Conclusions over chromosome disorders

Author: SARA PEDERSEN

Categories: Vets

Date: October 14, 2013

THROUGHOUT veterinary college you are always taught “common things are common” – and, most of the time, this is true. However, once in a while it isn’t the case. When rare conditions come along, they always bring a flurry of interest within the practice and usually involve a lot of literature searching.

I was called by a sheep client who had a problem with one of her pedigree Shropshire ewe lambs (Figure 1). She was concerned as it appeared to be prolapsing through its vulva and wasn’t urinating normally.

With my “common things are common” approach, I was considering differentials such as cystitis, urethritis or a vulva infection, but I was in for a surprise.

On examination, all the ewe lamb’s clinical parameters were normal, although it was in obvious discomfort around its perineum, with intermittent tail flicking. Its urethral opening was enlarged, although on palpation, there was no apparent discomfort or pain (Figure 2).

Closer examination of the area revealed the ewe lamb had fly strike. I grabbed my clippers and started to shear it, but got a bit of a shock when I turned it over as situated under what the owner had presumed to be a developing udder was a very small pair of testicles (Figure 3).

It was probable the testicular hypoplasia and abnormal vulva anatomy were linked.

Top of the list of possibilities was either a chromosomal disorder resulting in a sex karyotype of XXY – also known as Klinefelter’s syndrome – or a form of chimerism resulting in both XX and XY cell populations.

Unfortunately, I have not been able to confirm this, as I’ve been unable to locate a laboratory to carry out sex karyotyping. However, either way it was a different start to the week.
This case prompted me to look further into chromosomal disorders in sheep and cattle – which ones occur and how common are they? (Table 1). Surprisingly, a number of cases are reported in the literature, however, the majority of these are in cattle.

Cattle have 60 chromosomes – 29 pairs of autosomes and one pair of sex chromosomes. While numerical or translocation problems of the autosomal chromosomes occur comparatively more frequently, problems with the sex chromosomes are possible.

These are not usually lethal to the developing embryo, but do result in infertility or subfertility.

Too few sex chromosomes

The only instance when a sex chromosomal disorder is lethal is when a male fetus inherits a Y chromosome from the sire, but no X chromosome from the dam (YO), in which case the calf is aborted. Since the X chromosome is the larger of the two sex chromosomes and carries many essential genes for survival, an embryo cannot develop without one.

When the opposite occurs and an X chromosome is inherited from the dam, but no X or Y from the sire, the calf is viable, but will be sterile. Such animals are referred to as having Turner’s syndrome (XO). They will have a normal female phenotype, but the internal genitalia will not be properly formed and thus the heifer will never ovulate.

Too many sex chromosomes

As well as a sex chromosome being absent, in some instances there may be an additional chromosome present. This is due to non-disjunction of the sex chromosomes during meiosis.

A bull that inherits two X chromosomes from its dam and a Y from its sire has the karyotype XXY, known as Klinefelter’s syndrome. They usually have a male phenotype, but are infertile due to testicular hypoplasia and azoospermia, despite a good libido (Dunn et al, 1980). Germ cell transplantation, as a way of initiating spermatogenesis in affected bulls, has proved unsuccessful (Joerg et al, 2003).

When a heifer calf inherits XX from its dam and another X from its sire, it is referred to as trisomy X, with a karyotype of XXX. Although there are few reports of the fertility performance of these individuals, one case is documented to have had normal female but Klinefelter male offspring (Schmutz et al, 1994).

There is also speculation as to whether trisomy X individuals have a higher than average abortion rate, however, there is a lack of evidence to suggest whether this is the case.
Chimeras

If you read a lot of stories about mythical beasts, you may think a chimera is a fire-breathing creature with a lion’s head, a goat’s body and a serpent’s tail.

However, in the real world it is a term applied to individuals that have two genetically distinct cell populations, which originated from one or more zygotes. This occurs rarely in species other than cattle, in which it is a very frequent occurrence in heifers born cotwin to a bull (Figure 4).

In these cases, the heifer is almost always a chimera (approximately 11 in 12), more frequently known as a freemartin. These heifers have normal external genitalia, although this is usually immature, but an abnormal internal genital tract and are thus sterile.

The degree of abnormality varies, however, typically the vagina is very short and the uterine horns very small and ovaries hypoplastic. In contrast, the male twin remains relatively unaffected, although its testicular size may be lower than average, which can lead to reduced sperm output and fertility.

Freemartinism occurs due to the vascular connections that form between the placentae of the developing twin calves, which allow the passage of male hormones and some cellular material to the female calf.

The male hormones – specifically, müllerian inhibiting factor – inhibit the development of the female reproductive organs and result in varying degrees of masculinisation of the reproductive tract. However, chimeras don’t have to be XX/XY as an XY/XYY Japanese black bull has been reported (Hanada and Muramatsu, 1981), as has an XX/XXY Holstein heifer (Meinecke et al, 2007).

In contrast to cattle, the formation of a chimera in sheep is relatively rare, with a study in Rideau Arcott sheep finding only one in 25 lambs were XX/XY chimeras (Brace et al, 2008).

However, if you combine a sheep embryo with a goat embryo to produce a “geep”, these will always be chimeras and often the chimerism is evident. For example, some areas will be covered in wool and others in hair, rather than a combination of the two.

Summary

Although I have yet to find out the reason behind the hermaphrodite appearance of my “ewe” lamb, it shows just because these conditions are very rare, they sometimes pop up when you are not expecting it. However, whatever the cause, I have been informed it made some great lamb chops.
References

Figure 1. The pedigree Shropshire ewe lamb presenting with abnormal urination.
Figure 2. Abnormal vulval region.
Figure 3. The small pair of testicles palpable.
Figure 4. A heifer born co-twin to a bull is almost always a chimera and usually sterile.
<table>
<thead>
<tr>
<th>Combination</th>
<th>Syndrome</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>XO</td>
<td>Turner’s syndrome</td>
<td>Infertile Normal female phenotype</td>
</tr>
<tr>
<td>YO</td>
<td>–</td>
<td>Non-viable – abortion</td>
</tr>
<tr>
<td>XXY</td>
<td>Klinefelter’s syndrome</td>
<td>Infertile Testicular hypoplasia</td>
</tr>
<tr>
<td>XXX</td>
<td>Trisomy X</td>
<td>Some cases reported to be fertile Have XXY male offspring</td>
</tr>
<tr>
<td>XYY</td>
<td>–</td>
<td>Infertile Male phenotype</td>
</tr>
</tbody>
</table>

**TABLE 1.** Sex chromosomal disorders