Myth Busters

Non-Additive Genetic effects and their influence on Marbling in Australian Wagyu

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Marbling is defined as the accumulation of triacylglycerol in muscle tissue primarily occurring within adipocytes between muscle fibre bundles (Harper and Pethick 2004) and is quickly becoming an integral component within breeding objectives of Australian beef producers. Initial interest in marbling was from producers and exporters targeting high value export markets. However marbling is becoming increasingly sought after in domestic markets due to consumer associations with beef quality. Wagyu offer an entry point into these markets with a genetic predisposition to express higher marbling compared to other beef breeds (Gotoh et al. 2009).

In 2014-15 the Australian beef industry was comprised of 27.4 million head of cattle, producing 2.34 million tonnes (carcass weight) of beef and veal. In 2015/16 the industry was valued at $14.3 billion (Meat and Livestock Australia 2016). Currently it is estimated that Wagyu, and Wagyu infused stock, account for 1-2% of the national beef herd, with 80-90% of its production being exported (Australian Wagyu Association 2015). In 2013, approximately 10% of beef carcass production in Australia was Wagyu, which mostly likely included crossbred animals, and globally Wagyu accounted for about 2%,2%,4% and 8% of beef carcass production in the US, Brazil, China and Argentina respectively (Motoyama et al. 2016).

Wagyu cattle are typically bred in Japan by the crossing of three major bloodlines, identified and developed due to geographical isolation in Japan. These are the Tajima bloodline (Hyogo Prefecture), Ketaka bloodline (Tottori Prefecture) and the Itozakura bloodline (Shimane Prefecture)(Motoyama et al. 2016). Wagyu cattle all have pedigrees consisting of these three bloodlines to some degree and the specific crossing of these bloodlines is followed by breeders outside of Japan today (Wayne Pitchford, personal communication, March 15 2016).

Anecdotal evidence suggests that mating specific sire and dam lines will produce superior offspring compared to those of equivalent expected merit but in random combinations. This phenomenon is referred to by breeders as “nicking”. The current Australian genetic
evaluation program, known as BREEDPLAN, allows for genetic selection of sires and dams to advance carcass trait expression in progeny by utilising, mostly, additive genetic relationships between animals to estimate their individual ‘breeding value’ (Graser et al. 2005). This program does not purposefully account for non-additive genetic effects, such as dominance and epistasis, which could provide evidence for superior progeny performance above expectation. The influence of non-additive genetic effects in Wagyu, and specifically, their effect on marbling performance had not been investigated in the Australian Wagyu herd.

Early studies involving the term nicking (Johnson et al. 1940; Seath and Lush 1940) focused on dairy cattle populations where traits, such as milk production and butterfat, gave no conclusive evidence for nicking but could not completely dismiss the theory. Furthermore, heterosis effects have been well documented in the cross breeding of cattle for productive and economic gain in dairy (McDowell and McDaniel 1968; Ahlborn-Breier and Hohenboken 1991) and beef (Cundiff 1970; Gray et al. 1978; Gregory and Cundiff 1980) production systems, with improvements in milking, growth and reproductive traits noted. Certainly, separate family groups have been identified within beef cattle breeds, such as Hereford, where one group is distinctly different from another family group in genetic structure and performance but still remains the same breed (Urick 1966). Additionally, the three major bloodlines of Wagyu are treated somewhat as separate breeds with inbreeding coefficients reported to be 20% for the Tajima bloodline and expected to reach 39.0% within the next 10 years (Oyama et al. 2007), indicating how the separate bloodlines are kept “pure” before being crossed to produce beef animals. This could suggest that heterotic effects may exist within a breed that could be attributed to as nicking (Beckett et al. 1979; DeStefano and Hoeschele 1992) although Hansson et al. (1961) conclude the contrary opinion.

While the discussion above demonstrates the logic around the breeder myth of ‘nicking’, regarded to be due to non-additive genetic effects, it is widely accepted that the majority of genetic variation within traits, such as marbling, is additive, sometimes accounting for up to 100% of the variance in the trait (Hill et al. 2008). This is most evident in the trait heritabilities, calculated as the animals additive genetic component, which for carcass weight, subcutaneous fat, rib-eye area and marbling are 48%, 39%, 46% and 55% respectively (Oyama 2011). This implies that if nicking does have an effect on phenotypic performance, then the benefit of the potential additional genetic gain it provides will need to be considered against the cost of re-working genetic models when deciding whether to involve in breeding programs. Additionally nicking involves mating specific superior sires and dams to achieve superior progeny performance. However in Wagyu breeding, mating your best sires to your best dams will often result in mating animals that are more closely

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1 Dominance is a relationship between alleles of a gene at the same loci, where the effect on phenotype of one allele is expressed, masking the contribution of the second allele. Conversely epistasis is the interaction of genes at different loci where there is a suppression effect of one gene by another.

2 Heterosis, also known as hybrid vigour, is the tendency of a cross-bred individual to show phenotypic qualities superior to both of the parents. Heterosis is influenced by dominance and epistatic interactions.
related to each other. This becomes important when balancing genetic performance with
the level of inbreeding to sustain increases in production without experiencing depression in
animal performance, also known as inbreeding depression (Tempelman and Burnside 1989).

While many studies have investigated the influence of non-additive genetic components on
milking, reproductive traits and growth traits, their effect on meat quality, specifically
marbling, has not been fully investigated. This study will attempt to investigate the
relevance of “Nicking” in an Australian Wagyu herd. In addition, the investigation of the
different genetic variance components will serve to fill a space in literature that is sparse on
information regarding, specifically, Australian Wagyu. It is hypothesised that non-additive
genetic effects will be present through the mating of specific sire and dam lines however its
effect on carcass traits will only be minor.

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