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Y chromosome variants in cattle *Bos taurus* and *Bos indicus*

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Summary

It is shown that comparison of the size of the Y chromosome between individuals may be made as reliably by computation of measurement relative to the X chromosome as by proportionation relative to the genome in the cell. By either method agreement was found with previous studies : first in placing the Y in the size range, for the cattle karyotype, between autosomes 22 and 26 ; second by finding the Y in the Charolais breed to be larger than other breeds. The value of the C-band method for recognition of the Y in *Bos indicus*, in particular, is reaffirmed and acridine orange is used to confirm the hypothesis of pericentric inversion as the basis of the relationship between the Y of *Bos indicus* and that of *Bos taurus*. The G-band pattern showed seven discernable regions in either species, so that the terminal part of the q arm in *Bos indicus* is homologous with the p arm in *Bos taurus*. The overall size and centromeric index of the Y are defined for each of 18 breeds of *Bos taurus* and 8 breeds of *Bos indicus*. It was found that the Y might be expected to be distinctive in certain breeds or groups : *Afrikander, Augus, Charolais, Friesian, Guernsey, Hereford, Jersey, Murray Grey, Shorthorn* and *Simmental*. Furthermore the Y of *Simmental* bulls was found to be of the same order of size as that of *Charolais*, although differing in centromeric index, whilst the *Romagnola* Y was found to be one of the smallest of *Bos taurus* Y chromosomes. The Y in *Bos indicus* was found to have short p arms in a subtelocentric conformation, in a select group of *Sahiwal* ; other breeds also had subtelocentric rather than terminal point centromere in the Y. The Y is established as a marker for paternal descent in defined cases.

I. - Introduction

The first description of the karyotype of cattle, using hypotonic treatment of cultured embryo cells, was by MELANDER (1959) who confirmed earlier determinations of the diploid number 2n = 60 and noted the metacentric form of the sex chromosomes in *Bos taurus*. CROSSLEY & CLARKE (1962), using blood cultures, found the Y to be a submetacentric for several unspecified breeds of British cattle.

KIEFFER & CARTWRIGHT (1968) described the Y chromosome of *Brahman* and *Santa Gertrudis* breeds as acrocentric. The karyotype of a presumptive pure-bred *Bos indicus* breed was recorded in studies of *Sahiwal* cattle in Australia by HALNAN (1971)

and in India, together with *Red Sindhi,* by GUPTA, SINGH & RAY-CHAUDHURI (1974). The *Red Sindhi* in Australia was later found to have the same karyotype as that of the herds in India (HALNAN, 1976 i). Karyotypes of *Australian Brahman, Santa Gertrudis (King Ranch), Australian Milking* Zebu (AMZ), *Belmont Red* and *Afrikander* cattle were severally studied and reported showing the Y chromosome to be acrocentric in all those of *Bos indicus* paternity, excepting the Afrikander with a metacentric Y and presumptive *Bos taurus* male descent (HALNAN, 1971, 1972, 1976 i ; HALNAN & FRANCIS, 1976). In those studies the selection of the acrocentric Y chromosome from the autosomes was arbitrary.

GUPTA, SINGH & RAY-CHAUDHURI (1974) used C-banding to distinguish the Y chromosome in the *Sahiwal* and *Red Sindhi* cattle. POTTER & UPTON (1979) confirmed this and the earlier studies of the *Banteng* cattle (FISCHER, 1969 ; HALNAN, 1974). Thus C-banding is considered to be the method of choice for distinguishing the Y from the smaller autosomes in *Bos indicus.*

CRIBIU & POPESCU (1974) and CRIBIU (1973) have shown that the *Charolais* and *Montbeliard* have larger Y chromosomes than other breeds. POTTER & UPTON (1979) described the Y in a *Jersey* bull as metacentric rather than submetacentric. Nevertheless, there is as yet no overview for the morphology of the Y chromosome in cattle ; unlike the situation in human studies where Y polymorphisms are expected between races or individuals (MAKINO, 1975).

In studies in this laboratory it has frequently been found that the karyotype of an individual animal or the karyotypes of all the individuals in a select close-bred group or breed were distinctive and specifically recognisable, even without G-banding. This was often seen to be contributed to in part by the individuality of the Y chromosome. This paper describes the basis for those conclusions and adds to the collected work on cattle Y chromosomes.

II. - Materials and methods

1. *Animals*

Karyotypes were studied from blood lymphocytes of the following breeds of bulls, numbers indicate number studied : *Afrikander,* 9 ; *Angus,* 31 ; *Australian Illawarra Shorthorn* (AIS), 21 ; *AMZ,* 5 ; *Ayrshire,* 12 ; *Banteng,* 6 ; *Belmont Red,* 9 ; *Brahman,* 31 ; *Brahman* × various British breeds, 9 ; *Charolais,* 29 ; *Chianina,* 5 ; *Friesian,* 118 ; *Galloway,* 5 ; *Guernsey,* 9 ; *Hereford* (*Horn,* 59 and *Poll,* 120), *Jersey,* 9 ; *Lincoln Red,* 5 ; *Murray Grey,* 47 ; *Poll Shorthorn,* 7 ; *Red Poll,* 5 ; *Red Sindhi,* 4 ; *Romagnola,* 5 ; *Sahiwal,* 9 ; *Santa Gertrudis,* 15 ; *Shorthorn,* 2 ; *Simmental,* 5 ; *South Devon,* 2 ; Zebu & British × *Banteng,* 6. A total of 600 bulls.

2. *Techniques*

All the results were derived from studies of the metaphase chromosomes of peripheral blood culture as previously described (HALNAN, 1977). Preparations were

stained by orthodox Giema's stain, G-Band (HALNAN, 1976 ii & iii) and C-Band, modified to local conditions (POPESCU, 1973 ; GUPTA *et al.*, 1974) ; photographed and printed to a final magnification for working of 4 000 ×, for measurement and karyotyping.

Orthodox staining provided the core of the measured material described. In the case of every animal at least thirty metaphase cells were analysed. Where a count was made of cells according to sex, as for example in the case of chimeras or mosaics, it was found that the definitive sex of the cell could not be determined in every cell due to either overlapping or probable breaking of the cell with concomitant chromosome loss. A standard was set for the assayable cells : being no more than five overlappings and numerical completeness. Under this criterion both sex chromosomes would be expected to be able to be visualised in 87 p. 100 of female cells and 72 p. 100 of male cells according to determinations in *Bos taurus* (HALNAN, 1971).

3. *Measurement and statistics*

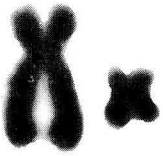
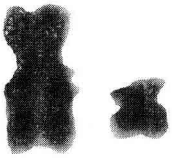
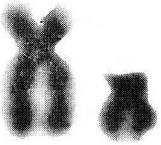
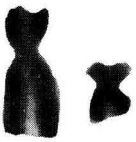
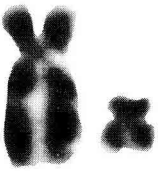
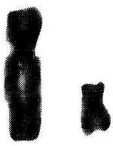
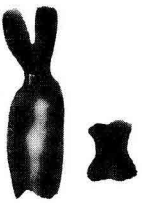
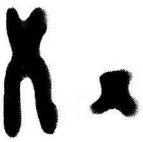
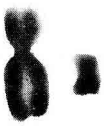
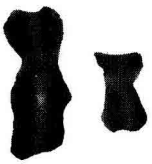
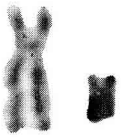
Measurements were made on photographs of orthodox stained preparations using a scale attached to a magnifier, calibrated to one tenth of a millimeter and engraved on a glass face, which was placed in contact with the photograph. The gauge, known as a Barton-eye gauge, was tested for reliability and accuracy by comparison with other methods (dividers and ruler, micrometer, ruler direct) and between different operators on the same photographs. Four sets of measurements were made on a cell, each by each operator, and analysed by Spearman's coefficient of rank correlation : they gave correlations of 98.5, 97 and 97 p. 100. The standard error of regression coefficient was 3, 3.5, 4 and 2.5 p. 100 using the gauge. Analysis of variance for regression by each of the four methods of measurement gave F values above 832 for 59 degrees of freedom. The tests in earlier work have been previously described and were more extensive than those outlined here (HALNAN, 1971).

The measurements were translated into relative size for the chromosomes by computation to parts per centum of the genome or total length of all the chromosomes. Then, using these figures, the Y chromosome was expressed as a proportion of X and X + A1 (CRIBIU, 1975) in both cases significant difference was based on the criteria suggested by MATERN & SIMAK (1967).

Results

In preparations where the chromosomes were resolved by orthodox Giemsa staining in all of the *Bos taurus* breeds in the study, the *Afrikander* and the *Belmont Red* (derived from *Bos Taurus*), the Y chromosome was identifiable as a small metacentric or submetacentric chromosome. The significant types are shown, by breed, in figs. 1 & 2.

The Y chromosome of the pure *Bos indicus* breeds *(Sahiwal and Sindhi)* and the *Brahman, Santa Gertrudis* and *Belmont Red* (derived from Zebu males) was generally described as acrocentric (fig. 2).

a  AMZ	b  ANGUS	c  HYPERTROPHIC ANGUS	d  CHAROLAIS
e  CHIANINA	f  FRIESIAN	g  GUERNSEY	h  HEREFORD
i  POLL HEREFORD	j  HOLSTEIN	k  JERSEY	l  MURRAY GREY
m  RED POLL	n  ROMAGNOLA	o  SIMMENTAL	p  SHORTHORN

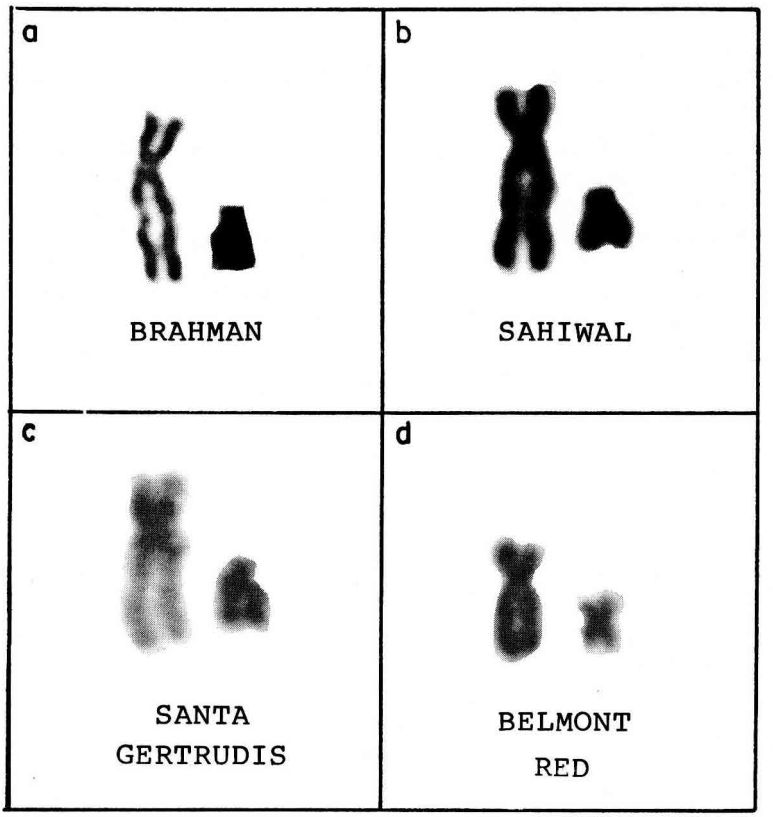


FIG. 2

The X and Y chromosomes from three breeds of Bos indicus *(a, b, c) and the* Belmont Red *(d) from an* Afrikander *bull. The conditions of printing are the same as for fig. 1.*

Les chromosomes X et Y de 3 races de Bos indicus *(a, b et c) et du* Belmout Red *(d) issu d'un taureau* Afrikander. *Même agrandissement qu'en fig. 1.*

←——— FIG. 1

The X and Y chromosomes each from the same cell from 16 breeds (a to p) of Bos taurus *bull to demonstrate relative size and morphology. Each was enlarged to provide optimum detail and therefore each breeds chromosomes are slightly different in magnification.*

Les chromosomes X et Y chacun de la même cellule de 16 races (a à p) de Bos taurus *afin de montrer la taille relative et la morphologie. Chaque vue a été agrandie de manière à donner le maximum de détail cependant qu'il y a entre les races des différences dans les rapports d'agrandissement.*

The Y in Banteng (*Bos sondaicus, Bibos banteng* or *Bali* cattle) was indistinguishable from that of the *Friesian* breed but insuffucient numbers were measured to include in the tables. The same is so for *Shorthorn,* like the AIS ; *South Devon,* like *Guernsey* ; *Brahman* crosses and the Zebu & British × *Banteng* as for paternal breed of origin.

The morphology of the Y, according to the rules proposed by LEVAN *et al.* (1964), was found to vary between breeds as shown in figs. 1 & 2 ; tables 1 & 2. The *Bos taurus* Y varied in centromeric index, expressed as P or * the percentage length of the p arm relative to the sum of the lengths of the p and q arms (P or * = p/p + q), from metacentric to submetacentric or 49 p. 100 to 27 p. 100. The size of the Y was found to vary between breeds. Expressed as a percentage of the diploid genome or as a percentage of the X, when measurements were corrected relatively by per centum of the genome, the Y was found to be typical in size for a particular breed. Over all animals studied it varied between 1.0 p. 100 and 1.5 p. 100 of the genome. The most common size being close to 1.2 p. 100.

TABLE 1

Relative size and arm ratios of the Y chromosome in select breeds of cattle to show Y : X is not significantly different from Y : X + Al.

Taille relative et rapport des bras du chromosome Y dans un échantillon de races choisi pour montrer que le rapport Y : X n'est pas significativement différent de Y : X + Al.

Breed - Number		Size % genome			Relative %			% P : P + Q of Y
		X	Y	Al	X : Al	Y : X + Al	Y : X	
Angus	(20)	2.97	1.1	2.94	101	19	37	40
Angus hyper.	(5)	2.87	1.2	2.96	97	21	42	40
Charolais	(15)	2.67	1.36	2.81	95	25	50	30
Simmental	(5)	2.85	1.4	2.94	97	24	49	36
Hereford poll	(40)	3.13	1.22	2.98	105	20	39	49
Friesian	(30)	2.97	1.2	2.97	100	20	39	37
Red poll	(5)	2.8	1.3	3.07	91	22	44	49
Jersey	(7)	3.13	1.07	2.76	114	18	34	44
Guernsey	(5)	2.93	1.05	2.84	103	18	36	47
Sahiwal	(8)	2.79	1.18	3.00	95	21	44	16

Note : The percentages are corrected to nearest whole number.

Table 1. Gives the mean figures derived from studied of the numbers of animals in parenthesis in selected breeds. It demonstrates the mensurate parameters, length and centromeric index, for the Y in relation to the X and shows that the largest autosome varies so little as not to significantly alter the relative size of the Y if added to the X in calculation. Thus the size and proportions of the Y, in relation to the X, were used to construct a graphical figure or analogue, table 2, to show visually the relative characteristics of the Y in different breeds. There is a descending size and an

increasing index suggesting a form of reciprocity such that : as the Y increases its little arm proportion seemingly decreases. The relative measurements of size per centum may be read off the top.

TABLE 2

Y chromosome centromeric index (*) and relative size as proportion p. 100 of the X (Y). Figures derived from lengths as parts p. 100 of the genome : see text.

Index centromeric du chromosome Y (*) et taille relative exprimée en p. 100 de X (Y). Chiffres déduits des longueurs exprimés en p. 100 du génôme, voir texte.

Breed	No.	p. 100 6 10 15 29 30 33 34 36 37 38 39 40 41 42 44 45 47 49 50
Charolais	15	* Y
Simmental	5	* Y
Poll shorthorn	5	* Y
Ayrshire	9	* Y
Red poll	4	Y *
Galloway	5	* Y
Angus hypertr.	5	* Y
A.I.S.	10	* Y
Friesian	15	* Y
Hereford poll	20	Y *
Murray grey	20	Y *
Angus	15	Y *
Hereford	10	Y *
Guernsey	5	Y *
Jersey	5	Y *
Chianina	5	Y Y
Lincoln red	4	* Y
Romagnola	4	Y *
Afrikander	5	Y *
Jersey-Sahiwal	2	* Y
Belmont red	5	* Y
Sahiwal	9	*
Amz	2	* Y
Red sindhi	4	* Y
Brahman	10	* Y
Santa gertrud.	10	* Y

Note : The figures across the top are true relative cent size of the Y to X and also the petite arm length as a per cent of the whole length of the Y. The figures after each breed are the number of different animals whose cells were used to produce the mean.

The *Charolais* and the *Simmental* breeds were found to have the largest Y chromosomes, furthermore, whilst similar in size they could be distinguished by difference in centromeric index (P or *). The *Romagnola* breed had one of the smaller Y chromosomes recorded.

On the criteria of size and the centromeric index together it was found that not only in *Charolais* and *Simmental* but also in other breeds the Y was characteristic. The *Charolais* has the largest Y on relative size at 50 p. 100 but one of the smallest indices at 30 p. 100. The *Jersey* is almost the reciprocal with 34 p. 100 for size and 44 p. 100 for index. It was found that the visual impression of symmetry in the index was subject to about a 5 p. 100 error, thus when a chromosome is measured an apparent median point centromere will be found to be median region. Constancy of the Y was found in crossbred stock such that the Y in *Murray Greys* was identical to the Y of *Angus* the breed of paternal origin.

FIG. 3

Orthodox Giemsa's stain karyotype of a Sahiwal *bull shows presumptive identification without banding methods.*

Karyotype d'un taureau Sahiwal *obtenu par un Giemsa orthodoxe et montrant des possibilités d'identification sans utiliser les méthodes des bandes.*

In *Bos indicus* the Y was always acrocentric fig. 2 & table 2. That is to say the centromeric index where p arms could be discerned, was less than 20 p. 100. It was found that in the select group of Sahiwal studied the Y was consistently subtelocentric (acrocentric not telocentric) in the other breeds this subtelocentric conformation was less marked and less consistent between cells. The Y was repeatedly recognised in the first instance without resort to C-banding as shown in fig. 3 an orthodox karyotype from the *Sahiwal.* The positive identification of the Y chromosome in *Bos indicus* is facilitated by C-band staining fig. 4. The measurement of the Y was less precise after C-banding than with orthodox stain. There was no hesitation that the size of the Y for *Bos indicus* compared to A22 to 26 and did not differ from *Bos taurus.*

In preparations treated with acridine orange (BOBROW & MADAN, 1974) the *Bos taurus* Y was found to have a bright fluorescent yellow segment for most of the p arm and the *Bos indicus* Y showed the same effect of fluorescence in the t region of the q arm figs. 5 & 6. This response in colour was also found in the centromeres of the autosomes and in *Bos indicus* in the terminal region of a limited number of autosomes (HALNAN *et al.*, 1981).

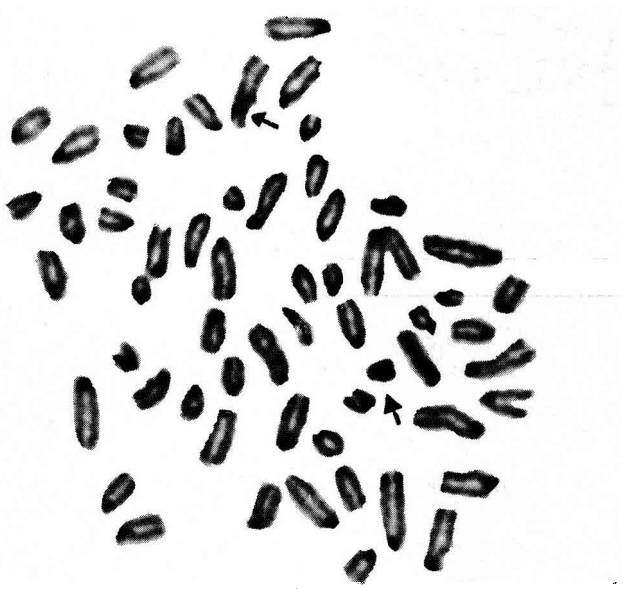


FIG. 4

C-Band delineating X and Y, arrowed, without the dark centromeric staining which distinguishes them from the autosomes. This was prepared by heat denaturation only.

Image en bandes C qui permet de distinguer X et Y (fléchés) par l'absence de centromère foncé. Préparation obtenue avec une simple dénaturation par la chaleur.

The G-banded karyotype from a *Sahiwal* bull is presented in fig. 6 and from a *Murray Grey* in fig. 7. Examples of the Y from *Bos indicus* (*Sahiwal* and *Brahman*) and from *Bos taurus (Murray Grey)* together with the interpretative diagrams (*Bos taurus* after LIN *et al.*, 1977) are presented in fig. 8. Fundamentally seven discernable landmarks in the Y were found here in both species. Whilst the G-banding does not serve to identify the Y as readily as C-band staining it is in agreement with the acridine orange results showing a darker « t » region for the q arm in *Bos indicus*, an increased pale region 21 merging with q13 of *Bt* : the homology noted earlier.

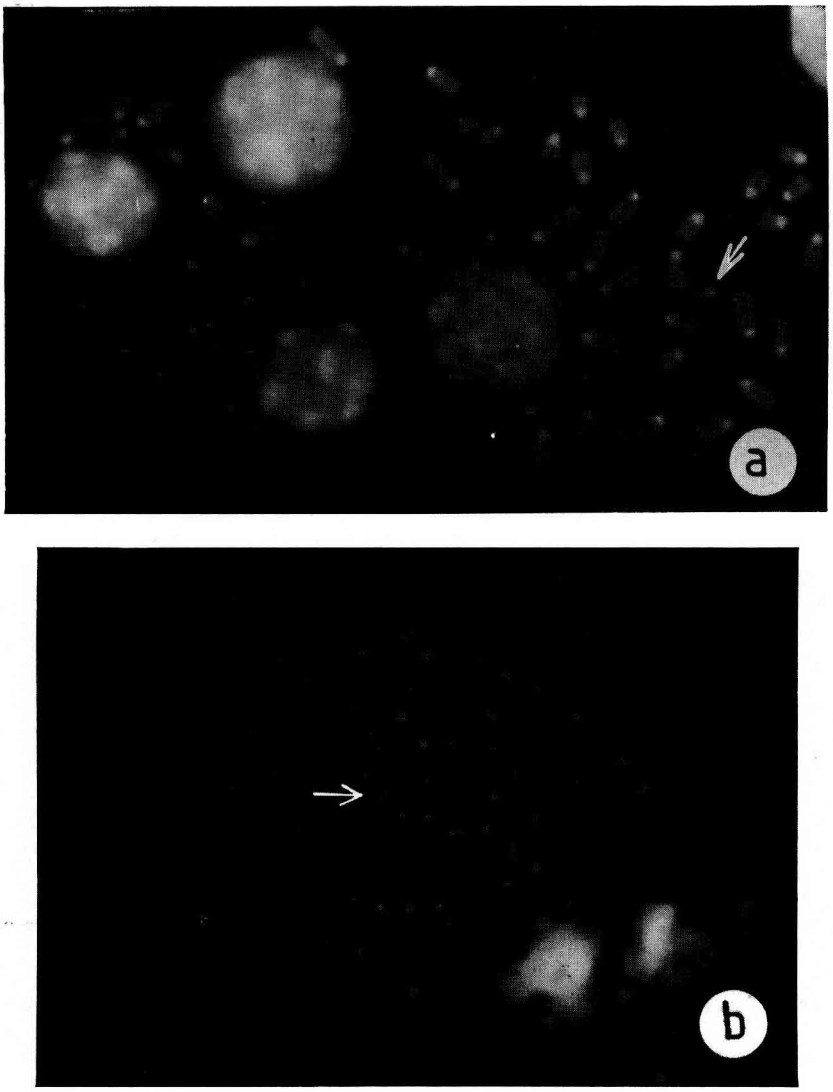


FIG. 5

a) Acridine orange fluorescence from Bos indicus *showing only dull emission in X, bright centromeric fluorescence for the centromeres of all the autosomes and bright emission in the subterminal part of the Y (arrowed).*

b) Acridine orange on Bos taurus *showing the bright fluorescence on the p arm of the Y chromosome (arrowed).*

a) Fluorescence en acridine orange de Bos indicus *montrant seulement une émission grise en X, une fluorescence centromérique brillante pour les centromères de tous les autosomes et une émission brillante dans la partie subterminale de Y (fléché).*

b) Fluorescence en acridine orange de Bos taurus *montrant une fluorescence brillante du bras p du chromosome Y (fléché).*

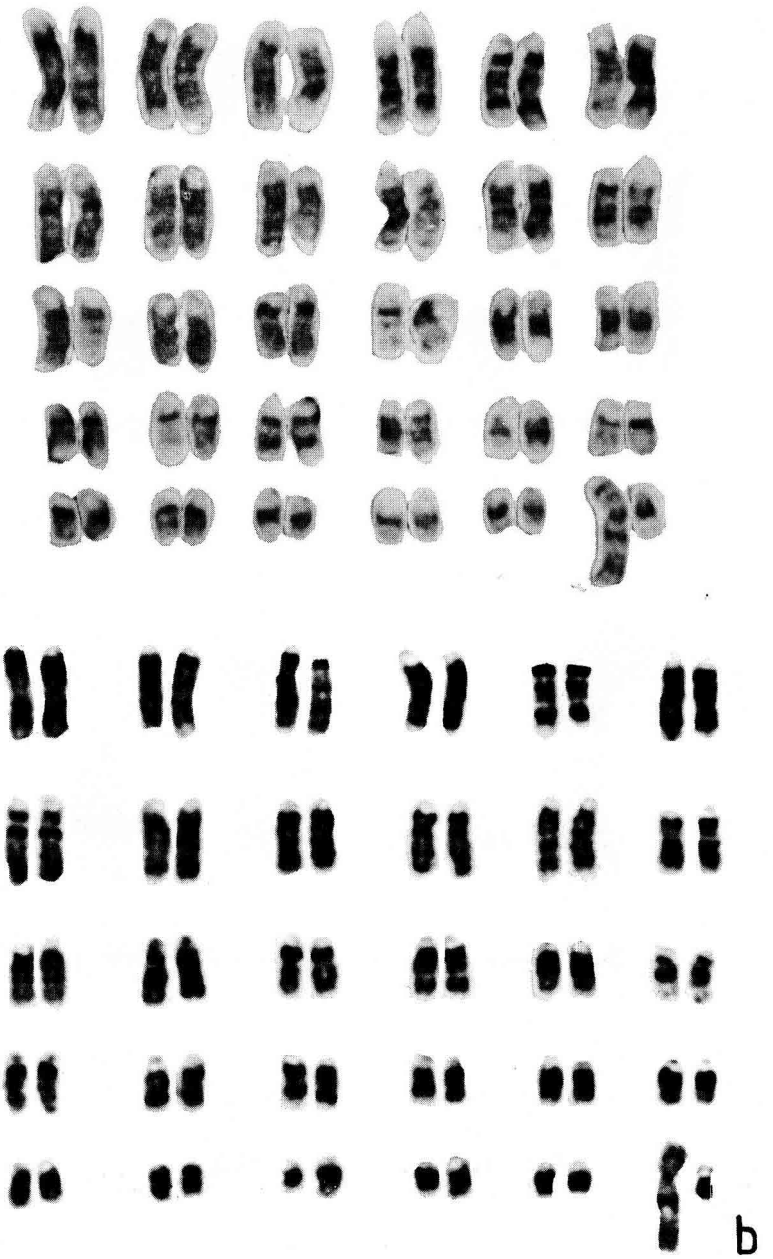
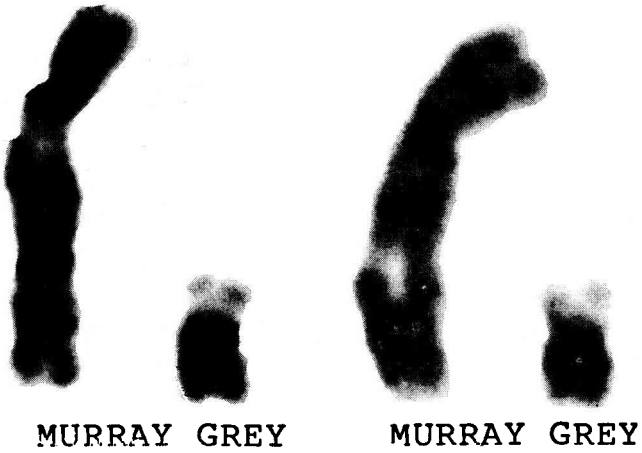
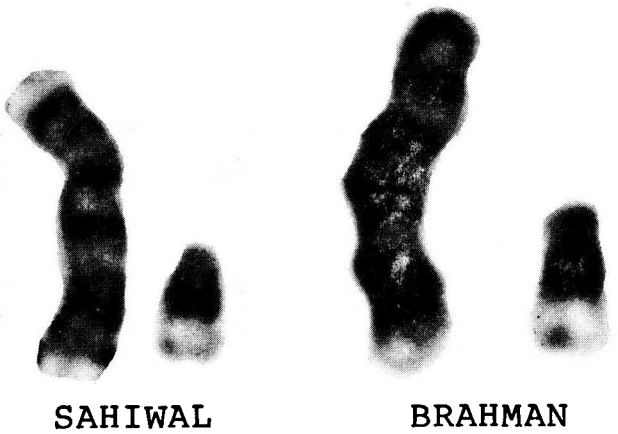


FIG. 6

G-Band karyotypes from Bos indicus (Sahiwal) *(a) and* Bos taurus (Murray Grey) *bulls (b).*

Karyotypes en bande G de taureaux Bos indicus (Sahiwal) *(a) et* Bos taurus (Murray Grey) *(b).*





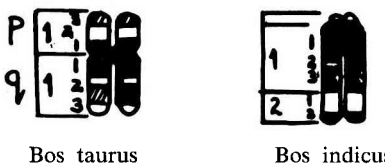


FIG. 7

Select G-Band Y chromosomes with X from the same cell representative of both species (a, b, c, d) together with interpretative (e).

Chromosomes Y en bandes G avec le X de la même cellule sélectionnés pour représenter les deux espèces (a et b Bos taurus, *c et d* Bos indicus*) avec leur interprétation (e).*

III. - Discussion

The estimation of relative size of the Y, chromosome has been simplified here, both in original measurement and in calculation of relative proportion, being the application of methods developed and tested in an earlier study (HALNAN, 1971). The sizes of the Y chromosomes of some of the breeds studied here were in close agreement with the conclusions of other authors in particular for the *Charolais* (CRIBIU & POPESCU, 1975 ; CRIBIU, 1975) and the *Romagnola* and *Chianina* (DE GIOVANNI & CRIBIU, 1977) for previously proposed estimates from animals in other national herds. Similarly the descriptions of morphology for the Y derived from our material were in harmony with the findings of other authors such as for *Jersey* (POTTER & UPTON, 1979).

Since the results here, the previous studies by this laboratory and the results of numerous other authors provided estimates of size which did not differ (GUSTAVSSON, 1969 ; HALNAN, 1971 and POPESCU, 1973) and since the method of relative computation used here markedly reduces the laborious measurement of all the chromosomes, it is suggested that the Y : X computation has potential for routine laboratory service.

The proposal that the Y chromosome is not one of the smallest is the restatement of the well established observations of the earlier workers in the field, it is emphasised that this is the case in the face of the occasional tendency to underestimate its size. At as true modal length of 3 microns the Y has a potential of ten resolvable segments in theory ; in practice no more than seven landmarks are likely to be defined using the G-band method.

The size and relative arm lengths of the Y chromosome are determined for 18 breeds of *Bos taurus* and 6 breeds of *Bos indicus* for the first time comparatively in one text, the first characterisations by breed being by CRIBIU (1975). This has made possible the proposal that in specific cases the Y chromosome is sufficiently distinctive to be used as a reference for the determination of disputed paternity by breed. The dependability of the estimates of relative size and proportion has been established by statistical tests : first using the measurement and computation of relativity for the whole cell or genome and then deriving the more simplified method using fewer chromosomes.

It is shown that the Y chromosome for *Charolais* and *Simmental* could not be mistaken the one for the other, neither should either of them be confused with many british breeds, for example : *Angus, Friesian, Guernsey, Hereford, Jersey* or any of the asiatic breeds. Furthermore, there is distinct difference in size between some breeds of the continental European cattle. Nevertheless, the size of the Y chromosome was always found to be within the range comparable to autosomes 22 to 26 so that the *Charolais* Y would be in the 22 zone, whereas the *Jersey* would be found in the 26 grouping. This presents the question of the significance of the difference in size which MATERN & SIMAK (1967) considered to be notable where it exceeds 8 p. 100 of the average length of the two chromosomes. The difference in the relative length of the Y in *Charolais* and *Angus* was more than 21 p. 100 making the distinction, in size alone, pronounced. It is of interest that the *Murray Grey*, product of Angus male line and original *Shorthorn* cow, was found to have a Y indiscernable from the

Angus (HALNAN, acd). Further to which the likeness between the *Charolais* × *Angus* cross and the *Greys* calls for an independent test for which the Y difference seems to be a candidate, although not the only factor.

C-banding has been used in cattle studies for the determination of the distribution of constitutive heterochromatin and for the identification of the Y chromosome (POPESCU, 1973 ; POPESCU & BOSCHER, 1974 ; GUPTA *et al.*, 1974 ; POTTER & UPTON, 1979). In *Bos indicus* C-banding is indispensable for the definite recognition of the Y, however, fluorescent staining with acridine orange also facilitates recognition, whilst G-banding provides the means of seeing alterations in finer structure. With the C-band method the Y has the dark uniform staining throughout, as previously described by the authors noted above, the similarity in the overall density of stain to the X as mentioned by POPESCU & BOSCHER (1974) is helpful in reading fresh preparations.

Morphologically the Y of all *Bos indicus* breeds studied here is considered to be acrocentric, which means that the centromere will be found at a variable distance from the terminal point of the small arm ; sometimes there will be no visible chromatin beyond the centromere and at other times the Y will have distinct p arms. The criteria for the definition of terms have been proposed by LEVAN *et al.* (1964) so whether the anglicised expressions or greek-stem terms are adopted their rules are helpful and to be recommanded as clarifying thought.

In optimum preparations in every *Sahiwal* bull studied by us the Y chromosome has been visibly subtelocentric, a definition which we do not see as significantly differing from acrocentric according to POTTER and UPTON or POTTER *et al.* (1979). In other breeds of *Bos indicus* the Y was for practical purposes indistinguishable from the telocentric state. These points serve to raise the question of possible Y polymorphism in *Bos indicus* in contradistinction to the theme here which proposes relative stability of the Y in *Bos taurus*. It follows that a definition for the line of demarcation in centromere index which would place the chromosome in the asiatic cattle class is desirable. Thus, it is proposed that the line be set at the ratio p : q of 2 : 8, wherein p will usually be less than 2 and q greater than 8. There seems to be a natural mensurate gap between the 20 p. 100 and 30 p. 100 zone.

The confirmation of the concept, proposed by BASRUR (1969), of the relationship of the Y of *Bos taurus* to the Y of *Bos indicus* being a pericentric inversion is reiterated here (HALNAN *et al.*, 1981) based on the use of acridine orange it adds a dimension to the interpretation of the G-band pattern in the asiatic breeds and provides an additional method of examining the Y in the European breeds. A dark band in the telomeric region of the *Bos indicus* Y, by G-banding, was not found in *Bos taurus* and appears to be the expected corollary to the bright fluorescent tip with acridine orange. The G-band pattern has otherwise been delineated by LIN *et al.* (1977) indicating a centromeric region and three regions in each arm in *Bos taurus*. The proposal for *Bos indicus* recognises the same number of regions leaving one on the p arm, which may not be resolved in many cases and finding five in the q arm. Since the completion of this work we note with pleasure that PINHEIRO *et al.* (1980) described the two types of Y in the *Ibage* cattle showing the same rearrangement between the acrocentric and metacentric forms.

CRIBIU & POPESCU (1975), in some measure, presupposed the possibility that the Y chromosome might be characteristic for certain breeds by their delineation of the unusually large size of the Y in certain of the european breeds. This study derived

from accumulated data over a period of eleven years has extended that primary concept to hypothesise that there is a grouping of breeds which do have similar Y chromosomes and which may have a similar origin in stem stock from which they were derived by human selection. This is of course compatible with the concept of Y polymorphism in man (MAKINO, 1975) if it be accepted that in man breeds have not been defined in relation to variation in the Y.

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Résumé

Variations du chromosome Y chez le bœuf domestique (Bos taurus) *et le zébu* (Bos indicus)

Deux critères différents ont été utilisés pour calculer la longueur relative du chromosome Y chez les bovins : le rapport X/Y et une fonction de la longueur totale des chromosomes du complément. Ces deux méthodes sont aussi fiables l'une que l'autre pour comparer la taille du chromosome Y entre les différents animaux. Les résultats d'études précédentes ont été retrouvés : le chromosome Y a une taille comprise entre la 22e et la 26e paire des autosomes et le chromosome Y des *Charolais* est plus grand que celui des autres races. L'utilisation du marquage C pour reconnaître le chromosome Y chez *Bos indicus* est confirmée et l'emploi de l'acridine orange a conforté l'hypothèse d'une inversion péricentrique entre le chromosome Y du bœuf domestique et du zébu.

Le marquage G fait apparaître 7 régions sur le chromosome Y de chaque espèce. La partie terminale du bras long q chez le zébu est homologue avec le bras court p du bœuf domestique. Nous avons calculé la longueur totale et l'indice centromérique du chromosome Y pour chacune des 18 races de *Bos taurus* et des 8 races de *Bos indicus*. Dans certaines races ou groupes le gonosome Y est distinctif : *Afrikander, Angus, Charolais, Frison, Guernsey, Hereford, Jersey, Murray Grey, Shorthorn* et *Simmental*. De plus, le chromosome Y des taureaux *Simmental* a la même taille que celui des *Charolais*, quoique leurs indices centromériques soient différents ; parmi les différentes races de bœuf domestique, le chromosome Y des *Romagnoles* est le plus petit. Le gonosome Y du zébu possède des petits bras p dans un groupe sélectionné de *Sihuval*. Dans d'autres races de zébu, la position du centromère est subterminale plutôt que terminale. Le chromosome Y peut être considéré comme un marker de la descendance paternelle dans certains cas.

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