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Comparison between the G-banded karyotype of the aoudad (*Ammotragus lervia*) and sheep (*Ovis aries*)

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Abstract. Karyotypes of the aoudad and sheep were compared on the basis of G-banded chromosomes at the 450 band level. The common G-banded karyotype showed the homology of all aoudad chromosomes (2n=58) with sheep chromosomes (2n=54) or sheep chromosome arms. The results of cytogenetic investigations suggest that in this case karyotype evolution has led to reduction in chromosome number as a result of centric fusions. The formation of the first metacentric chromosome occurred in the aoudad. The homology of the G-banding pattern in sheep and aoudad suggests the conservation in linear arrangement of genetic material. Thus comparative cytogenetics can be a useful tool in gene mapping.

Key words: aoudad, comparative cytogenetics, G-banding, karyotype, sheep.

Introduction

The phenomenon of genetic conservation enables genetic comparison of different species. Genetic conservation can be investigated at three levels, including similarities in chromosome banding pattern, syntenic and linkage genes, and nucleotide sequences.

The comparison between banding patterns of related species may answer some questions concerning the evolution of farm animals. Results of cytogenetic investigations suggest that sheep and goats have a common ancestor with karyotype formula 2n = 60. The goats retained this primitive karyotype, but in sheep a sequential reduction in the number of chromosomes by means of acrocentric chro-

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mosomes translocation occurred. Probably, the formation of the first metacentric autosome occurred in the aoudad (BUNCH et al. 1976).

The aim of the present study was the comparison between the aoudad and sheep, based on G-banded chromosomes at the 450 band level.

Material and methods

Blood samples were taken from eight sheep of the Polish Mountain breed (four males and four females) belonging to a private farm, and from three aoudads (one female and two males) originating from Krakow's ZOO.

The preparations with metapahase spreads were obtained after the routine lymphocyte culture procedure used in our laboratory. The 72-hour lymphocyte culture was performed from whole blood. The culture medium (RPMI 1640) was supplemented with 15% of foetal calf serum, antibiotics (penicillin 10 000 I.U., streptomycin 10 000 μg/mL) and pokeweed mitogen (2.5 μg/mL).

For chromosome staining, conventional Giemsa staining and GTG banding methods were applied. GTG banding was carried out according to the method described in the paper by WANG and FEDOROFF (1972) with small modifications. Chromosome preparations, 1-3 weeks old, were treated with 0.1% trypsin solution in GKN / versenian buffer for 30-90 seconds, washed quickly in GKN buffer and stained for 20 minutes in 5% Giemsa solution in Sörenssen buffer, pH = 6.8.

The length of the aoudad chromosomes was measured by computer image analysis system MultiScan (KOZUBSKA-SOBOCIŃSKA et al. 1999).

The sheep karyotype was prepared according to the paper by IANNUZZI and DIMEO (1995), and in the karyotype of aoudad chromosomes were arranged according to chromosome length. The G-banded chromosomes of sheep and the aoudad were compared and the common karyotype were prepared.

Results

Eight investigated sheep showed chromosome number 2n = 54, and in three aoudads the chromosome number was 2n = 58. The aoudad karyotype is characterised by one pair of biarmed, metacentric chromosomes and 27 pairs of acrocentric chromosomes, a large acrocentric X and small biarmed Y.

The aoudad G-banded chromosomes (Figure 1) were arranged according to their length, since there is no international standard of aoudad karyotype.

A common karyotype for the aoudad and sheep was prepared on the basis of the paper by IANUZZI and DIMEO (1995), compared with the international standard of sheep karyotype (ANSARI et al. 1999), and homology between sheep and aoudad chromosomes (Figure 2). It was found that the chromosome pair no. 4 (ac-

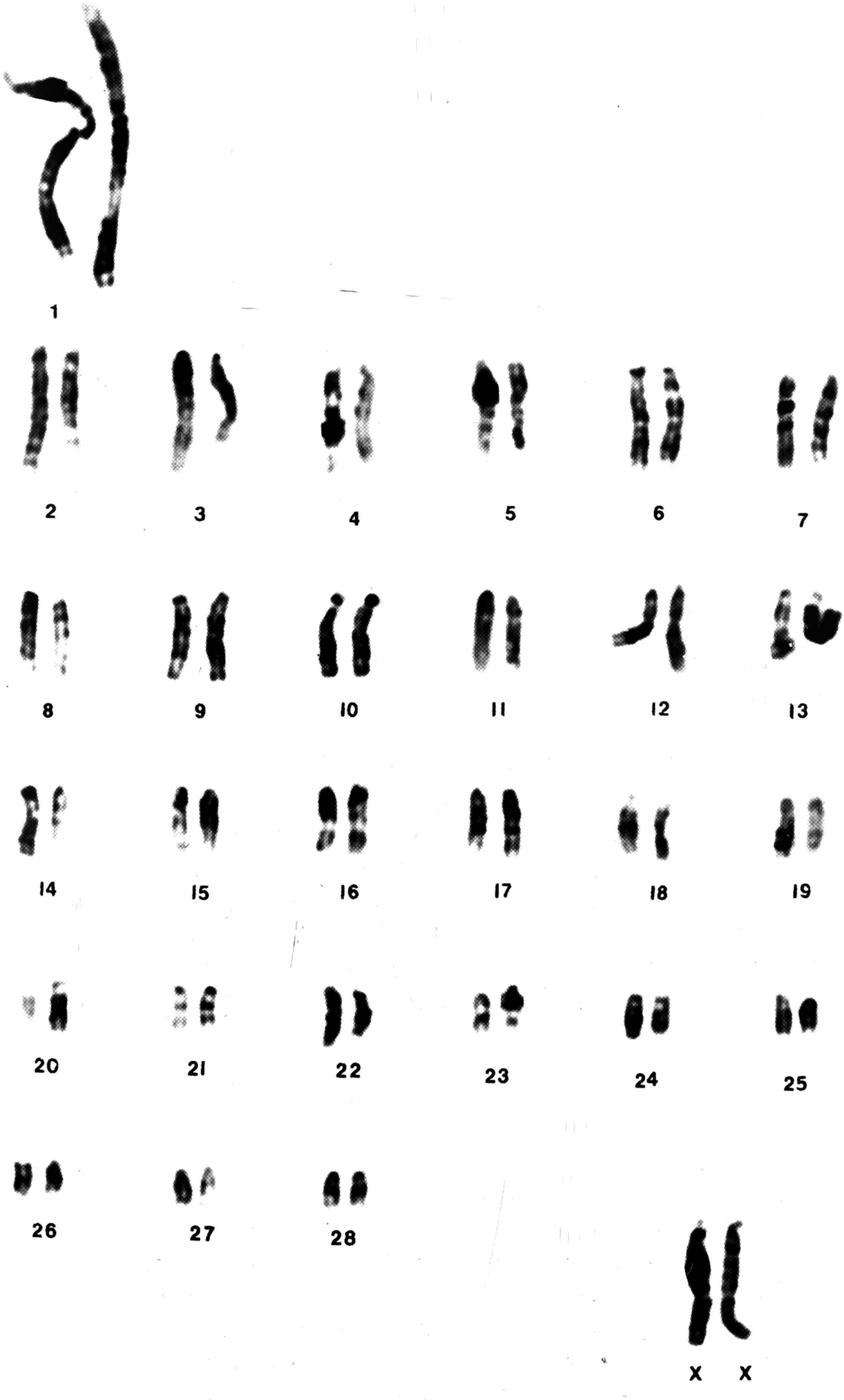

Figure 1. G banded karyotype of the aoudad (*Ammotragus lervia*). The karyotype was prepared from the picture of a single cell.

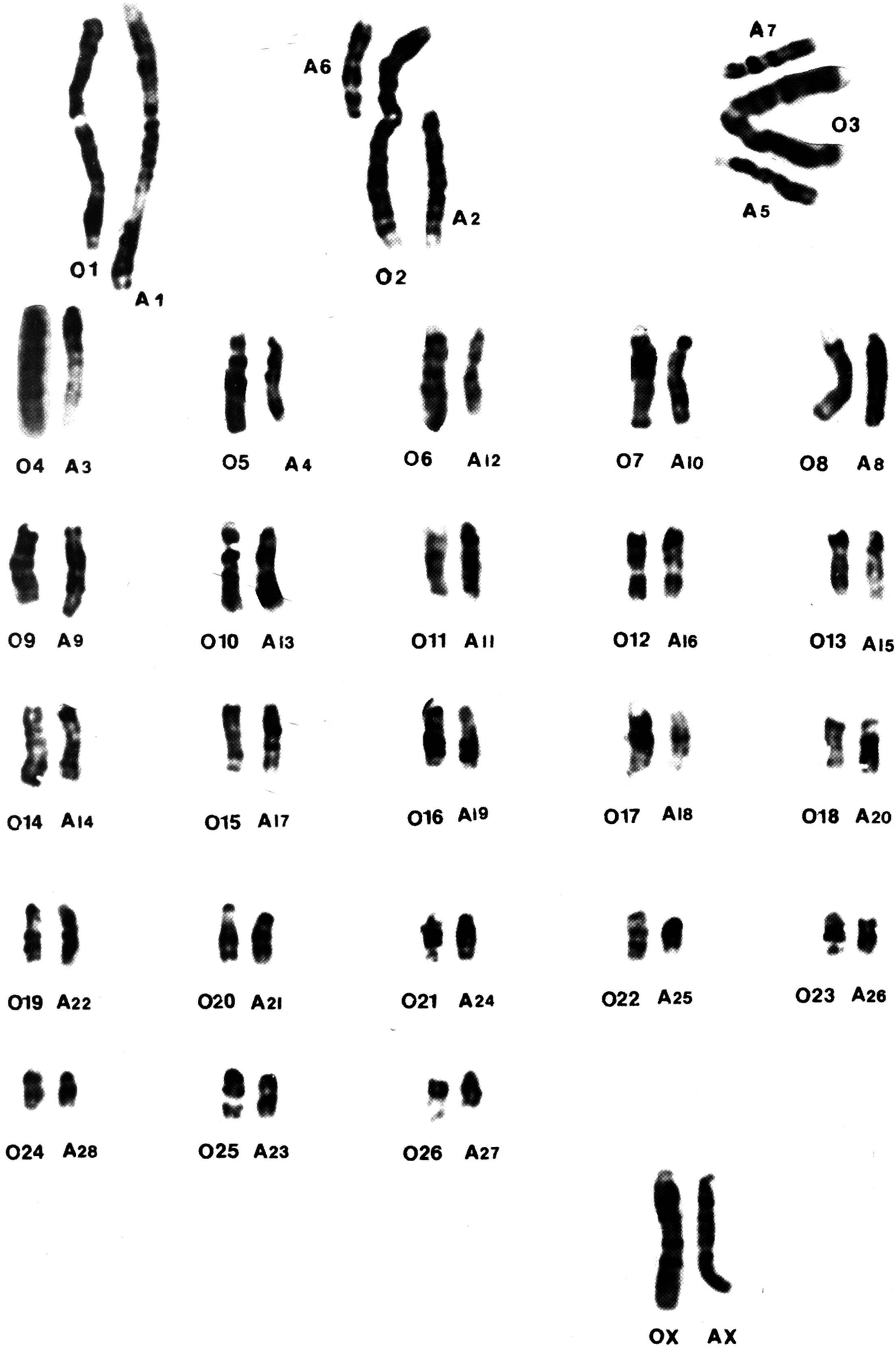

Figure 2. Comparison between the G-banded karyotype of the aoudad (*Ammotragus lervia*) and sheep (*Ovis aries*). The karyotypes were prepared from single cells.

cording to the international standard) is numbered as 6 (according to IANNUZZI and DIMEO 1995). The second difference refers to the exchange between pairs 8 and 9. Pair 8 according to the international standard is numbered as 9 according to IANNUZZI and DIMEO (1995).

The pair of metacentric chromosomes of the aoudad is fully homologous with the first pair of metacentric sheep chromosomes. The X chromosome of the aoudad, also homologous with X chromosome of sheep was the third chromosome in the aoudad karyotype, according to length. The homology of all aoudad chromosomes with sheep chromosomes or sheep chromosome p and q arms was observed.

Discussion

The number and morphology of aoudad chromosomes are different from the sheep chromosome complement. In the aoudad karyotype only one pair of chromosomes is metacentric, but the number of chromosome arms (NF) is the same as in sheep. Our findings are in agreement with the results obtained by BUNCH et al. (1977) and BUNCH and NADLER (1980).

Even if the chromosome number in caprines (sheep, goat and aoudad) ranges from 2n = 52 to 2n = 60 (BUNCH et al. 1976, 1977, LONG 1990), homologous G-banding pattern in these species indicates conservation in linear arrangement of genetic material in the chromosomes.

The aoudad (*Ammotragus lervia*) is characterised by a mixture of sheep and goat features. Probably the aoudad is the living representative of a sheep and goat ancestor (GEIST 1971).

The results of cytogenetic investigations suggest that evolution of karyotype may lead to a reduction in chromosome number. Formation of the first metacentric chromosome occurred in the aoudad. The G-banding pattern of this chromosome is homologous to the G-banding pattern of the first metacentric pair of sheep chromosomes.

The genus *Ovis* is characterised by a polymorphism of chromosome number and therefore it can be divided into four cytogenetic groups according to diploid number: 2n = 52 (*Ovis nivicola*), 2n = 54 (*O. aries*, *O. canadensis*, *O. dalli*, *O. musimon*, *O. orientalis*), 2n = 56 (*O. ammon*, *O. a. severtzovi*), 2n = 58 (*O. vignei*) (WURSTER, BERNISCHKE 1968, NADLER 1971, NADLER et al. 1971, KOROBITSYNA et al. 1974, BUNCH et al. 1998). In *Pseudois nayaur* (blue sheep/bharal) two different chromosome counts were observed: 2n = 54 in dwarf blue sheep and 2n = 56 in Subei blue sheep (BUNCH et al. 2000). The authors suggested that chromososome evolution within the blue sheep had led to a series of centric fusions. Reduction in chromosome number as a result of translocation is typical for the Caprini (BUNCH et al. 2000) .

We observed a very clear homology between the G-banded X chromosome of sheep and the aoudad. HAYES et al. (1991) found, by comparing RBG-banded karyotype of cattle, sheep and goat, that sheep and goat X chromosomes are more similar to each other than to cattle X chromosome. However, the large part of the q arm of goat and sheep chromosome X resembles the long arm of the cattle chromosome, turned upside down. Possibly chromosomal changes occurred in the X chromosome of a bovid ancestor, which was of the goat type. However, comparison between high resolution G-banded karyotypes of sheep and goats suggests that the terminal light band (Xq 2.9) present in goats is absent in sheep (MENSHER et al. 1989).

In the whole family Bovidae chromosome arm homologies have often been observed. GALLAGHER and WOMACK (1992) investigated karyotypes of 12 bovid species. Diploid chromosome number ranged from 30 to 60. At the same time they observed extensive chromosome arm homologies based on the similarity of Q bands.

The results of investigations based on gene mapping comparisons and comparative cytogenetics show that homology of banding patterns corresponds to a homologous genetic structure in the family Bovidae. So, the gene assignment an on identified chromosomal segment in one species of this family could be used for others (HEDIGER et al. 1991).

Also human specific chromosome painting probes could be a useful tool in gene mapping. A total of 48 human chromosome segments have been detected by this method in sheep chromosomes (IANNUZZI et al. 1999)

Conclusions

Karyotype evolution in the Caprini has led to a reduction in chromosome number as a result of translocations. Formation of the first metacentric autosome occurred in the aoudad. The G-banding homology of all aoudad chromosomes with sheep chromosomes or chromosome arms suggests the conservation in linear arrangement of genetic material in the chromosomes of these species.

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