ACTA ZOOLOGICA BULGARICA

Systematics and Phylogenetics
Research Article

Acta Zool. Bulg., 72 (3), September 2020: 363-367
Published online 24 January 2020
http://www.acta-zoologica-bulgarica.eu/002376

The Karyotype of Anatolian Ground Squirrel *Spermophilus xanthoprymnus* (Bennett, 1835) (Rodentia: Sciuridae) from two localities in Anatolia, Turkey

Atilla Arslan[1*], Kubilay Toyran[2] & Serdar Gözütok[3]

[1] Department of Biology, Faculty of Sciences, Selçuk University, 42031 Selçuklu, Konya, Turkey; E-mail: aarslan@selcuk.edu.tr
[2] Department of Biology, Faculty of Science and Letters, Bitlis Eren University, Bitlis, Turkey; E-mail: kubilaytoyran@hotmail.com
[3] Department of Wildlife and Ecology, Faculty of Agriculture and Natural Sciences, Abant İzzet Baysal University, Bolu, Turkey; E-mail: serdargozutok@ibu.edu.tr

Abstract: The standard karyotype and C-banding characteristics of six specimens of Anatolian Ground Squirrel *Spermophilus xanthoprymnus* (Bennett, 1835) collected in Gümüşhane Province and Bitlis Province, Turkey. The karyotype of the individuals from both localities contained 42 chromosomes and all the chromosomes were bi-armed. The arm number of autosomal chromosomes (NFa) was 80 and the fundamental number of chromosomal arms (FN) was 84. The X chromosome was medium-sized and submetacentric. The Y chromosome of Bitlis specimens was smallest and bi-armed, and the Y chromosome of Gümüşhane specimens was medium-sized and subtelocentric. All the autosomes and X chromosome of specimens from both localities possessed distinct centromeric or pericentromeric C-positive bands. An interstitial dark C-band was apparent also on the long arm of the submetacentric autosomal pair 4. However, submetacentric autosomal pair 4 was heteromorphic in the Bitlis specimens due to intrachromosomal translocation. The Y chromosome of Gümüşhane specimens had centromeric C-band and the Y chromosome of Bitlis squirels was entirely euchromatic.

Key words: C-banding, chromosome polymorphism, intrachromosomal translocation

Introduction

The rodent species of the family Sciuridae (squirels) are widely distributed in Europe, Africa, Asia and America (Kryštufek & Vohralík 2005). There are three species of the genus *Spermophilus* Cuvier, 1825 in Turkey. They are distributed in Central and Eastern Anatolia and in steppes of Thrace. The diploid chromosome number (2n) of *Spermophilus citellus* (Linnaeus, 1766), which is widespread in Central and Western Europe, Balkan Peninsula, including European part of Turkey (Thrace), is 40 (Doğramaci et al. 1994, Özkurt et al. 2002, 2007, Yiğit et al. 2005, Arslan & Zima 2014). *Spermophilus xanthoprymnus* (Bennett, 1835) inhabits the steppes and alpine meadows throughout central lowland and eastern highland Anatolia and adjacent Armenia and northwestern Iran and is characterised by long periods of hibernation in underground nests (Kart Gür & Gür 2010); its diploid

*Corresponding author: aarslan@selcuk.edu.tr

chromosome number (2n) is 42 (Doğramacı et al. 1994, Özkurt et al. 2002, Yiğit et al. 2005, Arslan 2005, Gaffaroğlu & Yüksel 2006, Arslan & Zima 2014). The diploid chromosome number (2n) of *Spermophilus taurensis* Gündüz et al. 2007, a species endemic for the Taurus Mountains, is 40 (Özkurt et al. 2002, Yiğit et al. 2005, Gündüz et al. 2007). Banded karyological features of *S. xanthoprymnus* and *S. taurensis* sampled in Konya Province have also been characterised (Arslan 2005, Matur 2009, Arslan & Arslan 2010).

The Y-chromosome morphology of *Spermophilus* spp. is variable; in some of them, the Y chromosome is defined as the smallest bi-armed or acrocentric while, in others, it is medium-sized bi-armed or acrocentric (Arslan & Zima 2014). Chassovnikarova et al. (2015) have presented an evolutionary model for the karyotype of the European ground squirrel (*S. citellus*) based on sex chromosome variants. Chromosomal rearrangements (deletions, duplications, inversions and translocations) in different mammalian species have been emphasised in various cytogenetic studies.

The aim of the present study is to investigate the karyological features of *S. xanthoprymnus* from the regions of the cities of Gümüşhane and Bitlis in order to examine the variations of the karyotype of this species from various parts of its geographical range.

Materials and Methods

Six Anatolian ground squirrels from localities in the vicinity of the cities of Gümüşhane (2 ♂♂, 1♀) and Bitlis (2 ♂♂, 1♀) were examined (Fig. 1). The Gümüşhane specimens were captured by the staff of the Terrestrial and Inland Water Ecosystems Biodiversity Inventory and Monitoring Service of the province and brought to the laboratory for karyological examination. Karyotype preparations were obtained from bone marrow after colchicine treatment (Ford & Hamerton 1956). Air-dried slides were stained routine by Giemsa. Constitutive heterochromatin was detected by using the C-banding techniques (Sumner 1972). From each specimen, 10 to 20 slides were prepared and at least 20 well-spread metaphase plates were analysed. The classification system of chromosomes according to the centromere position was adopted (Hsu & Benirschke 1967-1977) and the biarmed (metacentric – M, submetacentric – SM, subtelocentric – ST) and uniarmed (acrocentric – A) chromosomes were identified. The fundamental number of autosomal arms (NFa) and the number of all chromosomal arms in the female complement (NF) were calculated. Standard voucher specimens (skins and skulls) and slides were deposited at Selçuk University, Biology Department, Faculty of Science, Konya, Turkey.

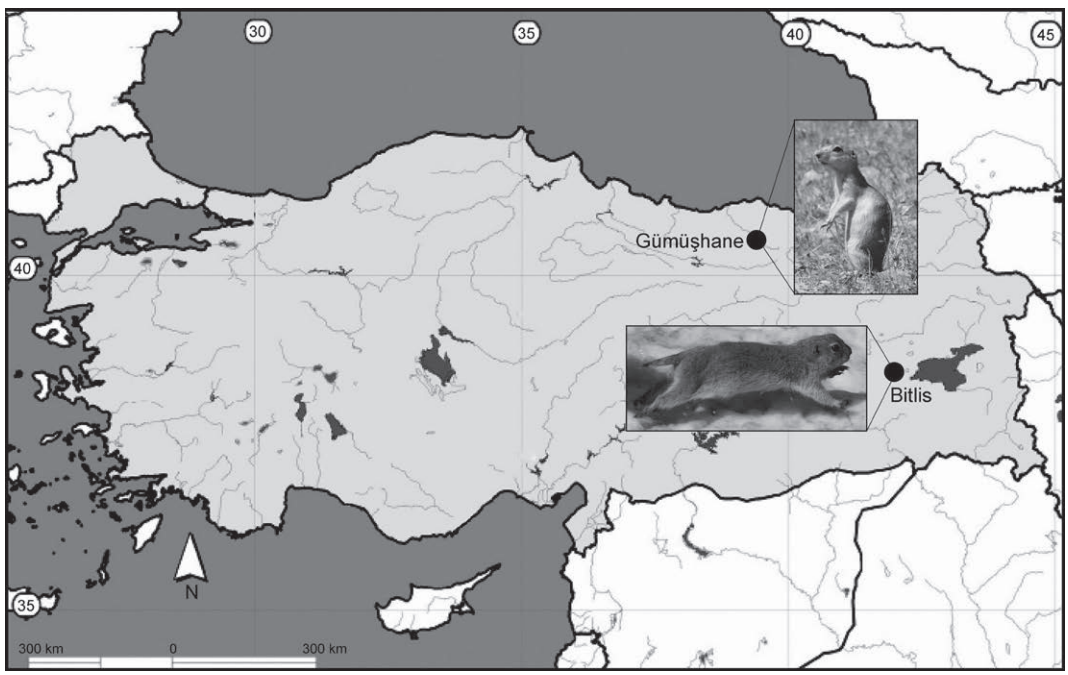

Fig. 1. Collecting sites of *Spermophilus xanthoprymnus* from the regions of cities of Gümüşhane and Bitlis.

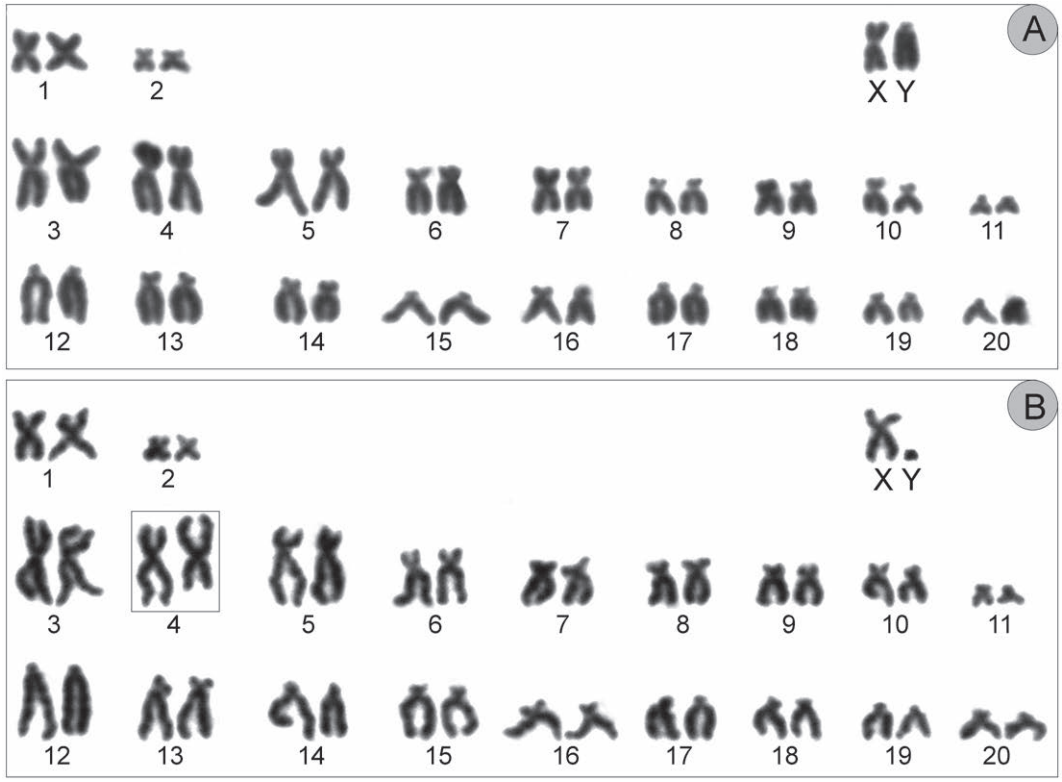

Fig. 2. Standard karyotype of *Spermophilus xanthoprymnus* from Gümüşhane (A) and Bitlis (B). The heteromorphic chromosome pair is in frame.

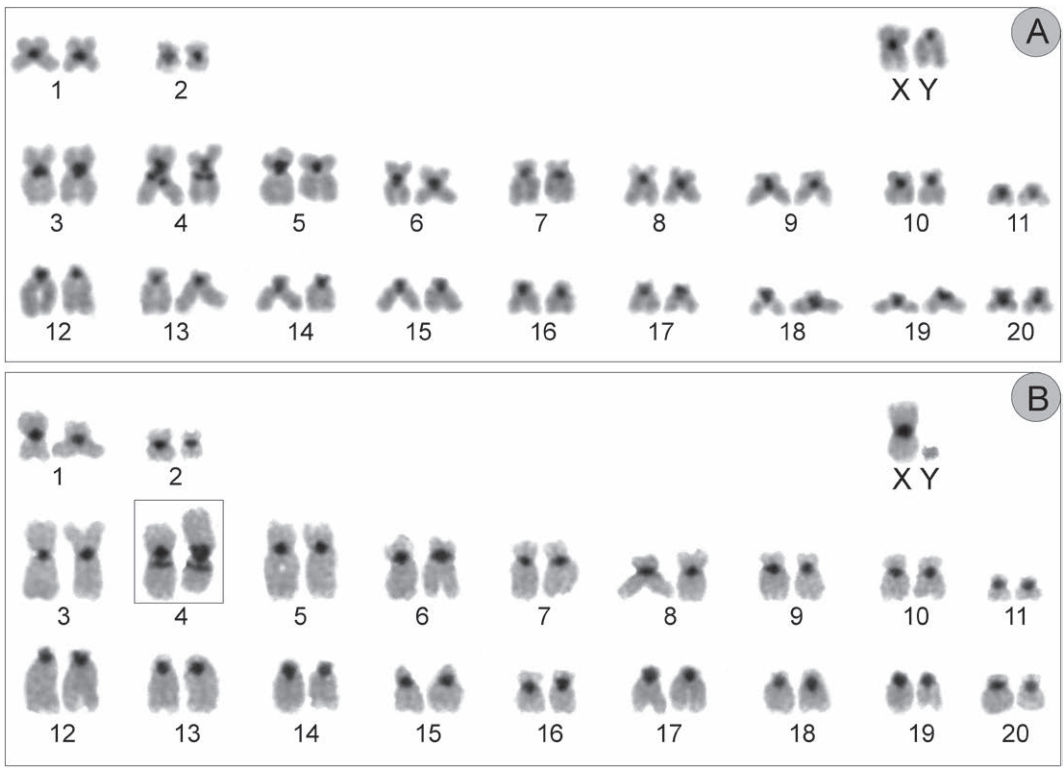

Fig. 3. C-banded karyotype of *Spermophilus xanthoprymnus* from Gümüşhane (A) and Bitlis (B). The heteromorphic chromosome pair is in frame.

Results

The diploid chromosomes number of *S. xanthoprymnus* specimens collected in the Provinces of Gümüşhane and Bitlis was 42. Karyotypes of the specimens examined from both sampling sites consisted of two pairs metacentric (no. 1-2), nine pairs submetacentric (nos. 3-11) and nine pairs subtelocentric (nos. 12-20) chromosomes. The fundamental number of autosomal arms (NFa) was 80. The X chromosome of Bitlis specimens was medium-sized and submetacentric, and the Y chromosome was dot-like and bi-armed. The X chromosome of Gümüşhane specimens was medium-sized and submetacentric as in Bitlis specimens, and the Y chromosome was medium-sized subtelocentric unlike Bitlis specimens. At both localities, the fundamental number of all chromosomal arms in the female complement (NF) was 84 (Fig. 2A and B).

At both sampling areas, all autosomes had different centromeric or pericentromeric C-positive bands. In addition, the submetacentric chromosome pair 4 in both studied areas had interstitial C-heterochromatin band. This interstitial C-heterochromatin block was on the long arm of the submetacentric autosomal pair 4 in the Gümüşhane population. However, this homologous chromosome pair was heteromorphic in the Bitlis population (Fig. 3A and B). This heteromorphism may be considered to be caused by intrachromosomal translocation occurring in one of the homologous chromosome pair (Fig. 4). The X chromosome had a centromeric or pericentromeric C-positive band in both populations. However, while the Y chromosome of the individuals in the Gümüşhane population had a centromeric band, the Y chromosome of the Bitlis population is entirely euchromatic. There are no differences in the constitutive heterochromatin appearance of the male and female individuals studied from both provinces.

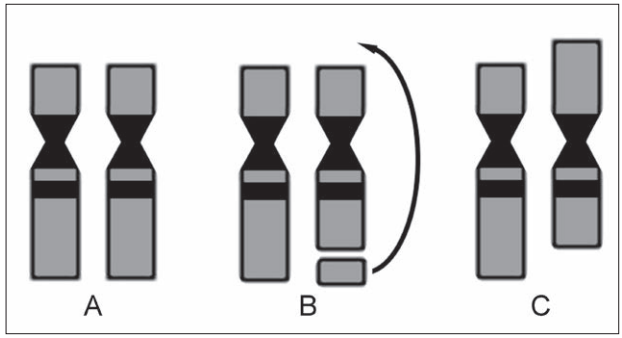

Fig. 4. The standard submetacentric autosomal pair 4 in Gümüşhane specimens (A) and intrachromosomal translocation in the submetacentric autosomal pair 4 in Bitlis specimens (B, C).

Discussion

The number of autosomal chromosomal arms (NF) of *Spermophilus xanthoprymnus* varies across the examined localities in Turkey (Bayburt, Çorum, Erzurum, Malatya, Sivas, Polatlı, Mining, Erzurum and Konya). However, in almost all of the studies, the Y chromosome was defined as the smallest and acrocentric in the set (Doğramacı et al. 1994, Özkurt et al. 2002, Arslan 2005). The Y chromosome of the same species in Armenia is bi-armed and the smallest in the set (Orlov et al. 1969, Voroncov & Lyunapunova 1969). The Y chromosome of *S. citellus* in Europe is also variable, reported as small (or dot-like) bi-armed or medium-sized acrocentric (Zima 1987, Doğramacı et al. 1994), being entirely heterochromatic (Chassovnikarova et al. 2015).

The karyotype and C-banding pattern of the Gümüşhane specimens are similar to the chromosomes of the species reported from Konya (Arslan 2005). However, the Gümüşhane specimens are differ from Konya specimens since they have medium-sized acrocentric Y chromosome and interstitial band in one of the autosomes. Similarly, the Bitlis individuals are different from those from Konya by the interstitial C-banding in the submetacentric autosomal pair 4. *Spermophilus taurensis* has no interstitial C-band in the set in Konya population (Arslan & Arslan 2010). The Y chromosome variations in *S. xanthoprymnus* from Anatolia may result of various chromosomal rearrangements.

Differences in the karyotypes may exist between mammal individuals, mammal species or major geographic forms within species. This can be associated with differences in ploidy, addition/deletion of specific chromosomes or major amounts of chromosomal material within chromosomes, or chromosomal rearrangements associated with Robertsonian fusions, tandem fusions and inversions (Pavlova & Searle 2018). Intrachromosomal translocations involve the movement of a chromosomal segment from one location in the chromosome to another location, and this is normally non-reciprocal. This translocation can be confirmed by G-banding. Banding techniques or molecular approaches are hitherto rather rare in this species. Chromosomal variations in different populations of *S. xanthoprymnus* in Turkey should be determined using advanced cytogenetic techniques and the results should be verified by molecular studies.

References

Arslan A. 2005. Cytogenetic studies on *Spermophilus xanthoprymnus* (Rodentia: Sciuridae) in Central Anatolia. Folia Zoologica 54: 278-284.

Arslan E. & Arslan A. 2010. Heterochromatin Distribution and Nucleolar Organizer Regions (NORs) of Taurus Ground Squirrel, *Spermophilus taurensis* Gunduz et al., 2007 (Mammalia: Rodentia) in Turkey. Turkish Journal of Zoology 34: 105-110.

Arslan A. & Zima J. 2014. Karyotypes of the mammals of Turkey and neighbouring regions: a review. Folia Zoologica 63: 1-62.

Chassovnikarova T., Rovatsos M., Atanasov N. & Koshev J. 2015. Sex chromosome variability of *Spermophilus citellus* (Linnaeus, 1766) in the Southeastern part of the Balkan Peninsula. Mammalian Biology 80: 365-371.

Doğramaci S., Kefelioğlu H. & Gündüz I. 1994. Karyological analysis of the genus, *Spermophilus* (Mammalia: Rodentia) in Turkey. Turkish Journal of Zoology 18: 167-170.

Ford C. E. & Hamerton J. L. 1956. A colchicine, hypotonic citrate, squash sequence for mammalian chromosomes. Stain Technology 31: 247-251.

Gaffaroğlu M. & Yüksel E. 2006. Karyotype analysis of ground squirrel (Mammalia: Rodentia) in Malatya (Türkiye). Journal of Biological Sciences 6: 754-757.

Gündüz İ., Jaarola M., Tez C., Yeniyurt C., Polly P. D. & Searle J. B. 2007. Multigenic and morphometric differentiation of ground squirrels (*Spermophilus*, Scuiridae, Rodentia) in Turkey, with a description of a new species. Molecular Phylogenetics and Evolution 43: 916-935.

Hsu T. C. & Benirschke K. 1967-1977. An Atlas of Mammalian Chromosomes. Vol. 1–10. Springer Verlag, Berlin-Heidelberg-New York.

Kart Gür M. & Gür H. 2010. *Spermophilus xanthoprymnus* (Rodentia: Scuiridae). Mammalian Species 42: 183-194.

Kryštufek B. & Vohralík V. 2005. Mammals of Turkey and Cyprus: Rodentia I: Sciuridae, Dipodidae, Gliridae, Arvicolinae. Koper: Knjiznica Annales Majora.

Matur F. 2009. A cytogenetic study on the Taurus ground squirrel, *Spermophilus taurensis* Gündüz et al., 2007 (Mammalia: Rodentia), in Turkey. Zoology in the Middle East 48: 103-105.

Orlov V. N., Rodova M. A. & Kotenkova E. A. 1969. Chromosomal differentiation of the ground squirrels subgenus *Citellus*. Materialy Vtorogo Vsesoyuznogo Soveshchaniya po Mlekopitayushchim, pp. 48-49 (In Russian).

Özkurt Ş., Yiğit N. & Çolak E. 2002. Karyotype variation in Turkey populations of *Spermophilus* (Mammalia: Rodentia). Mammalian Biology 67: 117-119.

Özkurt Ş., Sözen M., Yiğit N., Kandemir I., Çolak R., Gharkheloo M. M. & Çolak E. 2007. Taxonomic status of the genus *Spermophilus* (Mammalia: Rodentia) in Turkey and Iran with description of a new species. Zootaxa 1529: 1-15.

Pavlova S. V. & Searle J. B. 2018. Chromosomes and speciation in mammals. In: Zachos F. & Asher R. (Eds.): Handbook of Zoology; Mammalian Evolution, Diversity and Systematics. Walter de Gruyter GmbH & Co KG.

Sumner A. T. 1972. A simple technique for demonstrating centromeric heterochromatin. Experimental Cell Research 75: 304-306.

Voroncov N. N. & Lyapunova E. A. 1969. The chromosomes of Palearctic ground squirrels (Citellus, Marmotinae, Sciuridae, Rodentia). Materialy Vtorogo Vsesoyuznogo Soveshchaniya po Mlekopitayushchim, pp. 41-47 (In Russian).

Yiğit N., Neumann K., Özkurt Ş., Çolak E. & Çolak R. 2005. Biometric and genetic evolution of Spermophilus (Mammalia: Rodentia) populations in Turkey. Israel Journal of Zoology 51: 191-198.

Zima J. 1987. Karyotypes of certain rodents from Czechoslovakia (Sciuridae, Gliridae, Cricetidae). Folia Zoologica 36: 337-343.

Received: 01.09.2019
Accepted: 16.01.2020