Proc. Assoc. Advmt. Anim. Breed. Genet. 22:601-604

THE EFFECT OF INCLUDING IMMUNE COMPETENCE IN MERINO SHEEP BREEDING PROGRAMS

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SUMMARY

The effect of including general immune competence (IC) as a novel trait in a fibre production (FP) and a dual purpose selection (DP) index was investigated. Two levels of economic values were assumed for IC and the sensitivity of index responses to these were tested. The results showed that the addition of IC to a selection index requires careful consideration in order to achieve the envisaged improvements in health and welfare outcomes expected while addressing primary production objectives.

INTRODUCTION

Selection for production traits with little or no emphasis on health and welfare traits can lead to increased susceptibility to disease (Rauw *et al.* 1998). For example in sheep, Shaw *et al*. (2012) reported that production focused selection has led to a decrease in parasite resistance. In an effort to improve general disease resistance, methods to assess immune competence were first developed in both pigs and dairy cattle (Wilkie and Mallard 1999; Mallard and Wagter 2001). In Australia, methods for assessing immune competence in beef cattle (Hine *et al.* 2016) and sheep have recently been evaluated, providing estimates for this study (Hine and Smith, CSIRO Agriculture and Food, 2016, preliminary estimates). This study assumed economic values for immune competence and explored the effect of these on fibre and dual purpose selection indexes for Merino sheep.

MATERIAL AND METHODS

Immune competence. Responses of the immune system can be broadly classified as being innate or adaptive with innate responses providing the first line of defence, which arise quickly and are broad in action, while adaptive responses provide a second line of defence and are slower to develop but more specific in their action. Further, adaptive immune responses are specifically tailored to the type of pathogen being encountered with antibody-mediated immune responses (AMIR) predominating upon exposure to extracellular pathogens and cell-mediated immune responses (CMIR) predominating upon exposure to intracellular pathogens. Overall immune competence, defined as a combination of AMIR and CMIR, has been demonstrated to be correlated with infectious and metabolic diseases in dairy cattle (Thompson-Crispi *et al.* 2012). Overall immune competence (IC) has been used as breeding objective trait in this study.

Selection indexes. Breeding objectives were derived from the Sheep Genetics (2014) Dual Purpose Plus and Fibre Production Plus indexes. The breeding objective traits in the dual purpose (DP) index include the adult (a) expression of clean fleece weight (aCFW), fibre diameter (aFD), bodyweight (aWT), yearling eye muscle depth (yEMD) and number of lambs weaned (NLW). The breeding objective traits in the fibre index (FP) include aCFW, aFD, aWT, NLW and adult staple Strength (aSS). Selection criteria for both indexes include NLW and yWT, yCFW and yFD. Yearling staple strength (ySS) was a selection criterion for FP only, and yearling eye muscle depth (yEMD) for DP only. Traits were recorded on the selection candidates, sire and dam and half-sibs.

To test the effect of including immune competence as a novel trait in the FP and DP indexes, IC was added as a breeding objective trait (DP+IC and FP+IC). Additional selection criteria were IC and its component traits CMIR and AMIR.

Table 1. Heritabilities (on the diagonal in bold), genetic (below the diagonal) and phenotypic (above the diagonal) correlations, phenotypic trait variance (V_P), the economic value (EV in $) and standardized economic values (stdEV = EV* σp in $) for breeding objective traits of the dual purpose and fibre indexes (DP/FP and DP/FP+IC)

Traits	aWT	aCFW	aFD	aSS	NLW	yEMD	yWT	yCFW	yFD	ySS	IC	AMIR	CMIR
V_P	28.77	0.26	1.35	83.93	0.27	3.27	23.3	0.16	3.00	83.8	2.36	0.24	0.04
DP EV	0.08	0.74	-3.44	--	125.29	3.83	--	--	--	--	1.40/2.02	--	--
FP EV	-0.03	1.55	-13.74	1.57	126.96	--	--	--	--	--	1.40/2.02	--	--
DP stdEV*	0.43	0.38	-3.99	--	65.50	6.93	--	--	--	--	2.15/8.98	--	--
FP stdEV*	-0.16	0.79	-15.39	14.38	66.12	--	--	--	--	--	2.15/8.98	--	--
aWT	**0.44**	0.29	0.08	-0.13	0.01	-0.08	0.56	0.50	0.17	-0.13	0.00	-0.02	0.01
aCFW	-0.15	**0.50**	0.22	0.28	0.00	-0.20	0.26	0.50	0.22	0.26	-0.01	-0.01	0.01
aFD	0.02	0.28	**0.67**	0.01	0.02	0.02	0.13	0.22	0.7	0.35	0.05	0.06	0.04
aSS	-0.31	0.37	-0.03	**0.35**	0.00	--	0.09	0.03	0.03	0.40	0.00	0.02	-0.02
NLW	0.33	-0.47	0.01	0.15	**0.07**	0.10	0.02	-0.07	0.03	0.00	0.001	0.001	0.001
yEMD	-0.20	-0.11	-0.08	--	0.28	**0.33**	0.83	-0.03	0.06	--	-0.01	0.03	0.00
yWT	0.77	-0.09	0.22	0.17	-0.1	0.85	**0.43**	0.42	0.13	0.09	0.00	-0.02	0.01
yCFW	-0.15	0.80	0.15	0.14	-0.65	0.10	0.23	**0.36**	0.22	0.03	-0.01	-0.01	0.01
yFD	0.03	0.15	0.80	0.26	-0.07	0.17	0.22	0.15	**0.77**	0.48	0.05	0.06	0.04
yss	-0.31	-0.14	0.15	0.80	-0.45	--	0.17	0.16	0.27	**0.40**	0.00	0.02	-0.02
IC	0.06	-0.15	0.31	0.21	0.001	0.00	0.06	-0.15	0.31	0.21	**0.53**	0.76	0.76
AMIR	0.02	0.03	0.28	0.20	0.001	0.11	0.02	0.03	0.28	0.20	0.82	**0.47**	0.16
CMIR	0.02	-0.24	0.20	0.12	0.001	0.00	0.02	-0.24	0.20	0.12	0.79	0.29	**0.42**

*stdEV=EV*σp

Index calculations were performed using the MTIndex software (http://www.personal.une.edu.au/~jvanderw). The total dollar response and individual trait responses to selection were calculated per animal and per round of selection.

Genetic and phenotypic variances, heritabilities and correlations for breeding objective traits and selection criteria are shown in Table 1 (Brown and Swan 2015; Purvis and Swan 1999; Huisman *et al*. 2008; Huisman and Brown 2008; Huisman and Brown 2009a; Huisman and Brown 2009b; Swan *et al.* 2008; Dominik and Swan 2016).

Economic values. The economic value for IC was developed on the basis of the strong favourable correlation between IC with dag score post-weaning (r_g=-0.55; Hine and Smith, CSIRO Agriculture and Food, 2016, preliminary estimates). Dags (faecal soiling of the breech) cause hygiene and contamination issues at shearing and slaughter. Correlations suggested that lower IC is associated with higher dag score, potentially leading to the need for an extra crutch throughout the year and prior to shearing and potential penalties when selling lambs, which can result in extra costs for the producer. Based on costs for crutching obtained from High Voltage Shearing Pty Ltd. in Armidale, NSW (pers. comm., 15 December 2016), two economic values were used. A simple ‘market crutch’ that requires only the area around the breech to be shorn was valued at $1.40/head, marked in the index abbreviation as “a”. A full crutch on a non-mulesed sheep was valued at the highest price $2.02/head due to the tendency of the extra wool on those animals to be more soiled and difficult to remove (“b”). Using these two values, the sensitivity of index responses to different emphasis on IC was tested (DP/FP+ICa and DP/FP+ICb). Economic values for the other breeding objective traits were obtained from Brown and Swan (2015). All economic values are summarised in Table 1.

RESULTS AND DISCUSSION

The inclusion of IC in the DP index (Table 2), increased total dollar response per animal and round of selection from $11.75 (DP) by 27% (DP+ICa) and 26% (DP+ICb) respectively.

With a low economic value placed on IC (DP+ICa), an 8 micron decrease in aFD and an over 30% increase in NLW was observed, which led to the substantial increase in total dollar response. The response in IC was slightly unfavorable. When the economic value for IC was increased, the moderate unfavourable genetic correlations between IC with FD and CFW significantly influenced index responses. As a result, with increasing economic weight on IC the response in IC increased only slightly and the response in aFD, which has a high economic value, was maximised. The response in aWT was unfavorable, but NLW was still greatly improved compared to DP.

The total dollar response showed a small increase of $0.02 for the FP index with the inclusion of IC at a low economic weight (FP+ICa) and $0.21 at a high economic weight (FP+ICb) (Table 2). Compared to DP these increases were lower due to low individual trait responses. The inclusion of IC increased the emphasis on a FD, which has a high economic value in the FP index. However, this increased emphasis on aFD was balanced by aSS, which is unfavourably correlated with FD. Staple strength is as economically important as FD, but is not as heritable. The IC trait and its components (AMIR and CMIR) are correlated to both FD and SS. These competing interests are reflected in only small changes in all traits and a small increase in the total dollar response.

The results showed that with the assumed economic values, no major changes were achieved in IC. The assumptions on the economic value for IC were simplistic but could be considered conservative as it did not take into account any decrease in animal health treatment costs associated with a variety of common diseases which may be realised as a consequence of improved IC. Also the influence of improved consumer confidence that could be expected from improving IC, and as a consequence animal welfare by reducing disease incidence and deaths, was not considered. The influence of these factors on the economic value of IC could be substantial.

Table 2. Standard deviation of the breeding objective (SD_{BO}), total dollar response (SD_{Index}), index accuracy (Acc) and trait responses per animal per round of selection in the dual purpose (DP) and fibre production (FP) index without and with immune comptence at EV $1.40 (DP/FP+ICa) and EV $2.02 (DP/FP+ICb)

	SD_{BO}	SD_{Index} ($)	Acc	aWT (kg)	aCFW (kg)	aFD (micron)	NLW (no of lambs)	yEMD (cm)	aSS (Nktex)	IC (stddev)
DP	21.28	11.75	0.55	1.31	-0.19	-0.17	0.09	-0.12	--	--
DP+ICa	21.27	14.87	0.70	1.03	-0.13	-0.25	0.12	-0.12	--	-0.04
DP+ICb	21.30	14.86	0.70	1.04	-0.13	-0.24	0.12	-0.12	--	0.00
FP	27.42	14.90	0.54	0.55	-0.11	-0.35	0.09	--	-0.56	--
FP+ICa	27.73	14.92	0.54	0.55	-0.11	-0.32	0.09	--	-0.50	0.00
FP+ICb	27.73	15.11	0.55	0.55	-0.11	-0.32	0.09	--	-0.52	0.02

CONCLUSION

Improvement in overall immune competence in sheep is desirable for future production to improve welfare and reduce health costs. Here it was shown, that the inclusion of this novel trait in a sheep breeding framework that is highly production focused requires a full economic evaluation of immune competence to integrate it effectively in genetic improvement programs.

ACKNOWLEDGEMENTS

This research was supported by CSIRO, the Grains Research and Development Cooperation and Bayer. Access to data has kindly been provided by Meat and Livestock Australia

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