final report

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Adult Equivalent Methodology

A methodology to accurately and consistently calculate cattle grazing loads in northern Australia

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Abstract

The Adult Equivalent (AE) is the standard measure of grazing loads used in extensive cattle grazing areas across northern and pastoral Australia. Despite its common use, the measure has been inconsistently defined and applied and this has limited its application and utility.

This project has developed a practical, defendable methodology which provides an accurate, consistent means of calculating cattle grazing loads for production systems across northern Australia. The methodology calculates the energy demand of cattle based on animal specific variables. The calculated energy demand is expressed relative to the energy demand of the Adult Equivalent standard unit, ie a 450 kg *Bos taurus* steer at maintenance.

A spreadsheet based tool has been developed which applies the methodology to whole herd or individual classes of animals. It also generates a suite of tables which give AE ratings based on various physiological variables. These, along with the explanation of the methodology outlined in this report, will allow it to be adopted by producers as well as extension officers, researchers, advisors and other agribusiness personnel.

Executive summary

- This report details the methodology used to apply the 'Nutrient Requirements of Domesticated Ruminants' in the calculation of Adult Equivalents, proving an accurate, consistent measure of the cattle grazing load for production systems across northern Australia.
- The methodology is based on energy demand of animals as a result of animal specific factors. Is not based on animal/environment interactions, although these are explored in depth in order to derive and apply the methodology.
- The Adult Equivalent standard unit is a 450 kg *Bos taurus* steer at maintenance, 2.25 years of age, grazing on pasture with diet quality of 7.75 MJ ME/kg DM and walking 7 kilometres each day. Subsequent calculations express the energy demand of various animals relative to this standard unit.
- The variability of diet quality across northern Australia and its influence on energy demand is problematic in developing a consistent methodology based on animal specific factors. This project has shown that the range of diet quality across northern Australia is reasonably consistent and that fixing diet quality has no material effect on the relative Adult Equivalent ratings of animals. This model uses a fixed diet quality of 7.75 MJ ME/kg DM.
- Exercise, particularly distance walked each day by cattle, influences the energy demand of cattle. A review of existing research on distance walked by cattle showed that cattle generally walk a similar distance each day, regardless of paddock size or configuration, allowing the distance walked each day to be fixed without limiting the application of this methodology across northern Australia. This model uses a fixed distance walked of 7.0 km/day.
- It was determined that 1 AE = 72.6 MJ ME/day
- The outputs of this methodology include:
  1. Whole herd model: Calculates the energy requirements and, consequently, Adult Equivalents for a whole herd over a 12 month period.
  2. Individual animal model: Calculates the energy requirements and, consequently, Adult Equivalents of individual classes of animal on a monthly basis.
  3. Pro-forma tables: Tables of Adult Equivalent ratings of animals based on various physiological states (weight, weight gain, pregnancy, lactation).

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1. Introduction

1.1 Background

The Adult Equivalent (AE) is the standard measure of Grazing loads used in extensive cattle grazing areas across northern and pastoral Australia and is used for carrying capacity assessments, grazing management, nutrition management, land valuations and performance analysis.

Whilst the definition of an AE being equivalent to a 450 kg dry animal at maintenance is generally accepted, there has been neither clarity nor consistency within the commercial industry or the scientific and extension community on the relative AE rating of animal classes or the treatment of weight gain, pregnancy and lactation.

This inconsistency raises a number of problems in performing reliable analysis of, and comparisons between, beef enterprises and there is a need for an accurate, consistent, defendable measure upon which to base management decisions and evaluation.

This project addresses that need.

1.2 Technical review workshop

In the development of the methodology there were a number of unresolved matters and questions that required discussion and input from peers. Meat & Livestock Australia convened a technical panel in Brisbane on July 30, 2013, the panel consisted of Wayne Hall, Geoff Niethe, Mick Quirk, Geoff Fordyce, Stu McLennan, Maree Bowen, Robyn Cowley and the authors. The panel gave input and guidance to methodology and supported continuation of the project.

1.3 Audience

The primary audience of this report is Meat & Livestock Australia as a final report on the project. The secondary audience is technical, extension and advisory personnel, providing the sufficient detail on the technical approach to enable them to appraise the model and consider its application.

The accompanying tools have been developed for use by individual beef producers and technical officers, extension staff and advisory personnel.

This project was directed primarily at researchers, consultants and advisors in order to develop a robust methodology and gain widespread adoption of an improved and more accurate scientific basis for the adult equivalent rating. Acceptance and adoption is a necessary next step but is outside the scope of this project.

1.4 Objectives

1. Created practical, simple and robust suite of spreadsheet tools that standardise AE calculations and provide an accurate measure of animal demand and grazing pressure for production systems across northern Australia.
2. Communicated application and use of the tools to relevant advisors and extension staff working in the field of nutrition, grazing land management and economic modelling.

1.5 Scope

The scope of this project is to develop a standardised system for cattle only. Ratings for and substitution with other species is outside the scope of this project.

2. Methodology

2.1 Guiding Principles

The complexity of the issue, along with the number of variables and unknowns, has stalled attempts to resolve this issue in the past.

Whilst accuracy is important, there is a necessary trade-off in terms of the complexity of calculations and input information required to ensure a practical balance between accuracy and workability. The methodology developed strives to achieve optimal accuracy while simplifying user inputs.

2.2 What is "Equivalent"?

For an Adult Equivalent (or animal unit) methodology *'to have clear meaning, it should have precise equivalence to that something. The animal unit itself should be clearly definable and animal–unit equivalents of animals should be relatively easily measured or modelled.' (*Scarnecchia, 2004).

In developing a practical, defendable methodology which provides an accurate, consistent measure of the grazing load for production systems, a preliminary question is "what is an Adult Equivalent a measure of?".

Primarily it is a measure of animal units, quantified in terms of energy demand by animals. Previous approaches have attempted to standardise the units on the basis of live weight, metabolic weight and dry matter intake.

Many of the factors determining the energy demanded by cattle are animal specific factors, such as weight, growth, gestation and lactation. However there are also environmental factors affecting energy demand and intake, such as feed quality and temperature. This complicates the problem significantly, particularly in developing a consistent methodology for the whole of northern Australia.

This problem was addressed well by Scarnecchia (1986b) when he stated that *'an animal-unit should be a unit of animal. That sounds simple enough, but requires that animal unit equivalents be functions of variables describing animal characteristics (requirements for maintenance, lactation, etc.) and not variables describing animal-pasture or other animal-environment interactions'.*

Scarnecchia (1986b) goes on to say *'at best, an animal-unit can cleanly [sic] be unit of either (1) energy demand, (2) energy intake (3) dry matter intake or (4) dry matter forage supply. To have it vaguely be a unit of all of these variables is not good science, and not the basis of good management. Animal-unit-equivalents should express the demand of animals in animal-units; they should not involve diet quality, diet selection or other complex interactive processes. If systematically limited in this way, the animal-unit and animal unit-equivalent concepts can be used in quantifying animal demand in supply/demand analyses of range-livestock systems'.*

2.3 Calculating energy demand

In 1990, CSIRO published "Feeding Standards for Australian Livestock", providing the first comprehensive guide to calculating the nutrient requirements of livestock under Australian conditions. This book was updated in 2007 by a group of contributors under the editorial guidance of M. Freer, H. Dove and J.V. Nolan and was published as "Nutrient Requirements for Domestic Ruminants" by CSIRO Publishing.

"Nutrient Requirements for Domestic Ruminants" provides detailed equations to calculate requirements for energy, protein, minerals, vitamins and water across a range of classes of cattle and sheep. It also contains a section discussing feed intake. This document is referred to as 'feeding standards' throughout this report.

In line with Scarnecchia's recommendation that an animal unit be based on energy demand, this project draws on the energy calculations set out in the updated publication.

The formulas pertaining to energy demand are detailed below

2.3.1 Maintenance

$ME_m = K.S.M(0.28\ W^{0.75} \exp(-0.03A_y))/k_m + 0.1ME_p + ME_a + ME_c$ *Eqn 1.19*

ME_m	Metabolisable energy required for maintenance
K	Breed factor (*Bos taurus* 1.4, *Bos indicus* 1.2)
S	Sex (females & steers 1.00, bulls 1.15)
M	Dietary milk intake factor $1 + (.26 - 0.01A_w)$ *[minimum value 1]*
A_w	Age in weeks
W	Live weight (kg), excluding conceptus
A_y	Age in years
k_m	Net efficiency of use of ME for maintenance 0.02 x M/D + 0.5
M/D	Metabolisable energy content of the diet (MJ ME/kg DM)
ME_p	Total metabolisable energy used for production
ME_a	Metabolisable energy used in activity; walking, feeding, standing up, etc
ME_c	Metabolisable energy expenditure where the ambient temperature is below the critical threshold

2.3.2 Activity

$ME_a = W(0.0025DMI(0.9-D) + 0.0026.H)/k_m$ *Eqn 1.22*

ME_a	Metabolisable energy required for activity
W	Live weight (kg)
DMI	Pasture dry matter intake*
D	Dry matter digestibility
H	Distance walked (km)
k_m	Net efficiency of use of ME for maintenance

* assumed to be 2% of liveweight

2.3.3 Growth

$ME_g = 0.92LWG((6.7+R)+(b-R)/(1+exp(-6(Z-.04))))/k_g$ *Eqn 1.30*

ME_g	Metabolisable energy required for growth
LWG	Live weight gain (kg/day)
b	Breed dependent coefficient (*Bos taurus* 20.3, *Bos indicus* 16.5, Crossbreds 18.4)
R	Adjustment for rate of gain or loss $MEI/ME_m - 2$ or $.92LWG/(4{*}SRW^{0.75}) - 1$
SRW	Standard Reference Weight (breed and sex dependent)
Z	Relative size Lwt/SRW
k_g	Net efficiency of use of ME for growth .043M/D

2.3.4 Pregnancy

$ME_y = -B .C.exp(-Ct)(W/40.exp(A-B(exp(-Ct))))$ *Eqn 1.26*

ME_y	Metabolisable energy required for pregnancy
W	Calf birth weight
A	349.22
B	349.16
C	5.76×10^{-5}
t	Stage of gestation (days)
k_y	Net efficiency of use of ME for pregnancy 0.133

2.3.5 Lactation

$ME_l = NE_l/k_l$

ME_l	Metabolisable energy required for milk production
NE_l	Net energy required for milk production; equivalent to calf ME intake from milk
k_l	Net efficiency of use of ME for milk production 0.02 M/D + 0.5

2.3.6 Calf

Total calf ME intake (MEI) can be calculated from maintenance and growth equations.

The feeding standards (page 19) provide a series of equations from which the proportion of calf energy intake from milk can be predicted:

$M = 1 + (0.23 \times \%E_{milk})$
$M = 1 + (0.26 - 0.01 \times A_w)$

Solving for $\%E_{milk}$ yields $\%E_{milk} = (0.26 - 0.01 \times A_w)/.23$

A_w	Age in weeks

Applying $\%E_{milk}$ to total calf MEI determines calf MEI from milk.

The corollary being that the balance of calf MEI must come from pasture or supplement.

2.4 Defining the Adult Equivalent standard

An Adult Equivalent is the standard measure, against which the relative energy requirements of classes of animals are compared to determine their relative AE rating.

The standard animal used for the Adult Equivalent standard is a 2.25 year old, 450 kg *Bos taurus* steer at maintenance, grazing a 7.75 MJ ME/kg DM diet and walking 7.0 km per day.

Based on these metrics and using the formula prescribed by the feeding standards, *1 AE = 72.6 MJ ME/day*.

Table 1 ME demand for 450 kg steer at maintenance

$ME_{maintenance}$	Eqn 1.19	54.7	MJ ME/day
$ME_{activity}$	Eqn 1.22	17.9	MJ ME/day
ME_{growth}		n/a	
$ME_{pregnancy}$		n/a	
$ME_{lactation}$		n/a	
Total		72.6	MJ ME/day

2.5 Approaches to issues arising from the calculations

2.5.1 Age

The model assumes an age of 2.25 years in calculating the standard. This assumption is justified by the following example.

Table 2 Age calculation for adult Equivalent standard

Age at weaning	6	months
Weaning weight	180	kg
Standard weight	450	kg
Liveweight gain; weaning to standard weight	270	kg
Annual weight gain	155	kg
Age at standard weight	2.25	years

2.5.2 Diet quality

While diet quality is an environmental and non animal specific factor, it is a key variable in calculating the energy requirements of animals. Using the equations in the feeding standards, the energy density is the main driver in calculating the efficiency with which metabolisable energy is utilised for maintenance (k_m), growth (k_g) pregnancy (k_y) and milk production (k_l).

Therefore, the treatment of diet quality, expressed in megajoules of metabolisable energy per kilogram dry matter (MJ ME/kg DM), as an input to the calculations and in defining the Adult Equivalent is an issue that needed to be resolved in the development of the methodology.

One approach is to treat diet quality as a variable that is set by the user. This option was not pursued for three reasons;

1. it would make it a measure of animal/ pasture interaction, which is contradictory to the approach taken and 'not good science' (Scarnecchia 1986b),
2. it is unlikely that most users would have sufficiently accurate estimates of average diet quality through year, and
3. It would result in varying determinations of the AE standard, invalidating comparisons across situations.

It was a consensus within the review panel that the model be based upon a fixed diet quality, rather than attempting to infer it from the level of production or as an input variable.

However, to justify that approach, an understanding was required of what effect it might have on the calculations and the relative AE ratings of various animal classes.

To assess this, diet quality data were sourced from two long-running research projects across northern Australia.

1. Meat Quality CRC and Beef CRC. (Sullivan & Grant, 2007)
   This data set consists of over 400 samples collected by a large number of technical staff on Queensland Department of Agriculture, Fisheries and Forestry (QDAFF) beef cattle research stations from 2002 to 2007.
2. NBP.0382 Northern Australian Beef Fertility Project: CashCow. (McCosker, 2013)
   This data set consists of over 1,500 samples taken from properties across northern Australia as part of the Cash Cow project. Sample collection dates span the period October, 2007 to November, 2011.

These projects submitted dung staples for analysis by near infra-red spectroscopy (NIRS) which provided, among other data, a measure of dry matter digestibility (DMD) from which we were able to calculate apparent diet quality for each of the samples using equation 1.12a from the feeding standards: M/D = 0.172DMD - 1.707

Analysis of these results showed them to be normally distributed, as seen in Figure 1 below.

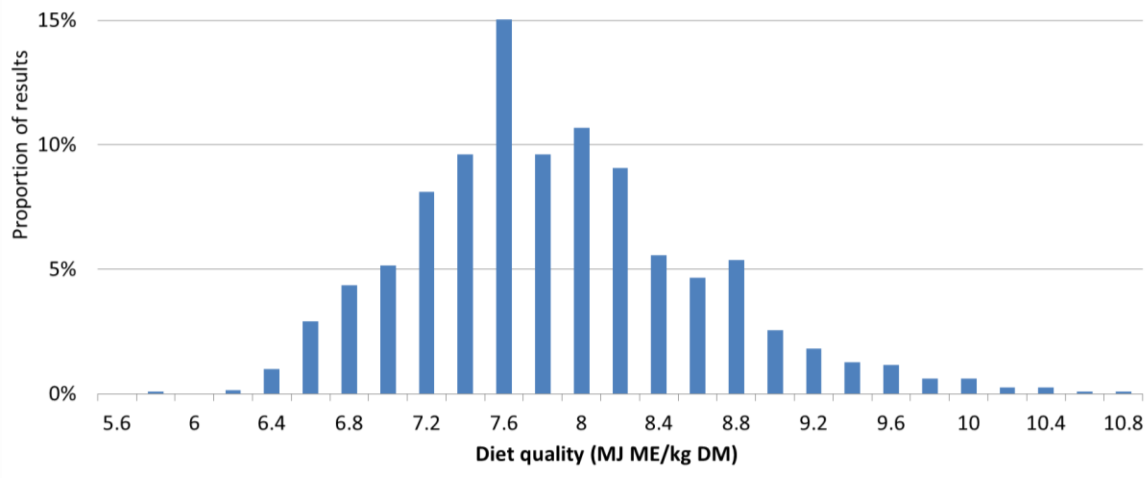

Figure 1 Distribution of diet quality as estimated level of Metabolisable Energy.

Figure 2 below shows box & whisker diagrams for the same data, broken up into regions for Cashcow data and research stations for QDAFF data. The boxes represent lower quartile, median and upper quartile. The whiskers represent minimum and maximum.

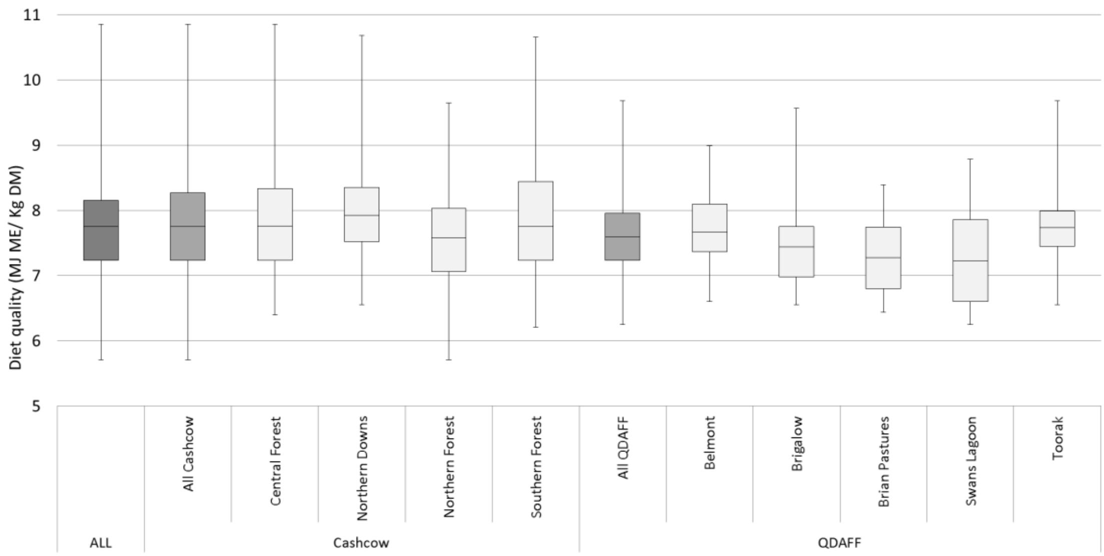

Figure 2 Summary of diet quality by region or research station

The above figures show that, while there is a significant spread in the data, the results were normally distributed and the majority of results were in a relatively narrow range (mean of 7.76 MJ ME/kg DM, median 7.75 and interquartile range of 7.24 to 8.15)

The first quartile, median and third quartile figures of the combined data were used to determine the sensitivity of the methodology to different diet quality figures. These sensitivities were done on three steer scenarios with starting weights of 200, 400 and 600 kg and gaining 150 kg over a twelve month period.

ME requirements were calculated for animals at three weights, consuming diets of three ME contents (Table 3).

Table 3 ME requirements for different diet quality inputs

	Diet quality (MJ ME/kg DM)		
Starting weight (kg)	7.24	7.75	8.15
200	63.8	61.7	60.1
400	95.8	92.7	90.5
600	119.4	115.7	113.1

As mentioned previously, there is the option to either vary or fix the calculations for the standard. Allowing diet quality to vary would result in variable energy requirements of the standard, i.e. a variable standard which is a contradiction in terms. A fixed diet quality enables a single, constant measure of the energy requirements of the standard.

A sensitivity analysis was conducted to examine the effect of fixing diet quality versus allowing variable diet quality as an input.

In the first instance, the calculation for the standard 450 kg steer was performed using M/D equal to the first quartile, median and third quartile figures of the combined CashCow/QDAFF NIRS data set. (Table 4)

Table 4 ME_m requirements of a 450 kg steer at various diet qualities

	Variable ME Content (MJ/ME/kg DM)			Fixed ME content (MJ/ME/kg DM)
M/D	7.24	7.75	8.15	7.75
ME_m for 450 kg steer	74.2	72.6	71.4	72.6

These ME_m were then applied to the growing steer examples from

Table **3**. The ME_m results for the three variable M/Ds were used as divisors to the energy requirements of the steers under the three variable M/D scenarios (Table 5). ME_m result for the median M/D was used as the divisor across the same fixed M/D scenarios.

Table 5 AE ratings under variable and fixed energy density scenarios

	Variable			Fixed		
ME_m divisor	74.2	72.6	71.4		72.6	
M/D scenarios	7.24	7.75	8.15	7.24	7.75	8.15
Starting weight (kg)			Calculated	AE ratings		
200	1.00	0.99	0.98	1.03	0.99	0.97
400	1.51	1.49	1.47	1.54	1.49	1.45
600	1.91	1.88	1.86	1.95	1.88	1.83

(Steers growing at 150kgs p.a.)

The resultant AE ratings show some minor variation within each steer category (horizontally), in the order of $\pm$ 1% to 2% either side of the median M/D in each subset.

Given that the purpose of the AE rating is to compare relative animal energy requirements, those same ratings were compared vertically between stated categories using the 400 kg steer AE rating as the divisor in each MD scenario. (Table 6)

Table 6 Comparison of relative AE ratings to a 400 kg steer rating

Starting weight (kg)	Variable			Fixed		
200	66.5%	66.6%	66.6%	66.5%	66.6%	66.6%
400	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
600	126.3%	126.2%	126.2%	126.3%	126.2%	126.2%

(Steers growing at 150 kgs p.a.)

There is consistency in the relativity between AE ratings of the 200, 400 and 600 kg steers within each M/D column, even across the variable and fixed approaches.

Given the relatively narrow range of average diet quality figures from northern Australian data and the immaterial effect that diet quality has on the absolute or relative AE ratings, diet quality can be fixed, allowing the environmental variable, diet quality, to be removed as an input.

This justifies fixing the diet quality (M/D) at the median of data sourced; 7.75 MJ ME/kg DM.

2.5.3 Standard Reference Weight

The feeding standards define Standard Reference Weight (SRW) as "the approximate live weight that would be achieved by the animal when skeletal development is complete and condition score is in the middle of the range". This datum is used in the growth algorithm to approximate the energy composition of growth and, hence, modulate the efficiency of energy use for growth.

The standard reference weight is breed and sex dependent as shown by data from the feeding standards (Table 7)

Table 7 Standard Reference Weights by breed and sex

Breeds	Females (kg)	Castrates (kg)	Males (kg)
Shorthorn, Angus, Hereford	500	600	700
Brahman, Brahman cross, Murray Grey, Limousin	550	660	770
Charolais, Simmental	650	780	910

(Nutrient Requirements of Domestic Ruminants, 2007)

At the technical workshop held in July 2013, there was some discussion on the application of these reference weights across the spectrum of livestock in northern Australia. For example, Brahman cows on a low quality tropical pasture may complete skeletal development at weights significantly lower than 550 kg.

Using a non-pregnant, dry 400 kg cow gaining 50 kg over three months as the baseline, successive iterations of the model were run with incremental adjustments to the standard reference weight of 25 kg to determine the impact of weight changes on AE ratings (Table 8).

Table 8 Effect of Standard Reference Weight changes on AE rating

SRW (kg)	Energy demand (Mj/ME/day)	AE	Variation
400	103.1 MJ ME/day	1.42	3.3%
425	102.8 MJ ME/day	1.42	2.9%
450	102.3 MJ ME/day	1.41	2.5%
475	101.8 MJ ME/day	1.40	1.9%
500	101.2 MJ ME/day	1.39	1.4%
525	100.6 MJ ME/day	1.39	0.7%
550	99.9 MJ ME/day	1.38	

It is apparent that, within the bounds of accuracy necessary for this model, there is no appreciable impact on energy requirements by varying the standard reference weight and, thus, no benefit in catering for a large number of possible values. We have elected to limit the possible reference weights to those shown in the feeding standards.

However, that document does not encompass all the breeds commonly found in northern Australia. We propose that additional genotypes be added (Table 9).

Table 9 Current feeding standards genotype groupings and proposed genotype additions.

Genotype groupings	Breeds currently in genotype groupings	Additional breeds for genotype groupings
Group 1	Shorthorn, Angus, Hereford	Other *Bos taurus*
Group 2	Brahman, Brahman cross, Murray Grey, Limousin	Santa Gertrudis, Droughtmaster, Composite
Group 3	Charolais, Simmental	

Although the feeding standards provide a standard reference weight series for Chianina cattle, we chose not to include this option in the model, given the dearth of those cattle in northern Australia.

2.5.4 Exercise

The distance walked by cattle each day, has an effect on their energy requirements. In developing the methodology, the energy used in exercise each day needs to be considered; in particular whether:

- there are significant differences in distance walked each day across northern Australia, and
- the actual distance walked can be calculated accurately based on user input (paddock size, number of waters, grazing radius etc) and if the resulting energy requirement calculation is more accurate than if a fixed allowance for exercise were used.

To answer these questions, a review of Australian research with information on distance walked each day by cattle was undertaken.

- **Trafalgar**
  Tomkins & O'Reagain (2007) looked at the distance walked each day in a 1,530 ha paddock with one water located in a corner of the paddock, 60km south-west of Charters Towers, Queensland.

  Seven 3-4 year old Brahman cows with calves (of a mob of 183) were tracked with GPS collars over late spring to mid-summer (56 days from November 2005 to January 2006). The distance walked each day (24 hours) averaged 8,127 metres with a range of 3,648m to 14,698m.

- **Wambiana**
  Tomkins et al (2009) collected information on distances walked by steers as part of the Wambiana grazing trial. Six Brahman cross steers were tracked for periods of up to six weeks on four different occasions, representing wet and dry seasons from October, 2004 to March, 2006. Three steers were in a high stocking rate paddock and three were in a low stocking rate paddock. The paddocks in the trial varied in size from 93 to 117 ha and all had two permanent water points.

  The work found that the difference in distance walked each day between high and low stocking rates was not significant at a mean of 6,967m and 6,262m respectively.

- **Pigeon Hole**
  In the Pigeon Hole project, Hunt et al (2013) looked at the distance walked by GPS collared Brahman or Brahman cross cattle under different grazing treatments. The cattle were collared for 2 to 6 periods of 6 months. The two treatments were grazing radius (1 km, 2 km and 3 km from water) and paddock configuration (1, 2 and 3 waters per paddock). There was also a larger commercial paddock with 3 water points.

  The research found that grazing radius did have a significant effect ($P<0.01$) on distance walked each day with the cattle in the 3 km radius paddock walking 1.5 km further (7,171m) than those in the 1 km radius paddock (5,637m).

  The paddock configuration treatment (number of water points) did not have a significant effect on distance walked.

Table 10 Pigeon Hole distance walked summary

	Paddock data				Distance from water[3]		Distance walked[4]	
	Area[1]	Waters	Radius[2]	Head	Mean	Median	Mean	SD
Grazing radius 1	8.9	1	1.0	16	1,152	1,191	5,637	906
Grazing radius 2	21.3	1	2.0	6	1,654	1,663	5,779	488
Grazing radius 3	34.5	1	3.0	7	2,053	1,915	7,171	1,595
Two waters	34.3	2	2.5	15	1,862	1,877	5,797	1,074
Multiple waters	56.9	5	3.0	15	2,341	2,364	5,378	587
Commercial paddock	148.6	3		4	3,251	3,212	7,533	1,267

[1] (km^2)
[2] (km)
[3] (m)
[4] (m/day)

- **Rockhampton Downs**
  Tomkins (2008) in a grazing trial at Rockhampton Downs collected GPS information from thirteen Santa Gertrudis cross cattle (out of 1,000) for 8 weeks in the 2007 dry season. The cattle were in 253 km^2 and 280 km^2 paddocks with one and three water points respectively.

  The study found that cattle travelled further in the paddock with 3 waters (9,350m vs 7,981m) and that this difference was statistically significant ($p<0.05$). Distance travelled from water (4.6 km vs 4.0 km) and animals' home range (19% vs 16% of paddock) was also greater for three waters but this was not statistically significant.

- H**amilton Downs**
  in the early 1980's, a two year study of the activities of individual Santa Gertrudis cows during 24-hour periods with observations made at two-weekly intervals over two years was conducted by Low et al (1981) at Hamilton Downs in Central Australia. The study was in a 170 km^2 paddock with two permanent and three temporary waters and relied on visual observation rather than GPS logging.

  From 41 observations, the mean was 9.3 km travelled in a 24 hour period, with a range of 4.8km to 14km.

- **Buttabone**
  Trotter et al (2010) collared three steers from a mob of 360 *Bos taurus* steers for eleven days in north-west New South Wales in a small paddock with one water. Mean velocity per steer was captured in the work, with an average of the three steers over the period of 0.06 m/s which equates to 5,200m/ day. It is noted that some of the difference between this mean and that of Swain et al below could be attributed to the latter using a more accurate, higher fix rate GPS.

- **Belmont Research Station**
  Swain et al (2008) collared six 18 month old *Bos taurus* females for five days in a five hectare paddock at Belmont Research Station, north of Rockhampton in Queensland. The mean velocity of the animals was 0.1m/s, which equates to 8,600m/day.

Figure 3 below summarises graphically data on distance walked by cattle from trials discussed in this report.

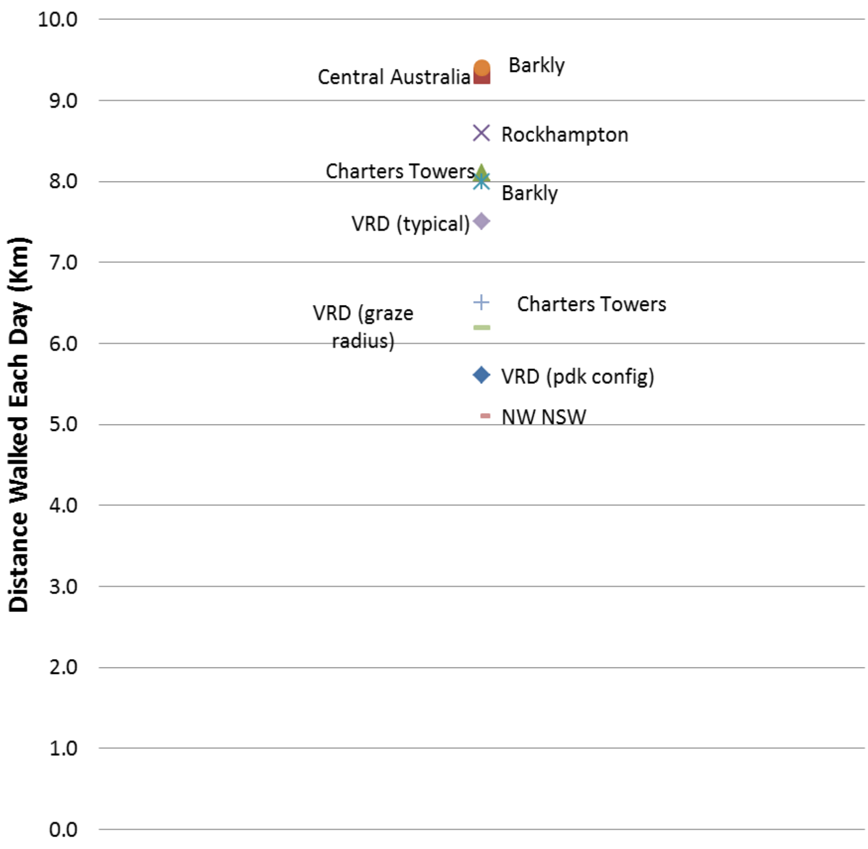

Figure 3 Summary of data on daily distance walked

This summary indicates that the distance walked each day by cattle is not sufficiently or consistently influenced by paddock size, number of waters or grazing radius to necessitate its inclusion as an input variable in calculating the energy requirement of cattle under grazing conditions.

McIvor (2010) came to this same conclusion and stated ‘in broad terms, cattle walk a similar distance each day, irrespective of paddock size’.

Therefore, the exercise provision in the methodology has been fixed at a distance walked of 7.0 km per day.

3. Models developed for AE Calculations

The model comprises three elements:

- a whole herd model
- an individual animal model, and,
- a series of pro-forma tables.

Whole herd model

The first element of the model calculates the energy requirements and, consequently, annual equivalents for a whole herd.

The user interface is configured as a dashboard where the user configures the herd profile and results are displayed in tabular and graphical form.

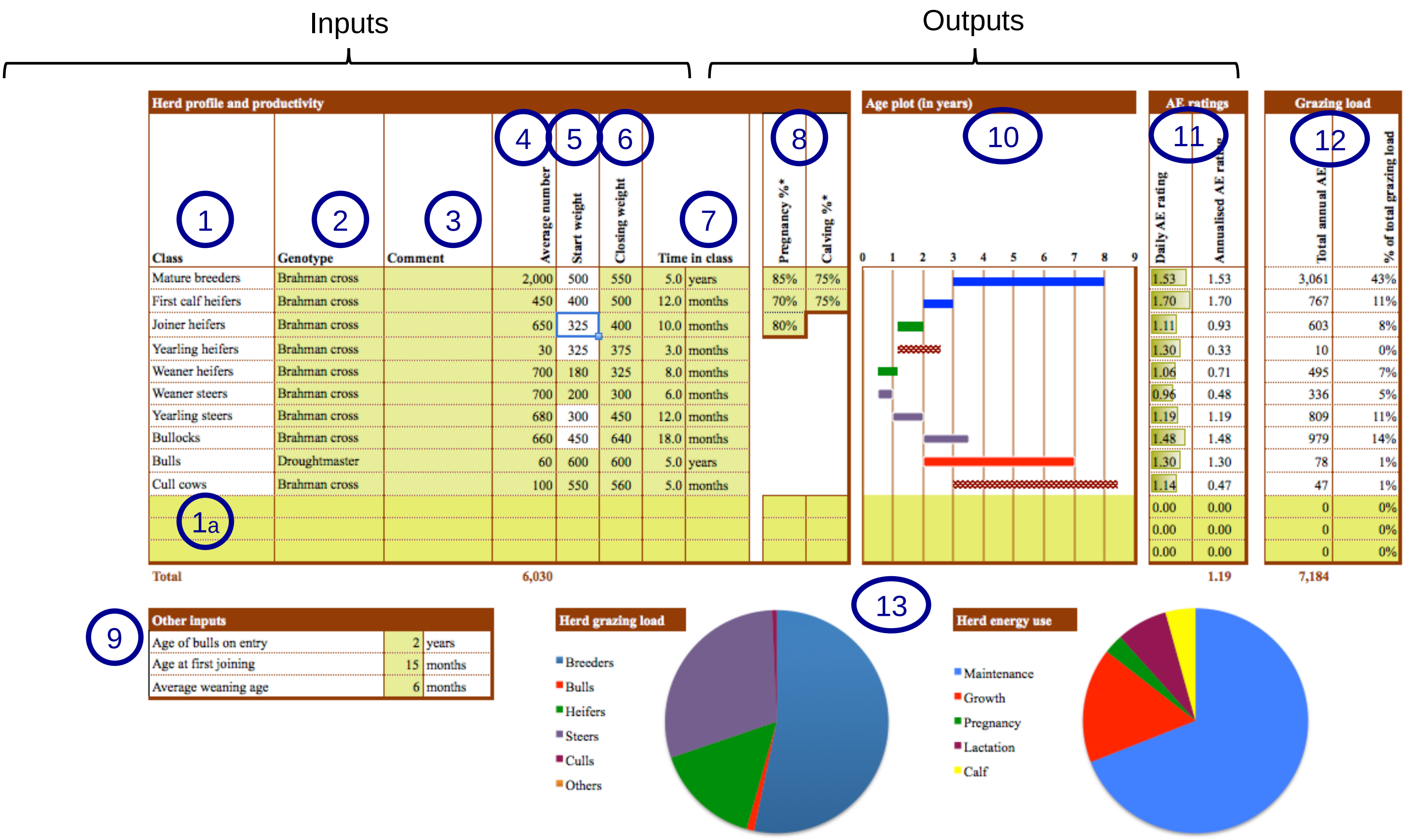

Figure 4 Whole herd dashboard

3.3.1 Inputs

The user interface works through a combination of drop-down lists and direct input. Categories selected by the user comprise:

- Cattle classes [1]
  The first ten lines are fixed entries describing the classes of cattle that make up the herd; i.e.:
  - Mature breeders
  - First calf heifers
  - Joiner heifers
  - Yearling heifers
  - Weaner heifers
  - Weaner steers
  - Yearling steers
  - Bullocks
  - Bulls
  - Cull cows

  The last three lines [1a] enable the user to select additional groups from the above classes via a drop-down list.

- Genotype [2]
  For each class of cattle, the user must select a breed from the following drop-down list:
  - Shorthorn
  - Angus
  - Hereford
  - Other *Bos taurus*
  - Brahman
  - Brahman cross
  - Santa Gertrudis
  - Droughtmaster
  - Composite
  - Charolais
  - Simmental

- Comment [3]
  This field is open for the user to enter a short note, if required.

- Average number [4]
  The user must enter the average number of cattle in each class for the period under consideration (see "Time in class").

- Starting weight [5]
  The user must enter starting or opening weights for weaner heifers and steers, bulls and cull cows. Starting weights for the other fixed classes are linked to the closing weights for the previous class in their transition; i.e. starting yearling heifer weight is linked to the closing weaner heifer weight, starting bullock weight equals closing yearling steer weight, etc.

- Closing weight [6]
  The user must define the closing weights for all classes of cattle.

Note: *The user must define both opening and closing weights for the user-defined classes in the last three lines.*

- Time in class [7]
  The user must enter the duration and select the time unit (months or years) for which each class of cattle is in the herd.

  For example, weaner heifers might be in that class for only six months before being transferred to the joiner heifer class. First calf heifers would typically be allocated twelve months in that category before transferring to the mature breeder category where they might be retained for five years or more.

- Reproductive rates [8]
  Pregnancy rates are to be entered by the user for joiner heifers, first calf heifers and mature breeders.

  Calving rates are to be entered for first calf heifers and mature breeders only.

- Initial transition ages [9]
  The user must enter:
  – age of bulls on entry,
  – age of heifers at first joining, and
  – average age at weaning.

Note: *Joiner heifer start weight defaults to weaner heifer closing weight on selection of 15 months age at first joining or to yearling heifer closing weight on selection of 27 months age at first joining.*

3.3.2 Assumptions and workings

- Underlying assumptions

Standard distance walked	7.00	km
Standard feed quality	7.75	MJ ME/kg DM
Birth weight	40	kg

- Workings
  Sex factors
  Sex factors are driven by the class nominated and draw from the following look up table:

Class	Sex	Coefficient	Reproductive*
Mature breeders	Female	1.00	Yes
First calf heifers	Female	1.00	Yes
Joiner heifers	Female	1.00	Yes
Cull heifers	Female	1.00	No
Weaner heifers	Female	1.00	No
Weaner steers	Steer	1.00	No
Yearling steers	Steer	1.00	No
Bullocks	Steer	1.00	No
Bulls	Bull	1.15	No
Cull cows	Female	1.00	Yes

*Reproductive includes pregnancy and lactation considerations

Breed factors
Breed factors are driven by the selected breed and draw from the following look up table:

		EBG* factors			Standard reference weights		
Breed	Breed factor	a	c	b	Female	Steer	Bull
Shorthorn	1.40	6.7	1.0	20.3	500	600	700
Angus	1.40	6.7	1.0	20.3	500	600	700
Hereford	1.40	6.7	1.0	20.3	500	600	700
Other *Bos taurus*	1.40	6.7	1.0	20.3	500	600	700
Brahman	1.20	6.7	1.0	20.3	550	660	770
Brahman cross	1.30	6.7	1.0	20.3	550	660	770
Santa Gertrudis	1.30	6.7	1.0	20.3	550	660	770
Droughtmaster	1.30	6.7	1.0	20.3	550	660	770
Composite	1.30	6.7	1.0	20.3	550	660	770
Charolais	1.40	6.7	1.0	16.5	650	780	910
Simmental	1.40	6.7	1.0	16.5	650	780	910

EBG* as described in Nutrient Requirements of Domesticated Animals, is the energy content of empty weight gain (MJ/kg EBG) and predictor equations for growing animals are incorporated in the composition of empty body gain (EBG).

Energy calculations

Energy requirements of each class of cattle are calculated using the equations described in Section 2.3, with the following qualifications:

1. There is no provision for ME_{cold} in the maintenance calculation as the critical thresholds are rarely, if ever, breached in northern Australia.
2. The model is driven by a fixed diet quality (7.75 MJ ME/kg DM) and assumes adequate availability. Hence, growth is deemed linear within the timeframe nominated by the user.
3. The energy needs of the suckling calf are met by milk and pasture. Both of these are modelled and included in the energy required by the relevant reproductive female class.

3.3.3 Outputs

The model output is presented on the dashboard as a combination of tables and graphics.

- Age plot [10]
  A stylised Gantt chart is embedded in the table to illustrate the time each class available is in the herd, based on entry age, time in class and transitions between classes.

- AE ratings table [11]
  The average daily energy requirement for the time in class is calculated for each class of animal and expressed as "Daily AE rating".

  It is also expressed as an "Annualised AE rating" by averaging the energy required for the nominated period over twelve months.

- Grazing load table [12]
  We have used the phrase "grazing load" rather than "grazing pressure". In this context, "grazing load" conveys a meaning of a quantum (e.g. lbs) whereas "grazing pressure" implies a ratio (e.g. lbs/sq inch).

  The "Grazing load" table states of total annual AE for each class and for the herd. It also expresses the class AE as a percentage of the total.

- Graphics [13]
  The herd grazing load is presented as a pie chart segmented into:

Grouping	Classes included
Breeders	reproductively active females; i.e. joiner heifers, first-calf heifers and mature breeders
Bulls	mature breeding bulls
Heifers	weaner and cull heifers
Steers	weaner steers, yearling steers and bullocks
Culls	mature cull females
Other	all cattle nominated by the user in the last three lines, regardless of class

  It was decided that grouping into summary categories provided a more meaningful representation.

  Total herd energy use is presented via a second pie chart. This graphic illustrates the apportionment of energy to maintenance, growth, pregnancy, lactation and calf across the whole.

Individual animal model

This element is also configured as a dashboard with a mix of user defined inputs and tabular and graphical outputs.

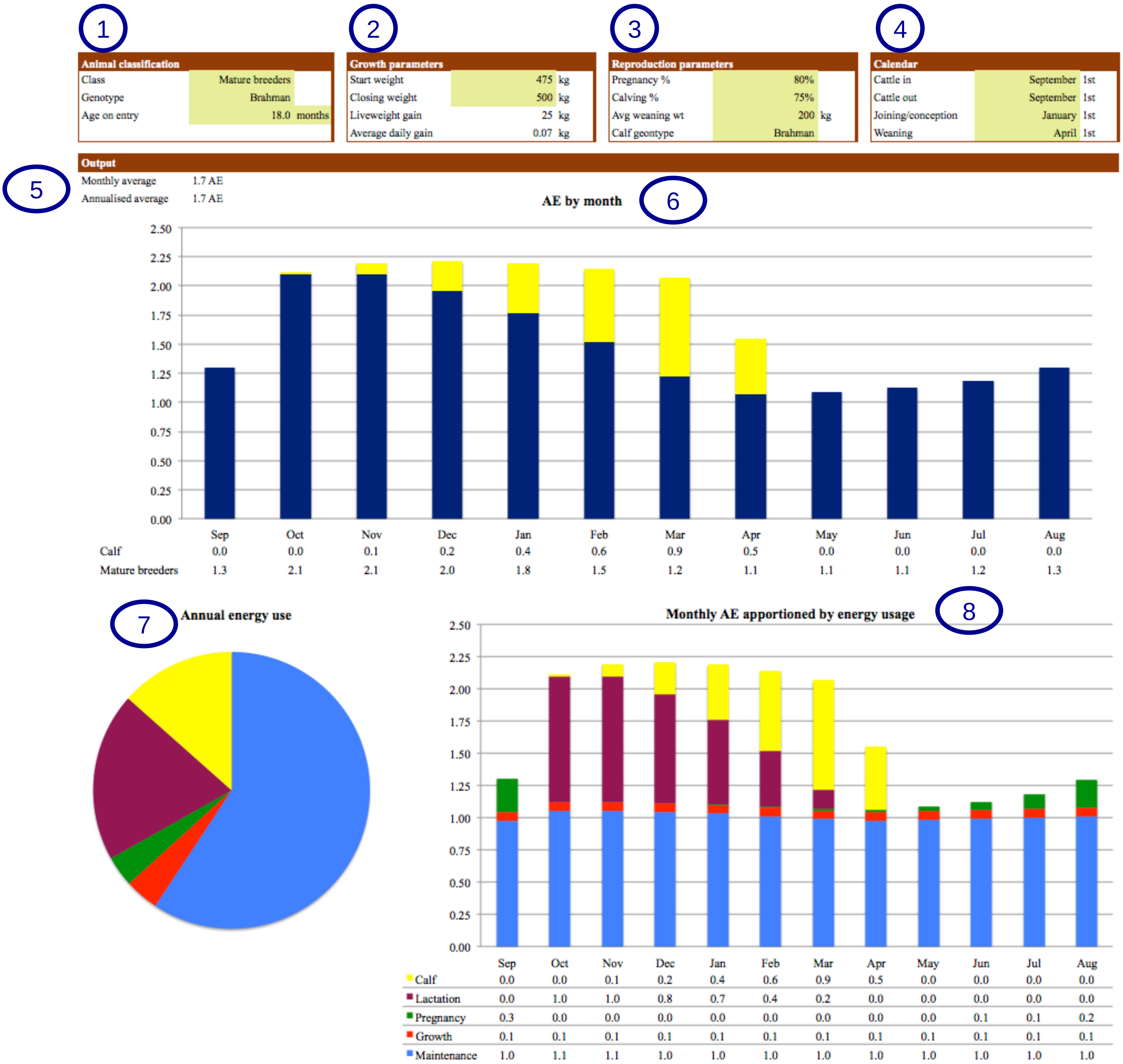

Figure 5 Individual animal dashboard

3.3.4 Inputs

Again, the user enters the criteria for the animal under consideration via drop-down lists and direct entry.

- Animal classification [1]
  Only one animal class may be nominated. Selection is from the same drop-down list as a whole herd model.

  Breed is selected from the same drop-down list as in the whole herd model.

  Age on entry must be entered by the user and time units selected from the adjacent drop-down list.

- Growth parameters [2]
  The user must enter both starting and closing live weights.

Note: Total live weight gain and average daily gain are displayed in this panel as a check.

- Reproduction parameters [3]
  The user must enter the pregnancy rate, calving rate and calf weaning weight, if applicable.

  The user must select the calf genotype from the drop down list.

Note: Reproduction criteria are not factored into heifer, steer and bull energy calculations, even if they are entered into this panel by mistake.

- Calendar [4]
  From the drop down list, the user selects the following time-based criteria:

Cattle in	the month the period under consideration commences
Cattle out	the month the period under consideration concludes
Joining/conception	the month by when 50% of females have conceived
Weaning	average month of weaning

Note: Cattle in and cattle out occur on the first of the month, so calculations for cattle in January and out in March are for two, not three months.

3.3.5 Assumptions and workings

- Underlying assumptions
  The distance, diet quality and birth weight assumptions details in Section 3.3.2 also apply to the individual animal model.

  All events are deemed to occur on the first day of the nominated month. This is analogous to it occurring on the last day of the previous month.

- Workings
  <u>Energy calculations</u>
  This element of the model is driven by the processes described in Section 3.3.2.

  <u>Production year</u>
  The individual animal model works within a twelve month production year, starting on the first day of the "Cattle in" month. If the time in class (Cattle in - Cattle out) is less than twelve months, only the relevant months are displayed in the model output.

  <u>End of process</u>
  A process is deemed to end on the first day of the nominated month. Consequently, concluding processes (time in class, pregnancy, location, etc) do not contribute to energy demand in the month out/finished.

Time series
A series of algorithms within the model engine "wrap" the production year into a cycle, even though the output is displayed as a linear temporal series, enabling the calculation of monthly energy requirements for cyclical processes (e.g. pregnancy and lactation) and their appropriate placement with in the period under consideration.

3.3.6 Output

- AE ratings [5]
  A small table displays results for:
  1. Average monthly AE rating for the period under consideration, and
  2. Annualised AE rating, extended from the average monthly AE rating as described in Section 3.3.3.
- AE by month display [6]
  The AE load is presented as a histogram for each month in the period under consideration. If the animal complex includes a suckling calf, the calf component is stacked above the adult animal component of the histogram.
- Energy use display [7]
  The total energy demand over the period is presented as a pie chart, apportioned to maintenance, growth, pregnancy, lactation and calf, as applicable.
- Monthly AE apportioned by physiological function [8]
  The final chart provides a more detailed illustration of monthly energy demand by physiological function in AE units.

Tables

The final element of the package is a series of static tables. The full set of tables are provided as Appendix 1.

Growing steer (1)

Liveweight (kg)	Liveweight gain (kg/hd/day)						
	0.0	0.2	0.4	0.6	0.8	1.0	1.2
150	0.43	0.53	0.64	0.75	0.87	0.99	1.11
200	0.52	0.64	0.77	0.90	1.03	1.17	1.31
250	0.62	0.77	0.91	1.06	1.21	1.37	1.53
300	0.72	0.89	1.05	1.22	1.39	1.56	1.74
350	0.82	1.00	1.18	1.37	1.55	1.74	1.93
400	0.91	1.11	1.30	1.50	1.70	1.90	2.10
450	1.00	1.21	1.41	1.62	1.83	2.04	2.25
500	1.09	1.30	1.52	1.73	1.95	2.16	2.38
550	1.18	1.40	1.62	1.84	2.05	2.27	2.49
600	1.27	1.49	1.71	1.93	2.15	2.38	2.60
650	1.36	1.58	1.80	2.02	2.24	2.46	2.69

Annualised breeder (2)

Liveweight (kg)	Weaning rate						
	60%	65%	70%	75%	80%	85%	90%
350	1.18	1.21	1.24	1.27	1.31	1.34	1.37
375	1.22	1.26	1.29	1.32	1.36	1.39	1.42
400	1.27	1.30	1.34	1.37	1.40	1.44	1.47
425	1.32	1.35	1.38	1.42	1.45	1.48	1.52
450	1.37	1.40	1.43	1.47	1.50	1.53	1.57
475	1.41	1.45	1.48	1.51	1.55	1.58	1.61
500	1.46	1.49	1.53	1.56	1.59	1.63	1.66
525	1.51	1.54	1.58	1.61	1.64	1.68	1.71
550	1.56	1.59	1.62	1.66	1.69	1.72	1.76
575	1.60	1.64	1.67	1.70	1.74	1.77	1.80
600	1.65	1.69	1.72	1.75	1.79	1.82	1.85

Pregnant female (3)

Liveweight (kg)	Days pregnant						
	0	45	90	135	180	225	270
350	0.77	0.78	0.79	0.81	0.86	0.99	1.30
375	0.82	0.82	0.83	0.85	0.91	1.03	1.34
400	0.87	0.87	0.88	0.90	0.95	1.08	1.39
425	0.92	0.92	0.93	0.95	1.00	1.13	1.44
450	0.96	0.97	0.98	1.00	1.05	1.18	1.49
475	1.01	1.02	1.02	1.05	1.10	1.22	1.53
500	1.06	1.06	1.07	1.09	1.15	1.27	1.58
525	1.11	1.11	1.12	1.14	1.19	1.32	1.63
550	1.16	1.16	1.17	1.19	1.24	1.37	1.68
575	1.20	1.21	1.22	1.24	1.29	1.42	1.73
600	1.25	1.25	1.26	1.29	1.34	1.46	1.77

Lactating female (4)

Liveweight (kg)	Days in milk						
	0	30	60	90	120	150	180
350	1.30	1.92	1.82	1.65	1.42	1.13	0.80
375	1.34	1.96	1.86	1.70	1.47	1.18	0.84
400	1.39	2.01	1.91	1.74	1.51	1.23	0.89
425	1.44	2.06	1.96	1.79	1.56	1.28	0.94
450	1.49	2.11	2.01	1.84	1.61	1.32	0.99
475	1.53	2.16	2.05	1.89	1.66	1.37	1.03
500	1.58	2.20	2.10	1.93	1.71	1.42	1.08
525	1.63	2.25	2.15	1.98	1.75	1.47	1.13
550	1.68	2.30	2.20	2.03	1.80	1.52	1.18
575	1.73	2.35	2.25	2.08	1.85	1.56	1.23
600	1.77	2.40	2.29	2.13	1.90	1.61	1.27
plus Calf	0.00	0.0	0.2	0.3	0.5	0.7	1.0

Figure 6. *Bos taurus* table set

3.3.7 Input

There is no user input to these tables.

3.3.8 Assumptions and workings

- Underlying assumptions
  The distance, diet quality and birth weight assumptions details in section 3.1.2 also apply to these tables.

  The annualised breeder calculation assumes a pregnancy rate equal to weaning rate plus 5%.

  Calf parameters comprise:

Weaning age	6	months
Weaning weight	190	kg

  There is no lightweight gain provision in any of the breeding female tables.

- Workings
  The same processes described in Section 3.3.2 drive the energy calculations in this element of the model.

3.3.9 Output

There are five table sets:

Breed		Table set
– *Bos taurus* – *Bos indicus* – Cross breed – European – Limousin	X	– Growing steer – Annualised breeder – Lactating female – Pregnant female

The separate Limousin table set is necessitated by the standards nominating a standard reference weight female/castrate/male series of 550/660/770 kg compared with the 650/780/910 kg specified for the Charolais and Simmental European breeds.

All results are "spot" figures for an animal in that state at one point in time.

- Growing steer [1]
  AE ratings are provided for steers ranging in live weight from 150 kg to 650 kg in 50 kg increments at growth rates spanning 0.0 to 1.2 kg/day in 0.2 kg increments.

- Annualised breeder [2]
  AE ratings are provided for a twelve month breeder cycle for cows in a live weight range from 350 kg to 600 kg in 25 kg increments at weaning rates from 60% to 90% in 5% increments (implied pregnancy rates of 65% to 95%).

- Lactating female [3]
  AE ratings are provided for lactating cows in a liveweight range from 350 kg to 600 kg in 25 kg increments at "Days in milk" spanning 0 to 180 days in 30 day increments.

- Pregnant female [4]
  AE ratings are provided for pregnant cows in a live weight range from 350 kg to 600 kg in 25 kg increments at "Days pregnant" spanning 0 to 180 days in 45 day increments.

4. Conclusion and recommendations

The approach developed appears robust and biologically logical. It fills the need for a consistent approach to determining grazing load across northern Australia.

Our recommendations regarding the product's roll-out and application are:

1. The methodology and tools should be reviewed by extension personnel for practical application.
2. The tools should be adapted to be publically available on a web-based platform.
3. A user manual should be developed to assist with and explain the application of the methodology, tools and tables for producers.
4. Previous Adult Equivalent classifications in reference material (eg EDGE products, Stocktake, Breedcow Dynama) should be replaced with this methodology to ensure consistency across the industry.
5. This methodology should be applied to sheep, goats and kangaroos for the Northern/ Pastoral areas of Australia so that they are expressed in AE's. This will provide a consistent methodology to accurately calculate total grazing loads for mixed pastoral areas.

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6. Appendices

6.1 Adult Equivalent Tables by Breed Type.

ADULT EQUIVALENT (AE) TABLES: BOS TAURUS

AE Ratings represent energy requirements relative to the AE standard, which is a 450kg Bos taurus steer at maintenance

Growing steer

Liveweight (kg)	Liveweight gain (kg/hd/day) 0.0	0.2	0.4	0.6	0.8	1.0	1.2
150	0.43	0.53	0.64	0.75	0.87	0.99	1.11
200	0.52	0.64	0.77	0.90	1.03	1.17	1.31
250	0.62	0.77	0.91	1.06	1.21	1.37	1.53
300	0.72	0.89	1.05	1.22	1.39	1.56	1.74
350	0.82	1.00	1.18	1.37	1.55	1.74	1.93
400	0.91	1.11	1.30	1.50	1.70	1.90	2.10
450	1.00	1.21	1.41	1.62	1.83	2.04	2.25
500	1.09	1.30	1.52	1.73	1.95	2.16	2.38
550	1.18	1.40	1.62	1.84	2.05	2.27	2.49
600	1.27	1.49	1.71	1.93	2.15	2.38	2.60
650	1.36	1.58	1.80	2.02	2.24	2.46	2.69

Annualised breeder

Liveweight (kg)	Weaning rate 60%	65%	70%	75%	80%	85%	90%
350	1.18	1.21	1.24	1.27	1.31	1.34	1.37
375	1.22	1.26	1.29	1.32	1.36	1.39	1.42
400	1.27	1.30	1.34	1.37	1.40	1.44	1.47
425	1.32	1.35	1.38	1.42	1.45	1.48	1.52
450	1.37	1.40	1.43	1.47	1.50	1.53	1.57
475	1.41	1.45	1.48	1.51	1.55	1.58	1.61
500	1.46	1.49	1.53	1.56	1.59	1.63	1.66
525	1.51	1.54	1.58	1.61	1.64	1.68	1.71
550	1.56	1.59	1.62	1.66	1.69	1.72	1.76
575	1.60	1.64	1.67	1.70	1.74	1.77	1.80
600	1.65	1.69	1.72	1.75	1.79	1.82	1.85

Pregnant female

Liveweight (kg)	Days pregnant 0	45	90	135	180	225	270
350	0.77	0.78	0.79	0.81	0.86	0.99	1.30
375	0.82	0.82	0.83	0.85	0.91	1.03	1.34
400	0.87	0.87	0.88	0.90	0.95	1.08	1.39
425	0.92	0.92	0.93	0.95	1.00	1.13	1.44
450	0.96	0.97	0.98	1.00	1.05	1.18	1.49
475	1.01	1.02	1.02	1.05	1.10	1.22	1.53
500	1.06	1.06	1.07	1.09	1.15	1.27	1.58
525	1.11	1.11	1.12	1.14	1.19	1.32	1.63
550	1.16	1.16	1.17	1.19	1.24	1.37	1.68
575	1.20	1.21	1.22	1.24	1.29	1.42	1.73
600	1.25	1.25	1.26	1.29	1.34	1.46	1.77

Lactating female

Liveweight (kg)	Days in milk 0	30	60	90	120	150	180
350	1.30	1.92	1.82	1.65	1.42	1.13	0.80
375	1.34	1.96	1.86	1.70	1.47	1.18	0.84
400	1.39	2.01	1.91	1.74	1.51	1.23	0.89
425	1.44	2.06	1.96	1.79	1.56	1.28	0.94
450	1.49	2.11	2.01	1.84	1.61	1.32	0.99
475	1.53	2.16	2.05	1.89	1.66	1.37	1.03
500	1.58	2.20	2.10	1.93	1.71	1.42	1.08
525	1.63	2.25	2.15	1.98	1.75	1.47	1.13
550	1.68	2.30	2.20	2.03	1.80	1.52	1.18
575	1.73	2.35	2.25	2.08	1.85	1.56	1.23
600	1.77	2.40	2.29	2.13	1.90	1.61	1.27
plus Calf	0.00	0.0	0.2	0.3	0.5	0.7	1.0

Developed for Meat & Livestock Australia (B.NBP.0779) by Shane Blakeley & Ian McLean, Bush AgriBusiness Pty Ltd.

ADULTL EQUIVALENT (AE) TABLES: BOS INDICUS

AE Ratings represent energy requirements relative to the AE standard, which is a 450kg Bos taurus steer at maintenance

Growing steer

Liveweight (kg)	Liveweight gain (kg/hd/day)						
	0.0	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.2**
150	0.38	0.48	0.58	0.68	0.79	0.91	1.03
200	0.46	0.58	0.69	0.81	0.94	1.07	1.20
250	0.55	0.68	0.82	0.96	1.10	1.25	1.40
300	0.64	0.79	0.95	1.10	1.26	1.43	1.59
350	0.73	0.90	1.07	1.24	1.42	1.60	1.78
400	0.81	1.00	1.18	1.37	1.56	1.76	1.95
450	0.89	1.09	1.29	1.49	1.69	1.89	2.10
500	0.97	1.18	1.39	1.60	1.81	2.02	2.23
550	1.06	1.27	1.48	1.70	1.91	2.13	2.35
600	1.14	1.36	1.57	1.79	2.01	2.23	2.45
650	1.22	1.44	1.66	1.88	2.10	2.33	2.55

Annualised breeder

Liveweight (kg)	Weaning rate						
	60%	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**
350	1.06	1.09	1.12	1.15	1.18	1.22	1.25
375	1.10	1.14	1.17	1.20	1.23	1.26	1.29
400	1.15	1.18	1.21	1.24	1.27	1.30	1.33
425	1.19	1.22	1.25	1.28	1.31	1.34	1.38
450	1.23	1.26	1.30	1.33	1.36	1.39	1.42
475	1.28	1.31	1.34	1.37	1.40	1.43	1.46
500	1.32	1.35	1.38	1.41	1.44	1.48	1.51
525	1.36	1.40	1.43	1.46	1.49	1.52	1.55
550	1.41	1.44	1.47	1.50	1.53	1.56	1.59
575	1.45	1.48	1.51	1.55	1.58	1.61	1.64
600	1.50	1.53	1.56	1.59	1.62	1.65	1.68

Pregnant female

Liveweight (kg)	Days pregnant						
	0	**45**	**90**	**135**	**180**	**225**	**270**
350	0.69	0.69	0.70	0.72	0.77	0.90	1.21
375	0.73	0.74	0.74	0.77	0.82	0.94	1.25
400	0.78	0.78	0.79	0.81	0.86	0.99	1.30
425	0.82	0.82	0.83	0.85	0.90	1.03	1.34
450	0.86	0.87	0.87	0.90	0.95	1.07	1.38
475	0.91	0.91	0.92	0.94	0.99	1.12	1.43
500	0.95	0.95	0.96	0.98	1.03	1.16	1.47
525	0.99	1.00	1.00	1.03	1.08	1.21	1.51
550	1.04	1.04	1.05	1.07	1.12	1.25	1.56
575	1.08	1.08	1.09	1.11	1.17	1.29	1.60
600	1.12	1.13	1.14	1.16	1.21	1.34	1.65

Lactating female

Liveweight (kg)	Days in milk						
	0	**30**	**60**	**90**	**120**	**150**	**180**
350	1.21	1.75	1.65	1.49	1.28	1.01	0.71
375	1.25	1.79	1.69	1.53	1.32	1.06	0.75
400	1.30	1.83	1.73	1.57	1.36	1.10	0.79
425	1.34	1.88	1.78	1.62	1.40	1.14	0.84
450	1.38	1.92	1.82	1.66	1.45	1.19	0.88
475	1.43	1.96	1.86	1.70	1.49	1.23	0.92
500	1.47	2.01	1.91	1.75	1.53	1.27	0.97
525	1.51	2.05	1.95	1.79	1.58	1.32	1.01
550	1.56	2.10	1.99	1.83	1.62	1.36	1.06
575	1.60	2.14	2.04	1.88	1.67	1.41	1.10
600	1.65	2.18	2.08	1.92	1.71	1.45	1.14
plus Calf	0.00	0.0	0.2	0.3	0.5	0.7	0.9

Developed for Meat & Livestock Australia (B.NBP.0779) by Shane Blakeley & Ian McLean, Bush AgriBusiness Pty Ltd.

ADULT EQUIVALENT (AE) TABLES: CROSSBREED

AE Ratings represent energy requirements relative to the AE standard, which is a 450kg Bos taurus steer at maintenance

Growing steer

Liveweight (kg)	Liveweight gain (kg/hd/day)						
	0.0	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.2**
150	0.41	0.50	0.60	0.71	0.82	0.93	1.05
200	0.49	0.61	0.72	0.84	0.97	1.10	1.23
250	0.59	0.72	0.86	1.00	1.14	1.28	1.43
300	0.68	0.83	0.99	1.15	1.31	1.47	1.63
350	0.77	0.94	1.11	1.29	1.47	1.64	1.82
400	0.86	1.05	1.23	1.42	1.61	1.80	2.00
450	0.95	1.14	1.34	1.54	1.75	1.95	2.15
500	1.03	1.24	1.45	1.66	1.87	2.08	2.29
550	1.12	1.33	1.55	1.76	1.98	2.19	2.41
600	1.20	1.42	1.64	1.86	2.08	2.30	2.52
650	1.29	1.51	1.73	1.95	2.17	2.39	2.62

Annualised breeder

Liveweight (kg)	Weaning rate						
	60%	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**
350	1.11	1.15	1.18	1.21	1.24	1.27	1.30
375	1.16	1.19	1.22	1.25	1.29	1.32	1.35
400	1.21	1.24	1.27	1.30	1.33	1.36	1.40
425	1.25	1.28	1.31	1.35	1.38	1.41	1.44
450	1.30	1.33	1.36	1.39	1.42	1.45	1.49
475	1.34	1.37	1.41	1.44	1.47	1.50	1.53
500	1.39	1.42	1.45	1.48	1.51	1.55	1.58
525	1.43	1.46	1.50	1.53	1.56	1.59	1.62
550	1.48	1.51	1.54	1.57	1.61	1.64	1.67
575	1.53	1.56	1.59	1.62	1.65	1.68	1.72
600	1.57	1.60	1.63	1.67	1.70	1.73	1.76

Pregnant female

Liveweight (kg)	Days pregnant						
	0	**45**	**90**	**135**	**180**	**225**	**270**
350	0.73	0.73	0.74	0.76	0.82	0.94	1.25
375	0.78	0.78	0.79	0.81	0.86	0.99	1.30
400	0.82	0.83	0.83	0.86	0.91	1.03	1.34
425	0.87	0.87	0.88	0.90	0.95	1.08	1.39
450	0.91	0.92	0.93	0.95	1.00	1.13	1.43
475	0.96	0.96	0.97	0.99	1.04	1.17	1.48
500	1.00	1.01	1.02	1.04	1.09	1.22	1.53
525	1.05	1.05	1.06	1.08	1.14	1.26	1.57
550	1.10	1.10	1.11	1.13	1.18	1.31	1.62
575	1.14	1.15	1.15	1.18	1.23	1.35	1.66
600	1.19	1.19	1.20	1.22	1.27	1.40	1.71

Lactating female

Liveweight (kg)	Days in milk						
	0	**30**	**60**	**90**	**120**	**150**	**180**
350	1.25	1.82	1.72	1.56	1.34	1.07	0.75
375	1.30	1.87	1.77	1.60	1.38	1.11	0.80
400	1.34	1.92	1.81	1.65	1.43	1.16	0.84
425	1.39	1.96	1.86	1.69	1.48	1.21	0.89
450	1.43	2.01	1.90	1.74	1.52	1.25	0.93
475	1.48	2.05	1.95	1.78	1.57	1.30	0.98
500	1.53	2.10	1.99	1.83	1.61	1.34	1.02
525	1.57	2.14	2.04	1.88	1.66	1.39	1.07
550	1.62	2.19	2.09	1.92	1.70	1.43	1.12
575	1.66	2.24	2.13	1.97	1.75	1.48	1.16
600	1.71	2.28	2.18	2.01	1.80	1.53	1.21
plus Calf	0.00	0.03	0.16	0.31	0.49	0.69	0.92

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ADULT EQUIVALENT (AE) TABLES: EUROPEAN

AE Ratings represent energy requirements relative to the AE standard, which is a 450kg Bos taurus steer at maintenance

Growing steer

Liveweight (kg)	Liveweight gain (kg/hd/day)						
	0.0	0.2	0.4	0.6	0.8	1.0	1.2
150	0.43	0.52	0.60	0.69	0.79	0.89	0.99
200	0.52	0.62	0.71	0.81	0.92	1.03	1.14
250	0.62	0.73	0.84	0.95	1.07	1.18	1.30
300	0.72	0.84	0.96	1.09	1.21	1.34	1.48
350	0.82	0.95	1.08	1.22	1.36	1.50	1.65
400	0.91	1.05	1.20	1.35	1.50	1.65	1.81
450	1.00	1.16	1.32	1.48	1.64	1.80	1.96
500	1.09	1.26	1.42	1.59	1.76	1.93	2.11
550	1.18	1.35	1.53	1.70	1.88	2.06	2.24
600	1.27	1.45	1.63	1.81	1.99	2.17	2.36
650	1.36	1.54	1.72	1.91	2.09	2.28	2.47

Annualised breeder

Liveweight (kg)	Weaning rate						
	60%	65%	70%	75%	80%	85%	90%
350	1.14	1.18	1.21	1.24	1.27	1.30	1.33
375	1.19	1.22	1.25	1.28	1.32	1.35	1.38
400	1.24	1.27	1.30	1.33	1.36	1.39	1.42
425	1.29	1.32	1.35	1.38	1.41	1.44	1.47
450	1.34	1.37	1.40	1.43	1.46	1.49	1.52
475	1.38	1.41	1.44	1.48	1.51	1.54	1.57
500	1.43	1.46	1.49	1.52	1.55	1.58	1.62
525	1.48	1.51	1.54	1.57	1.60	1.63	1.66
550	1.53	1.56	1.59	1.62	1.65	1.68	1.71
575	1.57	1.61	1.64	1.67	1.70	1.73	1.76
600	1.62	1.65	1.68	1.72	1.75	1.78	1.81

Pregnant female

Liveweight (kg)	Days pregnant						
	0	45	90	135	180	225	270
350	0.77	0.78	0.79	0.81	0.86	0.99	1.30
375	0.82	0.82	0.83	0.85	0.91	1.03	1.34
400	0.87	0.87	0.88	0.90	0.95	1.08	1.39
425	0.92	0.92	0.93	0.95	1.00	1.13	1.44
450	0.96	0.97	0.98	1.00	1.05	1.18	1.49
475	1.01	1.02	1.02	1.05	1.10	1.22	1.53
500	1.06	1.06	1.07	1.09	1.15	1.27	1.58
525	1.11	1.11	1.12	1.14	1.19	1.32	1.63
550	1.16	1.16	1.17	1.19	1.24	1.37	1.68
575	1.20	1.21	1.22	1.24	1.29	1.42	1.73
600	1.25	1.25	1.26	1.29	1.34	1.46	1.77

Lactating female

Liveweight (kg)	Days in milk						
	0	30	60	90	120	150	180
350	1.30	1.84	1.74	1.57	1.36	1.09	0.79
375	1.34	1.89	1.78	1.62	1.40	1.14	0.84
400	1.39	1.94	1.83	1.67	1.45	1.19	0.89
425	1.44	1.98	1.88	1.72	1.50	1.24	0.94
450	1.49	2.03	1.93	1.76	1.55	1.28	0.98
475	1.53	2.08	1.98	1.81	1.59	1.33	1.03
500	1.58	2.13	2.02	1.86	1.64	1.38	1.08
525	1.63	2.18	2.07	1.91	1.69	1.43	1.13
550	1.68	2.22	2.12	1.95	1.74	1.48	1.17
575	1.73	2.27	2.17	2.00	1.79	1.52	1.22
600	1.77	2.32	2.22	2.05	1.83	1.57	1.27
plus Calf	0.00	0.03	0.16	0.30	0.47	0.66	0.86

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ADULT EQUIVALENT (AE) TABLES: LIMOUSIN

AE Ratings represent energy requirements relative to the AE standard, which is a 450kg Bos taurus steer at maintenance

Growing steer

Liveweight (kg)	Liveweight gain (kg/hd/day)						
	0.0	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.2**
150	0.41	0.50	0.60	0.71	0.82	0.93	1.05
200	0.49	0.61	0.72	0.84	0.97	1.10	1.23
250	0.59	0.72	0.86	1.00	1.14	1.28	1.43
300	0.68	0.83	0.99	1.15	1.31	1.47	1.63
350	0.77	0.94	1.11	1.29	1.47	1.64	1.82
400	0.86	1.05	1.23	1.42	1.61	1.80	2.00
450	0.95	1.14	1.34	1.54	1.75	1.95	2.15
500	1.03	1.24	1.45	1.66	1.87	2.08	2.29
550	1.12	1.33	1.55	1.76	1.98	2.19	2.41
600	1.20	1.42	1.64	1.86	2.08	2.30	2.52
650	1.29	1.51	1.73	1.95	2.17	2.39	2.62

Annualised breeder

Liveweight (kg)	Weaning rate						
	60%	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**
350	1.11	1.15	1.18	1.21	1.24	1.27	1.30
375	1.16	1.19	1.22	1.25	1.29	1.32	1.35
400	1.21	1.24	1.27	1.30	1.33	1.36	1.40
425	1.25	1.28	1.31	1.35	1.38	1.41	1.44
450	1.30	1.33	1.36	1.39	1.42	1.45	1.49
475	1.34	1.37	1.41	1.44	1.47	1.50	1.53
500	1.39	1.42	1.45	1.48	1.51	1.55	1.58
525	1.43	1.46	1.50	1.53	1.56	1.59	1.62
550	1.48	1.51	1.54	1.57	1.61	1.64	1.67
575	1.53	1.56	1.59	1.62	1.65	1.68	1.72
600	1.57	1.60	1.63	1.67	1.70	1.73	1.76

Pregnant female

Liveweight (kg)	Days pregnant						
	0	**45**	**90**	**135**	**180**	**225**	**270**
350	0.73	0.73	0.74	0.76	0.82	0.94	1.25
375	0.78	0.78	0.79	0.81	0.86	0.99	1.30
400	0.82	0.83	0.83	0.86	0.91	1.03	1.34
425	0.87	0.87	0.88	0.90	0.95	1.08	1.39
450	0.91	0.92	0.93	0.95	1.00	1.13	1.43
475	0.96	0.96	0.97	0.99	1.04	1.17	1.48
500	1.00	1.01	1.02	1.04	1.09	1.22	1.53
525	1.05	1.05	1.06	1.08	1.14	1.26	1.57
550	1.10	1.10	1.11	1.13	1.18	1.31	1.62
575	1.14	1.15	1.15	1.18	1.23	1.35	1.66
600	1.19	1.19	1.20	1.22	1.27	1.40	1.71

Lactating female

Liveweight (kg)	Days in milk						
	0	**30**	**60**	**90**	**120**	**150**	**180**
350	1.25	1.82	1.72	1.56	1.34	1.07	0.75
375	1.30	1.87	1.77	1.60	1.38	1.11	0.80
400	1.34	1.92	1.81	1.65	1.43	1.16	0.84
425	1.39	1.96	1.86	1.69	1.48	1.21	0.89
450	1.43	2.01	1.90	1.74	1.52	1.25	0.93
475	1.48	2.05	1.95	1.78	1.57	1.30	0.98
500	1.53	2.10	1.99	1.83	1.61	1.34	1.02
525	1.57	2.14	2.04	1.88	1.66	1.39	1.07
550	1.62	2.19	2.09	1.92	1.70	1.43	1.12
575	1.66	2.24	2.13	1.97	1.75	1.48	1.16
600	1.71	2.28	2.18	2.01	1.80	1.53	1.21
plus Calf	0.00	0.03	0.16	0.31	0.49	0.69	0.92

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