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Prepared by: Dr Sam Clark
University of New England

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Feed intake measurement of cattle in the Tullimba R&D Feedlot BIN projects

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Executive summary

This report covers a summary of the 555 Angus and 120 Hereford steers that received feed intake testing at Tullimba from July 2018 to June 2019; and the 686 Angus and 74 Hereford steers that received feed intake testing at Tullimba from July 2019 to June 2020. Cattle have generally performed well.

2018/19- The Hereford cohort averaged 13.64 kg/day feed intake for the total trial period. Trial average weight gain was 1.55kg/day weight gain during the 70 day test period after adaptation to the feeders. The Angus Cohorts average 14.1 kg/day feed intake for the total trial period. Trial average weight gain was 1.62 kg/day weight gain during the 70 day test period after adaptation to the feeders.

2019/20- The Hereford cohorts averaged 12.02 kg/day feed intake for the total trial period. Trial average weight gain was 1.46 kg/day weight gain during the 70 day test period after adaptation to the feeders. The Angus Cohorts average 13.94 kg/day feed intake for the total trial period. Trial average weight gain was 1.58 kg/day weight gain during the 70 day test period after adaptation to the feeders.

A total of 1435 animals received feed intake testing at Tullimba feedlot from July 2018 to June 2020. Retrieval of valid daily feed intake data will allow robust estimates of RFI and EBVs. Feed intake and live weight data have been supplied to BREEDPLAN via Jim Cook.

In addition, a summary of the information collected since the introduction of the BIN projects in 2010 and the arrival of steers to Tullimba in 2012 has also been included in this report. A total of 5599 animals, from 5 breeds (Limousin 7%, Charolais 2%, Hereford 15%, Santa Gertrudis 1% and Angus 75%) have had feed intake and weight gain recorded on them since 2012. This data has been shared with project partners and subsequently underpins the genetic evaluation for net feed intake in a number of breeds of beef cattle in Australia.

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1 Background

1.1.1 RFI

Residual feed intake (RFI, also called 'net feed intake' or NFI in Australia and in this report) is a measure of feed efficiency in livestock. It is defined as the difference between an individual's feed intake and predicted feed intake, based on weight and growth. In practice, NFI is calculated by adjusting an individual's average daily feed intake for the amount of feed used for the maintenance of bodyweight (BW) and average daily gain (ADG) over a given test period. The adjustment for maintenance and growth (using multiple regression) forces NFI to be phenotypically independent of growth and body size, yet often a genetic relationship between the traits can remain (van der Werf 2004). Practically, an animal with a lower feed intake for the same maintenance requirement and growth is considered more efficient.

1.1.2 Genetic Variation in Feed Efficiency of Beef Cattle

National genetic improvement programs for beef cattle need to also consider avenues for reducing inputs in order to improve efficiency and profitability. There is considerable variation in feed intake above and below what is expected based on size and growth rate (Archer et al. 1999b, Berry and Crowley 2013). In growing beef cattle, Koch et al. (1963) found BW maintained and ADG affected feed requirements and suggested that feed intake could be adjusted for BW and weight gain, effectively partitioning feed intake into two components: 1) the feed intake expected for the given level of production and 2) a residual portion (RFI or NFI). The latter was used to identify animals which deviated from their expected level of feed intake, and was heritable (0.28 ± 0.11), with efficient animals having lower (negative) NFI. Following Koch *et al.*'s findings, the heritability of NFI in cattle has been estimated by many groups across the globe and can differ greatly depending on the population. A review by Berry and Crowley (2013) noted that the heritability ranged from 0.07 to 0.62. In Australian beef cattle estimates tend to me more moderate and approximately ~0.3 – 0.4 (Arthur and Herd 2006; Arthur and Herd 2008, 2012 and Torres-Vasquez et al 2018). Meaning that substantial opportunities exist to improve efficiency through selective breeding.

Previous studies conducted by NSW Agriculture at the Agricultural Research Centre, Trangie, NSW Australia, between 1993 and 2001 (Arthur et al. 2001a; 2001b) examined the relationship between NFI measured post weaning and other production traits such as carcass and meat quality traits, mature size, and lifetime reproductive performance of cows. In this study there were relationships between most traits and post weaning NFI (except early age growth). Recent research suggests that there may be a positive unfavourable correlation between NFI and intramuscular fat (or marbling) in Angus steers (Torres-Vasquez et al 2018). Positive genetic correlations between NFI and subcutaneous fat depth have also been reported in young Angus bulls and heifers (Arthur et al. 2001), and in feedlot-fed steers and heifers (Robinson and Oddy 2004; Barwick et al. 2009; Wolcott et al. 2009, Torres-Vasquez et al 2018), indicating that breeding for low RFI may also result in a reduction of subcutaneous fat. As part of the Maternal Productivity Project, Copping et al 2016 illustrated that cows selected for High –NFI were fatter for both scanned rump (P8) and rib (RIB) fat depth relative to Low-RFI contemporaries (lower RFI cows were leaner). They also found that cows with lower EBVs for RFI also had heavier calves at weaning; however, selection for lower RFI was also associated with a lower weaning rate. Furthermore Copping et al 2016 also noted that there was no

difference in performance when comparing High NFI with low NFI cows during lactation when feed was limiting. This agrees with the notion that NFI measured in a feedlot on *ad-lib* feed is different to NFI on pasture with restricted feed intake (Herd et al. 2011). Interestingly, the genetic correlation between postweaning NFI with feed intake by the cow is high and with NFI of the cow very high (0.64 and 0.98, respectively; Archer et al., 2002). These genetic correlations indicate that selection for improved NFI has the potential to lead to a reduction in feed intake by cows with little change in cow size, thus improving the feed efficiency of the cow herd.

It is clear from the previous studies stated above that correlations between NFI and key production traits exist. Importantly to select for overall production system efficiency, NFI needs to be included in the breeding objectives in breeding programs (as noted by Barwick et al 2018). There also needs to be a concerted effort to record NFI information on animals relevant to the breeding program so that optimal gains can be made.

This project, as well as those undertaken as part of B.SBP.0089, is key to increasing the number of records for NFI in the Australian beef cattle production system.

2 Project objectives

For each cohort of animals that go through Tullimba:

1. To measure and report on the feed intake of Beef Information Nucleus (BIN) Livestock at UNE Tullimba Feedlot Research Facility including provision of Reports containing data
2. To collect and store the data from this Project as well as other data generated by GrowSafe and other recording equipment. This data will be stored in a database accessible by UNE researchers subject to clause 8.9 of the Head Agreement.

3 Methodology

3.1 Feed intake and ADG collection

3.1.1 Protocols

To enable the accurate estimation of feed efficiency cattle were fed according to the following protocol

Table 1 Protocol for testing animals for NFI at Tullimba research feedlot

Day of trial	Process to be completed
Day -21	Animals Enter the feedlot and are acclimatised to the feed rations and pens.
Day 1-7	Animals are manually weighed (Trial starts) -7 days are used to check that animals are settled in and using the feeding system.
Day 14-21	Animals are manually weighed.
Day 28-35	Animals are manually weighed.
Day 42-49	Animals are manually weighed.
Day 56-63	Animals are manually weighed.

Day 70-77	Animals are manually weighed and removed from the intake measuring pens.
Day 1-77	All animals are provided Ad Lib feed and feed intake measured using the automated feeders located in the feedlot pens. All animals will be carrying electronic ear tags in accordance with national laws (National Livestock Identification Scheme (NLIS)).

Standards for feed intake data collection have been described previously. In general the amount of time required to collect stable data is the biggest influence on NFI testing. The current recommendation to the Australian industry for a 70-d RFI test is based on the results reported by Archer et al. (1997). They showed that for British breed cattle tested for RFI, with feed intake recorded daily and animal BW measured weekly, that while 35 d was adequate to measure feed intake, 70 d was required to accurately measure growth and RFI. All data was collected using equipment provided by Growsafe (GrowSafe Systems Ltd., Airdrie, AB, Canada). The data collected in this project (along with data from previous cohorts) is providing a great foundation for additional research regarding the relationship between feed intake and production.

This project aimed to collect feed intake and growth rate data on individual cattle from extended Angus and Hereford Beef Information Nucleus (BIN) projects for MLA at the Tullimba Feedlot Research Facility. Livestock was supplied by the respective breed society. The researchers involved in this project would like to acknowledge the important role our project collaborators and partners have played in the project. These include the breed societies for coordination of project activities relating to animals before they enter Tullimba; breeders, NSW DPI and commercial co-operator herds for the management of animals prior to feedlot entry; and Rangers Valley feedlot for their cooperation during the feed period and beyond.

In Australia data that flows into genetic evaluation are restricted to comparisons between animals raised in the same environment from conception to measurement (i.e., in the same contemporary group), as currently occurs with other traits recorded in BREEDPLAN (Skinner and Sundstrom 1997). The Australian standards manual requires a minimum pre-test adaptation period of 21 d and testing of animals in contemporary groups.

4 Results

4.1 Current project .1816

4.1.1 Feed intake and weight gain 2018/19

The number of animals measured for feed intake and weight is summarised (per breed) in Table 1 (ANGUS) and Table 2 (HEREFORD). This information was delivered to BREEDPLAN to enable the generation of RFI EBVs. All lower level feed intake data is stored at UNE.

The Angus steers were fed in 6 cohorts:

Cohort 1	74 Angus steers
Cohort 2	85 Angus steers
Cohort 3	100 Angus steers

Cohort 4 58 Angus steers

Cohort 5 148 Angus steers

Cohort 6 90 Angus steers

All cohorts of Angus steers were backgrounded on pasture prior to entering the feedlot. All steers were part of the Angus BIN project funded by MLA and Angus Australia. There was a good range of performance recorded for the key traits of weight gain and feed intake within each breed cohort. Although there was a large amount of variation this cohort performed well and had very low levels of animal loss due to sickness related issues.

Table 2 Summary of animal performance of the Angus steers over the test period

	TRIAL START WT (FITTED) (KG)	TRIAL END WT (FITTED) (KG)	ADG (KG)	AVG DAILY FI (G)
MIN	404	548	0.90	11027
MEAN	**490**	**604**	**1.58**	**13943**
MAX	647	795	2.76	19177

The Hereford steers were fed in 2 cohorts:

Cohort 1 51 Hereford steers

Cohort 2 69 Hereford steers

The two Hereford cohorts were fed for an extended period prior to entering the project to ensure that they were at similar entry/age specification of the past cohorts of steers. All Hereford steers were part of the Hereford BIN project funded by MLA and Herefords Australia. Again, there was a good range of performance recorded for the key traits of weight gain and feed intake within each breed cohort (Table 2). Although there was a large amount of variation this cohort performed well and had very low levels of animal loss due to sickness related issues.

Table 3 Summary of animal performance of the Hereford steers over the test period

	TRIAL START WT (FITTED) (KG)	TRIAL END WT (FITTED) (KG)	ADG (KG)	AVG DAILY FI (G)
MIN	422	542	0.90	10027
MEAN	**494**	**611**	**1.45**	**12021**
MAX	604	737	2.4	18132

Overall animals performed well in 2018/2019. The major challenge for the project related to the ongoing drought conditions in which our partners (owners of the cattle) experienced. Which further impacted the project in 2019/2020.

4.1.2 Feed intake and weight gain 2019/20

The number of animals measured for feed intake and weight is summarised (per breed) in Table 1 (ANGUS) and Table 2 (HEREFORD). This information was delivered to BREEDPLAN to enable the generation of RFI EBVs. All lower level feed intake data is stored at UNE.

The Angus animals were fed in 6 cohorts from co-operator herds in the ASBP and NSW DPI:

Cohort 1 74 steers

Cohort 2 71 steers

Cohort 3 29 steers

Cohort 4 100 steers

Cohort 5 84 steers

Cohort 7 134 steers and heifers

Cohort 8 96 steers

Cohort 9 98 steers and heifers

All cohorts of Angus steers were backgrounded on pasture prior to entering the feedlot. All steers were part of the Angus BIN project funded by MLA and Angus Australia. There was a good range of performance recorded for the key traits of weight gain and feed intake within each breed cohort. Although there was a large amount of variation this cohort performed well and had very low levels of animal loss due to sickness related issues. December 2019/January 2020 the weather was very hot and this may have impacted average feed intake during this period. Similarly during this period Tullimba experienced welcome rain that did impact the feeding of a number of cohorts.

Table 4 Summary of animal performance of the Angus animals over the test period

	TRIAL START WT (FITTED) (KG)	TRIAL END WT (FITTED) (KG)	ADG (KG)	AVG DAILY FI (G)
MIN	317	413	0.61	4879
MEAN	**485**	**603**	**1.62**	**14244**
MAX	651	803	2.54	19939

The Hereford steers were fed in 1 cohort:

Cohort 1 74 Hereford steers

All Hereford steers were part of the Hereford BIN project funded by MLA and Herefords Australia. Again, there was a good range of performance recorded for the key traits of weight gain and feed intake within each breed cohort (Table 2). Although there was a large amount of variation this cohort performed well and had very low levels of animal loss due to sickness related issues.

Table 5 Summary of animal performance of the Hereford steers over the test period

	TRIAL START WT (FITTED) (KG)	TRIAL END WT (FITTED) (KG)	ADG (KG)	AVG DAILY FI (G)
MIN	367	493	1.13	7,764
MEAN	**518**	**651**	**1.55**	**13,639**
MAX	639	759	2.08	18,512

In 2019/2020 the project was again impacted by drought conditions which resulted in a disrupted flow of cattle and subsequent challenges relating to the cost of feeding animals in Tullimba and managing animals in hot dry conditions. Tullimba received welcome rain in January which also meant that some days were lost due to the impact of such a long dry spell then hot humid conditions on animal performance. Despite such challenges, cattle generally performed well and data was recorded and delivered to Breed Societies for delivery to the respective BREEDPLAN analyses.

4.1.3 Past trials as part of the BIN projects

This trial brings to a close the feed intake collection components relating to the BIN projects. This section summarised the data collected under B.SBP.0089 (including the animals listed in the previous section).

Table 6 Summary of animals fed through Tullimba as part of B.SBP.0089 and the current project (2012-2020).

Trait summary	Breed					
	Limousin	Charolais	Santa Gertrudis	Hereford	Angus	Summary
Mean DFI (kg)	13.27	13.44	14.51	13.11	14.42	14.13
Mean Start Wt (kg)	500	392	535	488	510	504
Mean End Wt (kg)	615	540	661	612	625	621
Mean ADG (kg)	1.64	1.77	1.83	1.68	1.58	1.60
Total Number of Cohorts	6	1	1	11	43	62
Total Number of Animals	391	102	43	840	4223	5599

Since 2012, ~5600 animals have been processed through Tullimba research feedlot for feed intake and weight gain recording. Table 6 illustrates that the major breed to collaborate in the testing of individuals was the Angus Society of Australia, who collaborated heavily in this project contributing 75% of the cattle to the project. The comparisons across the breeds in this table is not possible because all animals were not contemporaries and had very different pre-feedlot treatment. The factors associated with farm of origin, age, age of dam and sex of the individuals, which can greatly impact ADG and DFI, have not been taken into account.

Figure 1 Number of records per breed for the BIN projects over time.

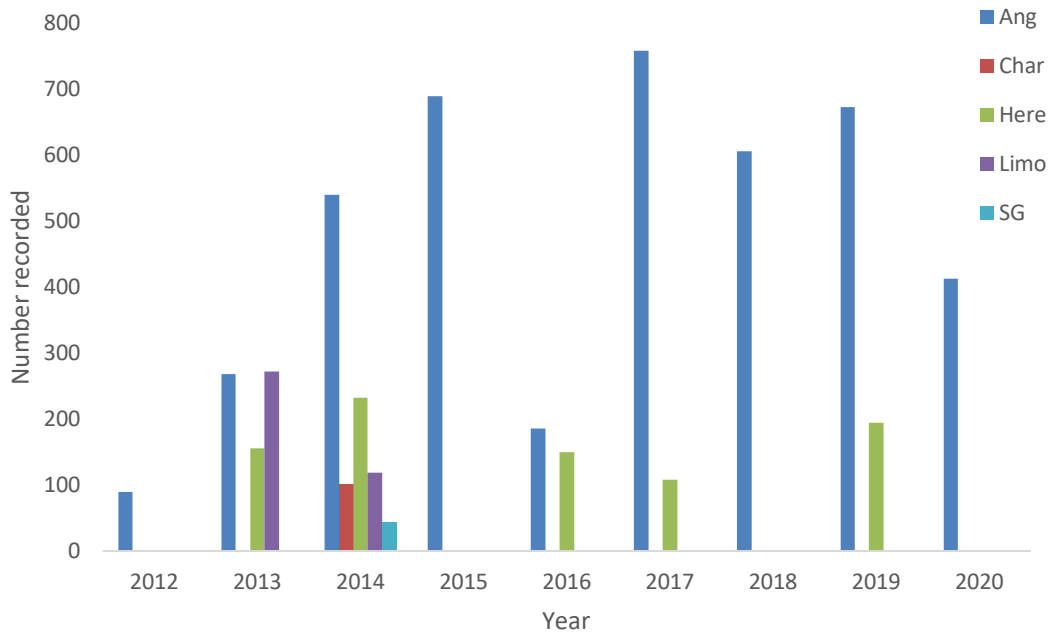

Figure 1 illustrates the number of animals recorded for feed intake and ADG over the duration of the BIN projects. It is clear that there was more balanced participation levels in the years 2013/2014. However, by 2019/2020 only Angus and Hereford animals were being recorded as part of the project. All DFI and ADG information has been shared with project partners for inclusion in each BREEDPLAN analysis.

4.1.4 Publications from feed intake data collected at Tullimba

A number of publications have been made using the information collected at Tullimba over this period. All have used the information collected on Angus individuals, with further data support provided by the Angus Society of Australia, and funded by the University of New England. There have been three (3) Journal Publications and three (3) conference articles.

Journal Publications

JA Torres-Vázquez, N Duijvesteijn, JHJ van der Werf, SA Clark., 2019. Longitudinal analysis of body weight and average daily feed intake during the feedlot test period in Angus cattle. Journal of Animal Breeding and Genetics, 137 (3), 281-291

S de las Heras-Saldana, SA Clark, N Duijvesteijn, C Gondro, *et al*., 2019. Combining information from genome-wide association and multi-tissue gene expression studies to elucidate factors underlying genetic variation for residual feed intake in … BMC genomics 20 (1), 939

JA Torres-Vázquez, JHJ van der Werf, SA Clark., 2018. Genetic and phenotypic associations of feed efficiency with growth and carcass traits in Australian Angus cattle. Journal of animal science, 96 (11), 4521-4531

Conference Publications

SA Clark and JHJ van der Werf., 2017.Possibilities of shortening the number days on feed for calculating Net Feed Intake in cattle. Proc. Assoc. Advmt. Anim. Breed. Genet 22, 175-178

JA Torres-Vazquez, JHJ van der Werf, SA Clark, 2017. Genetic and phenotypic parameters for feed efficiency traits in Australian Angus beef cattle. Proc. Assoc. Advmt. Anim. Breed. Genet 22, 461-464

JA Torres-Vázquez, JHJ van der Werf, SA Clark, 2019. Genome-wide association studies for body weight and average daily feed intake during the feedlot test period. Proc. Assoc. Advmt. Anim. Breed. Genet 23, 358-361

5 Discussion

5.1 Collection of Feed Intake and ADG

5.1.1 The cost of recording Net Feed Intake

The measurement of feed intake in a feedlot, with current technologies is expensive and difficult (Cottle 2013) so the cost | benefit for NFI is regularly questioned. The length of a NFI test period and the amount of data collected needs to be optimized or reduced to minimise the cost of recording animals. The current recommendation of a 70-d RFI test is based on the results reported by Archer et al. (1997) and are in line with those suggested by the feeding standards in Australia as well as those used by the US Beef Improvement Federation (BIF). Archer originally showed when feed intake was recorded daily and animal live weights measured fortnightly, 35 d was adequate to measure feed intake and 70 d was required to accurately measure growth and therefore NFI. Archer et al (1999) also suggested that the NFI test period was limited by the measurement of growth over the feed period and that more frequent weighing of cattle would likely improve the accuracy of measurement. Whilst they also noted that very frequent weighing in a standard chute based system may be undesirable because it impacted feeding behaviour and that other technologies would be needed. Archer and Bergh (2000) subsequently suggested that a test of 56 d might be sufficient for measurement of growth rate and feed intake in young bulls from five breeds in South Africa. Culberston et al. (2015) also showed that average daily DMI values from a 35-d test ($P < 0.0001$) and RFI values from a 56-d test ($P < 0.0001$) adequately predicted DMI and RFI when compared to a 70-d test. Similarly Clark et al (2017) confirmed this hypothesis in Angus BIN steers and suggested that testing periods of 35 d for determining DMI and 56 d for RFI could reduce testing costs, with only a slight reduction in recording precision. This would only be desirable if it resulted in the collection of data on a larger number of animals per year, in turn resulting in more data for genetic evaluation. An alternative to RFI is to test DFI over a shorted period and use other growth measured to form an

adjusted RFI using genetic regression or incorporating it in the breeding program using a selection index (Clark et al 2017).

5.1.2 Including selection pressure on NFI in breeding programs

To achieved balanced genetic gain for all traits of interest in a breeding program all traits of economic importance need to be included in the breeding objective. Single trait selection is dangerous and suboptimal in nearly all systems because it does not take into account the correlations between the single trait and other important traits. Selection for NFI is no different. The best way to achieve the breeding objective would be to include NFI as part of the objectives for the entire system. One major criticism of using NFI as the measure for feed efficiency has been that breed based selection indexes rarely include NFI in their breeding objective. This has been mainly due to the lack of animals being recorded for NFI and incorporating this information would be sub optimal and really represent correlated response due to the selection on other traits (Barwick et al 2018). Implementation of such a system would result in slowing genetic changes in some traits (for example IMF, rib fat and female fertility) and would not enable the identification of efficient animals that achieve the desired breeding objective. Finding such animals is only achieved by recording more individuals for the trait, implementing genomic selection from such records or by undertaking progeny test programs similar to the BIN projects.

NFI has recently been included in the BREEDOBJECT software to enable balanced selection on all traits including (NFI), using the principles of the bio economic model implemented in the software (based on Barwick et al 2018). Which is an important step in genetic evaluation as long as animals continue to be recorded for traits of interest (which ultimately includes feed efficiency). To date, the Angus population has achieved the highest number of animals recorded for NFI. Unfortunately, such levels of recording are required into the future so that balanced and efficient selection can occur.

In contrast, most other beef cattle breeds have relatively few records relating the NFI and therefore have little chance of altering feed efficiency without substantial increases in trait recording. Given the cost of testing (as noted in the previous section), this is unlikely without industry based support.

6 Conclusions/recommendations

1) A total of 5599 animals, from 5 breeds (Limousin 7%, Charolais 2%, Hereford 15%, Santa Gertrudis 1% and Angus 75%) have had feed intake and weight gain recorded on them since 2012.
2) A total of 1435 animals were recorded as part on L.GEN.1816 which is slightly less than the overall numbers due to drought conditions over the past 2 years.
3) This data is being used to underpin national genetic evaluation for NFI in respective breed based BREEDPLAN evaluations.
4) Additional recording of NFI is required to enable balanced and efficient selection.
5) Feed intake is expensive to record and is only possible with industry support but it is currently the best way to improve feed use efficiency.

7 Key messages

1) Feed efficiency is an important trait in beef cattle and needs to be recorded to enable selection for more efficient beef cattle
2) The Growsafe facility at Tullimba is a valuable industry resource for feed efficiency testing
3) The inclusion of NFI into beef cattle breeding objectives is needed to get the most out of the information being collected.

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