per day
 - Dry Sheep Equivalent (DSE): a 2 yo 45kg wether with zero liveweight gain, walking 7km/day
- The feeding standards apply the same equations for calculating energy demand for both sheep and goats, allowing the ratings derived to be applied to both.
- Empirical data on the growth path and production data of sheep and goats was not available for this work to the extent that it is for cattle. Industry knowledge has been drawn upon to inform this work.

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Development of Generic Animal Unit Ratings for Sheep and Goats

Introduction and Background

In recent years there have been advancements in defining and applying animal units for grazing animals in northern and rangelands Australia (McLean and Blakeley, 2014, McLennan et al., 2020).

These advancements have;

- defined the standard animals for use for Animal (or Adult) Equivalents (AE) and Dry Sheep Equivalents (DSE).
- Explained the use of metabolisable energy (ME) demand as the basis for deriving animal units.
- Explained how AE and DSE can be used interchangeably to express the grazing load of grazing animals and calculated the ratio of 8.4 DSE to 1 AE.
- Improved estimates of dry matter intake figures per animal unit, under extensive grazing conditions
- Suggested approaches for application of animal units to various applications (i.e., forage budgets, carrying capacity estimates, enterprise analysis and business analysis).
- Calculated generic animal unit ratings for cattle by class and age group for simple application (i.e., only animal sex and age required for estimate, no estimate of weight or weight gain), see Table 1.

Table 1 Cattle Generic AE Ratings

Productivity	Annual AE Rating		
	High	Moderate	Low
Females <1 [#]	0.77	0.68	0.57
Females 1-2	1.10*	0.91	0.72
Females 2-3	1.74*	1.12*	0.96*
Females 3-4	1.61*	1.49*	1.18*
Females 4+	1.53*	1.28*	1.08*
Steers <1 [#]	0.80	0.72	0.60
Steers 1-2	1.31	1.03	0.78
Steers 2-3	1.60	1.27	1.02
Steers 3-4		1.39	1.15
Grown Bulls	1.55	1.52	1.29

#Is from weaning to 12 months of age

**includes pregnancy, lactation and calf to weaning and accounts for reproductive rate (i.e. is average of all females in age group)*

The generic ratings are suited to applications such as the Stocktake app. Their development was made possible by thorough empirically derived data on the growth paths and production of cattle in northern Australia (Bray et al., 2015). The development of equivalent generic animal unit ratings for sheep and goats has been limited by there being no known equivalent industry data available.

This work has sought to address this deficiency through the development of growth path and production data for sheep and goats, based on industry knowledge, to calculate generic animal unit ratings for sheep and goats.

Animal Unit Definitions, Derivations and Intake

The standard animals used in this work are;

- Animal Equivalent (AE): a 2.25 yo 450kg Bos taurus steer with zero liveweight gain walking 7km per day
- Dry Sheep Equivalent (DSE): a 2 yo 45kg wether (McLaren, 1997) with zero liveweight gain, walking 7km/day and with no additional wool growth beyond that included in maintenance (6g GFW/day).

The animal unit rating of an animal (or class of animals) is their daily ME (metabolisable energy) demand relative to that of the standard animal. An essential component of deriving animal units is that identical methodology and assumptions are used for calculating the ME demand for both the standard animal and the animal(s) being assessed. This work uses the energy equations detailed in the Nutrient Requirements for Domesticated Ruminants (NRDR) (CSIRO, 2007) to calculate ME demand. The primary additional assumption beyond those included in the definitions is a diet quality of 55% dry matter digestibility, the justification for which is provided in McLean and Blakeley (2014) and McLennan et al. (2020). Genotype (i.e. bos indicus, bos taurus, crossbred or Euro) is a variable for cattle, but is not for sheep, so no genotype needs to be specified in the definition of the standard animal for sheep.

Applying these definitions and assumptions to the NRDR equations results in a metabolisable energy demand for the standard animals of 72.6MJ for an AE and 8.68MJ for a DSE. These figures are the denominators used to derive animal unit ratings, i.e., the ME demand of animal(s) in question are calculated using NRDR and divided by the above figures to calculate an AE or DSE rating.

The 45kg standard animal for the DSE is not universal, with some users applying a 50kg standard animal. The ME demand for a 50kg wether, with all other assumptions as detailed above, is 9.49MJ ME. If a 50kg standard animal is used then the DSE ratings detailed in this document would need to be adjusted by 91% (8.68/9.49) to produce a DSE rating expressing equivalence to the 50kg standard animal.

The dry matter intake of animals can be estimated by multiplying their animal unit rating by an intake constant per animal unit. The intake constants, from McLennan et al. (2020), are shown in

Table 2.

Table 2 Intake per Animal Unit

	Intake per Animal Unit (Kg DM/day)	
	DSE	AE
Low Productivity	1.02	8.5
Default (Moderate Productivity)	0.96	8.0
High Productivity	0.90	7.5

Development of Generic Animal Unit Ratings for Sheep and Goats

The following map shows the grazing land management regions with their default productivity zone displayed. The productivity zones are based on annual weight gain of steers, with low being less than 110kg/yr, moderate 110-150kg/yr and high over 150kg. These are broad classifications, individual properties within regions may be classified differently according to long term average steer growth on that property.

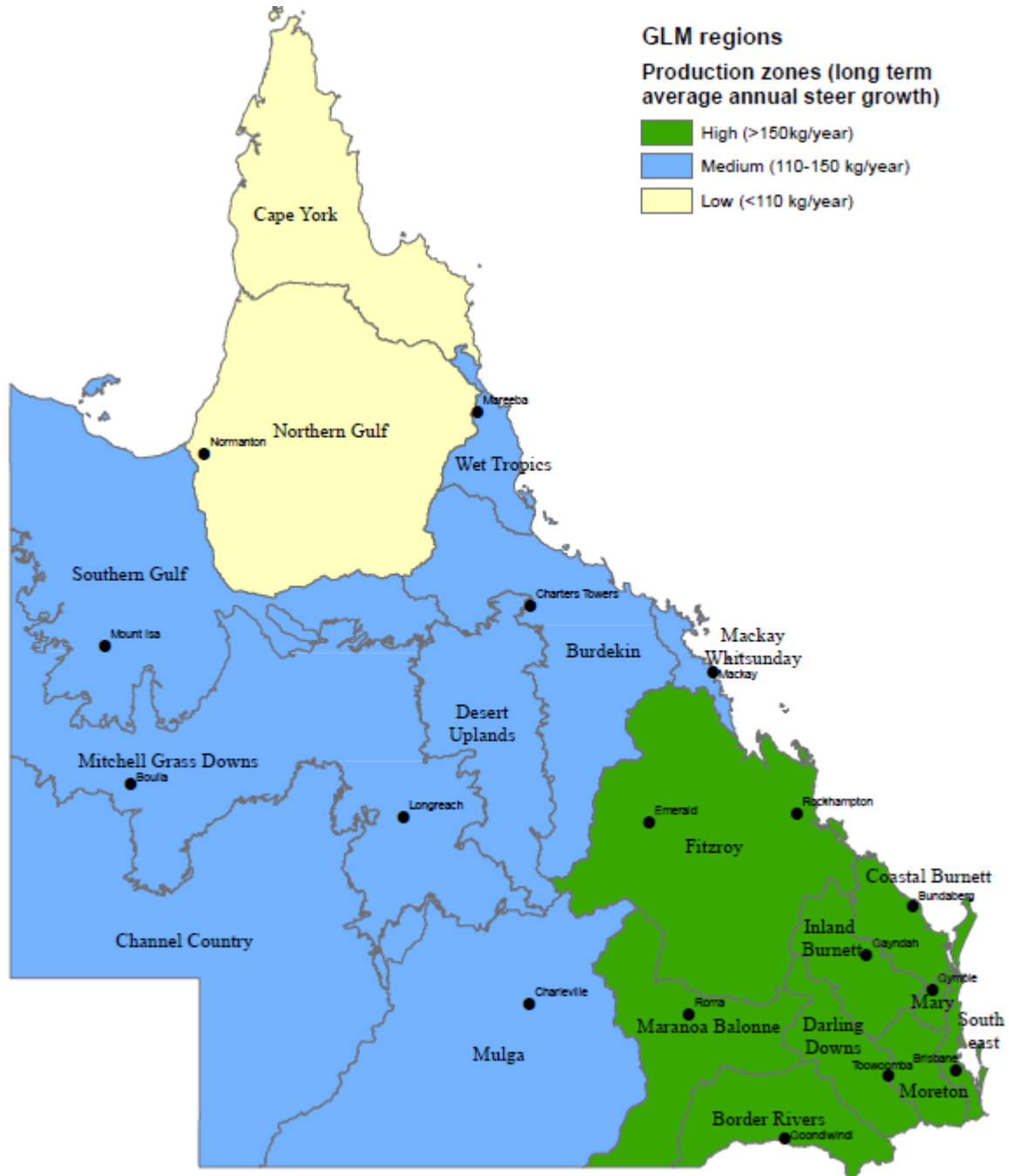


Figure 1 Map of grazing land management regions and productivity zones

It is important for users to understand that the animal unit ratings and resulting intake figures do not account for substitution or dietary overlap of grazing animals. That is, where the dietary preferences of different species meaning they graze differently and not compete for same pastures, see Scarnecchia (1986). Accounting for substitution and dietary overlap is important in application at property level and is influenced by type of animals, season and the types, quantity and quality of plants available for grazing, see Pahl (2020a).

Application to Goats

NRDR (CSIRO, 2007) recommends using the same equations for goats as for sheep in calculating the metabolisable energy requirements for maintenance, activity, weight gain and pregnancy.

Where milk production is known (volume and composition), NRDR provides a specific equation for MEI (metabolisable energy required for lactation) for goats. However, we approach the MEI calculation in grazing ruminants where those factors are unknown by first calculating the total energy demand of the suckling offspring based on its productive state, then using the NRDR equations to determine the proportion of energy intake from grass and milk based on the animal's age. From this, we can then determine MEI for a given number of days in milk. In the absence of specific NRDR instruction, we have applied the same approach to goats.

NRDR is silent on the energy required for fibre production in goats. We have assumed (for fibre producing goats) that it is similar to that of sheep.

Recent work by Pahl (2020b) suggested that goats grazing under rangeland conditions had higher energy requirements than sheep, at the same weight. However, that work also found that the dry matter intake of goats was the same as sheep, at the same weight. The conclusion was that the same DSE rating could be applied to goats as sheep. Given the application of an intake constant to the animal unit ratings in our approach, using the current feeding standards equations (CSIRO, 2007) to derive animal unit ratings for goats, will produce intake estimates consistent with the findings of Pahl (2020b).

For the purpose of calculating animal units, the same NRDR equations can be used for sheep as for goats. Consequently, the mob-based tool and animal unit tables developed by Bush AgriBusiness for sheep can also be used for goats.

Animal Production Data

Through the Leading Sheep program, Dr. Noel O'Dempsey a veterinarian, producer and Leading Sheep Regional Coordinator, was approached to provide sheep growth path and production data for the derivation of generic DSE ratings. Sheep extension staff from the Queensland Department of Agriculture and Fisheries (DAF) also provided input into and assisted in the process.

A starting point was deciding the classifications for the generic tables. It was decided that a more appropriate classification for sheep would be frame size, with three suggested for Merino sheep (small, medium and large) and two for meat sheep (medium and large), thus providing five broad classifications. A sixth was subsequently included for rangeland goats, with the medium meat sheep class also applying to large goats.

Growth path and production data were sourced from Dr. O'Dempsey and members of the Leading Sheep South Region Consultative Committee to populate a multi-variate animal demand model for small ruminants developed by Bush AgriBusiness. Figure 2 below shows the growth path and production parameters for the small merino classification and resulting DSE ratings.

Development of Generic Animal Unit Ratings for Sheep and Goats

Flock profile and productivity								Pregnancy %*	Lambing %*	Annualised DSE rating
Class	Comment	Start weight	Closing weight	Wool growth (kg GFW)	Time in class					
Mature ewe	Ewes 3yo+	48	48	3.80	5	years	90%	74%	1.39	
First parity ewe	Ewes 2-3yo	39	48	3.50	12	months	85%	60%	1.53	
Ewe hogget	Ewes 1-2yo	29	39	2.80	12	months	70%		1.10	
Ewe weaner	Ewes <1yo	18	29	1.50	7	months			0.56	
Wether weaner	Wethers <1yo	17	30	1.50	7	months			0.57	
Wether hogget	Wether 1-2yo	30	44	3.80	12	months			1.22	
Young Wether	Wether 2-3yo	44	52	4.30	12	months			1.32	
Grown Wether	Wether 3yo+	52	52	4.30	3	years			1.15	
Ram		85	85	6.02	3	years			2.02	
Cull ewe		50	50	2.50	6	months			0.53	

Figure 2 Flock Model Example- Small Merino data

The data provided were entered into the model for all of the classifications. The outputs were then reviewed and discussed by DAF extension staff, Bush AgriBusiness staff and Dr. O'Dempsey, with some minor adjustments made as a result.

As is the case for sheep, there is limited published data on growth paths for goats. Cowled et al. (2018) provides some data on the growth rates of rangeland goats and Refshauge et al. (2020) also provides some weight data.

Given the same equations apply for sheep and goats, the likely similarity in growth paths and, for simplicity in application, the large goat class will be incorporated with the medium meat sheep data, with the resulting animal unit ratings applying to both (large goats and medium sheep).

Separate generic ratings are developed for rangeland goats. The data for these has been informed by the above publications and from discussions with rangeland goat producers.

The graphs below (Figure 3 to Figure 6) show the final growth path and production data used to develop the generic sheep and goat animal unit ratings. These data can be revised as and when improved production data becomes available for both sheep and goats.

Development of Generic Animal Unit Ratings for Sheep and Goats

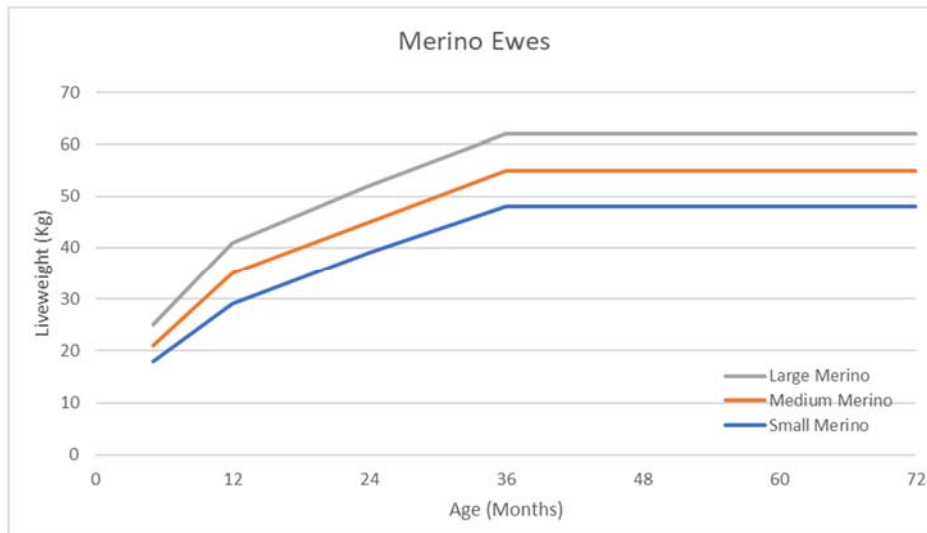


Figure 3 Growth path data for Merino ewes



Figure 4 Growth path data for Merino wethers

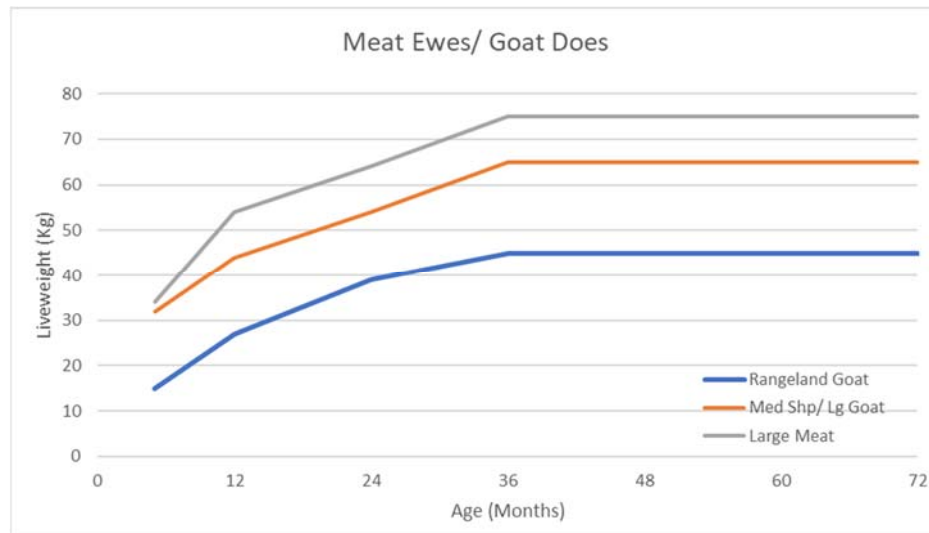


Figure 5 Growth path data for female meat sheep and goats

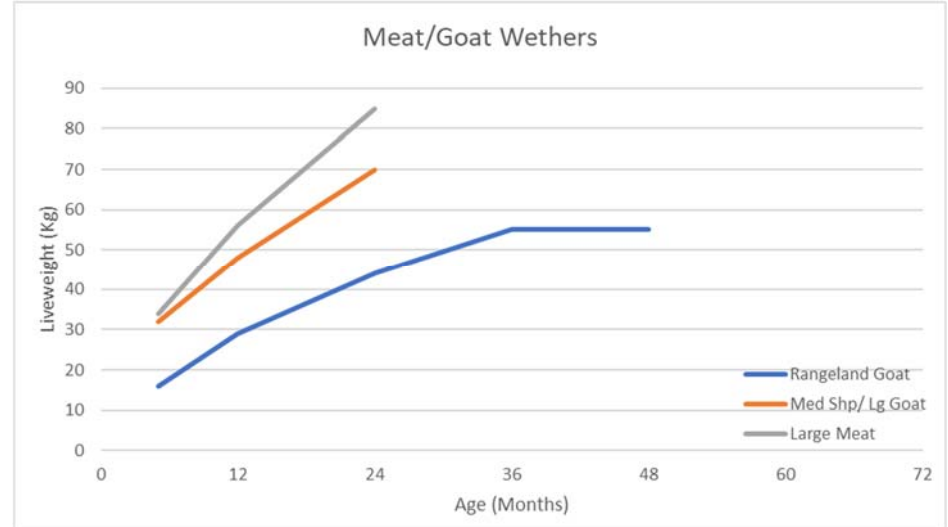


Figure 6 Growth path data for wether meat sheep and goats

Development of Generic Animal Unit Ratings for Sheep and Goats

Assumptions for reproduction are required also for determining animal unit ratings, as reproduction represents a material use of energy. The below graphs (Figure 7 to Figure 10) show the assumptions relating to reproductive performance.

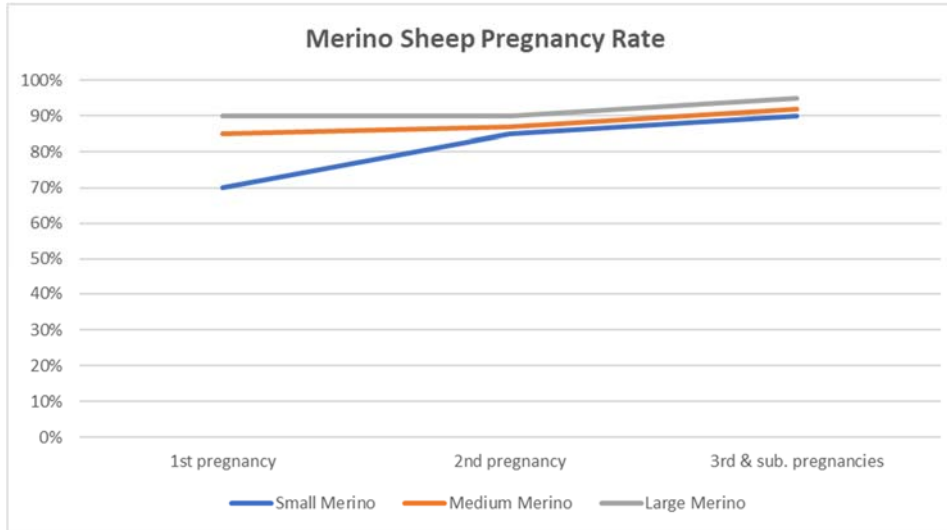


Figure 7 Merino sheep pregnancy rate data

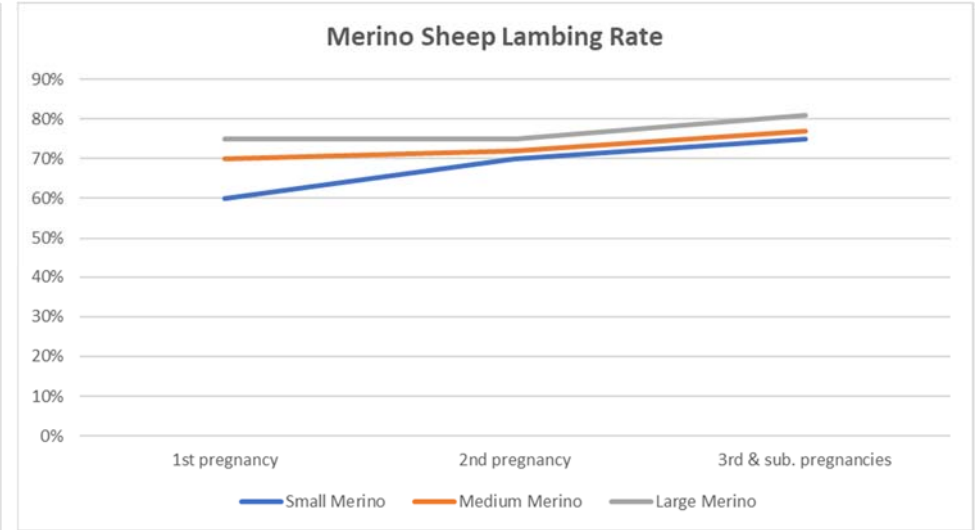


Figure 8 Merino sheep lambing rate data

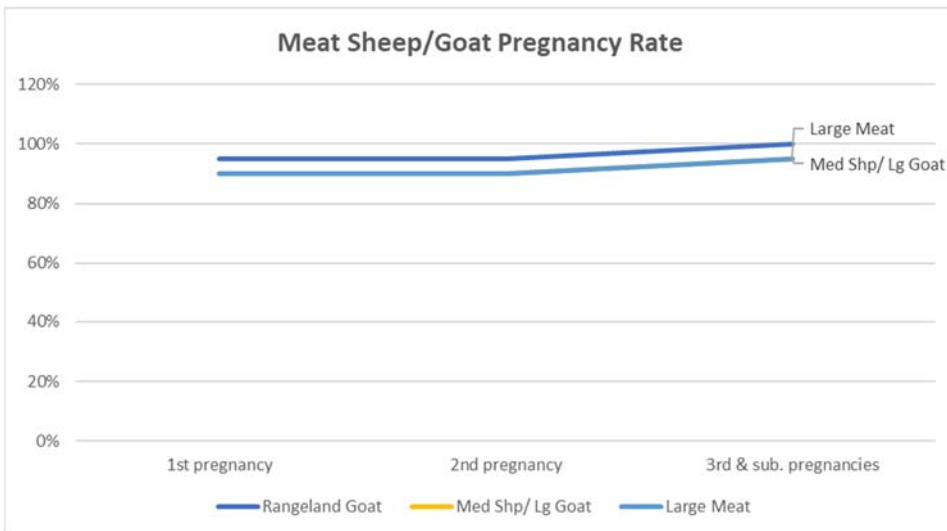


Figure 9 Meat sheep and goat pregnancy rate data

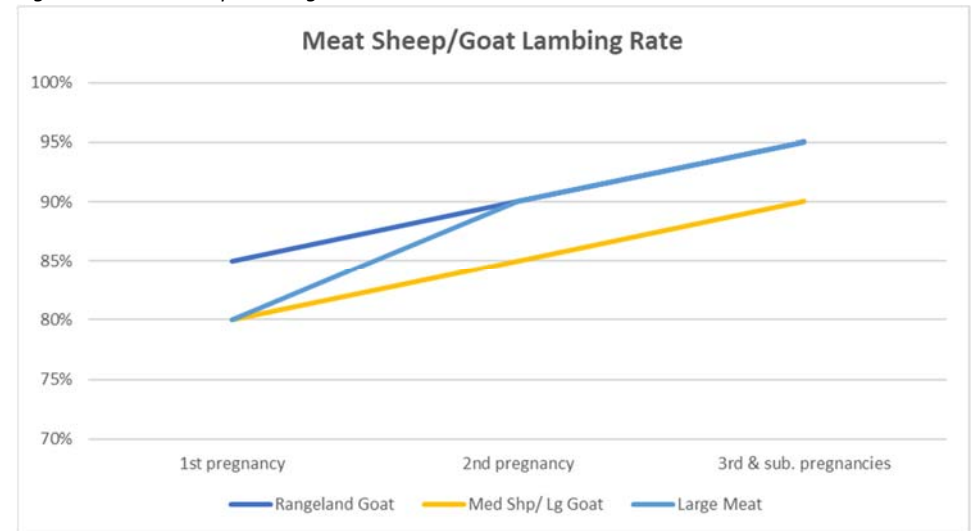


Figure 10 Meat sheep and goat lambing rate data

Development of Generic Animal Unit Ratings for Sheep and Goats

A component of wool growth (6g GFW/day) is inseparable from maintenance energy requirements (CSIRO, 2007), with wool growth beyond that contributing to the total energy demand of animals. For meat sheep and goats, no provision for wool growth beyond that included in maintenance has been accounted for, the below graphs (Figure 12 and Figure 11) show the wool growth assumptions used for the merino classes.

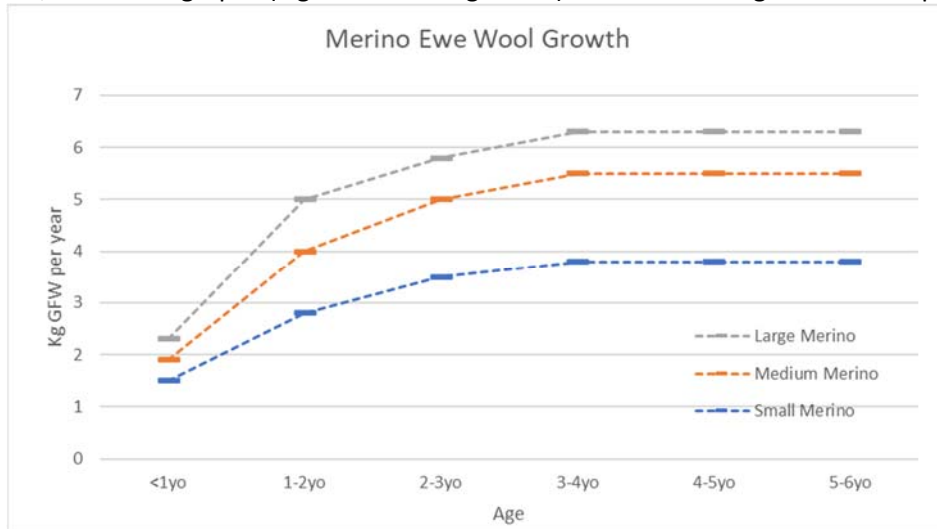


Figure 12 Wool growth data for merino ewes

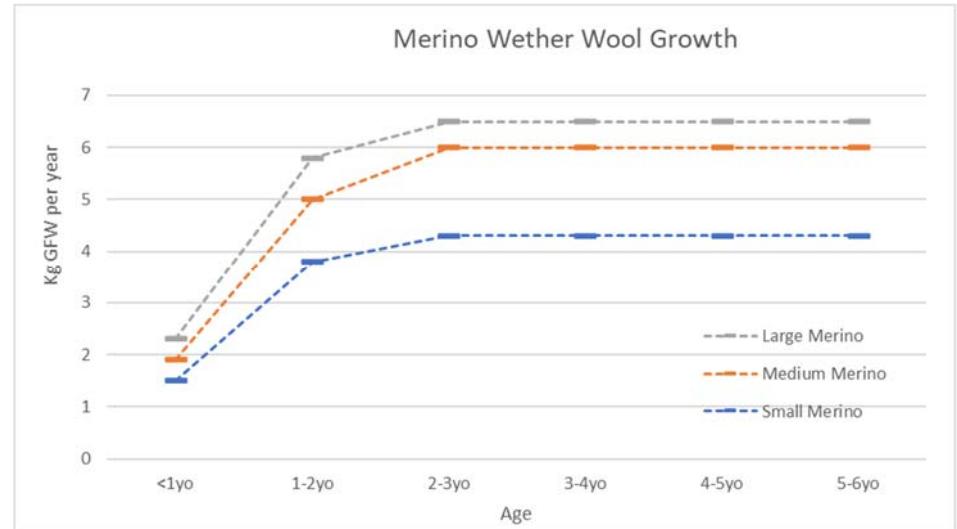


Figure 11 Wool growth data for merino wethers

Animal Unit Ratings

The above figures summarise the production parameters (growth paths, pregnancy rates, lambing rates, wool growth) used to calculate the standardised animal units for the various animal classifications. These ratings, expressed as DSE, are presented below (Figure 13 to Figure 16). It should be noted that the decrease in animal unit ratings when animals reach mature weight may seem counterintuitive, but is a function of cessation of growth, which is a significant use of energy.

The male rangeland goat class is based on wethers, with a single rating for Billy's included in the below tables, to be consistent with sheep. In reality many male animals may be entire, in which case the wether rating can be adjusted by increasing it by 10%.

The intake constants detailed in Table 2 can be applied to these animal unit ratings to calculate an intake estimate.

Development of Generic Animal Unit Ratings for Sheep and Goats

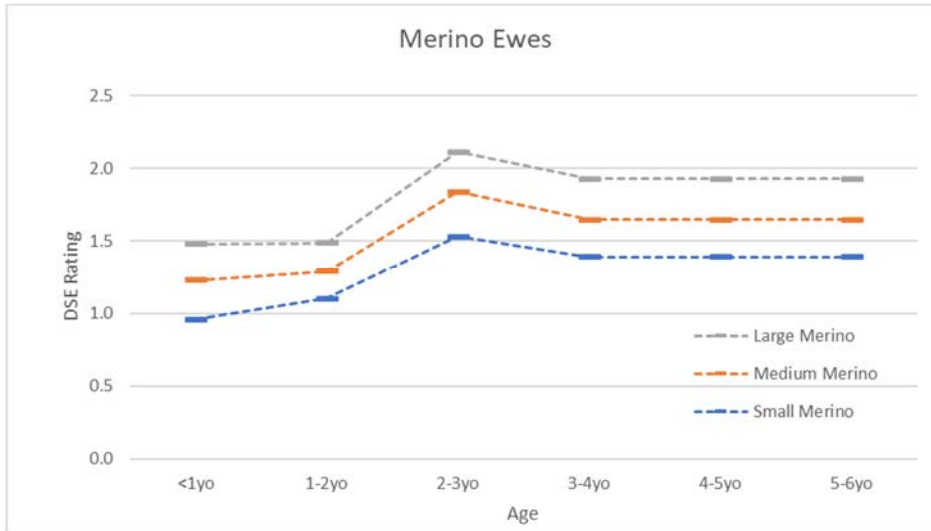


Figure 13 DSE ratings for merino ewes

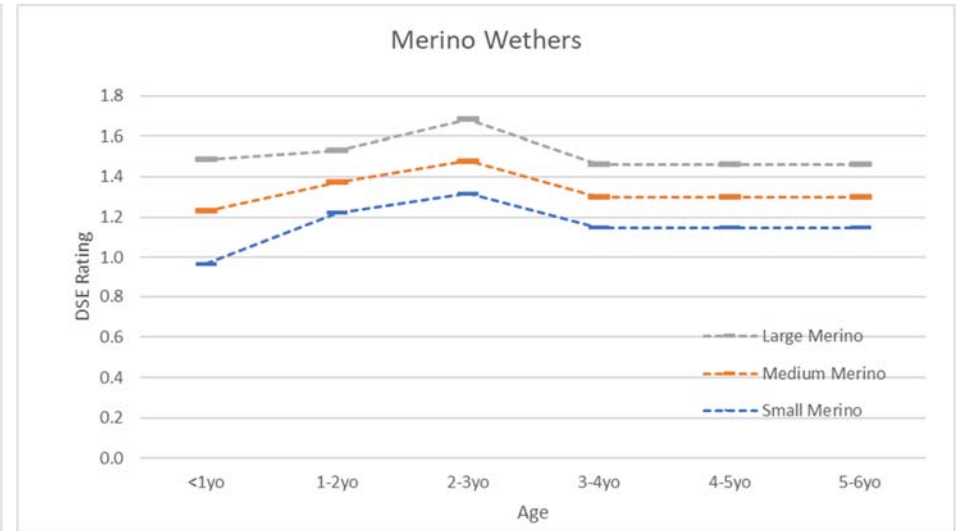


Figure 14 DSE ratings for merino wethers

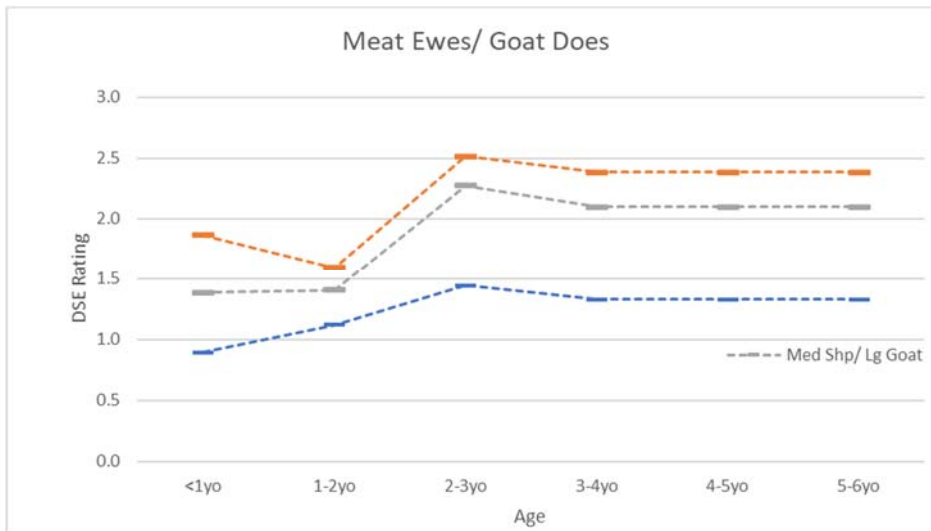


Figure 15 DSE ratings for female meat sheep and goats

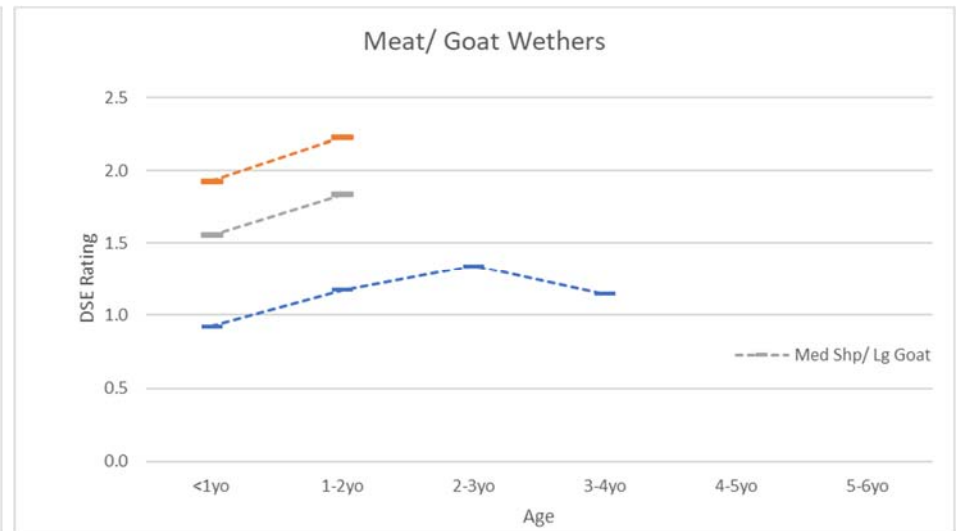


Figure 16 DSE ratings for meat sheep and goat wethers

Development of Generic Animal Unit Ratings for Sheep

These generic DSE ratings for sheep and goats are consolidated and presented in Table 3 and Table 4, below.

Table 3 DSE Ratings for merino sheep

Frame Size	Small	Medium	Large
Ewes <1 [#]	1.0	1.2	1.5
Ewes 1-2*	1.1	1.3	1.5
Ewes 2-3*	1.5	1.8	2.1
Ewes 3+*	1.4	1.6	1.9
Wethers <1 [#]	1.0	1.2	1.5
Wethers 1-2	1.2	1.4	1.5
Wethers 2-3	1.3	1.5	1.7
Wethers 3+	1.1	1.3	1.5
Grown Rams	2.0	2.3	2.4

From weaning to 1 year of age

** Includes energy demand of lambs from pregnancy through to weaning*

Table 4 DSE ratings for meat sheep and goats

Frame Size	Rangeland Goat	Med. Sheep/ Large Goat	Large Sheep
Ewes/does <1 [#]	0.9	1.4	1.9
Ewes/does 1-2*	1.1	1.4	1.6
Ewes/does 2-3*	1.4	2.3	2.5
Ewes/does 3+*	1.3	2.1	2.4
Wethers <1 ^{#@}	0.9	1.6	1.9
Wethers 1-2 [@]	1.2	1.8	2.2
Wethers 2-3 [@]	1.3		
Rams/ Billys	1.6	2.2	2.6

From weaning to 1 year of age

** Includes energy demand of lambs from pregnancy through to weaning*

@ Multiply by 1.1 to calculate entire male goat rating

Development of Generic Animal Unit Ratings for Sheep

The generic AE ratings for sheep and goats are consolidated and presented in Table 5 and Table 6 below. The AE tables are simply the DSE ratings divided by 8.4 (as 1 AE equals 8.4 DSE)

Table 5 AE Ratings for Merino Sheep

Frame Size	Small	Medium	Large
Ewes <1 [#]	0.11	0.15	0.18
Ewes 1-2*	0.13	0.15	0.18
Ewes 2-3*	0.18	0.22	0.25
Ewes 3+*	0.17	0.20	0.23
Wethers <1 [#]	0.12	0.15	0.18
Wethers 1-2	0.15	0.16	0.18
Wethers 2-3	0.16	0.18	0.20
Wethers 3+	0.14	0.15	0.17
Grown Rams	0.24	0.27	0.29

From weaning to 1 year of age

** Includes energy demand of lambs from pregnancy through to weaning*

Table 6 AE Ratings meat sheep and goats

Frame Size	Rangeland Goat	Med. Sheep/ Large Goat	Large
Ewes/does <1 [#]	0.11	0.16	0.22
Ewes/does 1-2*	0.13	0.17	0.19
Ewes/does 2-3*	0.17	0.27	0.30
Ewes/does 3+*	0.16	0.25	0.28
Wethers <1 ^{#@}	0.11	0.18	0.23
Wethers 1-2 [@]	0.14	0.22	0.27
Wethers 2-3 [@]	0.16		
Rams/ Billys	0.19	0.26	0.30

From weaning to 1 year of age

** Includes energy demand of lambs from pregnancy through to weaning*

@ Multiply by 1.1 to calculate entire male goat rating

Conclusion

This work has produced generic animal unit ratings for sheep and goats grazing under extensive conditions. The resulting ratings complement the generic cattle ratings detailed in McLennan et al. (2020) and the methodology to derive them is consistent with that work.

These generic ratings for cattle, sheep and goats allow for the total grazing pressure of domesticated ruminants to be more accurately quantified and managed. This will enable motivated users to better match stocking rate to carrying capacity; a fundamental tenet of grazing businesses. Users will need to account for dietary overlap and substitution between species on a case by case basis though.

There are various levels of sophistication in the application of animal units, with these generic tables being the most basic. More sophisticated applications can use;

- animal unit tables, which provide animal unit ratings for various liveweights and corresponding levels of production, liveweight growth or reproduction, or.
- Multivariate models which allow multiple variables influencing energy demand to be defined by the user.

In order to fill the research gap in growth path data for sheep and goats grazing in extensive conditions, industry expertise has been sought and provide to provide the data used in this work. This has provided a defensible basis for the derivation of these ratings. Should future work provide more detailed and accurate data, this work can be updated with the new data.

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