UNDERSTANDING STRUCTURAL SOUNDNESS EBVS

Claw Set and Foot Angle EBVs

This resource was created as a result of a collaboration between Angus Australia and Meat & Livestock Australia Donor Company (MDC) (Project P.PSH.1063).

Interpreting Structural Soundness EBVs

Claw Set EBVs provide estimates of genetic differences in claw set structure (shape and evenness of claws), with lower Claw Set EBVs indicating an animal is expected to produce progeny with more desirable claw structure, being toes that are symmetrical, even and appropriately spaced.

Foot Angle EBVs provide estimates of genetic differences in foot angle (strength of pastern, depth of heel), with lower Foot Angle EBVs indicating an animal is expected to produce progeny with more desirable foot angle, being a 45-degree angle at the pastern joint with appropriate toe length and heel depth.

Claw Set and Foot Angle EBVs are expressed as expected differences in score units, with lower Foot Angle and Claw Set EBVs being more favourable, and identifying animals that will produce progeny with more desirable structure (i.e. a score closer to 5).

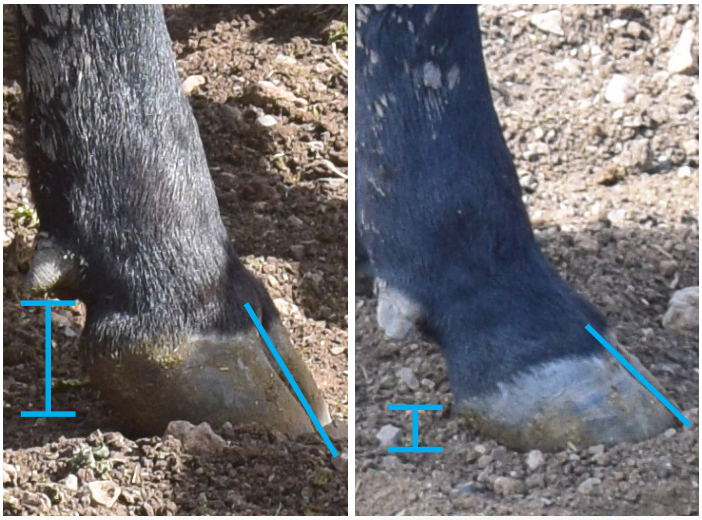
For example, if one sire has a Claw Set EBV of +0.46, and another sire has a Claw Set EBV of +1.20, the first sire would be expected to produce progeny that have, on average, 0.37 (i.e. the EBV difference of 0.74, divided by 2) of a score more desirable structure, all other things being equal.

EBV reference tables are published for Claw Set and Foot Angle that indicate where an animal's EBV sits relative to the Claw Set and Foot Angle EBVs of other Angus and Angus-influenced animals in Australia and New Zealand.

Currently, breed average for Claw Set is +0.85, meaning that animals with a Claw Set EBV of less than +0.85 can be considered a 'breed improver' for claw structure. Similarly, breed average for Foot Angle is +0.97, meaning that animal with a Foot Angle EBV of less than +0.97 can be considered a 'breed improver' for foot angle.

Percentile band values are also published in association with each Claw Set and Foot Angle EBV. For example, a percentile value of '10' for Claw Set EBV indicates the animal's genetics are ranking in the highest (most favorable) 10% of Angus animals for claw set structure.

Claw set structure reflects the shape on the inside edge of each claw, and the space between the claws



Foot angle structure reflects the angle of the pastern joint, indicated by the depth of heel & angle of the front of the claws

Advantages of Structural Soundness EBVs

While many producers have successfully managed the structural soundness of their animals using different selection strategies, such as the culling of animals with unacceptable structure, Claw Set and Foot Angle EBVs provide a useful tool that breeders can use in association with existing management and culling strategies to further improve the foot structure of their animals.

Claw Set and Foot Angle EBVs have several major benefits when used in association with traditional selection strategies, including:

- Like all traits of economic importance, the foot structure of an animal is a combination of the genetics it has inherited from its sire and dam, and a range of non genetic effects. Claw Set and Foot Angle EBVs take any differences in non-genetic effects into account and focus on the genetic differences between animals.
- The Claw Set and Foot Angle EBV calculated for an animal takes into consideration not only the foot structure of the individual animal, but also the foot structure of all the animal's relatives. In this manner, the Claw Set and Foot Angle EBVs provides a better indication of an animal's genetics for foot structure than an assessment of the animal's foot structure alone.
- Claw Set and Foot Angle EBVs allow for genetic differences in foot structure to be identified between animals who themselves may have acceptable foot structure. Animals who may have acceptable foot structure but are likely to produce a high percentage of progeny with poor foot structure can be removed from the breeding herd, or conversely, if two animals of similar genetic merit for other traits are being considered for use within a breeding program, the animal that is likely to produce a higher percentage of progeny with superior foot structure can be selected.
- Claw Set and Foot Angle EBVs allow for the genetics of an animal for foot structure to be considered in circumstances where it is not possible to assess the foot structure of an animal. For example, when considering the use of a new imported sire within a breeding program.

Information Used to Calculate Structural Soundness EBVs

The Claw Set and Foot Angle EBVs published in the TransTasman Angus Cattle Evaluation are based on over 100,000 structural scores that have been collected on Angus animals in Australia and New Zealand for claw set and foot angle.

Scores have been collected in over 200 Angus seedstock herds, and across all regions in which Angus seedstock cattle are represented.

Figure 1 - Number of Foot Angle & Claw Set Scores Collected on Australian and New Zealand Angus Animals

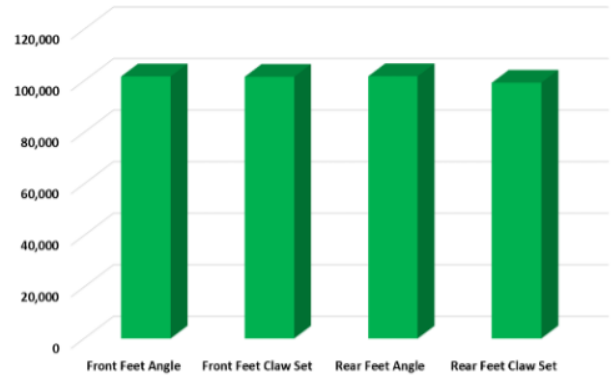


Figure 2 - Foot Angle & Claw Set Scores Collected by Region

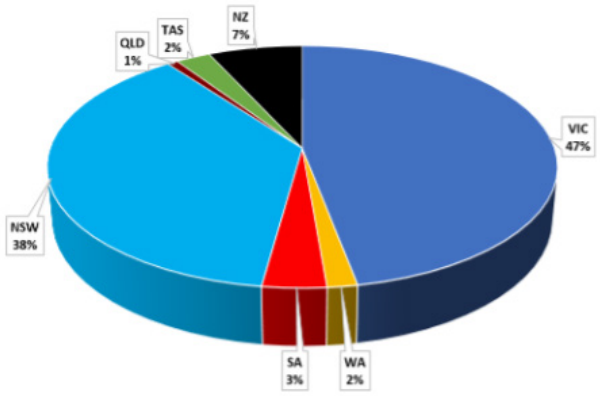
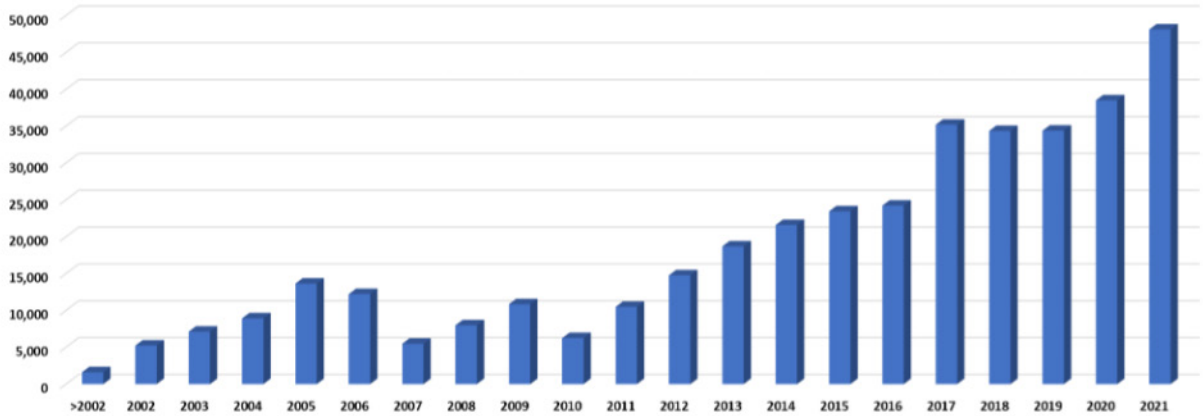


Figure 3 - Foot Angle & Claw Set Scores Collected by Observation Year



Recap - Improvements to Structural Soundness EBVs in December 2020

Considerable changes and improvements were implemented in December 2020 to the Structural Soundness EBVs that are published within the TransTasman Angus Cattle Evaluation.

The changes and improvements that were implemented can broadly be summarised as follows:

- Publication of EBVs for more animals
- Increased ability for members to submit structural scores
- Incorporation of genomic information
- Ability to directly compare EBVs with North American EPDs
- Changes to the analytical model

1. Publication of Structural EBVs for more animals

By comparison to the previous EBVs, EBVs are now published for a considerably greater number of animals.

For example, the number of animals born in 2020 with Structural Soundness EBVs increased from 6,179 to 37,512, representing a 6-fold increase (Figure 4).

Figure 4 - Number of Animals with Claw Set EBVs Published

Birth Year	Old	New
2015	6175	16595
2016	7524	21936
2017	7072	26467
2018	7786	31728
2019	7603	35040
2020	6179	37512

2. Increased Ability for Members to Submit Structural Scores

A number of strategies were adopted to increase the submission of structural scores and improve the accuracy of the EBVs being published.

- **Acceptance of breeder collected scores:** In addition to the scores collected by independent accredited assessors, breeder collected scores are now also accepted for analysis.

  Research has illustrated that the heritability of breeder collected scores is similar to the heritability of scores collected by an accredited assessor (i.e. 0.22 v 0.25 for claw set, 0.23 v 0.24 for foot angle), showing breeder collected scores can be incorporated without any detriment to the genetic evaluation.

  Members are encouraged to use an independent assessor for the collection of scores on sale animals, or in situations where they are not comfortable collecting scores, with the acceptance of breeder collected scores aimed at facilitating an increase in the recording of scores on replacement heifers and mature females.

- **Acceptance of scores from mature breeding females:** Scores collected on mature breeding females are now accepted for analysis.

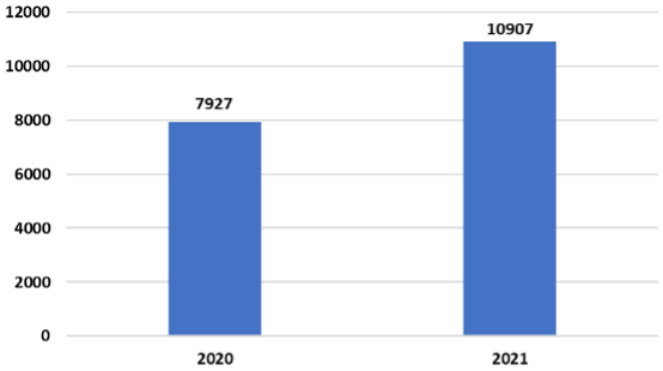
  Previously, scores were only analysed for animals aged younger than 750 days of age, where animals often showed limited variation in structural soundness by comparison to older animals.

- **Acceptance of multiple scores per animal:** Animals can now be scored multiple times across their life, whereas previously only one score per animal was accepted for analysis.

  In general, scoring animals once as yearlings (or rising 2 year olds), and once per year as mature females is recommended. Scores can be collected at any time throughout the year.

  The strategies adopted have been successful in increasing the number of structural scores being submitted, with a 38% increase in the number of structural scores submitted to Angus Australia in 2021, by comparison to 2020 (Figure 5).

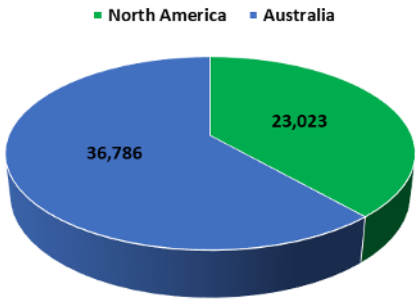
Figure 5 - Number of Front Feet Claw Set Scores Submitted to Angus Australia By Calendar Year



3. Incorporation of Genomic Information

Genomic information is now incorporated into the genetic evaluation, taking advantage of the considerable genomic reference population that now exists for structural soundness, not only in Australia, but also in North America (Figure 6). Previously only pedigree and phenotypic measurements (i.e. scores) were considered in the analysis.

Figure 6 - Number of Genotyped Animals with Structural Scores



Research has illustrated that the incorporation of genomic information, considerably improves the predictive accuracy of the Structural Soundness EBVs for Australian animals from 0.41 to 0.65.

4. Direct Comparison with North American EPDs

A feature of the new Foot Angle and Claw Set EBVs is that the analysis is now conducted jointly with the American and Canadian Angus Associations, meaning that the breeding values published on Australian Angus animals can be compared with the breeding values published on animals in North America.

This is of particular benefit when evaluating the potential use of imported sires within a breeding program, and provides Australian Angus breeders with more certainty regarding foot structure when selecting genetics from the global Angus gene pool.

While comparable, to assist with interpretation, the Structural Soundness EBVs are published in a manner that is consistent with the other EBVs in the TransTasman Angus Cattle Evaluation (Figure 7). This includes:

(i) Publication as an Estimated Breeding Value (EBV), rather than an Estimated Progeny Difference (EPD),

(ii) Publication of accuracy values as the correlation between the predicted and true breeding value, rather than as the BIF accuracy, and

(iii) Publication of TransTasman specific EBV reference tables (i.e. breed average and percentile bands).

With this in mind, the EBVs published in the TransTasman Angus Cattle Evaluation are simply twice the EPDs published in North America, and so to convert the Foot Angle or Claw Set EPD on a North American animal, simply multiply the EPD by two and it will give the equivalent EBV in Australia. Likewise, to convert the Foot Angle or Claw Set EBVs on an Australian animal, divide the EBV by 2 and it will produce the equivalent EPD in North America.

Australia	
EBV	+0.58
EBV Acc	98%
Perc	7
USA/Canada	
EPD	+0.29
EPD Acc	0.79
Perc	1

Figure 7 - Claw Set Breeding Values of Baldridge Beast Mode

5. Changes to the Analytical Model

Further to the beforementioned changes, two additional changes were made to the analytical model that is used to calculate the Claw Set and Foot Angle EBVs.

- **Transition from a single trait to multi-trait model**

  The Claw Set and Foot Angle EBVs are now calculated in a bi-variate (i.e. two trait) analysis that models the genetic correlation between claw set and foot angle. This genetic correlation is estimated to be +0.38.

  In the previous analysis, the EBVs were calculated in a series of single trait analyses where the genetic correlation between traits was not considered.

- **Transition from a threshold to a linear model**

  The Claw Set and Foot Angle EBVs are now calculated using a linear model, whereas previously a threshold model was used.

  Linear models are used across most traits in the TransTasman Angus Cattle Evaluation and are applied when the phenotypes are distributed normally (i.e. a bell curve).

  Threshold models are less commonly used and are usually applied when the phenotypes are distributed in categories (i.e. yes/no) with non-normal distribution. For example, calving ease where >95% of birth difficulty scores have a value of 1 (unassisted). In the previous analysis, a threshold model was used with structural scores grouped into three categories, being scores of 1-4, 5-6, and 7-9.

  Research investigated the differences between using a threshold or linear model in the structural soundness evaluation and determined results from both threshold and linear models were highly correlated.

A linear model was subsequently adopted as it is more compatible with other analytical features such as the incorporation of genomics, and the utilisation of multiple scores on each animal. A linear model also addressed concerns that had been raised previously with the grouping of scores in the threshold model.

While it does not result in the removal of many scores from the analysis (i.e. there are only a very small percentage of scores of 1-4), the new linear analytical model only incorporates scores of 5 and above in the calculation of EBVs.

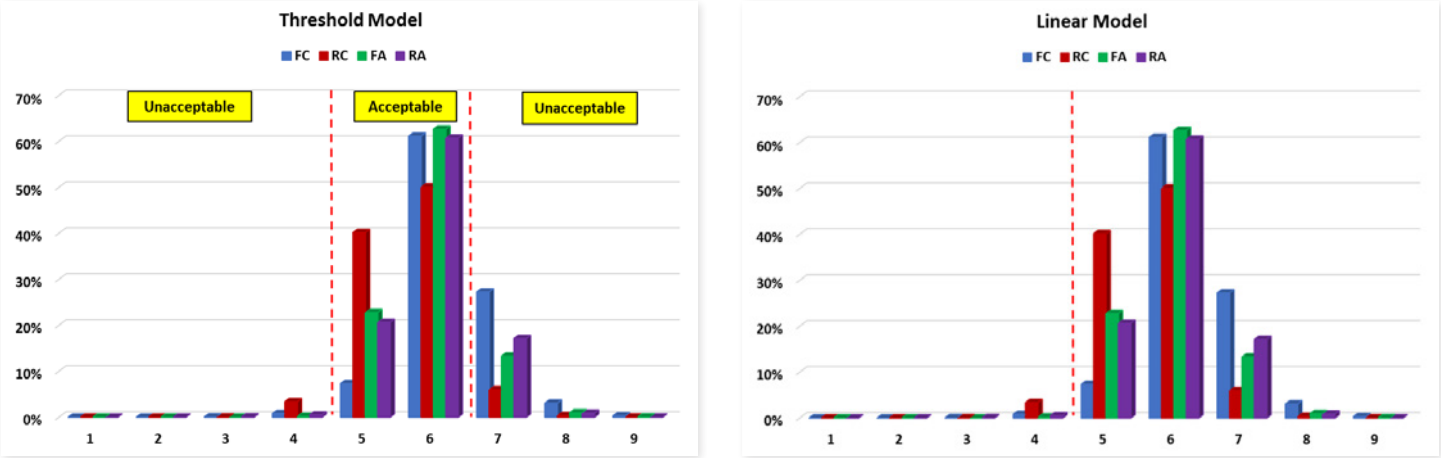


Figure 8 - Claw Set and Foot Angle EBVs are now calculated using a linear analytical model

Validation of EBVs

As part of the ongoing maintenance of the Claw Set and Foot Angle EBVs, Angus Australia recently conducted an analysis to assess the predictive ability of the EBVs.

To validate the EBVs, 2317 sires who had 5 or more progeny with structural soundness scores collected were ranked on their EBV and drafted into 4 quartiles.

The average progeny score of sires in each quartile, along with the percentage of progeny with a score of 5 or 6, were then used to assess whether the EBVs being calculated were reflective of the differences observed in progeny scores.

As illustrated in Figure 9, sires in the lowest (most favourable) quartile for Claw Set EBV had progeny with an average front foot claw set score of 6.05, by comparison to sires in the highest (least favourable) quartile who had progeny with an average front foot claw set score of 6.46.

Likewise, 78% of progeny from sires in the lowest (most favourable) quartile had a front foot claw set score of 5 or 6, by comparison to only 54% of progeny from sires in the highest (least favourable) quartile.

The analysis demonstrates that the Claw Set EBVs are reflective of the differences in progeny scores and can be used with confidence when making selection decisions.

Similar results were observed when sires were drafted into quartiles based on their Foot Angle EBV.

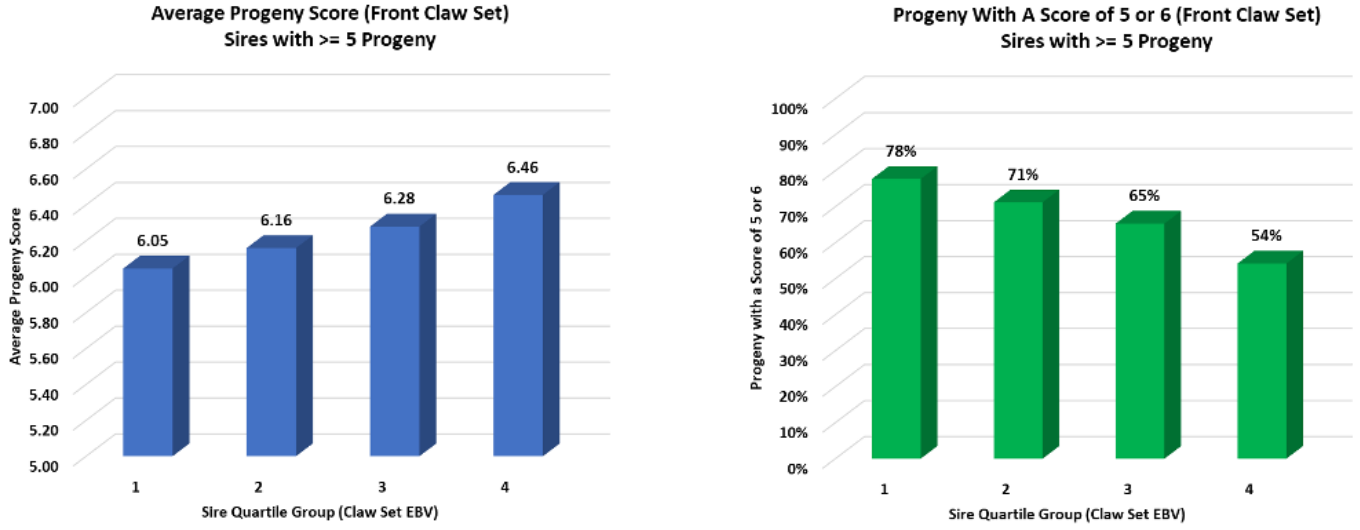


Figure 9. Relationship Between Claw Set EBVs and Progeny Scores for Front Feet Claw Set

Collecting Structural Soundness Scores

Seedstock breeders interested in having Claw Set and Foot Angle EBVs published for their animals need to collect subjective structural soundness scores.

Structural soundness scores are collected using the Beef Class Structural Assessment System.

Scores are collected using a 1 – 9 scoring system, where:

- A score of 5 is considered ideal
- Scores of 4 and 6 show slight variation from ideal, but this includes most animals. Any animal scoring 4 and 6 would be acceptable in any breeding program
- Scores of 3 and 7 show greater variation, but would be acceptable in most commercial breeding programs, however seedstock producers should be wary
- Scores of 2 and 8 are low scoring animals and should be looked at carefully before purchasing
- Scores of 1 and 9 should be considered culls

Front and rear feet should be scored separately.

Use of Accredited Technicians

Both breeder collected scores and scores collected by accredited technicians can be submitted for inclusion in the TransTasman Angus Cattle Evaluation.

It is suggested that independent accredited assessors are used for the collection of scores on sale animals, or in situations where the breeder is not confident with scoring their animals.

A "Paddock Guide to Structural Scoring for Genetic Evaluation" is available from Angus Australia to assist any breeders wishing to collect structural scores for their animals.

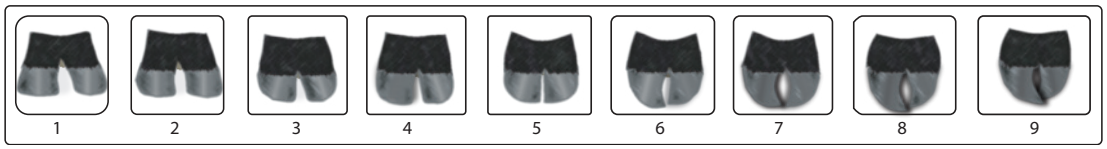
When should animals be scored?

Structural soundness scores can be submitted on animals older than 320 days of age at scoring (i.e. 10 months), with an animal able to be scored multiple times across its life.

Scores on both young animals, and mature females can be analysed. In general, scoring animals once as yearlings (or rising 2 year olds), and mature females once per year is recommended. Scores can be collected at any time throughout the year.

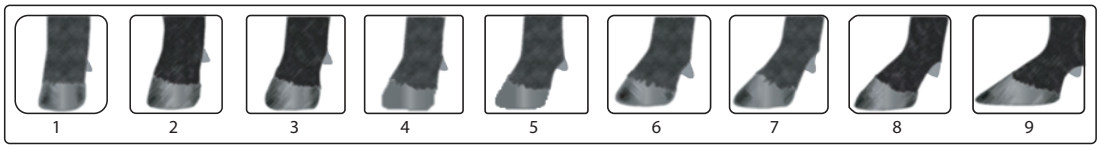
Tips when collecting structural soundness scores

- It is important to try and score as many animals within each contemporary group as possible. Collection of structural soundness scores for only a selection of



Claw Set

Assessing the level of separation between the claws and the degree of curl on the inside edge of the claws



Foot Angle

Assessing the depth of heel and level of slope on the hoof

animals (e.g. only collecting scores for sale bulls rather than the entire bull drop) may result in data biases and the subsequent calculation of Structural Soundness EBVs that do not reflect the true genetic merit of animals.

- There needs to be some variation in scores for them to be used in the genetic evaluation. Scoring all animals in a group with a score of [5] does not identify any differences in structural soundness between animals, and consequently does not provide any useful information for the calculation of Structural Soundness EBVs.
- If there is variation from foot to foot, the score that is collected should reflect the worst foot.
- A management group should be recorded for any animals or group of animals that have been treated differently or exposed to significant non-genetic influences prior to measurement that may affect their structural soundness scores. For example, differences in feed, or animals being run on different types of country (i.e. soft, rocky).
- Structural soundness scores should be recorded for all animals in a contemporary group on the same day. Scores collected on different days will not be compared together.
- It is important the same person scores all animals within a management group to account for variation between scorers.
- If foot trimming is practiced, structural soundness scores should be collected prior to trimming so that differences between animals are accurately described.
- Structural scores can only be analysed in the TransTasman Angus Cattle Evaluation for animals that have a prior 200 or 400 day weight included in the analysis. The most recent 200 or 400 day weight contemporary group forms an important criteria in determining the contemporary group in which structural soundness scores are analysed.

Future Research & Development

A number of research initiatives are underway to further improve the structural soundness EBVs that are available within the TransTasman Angus Cattle Evaluation.

- **EBVs for Rear Leg Side View**

  Previously, EBVs were also published for Rear Leg Side View (RS) and Rear Leg Hind View (RH).

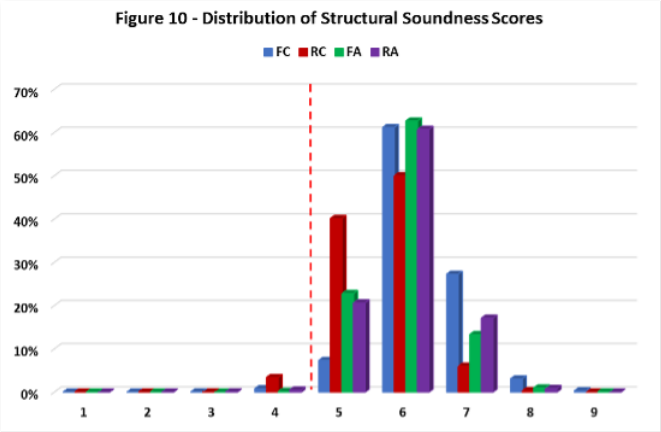
  It is anticipated that a new Rear Leg Side View EBV will be released for review and feedback during the second half of 2022, with targeted implementation into the TransTasman Angus Cattle Evaluation in December 2022. By comparison to the Claw Set and Foot Angle EBVs, the RS EBVs will only include animals from Australia and New Zealand.

- **Inclusion of 1-4 scores**

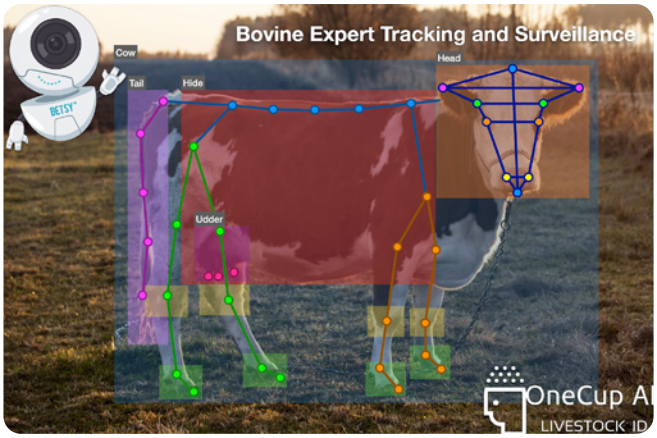
  The new linear analytical model currently only includes scores of 5 and above in the calculation of Structural EBVs. While it only results in the removal of a small number scores from the analysis (figure 10), research has commenced to explore the inclusion of scores of 1-4 in the analysis

- **Improving the collection of phenotypes**

  Angus Australia is providing a PhD stipend scholarship to a student at the University of New England to investigate the use of different image collection systems and sensor technologies combined with artificial intelligence to objectively collect hard to measure and novel phenotypes for genetic evaluation, with a particular focus on traits of structural and functional importance (e.g. feet, leg and udder structure).



The research is similar to a project being led by the Canadian Angus Association in collaboration with One Cup AI.



Further Information

To further discuss the Claw Set and Foot Angle EBVs that are published within the TransTasman Angus Cattle Evaluation, or the collection of structural soundness scores, please contact staff at Angus Australia. Comprehensive information is also available from the 'Understanding EBVs' and 'Collection Guidelines for TACE' modules in the Angus Education Centre.

www.angusaustralia.com.au/education