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IMPROVED REPORTING METHOD FOR GENETIC CONNECTEDNESS

B. Visser[1], T.J. Byrne[1], M.J. Young[2] and P.R. Amer[1]

[1]AbacusBio Limited, PO Box 5585, Dunedin
[2]Beef + Lamb New Zealand Ltd., PO Box 39-085, Harewood, Christchurch

SUMMARY

In order to compare the genetic merit of sheep from different flocks in different environments, the genetic connectedness (or linkage) between those flocks has to be adequate. Connectedness between flocks can be maintained or improved by using a common sire that has progeny with performance records in both flocks. A dendrogram was used previously by Sheep Improvement Ltd, NZ (SIL) as a tool to visualise across-flock connectedness. Due to its technical appearance, this reporting method has been found to be poorly understood. This has restricted breeder commitment to building and maintaining connectedness between flocks.

An improved and simplified reporting method for across-flock connectedness was developed (derived from dendrogram results), where a connectedness value is represented by a number from 3 to 0, strong to weak respectively. Traffic lighting — colour coding these numbers green, amber or red — is used to instantly show flocks where connectedness is weakening or is insufficient. In addition to traffic lighting, a smiley face (😐 or ☹) indicates a trend, i.e. when flocks will 'disconnect' in the future. The smiley face functions as an early warning signal to the flock manager, so action can be taken to maintain or add to that flock's connectedness in the future.

A new tool comprising the improved reporting method has been implemented by SIL. The new output format simplifies presentation of across-flock connectedness to ram breeders, and is designed to increase understanding and awareness, giving breeders more incentive to maintain or increase genetic connectedness of their flocks.

INTRODUCTION

In order to validly compare the genetic merit of animals from different flocks, genetic connectedness between these flocks has to be sufficient. Currently across-flock connectedness is already calculated, however, it has been found that numeric and graphical results from the analysis require technical knowledge to interpret and are therefore difficult to understand for many users. Specifically if multiple traits per flock are considered, it is not straightforward to get an overview of the situation. As a result, many breeders have not paid enough attention to maintaining good across-flock connectedness.

An improved reporting tool for across-flock connectedness was developed for and implemented by SIL, where a connectedness value is quantified and depicted visually by "traffic lights". This method is expected to greatly increase understanding of the across-flock connectedness analysis results.

Alongside the traffic lighting, another statistic is depicted that warns when a flock may lose connectedness in the following years. This assists bureaus and breeders in determining flocks and the traits they measure that need addressing to maintain or enhance connectedness.

This report describes the new method for presenting the results from an across-flock connectedness analysis, along with some improvements to the existing calculations of connectedness.

METHODS

The new across-flock connectedness tool is based on SAS code already in use by SIL. The following improvements to the earlier implementation were made:

1. Connectedness values are rescaled to correspond with their actual meaning (e.g. a high value corresponds to a strong connectedness);
2. Across-flock connectedness per flock and per trait is collected in a table, allowing for a compact overview;
3. Values in the table are coded to a colour (red, amber, or green), to indicate the quality of connectedness they represent (weak, adequate, or strong respectively), directing attention to flocks that need it;
4. When a flock's connectedness is adequate, but mostly from sires used in earlier years rather than recent years, it is marked with a warning sign, to flag when the flock will lose connectedness if no action is taken.

Calculating connectedness. A SAS program calculates parameters for across-flock connectedness for a trait by counting sire offspring in different flocks in the most recent years containing relevant data. Then the relative distances between flocks with respect to number of offspring from common sires is determined and the flocks are clustered according to the nearest neighbour algorithm. Connectedness per trait is defined as the distance between those clusters (Young and Newman 2009).

In the old method, all distances were normalized to the mean distance per trait by the SAS clustering procedure. This meant that the connectedness values were specific to a single trait analysis, making comparisons between traits unfair. The new implementation removes cluster normalization and this drawback.

A main cluster was defined as the cluster that held the highest number of strongly and adequately connected flocks. All other clusters then have to be connected to the main cluster in order to retain their connectedness value. This meant that although two flocks might be strongly connected to each other, unless they were connected to the main cluster, their original connectedness value would be discarded.

Rescaling. For the old method, a connectedness value was defined within a range from 0.0 to 0.5, where a value closer to 0 meant that a flock's connectedness is stronger. It has been found that this was counter-intuitive for most users, because a *high* connectedness value meant that a flock's connectedness was *weak*, and vice versa. Therefore, after calculating the connectedness values, they were rescaled so that high values meant stronger connectedness. This aims to clarify across-flock connectedness for users.

Traffic lighting. Colour coding can be used to show a reader if a result is good or bad without the need to assess the relative size of values. This practice is referred to as "traffic lighting".

For the across-flock connectedness summary, traffic lighting was applied to connectedness values. Numbers were tabulated and depicted as coloured symbols. This meant that for a trait, flocks have either a green, amber or red value, quickly highlighting strong, adequate and weak connectedness respectively.

It is worth noting that a value and colour essentially show the same information, i.e. how well the flock is connected to other flocks for a specific trait. Traffic lighting was added to further simplify the meaning of a value in the table. However, when the connectedness table is printed in black and white, it is not possible to distinguish between the colours, so numbers are the primary indicators in this situation.

Warning sign. Another feature of the new connectedness tool is the ability to flag the connectedness trend, an early warning for flocks that would lose connectedness in the later years if no action was undertaken by the breeder.

Because connectedness is calculated for a relatively short range of years, the contribution of a single year is large and can possibly skew the connectedness value. This becomes a problem when the oldest year in the range has a lot of strongly connected flocks, while the newer years in the range show a weaker connectedness per year. Overall the connectedness over a range of years

might still be adequate or even strong, but when connectedness is calculated in the future, say a year later, the oldest data is no longer included. This causes a steep (and unexpected) drop in the across-flock connectedness value.

The warning symbol in the form of a smiley face, was added to the connectedness table for flocks in danger of losing connectedness in the subsequent years. It is issued when the connectedness of the most recent years of the window are weak.

Table 1 Connectedness values are aggregated by flock and trait, providing a compact overview of the situation. Numbers in a range from 0 to 3 represent the level of current connectedness from weak to strong. Colours correspond to connectedness levels and (when colour printing is available) draw attention to flocks that need it. Smiley faces are used to warn of flocks that will have a weak connectedness in the next (☹), or year after next (😐) respectively.

Flock	Growth	Wool	Reproduction
A	3 *(g)*	3 *(g)*	2 *(y)*
B	3 *(g)*	1 *(r)*	3 😐 *(g)*
C	1 ☹ *(r)*	2 ☹ *(y)*	0 *(r)*
D	2 😐 *(y)*	3 *(g)*	2 ☹ *(y)*

(g) green, *(y)* yellow, *(r)* red – for interpretation here with grey scale printing

CONCLUSION

SIL's connectedness tool has been updated to include a simplified connectedness summary. Previously across flock connectedness was calculated and presented as a single dendrogram (graph) per trait; a fairly technical method of displaying results. This meant that several graphs had to be consulted for an overview of the connectedness across multiple traits. In addition, due to the method used to calculate connectedness, *low* values corresponded to *strong* connectedness and vice versa. This was thought to be counter-intuitive for most users.

Firstly connectedness values were aggregated for all traits in the analysis and presented in a single table, providing a compact overview. Secondly, connectedness values were rescaled so they correspond to the level of connectedness: high values for strong connectedness, and low values for weak connectedness. Lastly, traffic lighting (assigning colours to numerical values) is used to help interpret the numbers in the table, without the need to understand the underlying scale.

To give users an early warning, the connectedness trend is calculated separately and depicted by smiley faces. It shows whether connectedness will be weak in the next (☹), or year after next (😐) respectively.

It is expected that the new flock connectedness tool will increase awareness of connectedness and proactive use of link sires by ram breeders. As a consequence across-flock connectedness should strengthen, increasing the accuracy of across flock genetic evaluations.

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