Frequency and distribution of rob (1;29) in three Portuguese cattle breeds

TERESA RANGEL-FIGUEIREDO[1] and LEOPOLDO IANNUZZI[2]

[1]*Departamento de Zootecnia, U.T.A.D, Vila Real, Portugal*
[2]*National Research Council (CNR), I.A.B.B.A.M., Naples, Italy*

RANGEL-FIGUEIREDO, T. and IANNUZZI, L. 1993. Frequency and distribution of rob (1;29) in three Portuguese cattle breeds. — *Hereditas 119*: 233–237. Lund, Sweden. ISSN 0018-0661. Received February 10, 1993. Accepted June 24, 1993

Representative samples of Portuguese cattle from Barrosã, Maronesa, and Mirandesa breeds underwent cytogenetic investigation. Banding showed that 134 (65.0 %) Barrosas, 74 (40.2 %) Maronesas and 4 (1.6 %) Mirandesas carried rob (1;29). The frequency of this translocation in the three breeds (39 % in Barrosas, 23 % in Maronesas, and 1 % in Mirandesas) was in a genetic Hardy-Weinberg equilibrium for the three karyological forms (2n = 60, 2n = 59 and 2n = 58), strongly supporting the hypothesis for an ancient origin of this translocation and the hypothesis of the origin of Maronesas from Barrosã and Mirandesa cross-breeding.

L. Iannuzzi, National Research Council (CNR), I.A.B.B.A.M., Via Argine, 1085, 80147-Naples-Ponticelli, Italy

The total Portuguese cattle population numbers about one million, including both local and imported breeds (D.G.P. 1987). Barrosã, Maronesa, and Mirandesa (about 10 % of all Portuguese cattle) are raised primarily for meat production in three different but geographically similar regions of North-Portugal (West, Middle, and East, respectively). Barrosas are believed to have originated from the Mauritanian cattle (North-Africa), and Mirandesas from Berciana and Verinesa Spanish breeds (MASON 1988). It has been hypothesized that Maronesas derived from Barrosã and Mirandesa crossbreeding (MASON 1988), but no direct evidence has been reported.

Previous cytogenetic studies have shown high frequencies of rob (1;29) in Maronesas and Barrosas (RANGEL-FIGUEIREDO and IANNUZZI 1990, 1991). In the present study we included for the first time a representative sample of Mirandesas as well as a larger number of Barrosas and, primarily, of Maronesas, than in previous studies. We found that the three populations show frequencies of rob (1;29) which are in a genetic Hardy-Weinberg equilibrium for the three karyological forms (2n = 60, 2n = 59 and 2n = 58) and support the hypothesis for the origin of Maronesas from the other two breeds.

Materials and methods

Two hundred-forty-four Mirandesas (51 males and 193 females), 184 Maronesas (82 males and 102 females), and 206 Barrosas (27 males and 179 females), randomly sampled from 38, 26, and 55 small farms, respectively, underwent a cytogenetic investigation.

Peripheral blood was cultured for 72 h at 38.5°C in RPMI 1640 (Gibco) medium with L-glutamine (1 %), Pokeweed mitogen (1 %), and autologous plasma (15 %). Six hours before harvesting, 20 μg/ml of 5-Bromodeoxyuridine (BrdU) were added for R-banding. Colcemid treatment (0.05 μg/ml) lasted one hour. A hypotonic treatment (0.5 % KCl) and four fixations (the third overnight) in methanol/acetic acid (3:1) followed.

Additional cultures from 10 heterozygous Mirandesa and Maronesa carriers were set up with early-BrdU incorporation to obtain G-banding patterns, as previously reported (IANNUZZI et al. 1989).

CBG- (SUMNER 1972), RBA- (IANUZZI 1990), and GBA + CBA- (IANNUZZI et al. 1989) banding techniques were used.

G- and R-banded karyotypes were arranged according to ISCNDA (1989).

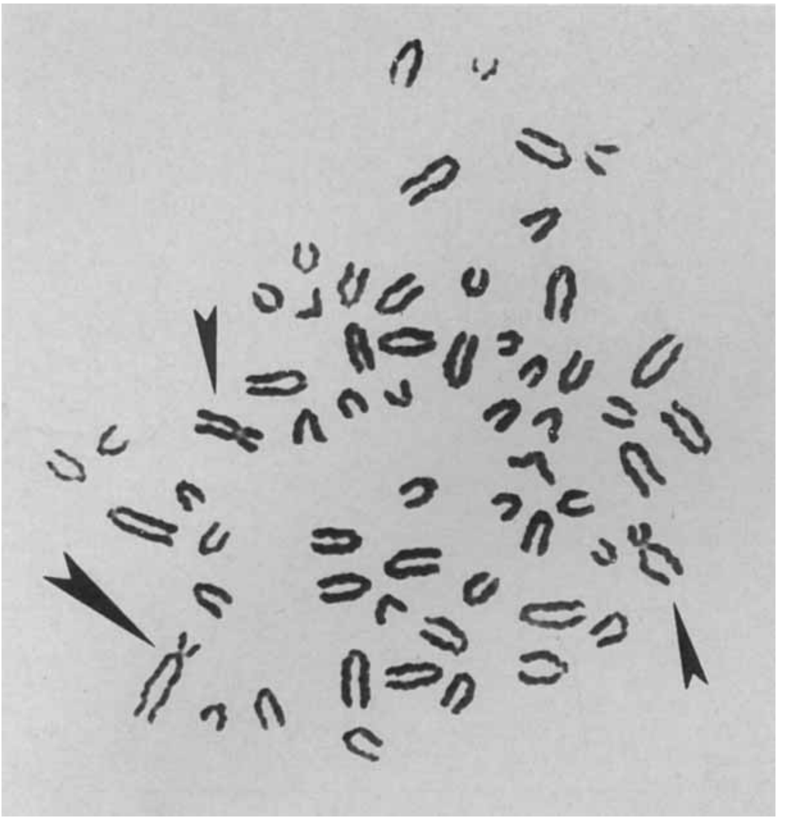

Fig. 1. Conventional stained female metaphase plate from a Mirandesa heterozygous carrier of rob (1;29) type (large arrow). X-chromosomes are indicated by small arrows.

Results and discussion

Fig. 1 shows a conventionally stained metaphase plate from a Mirandesa heterozygous carrier of rob (1;29) type. The G- and R-banding patterns (Fig. 2) revealed that chromosomes 1 and 29 of cattle standard karyotype were involved in the translocation. The CBG-banding patterns (Fig. 3) confirmed the presence of only one block of constitutive heterochromatin (HC = C-bands) in the proximal q-arm centromeric region of the translocated chromosome, as reported in other cattle breeds (GUSTAVSSON 1974; POPESCU and BOSCHER 1974; DI BERARDINO et al. 1979; CIUPERCESCU et al. 1984; IANUZZI et al. 1987, 1992; RANGEL-FIGUEIREDO and IANNUZZI 1990, 1991). All these authors agree on an ancient origin for rob (1;29), while WILSON (1990), examining the pedigree of a British Friesian bull, a heterozygous carrier of rob (1;29), hypothesized a de novo origin for this translocation which had never been found before in this breed (LONG 1985; ELDRIDGE 1985). However, the monocentric nature of this translocation and the high number (about 60) of different breeds where the rob (1;29) has been found so far with different frequencies (DE GIOVANNI and MOLTENI 1976; HARI et al. 1984; POPESCU and PECH 1991; LONG 1993) are in agreement with the first hypothesis.

Table 1 reports the frequency of rob (1;29) in three Portuguese cattle breeds. We examined only 11 Barrosas more than the number in our previous paper (RANGEL-FIGUEIREDO and IANNUZZI 1991), and found the percentage of carriers to be the same (65.0 %). Barrosas still remain the breed which shows the highest percentage of carriers of this translocation and two new Robertsonian

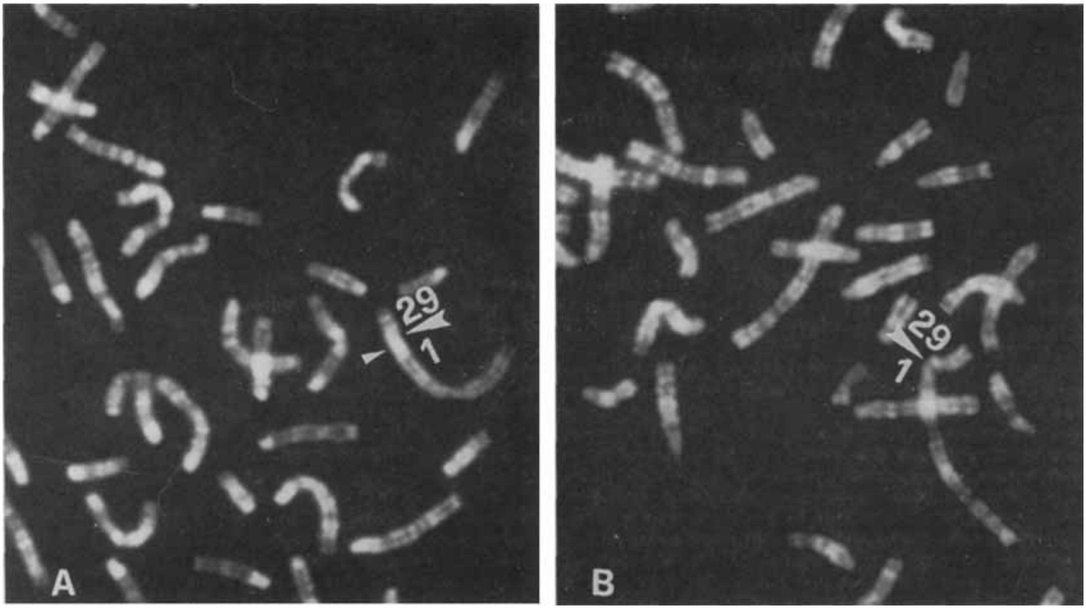

Fig. 2A and B. Two partial GBA + CBA (**A**) and RBA- (**B**) -banded prometaphase cells from Mirandesa cattle carrying rob (1;29). Notice in **A** the large fluorescent HC-block (small arrow) present in the proximal q-arm (chromosome 1) centromeric region of the translocated chromosome.

Table 1. Frequency of rob(1;29) in Barrosã, Maronesa, and Mirandesa cattle breeds

Breed	Animals studied	Without rob(1;29)			With rob(1;29)								
		Males	Females	Total	Males			Females			Total		
					HT	HM	HT + HM	HT	HM	HT + HM	HT	HM	HT + HM
Barrosã	206	6	66	72	16	5	21	90	23	113	106	28	134
		(2.9)*	(32.0)	(35.0)	(7.8)	(2.4)	(10.2)	(43.7)	(11.2)	(54.9)	(51.5)	(13.6)	(65.0)
Maronesa	184	48	62	110	28	6	34	36	4	40	64	10	74
		(26.1)	(33.7)	(59.8)	(15.2)	(3.3)	(18.5)	(19.6)	(2.2)	(21.7)	(34.8)	(5.4)	(40.2)
Mirandesa	244	48	192	240	3	/	3	1	/	1	4	/	4
		(19.7)	(78.7)	(98.4)	(1.2)	/	(1.2)	/	/	(0.4)	(1.6)	/	(1.6)

*The percentages are reported within parentheses; HT = heterozygous carrier; HM = homozygous carrier

translocations have recently been found in this breed (IANNUZZI et al. 1992, 1993). A similar high value (65.6 %) of rob (1;29) carriers has recently been found in British White cattle breed (LONG 1993). In Maronesas we studied 80 animals more than in our earlier study (RANGEL-FIGUEIREDO and IANNUZZI 1990) and found the percentage of carriers to be 40.2 % instead of 49.5 %. As for Mirandesas, we found only 4 (1.6 %) heterozygous carriers of rob (1;29).

It is very difficult to explain these great differences in the number of carriers of this translocation among the three breeds considering the proximity and similarity of the areas where the three breeds are raised. We could hypothesize that the frequency of carriers among Barrosas was very high in the original group of animals imported from North Africa, and this frequency remained stable because this balanced chromosomal abnormality escaped selection since the carriers were phenotypically normal, The same could have occurred among Mirandesas (coming from Spain) which have a very low frequency of this translocation. Maronesas showed a percentage of carriers

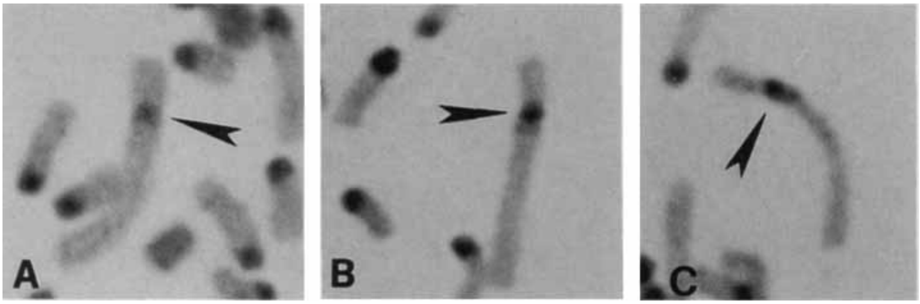

Fig. 3A–C. Details of CBG-banded rob (1;29) taken from three different cells of two different Mirandesa cattle. Arrows indicate the monocentric HC-blocks localized in the proximal q-arm centromeric region of the translocated chromosome.

Table 2. Numerical consistency, live weight, reproductivity coefficient, first calving and gain medium daily (GMD) in Barrosã, Maronesa, and Mirandesa breeds (D.G.P. 1987)

Breed	Numerical consistency (N)	Live weight* Males (kg)	Females (kg)	GMD* (kg)	Reprod.* coeff. (%)	First* calving (months)
Barrosã	40,000	600	375	0.875	70	33
Maronesa	15,000	525	350	0.850	75	33
Mirandesa	50,000	900	500	1.201	80	28

*Mean values

which is approximately intermediate between the other two breeds. This is particularly more evident if we consider the frequencies of rob (1;29) on the basis of the numbers of animals showing the three karyological forms (2n = 60, 2n = 59 and 2n = 58). From this point of view, the frequencies of this translocation were 39 % in Barrosas, 23 % in Maronesas and about 1 % in Mirandesas. The three breeds showed a chromosomal polymorphism which is in a genetic Hardy-Weinberg equilibrium for the three karyological forms. In fact, the chi-square test (1.287 in Barrosas and 0.024 in Maronesas and Mirandesas; df = 2) revealed no statistical differences between observed and expected frequencies of rob (1;29) in the three breeds when calculated according to the Hardy-Weinberg law. This implies that rob (1;29) inheritance follows the Mendelian principle in the three breeds. This is in agreement with the hypothesis for an ancient origin of rob (1;29) and with the hypothesis, never confirmed, for an origin of Maronesas from Barrosã and Mirandesa crossbreeding in the two close regions where Barrosas and Mirandesas are raised.

Table 2 shows the numerical consistency and mean values of live weight, gain medium daily, reproductivity coefficient (number of calves per 100 cows), and first calving in the three breeds. As known, rob (1;29) reduces the fertility of carriers (GUSTAVSSON 1969; DYRENDAHL and GUSTAVSSON 1979). The data here reported confirm this. In fact, the lower reproductivity coefficient in Barrosas, compared with that of Mirandesas can, in part, be explained by the high frequency of this translocation in the former. In Maronesas the reproductivity coefficient showed an intermediate value between the other two, thus agreeing with the intermediate frequency value of this translocation.

It still remains unclear if rob (1;29) in cattle is simply a very common chromosomal abnormality or an attempt on the part of some cattle breeds to reduce the diploid number from 60 to 58 so as to obtain possible advantages derived from new genetic linkage between chromosomes 1 and 29, as has occurred in many other Bovidae species which have extensively used this chromosomal rearrangement to evolve their karyotypes (WURSTER and BENIRSCHKE 1968; BUCKLAND and EVANS 1978;

DI BERARDINO et al. 1981; IANNUZZI et al. 1987, 1990; GALLAGHER and WOMACK 1992). Portuguese cattle breeds seem to be an interesting population for the study of this abnormality because no selection programs against this translocation have been undertaken so far.

Acknowledgements. — We wish to thank Mrs I. Abobeleira and Mr C. Aprea for their excellent technical assistance, Mr Pablo Aguas and Adelino Bernardo for the blood collection, and Mrs L. Keller for her kind cooperation in this paper.

References

BUCKLAND, R. A. and EVANS, H. J. 1978. Cytogenetic aspects of phylogeny in the Bovidae. I. G-banding. — *Cytogenet. Cell Genet. 21*: 42–63

CIUPERCESCU, D. D., LIVESCU, B. E. and LUNGEANU, A. 1984. Cytogenetic studies in artificial insemination bulls in Romania. — *6th Eur. Colloq. Cytogenet. Domest. Anim., Zürich, July 16–20, 1984*, p. 375–382

DE GIOVANNI, A. M. and MOLTENI, L. 1976. Further cytogenetic analysis on the Romagnola breed. — *Atti Soc. It. Sci. Vet. 30*: 479–480

D.G.P. 1987. Direcçao General de Pecuaria. — *38th Annu. Meet. EAAP, Lisbon, Portugal*

DI BERARDINO, D., IANNUZZI, L., FERRARA, L. and MATASSINO, D. 1979. A new case of Robertsonian translocation in cattle. — *J. Hered. 70*: 436–438

DI BERARDINO, D., IANUZZI, L., BETTINI, T. M. and MATASSINO, D. 1981. Ag-NORs variation and banding homologies in two species of Bovidae: *Bubalus bubalis* and *Bos taurus*. — *Can. J. Genet. Cytol. 23*: 89–99

DYRENDAHL, I. and GUSTAVSSON, I. 1979. Sexual functions, semen characteristics and fertility of bulls carrying 1;29 chromosome translocation. — *Hereditas 90*: 281–289

ELDRIDGE, E. F. 1985. Cytogenetics of Livestock. — *Avi Publishing Company, Inc, Westport, Connecticut, USA*

GALLAGHER, D. S. and WOMACK, J. E. 1992. Chromosome conservation in the Bovidae. — *J. Hered. 83*: 287–298

GUSTAVSSON, I. 1969. Cytogenetics, distribution and phenotypic effects of a translocation in Swedish cattle. — *Hereditas 63*: 68–169

GUSTAVSSON, I. 1974. Distribution and effects of the 1/29 Robertsonian translocation in cattle. — *J. Dairy Sci. 62*: 825–855

HARI, J. J., FRANCESCHI, P., CASABIANCA, F., BOSCHER, J. and POPESCU, C. P. 1984. Etude cytogénétique d'une population de bovins corses. — *C. R. Acad. Agr. de France 70*: 191–199

IANNUZZI, L. 1990. An improved characterization of cattle chromosomes by means of high resolution G- and R-band comparison. — *J. Hered. 81*: 80–83

IANNUZZI, L., DI BERARDINO, D., GUSTAVSSON, I., FERRARA, L. and DI MEO, G. P. 1987. Centromeric loss in translocations of centric fusion type in cattle and water buffalo. — *Hereditas 106*: 73–81

IANNUZZI, L., GUSTAVSSON, I., DI MEO, G. P. and FERRARA, L. 1989. High-resolution studies on late-replicating segments (G- + C-bands) in mammalian chromosomes. — *Hereditas 110*: 43–50

IANNUZZI, L., DI MEO, G. P., PERUCATTI, A. and FERRARA, L. 1990. A comparison of G- and R-banding in cattle and river buffalo prometaphase chromosomes. — *Caryologia 43*: 283–290

IANNUZZI, L., RANGEL-FIGUEIREDO, T., DI MEO, G. P. and FERRARA, L. 1992. A new Robertsonian translocation in cattle, rob (15;25). — *Cytogenet. Cell Genet. 59*: 280–283

IANNUZZI, L., RANGEL-FIGUEIREDO, T., DI MEO, G. P. and FERRARA, L. 1993. A new centric fusion translocation in cattle, rob(16;18). — *Hereditas 119*: 239–243

ISCNDA (1989) 1990. International System for Cytogenetic Nomenclature of Domestic Animals (*eds* D. DI BERARDINO, H. HAYES, R. FRIES *and* S. LONG). — *Cytogenet. Cell Genet. 53*: 65–79

LONG, S. 1985. Centric fusion translocations in cattle: a review. — *Vet. Rec. 116*: 516–518

LONG, S. 1993. Incidence of rob.t(1;29) centric fusion translocation in British White cattle in Britain. — *Vet. Rec. 132*: 165–166

MASON, I. L. 1988. World Dictionary of Livestock Breeds. — *CAB International, Wallingford, Oxon, U.K.*

POPESCU, C. P. and BOSCHER, J. 1974. Etude du caryotype bovin par une nouvelle méthode cytogénétique: les bandes C. — *1st World Congress Genetics Applied Livestock Production, 3 Symposia, Madrid*, p. 159–164

POPESCU, C. P. and PECH, A. 1991. Une bibliographie sur la translocation 1/29 de bovins dans le monde (1964–1990). — *Ann. Zootech. 40*: 271–305

RANGEL-FIGUEIREDO, T. and IANNUZZI, L. 1990. High incidence of 1/29 centric fusion translocation in a Portuguese cattle breed. — *J. Genet. Breed. 44*: 203–206

RANGEL-FIGUEIREDO, T. and IANNUZZI, L. 1991. A cattle breed close to 58 diploid number due to high frequency of rob(1;29). — *Hereditas 115*: 73–78

SUMNER, A. T. 1972. A simple technique for demonstrating centromeric heterochromatin. — *Exp. Cell Res. 75*: 304–306

WILSON, T. D. 1990. Identification of the 1/29 Robertsonian translocation chromosome in British Friesian cattle. — *Vet. Rec. 112*: 429–432

WURSTER, D. H. and BENIRSCHKE, K. 1968. Chromosome studies in the superfamily Bovidae. — *Chromosoma 25*: 152–171