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The karyotype of the European roe deer *(Capreolus capreolus* L.)

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Abstract

The karyotype of the European roe deer (*Capreolus capreolus* L.) is described by means of G- and C-banding techniques. A standardized idiogram (diagram, ordering of the chromosomes and designation of the bands) is proposed for the species *Capreolus capreolus* L., using the idiogram of the investigated Central European animals as an example.

Introduction

Previous investigations on the karyotype of *Capreolus capreolus* L. used orcein staining (Gustavsson 1965; Amrud and Nes 1966; Herzog and Höhn 1967; Wurster and Benirschke 1967; Gustavsson and Sundt 1968; Hsu and Benirschke 1968).

A chromosone number of 2n = 70, XX resp. XY was found. All 68 autosomes are designated as acrocentric, the X-chromosome submetacentric and the Y-chromosome subtelocentric. Amrud and Nes (1966) call the Y "apparently submetacentric".

A supernumerary submetacentric chromosome was detected by Herzog and Höhn (1967) in one specimen. The authors explained this phenomenon by a double trisomy, occurring as a centric fusion. More recently, banding techniques which allow to differentiate between single chromosomes were used by Neitzel (1982) for the investigation of the Siberian roe deer (subspecies *Capreolus capreolus pygargus*). She studied three specimens and found a chromosome number between 2n = 76 and 80, dependent on a varying number of microchromosome pairs. Similar results have been obtained by Sokolov et al. (1978), Stubbe and Passarge (1979), and Stubbe (1979), using orcein staining techniques.

In the European roe deer, a karyotype analysis by means of modern banding techniques as well as a systematic description of the bands of each chromosome in accordance with an international standard is still lacking. The purpose of the present paper is to study the karyotype of the Central European roe deer by means of G- and C-banding techniques and to propose an idiogram, thereby describing the single chromosomes in accordance with the International System for Human Cytogenetic Nomenclature (ISCN 1985), to set up a basis for further investigations, especially on homologisation of karyotypes between different taxa and studies concerning karyotype evolution.

Material and methods

In order to obtain the metaphase chromosomes, tissue cultures (kidney, skeletal muscle and testes) of 69 specimens from Hessen (Bundesrepublik Deutschland) were laid out using standard culture techniques. The metaphase chromosomes were studied by modified G- and C-banding techniques (Sumner et al. 1971; Seabright 1972) and photographed with a 1000-fold magnification under oil immersion. In order to obtain a homogeneous degree of condensation in the G-banded chromosomes, only metaphases exhibiting nine G-bands on the X-chromosome (three on the short arm and six on the long arm) were taken into consideration.

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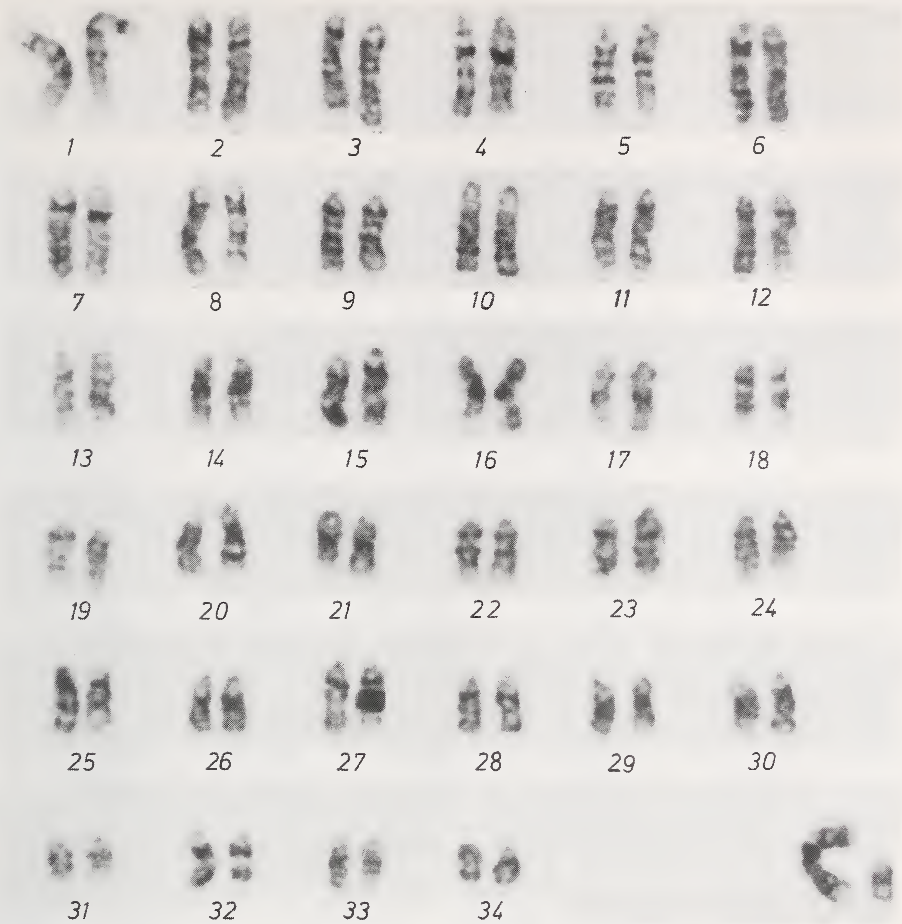

Fig. 1. G-banded idiogram of a male European roe deer (*Capreolus capreolus* L.)

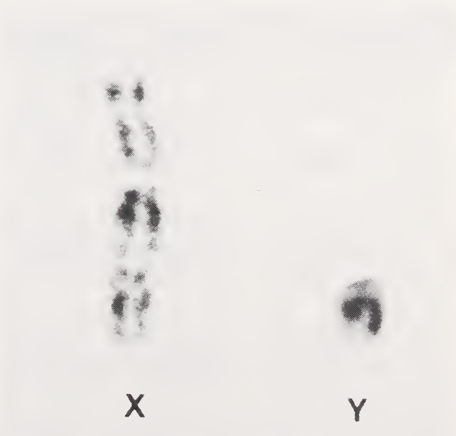

Fig. 2. Gonosomes (X and Y) of the European roe deer (*Capreolus capreolus* L.)

Table. **Arm-length-ratio in the X-chromosome of *Capreolus capreolus* L., revealed by measurements of 26 haploid chromosome sets**

Arm	relative length* ($\bar{x}$)	standard deviation (s_x)
p-arm	2.19	0.30
q-arm	3.00	0.39

* as percentage of the total length of the haploid autosome set.

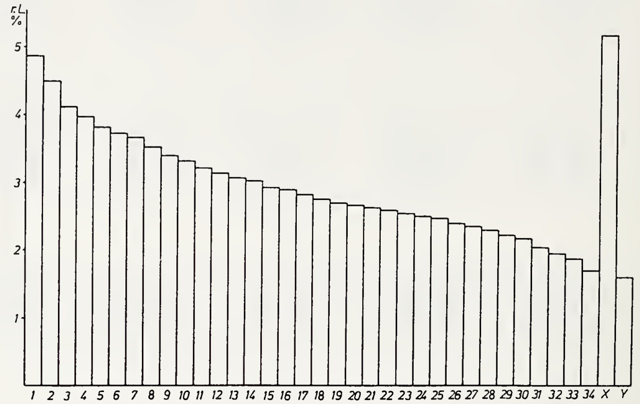

Fig. 3. Chromosome length in *Capreolus capreolus* L. (r. L. = relative length in percent of the total haploid autosome set)

Results

The somatic, diploid chromosome set of all 69 animals studied consists of 70 chromosomes, namely 68 autosomes and two gonosomes (2n = 70, XX resp. XY; figs. 1 and 2).

Measurements of the chromosome lengths show that all autosome pairs and the Y-chromosome are telocentric (according to the terminology of Nagl 1980) with an arm-length ratio less than 1:4. The female gonosome is subtelocentric (see table). Using high-quality preparations, short (p-)arms are obvious in all telocentric chromosomes. Thus, the Nombre fondamental (N. F.) is 140 if these short arms are taken into account, whereas it is 72 in the female and 71 in the male if the short p-arms are neglected.

The autosomal N. F. (N. F.a) is 68 resp. 136 in both male and female.

The centromeric index (c.i.) is not useful for the characterization of the chromosomes, because the p-arms of the telocentrics are not unequivocally measurable and chromosome lengths of the related chromosome pairs show only slight differences (fig. 3), mostly less than the standard deviation of the chromosome length of the relevant pairs.

Therefore it seems indispensable to use banding patterns as a tool for identification of the individual homologous chromosomes. Fig. 4 shows a proposal for the idiogram of *Capreolus capreolus* L. The bands and landmarks are drawn from the photos of the chromosomes of all 69 deer following the ISCN (1985). All autosomes exhibit distinct C-bands of different size. The euchromatin of a single autosome becomes stained over the whole length after C-banding treatment (facultative heterochromatin, fig. 5). The gonosomes show no visible C-bands, but in the female, one of the two X-chromosomes also exhibits facultative heterochromatin (sexchromatin), a phenomenon which is well known in other species, especially mammals. The occurrence of facultative heterochroma-

Fig. 4 (left). Proposition for a standard idiogram of *Capreolus capreolus* L. following the ISCN (1985): big numbers = landmarks, small numbers = bands, C = centromere. – *Fig. 5 (right).* C-banded idiogram of a female European roe deer (*Capreolus capreolus* L.)

tin in originally euchromatic regions is interpreted usually by the inactivation of one chromosome in a pair for gene dosis compensation (for a review see Nagl 1980).

Discussion

The present investigation on the karyotype of European roe deer confirms the results of Gustavsson (1965), Herzog and Höhn (1967), Wurster and Benirschke (1967), Gustavsson and Sundt (1968) as well as Hsu and Benirschke (1968) as regards the chromosome number of *Capreolus capreolus*. The Siberian roe deer *(Capreolus capreolus pygargus)* also shows the characteristic chromosome number of 2n = 70 and, in addition, an unstable number of microchromosomes (Sokolov et al. 1978; Stubbe and Passarge 1979; Stubbe 1979; Neitzel 1982). Neitzel (1982) assumes that the microchromosomes show regular mitotic segregation, because their number is constant within each investigated individual. A supernumerary submetacentric chromosome detected by Herzog and Höhn (1967) in one specimen of roe deer from Hessen (Bundesrepublik Deutschland) could not be found in the present investigation nor is it mentioned by other authors, which means that such a chromosome mutation is either uncommon in the European roe deer or it is lethal at an early ontogenetic stage. With respect to the form of the chromosomes, the previous investigations could be confirmed only partially, because the short p-arms are not described in these papers. In consequence, the autosomes are not acro- but telocentric, according to the terminology given by Nagl (1980). Moreover, the Y-chromosome is also telocentric and not subtelocentric or submetacentric as assumed by previous authors. The X-chromosome was identified as subtelocentric. The photos of the orcein stained chromosomes given in the above mentioned first papers about the karyotype of roe deer suggest that the differences in the morphology of the gonosomes, especially the Y-chromosome, might be explainable by the unconsistent use of the terminology. However, it also may be possible that Y chromosomes with p-arms longer than those of the autosomes are existing, but there is no certain indication. Further investigations on this question should be carried out using electron microscopy. Photos of G-banded chromosomes 1 to 16 are shown by Neitzel (1982) for the Siberian roe deer *(Capreolus capreolus pygargus)*. Although these chromosomes seem to be stained at a more condensed stage, the landmark patterns are similar to those of the investigated animals from Hessen. This indicates that there might be no considerable differences between the banding patterns of chromosomes 1 to 16 of the deer from Central Europe and from Siberia. Moreover, the other autosomes also seem to be similar in the Siberian and the Central European roe deer as regards their G-banding pattern, which is described by Neitzel (1982), who compares the karyotypes of different Cervidae, including the Siberian roe deer, with a karyotype assumed to be ancestral for the Cervidae.

The C-banding patterns described by Neitzel (1982) are similar to those revealed in the present investigation: She also found C-bands in each autosome, but not distinct C-bands in the gonosomes. The microchromosomes of the Siberian roe deer are described as fully heterochromatic. Banding techniques, such as G-banding, and a standard basis for description of the single chromosomes, such as the ISCN (1985), should enable the investigator to identify nearly all chromosomes reliably and appear to be useful for homologisation of the karyotypes between different taxonomic groups as well as for studies on karyotype evolution or for gene mapping. Moreover, C-banding is very important, especially for investigations on karyotype evolution. For studies on population genetics in this species, C-banding may become useful if any C-band polymorphisms can be found and identified as markers by genetic analysis.

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Zusammenfassung

Der Karyotyp des europäischen Rehes (Capreolus capreolus L.)

Der Karyotyp des mitteleuropäischen Rehes wurde mittels G- und C-Bandentechnik beschrieben. Ein standardisiertes Idiogramm (Anordnung der Chromosomen und Bezeichnung der Banden) wurde für die Species *Capreolus capreolus* L. am Beispiel des Idiogramms der untersuchten mitteleuropäischen Tiere vorgeschlagen.

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