Thermoregulation

and the impact of **SCROTAL TWIST** on fertility in Santa Gertrudis bulls

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1. Introduction

Fertility is one of the most economically important traits in beef production, and the bull contributes half of every calf crop. Because of this, anything that interferes with a bull's reproductive function can have major consequences for herd productivity. One of the most overlooked factors affecting bull fertility is thermoregulation—the ability of the testes to stay cooler than the rest of the body. Another is scrotal twist, a condition that disrupts normal testicular positioning and blood flow. This review explains how bulls regulate testicular temperature, why heat stress reduces fertility, and how scrotal twist interferes with both thermoregulation and semen quality.

2. Testicular thermoregulation in bulls

Thermoregulation of the testis in bulls is unique because they must remain about 2–6°C cooler than the core body temperature to ensure normal sperm production. Bulls use several mechanisms to cool the testis. Spermatogenesis, or sperm production, is a complex process in bulls that takes about 61 days and involves several stages of cellular division and differentiation to produce mature, fertile spermatozoa. Previous studies have confirmed that small increases in testicular temperature may adversely affect sperm cells, though the effects on sperm motility and fertility remain unclear. Heat stress has been shown to affect bull fertility for weeks, as it requires a full spermatogenesis cycle (ca. 61 days) to replace damaged spermatozoa.

3. Testicular cooling mechanisms

a) Scrotal Skin and Sweating

The scrotum has thin skin and a high density of sweat glands. Evaporation from this surface is the bull's most effective cooling method, especially in hot, dry climates.

b) Muscular Control

Two muscles regulate testicular position, namely the cremaster muscle, which lifts or lowers the testes, and the tunica dartos muscle, which wrinkles or relaxes the scrotal skin. Relaxation increases surface area and airflow, which significantly improves heat loss.

c) Pampiniform venous plexus

This specialized network of arteries and veins acts as a countercurrent heat exchanger, which functions much like a refrigerator. Warm arterial blood entering the testis is cooled by venous blood returning from the scrotum. This system is essential for maintaining the temperature gradient required for spermatogenesis.

d) Behavioral Adjustments

Bulls generally use a number of natural behaviour's

to adjust and reduce heat load, such as increasing water intake, seeking shade, standing rather than lying, grazing at night, and using seasonal changes in hair and coat characteristics (hair shedding in spring and summer).

4. Heat Stress and Its Effects on Fertility

The general perception is that heat stress is due to high ambient temperatures. However, the most harmful effects of heat stress are mostly due to environments with high ambient temperatures and high humidity, because evapotranspiration becomes increasingly ineffective as humidity increases.

When ambient temperature and humidity exceed a bull's ability to dissipate heat, testicular temperature rises. The effects of such thermal stressful conditions on fertility are so harmful because a cascade of physiological processes are usually affected, for example, sperm motility and concentration are reduced, sperm abnormalities increase, and many bulls become temporarily infertile for 6–8 weeks.

Heat stress also affects the epididymis, where sperm mature and are stored. Even fully formed sperm can be damaged by elevated scrotal temperatures. Bulls with dark hides, heavy muscling, or Bos taurus genetics are generally more susceptible to heat stress than heat-adapted breeds, like the Santa Gertrudis.

5. Understanding Scrotal Twist in Beef Bulls

Scrotal twist, or testicular rotation or torsion, occurs when the testis rotates around the spermatic cord. Rotation may vary between mild (≤180°), moderate (180–360°), and severe (>360°). The impact of testicular rotation on bulls' fertility is somewhat controversial, but even mild rotation can interfere with normal thermoregulation. Although mild cases of testicular rotation are chronic, they are not acutely painful, and bulls are not infertile. (Examples of scrotal twist are presented in the photos below)

By contrast, moderate and severe torsion disrupts venous return and cooling (thermoregulation), and such bulls tend to experience pain, low semen quality, or, in severe cases, are infertile.

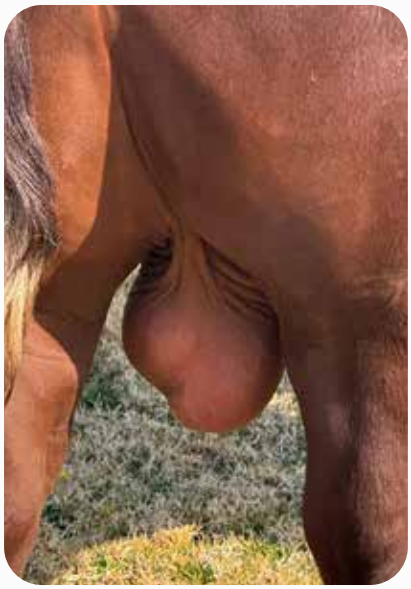
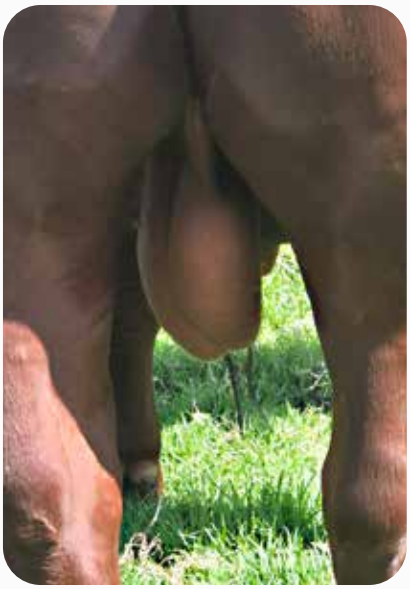


Photo credit: Dr P van Rooyen



Regardless of the severity of scrotal rotation, such bulls should not be used in breeding programs because it is unwise to capture such hereditary defects in sustainable production systems. Mild, chronic scrotal rotation is more common than producers realize, because it often goes unnoticed until a breeding soundness exam reveals reduced semen quality or sperm defects.

6. The effects of scrotal twist on testicular thermoregulation

The main effect of scrotal twist on testicular thermoregulation is by distortion of the pampiniform venous plexus, e.g., compromising the normal functioning of the vascular cooling system of the testes. Scrotal rotation alters the

alignment of the arterial and venous capillaries responsible for heat exchange between the core of the body and the testes. Secondly, scrotal twist alters the anatomical position and orientation of the testes. This positions the testes higher in the scrotum, causing an abnormal testicular angle, reduced smooth muscle function, and reduced airflow exposure and limits cooling through convection and evaporation.

A scrotal twist also compromises the vascular blood flow to the testes and lymphatic drainage. Moderate to severe rotation has been shown to partially obstruct venous drainage and lymphatic return. This leads to congestion, inflammation, heat retention, and pathological damage to the testicular epithelium and the functioning of Sertoli and Leydig cells.

Collectively, these effects mentioned above reduce cooling efficiency and increase testicular temperature. Research shows that even partial rotation can raise intratesticular temperature by 1–3°C, enough to impair sperm production and fertility.

7. Effects of scrotal twist on semen quality

A scrotal twist may cause one or several semen defects, such as lower sperm concentration, reduced semen motility, sperm abnormalities, and, in severe cases, permanent infertility.

- **Lower Sperm Concentration:** Chronic rotation reduces daily sperm output and epididymal storage due to both thermal injury and impaired blood flow.
- **Reduced Motility:** Heat-induced damage to sperm mitochondria and tail structures leads to lower progressive motility and reduced fertilizing ability. Typically, motility declines appear **2–4 weeks** after the thermal insult.
- **Increased Abnormal Morphology:** Common sperm defects include:
    - Proximal and distal droplets
    - Pyriform heads
    - Coiled or bent tails

  These abnormalities reflect disrupted spermatogenesis and epididymal dysfunction.
- **Risk of Permanent Infertility:** Long-standing or severe torsion may cause fibrosis, testicular atrophy, and irreversible loss of fertility.

8. What producers should watch for

Signs of scrotal twist in breeding bulls may include scrotal defects ranging from mildly tilted to severely rotated testes. It may be more difficult to identify the mild cases and quite challenging to cull animals from genetically ‘superior’ lines. Bulls with testes positioned higher than normal should be examined more thoroughly, as well as those exhibiting scrotal swelling or firmness, or with low BSE scores. Any bull with an abnormal testicular orientation should be evaluated by a veterinarian.

9. Practical Recommendations

It is recommended that all bulls intended for breeding should be examined by means of a breeding soundness examination (BSE). This should include an evaluation of the scrotal orientation, testicular mobility, and symmetry, and semen analysis. Breeding bulls should be monitored for reduced libido or discomfort, especially bulls where scrotal rotation was diagnosed.

10. Conclusion

Thermoregulation is essential for bull fertility, and any condition that elevates testicular temperature—including scrotal twist—can significantly reduce semen quality and pregnancy rates. Even mild rotation disrupts the pampiniform plexus and scrotal positioning, impairing heat exchange. Early detection and management are critical to maintaining herd reproductive performance.

References (Popular Scientific Format)

Barth, A. D. (2013). *Bull Breeding Soundness Evaluation Manual.* Society for Theriogenology. Brito, L. F. C., et al. (2004). Effects of scrotal insulation on testicular temperature and semen quality. *Theriogenology.* Chenoweth, P. J. (2005). Reproductive disorders in the bull. *Theriogenology.* Coulter, G. H., & Kozub, G. C. (1989). Testicular thermoregulation in bulls. *Canadian Journal of Animal Science.* Hahn, G. L. (1999). Dynamic responses of cattle to thermal stress. *Journal of Animal Science.* Kastelic, J. P., et al. (1996). Testicular thermoregulation and effects of heat stress on spermatogenesis. *Animal Reproduction Science.* Rao, T. K. S., et al. (2011). Testicular torsion and its effects on blood flow and fertility.