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# Cytogenetic studies on *Spermophilus xanthoprymnus* (Rodentia: Sciuridae) in Central Anatolia

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A b s t r a c t. The karyotype, C-banding and Ag-NORs of *Spermophilus xanthoprymnus* (Anatolian souslik) from the Konya in Central Anatolia were examined. The diploid number of chromosomes (2n) is 42, the fundamental number (FN ) is 81, the number of autosomal arms (NFa) is 78. C-banding positive regions appeared to be restricted to the pericentromeric regions in all autosome chromosome pairs and the X chromosome. The relative amount of C-positive heterochromatin is 28.9 % of the total length of the set. Nucleolar organizer regions (NORs), identified by the silver-staining technique, were found on the terminal region of the short arm of three pairs of subtelocentric chromosomes.

**Key words:** *Spermophilus xanthoprymnus*, karyotype, C-banding, NORs

## Introduction

The family Sciuridae is represented by 50 genera and 273 species and is found in a wide variety of habitats throughout the world, except the Australian region, Madagascar, southern South America, and certain desert regions, such as in Egypt and the Arabian Peninsula (H o f f m a n n et al. 1993). W i l s o n & R e e d e r (1993) and M i t c h e l l - J o n e s et al. (1999) recorded that the genus *Spermophilus* is distributed throughout Germany, Czech Republic, Slovakia, Poland and SE Europe as far as European Turkey, Moldova and Ukraine. B e n n e t first described *Spermophilus xanthoprymnus* (Anatolian souslik) from Erzurum (Turkey) in 1835. E l l e r m a n & M o r r i s o n - S c o t t (1951) and C o r b e t (1978) rejected *S. xanthoprymnus*, referring to this taxon as a subspecies of *Spermophilus citellus* (European souslik). However, O g n e v (1948) reported that the ground squirrel distributed in Northern Anatolia is *S. xanthoprymnus*. The first karyological investigation of *S. xanthoprymnus* was carried out by O r l o v et al. (1969), and V o r o n c o v & L' a p u n o v a (1969) on individuals from Armenia and it was determined that this population of *S. xanthoprymnus* has a karyotype of 2n = 42, NFa=66 and FN=70. In the most recent taxonomic study from Bayburt, Çorum, Erzurum, Malatya and Sivas in Turkey (2n=42, NFa=64 and NF=67), D o ğ r a m a c ı et al. (1994) stated that the karyotypes distinguish the Anatolian populations from the Thrace (European parts of Turkey) populations (*S. citellus*), and they also concluded that, according to this karyologic difference, the ground squirrel in Central Anatolia is *S. xanthoprymnus*. Ö z k u r t et al. (2002) determined that specimens from Polatlı (Ankara), Maden (Niğde), Erzurum, Akseki (Antalya), Mut (İçel) and Hadim (Konya) in Turkey. The diploid chromosome number of Polatlı, Maden and Erzurum specimens was 2n=42, NFa=78 and FN=81; Akseki was 2n=40, NFa=72 and FN=76; Mut and Hadim was 2n=40, NFa=72 and FN=75.

The aim of this study is to contribute to the C-banding and Ag-NORs of *S. xanthoprymnus* in Central Anatolia.

## Materials and Methods

The animals studied (2 males, 2 females) were collected from Konya (Selçuklu) in central Anatolia in July, 2004. Specimens were karyotyped from the bone marrow of the colchicined animal (Ford & Hamerton 1956). NOR bands were obtained by the modified technique of Howell & Black (1980), and C bands by the technique of Sumner (1972), performed in sequence on Giemsa-stained slides, without previous destaining, according to the technique described by Giannoni et al. (1991). A total of 10 to 20 slides were prepared from each specimen, and at least 20 well-spread metaphase plates were analysed. Chromosome morphologies were established according to Zima (1978) and Hillis et al. (1996) by calculating centromeric indexes. The diploid number of chromosomes (2n), the fundamental number (FN), the number of autosomal arms (NFa) as well as metacentric (m), submetacentric (sm), subtelocentric (st), acrocentric (a), and the X and Y chromosomes were determined.

## Results and Discussion

Karyotype of *S. xanthoprymnus* contains 42 chromosomes, the fundamental number (FN) is 81, the number of autosomal arms (NFa) is 78. The karyotype has one pair of medium-sized metacentric and one pair of small metacentric, 4 pairs of large submetacentric and 3 pairs of medium-sized submetacentric, 10 pairs of large to medium-sized subtelocentric and one pair of acrocentric chromosomes. The X chromosome is medium-sized and submetacentric, the Y chromosome is the smallest acrocentric one (Fig. 1). This shows that the karyotype of our specimens is different from the results of Orlov et al. (1969), Voroncov & Ľapunova (1969) and Doğramacı et al. (1994) in point of morphology of both autosomal and sex chromosomes, and therefore morphology of chromosomes may seem very variable among *S. xanthoprymnus* individuals (Table 1). Özkurt et al. (2002) noted

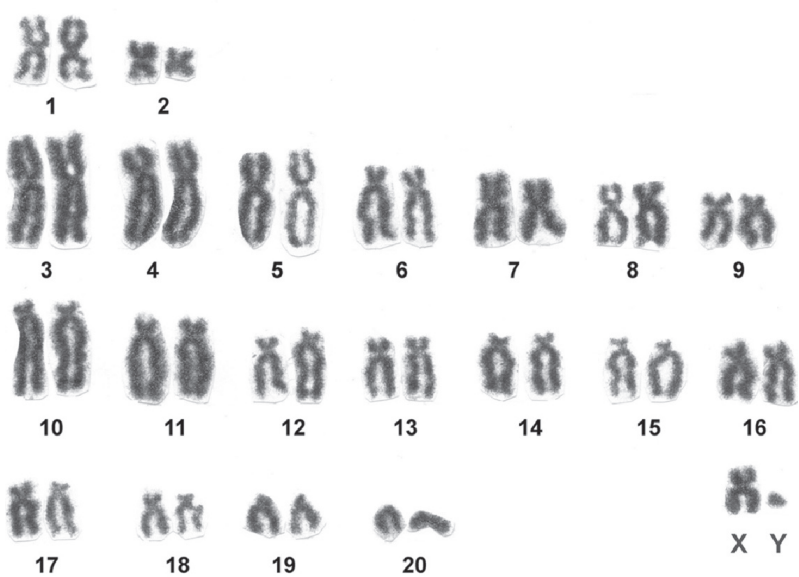


**Fig. 1.** Karyotype of male *S. xanthopyrmnus*, standard Giemsa staining.

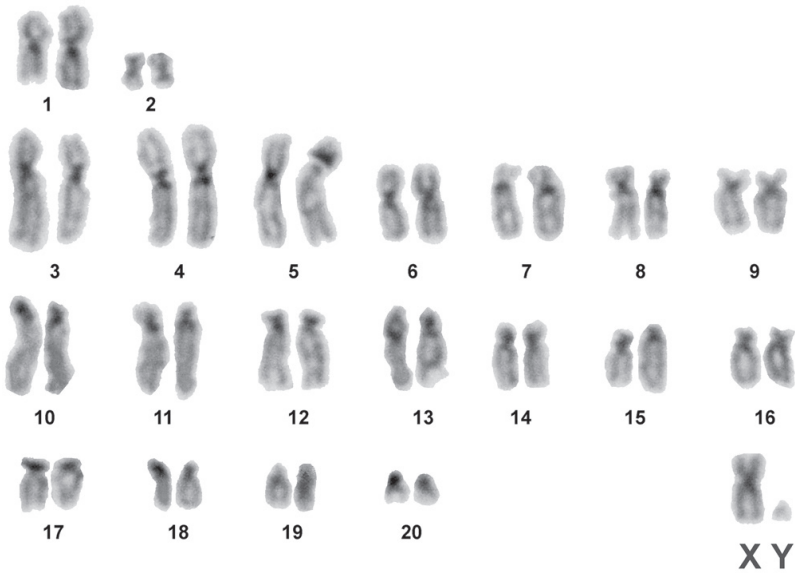


**Fig. 2.** Karyotype of male *S. xanthoprymnus*, C-banding.

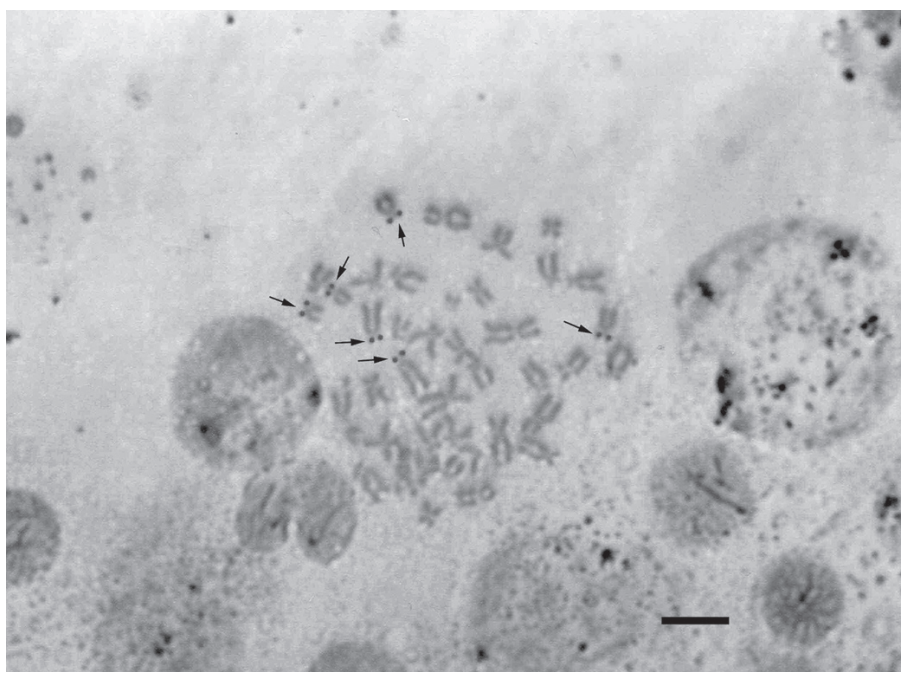

**Fig. 3.** Ag-NOR stained metaphase (male); arrows indicate positive stained regions (Scale bar: 10$\mu$m).

that the diploid number of chromosomes in Polatlı, Maden and Erzurum populations was different from that in Akseki, Mut and Hadim populations. The diploid number of chromosomes

**Table 1.** A comparison of the chromosomal data and location of Ag-NORs for *Spermophilus suslicus*, *S. citellus* and *S. xanthoprymnus* (M= metacentric, Sm= submetacentric, St= subtelocentric, A= acrocentric, D=dot-like).

| Species | Locality and References | 2n | FN | NFa | M | Sm | St | A | X | Y | Location of the Ag-NORs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *S. suslicus* | Elbrus (USSR) (Koralev et al. 1991 and Koralev 1994) | 36-34 | 72-68 | - | - | - | - | - | - | - | Interstitial region one autosome pair and terminal region of two autosome pairs |
| *S. citellus* | Yugoslavia (Živković et al. 1968, Savić et al. 1971, Hsu & Benirschke 1975), Moldavia (Voroncov & Ľapunova 1969) and Bulgaria (Belcheva & Peshev 1979) | 40 | - | 66 | 2 | 12 (Sm or St) | | 5 | bi-armed or A | Sm | Not examined |
| *S. citellus* | Czech Republic (Zima 1987) | 40 | - | - | 2 | 13 (Sm or St) | | 4 | Sm | D and bi-armed | Not examined |
| *S. citellus* | Thrace (Doğramacı et al. 1994) | 40 | 78 | 74 | 2 | 12 | 4 | 1 | M | bi-armed and smallest | Not examined |
| *S. citellus* | Thrace (Özkurt et al. 2002) | 40 | 69 | 66 | 2 | 12 | - | 5 | Sm | A | Not examined |
| *S. xanthoprymnus* | Armenia (Orlov et al. 1969 and Voroncov & Ľapunova 1969) | 42 | 70 | 66 | 13 | - | - | 7 | M | bi-armed and smallest | Not examined |
| *S. xanthoprymnus* | Bayburt, Çorum, Erzurum, Malatya and Sivas (Turkey) (Doğramacı et al. 1994) | 42 | 67 | 64 | 1 | 7 | 4 | 8 | M | the smallest | Not examined |
| *S. xanthoprymnus* | Polatlı, Maden and Erzurum (Turkey) (Özkurt et al. 2002) | 42 | 81 | 78 | 2 | 17 | - | 1 | M | A | Not examined |
| *S. xanthoprymnus* | Akseki (Turkey) (Özkurt et al. 2002) | 40 | 76 | 72 | 2 | 15 | - | 2 | M | M | Not examined |
| *S. xanthoprymnus* | Mut and Hadim (Turkey) (Özkurt et al. 2002) | 40 | 75 | 72 | 2 | 15 | 2 | - | M | A | Not examined |
| *S. xanthoprymnus* | Konya (Selçuklu) (Turkey) (This study) | 42 | 81 | 78 | 2 | 7 | 10 | 1 | Sm | A | Terminal region of short arm of pairs 10, 12 and 18 |

in our individuals and their morphology of chromosome are similar to Polatlı, Maden and Erzurum populations (Table 1). According to N e v o et al. (1994), the chromosome number shows a positive correlation because of the contraints of biotic and climatic factors such as dryness and temperature. The climate of both Selçuklu, Polatlı, Maden, Erzurum and the places where D o ğ r a m a c ı et al. (1994) studied the karyology of *S. xanthoprymnus* are similar (Terrestrial climate). However, Akseki, Mut and Hadim have a warmer climate when compared with other places (Mediterranean climate).

In this study, the C-banding pattern in the mitotic metaphase of *S. xanthoprymnus* is characterized by the presence of pericentromeric C-bands in all autosomes and on the X chromosome. The proportion of C-positive pericentromeric heterochromatin regions is also about 28.9 % of the total length of the chromosomes in the set (Fig. 2). B e l c h e v a & P e s h e v (1985) described variation in the relative amount of C-heterochromatin between the several subspecies of *S. citellus* in the western and northwestern region of Bulgaria (18.3–25.2 %). However, the karyotype of the populations inhabiting the south-eastern and coastal regions of Bulgaria had a lower amount of the constitutive heterochromatin (15.8–16.5 %). C-banding of a male *S. citellus* was described by Z i m a (1987), with intense C-bands in the centromere region of all autosomes and sex chromosomes. In addition, the proportion of C-positive centromeric heterochromatin regions was about 26 % of the total length of the chromosomes in the set. Constitutive heterochromatin includes repetitive DNA and satellite DNA (J o h n & M i k l o s 1979) and C-band is therefore considered to be major importance in the evolution of the morphology of a karyotype (H s u 1975). So, the Y chromosome of *S. xanthoprymnus* negatively stained can show a difference between these two species. Ç o l a k & Ö z k u r t (2002) compared the blood-serum proteins of *S. citellus* and *S. xanthoprymnus* by electroforetic methods and reported that there was no difference between the two species.

Nucleolar organizer regions (Ag-NORs) were presented at the end of the short arm of three pairs autosomal chromosomes (10,12 and 18) (Fig. 3). K o r a l e v et al. (1991) and K o r a l e v (1994) reported that spotted ground squirrel *Spermophilus suslicus* (2n=36 and 2n=34) had one interstitial and two terminal Ag-NORs (Table 1). Nucleolar organizer regions of mammalian chromosomes are known to contain the genes for 18S and 28S rRNA. The localisation of the nucleolar organizer regions has been considered as a useful taxonomic and phylogenetic marker (S a n c h e z et al. 1990).

The karyotype of *S. citellus* was investigated in Yugoslavia (Ž i v k o v i ć et al. 1968, S a v i ć et al. 1971, H s u & B e n i r s c h k e 1975), in Moldavia (V o r o n c o v & L' a p u n o v a 1969), in Bulgaria (B e l c h e v a & P e s h e v 1979), in the Czech Republic (Z i m a 1987) and in Thrace (D o ğ r a m a c ı et al. 1994 and Ö z k u r t et al. 2002). All these papers concluded that the karyotype of *S. citellus* contained 40 chromosomes (Table 1). The diploid number of chromosomes was considered by D o ğ r a m a c ı et al. (1994) to be taxonomically characteristic for separating *S. citellus* from *S. xanthoprymnus*. However, Ö z k u r t et al. (2002) noted that some populations of *S. xanthoprymnus* have 2n=40 chromosomes in their study. For this reason, the diploid number of chromosomes can not be diagnostic between these two species.

A c k n o w l e d g e m e n t s

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