

VARIABILITY IN THE NUCLEOLUS ORGANIZER REGIONS OF DOMESTIC PIG CHROMOSOMES (*Sus scrofa*)

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ABSTRACT

NOR-banded metaphase chromosomes were characterized in the domestic pig (*Sus scrofa*). Only the no. 10 pair showed NOR banding in the region adjacent to the centromere of the short arm, following silver staining. NOR region association at metaphases was not observed, though intraspecific size variation of labeled NORs was seen. Polymorphism was evident in two animals in which the NOR band was duplicated. A possible association of this polymorphism with reproductive problems detected in a female is discussed.

INTRODUCTION

In the karyotype of the domestic pig *Sus scrofa* ($2n = 38$) the chromosomes of pair 10 have a marked secondary constriction in the short arm near the centromere (Reading Conference, 1980; Committee for the Standardized Karyotype of the Domestic pig, 1988). McConnel *et al.* (1963) examined the karyotype of *S. scrofa* and observed that in addition to displaying the secondary constriction typical of pair 13 (equal to pair 10) one of the chromosomes of pair 8 also exhibited this same characteristic. The occurrence of such constrictions was not sex-linked (Haag and Nizza, 1969).

NOR-band polymorphisms in the pig are rare. Veijalainen and Rimaila-Paranen (1978) described a chromosomal polymorphism in pair 10 found in a Yorkshire female showing progressive ataxia and incoordination syndrome. This female had one chromosome lacking the secondary constriction which was nor-band negative.

Vischnevskaya and Vsevodolov (1986), Czaker and Mayr (1982) and Mellink *et al.* (1991) detected variations in the number and/or size of NOR bands in pigs.

We studied the karyotype and the nucleolus organizer regions in a group of six pigs with reproductive problems and one normal male farm sire, raised in the State of Rio de Janeiro, Brazil.

MATERIAL AND METHODS

The karyotypes of seven *S. scrofa* specimens from Aliança Farm, located in Barra do Pirai, state of Rio de Janeiro, Brazil, were analyzed (Table I).

Table I - Characteristics of the pigs.

Number	Race	Sex	Characteristics
1	L x LW	Female	Phenotypically normal but produced three piglets from two parturitions that died within seven days after birth.
2	L	Male	A farm sire. No abnormalities observed
3	L x LW	Male	Unilateral cryptorchidism.
4	L x LW	Male	Unilateral cryptorchidism.
5	L x LW	Intersex	Malformed external genitalia.
6	L x LW	Intersex	Malformed external genitalia.
7	L x LW	Intersex	Malformed external genitalia.

L - Landrace; LW - Large-White.

Metaphases were obtained from cultures of peripheral blood by the technique of Moorhead *et al.* (1960), using RPMI-1640 medium. The chromosomes were classified according to the Reading Conference (1980) and Committee for the Standardized Karyotype of the Domestic Pig (1988). NOR-banding was performed following the method described by Howell and Black (1980).

RESULTS AND DISCUSSION

The chromosome complements are presented in Table II.

Table II - Chromosome complements and NOR banding of the *Sus scrofa* specimens studied.

Number	Race	Sex	Karyotype	Ag-NOR banding
1	L x LW	Female	38,XX	Duplicated, heterozygous
2	L	Male	38,XY	Duplicated, heterozygous
3	L x LW	Male	38,XY	Normal
4	L x LW	Male	38,XY	Normal
5	L x LW	Intersex	38,XX	Normal
6	L x LW	Intersex	38,XX	Polymorphic, heterozygous
7	L x LW	Intersex	38,XX/38,XY (1:1)	Polymorphic, heterozygous

L - Landrace; LW - Large-White.

Animals 3 and 4, had normal karyotypes (Table II). Apparently cryptorchidism follows the two-locus inheritance model proposed by Rothschild *et al.* (1988).

The cellular proportion of animal 7 (Table II) differed from other intersex pig specimens previously studied (Jorge and Garcia, 1988), even though physiological characteristics such as "intermittent urination" were identical. Apparently distinct cellular proportions do not always result in noticeable differences in clinical signs.

Only the pair 10 chromosomes, in all seven animals, were stained by silver, results which agree with those of Giannoni (1979) and of Miyake *et al.* (1988). According to Giannoni *et al.* (1982), species bearing only one pair of chromosomes with NOR have increased chances to suffer a karyotype selection through evolution.

NORs associations, a common phenomenon in other animal groups having one or more chromosome pairs with such regions, were not detected.

Animals 3, 4 and 5 (Tables I and II), showed NOR bands of normal size in both chromosomes of pair 10.

In the domestic pig, NOR band polymorphism is rare. One of the few cases was reported by Veijalainen and Rimaila-Parmanen (1978), who observed absence of a secondary constriction in one of the pair 10 chromosomes in a Yorkshire female, with progressive ataxia and incoordination syndrome; this chromosome was negative for NOR banding.

Animals 6 and 7 (Table II) showed polymorphism in pair 10, represented by heterozygosity of a small NOR-banded region. This suggests different numbers of copies of rDNA per chromosome. Animals 1 and 2 had an apparently rare type of polymorphism (Figure 1), represented by a large block of NOR band. This could be due to a ribosomal gene duplication or triplication in a chromosome of pair 10 (Figure 2). This duplication

may have appeared recently in *S. scrofa* or was already present in its ancestors, a hypothesis supported by Giannoni *et al.* (1982) who found the same polymorphism in wild pigs. According to Gold (1979) unequal meiotic crossovers or sister chromatid exchanges, are usually causes for the development of heteromorphic NORs, including

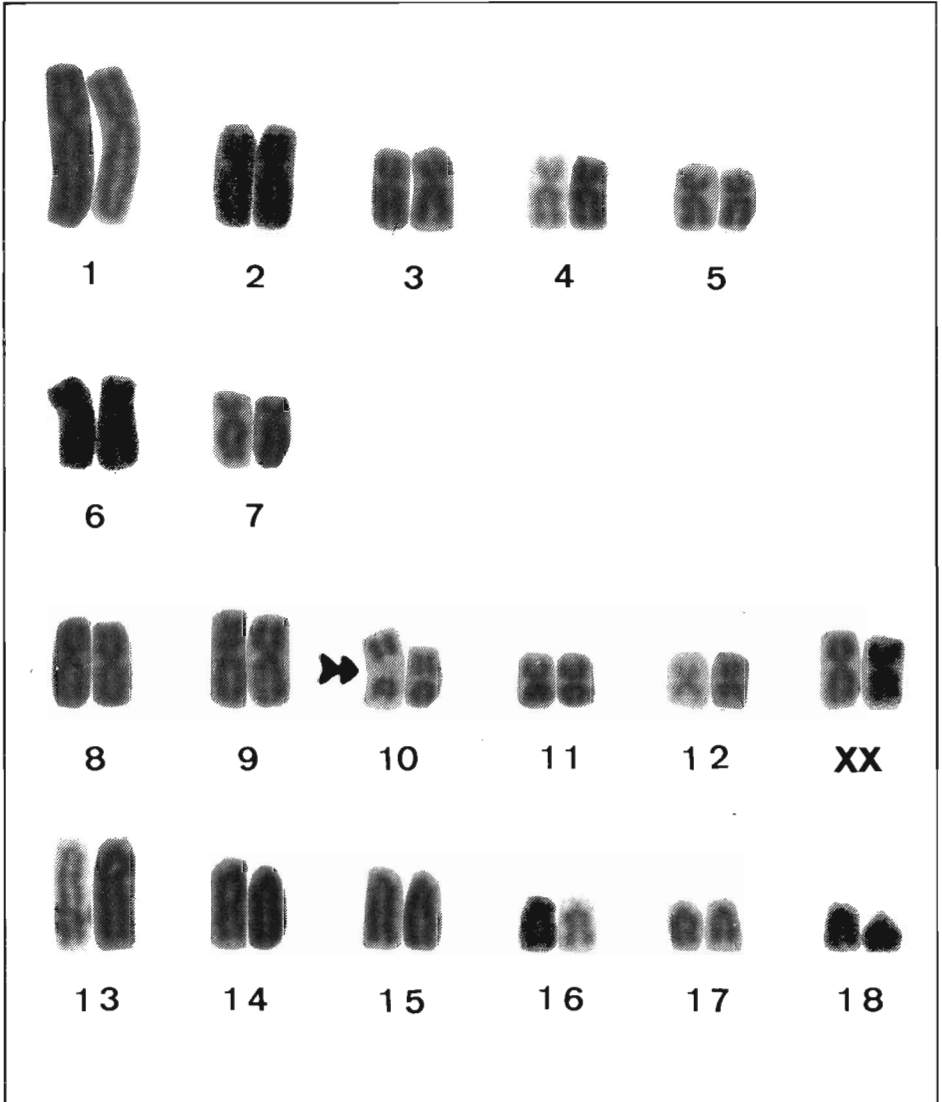


Figure 1 - Conventional coloration karyotype in a female pig, showing an apparently rare polymorphism in chromosome pair 10. (Arrow).

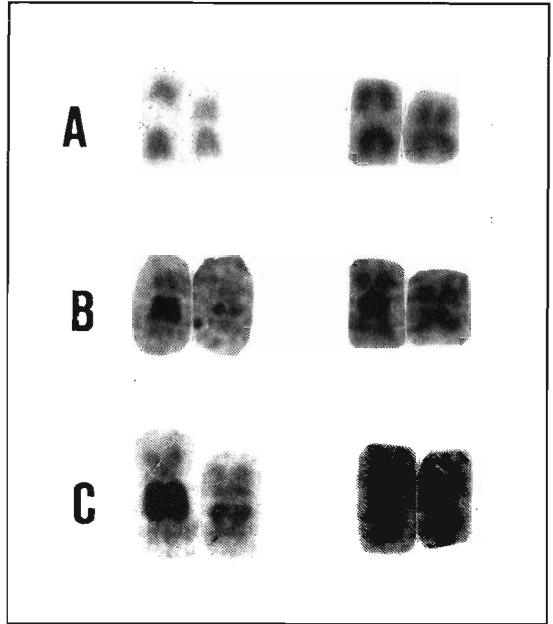


Figure 2 - Conventional coloration in a chromosome pair 10 of a female pig (A). Note duplicated or triplicated Ag-NOR band (B and C).

duplications and deletions. An accidental doubling of the DNA or a regional disturbance in the DNA replication pattern could also be responsible for spontaneous additions or deletions of the NORs.

Female 1, crossed twice with male 2, showing duplication in heterozygosity, produced only three piglets that died within seven days after birth. This occurrence could be interpreted as supportive of Schmid's hypothesis (Schmid, 1982), who postulated that homozygous polymorphism can be lethal.

Thus reproduction in the domestic pig could be influenced by NOR band duplication itself or by duplication of this band along with that of some genes close to this region in heterozygous animals. This could also be influenced by sex since male 2, presenting a duplicated NOR band turned out to be phenotypically normal.

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RESUMO

Foram caracterizados no porco doméstico (*Sus scrofa*) os cromossomos portadores de regiões organizadoras de nucléolos. Somente os cromossomos do par nº 10 mostraram marcação pela prata, no braço

curto, em uma região adjacente ao centrômero. Não foram observadas associações entre as regiões NOR. Foram detectadas, no entanto, variações no tamanho das NORs. Tal polimorfismo foi mais acentuado em dois animais onde essas bandas apresentavam-se duplicadas. Uma possível associação entre o polimorfismo observado e os problemas reprodutivos apresentados pela fêmea é discutida.

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