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Autosomal Trisomy in a Heifer

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Mäkinen, Auli, Ilkka Alitalo and Matti Alanko: Autosomal Trisomy in a Heifer. Acta vet. scand. 1987, 28, 1–8. – A malformed Ayrshire heifer had one additional autosome in all the lymphocyte metaphases studied. Chromosome banding techniques showed the karyotype of the calf to be 2n = 61, XX, +24.
Slight prognathia of the lower jaw and peculiar abbrevations in the structure of the genitals were the most apparent anomalies, in addition to heart abnormalities, a poorly-closed urachus and slow growth rate.

autosomal trisomy; congenital malformations; chromosome banding analysis.

Introduction

Evidence that chromosome alterations cause developmental defects in cattle is sparse. Cytogenetic studies of abnormal phenotypes in cattle are few compared with humans (*Alberman & Creasy* 1977, *Fechheimer* 1979, *Gustavsson* 1980a, *Chandley* 1981, *Rieck* 1984).
The development of chromosome banding techniques in 1970 (*Gustavsson* 1980b) has helped resolve the role of chromosome alternations in congenital abnormalities in cattle.

Material and methods

A female Ayrshire calf from a dairy farm in eastern Finland was remitted to the College of Veterinary Medicine by the local veterinarian, because of its small size and abnormal appearance. The weight of the calf was monitored weekly from the age of 7 months to 10 months. The tubular bones of the limbs and skull were radiographed at 7, 9 and 12 months. Clinical examinations were made weekly. Monthly laboratory studies were made on blood; Hb, Hkr and leucocyte counts were taken and serum ASAT, ALAT, AFOS and electrolytes were measured. The heifer died suddenly at the age of 12 months. A necropsy was performed. The genital organs were examined both macroscopically and histologically.
Blood samples for chromosome analysis were taken from both parents, a first-calving mother and an AI-bull, as well as from the calf.
The chromosomes were studied by the standard blood culture method of *Gustavsson et al.* (1983) and were identified by the GTG (*Seabright* 1971) and RBA (*Dutrillaux et al.* 1973) banding techniques. The amount and distribution of constitutive heterochromatin was analysed by the CBG technique of *Sumner* (1972).
The chromosomes were arranged into karyotypes according to the international standard karyotype for cattle (*Proceeding of the*

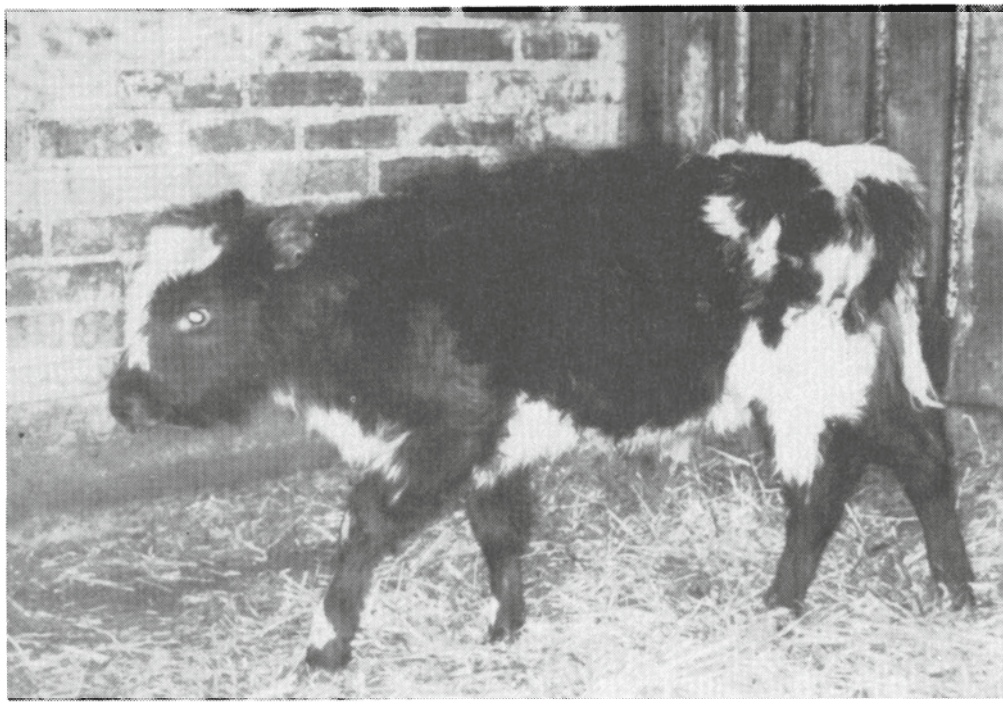

Figure 1. The trisomic calf at the age of 6 months.

First International Conference for the Standardization of Banded Karyotypes of Domestic Animals, Reading, England 1980). We also used the landmark system for GTG-banded chromosomes proposed by *Lin et al.* (1977) and followed the identifying features of RBA-banded chromosomes presented by *Di Berardino & Iannuzzi* (1982) and *Di Berardino et al.* (1985).

Results

Clinical findings

The calf was small throughout its life compared with animals of the same age (Fig. 1). Its lower jaw was about 2 cm longer than the upper jaw (prognathia inferior). Its coat was long-haired and of poor quality during the first 5 months of life, but then became normal. The calf had a small umbilical hernia, which persisted through all its life. Growth rate is shown in Figure 4. At the age of 8 months symptoms of indigestion were noted; is showed mild tympany and signs of pain which were reversed by medication. The heifer died suddenly at the age of 12 months. Prior to death mild tympany and sluggishness were seen.

Radiological findings

Radiography failed to show any pathological condition either in the bones or in the growth cartilages. In the skull, the mandibular bone was longer than the maxillar bone as mentioned above.

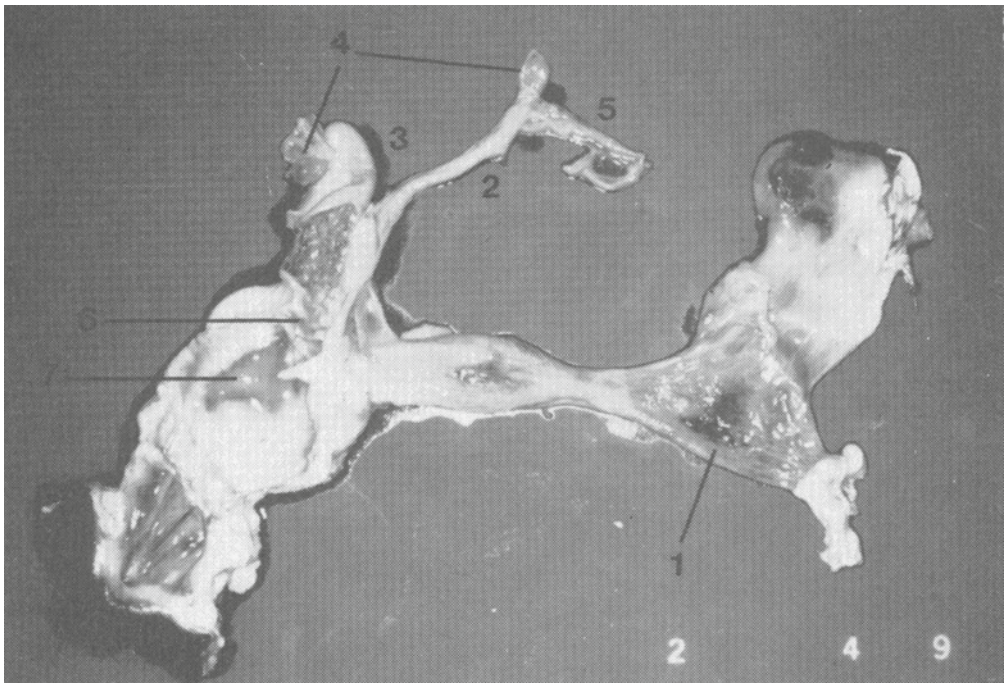

Figure 2. Urinary and genital tract of a heifer with autosomal trisomy. The urachus was partly open and the section concomitant to the urinary bladder was greatly distended with a very thin wall. This had ruptured about 5 cm away from the urinary bladder (1). The right uterine horn (2) was only a rudimentary cord of connective tissue. The left uterine horn (3) was short but normal in shape and structure. Ovaries (4), right oviduct (5), poorly developed cervix (6), distended vagine (7).

Laboratory findings

The blood haemoglobin value varied between 8.4 and 8.7 g/100 ml and the hematocrit value was 27–28 %. All other laboratory parameters corresponded to the reference values.

Necropsy findings and gynaecological examination

The heart. The only pathological finding outside the urinary and genital tract was in the heart, where a persistent foramen ovale and an incomplete interventricular septum were seen.

Urinary tract. The urachus was partly open and the section concomitant to the urinary bladder was greatly distended with a very thin wall. This had ruptured about 5 cm away from the urinary bladder (Fig. 2). The rupture hole was 3 cm in diameter. About 10 litres of urinous liquid were found in the abdominal cavity thus making clear the sudden death of the heifer.

Genital organs (Fig. 2). The vagina was short but greatly distended, especially at the cervical end. The cervix was poorly developed with a thin but complete cervical canal

of normal patency. The right uterine horn was only a rudimentary cord of connective tissue. The adjacent tube was of almost normal appearance but small and flaccid. The right ovary was small and rudimentary with two small follicles, 0,4 and 0,6 cm. The left uterine horn was short (12 cm) but normal in shape and structure. Histology showed an atrophic mucosa with small rudimentary uterine glands. The left uterine tube was missing, only a thin connective tissue cord represented the tubal rudiments. The left ovary was about 1 × 1.5 cm in size. It had one visible follicle, 0.9 cm in diameter. Histology showed that there were also several small, atretic follicles.

Chromosome studies

The chromosomes were analysed with GTG and RBA banding techniques and in all the lymphocytes studied, the 2n = 61, XX chromosome complement was found. The extra chromosome was a small autosome, number 24. Hence, the calf had a 2n = 61, XX +24 karyotype (Fig. 3). The constitutive heterochromatin identified by CBG staining was constant; the centromeric regions of the acrocentric autosomes were darkly stained and the submetacentric X chromosomes had no clear banding patterns.

Both parents had normal cattle karyotypes. Hence, the trisomy was established as a *de novo* chromosome rearrangement.

The trisomic calf was the first offspring of the 2-year-old female parent. The gestation age was normal. The male parent had no record of malformed progeny.

The birth weight of the calf is unknown, but it was considerably smaller than normal Ayrshire female calves.

Discussion

Disorders of segregation (non-disjunction) in the course of gametogenesis in either of the parents or in the somatic cells can cause trisomy or monosomy in the resulting primary products (*Jacobs & Morton* 1977). Chromosomal aneuploidy is more common in prenatal than in postnatal stages, autosomal trisomies tending to survive longer than monosomic ones (*Carr* 1971). In domestic animals, most autosomal monosomies and trisomies are probably eliminated prior to embryo implantation (*Hare et al.* 1980, *King et al.* 1980, *Popescu* 1980, *King et al.* 1981) but occasionally autosomal trisomies occur postnatally. They are then associated with malformations. The first report in humans was of an association between trisomy 21 and the Down syndrome by *Lejeune et al.* in 1959.

The first case of autosomal trisomy in cattle was found by *Herzog & Höhn* in 1968 in a calf which had morphological malformations, brachygnathia inferior and ascites congenitus. They used conventional chromosome staining and suggested that the trisomic chromosome was either number 17 or 18.

Mori et al. (1969) investigated an autosomal trisomy in a malformed newborn male calf with several phenotypic anomalies. *Gluhovschi & Bistriceanu* (1970) reported nanismus in association with trisomy in three calves. They suggested that the trisomic chromosome was number 23 with conventional chromosome staining. *Dunn & Johnston* (1972) found one trisomic male calf. The chromosomal defect was associated with extreme brachygnathia inferior. The extra chromosome was assumed to be a large autosome in nonbanded metaphases.

Höhn & Herzog (1970), *Herzog & Höhn* (1971), *Herzog* (1974) and *Herzog et al.* (1977) reported a further 16 cases of calves with brachygnathia inferior and other malformations. The trisomic autosome number was found to be 17 with chromosome ban-

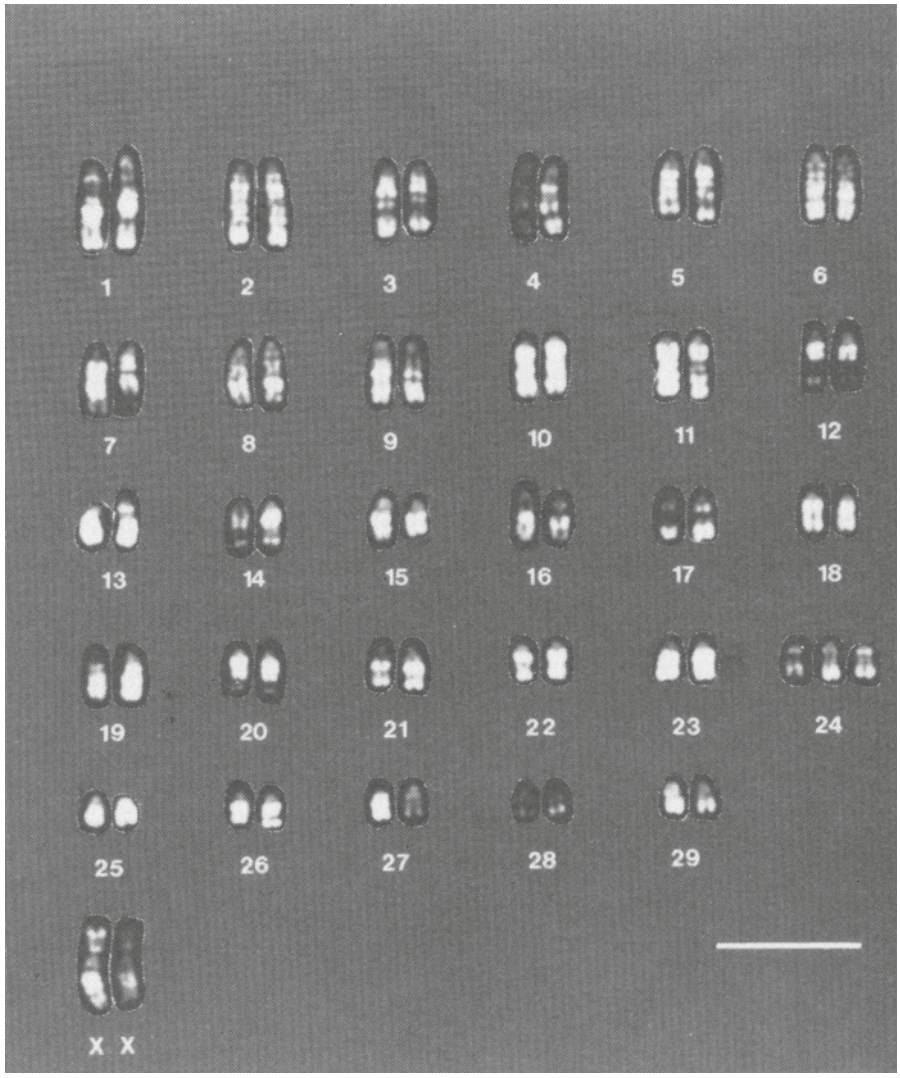

Figure 3. The RBA banded karyotype of the trisomic female calf, 2n = 61, XX, +24. – Scale is 10 μ.

ding analysis. *Tschudi et al.* in 1975 reported autosomal trisomy, 61, XX, +?(13–18) in a calf with an incomplete interventricular septum, patent foramen ovale and umbilical hernia; in 1977 they found the same chromosomal aneuploidy in another calf with reduced viability. The chromosomes were analysed with conventional chromosome staining. *Gluhovschi et al.* (1975) described a number of calves as trisomic, 61, XX or 61,+23 with a form of dwarfism characterized by short legs, reduced growth rate, de-

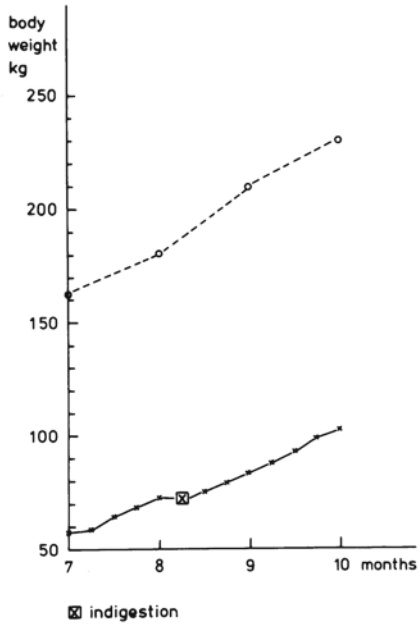

Figure 4. Growth of the trisomic calf (×—×) from the age of 7 months to 10 months compared to the normal female Ayrshire calves growth (O- - -O) (*Ettala & Ruohomäki* 1980). At the age of 8 months symptoms of indigestion were noted in trisomic calf.

layed puberty and abnormalities in the appearance of the optic papillae associated with the arrangement of the retinal vessels.

A trisomy of chromosome number 18 in a mosaic structure 61, XY, +18/60, XY was detected with chromosome banding in one male calf with dwarfism and other malformations (*Herzog et al.* 1982). The 2n=61, XY,+18 chromosome complement occurred in 20 % of the lymphocytes studied. *Mayr et al.* (1985) found a female calf trisomic for chromosome number 22. This calf had an umbilical hernia, an urachal fistula and slight brachygnathia. This trisomy was not associated with lethality. The chromosomes were examined with banding methods.

Autosomal trisomy is thus frequently associated with congenital anomalies and growth retardation. In our case the pathological findings were somewhat different from previously described ones, with slight prognathia of the lower jaw and peculiar abbrevations in the structure of genitals. The heart abnormalities, poorly-closed urachus and slow growth rate, which we also found, seem to be features common to several autosomal trisomies. The viability of the affected individuals varies according to the severity of the lesions in the important organs, such as the heart, the urinary tract or the urachus.

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Sammanfattning

Autosomal trisomi hos en kviga.

Hos en Ayrshire-kviga med långsam tillväxt och plötslig död i en ålder av 1 år kunde en extra autosomal kromosom påvisas i alla lymfocyter. Bandfärgning av kromosomerna visade karyotypen vara 2n = 61, XX, +24.

Kvigan hade en lindrig prognathia inferior, ett litet navelbrock samt utvecklingsstörningar i urogenitalsystemet och defekter i hjärtat.

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