A cytogenetic study of a Barbary sheep *(Ammotragus lervia)* x domestic goat *(Capra hircus)* hybrid

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Summary. An account is given of stillborn male twins born to a female Saanen goat *(Capra hircus)* and a Barbary ram *(Ammotragus lervia)*. The cytogenetics of the cultured hybrid cells are described and attention is drawn to the high proportion of cells which lacked one chromosome.

Experimental hybridization of Barbary sheep (*Ammotragus lervia*, 2n = 58) and goats (*Capra hircus*, 2n = 60) has been attempted in the past. Warwick and Berry[2] described the full-term stillborn hybrid of a female goat and a Barbary ram. Haltenorth[3] reported the successful backcrossing of a female Barbary/goat hybrid with a male ibex *(Capra ibex)*; the dam was the offspring of a Barbary ram and a female domestic goat. Gray[4] listed the occurrence of living *Ammotragus* × *Capra* hybrids; but, so far, no cytogenetic studies have been published. The present work was done on one of a pair of stillborn male twins born to a domestic female goat and a Barbary ram.

Animals and methods. The dam, a pure Saanen goat (601) ran for several months with the Barbary sire, a 4-year-old monorchid ram of proven fertility (5BA2). At slaughter 1 normal and 1 atrophic testis (2 cm × 1.2 cm) were found in the scrotum. A yearling Barbary ram (8BA1) also ran with the goat.

Chromosome spreads were prepared from cultures of blood lymphocytes, liver, kidney and skin cells. Lymphocyte chromosomes were prepared by a modification of the method of Basrur and Gilman[5]. Cell cultures of the other organs were made by a modification of the method of Tucker, Dain and Moor[6]. Pieces of liver and kidney were removed from the dead hybrids within 12 h (No. 1) and not sooner than 3 h (No. 2) of birth. A small skin biopsy was taken from the scapular region of Barbary ram 8BA1 under xylocaine local anaesthesia. Tissues from ram 5BA2 were removed at slaughter on 10.12.1979. G-banding of the chromosomes was done by a modification of the technique of Gallimore and Richardson[7] and C-banding by a modification of the method of Sumner[8].

Observations and discussion. Goat 601 mated with 8BA1 on 3.11.1978. Thereafter neither heat nor mating was seen, although the animals were observed daily. On 21.4.1979 she produced stillborn male twins, at an interval of several hours. Each weighed 1.2 kg and was apparently a normal, full-term kid, but neither had breathed. The usual signs of parturition in the goat were absent, and on the previous day her pregnancy had even been doubted. Transferrin typing[9] showed that Barbary ram 5BA2 was the sire. Cells of hybrid 2 grew in culture; but those of hybrid 1, which had probably lain undiscovered for several hours, did not. The table gives the chromosome counts. Many cells lacked more than 2 chromosomes: this category, which must include cells broken in preparation, is of similar proportions in all animals (except the goat, where lymphocytes appear to have been less fragile): 38.2% in hybrid 2, 38% in the sire 5BA2 and 30.1% in Barbary ram 8BA1. In contrast, the category which lacked a single chromosome was greater in the hybrid than in the rest. Figure e illustrates such a cell. The expected modal number of 59 chromosomes occurred in only 24.6% of hybrid cells while 34.1% had 58. The sire had 54% modal cells, 8BA1 61.3% and the goat 601, 81.6%; while loss of a single chromosome occurred in only 4.0%, 8.0% and 12.0% respectively. 2 of 145 hybrid cells lacked the paternal metacentric chromosome, but different acrocentrics were missing from other cells with a complement of 58 figures c and d). Barbary chromosome 1 resembles goat chromosomes 1 and 3 (figures a and b) (Buckland and Evans[14]). The Barbary C-bands were smaller than those in the goat, but the difference was insufficient to distinguish the chromosomes in hybrid cells.

The hybrid gestation period is uncertain. In the goat it is 148–153 days as it probably is in the Barbary sheep. Had a mating on 3.11.1978 been successful the gestation would have been 169 days: conception at the next heat period (unobserved) would have produced a pregnancy of 148 days and at the following period (also unobserved) one of 127 days.

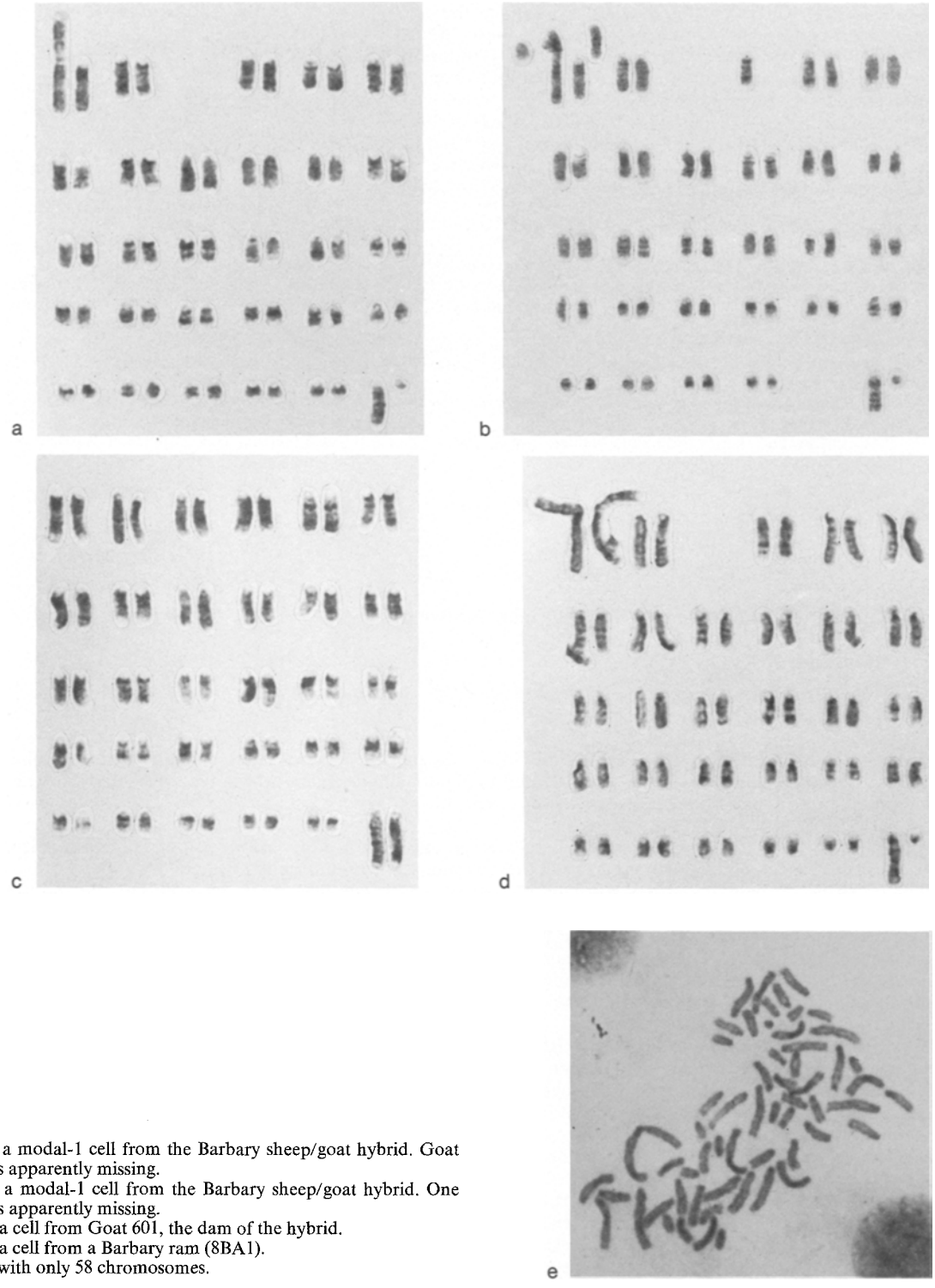
Buttle and Hancock[10] found aneuploidy in sheep/goat hybrid embryos; but Hancock and Jacobs[11] established the expected modality in others between 24 and 33 days gestation by short term culture. The latter was a study of embryos within the expected life-span of such hybrids. This work, in contrast was on the dead neonate and its living parents. The frequent loss of 1 chromosome from the hybrid cells may be characteristic of dying animals as it is of ageing ones[12,13], or it may require a different explanation, related to the hybrid character of the cells.

The death of hybrids is still unexplained. Success diminishes as phylogenetic differences increase, but is unpredict-

Chromosome numbers in cultured cells of the Barbary/goat hybrid (2), its dam goat 601 and Barbary rams 8BA1 and 5BA2

Animal	Tissue	Time in culture (days)	No. of cells	Chromosome count*					
				< −2	−1	Expected modal No.	+1	> +2	Polyploid (4 n)
Barbary/goat hybrid male (2)	Kidney and liver	12 (1ry)	70	25 (2)	16 (5)	19 (6)	1 (2)	0	3
Expected modal	Kidney	59 (2ry)	24	8 (2)	9 (5)	0 (3)	0	0	2
No. = 59	Kidney	69 (2ry)	51	14	17 (3)	15 (3)	0	0	2
Barbary ram 5BA2	Kidney	30 (2ry)	50	19	2	27	1	0	1
Barbary ram 8BA1	Skin	9 (1ry)	50	12	3 (2)	31 (2)	2	0	0
modal No. = 58	Skin	21 (2ry)	50	16 (1)	5 (2)	26 (2)	0	0	0
Goat 601 modal No. = 60	Blood lymphocytes	3	50	4	6 (1)	40 (1)	0	0	0

* The number of cells in which the count was doubtful is given in brackets, beside and in addition to the first total.



a Karyotype of a modal-1 cell from the Barbary sheep/goat hybrid. Goat chromosome 3 is apparently missing.
b Karyotype of a modal-1 cell from the Barbary sheep/goat hybrid. One chromosome 4 is apparently missing.
c Karyotype of a cell from Goat 601, the dam of the hybrid.
d Karyotype of a cell from a Barbary ram (8BA1).
e A hybrid cell with only 58 chromosomes.

able. Successful hybridizing of the horse (*Equus caballus,* 2n = 64; 28 metacentrics; NF = 94) and the donkey (*Equus asinus,* 2n = 62; 38 metacentrics; NF = 104) shows that differences in the fundamental number of arms (NF) and the number of Robertsonian translocations are not critical. The Barbary sheep and the goat have the same fundamental number (60) of arms, and the G-banding patterns of these are broadly similar[14]: the difference is in 1 pair of metacentric chromosomes but there is a bar to hybridization. No conceptions have been reported between Barbary and domestic sheep (*Ovis aries,* 2n = 54; 6 metacentrics; NF = 60)[3] but fertile hybrids occur between domestic and Afghan wild sheep (*Ovis ammon cycloceros,* 2n = 58; 2 metacentrics; NF = 60) which has a karyotype superficially like that of the Barbary sheep[4,15].

This is an intrageneric cross but living sheep/goat hybrids[16-18] illustrate the viability of intergeneric crosses. Genetic rearrangements have been suggested by Chandley et al[19] to explain infertility in the male mule *(Equus asinus* × *Equus caballus)* and the hinny *(Equus caballus* ×

Equus asinus) where abnormalities of synapsis at the primary spermatocyte stage interrupt spermatogenesis. Rearrangements in these viable hybrids include the position of the centromeric heterochromatin[20], but quantitative measurements have not yet been published. In the present case there is a clear difference in the size of the C-bands in the 2 species and quantitative measurements in the hybrid and its parents are being made. At present the significance of centromeric heterochromatin, if any, in connection with hybridization, is not understood.

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High IgM levels in women coincide with reproductive phase

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Summary. Quantitation of IgM in 875 individuals ranging in age from 2 to 95 years revealed that levels in females increased steadily until 15 years of age, remaind high until 40, decreased during the forties and fifties and remained stable after 60. Levels in males remained stable after 2 years of age.

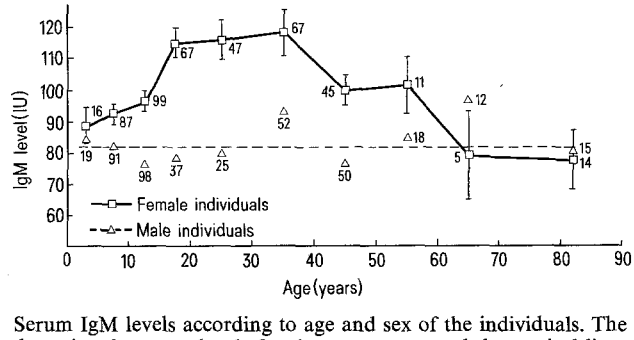
Among the 5 classes of immunoglobulins, IgM is the only one that has repeatedly been shown to be higher in females than in males[1-4]. The number of X chromosomes appears to have an effect because in XO females the IgM level equals that of males and in XXY males it equals that of females[5]. Furthermore, immunoglobulin studies on parents and offspring supported the hypothesis that the X chromosome carries quantitative genes for IgM[4].

Although general agreement seems to exist concerning the higher levels of IgM in women than in men, the duration of this sex difference seems not to have been documented. Our population studies on immunoglobulin levels provide pertinent information on the sex influences on IgM according to age of the individual. This information is summarized in the current report.

The individuals studied were obtained through the Medical College of Virginia Hospital and from the Tecumseh Community Health Study[3,6]. Both sources represented approximately average human populations. In Tecumseh it included the study of a whole community and in Virginia the individuals studied were close relatives of mothers who were in the hospital for delivery during the years 1961-1963 and who lived in the City of Richmond and surrounding counties. A total of 875 individuals, 417 males and 458 females of the black and white populations were included in the study. The individuals ranged in age from 2 to 95 years. To correct for the previously recognized higher mean IgM levels in blacks[6], their levels were multiplied by a factor of 0.89 to bring them to the same mean level as whites. This appeared feasible because blacks and whites displayed practically identical frequency distributions as was shown elsewhere[6]. IgM was quantitated by radial diffusion techniques under standardized conditions with commercially available plates[6].

The IgM levels according to age and sex are shown in the figure. The levels for males fit well to a linear regression line ($Y = 81.96 + 0.0045\ X$) the slope of which is very close to horizontal. None of the means for the various age intervals is significantly different from the grand mean ($p > 0.05$).

IgM levels in girls show a gradual increase up to age group 10-14. The increase is steep from this age group to that 15-19 years of age. A check of the annual means revealed that a rapid increase took place at 14-15 years of age. Each of



Serum IgM levels according to age and sex of the individuals. The data give the mean levels for the age groups and the vertical lines with crossbars represent SEM for females. The group on the far left includes children 2-4 years of age and that on the far right includes all individuals 70-95 years of age. The numbers in the figure represent the numbers of individuals in the age groups.