Do Estimated Breeding Values (EBVs) Really Work?

Estimated Breeding Values (EBVs) aim to predict the differences in the performance of progeny for each trait but how accurately do they actually predict these differences?

The EBVS produced by BREEDPLAN are calculated from a combination of pedigree information, individual performance information, progeny performance information and, in some breeds, from genomic information.

This Technical Note will discuss how EBVs are evaluated, and will work through several case studies using industry data to examine the effectiveness with which EBVs can predict the progeny performance for a team of sires, and for individual animals. Furthermore, this Technical Note will outline ways in which the risks associated with using young sires with low accuracy EBVs (which may change as these young sires have their own progeny) can be minimised.

FAST // FACTS

- EBVs can be evaluated through a progeny test program, where the progeny performance of a team of High EBV bulls can be compared to the progeny performance of a team of Low EBV bulls.
- Progeny must be raised together to eliminate environmental differences.
- Once the relevant trait has been measured, the average difference in performance between the progeny of the High EBV sires and the progeny of the Low EBV sires is calculated.
- The difference between the average EBV of the High EBV sires and the average EBV of the Low EBV sires is also calculated.
- Expect that ½ of the sire EBV difference will be equal to the average progeny difference (as progeny inherit ½ of their DNA from their sire and ½ of their DNA from their dam).

HOW ARE EBVS EVALUATED?

A good way to evaluate EBVs is through a progeny test program, as outlined in Figure 1. Some of the sires used in a progeny test program will have High EBVs (e.g. above breed average) and other sires will have Low EBVs (e.g. below breed average). Once the sires are selected, they are then used to generate progeny from cows of similar genetic merit and age. Where cows are not all of similar genetic merit or age, bulls are randomly allocated to cows to ensure bias is not introduced as it would be if High EBV sires were only mated to High EBV cows, and Low EBV sires were only mated to Low EBV cows.

The progeny from the High EBV and Low EBV sires are then raised together. This ensures that all progeny have equal opportunity to perform and prevents environmental biases from occurring.

Once the progeny are old enough to be measured for the trait of interest (e.g. 400 day weight), then the average performance of the progeny of the High EBV sires and the average performance of the progeny of the Low EBV sires can be calculated. The difference between these two averages, known as the mean progeny difference, can then be calculated.

The sire EBV difference, which is the difference between the average EBV of the High EBV Sires and the average EBV of the Low EBV Sires, can also be calculated. The EBVs used to calculate the sire EBV difference are the EBVs that were available prior to the beginning of the progeny test project, and thus do not include the performance of the progeny of each sire.

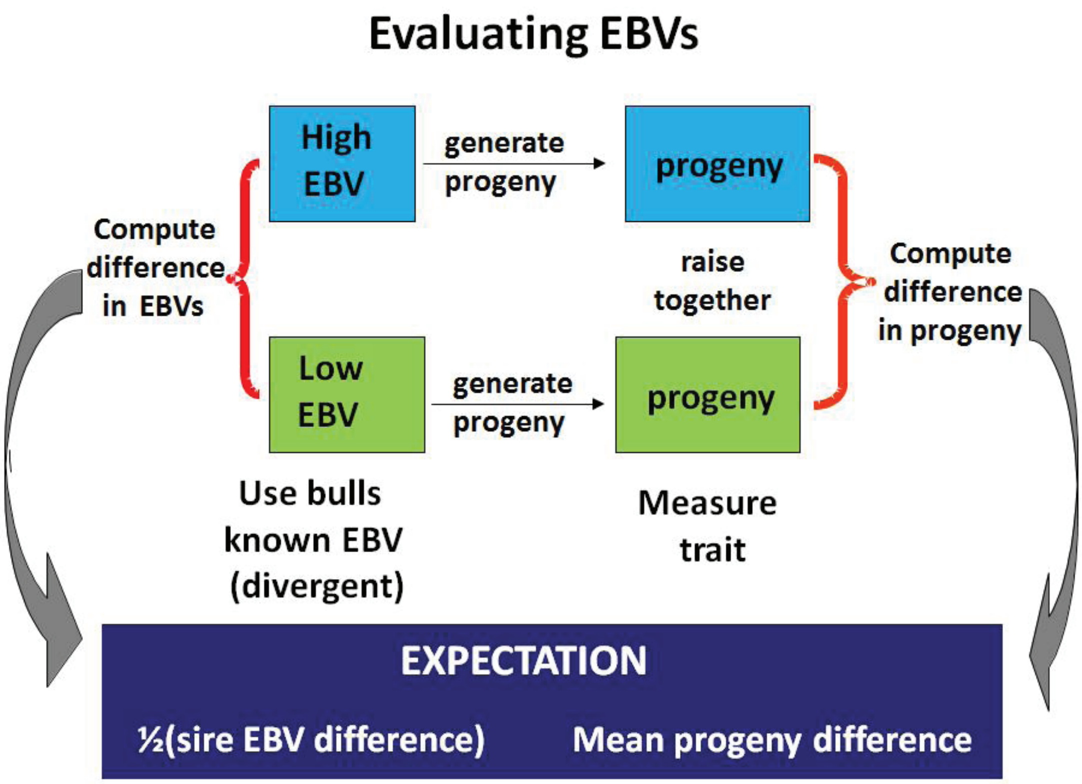

Figure 1. EBVS can be evaluated with data from a well-designed progeny test project. High EBV sires and Low EBV sires are randomly mated to a herd of cows. The progeny are raised together (to eliminate environmental differences), and the difference in the Sire EBVs and the progeny performance computed. The observed difference in progeny performance is compared to the expected difference in progeny performance (the expectation being that the mean progeny difference will be equal to half of the sire EBV difference).

Once the mean progeny difference and the sire EBV difference have been calculated, the expected progeny difference can be compared with the actual progeny difference. As the progeny have only received 50% of their DNA from their sire, the expected progeny difference will be half of the sire EBV difference. If, as expected, the EBVs are a good predictor of progeny performance, then the difference between the expected progeny difference and the actual progeny difference will not be significantly different.

EVALUATING EBVS - THE TEAM APPROACH

A progeny test project run by the Australian Brahman Breeders Association (ABBA) allowed for the evaluation of Weight EBVs (Table 1). For each of the traits, the observed progeny differences were calculated from the differences in weights between the steer progeny of the sires (e.g. no bull or heifer progeny). In this progeny test project, the top 5 sires for 200 Day Growth had an average EBV of +36 kg, while the bottom 5 sires had an average EBV of +11 kg. For 200 Day Growth, the expected progeny difference was 12.5 kg, and the observed progeny difference was 11 kg. For 400 Day Weight, the top 5 sires had an average EBV of +51 kg, while the bottom 5 sires had an average EBV of +16 kg. For 400 Day Weight, the expected progeny difference was 17.5 kg, and the observed progeny difference was 17 kg. For 600 Day Weight, the top 5 sires had an average EBV of +72 kg, while the bottom 5 sires had an average EBV of +25 kg.

Therefore the expected progeny difference for 600 Day Weight was 23.5 kg, while the observed progeny difference was 27 kg. For 200 Day Growth, 400 Day Weight and 600 Day Weight, the EBVs of the sire teams accurately predicted the differences in progeny performance.

The ABBA progeny test project also allowed for the evaluation of Carcase EBVs (Table 2). For each of the traits, the observed progeny difference was calculated from the differences in ultrasound scan measurements between the heifer progeny of the sires. For EMA, the top 5 sires had an average EBV of +5.3 cm2, while the bottom 5 sires had an average EBV of +0.6 cm2. Therefore the expected progeny difference was 2.35 cm2, while the observed progeny difference was higher than expected

Table 1. The Australian Brahman Breeders Association (ABBA) ran a progeny test project which allowed for the evaluation of EBVs. Here, the expected progeny difference and observed progeny difference for Braham steers are provided for a range of BREEDPLAN Weight Traits. The progeny used in this analysis were sired by the top 5 sires and bottom 5 sires for each trait in the ABBA Progeny Test Project.

Animal Traits	Sex of Progeny	Average EBV of Bottom 5 Sires	Average EBV of Top 5 Sires	Expected Progeny Difference	Observed Progeny Difference
200 Day Growth	Steers	+11 kg	+36 kg	12.5 kg	11 kg
400 Day Growth	Steers	+16 kg	+51 kg	17.5 kg	17 kg
600 Day Growth	Steers	+25 kg	+72 kg	23.5 kg	27 kg

at 4 cm2. For Rib Fat, the top 5 sires had an average EBV of +0.4 mm, while the bottom 5 sires had an average EBV of -2.0 mm. The expected progeny difference for Rib Fat was 1.2 mm, but the observed progeny difference was lower than expected at 0.5 mm. For Rump Fat, the top 5 sires had an average EBV of +0.6 mm, while the bottom 5 sires had an average EBV of -2.6 mm. The expected progeny difference for Rump Fat was 1.6 mm, and the observed progeny difference for Rump Fat was very similar being 1.4 mm. For EMA, Rib Fat and Rump Fat, the EBVs of the sire teams have predicted progeny performance for these traits with reasonable accuracy.

A progeny test project by Shorthorn Beef allowed for the evaluation of Carcase Weight and Intramuscular Fat (IMF) EBVs. In this progeny test project, the average Carcase Weight EBV of the top 5 sires was 46 kg, while the average Carcase Weight EBV of the bottom 5 sires was +18 kg (Table 3). With the sire EBV difference being 28 kg, the expected progeny difference in Carcase Weight between the progeny of the top 5 sires and the progeny of the bottom 5 sires was 14 kg. The observed progeny difference for Carcase Weight was 13.4 kg. Therefore, in the case of Carcase Weight, the EBVs of the sire teams accurately predicted the difference in progeny performance.

In the Shorthorn Beef progeny test project, the average IMF EBV of the bottom 5 sires was -0.5%, while the average IMF EBV of the top 5 sires was +1.1% (Table 3). With the sire EBV difference being 1.6%, the expected progeny difference in IMF between the progeny of the top 5 and bottom 5 sires was 0.8%. The observed progeny difference for IMF was 0.6%. Therefore, in the case of IMF, the EBVs of the sire teams did a good job of predicting the progeny differences.

Differences in IMF% are a predictor of the differences in AUS-MEAT Marble Score, which is scored on a different scale. In this case, the expected progeny difference in IMF was 0.8%, and the observed difference in AUS-MEAT Marble Score between the two groups of progeny was 0.4 (Table 3). This is not unexpected; IMF and Marble Score, while correlated, are not the same trait. Despite being different traits, the top 5 sires for IMF% produced progeny which had carcases with higher AUS-MEAT Marble Scores than carcases from the progeny of the bottom 5 sires for IMF%.

As this section has shown, when comparing groups of sires, EBVs for a particular trait provide a good prediction of differences in progeny performance for each trait.

Table 2. The Australian Brahman Breeders Association (ABBA) ran a progeny test project which allowed for the evaluation of EBVs. Here, the expected progeny difference and observed progeny difference for Braham heifers are provided for a range of BREEDPLAN Carcase Traits. The progeny used in this analysis were sired by the top 5 sires and bottom 5 sires for each trait in the ABBA Progeny Test Project.

Animal Traits	Sex of Progeny	Average EBV of Bottom 5 Sires	Average EBV of Top 5 Sires	Expected Progeny Difference	Observed Progeny Difference
Scan EMA	Heifers	+0.6 sq. cm	+5.3 sq. cm	2.35 sq. cm	4 sq. cm
Scan Rib Fat	Heifers	-2.0 mm	+0.4 mm	1.2 mm	0.5 mm
Scan Rump Fat	Heifers	-2.6 mm	+0.6 mm	1.6 mm	1.4 mm

Table 3. Shorthorn Beef ran a progeny test project which allowed for the evaluation of EBVs. Here, the expected progeny difference and observed progeny difference are shown for several BREEDPLAN Carcase Traits. The progeny used in this analysis were sired by the top 5 and bottom 5 sires for each trait in the Durham Shorthorn Trial.

Animal Traits	Average EBV of Bottom 5 Sires	Average EBV of Top 5 Sires	Expected Progeny Difference	Observed Progeny Difference
Carcase Weight	+18 kg	+46 kg	14 kg	13.4 kg
IMF	-0.5 %	+1.1 %	0.8 %	0.6 %
IMF/ AUS-MEAT Marble Score	-0.5 %	+1.1 %	0.8 %	0.4

EVALUATING EBVS - INDIVIDUAL ANIMALS

EBVs provide a good prediction of differences in progeny performance when we consider the progeny of a team of sires (e.g. top 5 sires vs bottom 5 sires). Do EBVs also work when we consider the progeny performance of an individual sire? To answer this question the results from Cohort 1 of the Herefords Australia Progeny Test Project are considered. There were 15 sires included in Cohort 1, and performance records on their progeny were collected for a number of BREEDPLAN traits.

Firstly, let's consider what has happened to the Birth Weight EBVs of the sires before and after their progeny were analysed in the progeny test project (Figure 2). The initial EBVs are shown in blue, and are EBVs from before these young sires were used in the progeny test project (e.g. low accuracy EBVs which do not include performance information collected in the progeny test project). The current EBVs are shown in red, and are EBVs after the young sires were involved in the progeny test project (e.g. higher accuracy EBVs which do include performance information collected in the progeny test project). As Figure 2 shows, the average Birth Weight EBV of the 15 bulls has remained relatively stable, and there is still a large difference between the average Birth Weight EBVs of the top 5 sires and the bottom 5 sires following the progeny test project.

However, the Birth Weight EBVs of some individual bulls have moved significantly following inclusion of the progeny test data. Specifically, the Birth Weight EBVs of bulls 1, 4, 6, 7, 8, 11, 12, 14 and 15 have decreased following the progeny test project, while the Birth Weight EBVs of bulls 2, 3 and 9 have increased. The Birth Weight EBVs of bulls 5, 10 and 13 have changed very little.

Now consider what happened to the 600 Day Weight EBVs of the sires after their progeny were analysed in the progeny test project (Figure 3). Once again the initial

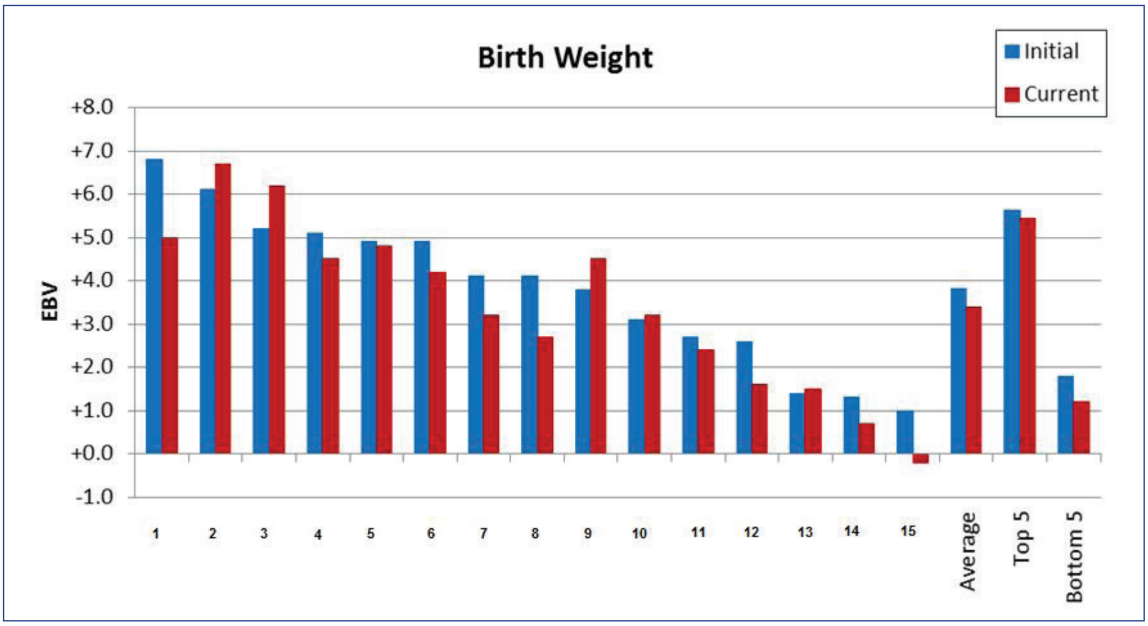

Figure 2. The Birth Weight EBVs of 15 individual sires, and the average Birth Weight EBVs of all 15 sires, the top 5 sires and the bottom 5 sires are shown prior to the progeny test project (Initial, blue) and following the progeny test project (Current, red).

EBVs (pre progeny test project) are shown in blue, and the current EBVs (post progeny test project) are shown in red. As was the case with Birth Weight, the average 600 Day Weight EBV of all 15 bulls has not changed significantly before and after the progeny test project, and neither has the average 600 Day Weight EBV for both the top 5 sires and the bottom 5 sires. Furthermore, the difference between the average EBVs of the top 5 sires and the bottom 5 sires has remained constant from the initial EBVs to the current EBVs.

When the 600 Day Weight EBVs of the 15 individual bulls are considered, we see a similar pattern to that which we saw for the Birth Weight EBVs. The 600 Day Weight EBVs of bulls 1, 5, 7, 8, 9, 11, 14 and 15 have decreased following the progeny test project, while the 600 Day Weight EBVs of bulls 4, 6, 10 and 12 have increased following the progeny test project. However, the 600 Day Weight EBVs for bulls 2, 3 and 13 have remained the same following the progeny test project.

As this section has highlighted, while EBVs provide an accurate prediction of progeny performance when we consider the progeny of a team of sires (even when the team of sires have EBVs of low accuracy), the low accuracy EBVs of an individual sire may move as more information is added to the BREEDPLAN analysis. In these cases, the EBVs of some individuals will increase, the EBVs of some individuals will decrease, and the EBVs of some individuals will remain the same.

USING EBVS - SPREAD THE RISK

It is impossible to predict in which direction an individual's EBVs (and Selection Indexes) will move. Therefore it is recommended that when using young sires with low accuracy EBVs, beef breeders spread the risk by using a team of young bulls wherever possible. While individuals within the team may re-rank, the average EBVs (and Selection Indexes) of the team are expected to remain the same.

This is highlighted in Table 4 below. Here, there are ten 18 month old bulls which a beef producer might consider for selection as sires. In scenario 1, the beef producer decides to select only one young sire, and chooses Bull 1 as this bull has the highest Selection Index of $116. However, over time, as more progeny information comes into the BREEDPLAN analysis, the Selection Indexes of the individuals changes. In this case, when the bulls are four years of age, the Selection Index of Bull 1 has dropped from $116 to $93. Furthermore, Bull 1 has dropped from 1st place to 7th place when the bulls are re-ranked on their current Selection Indexes. In this scenario, the beef producer has not spread the risk, and the Selection Index of the one bull selected has decreased with time. Unfortunately, however, the bull is now four years of age and has already sired several drops of calves.

In scenario 2, the beef producer decides to select a team of five 18 month old bulls based on their Selection

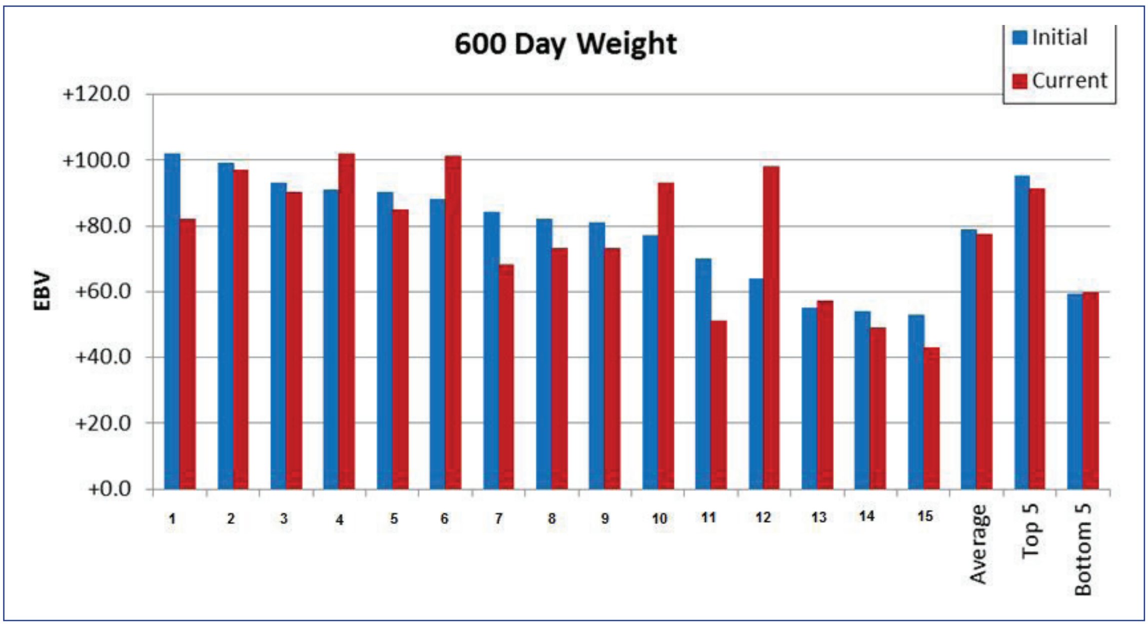

Figure 3. The 600 Day Weight EBVs of 15 individual sires, and the average 600 Day Weight EBVs of all 15 sires, the top 5 sires and the bottom 5 sires are shown prior to the progeny test project (Initial, blue) and following the progeny test project (Current, red).

Indexes. The producer selects Bulls 1, 2, 3, 4 and 5; together these young bulls have an average Selection Index of $106.

However, over time, as more progeny information comes into the BREEDPLAN analysis, the Selection Indexes of the individuals changes. When the bulls reach four years of age, the Selection Index for Bull 1 has decreased and he is ranked 7th, while the Selection Indexes for Bull 2 and Bull 3 have remained the same and they are ranked 2nd and 4th respectively.

The Selection Indexes for Bull 4 and Bull 5 have increased and they are ranked 4th and 3rd respectively. However, as four year olds, the average Selection Index of the bull team is $104, which is a slight decrease from the original average Selection Index of $106. In this scenario, by using a team approach, the beef producer has successfully managed the risk of the EBVs and Selection Indexes of an individual animal changing over time.

While it is recommended to us a team approach when selecting young sires, there will be situations where beef breeders do not have large enough herds to do so. In these cases, the use of high accuracy sires to reduce risk is recommended. Typically, these high accuracy sires will be AI sires.

SUMMARY

As this Technical Note has shown, when comparing groups of sires, EBVs provide an accurate prediction of the differences in progeny performance. However, as has also been shown, the EBVs on individual young animals may change over time as more information comes into BREEDPLAN. In the case of young animals, it is expected that the progeny of some will perform better than expected, the progeny of some will perform worse than expected, and the progeny of others will perform as expected.

To spread the risk of an individual young animal performing worse than expected, it is recommended that a team approach is used when selecting young sires. While individual bulls within the team may re-rank over time, the average EBVs and Selection Indexes of the team of bulls are expected to remain the same. However, if you are not able to use a team approach, then the use of older, high accuracy sires (typically AI sires) is recommended.

For further information on evaluating EBVs, or to further discuss a team approach when selecting young sires, please contact staff at Southern Beef Technology Services (SBTS) or Tropical Beef Technology Services (TBTS).

Table 4. The selection indexes and associated rankings of 10 young bulls are shown when the bulls are 1.5 years of age (and selection decisions are being made), and when the bulls are 4 years of age (and have produced several drops of calves).

Bull	Initial Selection Index (Rank) Bulls are 1.5 years old	Current Selection Index (Rank) Bulls are 4 years old
Bull 1	$116 (1)	$93 (7)
Bull 2	$108 (2)	$108 (2)
Bull 3	$105 (3)	$105 (4)
Bull 4	$102 (4)	$107 (3)
Bull 5	$99 (5)	$110 (1)
Bull 6	$97 (6)	$92 (8)
Bull 7	$93 (7)	$101 (5)
Bull 8	$92 (8)	$97 (6)
Bull 9	$89 (9)	$90 (9)
Bull 10	$83 (10)	$85 (10)

For Further Information Contact

Southern Beef Technology Services
Telephone: (02) 6773 3555
Email: office@sbts.une.edu.au

Tropical Beef Technology Services
Telephone: (07) 4927 6066
Email: office@tbts.une.edu.au