

International system for cytogenetic nomenclature of the domestic horse

Report of the Third International Committee for the Standardization of the Domestic Horse Karyotype, Davis, CA, USA, 1996*

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Received 1 July 1997; received in revised form and accepted for publication by H. C. Macgregor 6 August 1997

The history of domestic horse (*Equus caballus*) cytogenetics dates from 1912 when Kirillov reported the diploid chromosome number to be between 20 and 34 in male horses (see Power 1990). Later, Krallinger (1931) and Makino (1942) reported the number to be 64. Although this provided the correct chromosome number, the prevailing uncertainty was finally cleared in 1959 by Rothfels and co-workers who confirmed the correct chromosome number as $2n = 64$ (Rothfels *et al.* 1959). The horse has 13 pairs of metacentric/submetacentric and 18 pairs of acrocentric autosomes. The X chromosome is the second largest submetacentric, while the Y chromosome is one of the smallest acrocentrics.

During the 1970s, G-, Q-, C-, R- and NOR banding techniques were applied to horse chromosomes, and several arrangements of the chromosomes into a karyotype were presented (see Power 1990). The First International Conference for the Standardization of Banded Karyotypes of Domestic Animals held at Reading, UK, 1976, proposed a G-banded horse karyotype (the Reading Standard) with eight rows of chromosomes (Ford *et al.* 1980). Biarmed autosomes were arranged by decreasing

length in the first four rows. Acrocentrics were similarly arranged in the next three rows. The last row had only the sex chromosomes. This standard karyotype was used for several years. The lack of complete consensus among horse cytogeneticists led to a new standard (the Paris Standard) defined in 1989 (Richer *et al.* 1990). The chromosomes were arranged into two groups – non-acrocentrics and acrocentrics. Within each group the chromosomes were ordered by length. The sex chromosomes were placed in the middle of the karyotype, along with the smallest biarmed chromosomes. C-, R- and NOR banded karyotypes were also presented. The Paris standard karyotype was more compact, with relatively better band resolution than the Reading Standard.

Despite acceptance of the Paris Standard, the quality of the published banded images was a matter of concern. Furthermore, idiograms, band numbers and landmark descriptions were not provided, limiting the use of the standard to chromosome identification only. The need for schematic drawings and band designations became particularly obvious in 1988 with the first reports of physical gene mapping in horses (MHC: Ansari *et al.* 1988, Mäkinen *et al.* 1989; CRC: Harbitz *et al.* 1990; GPI: Chowdhary *et al.* 1992; PGD: Gu *et al.* 1992). Even though G-band idiograms and band descriptions (Maciulus *et al.* 1984) were available before these mapping efforts, difficulties were encountered in the precise definition of the band locations primarily because of the lack of consensus on landmarks and band numbers. Development of the physical and genetic

This report should be cited in text as ISCNH (1997). The complete citation for reference lists is: ISCNH (1997) International System for Cytogenetic Nomenclature of the domestic Horse, Bowling, A. T., Breen, M., Chowdhary, B. P., Hirota, K., Lear, T., Millon, L. V., Ponce de Leon, F. A., Raudsepp, T. and Stranzinger, G. (Committee), *Chromosome Research* 5: 000–000.

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linkage map of the horse is currently accelerating. Fluorescence *in situ* hybridization (FISH) technique has been used to localize genes (C3 and NORs, Millon *et al.* 1993; HBA, Oakenfull *et al.* 1993) and a number of microsatellite markers (Sakagami *et al.* 1995, Tozaki *et al.* 1995, Godard *et al.* 1996, Marti *et al.* 1996) to specific chromosomal regions. Recently, comparative painting (Zoo-FISH) has demonstrated homologies between individual human and horse chromosomes, defining precisely the physical boundaries of correspondence between the two genomes (Raudsepp *et al.* 1996). Furthermore, individual cases of chromosomal trisomies (28, Power 1987; 23, Klunder *et al.* 1989; 26 and 30, Bowling & Millon 1990) and translocations (tlq;3q, Power 1991; tX;15, Power 1987; t1;30, Long 1996; see also Halnan 1989) have been reported that define phenotypes associated with specific abnormal karyotypes. To show precise regions of chromosomal homologies between species, and band designations of the mapped markers and detected chromosomal aberrations, a horse idiogram defining regions, bands and sub-bands for individual chromosomes is urgently required. The Committee recommends that this standard be used by all groups working with equine cytogenetics and gene mapping, which would allow for a consensus reference for physical location of markers and more precise location of chromosomal breakpoints and rearrangements. At the First International Equine Gene Mapping Workshop, Lexington, Kentucky, USA, 1995, the groups working with horse cytogenetics and physical gene mapping highlighted the above needs and agreed to prepare an improved standard karyotype of G- and R-banded chromosomes. The karyotypes were to be supplemented with drawings of the chromosomes, defined landmarks and band numbers.

Aspects discussed and decisions made by the Committee

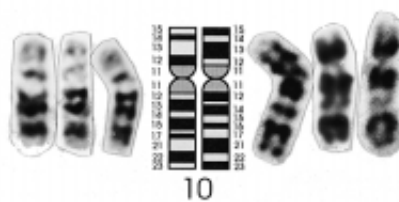
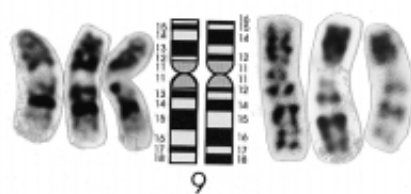
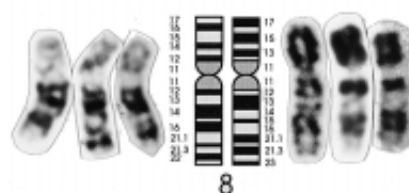
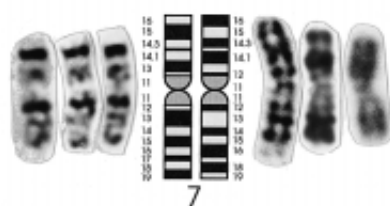
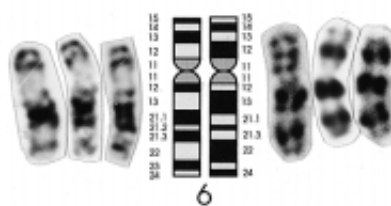
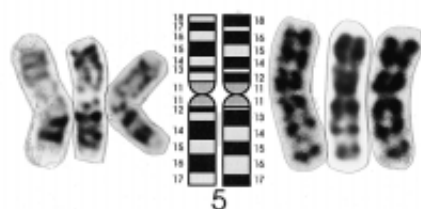
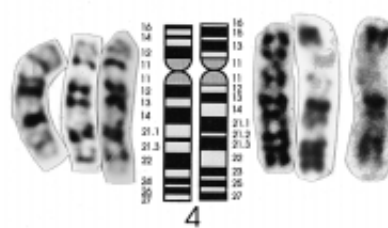
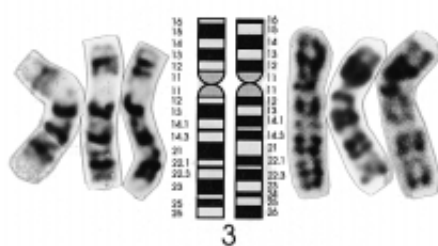
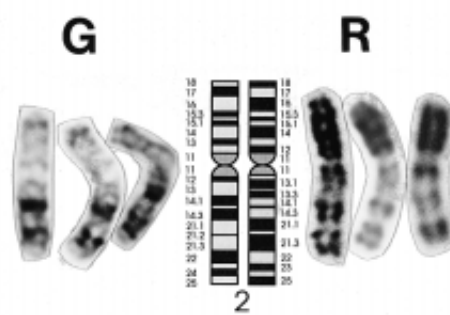
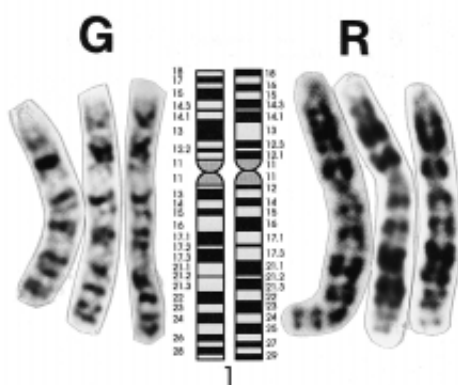
The Committee concentrated the discussions primarily on: (a) preparation of distinct G- and R-banded horse karyotypes, (b) description of individual chromosomes for both karyotypes and (c) preparation of idiograms of G- and R-banded chromosomes showing landmarks and band numbers. The committee adhered to the chromosome numbering system of the Paris Standard (Richer *et al.* 1990). GTG and RBG banding of the chromosomes was carried out as described earlier (Seabright 1972, Rønne *et al.* 1993). Figure 1 presents standard karyotypes for the two techniques used. To meet the needs of chromosome analysis at different resolution levels, the G- and R-banded karyotypes include chromosomes representing three levels of condensation varying between prometaphase and metaphase stage. Thus, for the standard karyotypes using either banding technique, three different cells provide a haploid set each. The chromosomes presented in Figure 1 are arranged such that each column contains chromosomes from the same haploid set.

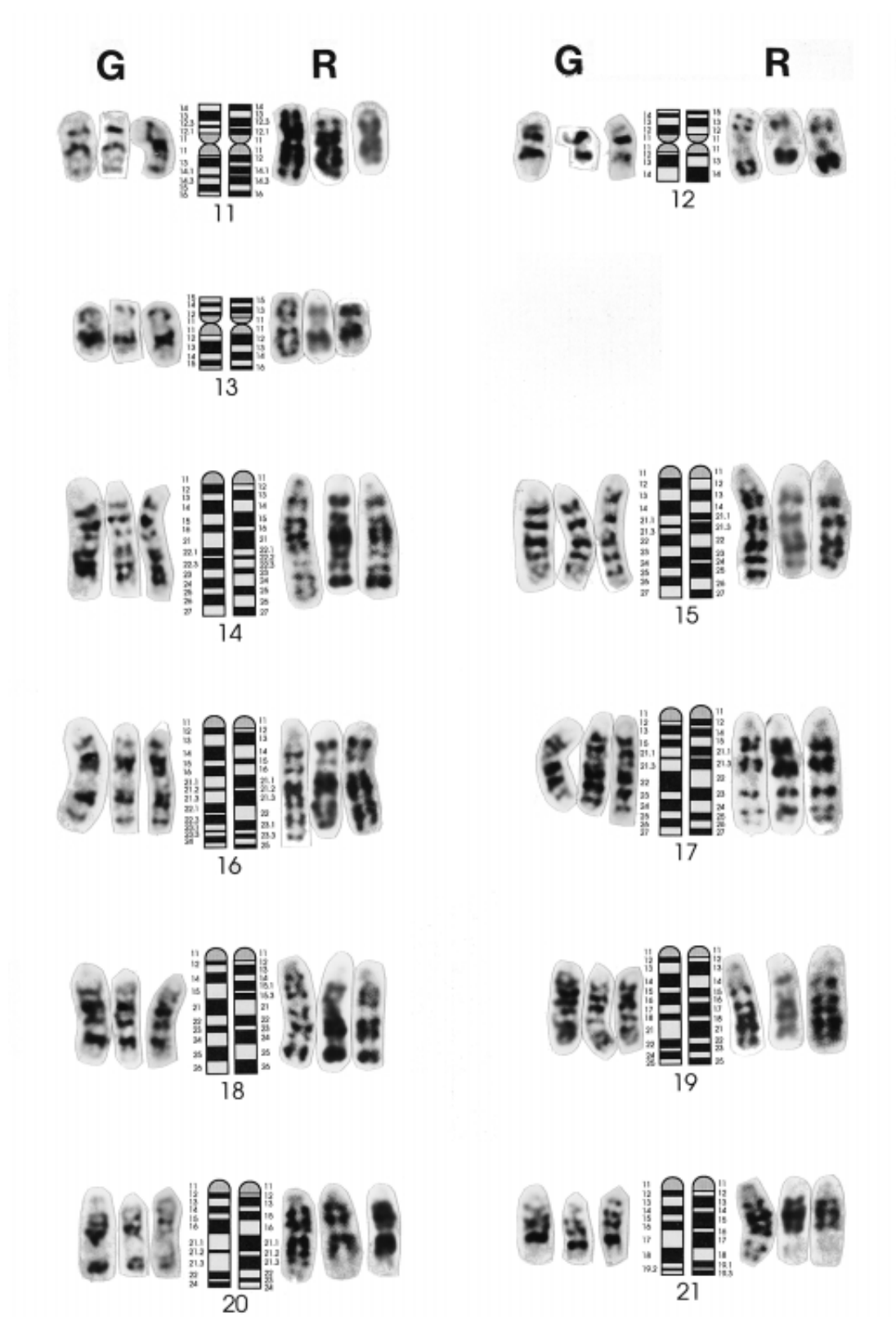
Idiograms for both G- and R-banded chromosomes were constructed using 10–20 well-banded metaphase spreads. Relative length measurements of horse chromosomes (Stranzinger 1980, Hansen 1984) were used for preparing the schematic drawings. The scheme for numbering regions and bands presented herein corresponds to the International System for Human Cytogenetic Nomenclature (ISCN 1995). Irrespective of the type of banding, the euchromatic regions were drawn as black and white, representing the positive and negative bands respectively. The heterochromatic regions, namely the centromeres, are shown as hatched areas. The size of the centromeres has been arbitrarily fixed for all the chromosomes. Centromeres form the first band (p11 or q11) on a chromosome or chromosome arm, and therefore the euchromatic bands begin with either p12 or q12. The only heterochromatic band known to be present at sites other than the centromere is on Xq (Buckland *et al.* 1976). This band (Xq21) stains positively with C-banding and is observed as a band of variable intensity in R-banding. Hence, in the idiogram, it is presented as a hatched region.

In the schematic drawings of individual chromosomes, landmarks were placed in those chromosomal areas where a prominent positive or negative band divided the chromosome/chromosomal arm into regions. The maximum number of regions on any chromosome/chromosomal arm was not more than two. Attempts were also made to restrict the number of bands within a region to nine. In some cases, complete reverse correspondence between the G- and R-banding patterns was not observed, so the bands in one of the idiograms were grouped as sub-bands. For example, R-banding patterns on chromosome 18 show three bands (15.1, 15.2 and 15.3) corresponding to band 15 observed with G-banding. Similarly, on chromosome 23, bands 15.1, 15.2 and 15.3, observed through R-banding, correspond to a single band (15) in G-banding patterns.

The description of G- and R-banded chromosomes (Tables 1 and 2) details the general appearance of individual equine chromosomes and enables one to follow correspondence with the schematic drawings. Depending on the width, the bands are classified as narrow, medium or broad. The intensity of the positive bands on both G- and R-banded chromosomes has been classified as light, medium or dark staining. If a band is clearly visible and is well identified in the background of neighbouring bands, it is referred to as distinct. However, if a band is characteristic for a chromosome and is striking at the first glance, it is referred to as prominent.

The band resolution of the karyotypes and the schematic drawings were prepared keeping in mind their future use both in cytogenetic and in genome analysis. The number of bands in the G- and R-banded idiograms per haploid set are 434 and 438, respectively, which corresponds to medium- to high-resolution karyotypes/schematic drawings in other species. Although higher band resolution (400 bands in G- and 550 bands





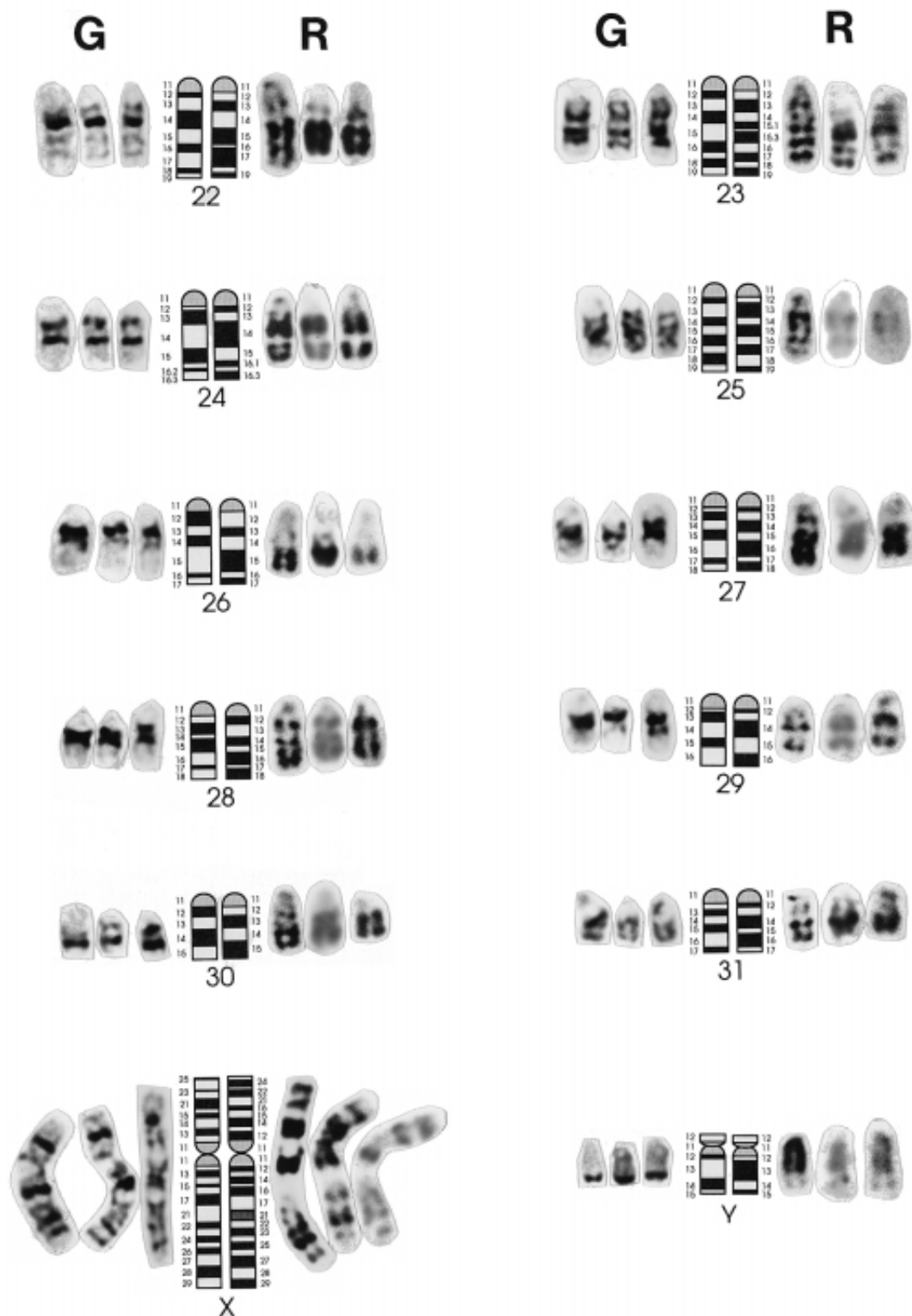


Figure 1. Diagrammatic representation of G- (left) and R-banded (right) horse chromosomes. Three examples of chromosomes obtained from either banding techniques are presented besides the ideograms. The chromosomes have been arranged numerically for the sake of convenient presentation. However, the karyotype format recommended by the Paris Standard (Richer *et al.* 1990) should be followed.

Table 1.

G-bands		Description
Chromosome	Arm	
1	p	Narrow positive band close to the centromere (12.2); prominent dark-staining proximal band (13), broad negative central region (14.1 and 14.3); two distal positive bands (15 and 17), of which the former is dark staining while the latter is of medium to light intensity; narrow negative terminal band (18).
	q	Four pairs of evenly spaced positive bands: two proximal (13 and 15) and (17.1 and 17.3), two distal (22 and 24) and (26 and 28), separated by a prominent negative central region (21.1 + 21.3).
2	p	Light staining. Four narrow positive bands: one proximal (13), two central (15.1 and 15.3) and one distal (17), the last being more prominent.
	q	Narrow positive band adjacent to the centromere (12); two pairs of dark-staining proximal (14.1 and 14.3) and distal (22 and 24) positive bands separated by a broad negative central region (21.1 and 21.3); narrow negative terminal band (25).
3	p	Distinct positive bands in the proximal (13) and distal (15) region.
	q	Three evenly spaced dark-staining positive regions: proximal (13), central (21) and distal (23 and 25); terminal negative band (26).
4	p	Dark-staining positive band adjacent to the centromere (12); distal half light staining with narrow positive distal (14) and terminal (16) bands of medium to low intensity.
	q	Two proximal (12 and 14) and three distal (22 and 24 + 26) positive bands separated by a distinct negative central region (21.1 + 21.3); of the three distal bands, band 22 is prominent and dark staining while bands 24 and 26 are narrow and of medium intensity.
5	p	Light staining. Narrow proximal (13) and distal (17) positive bands; distinct positive central band (15); narrow negative terminal band (18). Banding often not very distinct.
	q	Narrow positive band adjacent to the centromere (12); broad dark-staining proximal (14) and distal (16) positive bands; negative terminal band (17).
6	p	Proximal half light staining; distinct central (13) and narrow terminal (15) positive bands.
	q	Narrow positive band adjacent to the centromere (12); two dark prominent central bands (21.1 and 21.3), distinct proximal and distal negative bands (13 and 22); positive distal band (23).
7	p	Dark-staining positive proximal (13) and distal (15) bands separated by distinct negative central region (14.1 + 14.3); negative terminal band (16).
	q	Prominent dark-staining positive proximal band (13); positive central (15), distal (17) and terminal (19) bands, the distal being narrower.
8	p	Light staining with two proximal (12 and 14) and one distal (16) narrow positive bands of low intensity.
	q	Proximal half dark staining; narrow positive band adjacent to the centromere (12); a pair of distinct dark-staining central bands (14 and 16); negative distal region (21.1 and 21.3); subterminal positive band (22).
9	p	Distinct broad positive proximal band adjacent to the centromere (13); central negative band (14); narrow positive subterminal band (15).
	q	Proximal and distal parts light staining with narrow proximal (13) and distal (17) positive bands; prominent dark-staining positive central band (15).
10	p	Dark-staining narrow positive band adjacent to the centromere (12); prominent negative central band (13); narrow distal positive band (14) of low intensity.
	q	Dark-staining proximal (13) and central (15 and 17) positive bands; distinct subcentral negative band (21); dark-staining subterminal positive band (22).
11	p	Distinct proximal (12.1 and 12.3) and distal (14) negative bands with a dark-staining central positive band (13).
	q	Prominent dark-staining positive band (13) adjacent to centromere; broad negative central region (14.1 + 14.3); positive subterminal band (15) of medium intensity.
12	p	Prominent dark-staining positive band (13) adjacent to the centromere; narrow positive distal band (14).
	q	Prominent dark-staining positive band (13) adjacent to centromere; remaining arm negatively stained (14).
13	p	Narrow positive band (12) of low intensity adjacent to the centromere; positive distal band (14) of medium intensity.
	q	Broad positive proximal band (13); narrow positive subterminal band of low intensity (15).
14	q	Three evenly spaced positive bands (12, 14 and 16) in the proximal half, of which the middle band is prominent; distinct negative central band (21); closely spaced subcentral positive bands (22.1 and 22.3); a pair of evenly spaced positive distal bands (24 and 26); distinct negative terminal band (27).

Table 1. continued

G-bands		Description
Chromosome	Arm	
15	q	Five evenly spaced positive bands: two prominent bands in the proximal half (12 and 14), of which the former is adjacent to the centromere, and three in the distal half (22, 24 and 26) of which the first is subcentral; distinct negative terminal band (27).
16	q	A narrow subcentromeric (12) and two prominent positive bands (14 and 16) in the proximal half; broad central negative region (21.1 + 21.3); prominent dark-staining subcentral region (22.1 + 22.3); distinct distal negative region (23.1 + 23.3) followed by a narrow positive subterminal band (24).
17	q	Two positive proximal bands (13 and 15); broad negative proximal region (21.1 + 21.3); three positive bands in the distal half (22, 24 and 26), of which the first two are dark staining and prominent; narrow terminal negative band (27).
18	q	Two proximal (14 and 21) and one distal (25) dark-staining distinct positive bands; subcentral region light staining with a narrow positive band (23) of low intensity; distinct terminal band (26).
19	q	Proximal half dark staining with a narrow subcentromeric (12) and three equally spaced positive bands (14, 16 and 18), band 18 being almost central; prominent negative subcentral band (21); pair of equal-sized distal positive bands (22 and 24).
20	q	Proximal half dark staining with three positive bands (12, 14 and 16) of which band 16 is more prominent; broad negative region (21.1 + 21.3) extending from central region to majority of distal half; a pair of closely placed positive bands (22 and 24) in the terminal region.
21	q	Three well-spaced positive bands (12, 14 and 16) in the proximal half; distinct central negative band (17); prominent dark-staining distal positive band (18); terminal region light staining with a narrow positive band (19) of low intensity.
22	q	Prominent dark-staining positive proximal band (14); three narrow low-intensity bands: subcentromeric (12); subcentral (16) and subterminal (18). An overall light-staining chromosome except for the 14 band.
23	q	A pair of positive proximal (12 and 14) and distal (16 and 18) bands separated by a distinct negative central band (15); narrow terminal negative band (19).
24	q	Prominent dark-staining subcentromeric and distal positive bands (13 and 15), separated by a broad negative central band (14). Distal one-quarter light staining with a narrow low-intensity positive band (16.2).
25	q	Narrow positive band adjacent to centromere (12) separated by a distinct negative band (13) from three positive bands (14, 16 and 18) in the distal two-thirds.
26	q	Proximal part dark staining with a pair of prominent positive bands adjacent to the centromere (12 and 14); distal half light staining with a positive band of low intensity (16).
27	q	Pair of proximal (13) and central (15) positive bands; distal half light staining with a narrow subterminal band of low intensity (17). Similar to chromosome 28 except that band 17 is prominent.
28	q	Proximal half dark staining with proximal and central positive bands (13 and 15); distal half light staining with a narrow band of light intensity (17).
29	q	Positive proximal (13) and subcentral (15) bands, the former being relatively more prominent; distinct terminal negative band.
30	q	Two distinctly separated positive bands, one adjacent to centromere (12) and the other relatively more prominent and subcentral (14); negative terminal band (15).
31	q	Light staining; narrow positive proximal (13), central (15) and terminal (17) bands.
X	p	Positive proximal band (13) followed by a distinct negative band (14); prominent central positive bands (15 and 21) of which the latter is broad and dark staining. Distal one-third light staining with narrow distal (23) and terminal (25) positive bands of low intensity.
	q	Three positive proximal bands (13, 15 and 17) of which band 17 is prominent and dark staining; prominent negative central band (21); four well-spaced positive bands (22, 24, 26 and 28) in the distal half, the former three being narrow while the latter (28) being more distinct; negative terminal band (29).
Y	p	Minute and negatively staining.
	q	Light staining. Narrow low-intensity positive band adjacent to the centromere (12); distinct positive subterminal band (14).

Table 2.

R-bands		Description
Chromosome	Arm	
1	p	Prominent pairs of positive bands in the subcentromeric (12.1 and 12.3) and central (14.1 and 14.3) regions separated by a distinct negative band (13); distal part light staining with two narrow, light-intensity positive bands (16 and 18), the latter being terminal.
	q	Narrow positive band adjacent to centromere (12); two evenly spaced proximal positive bands (14 and 16) followed by a prominent negative region extending to the middle of the chromosome (17.1 and 17.3); two subcentral positive bands (21.1 and 21.3); four equally spaced positive bands in the remaining distal region – two proximal ones (23 and 25) are distinct while the two distal/terminal (27 and 29) are narrow and of light intensity.
2	p	Dark staining. Narrow positive band adjacent to centromere (12); positive proximal (14), distal (16) and terminal (18) bands, band 18 being narrow.
	q	Three pairs of prominent positive bands – proximal (13.1 and 13.3), central (21.1 and 21.3) and subterminal/terminal (23 and 25), separated by distinct proximal (14.1 + 14.3) and distal (22) negative bands.
3	p	Proximal two-thirds darkly staining with subcentromeric (12) and central (14) positive bands; distal one-third light staining with a narrow light-intensity positive terminal band (16).
	q	Positive band adjacent to centromere (12); prominent positive proximal (14.1 and 14.3), subcentral (22.1 and 22.3) and terminal (26) regions, intervened with distinct negative bands – one central (21) and two distal (23 and 25). The latter pair of negative bands have a narrow, light-intensity positive band (24) in the middle. The terminal positive band (26) may resolve into two in elongated chromosomes.
4	p	A pair of equal-sized positive bands – one proximal (13) and one subterminal (15).
	q	Proximal one-third light staining with a medium-intensity positive band (13); distinct pair of central positive bands (21.1 and 21.3); broad negative band (22) in the middle of the distal half, followed by three positive bands, of which the proximal (23) is more prominent, while the middle (25) and terminal (27) are narrow.
5	p	Dark staining. Prominent positive bands (12 and 14) adjacent to centromere; distinct central negative band (15) followed by equal-sized positive distal (16) and terminal (18) bands.
	q	Broad positive proximal band (13); positive central band (15) followed by broad negative band (16); light-intensity positive terminal band (17).
6	p	Broad subcentromeric positive band (12) extending to the central part (in elongated chromosomes, this may resolve into two); subterminal narrow positive band (14); narrow terminal negative band (15).
	q	Almost equal-sized broad positive proximal (13) and distal (22) bands separated by a prominent negative central region (21.1 + 21.3); narrow positive terminal band (24).
7	p	Narrow positive band adjacent to centromere (12); equal-sized positive proximal (14.1) and central (14.3) bands followed by broad negative distal band (15); distinct positive terminal band (16).
	q	Proximal half light staining with a medium-intensity central positive band (14); distal half relatively dark staining with two distinct positive bands (16 and 18); narrow terminal negative band (19).
8	p	Dark staining, with almost equal-sized positive proximal (13), central (15) and terminal (17) bands.
	q	Prominent subcentromeric positive band (13); central region distinctly negative (14 and 16) with a narrow light-intensity positive band (15); two evenly spaced positive bands (21.1 and 21.3) in the distal region; remaining part less intensely stained with a medium-intensity narrow positive terminal band (23).
9	p	Narrow positive band (12; sometimes not visible) adjacent to the centromere; distinct positive central band (14); narrow subterminal negative band (15) followed by a narrow terminal positive band (16).
	q	Narrow light-intensity positive band adjacent to centromere (12); distinct positive band (14) in the proximal region separated by a broad central negative band (15) from a prominent positive distal band (16); terminal region with a distinct negative band (17) and a medium-intensity terminal positive band (18).
10	p	Prominent positive band (13) in the middle; distal part relatively less intense with a narrow positive terminal band of medium intensity (15).
	q	Distinct pairs of subcentromeric/proximal (12 and 14) and distal/terminal (21 and 23) positive bands separated by a prominent negative central region (15 and 17), which has a narrow medium-intensity positive band (16).

Table 2. continued

R-bands		Description
Chromosome	Arm	
11	p	Resembles the q arm; proximal two-thirds dark staining with two distinct positive bands (12.1 and 12.3); distal two-thirds light staining with a medium-intensity terminal positive band (14)
	q	Resembles the p arm; proximal two-thirds dark staining with a distinct subcentromeric positive band (12) and a pair of prominent central positive bands (14.1 and 14.3), which may fuse in more condensed chromosomes; medium-intensity terminal positive band (16).
12	p	Medium- to light-intensity staining; one central (13) and one terminal (15) positive band most often clearly separated.
	q	Proximal half light staining; distal half dark with a broad positive band (14).
13	p	Distinct positive central band (13) and narrow positive terminal band (15).
	q	Prominent positive subcentromeric band (12); positive central band (14); distal part light staining with a narrow low-intensity terminal band (16).
14	q	Distinct subcentromeric positive band (13) followed by a negative band (14) and two prominent proximal positive bands (15 and 21) that extend to the middle of the chromosome; large subcentral negative area (22.1 + 22.3 + 24) containing two narrow light-intensity bands (22.2 and 23); medium-sized distal (25) and terminal (27) positive bands separated by a distinct negative band (26).
15	q	Two major positive bands in proximal half (13 and 21.1 + 21.3) separated by a distinct negative band (14); prominent central negative band (22); two broad positive distal bands (23 and 25); narrow positive terminal band (27).
16	q	Positive subcentromeric band (13) followed by two prominent negative bands (14 and 16) separated by a medium-intensity positive band (15); prominent positive central bands (21.1 and 21.3) may fuse in more condensed chromosomes; distinct negative band (22) in the distal half followed by three positive bands, of which the proximal (23.1) is more distinct, while the middle (23.3) and terminal (25) are narrow and of medium intensity.
17	q	Proximal half dark staining with two pairs of prominent positive bands (12 and 14; 21.1 and 21.3) separated by a distinct negative band (15); distal half light staining; two prominent negative bands (22 and 24) separated by a positive band (23); two light-intensity narrow bands at the distal end (25 and 27), the latter being terminal.
18	q	Positive proximal band (13) separated by a negative band (14) from a pair of positive bands (15.1 and 15.3), which may appear as a broad positive proximal band in less condensed chromosomes; prominent central negative band (21); a pair of prominent positive subcentral bands (22 and 24) followed by a broad negative distal band (25); prominent positive terminal band (26).
19	q	Proximal one-quarter has a prominent positive band (13) followed by a broad negative band (14); distal three-quarters appears dark staining with a series of five positive bands (15, 17, 21, 23 and 25), of which bands 17 and 21 are prominent.
20	q	Two positive proximal bands (13 and 15) separated from two prominent positive subcentral bands (21.1 and 21.3) by a broad negative band (16); distal end light staining with a narrow positive band (23) in the middle.
21	q	Proximal two-thirds dark staining with three positive bands evenly spaced (13, 15 and 17); distinct negative band (18) followed by two light intensity narrow positive bands (19.1 and 19.3), the latter being terminal.
22	q	Proximal one-third light staining and distal two-thirds dark staining. Light-intensity proximal positive band (13); broad negative band (14); two prominent broad positive bands (15 and 17), which may appear fused in more condensed chromosomes; narrow positive terminal band (19).
23	q	Positive proximal band (13); two positive central bands (15.1 and 15.3) in close proximity; equal-sized positive distal (17) and terminal (19) bands.
24	q	Narrow positive band adjacent to centromere (12); prominent positive band (14) in the proximal half; prominent subcentral negative band (15); two narrow positive distal bands (16.1 and 16.3) that may fuse in more condensed chromosomes.
25	q	Light staining. Two proximal positive bands (13 and 15) are more prominent than the less intense subcentral band (17); narrow positive terminal band (19).
26	q	Proximal half light staining and distal half dark staining. Narrow, light-intensity proximal positive band (13); prominent negative central band (14); prominent positive distal band (15); narrow positive terminal band (17).
27	q	Light-staining narrow positive band adjacent to centromere (12) followed by a narrow negative band (13); distal two-thirds dark staining with a narrow positive proximal band (14) and a broad positive distal band, which may resolve into two (16 and 18).

Table 2. continued

R-bands		Description
Chromosome	Arm	
28	q	Prominent subcentromeric positive band (12); prominent negative band (13); distal two-thirds darkly staining because of three positive bands (14, 16 and 18), which may appear fused in more condensed chromosomes.
29	q	Narrow light-intensity positive band adjacent to centromere (12); prominent positive proximal band (14), which may resolve into two; prominent negative band (15), followed by a positive terminal band (16).
30	q	Dark staining. Positive proximal band (13); prominent positive band (15) spanning distal half of chromosome; the band may resolve into two.
31	q	Narrow light-intensity positive band adjacent to centromere (12); positive central (14); and a positive distal band (16) separated by a narrow negative band (15).
X	p	Broad positive band adjacent to centromere (12); the band may resolve into two; proximal positive band (14); prominent central negative region (15 + 21) divided by a narrow positive band (16); two distal positive bands (22 and 24).
	q	Narrow dark band adjacent to centromere (12); two prominent proximal positive bands (14 and 16), in more condensed chromosomes seen as one broad band; prominent negative central region (17 + 22) separated by a light-staining positive band (21); three positive distal bands (23, 25 and 27) band 27 being more prominent; terminal positive band (29).
Y	q	Broad light-staining positive band covering distal two-thirds (13); narrow positive terminal band (15).

in R-banded karyotypes) has been reported (Maciulus *et al.* 1984, Romagnano & Richer 1989, Richer *et al.* 1990, Rønne *et al.* 1993), we believe that the present standard is a step towards providing distinct banding images together with schematic drawings and band designations for individual horse chromosomes. Depending on the needs of horse cytogeneticists and gene mappers, the standard karyotype should be reviewed after a period of 5 years, and necessary steps should be taken to prepare a high-resolution version. This may also include a list of chromosome-specific markers and probes that give reasonably strong hybridization signals and assist in unambiguous identification of chromosomes without the application of any banding technique.

Acknowledgements

The financial support provided by the Dorothy Russell Havermayer Foundation for this project is gratefully acknowledged. We are thankful to the Veterinary Genetics Laboratory for providing facilities for the meeting. The standardization work carried out in Sweden (B.C. and T.R.) was supported by the Erik Philip-Sørensen Foundation.

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