Contributed paper

INDEXES SUPPORTING GENOMIC TOOLS FOR SELECTING COMMERCIAL ANGUS HEIFER REPLACEMENTS AND IDENTIFYING STEERS FOR LONG-FED PROGRAMMES IN AUSTRALIA

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SUMMARY

Angus Australia, in collaboration with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), have developed new genomic tools for early life evaluation of commercial straightbred Angus heifers and steers. To aid producers to make optimal multi-trait selection decisions, two new commercial economic indexes have been developed. These indexes are based on economic value models for core GEBVs calculated with the new genomic products.

The heifer index is designed to aid selection of replacement heifers in commercial herds and is based on costs and revenues from cows and their offspring in Australian short/mid-fed and long-fed production systems. This index contains maternal (birth weight, weaning weight, milk, mature cow weight) and terminal (post-wean growth, feedlot growth and intake, rib fat and marbling) traits. Non-linear functions are applied to value birth weight as it relates to calving ease, milk, and marbling. This index should identify more efficient heifers with genetic potential to produce progeny with improved post-wean growth, feed efficiency and carcase merit.

The long-fed steer index is designed to identify steers best suited to Australian long-fed production systems. This index focuses on feedlot growth and intake, and carcase traits rib fat and marbling. This index should identify efficient steers with high marbling.

INTRODUCTION

Angus Australia, in collaboration with the Commonwealth Scientific and Industrial Research Organisation, have developed new genomic products to evaluate commercial straightbred Angus beef heifers and steers. The products include GEBVs for birth weight (BW), weaning weight (WW), yearling weight (YW), mature cow weight (MCW), milk, average daily gain (ADG), dry matter intake (DMI), carcase weight (CWT), eye muscle area (EMA), MSA marbling (MSA), rib fat (RIB), ossification, antibody, cell-mediated antibody and ImmuneDEX (Hine *et al.* 2021 submitted). These evaluations are designed to aid producers to make early life selection and management decisions on commercial animals.

For commercial cow herds, a major decision is selection of heifer calves to be retained as replacements. A commercial heifer selection index was needed to identify heifers with genetic potential for maternal traits they (and possibly their daughters) will express, as well as beef traits expressed by their calves.

For commercial market animals, producers have a management decision to direct steers to either short/mid fed (SF) production, or to long-fed (LF) production. A LF steer index was needed to identify steers with genetic potential for marbling as well as feedlot growth and feed efficiency.

The objective of this work was to develop two new commercial economic indexes to aid the above decisions. These indexes are based on economic value models for core GEBVs calculated with the new genomic products and consider amount and timing of gene expression in animals' lifetimes.

MATERIALS AND METHODS

Economic index model. An economic index model was built to calculate index traits' economic values (EVs) and discounted genetic expression coefficients (DGEs). This contains models for Australian Angus commercial breeder cow daily growth and feed requirements, and separate models for steer and heifer daily growth, feed requirements and carcase value in short/mid fed (SF) and long fed (LF) production systems. The SF model assumed 70% steers in feedlot from 420 to 520 days old with exit live weight (LW) 640 kg, and 30% heifers in feedlot from 360 to 430 days old with exit LW 490 kg. The LF model assumed only steers in feedlot from 420 to 620 days with exit LW 760 kg. Both models assumed age-constant slaughter endpoints. Feed requirements were based on Primary Industries Standing Committee (2007) metabolizable energy. Carcase value and feed costs were based on Australia industry averages in last 5 years. System-specific trait EVs were calculated as described below, as well as trait DGEs. Ossification and immune traits GEBVs were not included in these indexes.

Heifer Index. This index contains maternal and terminal traits. Calculations assume 75% of surplus calves will enter SF systems and 25% will enter LF systems.

Birth weight (kg) is valued with a non-linear EV function based on its relationship with heifer calving ease and associated effects on labour, heifer survival and calf survival. Angus Australia data of bull BW EBVs and their daughters' calving ease phenotypes were applied to fit an exponential function that related BW EBVs to calving costs (based on observed calving difficulty scores). This approach has been applied in other beef indexes to value dystocia (Quinton *et al*. 2019).

Weaning weight (kg) linear EV was calculated as change in profit expected from a 1 kg increase in WW, assuming animals grow at the same rate post-weaning to reach 1 kg heavier live weight at slaughter age. This increases carcase weight and revenue, with increased feed requirements and costs.

Milk (kg, defined as maternal genetic WW) is valued with a non-linear EV function as differences in milk genotype have the greatest economic impact, compared to other traits, at low GEBVs, but less relative economic impact at higher GEBVs. This approach has been applied in other beef maternal indexes (Quinton *et al*. 2019). The EV function incrementally decreases EV of milk up to an optimum GEBV, above which all individuals receive the same value. The optimum GEBV was defined as midpoint of 10th and 90th percentile of bull population GEBVs.

Mature cow weight (kg) linear economic weight was calculated from 3 component EVs. Replacement heifer MCW EV was calculated from the increase in feed costs associated with 1 kg additional growth from yearling to maturity (2nd calving), expressed in heifers. Annual cow MCW EV was calculated from the increase in maintenance feed costs for a 1 kg heavier cow, expressed annually from maturity over the cow's lifetime. Cull cow MCW EV was calculated from the increase in carcase revenue from a 1 kg LW heavier cow, expressed at average culling age. The MCW index economic weight was calculated as the sum of each component EV multiplied by the component DGE.

Post-wean gain (PWG, kg) was defined as a proxy trait where $GEBV_{PWG} = GEBV_{YW} - GEBV_{WW}$. This was done because YW is composed of two phenotypes WW + post-wean growth; but the EVs for WW and growth between weaning and 1 year need to be independent. The PWG linear EV was calculated as change in profit expected from 1 kg increase in PWG, assuming animals grow at same rate pre-weaning and post-yearling to reach 1 kg heavier live weight at slaughter age. This increases carcase weight and revenue, with increased feed requirements and costs.

Feedlot gain (FG, kg) was also defined as a proxy trait where $GEBV_{FG} = (GEBV_{CWT}$ / dressing %) $- GEBV_{YW}$. This was done because CWT is composed of YWT=WW+PWG at fixed dressing % and post-yearling growth, but these EVs need to be independent. Note FG differs from the ADG GEBV which is defined differently. The FG linear EV was calculated from change in revenue expected from 1 kg increase in FG, assuming animals grow at same rate pre-feedlot. This increases carcase weight and revenue. This EV is independent of feedlot feed costs valued via DMI.

Feedlot DMI (kg/d) linear EV was calculated from increased feed costs from 1 kg/d increased intake during fixed feedlot time.

Rib fat (RIB, mm) linear EV was based on industry rib fat pricing categories which penalize under- and over-fat carcases. Assuming RIB has an underlying standard normal distribution which is expressed as percentages of animals that occur in the rib fat price categories, the EV is calculated from the change in carcase revenue that results from shifting the distribution of RIB by 1 mm with according changes in proportions of animals in the rib fat price categories.

MSA marbling (MSA, score) is valued as a non-linear economic value based on the shift in marbling distribution expected for an individual GEBV. Marbling is assumed to have a normal distribution, with thresholds determining the value paid for an animal within a proportion of the distribution. A change to the proportion of animals falling within each marbling price category occurs in response to a shift in the distribution mean. The function also considers the different SF and LF industry marbling pricing categories and weights the value according to the proportions of animals in each system.

For WW, PWG, FG, DMI and RIB, separate EVs were calculated for SF and LF systems and a weighted average EV was calculated based on Australian industry proportions. Other traits' EV calculations incorporated SF and LF parameters. For each trait, EVs were multiplied by DGE coefficients that incorporate timing and frequency of expression in heifers and their calves.

The structure of this index is as follows, where *f(GEBV)* represent non-linear functions and *b* are linear index economic weights, to calculate an index value in units $/heifer at selection:

$$I_{Heifer} = f(GEBV_{BW}) + (b_{WW}GEBV_{WW}) + f(GEBV_{Milk}) + (b_{MCW}GEBV_{MCW}) + (b_{PWG}GEBV_{PWG}) + (b_{FG}GEBV_{FG}) + (b_{DMI}GEBV_{DMI}) + (b_{RIB}GEBV_{RIB}) + f(GEBV_{MSA})$$

Long-fed Steer Index. This index contains only terminal beef traits FG, DMI, RIB and MSA. Economic value calculations for these traits followed the same methods as described for the heifer index, but incorporated only LF system parameters. These traits were assumed to be expressed at steer slaughter and therefore DGEs were set to 1.

This structure of this index is as follows to calculate an index value in units $/steer fed:

$$I_{Steer} = (b_{FG}GEBV_{FG}) + (b_{DMI}GEBV_{DMI}) + (b_{RIB}GEBV_{RIB}) + f(GEBV_{MSA})$$

Preliminary index selection predictions. At this time, the pipeline for routinely calculating GEBVs for commercial heifers and steers is under development and the availability of GEBVs for large numbers of individuals is limited. For this study, the effectiveness of each selection index was assessed using a set of GEBVs from 333 bulls that represent the range of genotypes in the population (Table 1). Because the bull GEBVs are based on DNA only, we expect very similar outcomes from heifer or steer GEBVs. Mean GEBVs were calculated and compared for all bulls in the set and for the top 20% of bulls according to each index.

RESULTS AND DISCUSSION

Mean GEBVs of the top 20% of bulls selected according to preliminary versions of the new indexes are shown in Table 1.

Top bulls with the Heifer Index had substantially higher mean GEBVs for growth (WW, YW, PWG, FG), CWT, EMA and MSA, with only slightly higher DMI, as well as lower RIB and MCW. Mean GEBVs for BW, WW and Milk were similar to the population average. Therefore, this index should identify heifers that are on average more efficient at maintaining similar mature weight and milk production, but with genetic potential to produce progeny with improved post-wean growth, feed efficiency and carcase merit.

Top bulls with the LF Steer Index had substantially higher mean GEBVs for FG, CWT, EMA and MSA than population average, but lower mean DMI and RIB. Therefore, this index should identify efficient steers with high marbling suited to long-fed production systems. The LF steer index contains growth only in terms of feedlot gain and therefore does not differentiate between steers that have different feedlot entry weight but the same growth rate in feedlot. This index assumes that the user accounts for pre-feedlot growth value by selling/purchasing steers on a per kg basis.

Table 1. GEBV means, SD, minimum and maximum values for all bulls in data set and mean GEBVs of top 20% selected according to the Heifer Index, and Long-fed Steer Index

	All bulls (N=333)				Heifer Index Top 20% bulls	LF Steer Index Top 20% bulls
GEBV, unit	**mean**	**SD**	**min**	**max**	**mean**	**mean**
BW, kg	-1.24	1.80	-6.76	3.51	-1.29	-
WW, kg	-2.94	6.35	-24.30	16.71	-0.25	-
YW, kg	2.48	10.65	-36.45	31.08	10.24	-
PWG, kg	5.43	6.92	-22.46	26.81	10.49	-
FG, kg	12.23	28.94	-78.44	78.81	37.05	26.03
MCW, kg	-5.45	14.88	-44.63	39.35	-7.36	-
Milk, kg	-5.39	3.70	-15.51	6.93	-4.77	-
ADG, kg/day	0.03	0.09	-0.21	0.33	0.07	0.03
DMI, kg/day	0.51	0.71	-1.46	2.51	0.69	0.38
CWT, kg	8.09	19.01	-51.87	51.71	26.01	15.17
EMA, cm^2	0.73	4.35	-11.19	12.94	4.18	3.29
MSA, score	90.57	59.03	-76.19	262.34	136.79	157.55
RIB, mm	0.08	1.66	-4.69	5.37	-0.08	-0.08

CONCLUSIONS

The recent development of commercial genomic tools for cost-effective evaluation of commercial Angus heifers and steers provide producers with new information to access an animals' genetic potential for performance in different sectors of the Australian beef industry. The new commercial replacement heifer and long-fed steer indexes offer tools to aid producers in multi-trait selection and management decisions.

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