Does it really matter that bison have cattle genes?

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While there are many arguments on both sides of the issue, all of which will be addressed below, whether it really matters will boil down to your own personal beliefs and values, more so than science. However, before addressing moral and ethical values, there are a variety of erroneous myths and untruths that are factually incorrect, as well as hypocritical beliefs, which need to be addressed and dismissed.

There have been erroneous claims and misunderstandings that the cattle markers being detected are ancient DNA from before modern bison crossed the Bering Strait. After all, ancient bison (Stepp) did hybridize (breed) with ancient cattle (Auroch) [20, 21], as well as the Yak [26]. However, the markers (alleles) being detected are unique to modern-day cattle and not associated or have anything to do with so called "ancient" evolutionary genes [18, 3]. Suggestions to the contrary represent misinformation and are erroneous and will not be discussed further.

Similarly there is an argument that introgression, hybridization, interbreeding and admixture are all natural evolutionary events and thus the bison-cattle introgressions that occurred was just a normal evolutionary process. There is a big difference between natural introgressions (natural selection) and those deliberately caused or created by humans. This was not natural selection, but rather artificial (man) selection, in which humans intervened and created unnatural hybrids. While artificial selection is useful in producing beneficial traits favored by humans, studies have shown that natural selection favors diversity and a greater ability to adapt to changing environments [19]. The argument that cattle-bison introgressions that occurred in the early 1900's were a normal evolutionary process is simply erroneous.

By definition, animals with evidence of introgression are hybrids of the original species and the US Code of Federal Regulations defines Catalo or Cattalo as "*any hybrid animal with American bison appearance resulting from direct crossbreeding of American bison and cattle*" [17]. It is hypocritical to condemn crossing bison with other animal species, within the code of ethics of all bison associations [1], while at the same time excusing such acts in the past by accepting

HIGHLIGHTS

- Cattle markers (alleles) detected within the genome or mitochondria of bison are not associated with ancient evolutionary DNA but are unique to modern-day cattle.
- Cattle markers in bison are not a reflection of a normal evolutionary process or natural selection but artificial (man-made) selection.
- Cattle markers being detected by current DNA methods are not genes and do not reflect the amount of cattle genes in the animal.
- Bison introgression tests only identify that introgression has occurred and the animal is a hybrid.
- Except for small isolated closed herds, all studies have shown that modern bison have good and healthy genetic diversity.
- There is no evidence that reduced diversity has had a detrimental effect on the bison population.
- There is no evidence that cattle genes within bison (as detected by DNA markers) are beneficial.
- All studies have shown that bison with evidence of cattle introgression have reduced weight gains and size as compared to animals without evidence of introgression.
- By definition, bison with evidence of cattle introgression are bison-cattle hybrids.

animals with evidence of cattle introgression. By definition, bison with evidence of cattle introgression are unnatural hybrids.

Because of the bottleneck that occurred in the early 1900's, modern day bison can be traced back to a few small foundation herds comprising a total of about 30 bison, maybe 50 at most. The Pablo-Allard herd in Montana had its foundation in 4 buffalo calves started by Walking Coyote; the Charles Goodnight herd in Texas was started with 5 captured animals; James "Scotty" Phillips herd in South Dakota had its origin in 5 animals of the Dupree herd; the Charles Alloway and James McKay herd in Canada also started with 5 animals; the Charles "Buffalo" Jones herd in Kansas may have stared with as many as 18 animals (although they may have come from the other private herds and not the wild); and there were 23 bison left in Yellowstone [8]. This assumes that all these bison were not related. Hence, the modern day North American bison, in private and public herds combined, has a very small gene pool and there is justifiable concern about the limited genetic diversity within the bison population. This has led to the argument that genetic diversity (created by cattle introgressions) is more important than genetic purity [10]. While a valid argument, except for a few instances in tightly closed herds with extensive inbreeding [9], there is no evidence that the reduced diversity has had a detrimental effect on the bison population.

Genetic diversity is the total number of genetic differences within a species and serves as a way for populations to adapt to changing environments [24]. Maintaining diversity gives the population a buffer against change, providing the genetic flexibility to evolve and adapt to changing conditions. When a genetic bottleneck occurs and results in a population with a low number of individuals, as is known to have occurred with the bison population, there is a rapid decrease in genetic diversity. Even with an increase in population size, the genetic diversity often continues to be low if the entire species began with a small population, since **beneficial mutations** are rare, and the gene pool is limited by the small starting population.

As previously noted, although a valid argument and bona fide concern exists for the relative low genetic diversity, there is no evidence that the reduced diversity has had a detrimental effect on the bison population. In fact, despite the bottleneck, all studies to date have shown relatively high and healthy levels of genetic diversity within the bison population as compared with other large mammals [7, 12]. This argument is invalid.

If concerned about diversity in your herd, diversity in bison can be defined by determining variability within nuclear microsatellites. Such services are available through Texas A&M [23] and University of California-Davis [4] and these services have shown a surprising amount of diversity within the bison population.

Creating man-made hybrids and/or condoning such acts by repeated breeding of the resulting hybrids are generally frowned upon and are not generally considered appropriate to increasing genetic diversity [22]. Such hybrids are considered to be genetically polluted and produce a new species rather than rescue the endangered one. Hybridization (introgression) and the continued breeding of the resulting hybrids drives species to extinction whereby the original species is replaced by hybrids [22].

The suggestion that "*genetic purity is less important than genetic variability*" as a beneficial aspect of cattle introgression is inherently flawed as is the suggestion that "*detectable cattle ancestry at low levels have important genetic value and contain unique genetic variation that is absent from Yellowstone or other conservation herds with no molecular evidence of cattle ancestry*" [6].

The purpose of species conservation is just that - conserving the species, not altering the species through hybridization and then claiming that the destruction of the species through hybridization is somehow essential to its "conservation."

There is also the argument that these cattle genes could be beneficial to the survival of the bison population. Perhaps these genes will confer greater resistance to disease and/or parasites such as *Haemonchus*. This is another unfounded suggestion - there is no evidence that the presences of cattle genes (or markers) are beneficial and there is an equal probability that these genes are detrimental. After all, bison-cattle introgression was performed to improve cattle not to improve bison. Contrary to unfounded speculation about beneficial effects of cattle genes, there is evidence that these genes are detrimental to bison, at least in terms of meat production. Studies have shown that bison with bovine-type markers or bovine mtDNA have reduced weight gains and reduced size as compared to bison without evidence of introgression [5, 14].

Equally erroneous is the suggestion that we must accept what history has left us with, i.e., cattle genes in the bison. History provided us with bison and bison-cattle hybrids (bison with evidence of cattle introgression) and a choice. It has been our choice to propagate the cattle genes or make our best effort to limit their spread.

There is also the unfounded suggestion that the detrimental effects of cattle genes are only associated with mtDNA and not nuclear DNA markers. Although diminished weight gains have been mostly associated with bovine-type mtDNA [5], there is no evidence that it is actually the mtDNA that is having the detrimental effects – the female bovine did not just pass her mtDNA to her offspring but a host of other bovine genes that are just as likely to be the cause. This is dangerous, and an erroneous extrapolation, to suggest that these microsatellites and mtDNA are genes rather than markers of bison-cattle introgression. Association is not the same as causation and only association has been demonstrated.

The detection of cattle-associated microsatellites and/or bovine-type mtDNA is not a reflection of the amount of cattle genes, only that introgression has occurred and the animal is a hybrid.

It must be assumed, until there is evidence to the contrary, that the demonstrated detrimental effects on growth rates are associated with cattle introgression and not just a particular marker, e.g., mtDNA. Getting rid of the marker (offspring of a breeding a bull with bovine-type mtDNA) is not getting rid of the cattle genes; it is just masking the presence of cattle introgression based on our limited ability to detect such.

There is also the unfounded argument that we do not know what a "pure" bison is and we should wait till we know more. While it is true that we may not know genetically what "pure" bison is, we do know what is not; i.e., having modern-day cattle genes. It is irresponsible to do nothing and allow further pollution of the bison genome, just because we may not know what pure bison is. This is an unfounded and irrational argument.

There is also the "What if" argument. What if these genes are beneficial? What if these genes are actually normal? And a host of other "What if" and "Maybe" scenarios. These "what if's" and "maybe's" are simply hypotheticals and imaginary possibilities that are unfounded in fact. Since there are endless hypothetical possibilities, all of which are unsubstantiated, they will not be considered or addressed. Thus any "what if" or "maybe" arguments are unequivocally dismissed without further consideration.

Lastly is the erroneous suggestion that you can breed-out the cattle genes. Logic will tell you that, as mention in previous articles, if Neanderthal and Denisovan DNA exist in humans after 100,000 years, can you rationally expect cattle genes to disappear from bison in 100 years? There are ways you can hide and mask the currently known markers, like in prior examples breeding a bull with cattle-type mtDNA, but you are not getting rid of the cattle genes themselves. Doing this knowingly, breeding an introgressed bull and claiming his offspring are cattle-gene free, is unethical to say the least. Suggesting to others that the cattle genes can be bred-out is also unethical as the claim is inherently false, misleading, and promotes the spread of cattle genes.

All that being said, how does it relate to personal beliefs and values?

This is as complex and as convoluted as the above with various arguments, beliefs, and hypocrisies to support the position.

Many of the opinions expressed are based on abductive reasoning: "*If it looks like a bison, walks like a bison, and tastes like a bison, then it probably is a bison whether or not it has cattle genes (markers), and that's good enough for me*". This abductive reasoning is based on assumptions and hypocrisy. Even the original cattalo breeders noted that the hybrids could not be distinguished from pure bison. Since there are no studies comparing the taste of meat from "pure" bison as opposed to genetically polluted bison, it is being assumed that they taste the same. Do Herefords, Angus, and Charolais all taste the same? More important is the hypocrisy in this view.

Most frown upon the "white" or blond bison and call them beefalo simply because of their color, presumably the result of the Charolais SILV gene. Except for the color, many of these animals look exactly like bison, walk and act like bison, and probably taste like bison. Many have no evidence of cattle nuclear or mitochondrial markers. Is it not hypocrisy to condemn an animal that has overt signs of cattle introgression (coat color) while ignoring and accepting those that have genetic evidence of cattle introgression? How can you condemn one and not the other? Is a "white" bison any more genetically polluted than a brown bison with nuclear and/or mitochondrial cattle markers? These are the questions you must ask yourself when thinking about cattle introgression in bison and the presence of cattle markers.

Genetically we have essentially eliminated the Wood bison (*Bison bison athabascae)* and the Plains bison (*Bison bison bison*) as there no longer appears to be enough genetic differences between the Wood and Plains bison to warrant their subspecies status [3, 25]. This was accomplished by the crossing of the Wood bison in Canada with the Plains bison of the Pablo-Allard herd and the crossing of the Yellowstone Wood bison with the Pablo-Allard and Goodnight Plains bison [11]. Although this cross-breeding was apparently done to save the bison, it nevertheless genetically eliminated the wood bison population and created the Plains-Woods genetic hybrids of today. Are we going to do the same to the entire North American bison population through the propagation of cattle genes and be left with bison-cattle hybrids?

At the current rate and general "who cares" views which have dominated most of the bison industry over the past 25+ years, it will only be a matter of time before the presence of cattle genes and markers in bison will have little meaning <u>because all bison will be genetically polluted with cattle genes</u>, if they are not already. Then the true North American Bison will be genetically extinct and only hybrids will exist.

It is hypocrisy to ignore the presence of cattle introgression (makers, alleles, or whatever you choose to call them) and knowingly or unknowingly breed these animals and then state that "*We would*

never knowingly breed down, or away from bison" and that "*We will continue to do our part, while we wait for science to have more facts, and breed bison to bison, only*!" [2]. Breeding hybrids (bison with evidence of introgression) is certainly "*breed(ing) down (and) away from bison"* and is not breeding "*bison to bison, only!"*

Even if new NGS sequencing methods [27] show that all bison have been polluted with cattle genes, do you continue to further erode the bison genome or do we try to limit further erosion and genetic pollution? That is our choice. On our current path ("see no evil, hear no evil, speak no evil" and "turning a blind eye") of ignoring and/or accepting the problem of introgression, it is only a matter of time before the true North American Bison will be genetically extinct and only hybrids will exist.

Genetic purity or pollution should not matter to the producer only interested in meat production. The commercial dairy or beef farmer could care less if their animals are pure bred or if they have a little bit of something else in its DNA as long as it a good milk or meat producer. Most people know that when they buy Angus beef at the supermarket that these are not all registered pure Angus but black cattle that look like Angus. By the same token, commercial bison meat rancher shouldn't care if there are a few remnant cattle genes as long as his animals produce quality meat. As long as you are raising meat animals, cattle introgression genes should be of no concern.

Thus, if you are solely a bison meat producer, this entire series is irrelevant and has no meaning. Moreover, a meat producer with no regard for bison purity should not be selling breeding stock or claim to be a steward of the bison or maintaining a bison conservation herd. Neither of the latter are consistent with meat production.

However, when it comes to breeding animals, is it appropriate and ethical to further pollute the bison genome and cause genetic drift, erosion and possible genetic extinction? Is it not the obligation of a responsible breeder to only **breed** to improve the **breed** in which they are breeding, and to emphasize conservation and species integrity?

The introgression of genes into a population through hybridization is a substantial issue for conservation, specifically when attempting to maintain the genetic integrity of a species. There is general agreement that there is a moral obligation and ethical duty to preserve the genetic integrity of species [16, 5]. In this era of genetics and conservation genomics [15, 13], it is hypocrisy to suggest stewardship of the North American Bison and/or maintain a bison conservation herd while promoting the propagation of cattle genes and genetic pollution within the bison population, either consciously, by ignoring the problem, or by simply not caring.

The questions that one needs to address include:

1. Does it matter if all bison are hybrids with genetic pollution and cattle genes (i.e., actually bison-cattle hybrids regardless of the amount of cattle genes present)?

2. Can an individual, either knowingly or unknowingly by disregard, that propagates cattle genes within the bison population and contributes to the genetic pollution of the species, be considered a steward of the North American bison?

3. Can a bison herd be considered a conservation herd when the animals in the herd are genetically polluted with cattle genes (hybrids) and introgressions are being propagated?

4. Is a white or blond bison with no cattle markers any less of a bison then a brown bison with cattle markers and genes?

5. Do you make the minimum effort to insure that breeding bulls do not have any cattle introgression markers?

6. Do you sell breeding animals, particularly to new ranchers, that are known or are unknown to have cattle introgression markers and genes?

7. Are you contributing to the spread of cattle genes and genetic pollution within the bison population?

Only you can answer these questions and decide, based on your own personal views and values, whether or not the presence or absence of cattle genes is important to your own operation and/or to the bison population at large.

In the author's opinion, at an absolute minimum even for meat producers, breeding bulls should be tested for cattle introgression genes and only bison without cattle markers or bovine mtDNA should be used as breeding bulls. Likewise, no breeding bulls should be offered for sale without having them tested and verified to be free of nuclear introgression markers and have bison-type mitochondrial DNA. Failure to do the bare minimum contributes to the further erosion of the bison genome and promotes the establishment of bison hybrids as the dominant species of the North American bison.

It is completely up to you and your own personal views and values whether you believe this is an issue and whether or not you wish to be part of the problem or the solution.

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Finding and maintaining genetically pure bison.
There is no easy way to locate bison without evidence of cattle introgression.

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Understanding Bison-Cattle Introgression
How Introgression is detected

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