Moving Towards SNP Parentage Verification

DNA parentage verification offers beef producers a tool to accurately determine animal parentage and reduce pedigree errors which may otherwise occur. This article will explore how parentage verification works, the DNA markers that are used for parentage verification, and examine the best way for beef producers to manage the transition from microsatellite to SNP parentage verification.

HOW DOES PARENTAGE VERIFICATION WORK?

DNA parentage verification works by analysing a series of DNA markers in the progeny and in potential parents. For each DNA marker, one of the two variants observed in the progeny must have come from the dam and the other from the sire. Therefore, potential parents can be ruled out if their DNA markers do not match those observed in the progeny.

In the example shown in Figure 1, the calf and dam have been genotyped, as have five candidate sires. For simplicity, five different markers (Markers A, B, C, D and E) are being used. When we examine Marker A, we can see that the calf has the genotype 'Aa', and the dam has the genotype 'aa'. In this instance, the dam must have passed on 'a' to her calf. Therefore, the 'A' must have come from the sire. Sires 1, 2, 3 and 5 could have passed on an 'A' to the calf, so are potential sires of the calf. Sire 4, having the genotype 'aa', could not have passed on an 'A' to the calf, so can be ruled out as a potential sire.

We can then repeat this process for Markers B, C, D and E. For Marker B, the calf has the genotype 'BB', so one 'B' allele must have come from the dam and the other from the sire. Of the five sires, Sires 1, 3, 4 and 5 have a 'B' which they could have passed on to the calf. Sire 2 can be ruled out. For Marker C, the sire of the calf must have passed on 'C' – once again this rules out Sire 4. Sires 2 and 4 are ruled out yet again at Marker D, where the sire of the calf must have passed on 'd'. For Marker E, the sire of the calf must have passed on 'e', which rules out Sires 1 and 5 as possible sires.

Animal	Marker A	Marker B	Marker C	Marker D	Marker E
Calf	Aa	BB	CC	dd	Ee
Dam	aa	Bb	CC	Dd	EE
Sire 1	AA ✓	Bb ✓	Cc ✓	dd ✓	EE
Sire 2	Aa ✓	bb	CC ✓	DD	ee ✓
Sire 3	Aa ✓	BB ✓	CC ✓	Dd ✓	Ee ✓
Sire 4	aa	Bb ✓	cc	DD	ee ✓
Sire 5	AA ✓	Bb ✓	Cc ✓	dd ✓	EE

Figure 1. Parentage verification compares the genotype of a calf against the genotype of its dam and candidate sires. Here, five markers are used to eliminate four of the five sire candidates as the potential sire of the calf.

Microsatellite	SNP
Animal 1: ATGCCACACAATGC	Animal 1: ATGCCACCATGCCAT
Animal 2: ATGCCACACACACAATGC	Animal 2: ATGCCTCCATGCCAT

Figure 2. There are two types of DNA markers; microsatellites (shown here as a CA repeat) and SNP (shown here as an A/T SNP).

At the end of this process, the only sire left as a potential sire candidate is Sire 3. Note that this process does not "prove" that Sire 3 is the sire of the calf; rather, it does not eliminate him as the sire. In this simple example, five markers were enough to eliminate four of the five sire candidates from contention. In real life situations, many more markers are used to for parentage verification.

DNA MARKERS USED FOR PARENTAGE VERIFICATION

The two types of DNA markers that have been used for DNA parentage verification in cattle are microsatellites and Single Nucleotide Polymorphisms (SNPs). A **microsatellite** is a repeat of a particular base pair sequence at a specific location in an animal's DNA. The number of base pair repeats can differ between animals. Figure 2 shows a CA microsatellite, where animal 1 has three repeats and animal 2 has five. **SNPs** occur where there is a difference in a single base pair. This is highlighted in Figure 2 where A is substituted for T between the animals.

Historically, microsatellites were the DNA marker used for parentage verification. However, SNPs are replacing microsatellites as the genetic marker of choice because of their greater abundance and stability. The greater abundance of markers means more markers can be included in tests, allowing them to be more powerful and accurate, while the greater stability means the test will remain accurate over many generations.

TRANSITIONING FROM MICROSATELLITE TO SNP PARENTAGE VERIFICATION

While many beef cattle societies are moving away from microsatellite parentage verification tests to the newer SNP parentage verification test, one limitation to this upgrade is that microsatellites and SNPs are incompatible. Unfortunately, microsatellite profiles **cannot** be converted to a SNP profile equivalent. Therefore, animals which require parent verification via DNA need to have the same type of DNA profile as their parents. In situations where the calf is to be parent verified using a SNP profile, and the parents only have a microsatellite profile, then the parents would need to be re-genotyped to have a SNP profile.

Let us consider the best way to manage the upgrade from microsatellite to SNP parentage verification when full parentage verification is required (both sire and dam), as outlined in Figure 3. In Year 1, all sires and dams that

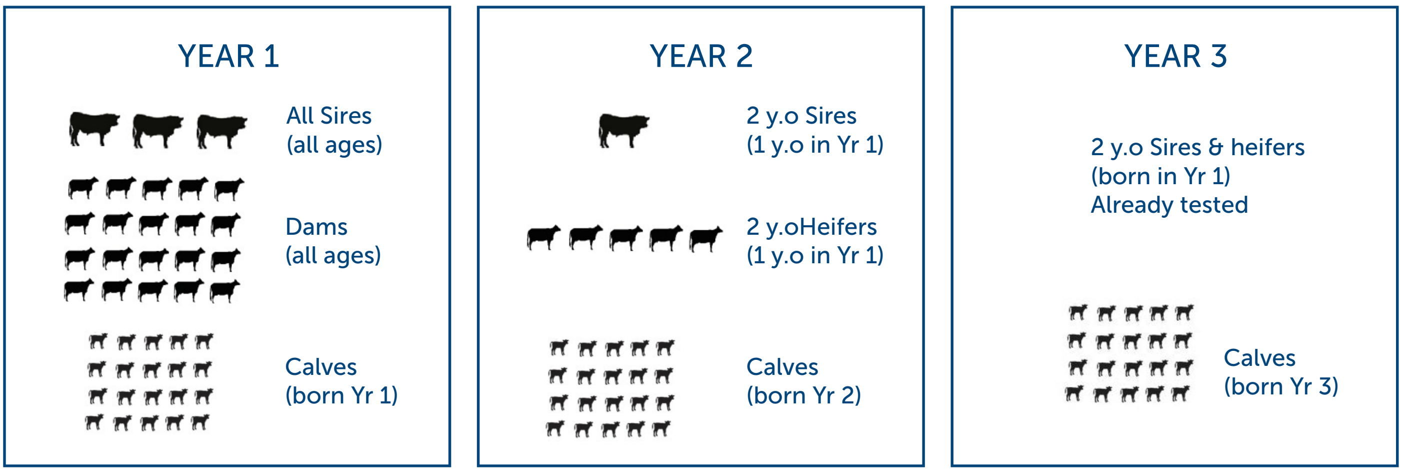

Figure 3. The upgrade from microsatellite to SNP parentage verification can be managed to reduce the number of animals that already have a microsatellite profile and will require re-testing to get a SNP profile. In this full parentage verification example, all sires and dams of the Year 1 calves are re-tested using a SNP profile, allowing the calves to be parent verified using SNP. In Year 2, the calves will have a SNP parentage verification test done, with only new sires and heifers entering the herd requiring re-testing to get a SNP profile. From Year 3 onwards, all new sires and heifers entering the herd should already have a SNP profile, so only the current drop of calves will require a SNP parentage verification test.

have calves born in the Year 1 calving drop should be re-tested using SNP, as their microsatellite profile will not be compatible with a SNP profile. Their calves could then be parent verified using SNP. In Year 2, the only parents requiring a SNP profile are the new sires and dams coming into the herd (in this case, 2 year old bulls and 2 year old replacement heifers). The calves born in Year 2 can then be parent verified using SNP, as their parents would either have a SNP profile on file from Year 1 or have been tested in Year 2. In Year 3, the 2 year old sires and replacement heifers coming into the herd were born in Year 1, and so already have a SNP profile from when they were parent verified as calves. Therefore, in Year 3 and beyond, only the new calves would need to have a SNP profile done.

Of course, not all breed societies require full parentage verification. Where only sire verification is required, a similar strategy should be employed. The only difference would be that the dams would not need to have a SNP profile taken (i.e. only sires and calves would require a SNP profile).

SUMMARY

The process of parentage verification, where a series of DNA markers are analysed in the progeny and potential parents, allows breeders to identify the most likely sire and/or dam of the animal being tested. While traditionally microsatellite markers have been used for parentage verification, the newer SNP parentage verification method provides improved accuracy and stability. In the upgrade from microsatellite to SNP parentage verification, some animals that have previously been tested via a microsatellite profile will need to be re-tested using a SNP profile. However, this can be managed effectively to reduce the number of animals that already have a microsatellite profile and require re-testing to get a SNP profile.

Should you have any questions on parentage verification, or wish to discuss transitioning from microsatellite to SNP parentage verification, please contact staff at SBTS or TBTS.

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March 2018

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