Human and animal cytogenetics are experimental disciplines highly depending on the development of investigation techniques. The quality of chromosomes preparations, the mode of staining and observation of chromosomes have played an important role in the development of this type of research.

Since the first chromosome observations at the end of the last century, the history of cytogenetics can be divided into three periods:

The first one started at the beginning of this century and lasted until nineteen hundred and sixty. During this period, the chromosomes were observed in histological sections made on dividing tissues. The chromosomes were dammaged by the microtom and distributed over several planes. For these reasons, counting and study of the morphology were extremely difficult and the results were very often erroneous.

Towards nineteen hundred and sixty, several new technical procedures such as use of in vitro cell cultures, mitogenic products and a hypotonic treatment, replaced the old histological method and improved the quality of chromosomes preparations. This second period of modern cytogenetics began towards nineteen hundred and fifty nine, by the discovery of the 21 trisomy in man.

Thereafter came a period about ten years during which better knowledge of the human karyotype was obtained. During this time, many chromosome abnormalities were discovered in man, often connected with syndromes or severe malformations.

* Institut National de la Recherche Agronomique, Centre National de Recherches Zootechniques, Laboratoire de Cytogénétique, 78350 JOLY-en-JOSAS (France).
The third period of cytogenetics began towards nineteen hundred and seventy, with the discovery of "banding methods". Before, the accurate identification of each chromosome pair in human and animal species was the main difficulty. The banding methods resulting in a differential staining of each chromosome pair allowed their precise identification.

The development of animal cytogenetics including that of domestic animals followed with some delay that of human cytogenetics.

BANDING METHODS IN DOMESTIC ANIMALS.

The main domestic species except the pig, possess a very high number of chromosomes with similar morphology. In some species such as cattle and goat, the chromosomes stained by classical methods, could not be classified and there was a considerable risk for confusion between two or several pairs. At the present time, the banding techniques give a reproducible longitudinal differentiation of the chromosomes for each animal species and an international convention has been established for recognition and classification of karyotype in domestic species (FORD and al., 1980). In a recent review, GUSTAVSSON (1980) described all these methods used in domestic animal cytogenetics.

It would be advisable that all scientists working on domestic animals cytogenetics use this classification for the description of chromosomal abnormalities. This would allow a periodic establishment of an inventory of abnormalities for each species and thus lead to a better knowledge of their effects upon karyotype and animal production performances.

INVENTORY OF CHROMOSOME ABNORMALITIES IN DOMESTIC SPECIES.

The discovery in 1964 of the 1/29 translocation in cattle by GUSTAVSSON and ROCKBORN, drew the attention of cytogenetists upon the chromosome abnormalities and their consequences in animal breeding. Cytogenetics studies on large number of animals were started in different European and American countries. They resulted in the description of new chromosomal abnormalities and the first estimation of the frequency of some of them such as, for example, the 1/29 translocation and leucocyte chimerism in cattle. Cytogenetics laboratories studying the domestic species were created in most European and American countries; at present their number ranges around thirty.
Table 1. Frequency of 1/29 translocation and chimeric condition in cattle population studied in the Laboratory of Cytogenetics, National Institute of Agricultural Research

<table>
<thead>
<tr>
<th>Breed</th>
<th>Animals studied</th>
<th>Heterozygotes for 1/29 translocation</th>
<th>%</th>
<th>Homozygotes for 1/29 translocation</th>
<th>%</th>
<th>Chimerics</th>
<th>%</th>
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<tbody>
<tr>
<td>Abondance</td>
<td>11</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>Armoricaine</td>
<td>10</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
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<td></td>
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<tr>
<td>Blonde d'Aquitaine</td>
<td>46</td>
<td>6</td>
<td>13,04</td>
<td>0</td>
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<td>Brune des Alpes</td>
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<td>0</td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>Charolais</td>
<td>359</td>
<td>11</td>
<td>3,06</td>
<td>1</td>
<td>0,28</td>
<td>3</td>
<td>0,84</td>
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<td>F.F.P.N.</td>
<td>798</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td>9</td>
<td>1,13</td>
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<td>Holstein</td>
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<td></td>
<td>0</td>
<td></td>
<td>8</td>
<td>2,00</td>
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<tr>
<td>Hereford</td>
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<td>Limousine</td>
<td>133</td>
<td>10</td>
<td>7,52</td>
<td>0</td>
<td></td>
<td>2</td>
<td>1,50</td>
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<td>Maine-Anjou</td>
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<tr>
<td>Montbéliard</td>
<td>365</td>
<td>8</td>
<td>2,19</td>
<td>0</td>
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<td>1,92</td>
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<td>Normand</td>
<td>312</td>
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<td>0,32</td>
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<td>Pie Rouge</td>
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<td>Tarentaise</td>
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<td>Vosgienne</td>
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<td>1,23</td>
<td>0</td>
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<td>Simmenthal</td>
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<td></td>
<td>0</td>
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<td>Baladi</td>
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<td></td>
<td>0</td>
<td></td>
<td>0</td>
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<tr>
<td>Boule</td>
<td>85</td>
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<td>3,53</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>N'Damas</td>
<td>26</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Zébu et croisés</td>
<td>51</td>
<td>3</td>
<td>5,89</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2 833</strong></td>
<td><strong>43</strong></td>
<td></td>
<td><strong>1</strong></td>
<td></td>
<td><strong>31</strong></td>
<td></td>
</tr>
</tbody>
</table>
However, the most frequent chromosomal abnormalities involved in reproductive disorders and embryonic death in pigs are the reciprocal translocations. Ten different types of reciprocal translocations have been described up till now, despite a very small number of pigs studied (Table 3). They reduce the prolificacy by 25 to 50% and in some cases they cause total sterility.

Another domestic species in which chromosomal abnormalities seem to be very frequent is the sheep. Thus BRUERE and al. (1976) in New Zealand have studied a large number of animals and found three types of Robertsonian translocations. In Germany, GLAHN and WASSMUTH (1980) observed a reciprocal translocation and an autosomal deletion. (LUFT, 1973).

In the horse only few studies have been made on large populations. The most common abnormalities whose frequency seems to be much higher than in other species is X monosomy. A systematic survey in-horses was started in our laboratory in 1979, and about 300 animals have been examined at present. Several cases of X monosomy have been discovered (METENIER and CRIBIU, 1980; CRIBIU, unpublished).

A review of abnormalities described in this species was published in 1978 by DE GIOVANNI and CRIBIU.

In the other species of domestic Mammals, only few animals have been studied and the abnormalities described concern isolated individuals, so that the frequency of abnormalities cannot be estimated.

CYTOGENETIC STUDIES OF DOMESTIC ANIMAL EMBRYOS.

Owing to the improvement of cell culture technics and cytogenetics methods the last few years, study of human and animal chromosomes in very young embryos is now possible. In man this type of investigation is used for prenatal diagnosis of chromosomes abnormalities by amniocentesis.

In domestic animal and in particular in cattle, studies of embryos chromosomes have much progressed because of the development of embryo transfer the last ten years. They allowed to choose the sex of the future calf and they also present the effects of free-martinism. The first studies were made on 13-14...
day-old embryos (HARE and al., 1978; WINTENBERGER-TORRES and POPESCU, 1980). At present 6 to 7 day-old embryos are used leading to a higher success of freezing and transfer (SINGH and HARE, 1981). Embryonic cell culture techniques have been improved (POPESCU and al., 1982) and embryonic cell sampling are now performed by micromanipulation.

This method can also be used to study the effects on fertility of some abnormalities. Indeed, it is possible to observe in the embryos the various unbalanced karyotypes, caused by the gametes coming from meiosis of heterozygotes for structural abnormalities. In cattle, studies at seven (KING et al., 1981) and fourteen day-old embryos (POPESCU, 1980) sired by a carrier of the 1/29 translocation has evidenced the presence of unbalanced karyotypes.

In the pig, in three cases of reciprocal translocations, several types of unbalanced karyotypes have been found in preimplantation embryos. This chromosomally abnormal embryos die before birth (POPESCU, 1982).

**CYTOGENETICS AND ANIMAL BREEDING.**

Cytogenetics of domestic animals is becoming a more independent discipline. The very important theoretical interest of chromosome studies for the understanding of the chromosomal evolution and its role in animal speciation, but also its immediate practical application fully justifies the recent development of this field.

Population of domestic animals are very different from wild animal populations. The interest of farmers and the artificial selection pressures are variable according to the time elapsed after the domestication and the geographical position. In that reason, it is very difficult to establish whether a given chromosome abnormality constitutes a polymorphic system and to detect a possible selective advantage. Conversely, it has been proved that some abnormalities in cattle and pig cause unbalanced gametes, leading to lethal embryos and subsequently to a reduction of male and female prolificacy and to large economic losses.

In a modern animal production, where artificial insemination becomes generalized, the risks of a large spreading of chromosomal aberrations are increased...
sing. In addition, the transfer of animal populations, very common at present, without cytogenetics survey, increase the possibilities of chromosomal abnormalities dissemination in countries constituting new animal populations.

Because of these negative consequences of chromosomal abnormalities on reproduction, determination of the karyotype of large animal populations from each domestic animal species is very important.

However, the study of chromosomes in domestic species, may also lead to discovery of different chromosomal variants. They may be interesting in selection as genetic markers or in phylectic and phylogenetic investigations.

Some deeper modifications of chromosome complements, such as trisomies or duplications, tolerated by the living organisms, might have a positive effect in animal breeding of tomorrow.

**SUMMARY**

The development of domestic animal cytogenetics, followed that of human cytogenetics. The last few years cytogenetic studies have been made on large number of animal, especially in cattle. They resulted in the discovery of a relatively large number of chromosomal abnormalities in main domestic animal species. Some of them have a negative effect on fertility. In connection with embryo transfer the cytogenetics of cattle embryos have been improved. These studies can also be used to study the effects on fertility of some chromosomal abnormalities. Because of all these application the cytogenetics study of domestic animal becomes absolutely necessary in a modern animal breeding.

**RESUME**

REFERENCES

BRUERE A.N., CHAPMAN H.M., JAINE P.M. al., 1976 : Origin and significance of centric fusions in domestic sheep. J.Hered. 67(3) 149-154


383
Zuchthygiene 8(3), 125-129

METENIER L., DRIANCOURT M.A., CRIBIU E.P., 1979 : An XO chromosome constitution in a sterile Mare (Equus caballus).


POPESCU C.P., 1980 : Cytogenetics study on embryos sired by a bull carrier of 1/29 translocation.

J.of Heredity (in press)

POPESCU C.P., 1982 : Reciprocal translocations in pigs and consequences on their performances.
Pig News and Information (in press).

Theriogenology 14(6) 421-428

Theriogenology 14(5) 309-318