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EFFECTS OF ADDING A NEW FERTILITY TRAIT TO THE ANGUS AUSTRALIA HEIFERSELECT INDEX

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SUMMARY

The Angus Australia HeiferSELECT index is designed to aid selection of replacement heifers in commercial beef herds. This index contains cow-calf, feedlot and carcase traits. However, when this index was developed in 2020, fertility evaluations were not available. Recently, Angus Australia in collaboration with CSIRO, developed a new fertility evaluation "Heifer Conception" defined as number of weeks pregnant at test following first mating (PREG). In this study we calculated an economic value for PREG ($/wk PREG) by modelling economic impacts from its effects on cow survival, and on calves' birth dates. Adding PREG to the index substantially changed animal rankings. Top heifers selected according to the index with PREG added had better average fertility than those selected according to the index excluding fertility, with only minor or negligible sacrifice in growth and carcase traits superiority.

INTRODUCTION

The Angus Australia HeiferSELECT is a genomic toolkit designed to aid beef producers selecting commercial Angus replacement females. This genomic selection tool includes GEBVs, developed in collaboration with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), for birth weight (BW), weaning weight (WW), yearling weight (YW), mature cow weight (MCW), milk, average daily gain (ADG), daily feed intake (DFI), carcase weight (CWT), eye muscle area (EMA), MSA marbling (MARB), rib fat (RIB), ossification and ImmuneDEX (Angus Australia 2023).

The HeiferSELECT index is designed to apply most of these GEBVs in multi-trait selection and identify commercial heifers with genetic potential for maternal traits they, and future daughters, will express as well as beef traits expressed by their calves. This index contains maternal (BW, WW, milk, MCW) and terminal (post-wean growth PWG, feedlot growth FG, DFI, RIB and MARB) traits (see Quinton *et al*. 2021 for trait details including calculation of PWG and FG from WW, YW and CWT). When this index was developed in 2020 GEBVs for fertility were not yet available.

Recently a new fertility trait "Heifer Conception" defined as number of weeks pregnant at test following first mating, based on foetal aging (PREG; Alexandre *et al*. 2023) was developed and added to the HeiferSELECT toolkit. The objectives of this study are 1) to calculate an economic value for PREG; and 2) to assess the effects of adding PREG to the HeiferSELECT index on animal rankings and selected trait genotypes.

MATERIALS AND METHODS

Fertility Economic Value. The economic value (EV) of PREG ($/wk PREG) is built from three component linear EVs: the EV of the effect of fertility on cow survival, and the EVs of effects of fertility on birth dates of each of heifers' and cows' calves. All component EVs are calculated as the change in profitability ($) per animal, per week change in PREG, independent of changes in other index traits.

The EV of the effect of fertility on cow survival within a producing cow herd of fixed size (EV_{cs}) was modelled from a direct comparison of two herd scenarios: *i*. a BASE herd with population

average survival for cows ages 2 to 11 years, and *ii*. a BASE+improved fertility herd where survival in all age classes (except final) was assumed to improve due to less fertility-related culling. The BASE+improved fertility herd has longer average lifespan, lower replacement rate and corresponding lower replacement costs, lower cull cow revenue, and slightly higher profit from weaned calf weight (young cows have smaller calves). This results in a net increase in profit from improved fertility. Note that this model assumes a herd with fixed number of producing cows, and therefore improved survival reduces replacement rate but does not change the number of calves produced and sold. The relationship of fertility with probability of survival is based on Johnston and Bunter (1996) and assumes calving success and survival have a 1:1 relationship; i.e., that non-producing cows are culled. The value is scaled for heifer PREG GEBV based on the relationship of cow days to calving phenotype (approximated with deregressed EBVs) with heifer PREG GEBV, estimated from bull data.

The EV of the effect of fertility on heifers' calves birth date (EV_{hcb}) assumes that in a herd with fixed initial mating date and weaning date, heifers that conceive 1 week earlier have calves with 1 additional week of growth at weaning and require 1 week of additional lactation feed. The difference in calf profit from an additional week of growth at weaning is calculated from the bio-economic model's calf growth model and the model WW EV which incorporates economic effects on market animal carcase revenue and feed costs for both short/mid fed and long fed production systems (Quinton *et al*. 2021). The cost of 1 week of additional cow lactation feed energy is calculated from the model's cow energy model. The overall component EV is calculated from the average calf profit difference minus lactation costs in short/mid fed and long fed production systems, weighted by the industry proportions of these systems.

The EV of the effect of fertility on mature cows' calves birth date (EV_{ccb}) follows the same logic as for heifers' calves but the effects on calf profitability and lactation feed costs were scaled to account for the less-than-unity genetic correlation between heifer fertility and mature cow fertility as per EV_{cs}.

The overall PREG index economic weight was calculated as $b_{PREG} = (EV_{cs} \times DGE_{cs}) + (EV_{hcb} \times DGE_{hcb}) + (EV_{ccb} \times DGE_{ccb})$, where DGE_{cs}, DGE_{hcb} and DGE_{ccb} are the respective component's coefficients of discounted genetic expression in heifers and their offspring over 20 years.

Effects of adding fertility to the index. The structure of the HeiferSELECT index including PREG (I_{HSPREG}) is as follows, where *b* are linear index economic weights and *f(GEBV)* represent non-linear economic functions, to calculate an index value in units $/heifer at selection:

$$I_{HSPREG} = f(GEBV_{BW}) + (b_{WW}GEBV_{WW}) + f(GEBV_{Milk}) + (b_{MCW}GEBV_{MCW}) + (b_{PWG}GEBV_{PWG}) + (b_{FG}GEBV_{FG}) + (b_{DFI}GEBV_{DFI}) + (b_{RIB}GEBV_{RIB}) + f(GEBV_{MSA}) + (b_{PREG}GEBV_{PREG})$$

The effects of adding PREG to the index were assessed using a set of heifer GEBVs that represent the range of genotypes in the population (Table 1). Index values were calculated for each animal according I_{HSPREG} and according to the index excluding fertility (I_{HS}, calculated with the above equation excluding the PREG term). Mean GEBVs were calculated and compared for all heifers in the set and for the top 20% of heifers according to I_{HS} and I_{HSPREG}. Means analysis included the traits previously listed plus heifer age at first calving (AFC; Alexandre *et al*. 2023).

RESULTS AND DISCUSSION

The Pearson correlation between I_{HS} and I_{HSPREG} was 0.80; therefore, adding PREG to the HeiferSELECT index had substantial effect on animal rankings. This was caused by moderate negative correlations between PREG and major index traits WW and PWG (correlation of $GEBV_{PREG}$ with $GEBV_{WW}$ = -0.13, with $GEBV_{PWG}$ = -0.11). PREG had favourable correlation with

MCW (correlation of $GEBV_{PREG}$ with $GEBV_{MCW}$ = -0.14) but approximately neutral correlations with other index traits.

Mean GEBVs of the top 20% of heifers selected according to I_{HS} and I_{HSPREG} are shown in Table 1. Overall, adding PREG to the HeiferSELECT index selected heifers with better fertility, with minor or negligible sacrifice in other traits. Top heifers according to I_{HSPREG} had significantly better PREG than top heifers according to I_{HS} (paired t-test P<0.0001). WW and YW means were slightly lower with I_{HSPREG} (P=0.0633 and 0.0551 respectively), but the indexes did not differ significantly for other traits means (P>0.1).

Table 1. GEBV means, SD, minimum and maximum values for all heifers in data set and top 20% selected according to the HeiferSELECT Index excluding and including fertility

	All heifers (N=921)			**HSIndex Top 20%**			**HSIndex+fert Top 20%**		
GEBV, unit	**mean**	sd	*min, max*	**mean**	sd	*min, max*	**mean**	sd	*min, max*
BW, kg	**-0.8**	1.3	*-4.6, 3.4*	**-0.7**	1.4	*-4.2, 3.4*	**-0.7**	1.4	*-4.2, 3.4*
WW, kg	**-1.2**	6.0	*-21.9, 18.6*	**1.9**	6.2	*-12.2, 18.6*	**0.7**	5.9	*-14.4, 13.3*
MCW, kg	**4.2**	12.8	*-39.0, 44.7*	**7.8**	14.1	*-26.4, 44.7*	**6.8**	13.6	*-29.7, 44.7*
MILK, kg	**2.5**	2.3	*-5.0, 8.8*	**3.3**	2.0	*-0.9, 8.3*	**3.1**	2.1	*-1.6, 8.3*
YW, kg	**2.4**	7.2	*-22.4, 25.4*	**6.4**	7.3	*-10.6, 25.4*	**5.0**	7.0	*-11.4, 18.6*
PWG, kg	**3.6**	2.0	*-2.0, 9.6*	**4.5**	1.9	*-0.7, 9.6*	**4.3**	1.9	*-0.7, 9.6*
FG, kg	**-9.0**	16.8	*-59.7, 39.9*	**0.9**	14.7	*-40.5, 39.9*	**0.2**	15.7	*-42.9, 39.9*
ADG, kg/d	**0.1**	0.0	*-0.1, 0.2*	**0.0**	0.0	*0.0, 0.2*	**0.0**	0.0	*0.0, 0.2*
DFI, kg/d	**0.2**	0.4	*-0.9, 1.3*	**0.1**	0.4	*-0.8, 1.2*	**0.2**	0.4	*-0.8, 1.2*
EMA, cm^2	**-0.4**	2.5	*-8.3, 8.2*	**0.3**	2.8	*-5.1, 8.2*	**0.3**	2.8	*-6.6, 8.2*
MARB, score	**46.7**	30.1	*-43.7, 153.8*	**68.4**	25.5	*11.5, 153.8*	**64.2**	26.2	*11.0, 153.8*
RIB, mm	**0.0**	1.1	*-3.3, 3.3*	**0.0**	1.1	*-2.7, 3.3*	**0.0**	1.1	*-3.1, 3.3*
CWT, kg	**-3.6**	9.7	*-30.1, 27.2*	**4.0**	8.0	*-16.1, 26.4*	**2.8**	9.1	*-19.5, 27.2*
AFC, d	**0.8**	8.0	*-24.2, 29.2*	**0.2**	8.2	*-23.2, 20.1*	**-0.5**	8.0	*-23.2, 20.1*
PREG, wk	**-0.4**	1.0	*-3.9, 3.1*	**-0.5**	1.1	*-3.9, 2.5*	**0.4**	0.9	*-2.4, 3.1*

CONCLUSION

The HeiferSELECT genomic tools offer cost-effective evaluation of commercial Angus heifers for cow-calf, feedlot, carcase and resilience traits. Adding the new Heifer Conception fertility trait to the HeiferSELECT index should aid producers in multi-trait selection decisions by identifying commercial heifers with optimal genetic profile for fertility and maternal traits combined with growth and carcase quality traits to be expressed in their market progeny.

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