How many progeny are needed to give an evaluation of breeding merit of Wagyu cattle?

Before genomic EBVs became available, I used to suggest that some progeny should be raised for carcass analysis when potential young sires needed to be evaluated for breeding merit. However, I started to get some doubts when I detected that the association between predicted breeding values and progeny test results in Japan was quite low during the period when Yasufuku and his contemporaries were going through progeny testing.

The difficulty in determining sire effects from raw data from progeny test results is illustrated by the example of two sires from the generation following after Yasufuku that had their progeny scored under the same JMGA standards. The average from the progeny tests for Tanifuku Doi was 3.2 and the average for Yasuku 6-3 was 28% lower with an average score of 2.3 (小野健一続・日本名牛百選). The distribution of BMS is illustrated below. 87.5% of Tanifuku Doi’s progeny scored 3 or higher, whilst 60% of Yasufuku 6-3’s progeny scored 2+ or lower. Both sires performed well in their progeny tests, but progeny from Tanifuku Doi had a higher average. However, when the final evaluation was completed using best linear unbiased prediction (BLUP), the order was different. BMS predicted breeding value for Yasufuku 6-3 was 1.445 with an accuracy of 0.948 and this ranked him 13th in Hyogō in July 2001. Tanifuku Doi was posted with 1.350 with an accuracy of 0.920 in March 2002 and he was ranked 20th. Even though the difference was only a 7% advantage in BMS PBV for Yasufuku 6-3 over Tanifuku Doi, it does correct the initial impression assessment that could have been made if only raw data from eight to 10 progeny in a controlled progeny test in Japan had been used. The environmental influences – such as genetic contribution and age of dam, etc - need to be eliminated from progeny test by BLUP analysis.

This prompts the question “how many progeny are actually needed to reveal breeding merit on-farm if ten is insufficient?”

The accuracy from progeny tests in Japan, Australia and USA are reviewed to enable recommendations to be made for on-farm evaluation.
Progeny testing and BMS in Japan

Within another ten years of testing an average of ten progeny per sire, the number of progeny from each sire was doubled. The raw data from 20 progeny from the prefectural stations were reviewed (小野健一 新日本の牛百選, 小野健一 日本名牛百選IV and 小野健一 日本名牛百選V).

The association between BMS breeding value with BMS average from progeny test from 10 Fullblood (100% pure Wagyu) progeny per sire was positive but weak ($r = +0.17$). The association increased by more than double from an average of 20 progeny per sire ($r = +0.39$) but even that would not be considered to give enough confidence to make selection decisions. It was much later that digital imaging exposed the variation of IMF% within each BMS grade. The measurement of marbling using BMS is not precise so the number of results that are required to predict marbling breeding value needs to be high. Measuring Rib Eye Area and Carcass Weight is more accurate than measuring Marbling % and there is a higher correlation between predicted breeding value (PBV) and progeny test results for those traits. A lower number of progeny would be required to obtain an indication of breeding merit for Rib Eye Area and Carcass Weight than the number that is required to evaluate Marbling.

The overlap in IMF% between each BMS for Fullblood and F1 Wagyu is illustrated below, to the left (Kuchida K, undated). The lowest reading for BMS 8 was 44% IMF, and the highest for BMS 8 was 67%. The highest IMF% did not fluctuate much between BMS 8 through to BMS 12.

It is challenging to manually interpret the raw data from a field progeny test using 20 progeny from each sire. BMS progeny tests from two modern Japanese Black sires processed by Iwate Prefectural Research Centre are presented in a chart above, and to the right hand side. The average BMS for the sire with black bars is 8.76 and the average for the sire with blue bars is slightly lower with an average BMS of 8.50. The difference is only 3% so both sires could be expected to have similar breeding values from the averages.

The published BMS predicted breeding value in Iwate prefecture for 菊福秀 in black bars is 49% higher than that for 金菊徳 with blue bars. A simple average from the tests rates them to be almost equal but it required a BLUP analysis to establish breeding merit which gives the blue bar bull almost a 50% higher predicted breeding value. This demonstrates that 1, 5, 10 or even 20 progeny - as in this example - may not be sufficient to truly reveal Wagyu
marbling breeding merit when only progeny test BMS results are used without a BLUP analysis.

**Australian BLUP and grading**

In Australia, AUS-MEAT and MSA marbling reference standards are assessed visually. The AUS-MEAT marble score is the grade that is more commonly referred to. Variation in IMF% within each Marble Score grade is extensive and there is considerable overlapping between different Marble Scores (Grose J, 2011).

Despite a strong correlation of marbling (IMF) % with the AUS-MEAT Marble Score ($r = 0.88$), the inconsistency in the grading of marbling in Australia has probably resulted in a low heritability of marbling in Wagyu of 0.23 when measurement was by AUS-MEAT Marble Score. Heritability increased to 0.54 when IMF% was used from digital imagining (Maeda et al 2013). To obtain an equivalent assessment of marbling merit in Wagyu in Australia, a higher number of progeny would be required than when digital imaging was taken.

Nearly 1,500 progeny from 30 sires that were finished at Mayura Station have been analysed (Lamb 2019). In my analysis the association between AUS-MEAT Marble Score average per sire with Marble Score EBV of each sire was stronger when there were more than 50 carcasses per sire. In the chart below the association became weaker with fewer carcasses. Within each group 1-9, 10-19 and 20-49 carcases per sire, some associations were strong and close to the trend line but divergence from the trend line were greatest for fewer than 10 carcasses per sire.
It is concluded by Wagyu International that fewer than 50 carcass progeny are not a reliable indication of breeding merit for marbling when they are graded by AUS-MEAT Marble Score. Scott is quoted to have said that a minimum of 50 Fullblood carcasses from A.I. sires are required for any kind of reliability in decision making. However, due to limits in availability he lowers the threshold to 10 carcasses for natural service sires, and 2 for dams. Scott uses EBVs in combination with performance data.

Lone Mountain Ranch in USA has been using digital imaging for a number of years and this has resulted in much of the herd having either genomic EBVs, or EBVs from carcass progeny alone, or both from Australian BREEDPLAN. The relationship between number of carcass progeny and the correlation between IMF% and AUS-MEAT Marble Score EBV was reviewed from data posted by Lamb, 2018. There is a stronger association between IMF% from progeny with sire AUS-MEAT Marble Score EBV when there is a minimum of ten carcass progeny per sire.

The two sires with the highest average IMF% content have only had four and six carcasses analysed each. They are represented by the two yellow dots to the very right in the chart above, while their EBVs are +1.6 and +1.7 with good accuracy, but they are not the highest. The averages from this cluster with a limited number of progeny show the greatest deviation from the trend of correlation of IMF% with breeding value for this herd. It will be interesting to see if there is a shift in phenotypic measurements - or a shift in EBV - as more data becomes available over time.

The accuracy from breeding values increased in Australia from the concurrent implementation of single step technology together with genomically enhanced evaluations. A review from a dump of estimated breeding values from the AWA database from animals which do not have carcass progeny showed a trend of an increase overall of about 5% when genomic EBVs from DNA are compared with the conventional EBVs that were based on pedigree relationships. 66% of genomic Marble Score EBVs had accuracies of 60% of higher. The trend is illustrated over the page, to the left.

The accuracy for genomic AUS-MEAT Marble Score EBV (from DNA analysis) of the 2018 calf crop at Mayura Station has been found by Wagyu International to average 60.9%, with a range extending from 52 to 65%.
When accuracies from carcass progeny enhanced those from genomic MS EBVs, there was a marked increase in accuracies as shown in the chart above, to the right. 10 carcass progeny increased accuracy from 60% to around 75% in this random pool, but there is quite a variation because a number of different factors contribute to accuracy. The accuracy from around 50 carcass progeny was 85%. When the number of carcass progeny increases above 150, the influence on accuracy of genomic EBVs does not appear to increase proportionally above 95% and has very little effect in differentiating breeding value.

New registrations in Australia are mainly processed by using the 50K SNP profile so genomic EBVs are rapidly becoming the standard in that population. Most of the foundation sires were profiled by HD SNP in a process that commenced many years ago when the reference for the Wagyu breed was being built up. The AUS-MEAT Marble Score EBVs are presented below of sires with genomic EBVs. The accuracy for each sire is applied to their EBV. EBVs with lower accuracy have a wider range on either side from the published value and look like this in the chart. EBVs with higher EBV have higher consistency and narrower spread so are represented like this. This gives a visual impression of Marble Score EBVs with the expected spread that is determined by accuracy.
Foundation sires that have conventional pedigree EBVs are in the chart below.

Sires with genomic EBVs invariably have more carcass progeny because it is inevitable that the more popular sires would have a higher number of registered progeny together with a higher number of carcass progeny and would also be more likely to have a DNA SNP profile completed. The higher accuracy amongst genomic EBVs is more likely to be influenced more
by number of carcass progeny than by the more modest advantage of analysis from DNA relationships over pedigree relationships.

Commentary in USA states: “While genomics can be a valuable tool to assess what genes, traits, strengths, or weaknesses animals inherited from each parent, it is not an absolute measure of potential or a guarantee of performance. Remember, genomics in Wagyu still have relatively low reliabilities and are only as good as the data that was originally input into the system (Lamb 2019).” There are a number of sources of pedigree EBVs but there aren’t many sources of genomic EBVs. Genomic EBVs in Australian BREEDPLAN are an excellent starting point, but the accuracies must be checked in every case. The average Marble score EBV for the 2017 born calf crop is +0.6. The average for the genomically enhanced foundation Marble score EBV sires is +0.3. The increase in breeding merit of the younger generation of Wagyu over that from the original founders is confirmation of progress since the introduction of carcass EBVs. The benefits from genomic evaluation cannot be measured yet because no progeny carcass data have been processed yet that is the result from the implementation of selection from genomic EBVs. However the pace of improvement is more likely to increase because the generation interval for selection will be reduced because initial assessment is carried out at a younger age. The long generation interval in cattle hinders the rate of genetic improvement when compared to most other farm species.

USA progeny testing.

HeartBrand has published expected progeny differences (EPDs) for Red Wagyu/Akaushi in sales catalogues in the past but they are not in the public domain so are only available on request.

The American Wagyu Association publishes EPDs that have been generated from F1 progeny by Washington State University to give the best estimate of Black Wagyu sires’ genetic potential in USA. An association was found by Wagyu International between 2017 Marbling EPD’s with AUS-MEAT Marble Score EBVs (R = + 0.57) from Australian BREEDPLAN. The correlation was + 0.68 for sires that had accuracies above 0.4 for marbling EPD, but it dropped to + 0.44 for those that had accuracy that was below 0.4. This suggests that performance from sires that have an EPD with accuracy that is lower than 0.4 may not be consistent over time. 70% of the sires that have reported Marbling EPDs in the 2017 National Wagyu Sire Summary have an accuracy that is below 0.4.

There is a strong association of number of progeny per sire with the accuracy of marbling EPD (R = + 0.63) and individual charts illustrate the relationship for Marbling, Rib Eye Area, Carcass Weight and Subcutaneous Fat Thickness ‘backfat’ EPDs.
The average number of progeny that are expected to give accuracy of 0.4 for Marbling EPD is almost 25 and this is the number of F1 progeny that would be expected on average to give accuracy that exceeds 0.4 by evaluation from BLUP/Bolt analysis.

The correlation between Eye muscle (Rib eye) area EBV from Australian BREEDPLAN and EPD from Washington State is higher for accuracies greater than 40% (R = + 0.77) than when accuracy was lower than 40% (R = +0.63). Fewer progeny are required to obtain the same accuracy with Rib eye area EPD in USA than from Marbling EPD.

It is summarised that 25 F1 progeny, after analysis by BLUP/Bolt, will give an accuracy of 0.4 for marbling. A review of the chart showing accuracy of Marbling EPD suggests that more than 150 F1 progeny would be required to give Marbling EPD accuracy of 0.6 after analysis by BLUP/Bolt. The trend line cuts 0.75 accuracy at 650 F1 progeny.

Delegates to the Australian Wagyu Association tour to Nick & Vicky Sher’s property in Victoria in May 2019 were told that they evaluate their candidate sires of-farm by using F1 progeny. While walking through the paddocks I asked Leigh Bradbury, Operations Manager, how many progeny results are required from each sire for on-farm breeding evaluation. He answered 70. When this is related to the USA results, 70 F1 progeny there give approximately 50% accuracy from BLUP evaluation. However at the Sher property, cohorts could be raised in large herds, and there should be more consistency within one operation than over the diversity in as many as 20 contemporary groups for some sires in the Washington State pool.
On-farm application of progeny test results

In each instance that has been reviewed above, it has been demonstrated in Japan, USA and Australia that large numbers of either Fullblood or F1 progeny are required to ‘prove’ the breeding merit of a Wagyu sire or dam. This can be fast tracked by securing genomic EBVs at a young age. Breeding merit is locked in at conception and as soon as a hair sample can be taken, genomic EBVs can be obtained which give an average accuracy of 60% for marbling. This is usually carried out when registration is undertaken of weaners together with DNA parent verification. The first phenotypic examination can be carried out on-farm when genomic EBV results are posted after parent verification completes the registration process.

Selection is completed using weaning performance, conformation and genomic EBVs. Carcass traits with economic importance are given higher priority for use in production; or maternal traits are weighed up with pedigree, prefectural classification and conformation for seed stock breeding. Either way, the best young bulls and heifers are retained for breeding or sale while the remainder are processed. Semen is taken from the very best elite bulls so that ten carcass progeny can be produced from each and after four years, the very best candidate sires will be proven. If insufficient accuracy has been generated for any sires from ten carcass progeny, then it may possibly not be worth persevering with them. Low accuracies flag that inconsistent associations have been encountered in the data. Causes can range from low genetic merit from the candidate, insufficient cohorts or links, etc.

What should the benchmark be for the industry? Through the media there are frequent claims that are based on results from a low number of progeny. To keep this in perspective, it should always be remembered that Scott de Bruin requires 50 Fullblood progeny for reliability, and Sher Wagyu screen with 70 F1 progeny. The target is 75% accuracy, and this will be secured in most cases from 10 carcass progeny in combination with genomic EBVs. Alternatively, BLUP/Bolt analysis from 650 F1 progeny will give the same result.

60% accuracy should be obtained from:
Genomic EBVs, or
BLUP analysis from 20 Fullblood progeny, or
40 Fullblood progeny
BLUP/Bolt analysis from 150 F1 progeny.

So what is the lowest number of progeny for any credible claims? Results from fewer progeny than 20 Fullblood or 70 F1 should be generally be considered to be speculative.

It is just a fact of life that the 50% contribution of DNA from the dam in every union requires a large number of offspring to give an indication of a sire’s breeding merit. Sadly it turned out to be many more than I thought.

Steve Bennett
Wagyu International
23rd August 2019
Check this webpage for any updates that have been posted

Definitions

Refer to Definitions at the end of "Factors influencing, and selection for, eating quality in Wagyu beef". http://www.wagyuinternational.com/eating_quality.php

References and further reading


Lamb, Mitchell & Lindsay, 2018. Lone Mountain Ranch. International Wagyu Breeder e-magazine, July/August 2018:12

