

# CENTRIC FUSION (CF) TRANSLOCATIONS IN NORTH AMERICAN CATTLE.

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## INTRODUCTION

Centric fusion (Robertsonian translocation) occurs in telocentric chromosomes and involves a permanent union (fusion) at their centromere ends. There are two types of CF, namely, monocentric and dicentric (Figure 1). In the monocentric type the fusion resulted in a loss of one centromere, while in the dicentric type both centromeres are present. Currently 23 different CF's are present throughout the world, involving approximately 50 breeds of cattle<sup>1</sup>. The 1/29 CF condition, the only one of the monocentric type, is said to have originated in ancient times as the Romans moved their cattle throughout Europe. Thus it is found in many of the modern breeds, while other CF's, of allegedly more recent origin, are restricted to only a few breeds in isolated geographic locations. Nearly all CF's are present in the heterozygous form.

The 1/29 CF was the first CF to be reported in cattle. Gustavsson and Rockborn<sup>2</sup> identified the condition in Swedish Red and White cattle during diagnostic testing for bovine leukosis. Now found in approximately 50 breeds worldwide, this particular CF is concentrated in Continental beef breeds. In the United States it presently is of concern primarily in the Charolais

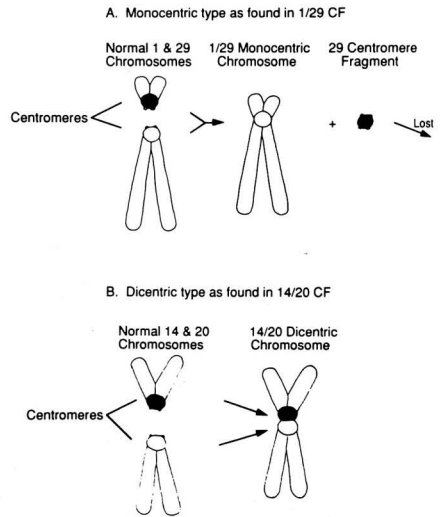


FIGURE 1. Theoretical mechanisms for the permanent joining of telocentric chromosomes, resulting in the anomalous condition called centric fusion (CF; Robertsonian translocation).

breed<sup>3</sup>. Interestingly the Holstein-Friesian breed is free of the condition, except for one report of its presence in Great Britain<sup>4</sup>. Other CF's (7/21;25/27;

14/20) are present in only one or a few breeds in isolated geographic locations. The 14/20 CF, found only in the Simmental breed, is of primary concern at present in the United States.

Following the discovery of the 1/29 CF condition in Sweden, Dyrendahl and Gustavsson found it to be associated with a 5-7% reduction in fertility. This led to a recommendation by the Association for Swedish Livestock Breeding and Production to the A.I. associations to have their bulls tested cytogenetically. This control effort was followed by similar discoveries and eradication measures in Europe and other countries in the early 1980's. For example, in the Hungarian Grey cattle breed the incidence of the 1/29 CF condition was found to increase dramatically from 11.9 to 30.4% between 1977 and 1983. In Brazil the carrier frequency of the 1/29 CF condition was reduced from 31.5 to 9.6% in five years following adoption of a federal policy requiring the cytogenetic evaluation of bulls. In Germany it was found that beef cattle carrying the 1/29 CF condition had an 18.5 days longer calving-to-conception interval than non-carriers.

In the United States the information from abroad of the widespread occurrence of the CF condition prompted the survey of a large representative group of cattle to ascertain the frequency of such aberrations. In a study of 743 dairy and beef bulls, no translocations were found. It was concluded that "in view of the reports of the occurrence of translocations at relatively high frequency in a number of breeds, it is reassuring to find that centric fusions are not ubiquitous among cattle of all types." Admittedly in that study most of the animals tested were of the

Holstein-Frisian breed, one found to be essentially free of the 1/29 CF condition.

In years following the discovery of the CF condition, considerable efforts were made to determine the mechanism of fertility reduction. Results of the studies of Popescu<sup>1</sup>, King<sup>1</sup>, and Schmutz et al<sup>4</sup> showed that while monosomy and trisomy sperm from 1/29 CF carrier bulls are capable of fertilization, unbalanced chromosomal complements lead to early embryonic death. As a result, recyrcycling dams could be misdiagnosed for failure of fertilization related to the presence of infection or abnormal hormone conditions.

Very little evidence has been presented concerning the effect of the 14/20 CF condition on fertility, as has been demonstrated for the 1/29 CF condition. In one study<sup>5</sup>, it was found that though semen quality of a heterozygous carrier was good, there was an unequal chromosomal segregation (non-disjunction) rate of 6.4% during sperm formation as compared to 2.9% in non-carrier bulls. In another study it was reported that 215 cows inseminated with semen from a 14/20 CF carrier bull had a conception rate of 49.3% compared to 59.2% for 915 cows inseminated by a non-carrier bull.

#### **RECENT CYTOGENETIC SURVEILLANCE FOR CF TRANSLOCATIONS IN NORTH AMERICA**

Only sporadic cytogenetic testing was carried out in the United States and Canada in the 1980's. Our large scale efforts began by chance. In the process of cytogenetic testing for freemartinism, a Charolais heifer born co-twin to a bull was found to be 1/29 CF positive. When a second co-twin

also was found to be positive, the owner would not permit testing beyond the dams. By inference it was determined that the herd sire was obligate 1/29 CF positive. Our University of Minnesota Charolais herd was then tested since it contained offspring of the suspected 1/29 CF positive bull. Results showed that of 43 animals tested in three pedigrees, 13(30%) were cytogenetically positive.

When officials of the American-International Charolais Association were appraised of the presence of the 1/29 CF condition in their breed, they recommended that all herd sires and bulls planned for breeding purposes be tested prior to usage. As a result, we began to receive blood from owners of Charolais and other beef cattle breeds for cytogenetic testing. By the spring of 1990 we diagnosed 1/29 CF carriers in 23 states and four Canadian provinces. Our results show that of 659 Charolais tested, 142 (22%) were positive. Only 4 of these animals (3 bulls, 1 cow) were found to be homozygous carriers. The percentages of male and female 1/29 CF carriers (21% vs 22%) is essentially identical. Our cytogenetic surveillance of 60 animals of other beef breeds and 598 dairy breed animals showed no cases of 1/29 CF. In a recent Canadian cytogenetic survey, the following prevalence of this condition was found: Simmental-0/60; Blond d / A q u i t a i n e - 2 / 1 2 ; Romagnola-4/10; Charolais-1/4; and Marchigiana-1/3.

Following the finding of a 14/20 CF in domestic Simmental cattle, we were contacted by the American Simmental Association regarding testing for that condition. To date cytogenetic evaluation has been made on 353 Simmental cattle (166 male, 187 female) from 113 herds in 26

states. One hundred-thirty eight (39%) were found to be heterozygous for the 14/20 CF condition, including 41 (25%) male and 97 (52%) female. Additionally, one Simbrah bull was found to be positive for both 1/29 CF and 14/20 CF conditions.

While the prevalences of both 1/29 CF and 14/20 CF conditions in sampled animals is high, they do not represent the true prevalences of the breeds at large. Rather they reflect the concerns of herd owners and their response in dealing appropriately with the problem when it occurs in any breed line.

It is obvious that European and other countries are far ahead of the United States in controlling the spread of inherited cytogenetic aberrations of reproductive importance. It also is reassuring that American cattle breeders are responding favorably to the admonitions of animal scientists to participate in similar surveillance programs.

#### ACKNOWLEDGEMENTS

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#### SUMMARY

Cytogenetic investigations were made concerning the presence of the 1/29 and 14/20 Robertsonian translocations in the Charolais and Simmental cattle breeds in the United States and Canada. The results indicated that positive cases were present in some of these beef cattle populations. Of the 659 Charolais cattle tested, 142 (22%) were 1/29 CF translocation positive. Of the 353 Simmental cattle tested, 138 (39%) were 14/20 CF translocation positive. For both breeds these results are not representative of the prevalence of the chromosomal aberration in the entire population.

#### ZUSAMMENFASSUNG

Zytogenetische Untersuchungen sind über den Vorkommen von 1/29 und 14/20 Robertsonsonchen Translokationen (centric fusion, CF) in den Charolaise und Simmentalern Rassen in den Vereinigten Staaten und Kanada durchgeführt. Die Ergebnisse zeigten dass positiven Fälle in b e s t i m m t e n Fleischrindpopulationen existieren. Ergebnisse zeigten dass von 659 Charolaise getestet, waren 142 (22%) gegen den 1/29 CF positive. Von 353 Simmentaler Rasse getestet waren 138 (39%) gegen den 14/20 CF Translokation positive. Bei

beiden Rasse sind diese Ergebnisse nicht für den ganzen Populationen repräsentierend.

#### RESUMEN

Fueron hechas investigaciones citogenéticas para encontrar translocaciones Robertsonianas en razas Charolais y Simmental en los Estados Unidos y Canadá. Los resultados indicaron que habia casos positivos en algunas de esas poblaciones de ganado de carne. De 659 vacas Charolais examinadas, 142 (22%) tuvieron translocaciones en la fusión céntrica 1/29. De 353 vacas Simmental examinadas, 138 (39%) tuvieron translocaciones en la fusión céntrica 14/20. Para ambas razas estos resultados no son representativos de la prevalencia de aberraciones cromosomales en toda la población.