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Karyotypes of the mammals of Turkey and neighbouring regions: a review

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Abstract. Available data on karyotypes of the mammals from Turkey and neighbouring regions (the Balkans, the Caucasus, and the Middle East) were summarized and reviewed in respect of their implications to taxonomy and systematics. In this review, previously unpublished data are presented in 20 species. Terrestrial mammals were taken into consideration, both the native and introduced. Altogether, 156 species occurring in the region concerned were included. The karyotype was studied in 109 of these species in Turkey, in most other species data are available from other geographic regions, and only three species remain unstudied cytogenetically. Intraspecific chromosomal variation (polymorphism or polytypy) was reported in 22 species. A karyotype different from the findings made in other regions was reported in Turkish populations of 17 species. Possible future directions of the cytogenetic investigations of mammals in the region are proposed.

Key words: chromosomes, banding pattern, Balkan, Caucasus, Middle East, species, taxonomy

Introduction

Turkey is situated in north-eastern parts of the Mediterranean area and it shows distinctly diverse landscape, climate, and biota. This region is of prime biogeographical interest due to its position between Europe and Asia, and its biota has been affected by complex vicariant interactions between the two continents. There is an apparent strong biogeographical impact of other regions neighbouring Turkey on the country's fauna and its species richness. In this respect, the European, Caucasian, Iranian, and Arabian regions are of the major importance, and the recent composition of the fauna of Turkish mammals reflects the influences of these biogeographical units. The territory of modern Turkey partly coincides with the "fertile crescent" and it has experienced an extraordinarily long period of intensive agricultural use and development resulting in large-scale changes in natural habitats. These long-term effects contributed to the vulnerability of the native species (Kryštufek et al. 2009b).

Research of the mammals of Turkey has a long tradition starting as early as in the 19th century and its history was reviewed by Kummerloeve (1975, 1982) and Kryštufek & Vohralík (2001). The results of mammalogical studies have recently been summarized in several review papers or comprehensive monographs (Spitzenberger 1978, 1979, Doğramacı 1989, Demirsoy 1996, Kurtonur et al. 1996, Benda & Horáček 1998, Kryštufek & Vohralík 2001, 2005, 2009, Özturk & Özturk 2002, Yiğit et al. 2006a, Benda et al. 2007). The mammalian fauna of the neighbouring regions was characterized in general publications reporting the species lists and distributional data (Mitchell-Jones et al. 1999, Aulagnier et al. 2009). We have considered in this review 156 species of terrestrial mammals, including three species recently extirpated in Turkey (*Panthera tigris*, *Ochotona rufescens*, *Castor fiber*) and two introduced species (*Oryctolagus cuniculus*, *Myocastor coypus*). We follow the taxonomic nomenclature applied by Wilson & Reeder (2005), with later modifications proposed by Kryštufek & Vohralík (2009) and a few other minor changes which are referred to in the text.

The cytogenetic research of the mammals in Turkey and neighbouring regions has been remarkably intensive during the last decades, and most of the species occurring on the area have been studied. The karyological studies have been conducted mainly

by Turkish researchers who published dozens of papers reporting karyotypes and chromosomal variation in the local mammals. The results of chromosomal investigations contributed significantly to understanding and resolving of various systematic and zoogeographic questions. The literature reporting karyotypes and chromosomal variation in mammals inhabiting the region under study has been scattered in many journals and proceedings. The aim of the present review is to compile the data, provide critical evaluation of the published findings, and contribute some unpublished results.

Methods

The description of the karyotypes and chromosomal characteristics in this study is following commonly used approaches. The system of classification of chromosomes according to the centromere position was adopted after Hsu & Benirschke (1967-1977). We distinguished four categories of chromosomes according to the centromere position: metacentric (M), submetacentric (SM), subtelocentric (ST), and acrocentric (A). The standard and commonly known abbreviations are used for the diploid number of chromosomes (2n), the fundamental number of autosomal arms (NFa), the fundamental number of all chromosomal arms in the female complement (NF), nucleolar organizer regions (NORs), the X chromosome (X), the Y chromosome (Y), and supernumerary chromosomes (Bs).

In the literature review, we refer to the previously published data on the karyotypes of European mammals (Zima & Král 1984a, b, c) and, usually, only recent publications published after 1984 are cited. In some species, we have included also own unpublished results which are only briefly commented.

The European part of Turkey is known as Turkish Thrace (Trakya, Rumeli) and the Asiatic part as Asia Minor or Anatolia (Anadolu). Asiatic Turkey consists of two main folded zones, the northern and southern, with a high plateau lying between them. In order to precise the geographic position of the localities and sites referred to, we provide a name of the administrative province (vilayet) in parentheses.

Species accounts

White-breasted hedgehog, *Erinaceus concolor* Martin, 1838

2n = 48, NFa = 90, NF = 94; X = M, Y = M

The karyotype consists of 12 pairs of metacentric, six pairs of submetacentric, four pairs of subtelocentric, and one pair of acrocentric autosomes. The X chromosome is medium-sized and metacentric and the Y chromosome is minute and metacentric (see Zima & Král 1984a for review, O'Brien et al. 2006). Chromosome evolution in Eulipotyphla was reviewed by Biltueva & Vorobieva (2012).

No distinct variation was found in samples investigated by conventional staining in various regions in Turkey (Doğramacı & Gündüz 1993, Ulutürk & Coşkun 2011). The hedgehogs from northern, central and southern Anatolia (Sinop, Trabzon, Kırıkkale, Konya, Antalya, Gaziantep, Şanlıurfa) were examined with application of G-, C- and AgNOR banding (Arslan et al. 2008c). Large blocks of positive C-bands were found in the terminal regions of the long arms of three autosomal pairs (Fig. 1). The NORs were found in telomeric regions of the arms of four autosomal pairs, and the two distinct distribution variants of nucleolar organizers were observed in samples from central-southern Anatolia and north-eastern Turkey, respectively. The karyotype reported from Turkey corresponded to the chromosomal type designated as E I by Mandahl (1978).

The karyotype was investigated also in Jordan (Qumsiyeh 1991), the southern side of the Caucasus Mts. (Sokolov et al. 1991), Iran (Karataş et al. 2007a) and in China (Wang et al. 1988). Karataş et al. (2007a) assumed the presence of two acrocentric pairs in the complement of studied Iranian specimens. The taxonomic status of the Chinese populations

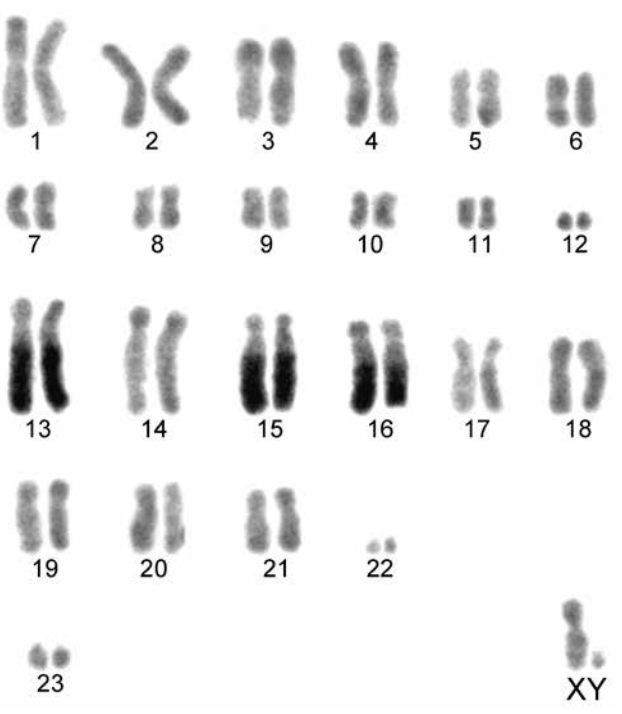

Fig. 1. C-banded karyotype of *Erinaceus concolor* (Anatolia).

is questionable (the specimens studied probably belonged to *E. amurensis*) and the reported karyotypes are different from those observed in *E. concolor* from the western Palaearctics.

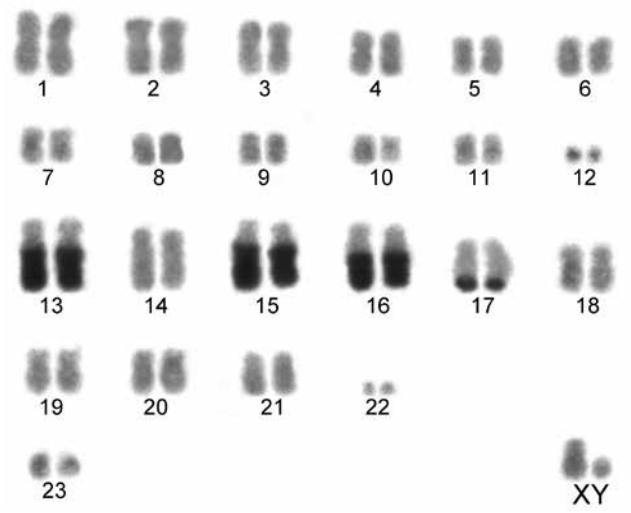

Fig. 2. C-banded karyotype of *Erinaceus roumanicus* (Thrace).

Eastern hedgehog, *Erinaceus roumanicus* Barret-Hamilton, 1900
2n = 48, NFa = 90, NF = 94; X = M, Y = M
The basic karyotype characteristics are similar as in *E. concolor* but distinct differences exist between the two species in the distribution of C-heterochromatin and AgNORs (Sokolov et al. 1991, Gavrilă et al. 1998, O'Brien et al. 2006, Arslan et al. 2008c).
The karyotype examined in Turkish Thrace (Tekirdağ, Edirne province; Arslan et al. 2008c) corresponded to the chromosomal type designated as E II by Mandahl (1978). In this karyotype, the large positive C-bands were localized in the terminal region of the long arms of four autosomal pairs. The C-block in one autosome pair (autosome 17 in Fig. 2) had a size about one third of that recorded in other large C-blocks and this C-band was lacking in the complement of the white-breasted hedgehog. The NORs were localized in telomeric regions of the long arms of four autosomal pairs and in the short arms of the small acrocentric autosomal pair.

Long-eared hedgehog, *Hemiechinus auritus* (Gmelin, 1770)
2n = 48, NFa = 90-92, NF = 94-96; X = M, Y = M/SM
The autosomal complement comprises one pair of large submetacentric, 20 pairs of meta- and submetacentrics of decreasing size and two pairs of very small elements. The X chromosome is a medium-sized metacentric; the Y chromosome is the smallest bi-armed element (see Zima & Král 1984a for review, O'Brien et al. 2006; Fig. 3). Cross-species chromosome painting was studied by Yang et al. (2006).
The conventionally stained karyotype described in Turkey is slightly different from complements reported from other areas of the species distribution range. Çolak et al. (1998a, b) and Ulutürk & Coşkun (2011) distinguished the smallest autosome as biarmed (NFa = 92) whereas Kefelioğlu (1997a) as acrocentric (NFa = 90). The chromosome banding pattern was

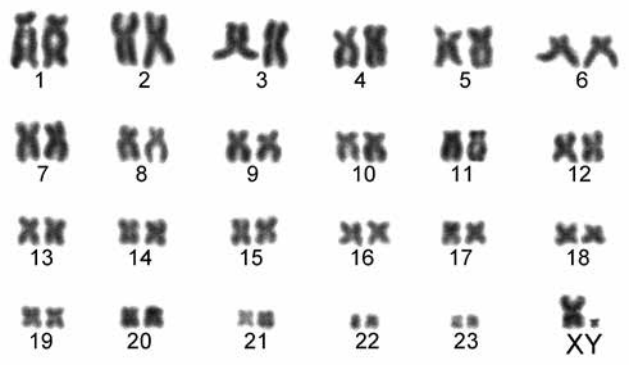

Fig. 3. Karyotype of *Hemiechinus auritus* (Anatolia).

described by Arslan et al. (2009) in individuals from the Şanlıurfa and Kilis provinces. Most of the autosomes possessed centromeric C-heterochromatin. The sex chromosomes appeared euchromatic and possible geographic variation in their morphology was indicated in comparison with previously published data. The NORs were located in terminal areas of the long arm of four bi-armed autosomes. The localization of the NORs was not associated with the C-positive autosomal regions as in the hedgehogs of the genus *Erinaceus*.

Pygmy shrew, *Sorex minutus* Linnaeus, 1766
2n = 42, NFa = 54, NF = 56; X = A, Y = A
The karyotype comprises five large meta- and submetacentric autosomal pairs, one small metacentric autosomal pair, one small submetacentric autosomal pair, and 13 acrocentric autosomal pairs of diminishing size. A prominent secondary constriction is localized in an acrocentric autosomal pair. The X chromosome is a medium-sized acrocentric; the Y chromosome is a small acrocentric. The chromosomal banding pattern was described in the pygmy shrew karyotype by various authors (see Zima & Král 1984a for review, Ivanitskaya 1989, Dannelid 1994, Zima et al. 1998, Biltueva et al. 2000, O'Brien et al. 2006).

The conventionally stained karyotype of the species was reported by Zima et al. (1997b) from the Istranca Mts. in Thrace, and it was the same as in many other populations examined throughout the species range.

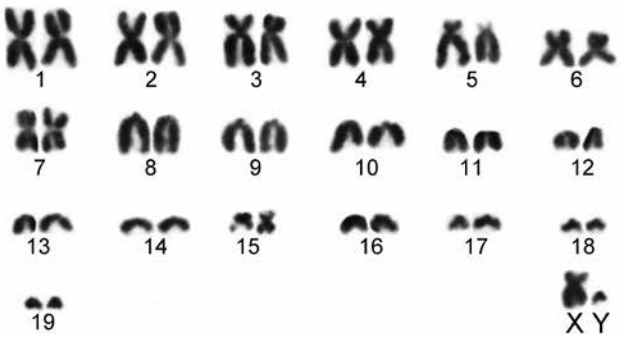

Fig. 4. Karyotype of *Sorex volnuchini* (Anatolia).

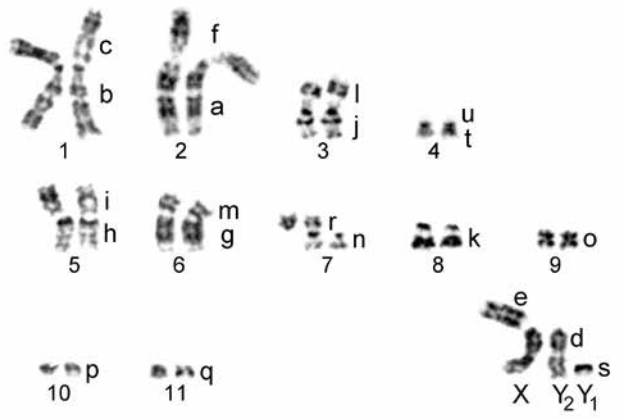

Fig. 5. G-banded karyotype and chromosomal arm nomenclature of *Sorex araneus* (Ulm race, Czech Republic).

Caucasian pygmy shrew, *Sorex volnuchini* Ognev, 1922
2n = 40, NFa = 56, NF = 60; X = M, Y = A
The karyotype includes four large meta- and submetacentric autosomal pairs, one large subtelocentric autosomal pair, two metacentric autosomal pairs of medium size, two small biarmed autosomal pairs, and 10 acrocentric autosomal pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a for review, Fig. 4).
We have examined the karyotype of a single individual of this species from Meryaman (Trabzon province) (Zima et al. 1998), and it seemed to be similar to the complements reported from the Caucasus Mts. (Sokolov & Tembotov 1989).

Common shrew, *Sorex araneus* Linnaeus, 1758
2n = 26 in females/27 in males, NFa = 36, NF = 40;
X = M, Y_1 = A, Y_2 = A
The karyotype of the common shrew is characteristic by the composite sex chromosome system, XY_1Y_2 in males and XX in females, and extensive Robertsonian variation in the autosomal complement. The composite sex chromosome system evolved after a translocation of an autosome to the original X chromosome. The resulting X chromosome is a large metacentric, the Y_1 chromosome is a small acrocentric and the Y_2 chromosome is a medium-sized acrocentric with distinct short arms. In the standardized karyotype, each substantial chromosome arm is denoted by an italicized lower-case letter of the alphabet with *a* the largest (Searle et al. 1991). Three pairs of bi-armed autosomes *af*, *bc*, and *tu* are invariant, while other arms *g – r* occur as dissociated uni-armed acrocentrics and/or combined together as fused biarmed metacentrics. The karyotype can be described as *af*, *bc*, *de*, *(g*, *h*, *i*, *k*, *m*, *n*, *o*, *p*, *q*, *r)*, *jl*, *s*, *tu* where the arms in parenthesis can ocurr either as uni-armed or bi-armed autosomes (Fig. 5). Cross-species chromosome painting was studied by Ye et al. (2006) and Biltueva et al. (2011).
Populations or groups of populations sharing the same distinct karyotype have been recognized as races. A chromosome race of *Sorex araneus* is defined as a group of geographically contiguous or recently separated populations which share the same set of metacentrics and acrocentrics by descent (Hausser et al. 1994).
The complement of the Turkish common shrews examined in Demirköy (Kırklareli province, Turkish Thrace) included specific arm combinations in bi-armed autosomes *g*, *h*, *ik*, *mn*, *o*, *p*, *q*, *r*, and the studied population was described as a separate chromosomal race called Istranca (Zima et al. 1997b). Similar arm combinations in Robertsonian metacentrics were reported only from some populations in northern and eastern Europe and Siberia (Zima et al. 1996, Wójcik et al. 2003).

Caucasian shrew, *Sorex satunini* Ognev, 1921
2n = 24 in females/25 in males, NFa = 42, NF = 46;
X = M, Y_1 = A, Y_2 = A
The autosomal set consists of one pair of large submetacentrics, one pair of large subtelocentrics, four pairs of medium-sized meta- and submetacentrics, four pairs of small metacentrics and one pair of small acrocentrics. The sex chromosomes are made up of the same trivalent XY_1Y_2 as in *S. araneus* (Zima & Král 1984a for review, Ivanitskaya 1985). The karyotype of *S. satunini* can be symbolized as *af*, *bc*, *de*, *gh*, *ik*, *jn*, *lo*, *m**, *p**, *q**, *r**, *s*, *tu* (Orlov et al. 2010), where the arms marked with asteriscs are assumed to be slightly re-arranged in comparison with the karyotype

of *S. araneus*. The distribution of AgNORs in the karyotype was reported by Ivanitskaya (1989).
The karyotype of populations from Turkey was reported by Macholán (1996), and it seemed to be the same as in studies from other regions.

Radde's shrew, *Sorex raddei* Satunin, 1895
2n = 36, NFa = 66, NF = 68; X = A, Y = SM
The autosomal complement includes 16 pairs of large to small bi-armed elements, and a pair of small satellited acrocentrics. The X chromosome is a medium sized acrocentric, the Y chromosome is a small submetacentric (Zima & Král 1984a for review, Fig. 6). The G-banding pattern was described in the karyotype of this species by Biltueva et al. (2000) and O'Brien et al. (2006).
We have examined the conventionally stained karyotype of a single individual of this species from Meryem Ana (Trabzon province) (Zima et al. 1998), and it seemed to be similar to that reported from the Caucasus Mts. (Sokolov & Tembotov 1989).

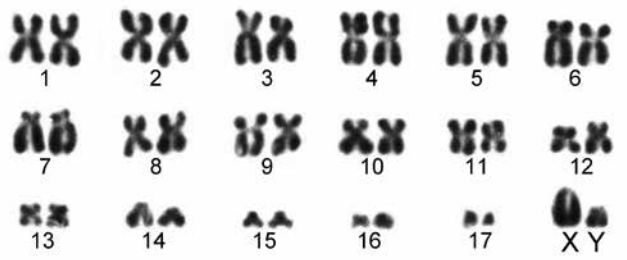

Fig. 6. Karyotype of *Sorex raddei* (Anatolia).

Miller's water shrew, *Neomys anomalus* Cabrera, 1907
2n = 52, NFa = 94, NF = 98; X = ST, Y = SM
The autosomal complement consists of 22 bi-armed (11 metacentric, 9 submetacetric, and two subtelocentric pairs) and three acrocentric pairs. The X chromosome is a large subtelocentric; the Y chromosome is the smallest submetacentric (see Zima & Král 1984a for review). The G-banded karytype was shown by Zima et al. (1998), the C-banding pattern and the distribution of NORs were described in animals from Bulgaria by Chassovnikarova et al. (2009).
We found the standard karyotype of this species in samples from Demirköy (Kırklareli), Lake Abant (Bolu), Uludağ (Bursa), Yenice (Zonguldak), Doğanköy, Eber Gölü (Afyon), and Çirpilar (Çanakkale).

Transcaucasian water shrew, *Neomys teres* Miller, 1908
2n = 52, NFa = 94, NF = 98; X = ST, Y = ST
The conventionally stained karyotype is the same as in *N. anomalus* and it was reported for the Causasian populations (Sokolov & Tembotov 1989). Data from Turkey are not yet available.

Bicoloured white-toothed shrew, *Crocidura leucodon* (Herrmann, 1780)
2n = 28, NFa = 46, NF = 50; X = SM, Y = A
The autosomal complement includes five large meta- and submetacentric pairs, one large subtelocentric pair, four small meta-, submeta- and subtelocentric pairs, and three smaller acrocentric pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is an acrocentric and its size may vary (Zima et al. 1998 for review). The chromosome banding (G-, C-, AgNOR) was reported by Graphodatsky et al. (1988). The findings from the Caucasus Mts. and Europe (Biltueva et al. 2001) demonstrated that two divergent karyotypes exist differing in the composition of arms in some large biarmed autosomes. The two main mitochondrial clades within this species that were revealed by Dubey et al. (2007) could represent the chromosomal differences detected in the karyotype analyses undertaken by Biltueva et al. (2001). In this respect we can assume that populations of *C. leucodon* in European Turkey, western Anatolia and other parts of Asiatic Turkey may be different in respect of the arm combinations in bi-armed autosomes.
The Turkish populations were studied by Kefelioğlu & Tez (1999) and Tez (2000) and conventional staining revealed a standard karyotype. We found a similar result in samples from Harput (Elazığ) and Narlikuyu (Icel). Chromosomal banding investigations are necessary to reveal the actual arm composition in the karyotype.

Lesser white-toothed shrew, *Crocidura suaveolens* (Pallas, 1811)
2n = 40, NFa = 46, NF = 50; X = SM, Y = A
The complement comprises one large submetacentric autosomal pair, three smaller biarmed autosomal pairs, and 15 acrocentric autosomal pairs. The X chromosome is a large submetacentric; the Y chromosome is an acrocentric (Fig. 7). B chromosomes were exceptionally reported in European populations (see Zima et al. 1998 for review). The chromosome banding (G-, C-, AgNOR) was reported by Graphodatsky et al. (1988), Ivanitskaya (1989), Maddalena & Ruedi (1994), and O'Brien et al. (2006).
Karyotypic data from various regions in Turkey were published by Catzeflis et al. (1985), Kefelioğlu & Tez (1999) and Tez (2000) and the standard complement with 40 chromosomes was found. Kefelioğlu & Tez (1999) found the same karyotype in samples from

the type localities of *C. russula monacha* a *C. r. aralychensis*. We recorded the standard karyotype in individuals examined from Konacık Köyü (Uluçınar), Çayır, Yenice, Çaycuma (Zonguldak), Kürtler (Samsun), Harput (Elazığ), Doğanköy, Eber Gölü (Afyon) and Karabulut, Akşehir Gölü (Konya).
The same complement was recorded in populations from the Caucasus recognized as *C. gueldenstadti* or *C. caspia* (Mamedov 1986, Tembotova 1987, Anisimov & Dolgov 1990). We found this karyotype also in several sites in Syria (Qanawat, Bloudan, Ras al-Bassit, Qattinah) and Iran (Churti, Nowkande – Mazandaran, Asalem – Gilán, Bastam, Chuplu, Bisotun, Mohammad Yar).

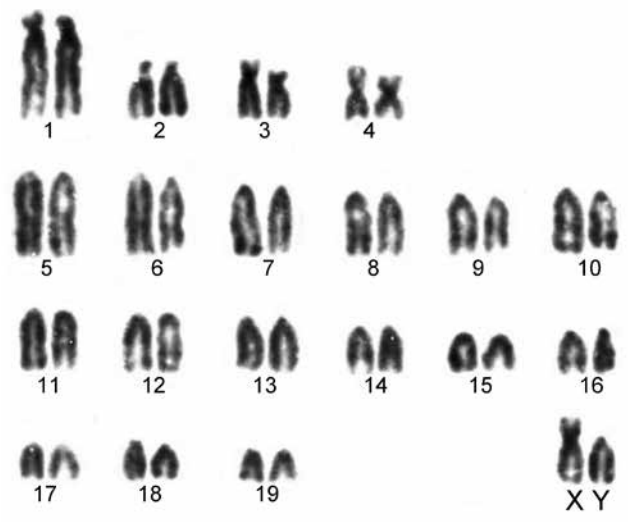

Fig. 7. Karyotype of *Crocidura suaveolens* (Anatolia).

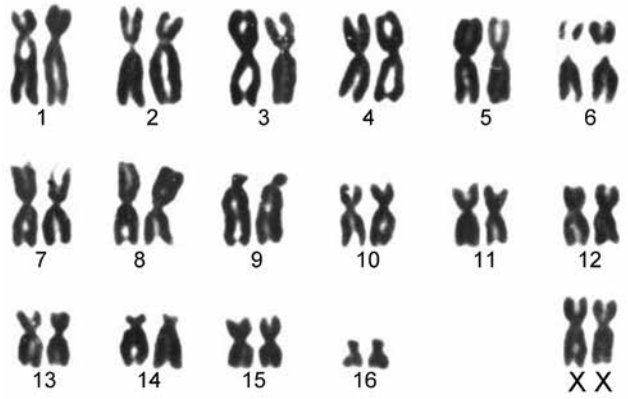

Fig. 8. Karyotype of *Talpa europaea* (Czech Republic).

Cyprus white-toothed shrew, *Crocidura cypria* Bate, 1904
2n = 40, NFa = 46, NF = 50; X = SM, Y = A
The karyotype was described by Catzeflis (1983) and it seemed to be identical with that of *C. suaveolens*.

Jackass shrew, *Crocidura arispa* Spitzenberger, 1971
The karyotype is not known. There are chromosomal records in two possibly related species, *C. serezkyensis* from Azerbaijan (2n = 22; Graphodatsky et al. 1988, O'Brien et al. 2006), and *C. ramona* from Israel (2n = 28; Ivanitskaya et al. 1996b).

Pygmy white-toothed shrew, *Suncus etruscus* (Savi, 1822)
2n = 42, NFa = 68-74, NF = 72-78; X = ST, Y = A
The autosomal set reported from Europe consists of six metacentric, four submetacentric, four subtelocentric and six acrocentric pairs (NFa = 68). The karyotype described in India had the same chromosome number but included only three acrocentric pair (NFa = 74). The X chromosome is a large subtelocentric; the Y chromosome is an acrocentric of medium size (see Zima & Král 1984a for review, Aswathanarayana et al. 1987). Karyological data from Turkey are not yet available.

European mole, *Talpa europaea* Linnaeus, 1758
2n = 34, NFa = 64, NF = 68; X = M, Y = M
The autosomal complement consists of bi-armed elements. A large metacentric pair carries a secondary constriction in the pericentromeric region. The X chromosome is a medium-sized metacentric; the Y chromosome is dot like and bi-armed (Fig. 8). Cross-species chromosome painting was studied by Volleth & Müller (2006).
No data are available from Turkey, but the karyotype was described in various parts of Europe (see Zima & Král 1984a for review, Belcheva et al. 1988). The banding pattern was described by Zima (1983b) and Belcheva et al. (1988); variation in the karyotype characteristics was reported from the Balkans (Soldatović et al. 1987, Todorović et al. 1987).

Caucasian mole, *Talpa caucasica* Satunin, 1908
2n = 38, NFa = 62, NF = 66; X = M, Y = D
The autosomal complement consists of a large subtelocentric, 12 meta- and submetacentric and five acrocentric pairs. The X chromosome is a large metacentric; the Y chromosome is dot-like and bi-armed (see Zima & Král 1984a for review).
Karyological study of populations in Turkey was provided by Kefelioğlu & Gençoğlu (1996) who examined individuals from Artvin. The karyotype reported from Turkey was different from that from the Caucasus (Sokolov & Tembotov 1989), because the largest chromosome was identified as bi-armed in the Turkish population (NFa = 62) whereas it was

described as acrocentric in the Caucasian populations (NFa = 60).

Levantine mole, *Talpa levantis* Thomas, 1906
2n = 34, NFa = 64, NF = 68; X = M, Y = M
The autosomal set consists of 16 bi-armed pairs. The X chromosome is a large metacentric; the Y chromosome was identified either as a medium-sized metacentric or dot-like (see Zima & Král 1984a for review).
The karyotype was examined in the Black Sea Mts. in northern Anatolia by Kefelioğlu & Gençoğlu (1996) and it was similar to descriptions from the Caucasus (Sokolov & Tembotov 1989).

Persian mole, *Talpa davidiana* (Milne-Edwards, 1884)
2n = 34, NFa = 62, NF = 66; X = M, Y = A
The autosomal complement includes 15 metacentric and submetacentric pairs and one acrocentric pair of medium size. The last pair of bi-armed autosomes is distinctly smaller than the others. The X chromosome is metacentric; the Y chromosome is acrocentric and dot-like.
The karyotype was for the first time examined on the Kızıldağ high plateau (Adana) by Sözen et al. (2012).

Egyptian fruit bat, *Rousettus aegyptiacus* (Geoffroy, 1810)
2n = 36, NFa = 66, NF = 70; X = SM, Y = A
The autosomal set comprises 12 large to small meta- and submetacentric pairs, four medium-sized subtelocentric pairs and one small acrocentric pair. The X chromosome is a medium-sized submetacentric; the Y chromosome is the smallest dot-like element (Haiduk et al. 1981, Salleh et al. 1999). The chromosome G-banding pattern was reported by Haiduk et al. (1981) and O'Brien et al. (2006). Chromosome evolution in bats was reviewed by Volleth & Eick (2012).
The karyotype in Turkey was studied by Karataş et al. (2003a) and Albayrak et al. (2008) in southern Anatolia (Adana, Antalya, Mersin and Hatay provinces) and a standard complement was found.

Naked-rumped tomb bat, *Taphozous nudiventris* Cretzchmar, 1830
2n = 42, NFa = 64, NF = 68; X = M/SM, Y = A
The autosomal complement consists of 12 metacentric and submetacentric pairs and eight acrocentric pairs of autosomes decreasing in size. The X chromosome is a medium-sized metacentric or submetacentric and the Y is a small acrocentric (O'Brien et al. 2006).

Karataş & Sözen (2002) and Aşan & Albayrak (2007) examined the karyotype of this species in individuals from Nizip (Gaziantep). The results of these studies from the same site differ in evaluation of the centromeric position in the X chromosome (metacentric or submetacentric) and the size of the Y chromosome (small or dot-like).
The karyotype and its G- and C-banding patterns were studied from Egypt by Hood & Baker (1986). The comparison with other data from Egypt (El-Dawy & Ibrahim 1994, Yaseen et al. 1994) and India (Sreepada et al. 1995), inhabited by different subspecies, respectively, indicated variations in chromosome morphologies between geographic populations.

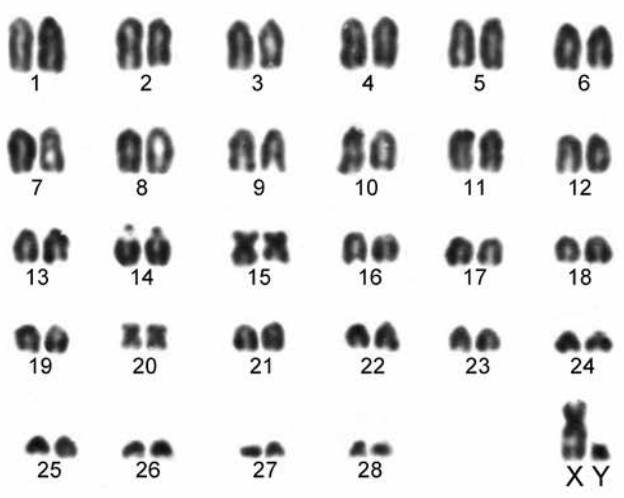

Fig. 9. Karyotype of *Rhinolophus ferrumequinum* (Anatolia).

Greater horseshoe bat, *Rhinolophus ferrumequinum* (Schreber, 1774)
2n = 58, NFa = 60-62, NF = 64-66; X = M, Y = A/M
The autosomal complement includes two medium-sized bi-armed pairs and 26 acrocentric pairs (NFa = 60). Some authors recognized one of the two dot-like autosomal pairs as bi-armed (NFa = 62). One of the acrocentric autosomes carries a secondary constriction. The X chromosome is a large metacentric; the Y chromosome is dot-like, acrocentric or metacentric (see Zima & Král 1984a for review, Qumsiyeh et al. 1986, Iliopoulou-Georgudaki 1986, Belcheva et al. 1990, O'Brien et al. 2006). Cross-species chromosome painting was applied in this species by Mao et al. (2007).
The karyotype of Turkish populations was investigated by Karataş et al. (2006b) in samples collected in the Karabük and Zonguldak provinces in northern Anatolia, and the findings agreed with published data. We found the same karyotype in three specimens

examined from the Yalan Dünya Mağarası (Içel) and Çevlik (Hatay) (Fig. 9). Karataş et al. (2008b) found a similar karyotype in populations from Jordan but Karataş et al. (2006a) recorded a different number of autosomal arms (NFa = 58) in Iran.

Lesser horseshoe bat, *Rhinolophus hipposideros* (Bechstein, 1800)
2n = 54, NFa = 60, NF = 64; X = SM, Y = A or 2n = 58, NFa = 60, NF = 64; X = M/SM, Y dot-like
Three different diploid numbers (2n = 54, 56, 58) have been reported in this species (review in Zima et al. 1992a, Puerma et al. 2008). The populations with different chromosome numbers can be considered intraspecific karyotypic races. The race with 2n = 54 was recorded in Western Europe (Puerma et al. 2008, Volleth et al. 2013), the race with 2n = 56 in other areas studied in Europe (Belcheva et al. 1990, review in Zima et al. 1992a; Fig. 10), and the race with 2n = 58 in Jordan (Qumsiyeh et al. 1986, 1988). The populations with 2n = 62 from southern Kyrghyzstan (Zima et al.

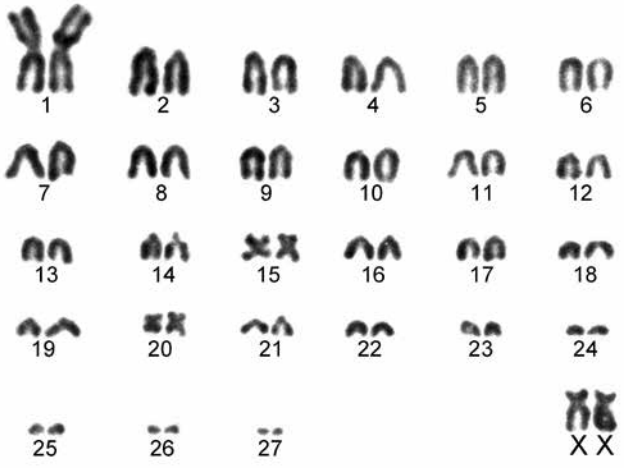

Fig. 10. Karyotype of *Rhinolophus hipposideros* with 56 chromosomes (Czech Republic).

1992a) has recently been attributed to *R. lepidus* (Benda et al. 2011). In all the races, the X chromosome has uniformly been reported as a medium-sized bi-armed element; the Y chromosome as dot-like.
The karyotype of Turkish populations was investigated by Karataş et al. (2006b) in samples collected in the Karabük and Zonguldak provinces in northern Anatolia. A unique complement was recorded differing from those reported from other regions (2n = 54, NFa = 60, NF = 64; X = SM, Y = A). The autosomal complement included three large and one small metacentric pairs and 22 acrocentric pairs. The X chromosome was a medium-sized submetacentric;

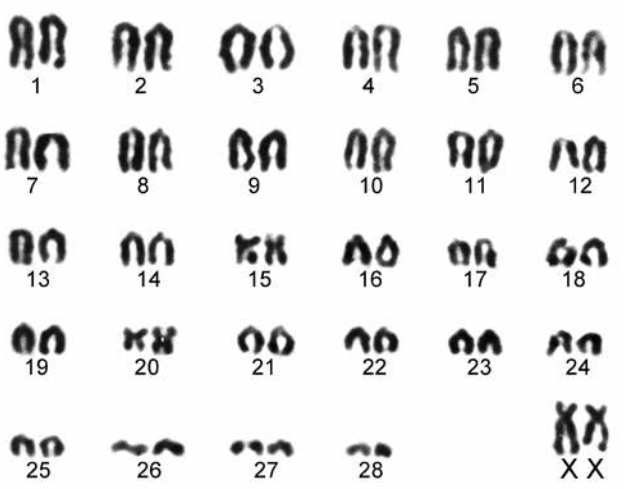

Fig. 11. Karyotype of *Rhinolophus hipposideros* with 58 chromosomes (Anatolia).

the Y chromosome dot-like and acrocentric.
We have examined the karyotype of the lesser horseshoe bat in four individuals from Konacik Köyü (Ulucinar), Safranbolu (Zonguldak), Narlikuyu and the Yalan Dünya Mağarası (Içel), and we found the karyotype with 2n = 58, NFa = 60, NF = 64 (Fig. 11) which was quite similar to the finding from Jordan (Qumsiyeh et al. 1986, 1988). The autosomal complement consisted of two medium-sized or small metacentric pairs and 26 acrocentric pairs. The X chromosome was meta- or submetacentric; the Y chromosome was dot-like. We recorded the same karyotype in Syria (Qala'at al-Hosn) and Iran (Emamzadeh, Esfahan province).

Mediterranean horseshoe bat, *Rhinolophus euryale* Blasius, 1853
2n = 58, NFa = 60, NF = 64; X = M, Y = A/M
The autosomal complement includes two medium-sized bi-armed pairs and 26 acrocentric pairs. One of the acrocentric autosomes carries a secondary constriction. The X chromosome is a large metacentric; the Y chromosome is dot-like, acrocentric or metacentric (see Zima & Král 1984a and Zima et al. 1992a for review).
Karyological data from Turkey are not yet available. Karataş et al. (2008b) found the standard karyotype in populations from Jordan.

Mehely's horseshoe bat, *Rhinolophus mehelyi* Matschie, 1901
2n = 58, NFa = 62, NF = 66; X = M, Y = A
The karyotype is similar to those of the previous species but the varying number of bi-armed autosomes (two, three or four pairs; NFa = 60, 62, 64) was

described (see Zima & Král 1984a and Zima et al. 1992a for review). Chromosome painting was used in establishing the comparative map by Ao et al. (2007). We examined the karyotype of a male from the Insuyu Mağarası (Burdur) and we found that the autosomal complement included two medium-sized bi-armed pairs and one bi-armed dot-like pair (NFa = 62). The karyotype of *Rh. mehelyi* from Turkey is thus almost identical to that reported in *Rh. ferrumequinum* and other horseshoe bat species.

Blasius' horseshoe bat, *Rhinolophus blasii* Peters, 1866
2n = 58, NFa = 60, NF = 64; X = SM, Y = A/M
The autosomal complement includes two medium-sized bi-armed pairs and 26 acrocentric pairs. One of the acrocentric autosomes carries a secondary constriction. The X chromosome is a large submetacentric; the Y chromosome is dot-like, acrocentric or metacentric (see Zima & Král 1984a, Qumsiyeh et al. 1986, Zima et al. 1992a for review). We examined the karyotype of a male from the Insuyu Mağarası (Burdur) and we found a standard karyotype of the species (Fig. 12). Karataş et al. (2008b) found the same karyotype in populations from Jordan.

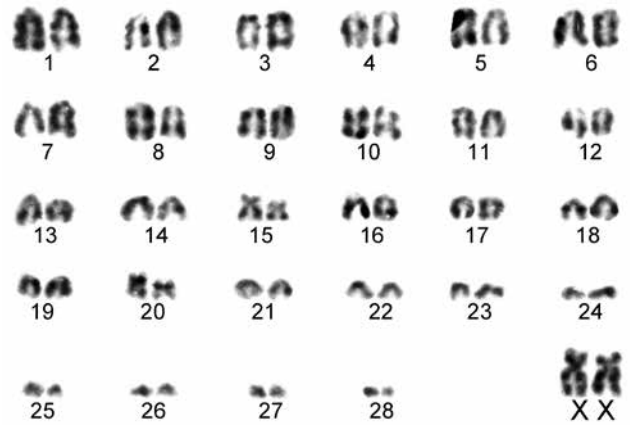

Fig. 12. Karyotype of *Rhinolophus blasii* (Anatolia).

Whiskered bat, *Myotis mystacinus* (Kuhl, 1817)
2n = 44, NFa = 50, NF = 54; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs. The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric (see Zima & Král 1984a for review, Volleth 1987, 1989). Karyological data from Turkey are not yet available.

Golden bat, *Myotis aurascens* Kusjakin, 1935
2n = 42-44, NFa = 48-50, NF = 52-54; X = M, Y = A
The karyotype is similar to the previous species. The specimens examined by Volleth (1987) as *Myotis* sp. A from Greece and Turkey (Beşkonak, Antalya Province) apparently belonged to this species and possessed 44 chromosomes in their karyotypes. However, Arslan (2013) found only 42 chromosomes in the karyotype of specimens from Konya. The fundamental chromosome number (NF) was 52 and the number of autosomal arms (NFa) was 48. The karyotype included three large and one small metacentric autosomal pairs and 16 acrocentric autosomal pairs. The X chromosome was a medium-sized metacentric (Fig. 13). The Ag-NOR regions of this species were found in telomeric regions of the short arms of three acrocentric autosomal pairs and the NORs were heteromorphic in two of these pairs (Arslan 2013).

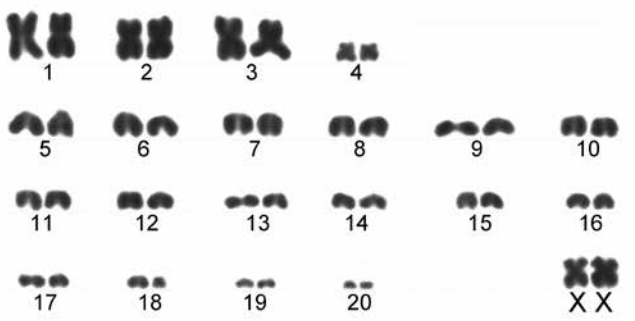

Fig. 13. Karyotype of *Myotis aurascens* (Anatolia).

Nepalese bat, *Myotis nipalensis* (Dobson, 1871)
2n = 44, NFa = 50, NF = 54; X = M, Y = A
We can assume that the specimens studied from Tadjikistan and identified as *M. mystacinus* by Radjabli et al. (1970) actually belonged to *M. nipalensis*, and the karyotype contained 44 chromosomes with similar morphology as in other *Myotis* species. Karyological data from Turkey are not yet available.

Brandt's bat, *Myotis brandtii* (Eversmann, 1845)
2n = 44, NFa = 50, NF = 54; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs. The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric (see Zima & Král 1984a for review).
M. brandtii from Turkey was karyologically examined by Karataş et al. (2007b), and a standard complement was found.

Alcathoe bat, *Myotis alcathoe* von Helversen et Heller, 2001
2n = 44, NFa = 50, NF = 54; X = M, Y = A

The karyotype is similar to the previous species. The specimens examined by Volleth (1987) as *Myotis* sp. B from Greece apparently belonged to *M. alcathoe*.

Geoffroy's bat, *Myotis emarginatus* (Geoffroy, 1806)
2n = 44, NFa = 52, NF = 56; X = M, Y = A/SM
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs, one of which is bi-armed. The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric or submetacentric (see Zima & Král 1984a for review, Volleth 1989). Karyological data from Turkey are not yet available.

Natterer's bat, *Myotis nattereri* (Kuhl, 1817)
2n = 44, NFa = 52, NF = 56; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs. The X chromosome is a medium-sized metacentric; the Y chromosome is a relatively large acrocentric (see Zima & Král 1984a for review). The banding pattern and the distribution of nucleolar organizer regions were described by Volleth (1987, 1989) and Ono & Obara (1994). Karyological data from Turkey are not yet available.

Bechstein's bat, *Myotis bechsteinii* (Kuhl, 1817)
2n = 44, NFa = 52, NF = 56; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs (an acrocentric and a bi-armed). The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric (see Zima & Král 1984a for review). The complement comprises up to 10 autosomal pairs possessing NORs (Volleth 1987).
M. bechsteinii from Turkey was karyologically examined by Volleth (1987) from Beşkonak (Antalya Province) and by Karataş et al. (2007b). Their findings were congruent with other reports.

Greater mouse-eared bat, *Myotis myotis* (Borkhausen, 1797)
2n = 44, NFa = 50-52, NF = 54-56; X = M, Y = A
The autosomal complement comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs (one of these minute pairs is reported bi-armed in some papers). The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric (see Zima & Král 1984a for review, Iliopoulou-Georgudaki & Giagia 1984, Volleth 1987, 1989; Fig. 14). The complement comprises up to 14 autosomal pairs possessing NORs (Volleth 1987). Chromosome painting and G-banding comparisons with karyotypes of related species were presented by Ao et al. (2006, 2007).
The karyotype of Turkish populations was studied by Karataş et al. (2004, 2007b). The largest acrocentric pair possessed a tiny heterochromatic arm (Aşan & Albayrak 2011). The G-banded chromosomes were studied by Aşan et al. (2011) and the same pattern was revealed in comparison between *M. myotis* and *M. blythii*. Arslan (2013) studied the distribution of NORs in specimens from Konya. The Ag-NOR regions were localized in the pericentromeric region of a biarmed autosomal pair and telomeric regions of the short arms of four acrocentric autosomal pairs. A similar standard karyotype was found in Bulgaria (Belcheva et al. 1992).

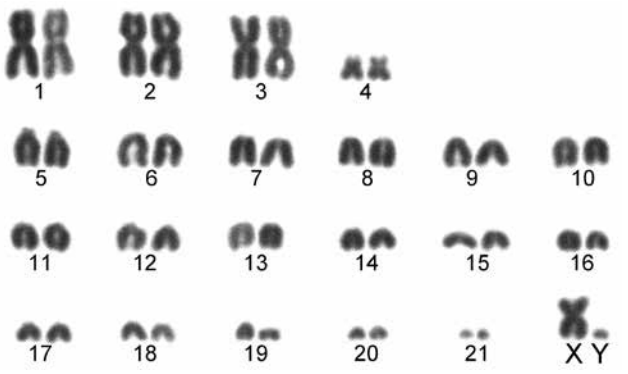

Fig. 14. Karyotype of *Myotis myotis* (Anatolia).

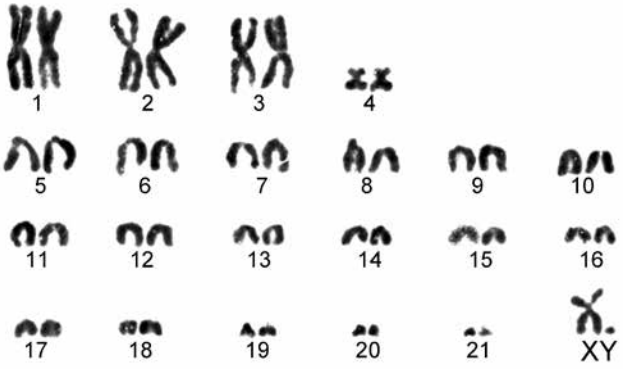

Fig. 15. Karyotype of *Myotis blythii* (Slovakia).

Lesser mouse-eared bat, *Myotis blythii* (Tomes, 1857)
2n = 44, NFa = 50-52, NF = 54-56; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs (one of these pairs may be bi-armed). The X chromosome is a medium-sized metacentric; the Y

chromosome is a minute acrocentric (see Zima & Král 1984a for review, Volleth 1989; Fig. 15). The NORs are dispersed over the complement (Volleth 1989).
The karyotype in Turkish populations was studied by Karataş et al. (2004), Karataş & Sözen (2007), and Aşan & Albayrak (2011). A distinct secondary constriction was situated near the centromere in the largest acrocentric autosome. In individuals from Antalya, a dot-like autosomal pair was bi-armed, and a female had heteromorphic X chromosomes differing in the size of the long arm (Aşan & Albayrak 2011). The G-banding pattern was studied by Aşan et al. (2011). A similar karyotype was found in Bulgaria (Belcheva et al. 1992) and Iran (Karataş et al. 2008a).

Daubenton's bat, *Myotis daubentonii* (Kuhl, 1817)
2n = 44, NFa = 52, NF = 56; X = M, Y = A/SM
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs (an acrocentric and a bi-armed). The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric or submetacentric. The complement comprises three autosomal pairs possessing NORs (see Zima & Král 1984a for review, Volleth 1987, 1989).
Karyological examination from Turkey is not yet available, Greek populations were studied by Volleth (1987, 1989).

Long-fingered bat, *Myotis capaccinii* (Bonaparte, 1837)
2n = 44, NFa = 52, NF = 56; X = M, Y = A
The autosomal set comprises three large metacentric, one small metacentric, 15 acrocentric and two dot-like pairs. One of the dot-like pairs is acrocentric, the other is bi-armed. The X chromosome is a medium-sized metacentric; the Y chromosome is a minute acrocentric. The complement comprises 12 autosomal pairs possessing NORs (see Zima & Král 1984a for review, Volleth 1987, 1989).
The karyotype of Turkish populations was studied by Volleth (1985), Albayrak & Aşan (2002) and Karataş et al. (2004). We examined the karyotype of a male from the Dupnisa Mağarası, Demirköy (Kırklareli, Turkish Thrace) and we found the standard karyotype of the species. The karyotype of specimens from Greece was reported by Volleth (1987).

Particoloured bat, *Vespertilio murinus* Linnaeus, 1758
2n = 38, NFa = 50-52, NF = 54-56; X = M, Y = A/SM
The autosomal complement includes six large metacentric pairs, one small submetacentric pair, nine acrocentric pairs and two dot-like pairs. The centromeric position in the dot-like autosome is recognized as uni-armed or bi-armed by different authors and this results in variation of the reported number of arms (NFa = 50 or 52). The second largest acrocentric autosome has a distinct secondary constriction. The X chromosome is a medium-sized metacentric; the Y chromosome is dot-like acrocentric or submetacentric (see Zima & Král 1984a for review, Volleth 1985, 1987, 1989, Kulemzina et al. 2011).
Karyological data from Turkey are not yet available in this species; chromosomes of a specimen from Greece were studied by Volleth (1987).

Serotine, *Eptesicus serotinus* (Schreber, 1774)
2n = 50, NFa = 48-50, NF = 52-54; X = SM, Y = A/SM
The standard karyotype consists of acrocentric autosomes, a bi-armed X chromosome and a dot-like Y chromosome (see Zima & Král 1984a for review, Volleth 1987, 1989).
The same complement with all-acrocentric autosomes (NFa = 48) was found in Turkey by Karataş & Sözen (2007) but Aşan (2001) reported single subtelocentric pair in the autosomal set (NFa = 50). The latter author mentioned a secondary constriction located on a medium-sized acrocentric autosome. The X chromosome was identified as a large submetacentric; the Y chromosome as the smallest dot-like element and apparently acrocentric. The karyotype of a specimen from Greece was studied by Volleth (1987).

Anatolian serotine, *Eptesicus anatolicus* Felten, 1971
2n = 50, NFa = 48, NF = 52; X = M, Y dot-like
The karyotype in Turkey was investigated by Karataş & Sözen (2007) from Silifke (Içel) under the name of *E. bottae*. All the autosomes are acrocentric; the two smallest pairs are dot-like. The X chromosome is a medium-sized metacentric; the Y chromosome is dot-like.

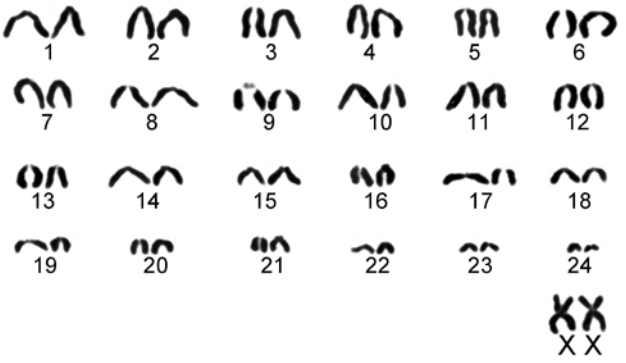

Fig. 16. Karyotype of *Eptesicus bottae* (Kyrghyzstan).

The same standard karyotype is reported in some other species of the genus *Eptesicus*, including closely related *E. bottae* (Zima et al. 1989, Toktosunov & Imanalijeva 1990, Volleth et al. 2001, O'Brien et al. 2006; Fig. 16).

Leisler's bat, *Nyctalus leisleri* (Kuhl, 1817)
2n = 44 + Bs, NFa = 50, NF = 54; X = M, Y = A
The standard autosomal complement includes three large metacentric, one small submetacentric and 17 acrocentric autosomal pairs. The set can additionally include 1-3 dot-like supernumerary chromosomes (Bs). Two acrocentric pairs possess secondary constrictions near the centromere. Two nucleolus organizer regions are located at the secondary constriction of an acrocentric autosome and at a minute short arm of another acrocentric autosome, respectively. C-heterochromatin positive regions occur in the pericentromeric areas and the amount of centromeric heterochromatin is higher compared to *N. noctula* and *N. lasiopterus*. The X chromosome is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a and Zima & Horáček 1985 for review, Volleth 1992).
Volleth (1992) recorded in a specimen examined from Beşkonak in Turkey 45 chromosomes and the set included one dot-like, completely heterochromatic B chromosome. We examined a male from Demirköy (Kırklareli, Turkish Thrace) and we found the same karyotype as Volleth (1992) with 2n = 45 and a single dot-like supernumerary chromosome.

Noctule, *Nyctalus noctula* (Schreber, 1774)
2n = 42, NFa = 50, NF = 54; X = M, Y = A
The autosomal complement includes four large metacentric, one small subtelocentric and 15 acrocentric pairs. The two smallest acrocentric pairs are dot-like. Two nucleolus organizer regions are located within the secondary constriction of an acrocentric autosome and at a minute short arm of another acrocentric autosome, respectively. The X is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a for review, Volleth 1987, 1989, 1992). The same karyotype was found in Demirköy (Kırklareli) by Karataş & Sözen (2007).

Greater noctule, *Nyctalus lasiopterus* (Schreber, 1780)
2n = 42, NFa = 50, NF = 54; X = M, Y = A
The chromosomal complement consists of four large metacentric, one small submetacentric and 15 acrocentric autosomal pairs. The X chromosome is a medium-sized metacentric; the Y chromosome is a small acrocentric with C-heterochromatin restricted to the centromeric region. Two nucleolus organizer regions are located at the secondary constriction of an acrocentric autosome and at a minute short arm of another acrocentric autosome, respectively (see Zima & Horáček 1985 for review, Volleth 1987, 1992).
The karyotype in Turkey was investigated by Yiğit et al. (2008) in four females from the Çığlıkara National Park (Antalya). The autosomal complement consisted of four large, one medium-sized and one small pair of meta- and submetacentrics, and 15 pairs of acrocentrics. The medium-sized metacentric pair can be distinguished as the X chromosomes. The karyotype of a specimen from Greece was studied by Volleth (1987).

Common pipistrelle, *Pipistrellus pipistrellus* (Schreber, 1774)
2n = 42-44, NFa = 48-50, NF = 52-54; X = M/SM, Y = A
The standard autosomal complement with 44 chromosomes consists of three large metacentric, one small metacentric and 17 acrocentric pairs. One of the acrocentric pairs bears a secondary constriction but the NORs are multiple (Volleth 1987). The X chromosome is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric. This karyotype was reported from several areas in Europe and Asia (see Zima & Král 1984a for review, Volleth 1987, 1989, Toktosunov & Imanalijeva 1990). The diploid number of 2n = 42 chromosomes was recorded in a study from Tadjikistan (Vorontsov et al. 1969). The banding pattern was described by Kasahara & Dutrillaux (1983), Volleth (1987, 1989), and O'Brien et al. (2006).
The karyotype in Turkish populations was studied by Volleth (1987) and Karataş et al. (2004) who found the standard karyotype with 44 chromosomes. However, Ulutürk & Coşkun (2007) examined the karyotypes of specimens from Diyarbakir in south-eastern Anatolia and ascertained a complement comprising only 42 chromosomes. The set included three pairs of large metacentric, one pair of small metacentric and 16 pairs of acrocentric autosomes. The X chromosome was a medium-sized metacentric; the Y chromosome a small acrocentric.

Soprano pipistrelle, *Pipistrellus pygmaeus* (Leach, 1825)
The species identity has not been recognized in most of published papers reporting the karyotype of *P.*

pipistrellus sensu lato. Therefore it is possible that at least some of the samples studied contained also specimens of *P. pygmaeus*. The revision of the material should be made using reliable identification criteria.

Nathusius's pipistrelle, *Pipistrellus nathusii* (Keyserling et Blasius, 1839)
2n = 44, NFa = 50, NF = 54; X = M, Y = A
The standard autosomal complement consists of three large metacentric, one small metacentric and 17 acrocentric pairs. One or two acrocentric pairs bear secondary constrictions. The X chromosome is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a for review, Volleth 1987, 1989).
Karyological data from Turkey are not yet available. The karyotype of a specimen from Chalkidiki in Greece was studied by Volleth (1987).

Kuhl's pipistrelle, *Pipistrellus kuhlii* (Kuhl, 1817)
2n = 44, NF = 50, NFa = 54; X = M, Y = A
The autosomal complement comprises three large and one small metacentric pairs, 15 acrocentric pairs and two dot-like pairs. A secondary constriction is located on a medium-sized acrocentric pair. The X chromosome is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a for review, Iliopoulou-Georgudaki & Giagia 1986, Volleth 1989, O'Brien et al. 2006; Fig. 17). The diploid number of 42 chromosomes was reported by Volleth et al. (2001) from Madagascar, however, the taxonomic identification of the studied animals is not sure.
The karyotype in Turkey was studied by Arslan (2004) in Antalya and Şanlıurfa and by Karataş et al. (2004). The findings are congruent with data from other regions, e.g. a similar karyotype was found in specimens examined in Greece (Iliopoulou-Georgudaki & Giagia 1986, Volleth 1989), Jordan (Karataş et al. 2008b) or at the Azov Sea coast in Ukraine (own unpublished data).

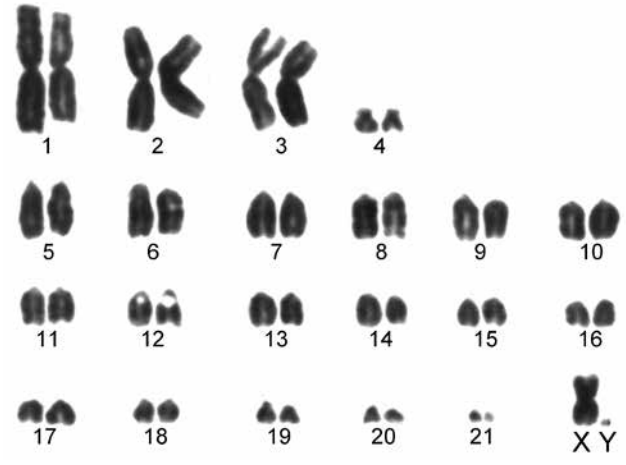

Fig. 17. Karyotype of *Pipistrellus kuhlii* (Libya).

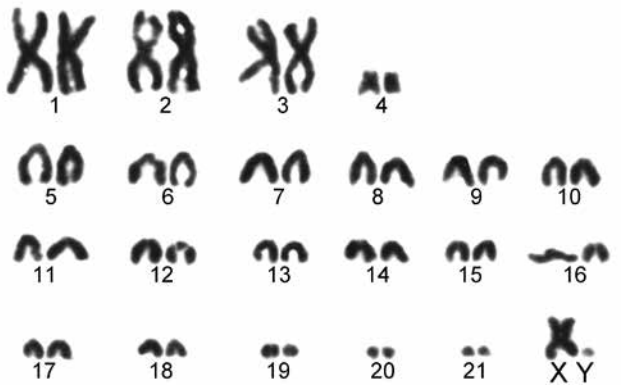

Fig. 18. Karyotype of *Hypsugo savii* (Bulgaria).

Savii's pipistrelle, *Hypsugo savii* (Bonaparte, 1837)
2n = 44, NF = 50, NFa = 54; X = M, Y = A/SM
The autosomal complement comprises three large and one small metacentric pairs, 15 acrocentric pairs and two dot-like pairs. A secondary constriction is located on a medium-sized acrocentric pair. The X chromosome is a medium-sized metacentric; the Y chromosome is a dot-like acrocentric or submetacentric (see Zima & Král 1984a for review, Volleth 1987, 1989; Fig. 18). The G-banding pattern was described in specimens from Bulgaria by Zima (1982) and in a specimen from Greece (Rhodos Island) by Volleth (1987). Karyological data from Turkey are not yet available.

Brown long-eared bat, *Plecotus auritus* (Linnaeus, 1758)
2n = 32, NFa = 50, NF = 54; X = M, Y = A
The autosomal complement consists of ten meta- and submetacentric and five acrocentric pairs. The two smallest acrocentric pairs are dot-like. The X chromosome is a medium-sized metacentric; the Y chromosome is a tiny acrocentric (see Zima & Král 1984a for review, Volleth 1985, 1987, Kulemzina et al. 2011).
The standard karyotype was reported from Turkey by Karataş et al. (2003b) but the species status of the specimens studied should be re-considered (Karataş & Sözen 2006). The karyotype of populations from the Caucasus was studied by Dzujev (1986).

Mountain long-eared bat, *Plecotus macrobullaris* Kuzyakin, 1965
2n = 32, NFa = 50, NF = 54; X = M, Y = A
The karyotype is apparently similar to *P. auritus*. Populations investigated by Karataş et al. (2003b) in

Anatolia may belong to *P. macrobullaris* (Karataş & Sözen 2006).

Grey long-eared bat, *Plecotus austriacus* (Fischer, 1829)
2n = 32, NFa = 50, NF = 54; X = M, Y = A
The autosomal complement consists of ten meta- and submetacentric and five acrocentric pairs. The two smallest acrocentric pairs are dot-like. The X chromosome is a medium-sized metacentric; the Y chromosome is a tiny acrocentric (see Zima & Král 1984a for review, Volleth 1985, 1987, Leniec et al. 1987, Belcheva et al. 1992, Qumsiyeh & Bickham 1993).
The standard karyotype of this species was reported from Turkey by Karataş et al. (2003b) but the species status of the specimens studied may be reconsidered (Karataş & Sözen 2006).

Balkan long-eared bat, *Plecotus kolombatovici* Dulić, 1980
2n = 32, NFa = 50, NF = 54; X = M, Y = A
The karyotype is apparently similar to *P. austriacus*. Populations investigated by Karataş et al. (2003b) in Anatolia may belong to *P. kolombatovici* (Karataş & Sözen 2006).

Barbastelle, *Barbastella barbastellus* (Schreber, 1774)
2n = 32, NFa = 50, NF = 54; X = M, Y = A
The autosomal complement is almost similar as in the species of the genus *Plecotus* (see Zima & Král 1984a for review, Volleth 1985, 1987). The identical karyotype was recorded also in related species, *B. darjelingensis* (Zima & Horáček 1985 for review, Ono & Obara 1994).
The karyotype of individuals from Turkey was studied by Volleth (1985) and Karataş et al. (2004). The karyotype of a specimen from Greece was described by Volleth (1987).

Hemprich's long-eared bat, *Otonycteris hemprichii* Peters, 1859
2n = 28, NFa = 46, NF = 50; X = SM, Y not reported
The autosomal complement includes seven large metacentric, two large submetacentric, one small metacentric and three acrocentric pairs. The smallest acrocentric pair is dot-like. The X chromosome is a medium-sized submetacentric; the Y was not distinguished. Qumsiyeh & Bickham (1993) examined the karyotype and its banding pattern from Jordan. The related species, *O. leucophaea* from central Asia (Benda & Gvoždík 2010) has a different karyotype with 2n = 30, NFa = 48 (Zima et al. 1992b). The karyotype of Turkish populations of *O. hemprichii* has not been studied.

Schreiber's bat, *Miniopterus schreibersii* (Kuhl, 1817)
2n = 46, NFa = 50-52, NF = 54-56; X = M, Y = A
The autosomal complement comprises two large metacentrics, one medium-sized metacentric, 17 acrocentric and two dot-like pairs (one of these pairs may be bi-armed). One of the medium-sized acrocentrics has a secondary constriction on the long arm near the centromere. The X chromosome is a medium sized metacentric; the Y chromosome is a dot-like acrocentric (see Zima & Král 1984a for review, Volleth 1989, Ono & Obara 1994).
The karyotype in Turkey was studied by Karataş & Sözen (2004) and Albayrak (2006) who examined specimens originating from the provinces of Kırklareli, Ankara, Antalya, Balıkesir, Burdur, Isparta, Şanlıurfa, and from the western Black Sea region. The populations from south-eastern Turkey (e.g. Şanlıurfa) could belong to a separate species *M. pallidus*. This species has the same karyotype which was studied in Iran (Karataş et al. 2008a).

European free-tail bat, *Tadarida teniotis* (Rafinesque, 1814)
2n = 48, NFa = 78, NF = 82; X = ST, Y = A
The chromosomal complement consists of five meta- and submetacentric pairs, and 19 subtelocentric and acrocentric pairs. The smallest acrocentric pair is dot-like (see Zima & Král 1984a for review; Fig. 19).
The karyotype of Turkish populations was investigated by Karataş et al. (2006b) in samples collected in the Adıyaman, Aksaray, Konya, Sinop and Trabzon provinces. The sex chromosomes were not identified in individuals studied in Turkey. In other studies, the X chromosome was determined as subtelocentric, the Y chromosome as acrocentric (Zima & Král 1984a, Arroyo-Nombella et al. 1986).

Wolf, *Canis lupus* Linnaeus, 1758
2n = 78, NFa = 76, NF = 80; X = M, Y = M
All the autosomes are acrocentric, the X chromosome is a large metacentric and the Y chromosome a small bi-armed element. C-heterochromatin is localized in centromeric blocks on most of the autosomes. The centromeric region of the X chromosome and the long arm of the Y chromosome are C-positive (Wurster-

Hill & Centerwall 1982, O'Brien et al. 2006). The NORs are localized in telomeres of the long arm in four autosomal pairs (see Zima & Král 1984c for review, Wayne et al. 1987, Stone et al. 1991). The same karyotype is reported in the domestic dog (Fig. 20). The chromosome painting and high-resolution G-banding pattern of the dog karyotype was described by Graphodatsky et al. (1995, 2000b, 2008). The karyotype of Turkish wolf populations has not been studied.

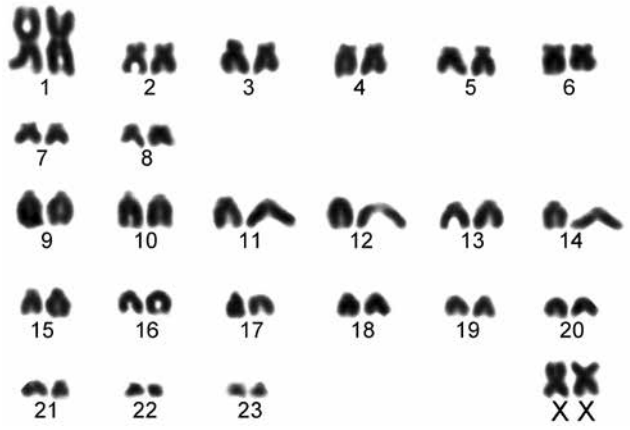

Fig. 19. Karyotype of *Tadarida teniotis* (Kyrghyzstan).

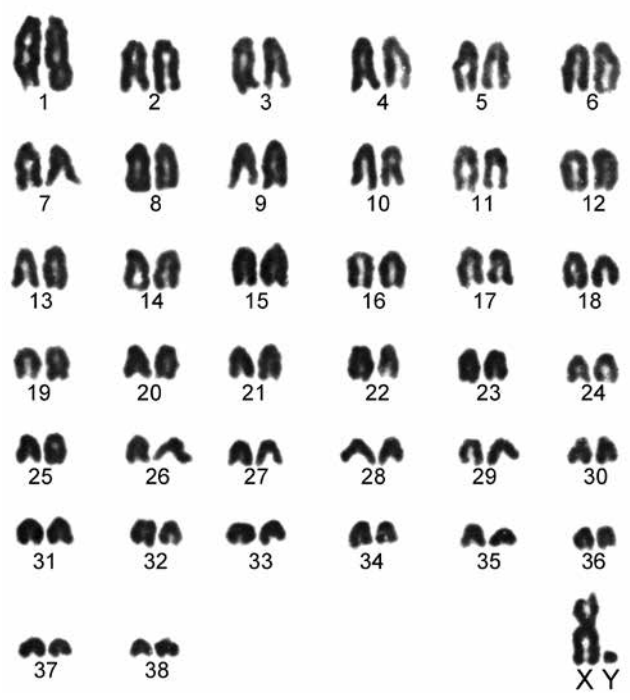

Fig. 20. Karyotype of domestic dog.

Golden jackal, *Canis aureus* Linnaeus, 1758
2n = 78, NFa = 76, NF = 80; X = M, Y = M
The karyotype of the golden jackal seems to be the same as that of the wolf (see Zima & Král 1984c for review). The karyotype of Turkish populations is not known.

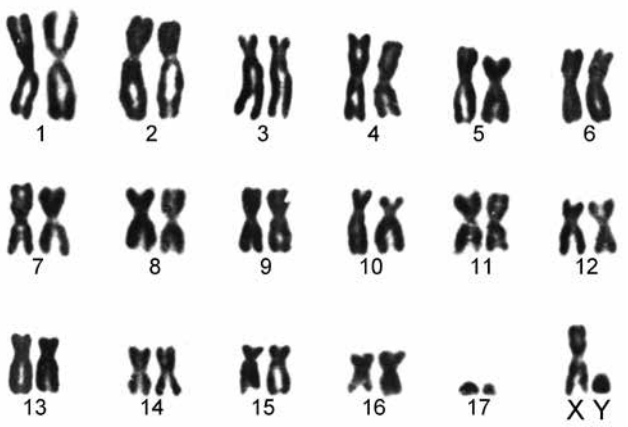

Fig. 21. Karyotype of *Vulpes vulpes* (captive colony).

Red fox, *Vulpes vulpes* (Linnaeus, 1758)
2n = 34 + Bs, NFa = 64; NF = 68; X = SM, Y = SM
The standard autosomal complement includes 16 meta- and submetacentric pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is a small submetacentric. Up to eight supernumerary chromosomes (Bs) can occur in a cell (Zima & Král 1984c for review, O'Brien et al. 2006; Fig. 21). The supernumerary chromosomes are usually of the size of the Y chromosome and the position of their centromere varies. The amount of C-heterochromatin is low and it is concentrated in pericentromeric areas of several autosomes and the X chromosome. The Y chromosome stains C-positively but the supernumerary chromosomes are C-negative (see Zima & Král 1984b for review, Committee 1985, Wayne et al. 1987, Flow et al. 1988, Rubtsova 1998). The chromosome painting and high-resolution G-banding pattern was described by Graphodatsky et al. (1995, 2000b, 2008). The karyotype of Turkish populations has not been studied.

Brown bear, *Ursus arctos* Linnaeus, 1758
2n = 74, NFa = 80/82/84, NF = 84/86/88; X = M, Y = A
The autosomal complement includes four, five or six bi-armed pairs and 30-32 acrocentric pairs. The X chromosome is a metacentric; the Y chromosome is a small acrocentric or subtelocentric (see Zima & Král 1984c for review, Nash & O'Brien 1987, O'Brien et al. 2006).
In the specimens belonging to the subspecies *U. a. syriacus* and in individuals examined in former

Yugoslavia, the lowest number of autosomal arms (NFa = 80) was found (Zima & Král 1984c for review). The karyotype of Turkish populations is not known.

Pine marten, *Martes martes* (Linnaeus, 1758)
2n = 38, NFa = 64, NF = 68; X = SM, Y = M
The autosomal set consists of 14 bi-armed and four acrocentric pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is the smallest bi-armed element. There are certain differences in the arrangement of chromosomes into morphological groups between individual studies (see Zima & Král 1984c for review). The chromosome banding pattern was described by Graphodatsky et al. (1982a, 1985a) and O'Brien et al. (2006). The karyotype of Turkish populations is not known.

Stone marten, *Martes foina* (Erxleben, 1777)
2n = 38, NFa = 66/72, NF = 70/76; X = M, Y = A
The complement reported in literature comprises 16 bi-armed and three acrocentric pairs (see Graphodatsky et al. 1982c, Zima & Král 1984c for review). The X chromosome is bi-armed, and the small Y chromosome is probably acrocentric. The chromosome banding pattern was further reported by Nie et al. (2002) and O'Brien et al. (2006). Cross-species chromosome painting was studied by Yang et al. (2006) and Nie et al. (2012).
A Turkish population was karyologically examined by Yiğit et al. (1998b) in two females from Çankırı. The complement included 17 pairs of meta- and submetacentric chromosomes and two pairs of subtelocentric autosomes. The sex chromosomes were not determined. In contrast to published data (e.g. Graphodatsky et al. 1982c) no acrocentric chromosomes were distinguished in the karyotype of Turkish specimens.

Weasel, *Mustela nivalis* Linnaeus, 1766
2n = 42, NFa = 72, NF = 76; X = SM, Y = M
The karyotype comprises 16 bi-armed (11 metacentric and submetacentric, five subtelocentric) and four acrocentric autosomal pairs. One of the acrocentric pairs bears a distinct secondary constriction in the pericentromeric region of the long arm (Peshev et al. 1985, Zima & Graphodatskij 1985 for review, O'Brien et al. 2006). Cross-species chromosome painting with American mink probes was studied by Graphodatsky et al. (2002).
The karyotype of this species in Turkey was studied by Çolak et al. (1999a) in two individuals from Bolu and Zima & Cenevová (2002) from the Istranca Mts. In the specimens from Thrace the number of the whole C-heterochromatic arms was six, and the same pattern of the C-heterochromatin distribution was found as in specimens from central Europe. The conventionally stained karyotype from Anatolia (Çolak et al. 1999a) seemed to be similar as that from Thrace (Zima & Cenevová 2002) and a banding technique should be used to demonstrate the pattern of the C-heterochromatin distribution.

European polecat, *Mustela putorius* Linnaus, 1758
2n = 40, NFa = 64, NF = 68; X = SM, Y = M
The autosomal complement consists of six meta- and submetacentric pairs, seven subtelocentric pairs and six acrocentric pairs (two acrocentric pair may also be recognized as subtelocentric) (see Zima & Král 1984c for review; Fig. 22). The centromeric regions of all chromosomes and the whole arms of three pairs of bi-armed autosomes stain C-positively. The NOR is localized in the secondary constriction on an acrocentric autosomal pair. The X chromosome is a medium-sized submetacentric; the Y chromosome is small and bi-armed (Graphodatsky et al. 1985a, b, O'Brien et al. 2006). Cross-species chromosome painting with American mink probes was studied by Graphodatsky et al. (2002). The karyotype of Turkish populations is not known.

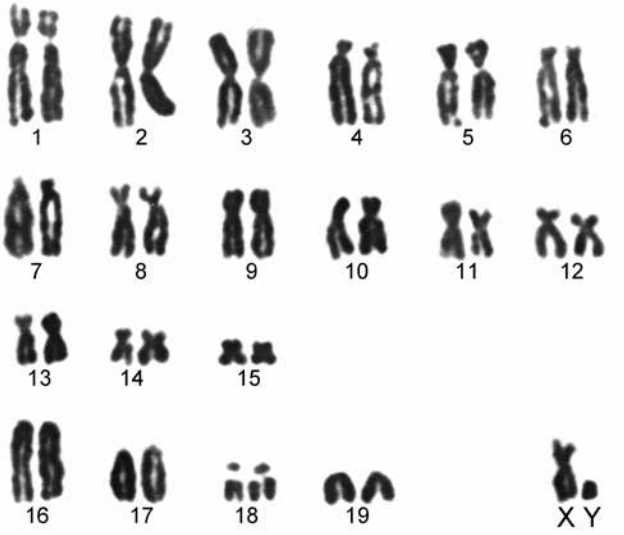

Fig. 22. Karyotype of *Mustela putorius* (captive colony).

Marbled polecat, *Vormela peregusna* (Gueldenstaedt, 1770)
2n = 38, NFa = 68-70, NF = 72-74; X = SM, Y = D
The autosomal complement includes 16-17 bi-armed and two or one acrocentric pairs. The X chromosome

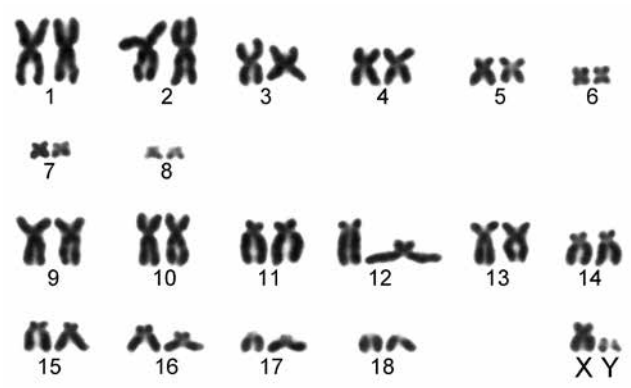

Fig. 23. Karyotype of *Vormela peregusna* (Anatolia).

is a medium-sized submetacentric; the Y chromosome is a small dot-like element (see Zima & Král 1984c for review, Fig. 23). Graphodatsky et al. (1982b) and O'Brien et al. (2006) reported the C- and G-banding pattern and NORs distribution in a specimen originating probably from western Siberia.

The karyotype in Turkey was studied by Özkurt et al. (1999b) in a female from Gönen (Balıkesir), north-western Anatolia, and by Özkurt et al. (2000) in another female from south-eastern Anatolia. The karyotype of the specimen from north-western Anatolia had two acrocentric autosomal pairs (NFa = 68) whereas that of the specimen from south-eastern Anatolia only one acrocentric autosomal pair (NFa = 70). The latter finding is congruent with other published data including the results obtained in specimens from Syria (Peshev & Al-Hossein 1989).

The C-banding pattern and the distribution of AgNORs were studied by Arslan & Zima (2013b) in a male from Anatolia (Konya province). The C-heterochromatin regions were observed in large blocks forming the whole long arms of five bi-armed autosomal pairs, in telomeric regions of the short arms of two subtelocentric autosomal pairs, and in centromeric areas of four autosomal pairs. The X chromosome appeared to be uniformly C-negatively stained and the short arm and centromeric area of the Y chromosome were entirely C-positive. The Ag-NOR regions were found within the large C-heterochromatic blocks on the long arms of four large biarmed autosomal pairs.

Graphodatsky et al. (1982b) recorded another C-heterochromatic block forming the short arm of one of the medium-sized submetacentric autosomes. This C-heterochromatic short arm was not observed in cells of the male examined in Turkey. Graphodatsky et al. (1982b) further recorded C-positive telomeric regions on the short arms of four submeta- and subtelocentric autosomal pairs but only two autosomal pairs possessing such telomeric dark bands were demonstrated by Arslan & Zima (2013b). Finally, Graphodatsky et al. (1982b) characterized the dot-like Y chromosome as completely C-heterochromatic but the long arm of the submetacentric Y chromosome appeared euchromatic in the complement of the Turkish specimen.

Badger, *Meles meles* (Linnaeus, 1758)
2n = 44, NFa = 62-68, NF = 66-72; X = SM, Y = A
The chromosomal complement includes 10-13 bi-armed and eight to eleven acrocentric pairs. Secondary constrictions are localized in the short arm of three acrocentric pairs. The X chromosome is submetacentric; the Y chromosome is dot-like and uni-armed. C-heterochromatin occurs in small centromeric or intercalar blocks, the NORs are localized at three pairs of acrocentric autosomes (see Zima & Král 1984c for review, Obara 1987, Graphodatsky et al. 1989, Wang et al. 1990). Cross-species chromosome painting with American mink probes was studied by Graphodatsky et al. (2002). The karyotype of Turkish populations which may belong to a distinct species, *M. canescens* (see Abramov & Puzachenko 2013) is not known.

Eurasian otter, *Lutra lutra* (Linnaeus, 1758)
2n = 38, NFa = 60, NF = 64; X = M, Y = M
The autosomal complement includes five metacentric, seven submetacentric and six acrocentric pairs. Some authors recognized some of the acrocentric autosomes as subtelocentric. The X chromosome is a metacentric; the Y chromosome is a small metacentric. C-heterochromatin occurs in small centromeric and telomeric blocks and in the short arms of four autosomal pairs, the NORs are localized at three or four autosomal pairs (see Zima & Král 1984c for review, Graphodatsky et al. 1989, O'Brien et al. 2006). The karyotype of Turkish populations has not been studied.

Egyptian mongoose, *Herpestes ichneumon* (Linnaeus, 1758)
2n = 43 in males/44 in females, NFa = 64, NF = 72; X_1 = M, X_2 = ST, Y = ST/A
The autosomal complement consists of six metacentric, four submetacentric, two subtelocentric and eight acrocentric pairs. The sex chromosome system is composite, X_1X_2Y in males and $X_1X_1X_2X_2$ in females, owing to a translocation between the original Y chromosome and an autosome. The X_1 chromosome is metacentric, the X_2 chromosome is subtelocentric and the Y chromosome is a very long acro- or subtelocentric element (see Zima &

Král 1984c for review). The karyotype of Turkish populations is not known.

Striped hyena, *Hyaena hyaena* (Linnaeus, 1758)
2n = 40, NFa = 70, NF = 74, X = M, Y = SM
The karyotype consists of 16 pairs of meta- and submetacentric and three pairs of acrocentric autosomes. The X chromosome is metacentric; the Y chromosome is acrocentric (Hsu & Arrighi 1966, Berube-Genest et al. 1987). The karyotype has not been reported from Turkey.

Wildcat, *Felis silvestris* Schreber, 1777
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype of the wildcat (see Aulagnier et al. 2009 for discussion of the species taxonomic status) includes three pairs of large submetacentrics, four pairs of large subtelocentrics, two pairs of large metacentrics, four pairs of small subtelo- or submetacentrics, three pairs of small metacentrics, two pairs of small acrocentrics, a large submetacentric X chromosome and a small submetacentric Y chromosome. The karyotype (Fig. 24) and its banding pattern is the same as in the domestic cat (Wurster-Hill & Centerwall 1982, Zima & Král 1984c for review, Cho et al. 1997, O'Brien et al. 2006). The karyotype of Turkish wildcat populations is not known.

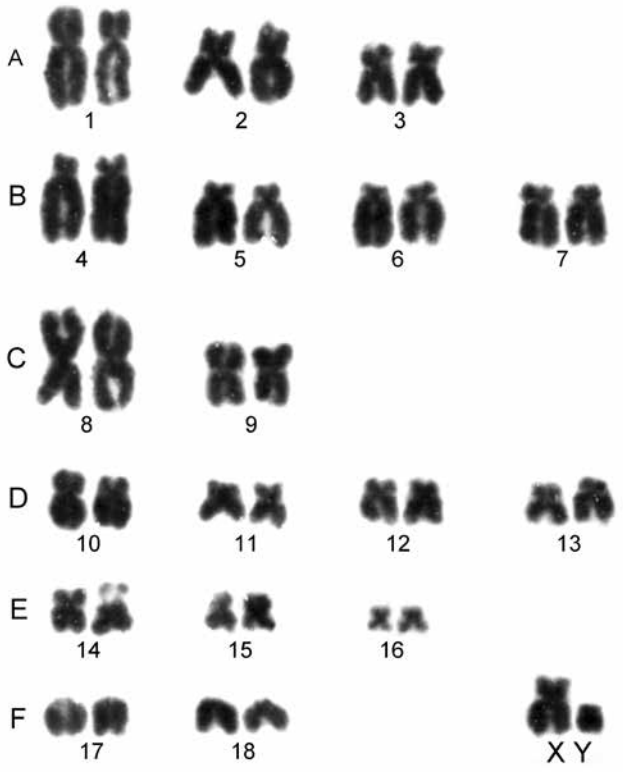

Fig. 24. Karyotype and chromosome nomenclature of domestic cat.

Jungle cat, *Felis chaus* Gueldenstaedt, 1777
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype is the same as in the previous species (see Wurster-Hill & Gray 1973, Zima & Král 1984c for review, O'Brien et al. 2006). Turkish populations have not been studied.

Caracal, *Caracal caracal* (Schreber, 1776)
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype and its banding pattern is the same as in the domestic cat (Wurster-Hill & Gray 1973, O'Brien et al. 2006). Turkish populations have not been studied.

European lynx, *Lynx lynx* (Linnaeus, 1758)
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype is similar as in the domestic cat but the banding pattern of the two small acrocentric autosomes is slightly different (Wurster-Hill & Centerwall 1982, O'Brien et al. 2006). Cross-species chromosome painting with dog probes was studied by Nie et al. (2002). The karyotype of Turkish populations is not known.

Leopard, *Panthera pardus* (Linnaeus, 1758)
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype of the leopard includes four pairs of large submetacentrics, three pairs of large subtelocentrics, two pairs of large metacentrics, four pairs of small subtelo- or submetacentrics, three pairs of small metacentrics, two pairs of small acrocentrics, a large submetacentric X chromosome and a small submetacentric Y chromosome. The complement differs from that of the wildcat also by a single inversion in a small acrocentric autosome (group F; see Wurster-Hill & Gray 1973, Zima & Král 1984c for review). The karyotype has not been reported from Turkey.

Tiger, *Panthera tigris* (Linnaeus, 1758)
2n = 38, NFa = 68, NF = 72; X = SM, Y = SM
The karyotype is identical with that of the leopard (see Zima & Král 1984c for review). Specimens from Turkey have not been studied because the species became extinct in the country.

Mediterranean monk seal, *Monachus monachus* (Hermann, 1779)
The karyotype is not known.

Wild boar, *Sus scrofa* Linnaeus, 1758
2n = 38, NFa = 60, NF = 64; X = SM, Y = A
The karyotype may differ between the domestic pig (2n = 38, Fig. 25) and the wild boar (2n = 36 or 38) (see Bosma et al. 1984, Zima & Král 1984c for review). The

chromosome banding patterns, the NORs distribution and chromosome painting in the complement of the wild boar and domestic pig were reported by Troshina (1986), Vishnevskaya & Vsevolodov (1986), Biltueva et al. (2004), O'Brien et al. (2006), Kulemzina et al. (2009), Rubeš et al. (2009) and others.

The karyotype of a Turkish population was investigated by Albayrak & Inci (2007) who examined four individuals from the Kırıkkale province and found 38 chromosomes. The autosomal complement included 12 bi-armed and six acrocentric pairs. A secondary constriction was located on a pair of the medium-sized metacentric autosomes. The X chromosome was a medium-sized submetacentric; the Y chromosome was a small acrocentric. Arslan & Albayrak (2009) investigated the C-banding pattern and the distribution of nucleolar organizer regions in the karyotype (2n = 38) of Turkish wild boar from the same area. C-positive regions were restricted to the centromeric areas of seven autosomes but were not observed in most of bi-armed autosomes. The Y chromosome was entirely C-positive. The NORs were located in secondary constrictions on two medium-sized autosomal pairs.

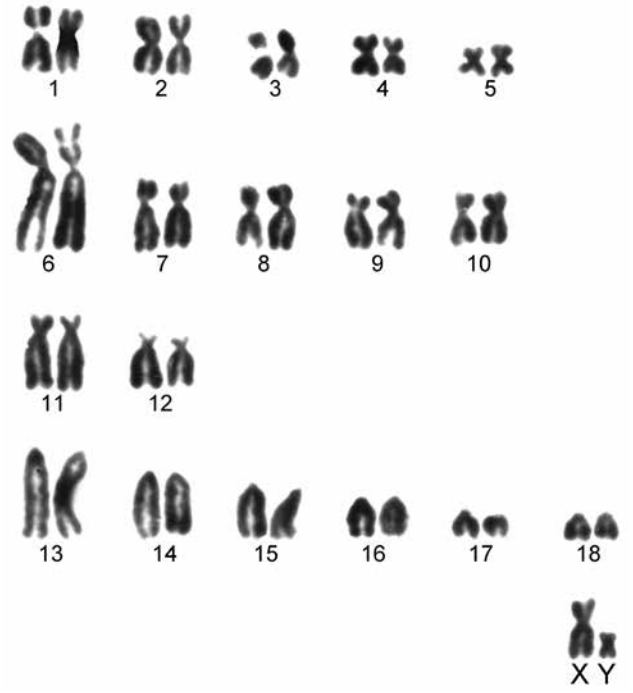

Fig. 25. Karyotype of domestic pig.

Red deer, *Cervus elaphus* Linnaeus, 1758
2n = 68, NFa = 68, NF = 70; X = A, Y = M

The autosomal complement includes a single large metacentric pair and 32 acrocentric pairs of diminishing size. The X chromosome is a large acrocentric; the Y chromosome is small and bi-armed (Fig. 26). The centromeric regions of all chromosomes are stained C-positivelly. The NORs are localized in telomeric regions of two large autosomal pairs (see Zima & Král 1984c for review, Graphodatsky & Radjabli 1985, Herzog 1987, Mayr et al. 1987a, b, Rubini et al. 1991, O'Brien et al. 2006). Comparative chromosome painting studies by Huang et al. (2006) and Kozubska-Sobocinska et al. (2012) involved the red deer. The karyotype of red deer has not been reported from Turkey.

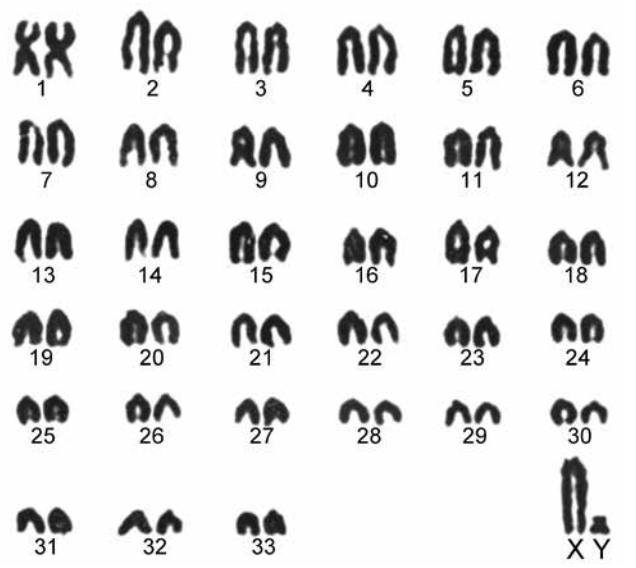

Fig. 26. Karyotype of *Cervus elaphus* (captive herd).

Fallow deer, *Dama dama* (Linnaeus, 1758)
2n = 68, NFa = 68, NF = 70; X = A, Y = M

The karyotype is the same as in the red deer (see Zima & Král 1984c for review, Mayr et al. 1987a, b, Herzog 1990, Rubini & Fontana 1990). G-banded chromosomes of the related species *D. mesopotamica* were presented by O'Brien et al. (2006). A comparative chromosome painting study by Kozubska-Sobocinska et al. (2012) involved the fallow deer.

The standard complement was found also in captive fallow deer of Turkish origin (Arslan & Zima, in press; Fig. 27). All the acrocentric autosomes and the X chromosome revealed distinct dark C-bands in the pericentromeric position. AgNOR regions were detected in the telomeric position on the two largest acrocentric autosomes.

European roe deer, *Capreolus capreolus* (Linnaeus, 1758)
2n = 70, NFa = 68, NF = 72; X = SM, Y = A

The autosomal set includes only acrocentric pairs. The largest pair of autosomes bears satellites

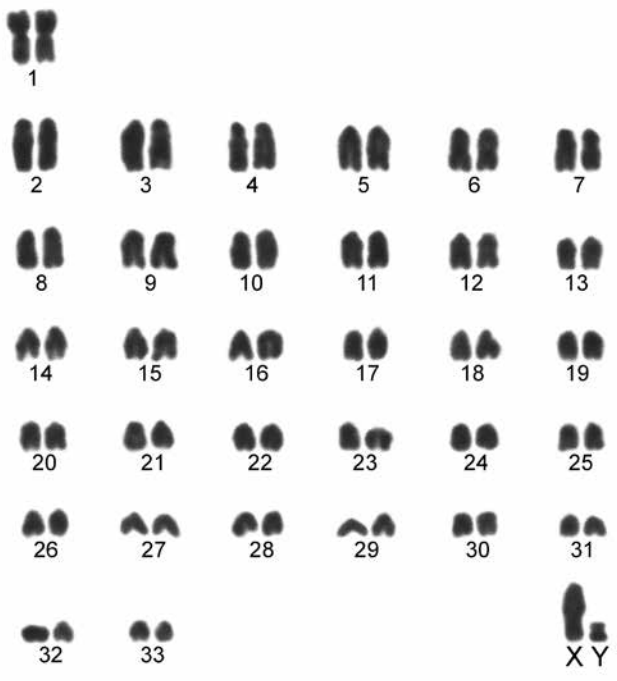

Fig. 27. Karyotype of *Dama dama* (Anatolia).

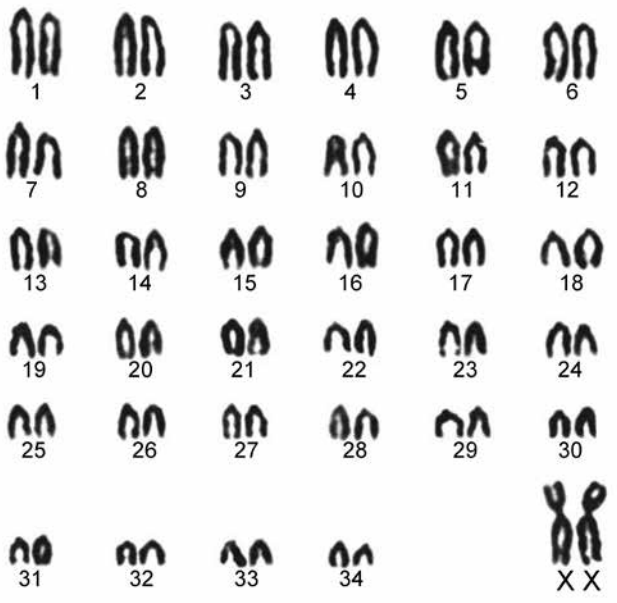

Fig. 28. Karyotype of *Capreolus capreolus* (Czech Republic).

located at telomeres. C-heterochromatin is localized in centromeric areas of all the autosomes. The X chromosome is a large submetacentric; the Y chromosome is a small acrocentric (Fig. 28). The sex chromosomes stain C-negatively (see Zima & Král 1984c for review, Danilkin 1985, Markov & Dobrijanov 1985). The chromosome banding patterns in the complement of roe deer were reported by Mayr et al. (1987a, b), Herzog (1988) and Rubini & Fontana (1988). The chromosome painting pattern was studied in the related species *C. pygargus* by Dementyeva et al. (2010). The karyotype of Turkish populations has not been studied.

Goitered gazelle, *Gazella subgutturosa* (Gueldenstaedt, 1780)
2n = 31 in males/30 in females, NFa = 56, NF = 60; X = SM, Y_1 = A, Y_2 = A
The autosomal complement includes bi-armed elements only. The composite sex chromosome system originated from a translocation of the original X chromosome to an autosome (XY_1Y_2 in males, XX in females). The X chromosome is a large submetacentric; the Y_1 and Y_2 chromosomes are medium-sized acrocentrics (see Zima & Král 1984c for review, Benirschke & Kumamoto 1987, Kingswood & Kumamoto 1988, Granjon et al. 1991, Vassart et al. 1993, O'Brien et al. 2006).
A Robertsonian translocation involving two autosomal pairs may account for the variation in the diploid number within the sexes. Benirschke & Kumamoto (1987) examined individuals recognized as *G. s. marica* from the Arabian Peninsula and found diploid numbers of 30, 31, 32, 33 chromosomes. Granjon et al. (1991) and Vassart et al. (1993) studied this subspecies from Saudi Arabia and found the same variation in diploid numbers. The variation in diploid number was tentatively related to hybridization with the nominate subspecies. Neither the autosomal nor the gonosomal heteromorphism reduced the meiotic fitness of male goitered gazelle (Kingswood et al. 1994).
Tez et al. (2005) studied the karyotype of this species in specimens kept in the Beştepeler Zoo in Kayseri. The karyotype of the two males of *G. subgutturosa* consisted of 31 chromosomes, with an autosomal complement including 14 pairs of bi-armed chromosomes, and the sex chromosome trivalent. The X chromosome was a large submetacentric, the Y_1 chromosome a small acrocentric and the Y_2 chromosome a medium-sized acrocentric.

Mountain gazelle, *Gazella gazella* (Pallas, 1766)
2n = 35 in males/34 in females, NFa = 56, NF = 60; X = SM, Y_1 = A, Y_2 not reported
The autosomal complement contains 12 biarmed and four small acrocentric pairs. The composite sex chromosome system (XY_1Y_2/XX) includes a large submetacentric X chromosome and its short arm is represented by the translocated originally acrocentric autosome (Vassart et al. 1995, O'Brien et al. 2006).

The karyotype of Turkish populations is not known but karyological research could contribute to confirmation of the species status (see Kankılıç et al. 2012). Considerable variation in the diploid number was reported in some related species with similar geographical distribution. Furley et al. (1988) studied individuals recognized as *G. bennetti* which were kept in a ZOO in Pakistan. The diploid number of chromosomes was 2N = 50 in females and 2N = 51 in males. The autosomal complement consisted of four metacentric and 20 acrocentric pairs. The X chromosome was submetacentric, the Y_1 chromosome submetacentric, and the Y_2 chromosome acrocentric. C-heterochromatic arms were observed on the original sex chromosomes. Kumamoto et al. (1995) reported variation in the chromosome number in *G. bennettii* (2n = 49-52) and in *G. sandiga* (2n = 46-53). This variation might possibly originated after interspecific hybridization in captivity.

Alpine chamois, *Rupicapra rupicapra* (Linnaues, 1758)
2n = 58, NFa = 58, NF = 60; X = A, Y = M
The autosomal complement includes a single large bi-armed and 27 acrocentric pairs. The X chromosome is acrocentric; the Y chromosome is dot-like and bi-armed (see Zima & Král 1984c for review). C-heterochromatin is localized in the centromeric areas, the NORs on five autosomal pairs (Mayr et al. 1987c). The karyotype of Turkish populations is not known.

Wild goat, *Capra aegagrus* Erxleben, 1777
2n = 60, NFa = 58, NF = 60; X = A, Y = D
The autosomal complement consists of acrocentric pairs only (see Zima & Král 1984c for review). The X chromosome is an acrocentric; the Y chromosome is dot-like and the centromeric position is reported as acrocentric or bi-armed. C-heterochromatin is localized in centromeric areas. The NORs are localized in telomeric areas of three autosomal pairs. The karyotype is identical with that of domestic goat (see Zima & Král 1984c for review, De Hondt et al. 1988, O'Brien et al. 2006). A comparison of G- and R-banding pattern was provided by Iannuzzi & Di Meo (1995), molecular cytogenetics was reviewed by Rubeš et al. (2009). The karyotype has not been studied in Turkey but there are data from the Caucasus (Mamedov 1978, Mamedov & Agajev 1990).

Mouflon, *Ovis orientalis* Gmelin, 1774
2n = 54, NFa = 58, NF = 60; X = A, Y = M
The complement includes six large metacentric autosomes, 46 acrocentric autosomes of decreasing size, a medium-sized acrocentric X chromosome, and a small bi-armed Y chromosome. The karyotype is the same as reported in various breeds of domestic sheep (see Zima & Král 1984c for review, Mayr et al. 1985, Mamedov & Agajev 1990, Iannuzzi & Di Meo 1995, O'Brien et al. 2006, Di Meo et al. 2007, Goldammer et al. 2009, Rubeš et al. 2009; Fig. 29).
The karyotype, G- and C- banding pattern and NORs distribution of the population from Konya, recognized usually as *O. o. anatolica*, were described by Kırıkçı et al. (2003) and Arslan & Zima (2011). G-banding allowed reliable identification of all the chromosome pairs and the pairing of homologous elements. All the autosomes possessed distinct centromeric or pericentromeric C-positive bands. The X chromosome had a pericentromeric C-positive band and the Y chromosome was entirely C-heterochromatic. The NORs were located in the terminal regions of the long arms of three metacentric and two acrocentric autosomes. The karyotype of the Konya wild sheep and its banding patterns were quite similar to chromosome complement reported in domestic sheep and European mouflon (Arslan & Zima 2011).

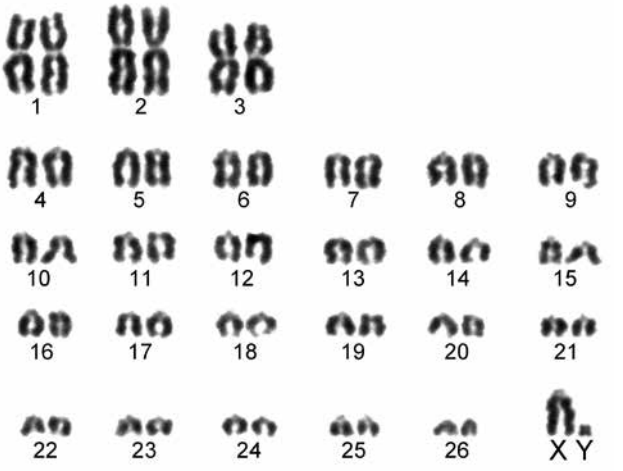

Fig. 29. Karyotype of *Ovis orientalis anatolica* (Anatolia).

European hare, *Lepus europaeus* Pallas, 1778
2n = 48, NFa = 88, NF = 92; X = SM, Y = A
The autosomal set consists of eight meta- and submetacentric pairs and 15 subtelo- and acrocentric pairs. The X chromosome is a large submetacentric; the Y chromosome is a small acrocentric (see Zima & Král 1984a, Robinson & Matthee 2005 for review; Fig. 30). Arslan (2010) studied the karyotype of this species in samples from the Mersin, Konya. All the autosomes of *L. europaeus* contained centromeric and pericentromeric constitutive heterochromatin, except one chromosome pair. In addition, the whole short

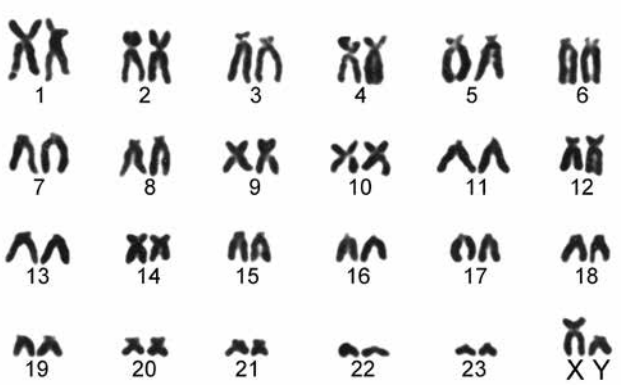

Fig. 30. Karyotype of *Lepus europaeus* (Czech Republic).

arms of other two pairs were C-heterochromatic. The X and Y chromosomes possessed pericentromeric C-heterochromatin. Nucleolar organizer regions were localized at satellites of three pairs of subtelocentric chromosomes. All signals of the active NORs were homomorphic.

Demirbaş et al. (2010) examined the karyotype of this species in samples from the Edirne, Tekirdağ, Kastamonu, Kırıkkale, Çorum, Kırşehir, Kayseri, Niğde, Iğdır, Ağrı, and Kilis provinces. Pericentromeric C-heterochromatin was found in 14 autosomal pairs and the X chromosome. One metacentric pair possessed a dark telomeric C-band. The Y chromosome stained C-positively. NORs were located in telomeric or pericentromeric areas of eight autosomal pairs. Three males from the Kilis province with yellowish pelage colour had a heterozygous duplication on the long arm of one subtelocentric autosome. The duplicated region on the rearranged autosome was C-positive. Tez et al. (2012) reported a standard karyotype and the chromosome banding pattern in specimens examined from Kayseri, Çankırı, and Nevşehir provinces in Central Anatolia. The arrangement of chromosomes into morphological groups differs between individual papers in some details.

Rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758)
2n = 44, NFa = 76, NF = 80; X = SM, Y = A
The autosomal complement consists of six metacentric, five submetacentric, six subtelocentric and four acrocentric pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is the smallest acrocentric of the set (O'Brien et al. 2006; Fig. 31). The amount of C-heterochromatin is rather low. The chromosome banding and painting data are usually derived from studies in domestic rabbit (see Zima & Král 1984a for review, Yerle et al. 1987, Poulsen et al. 1988, Arruga & Monteagudo 1989, Korstanje et al. 1999, Hayes et al. 2002, Robinson et al. 2002). The Y chromosome stains C-positivelly. The NORs are localized in short arms of three bi-armed pairs and in telomeric area of another pair. The karyotype of Turkish populations of wild rabbits is not known.

Afghan pika, *Ochotona rufescens* (Gray, 1842)
2n = 60, NFa = 88, NF = 92; X= SM, Y = A
The autosomal complement consists of 15 meta- and submetacentric and 14 acrocentric pairs. The X

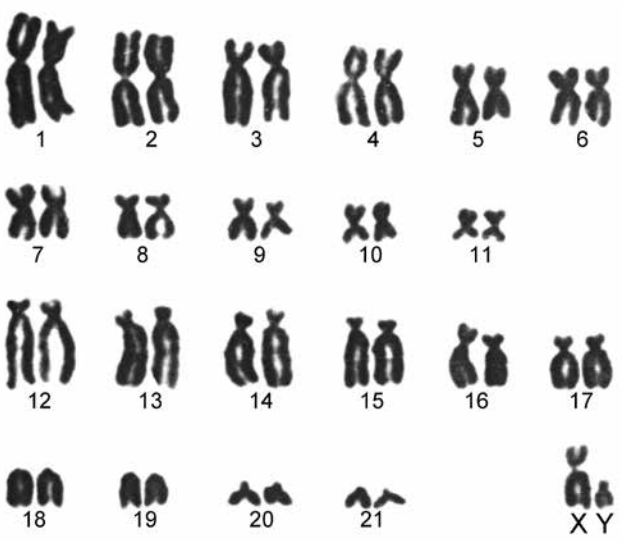

Fig. 31. Karyotype of domestic rabbit.

chromosome is submetacentric, the Y chromosome is acrocentric (Nadler et al. 1969, Vorontsov & Ivanitskaya 1973, Ivanitskaya 1985). The chromosome banding pattern was described by Kimura et al. (1983). The karyotype of this species, presumably extinct in Turkey, was not studied in this country but karyological records are available from neighbouring regions (Nadler et al. 1969, Vorontsov & Ivanitskaya 1973, Ivanitskaya 1985).

Red squirrel, *Sciurus vulgaris* Linnaeus, 1758
2n = 40, NFa = 72, NF = 76; X = M, Y = A/ST
The autosomal complement consists of 17 bi-armed and two acrocentric pairs. The X chromosome is a medium-sized metacentric; the Y chromosome is small, possesses distinct short arms and it is designated as acrocentric or subtelocentric (see Zima & Král 1984b for review; Fig. 32). The chromosome banding and painting patterns were studied by Petit et al. (1984), Petit & Dutrillaux (1985) and Beklemisheva et al. (2011). Chromosomal relationships between Sciuridae and Gliridae were proposed by Sannier et

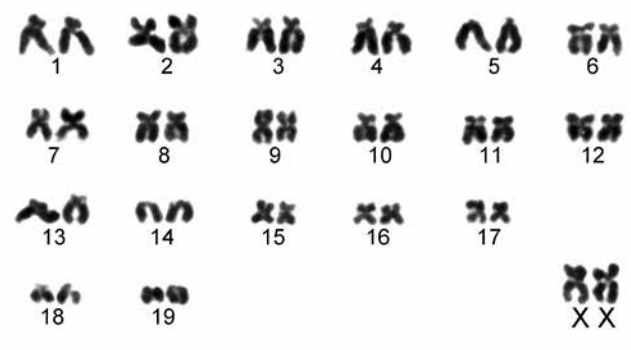

Fig. 32. Karyotype of *Sciurus vulgaris* (Slovakia).

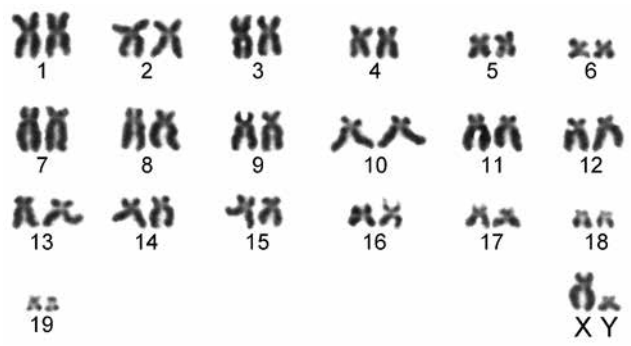

Fig. 33. Karyotype of *Sciurus anomalus* (Anatolia).

al. (2011). The karyotype has not yet been studied in Turkey, however, karyological records are available for various European populations (e.g. Zima 1987).

Persian squirrel, *Sciurus anomalus* Gueldenstaedt, 1785
2n = 40, NFa = 76, NF = 80; X = SM, Y = SM
The autosomal complement comprises six pairs of metacentrics and 13 pairs of submetacentrics or subtelocentrics. Secondary constrictions are localized in telomeric regions of the short arms of one or two autosomal pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is a small submetacentric (see Zima & Král 1984b for review, Petit & Dutrillaux 1985; Fig. 33).
In Turkey, Özkurt et al. (1999c) studied the conventionally stained karyotype of this species from Gönen and Akkuş (Balıkesir), Albayrak & Arslan (2006) from Konya and Tez et al. (2006) from Kayseri and Adana. Arslan et al. (2008a) described G- and C-banded and Ag-NOR stained karyotype of this species from Aydın, Balıkesir, Çorum, Elazığ and Konya, and Arslan & Zima (2012) studied the C-band and NORs distribution in the karyotype of an introduced population in Thrace, European Turkey. Two autosomal pairs possessing NOR were found in the introduced population in Thrace, whereas a single NOR-bearing pair was recognized in Anatolia.

European souslik, *Spermophilus citellus* (Linnaeus, 1766)
2n = 40, NFa = 66, NF = 70; X = M/SM, Y = A/M
The autosomal complement contains one large and one small pair of metacentrics, 12 submetacentric pairs, and five acrocentric pairs. The X chromosome is a bi-armed element of larger size; the Y chromosome is very small and acrocentric or bi-armed (Korablev 1984, Nadler et al. 1984, Zima & Král 1984b for review, Belcheva & Peshev 1985, Peshev 1987, Zima 1987, Mitsainas et al. 2008).
The karyotypic studies of populations from Thrace in European Turkey were published by Doğramacı et al. (1994b) and Özkurt et al. (2002). The autosomal complement is similar to that reported from various European populations. The Y chromosome was mostly identified as acrocentric, with an exception of the paper by Doğramacı et al. (1994b) reporting this sex chromosome as bi-armed.

Asia Minor souslik, *Spermophilus xanthoprymnus* (Bennet, 1835)
2n = 42, NFa = 76-78, NF = 80-82; X = M, Y = A/M
The karyotype comprises two metacentric, 16 or 17 submetacentric and subtelocentric, and one or two acrocentric pairs of autosomes. The X is metacentric and the centromeric position on the Y chromosome has been reported as metacentric (Doğramacı et al. 1994b; Fig. 34) or acrocentric (Özkurt et al. 2002, Yiğit et al. 2006b).
Other data from Turkey were published by Arslan (2005), Gaffaroğlu & Yüksel (2006), Yiğit et al. (2006b), and Gündüz et al. (2007). We have examined the karyotype of two specimens from the vicinity of

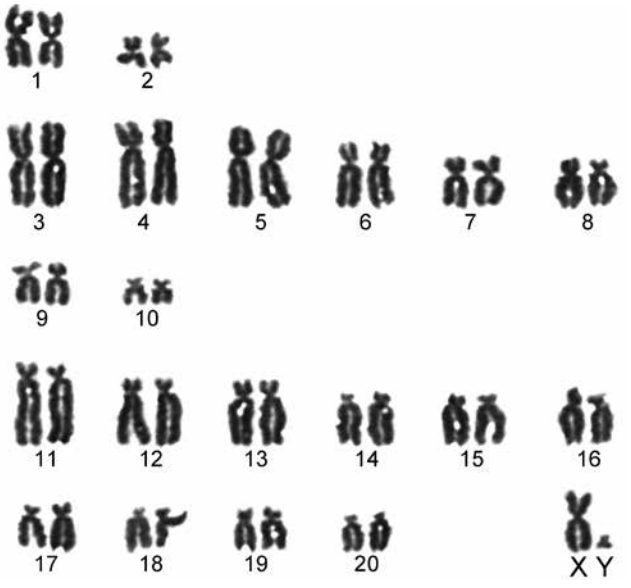

Fig. 34. Karyotype of *Spermophilus xanthoprymnus* (Anatolia).

Eber Gölü (Afyon). Individual descriptions differed in the determination of the centromere position in one autosomal pair and in the Y chromosome. Variation in the fundamental number of arms was indicated also in published data from Armenia (Nadler et al. 1984, Korablev 1984). Dark pericentromeric C-bands were revealed in all the autosomes and the X chromosome. Contrary to *S. citellus*, the Y chromosome was entirely C-negative (Arslan 2005).

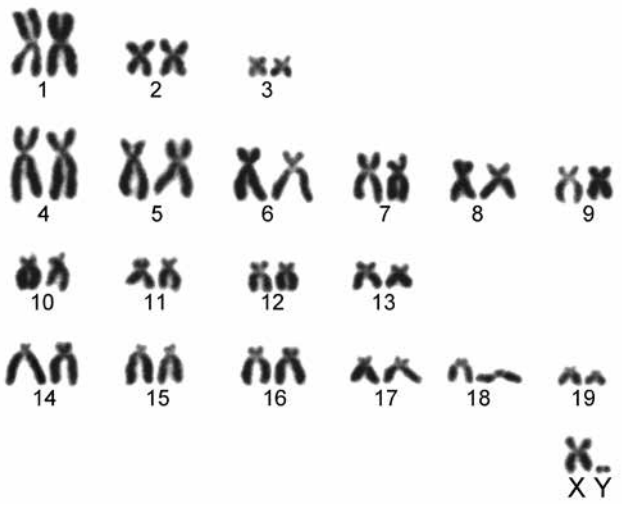

Fig. 35. Karyotype of *Spermophilus taurensis* (Anatolia).

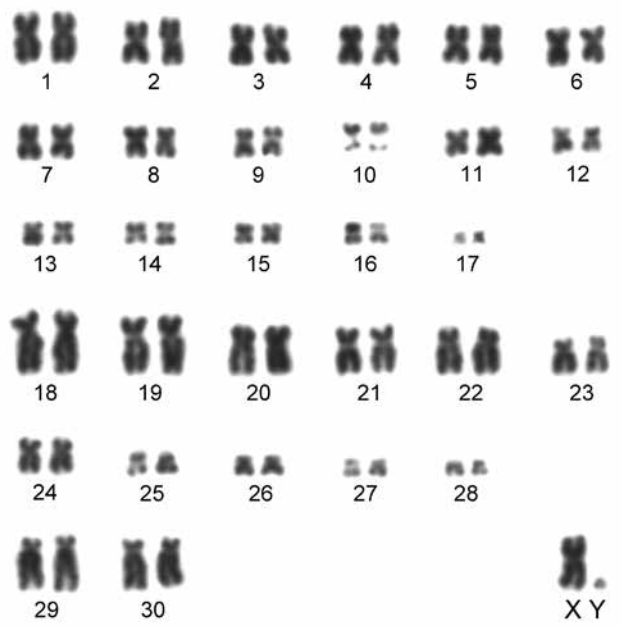

Fig. 36. Karyotype of *Glis glis* (Anatolia).

Taurus souslik, *Spermophilus taurensis* Gündüz, Jaarola, Tez, Yeniyurt, Polly et Searle, 2007
2n = 40, NFa = 72-76, NF = 76-80; X = M, Y = A/M
The conventionally stained karyotype was investigated by Özkurt et al. (2002), Yiğit et al. (2005), Gündüz et al. (2007), Matur (2009) and Arslan & Arslan (2010) (Fig. 35). These descriptions slightly differ in morphology of certain chromosomes. Özkurt et al. (2002) reported that the karyotype comprises two pairs of metacentric, 15 pairs of submetacentric and two pairs of acrocentric autosomes but Arslan & Arslan (2010) identified all autosomes in the set as bi-armed (three metacentric, ten submetacentric and six subtelocentric pairs). The X chromosome was metacentric; the Y chromosome was identified as bi-armed and/or acrocentric in different geographic populations (Özkurt et al. 2002, Arslan & Arslan 2010). All the autosomes and the X chromosome possessed distinct pericentromeric heterochromatin; the Y chromosome was entirely C-heterochromatic. The NORs were localized in telomeric areas of the short arm of two pairs of submetacentric and two pairs of subtelocentric autosomes (Arslan & Arslan 2010).

Fat dormouse, *Glis glis* (Linnaeus, 1766)
2n = 62, NFa = 120, NF = 124; X = M, Y = A
All the autosomes are bi-armed, the X chromosome is a large metacentric, the Y chromosome is dot-like, and usually it is identified as acrocentric (Fig. 36). An autosomal pair possesses a distinct secondary constriction (Zima & Král 1984b, Belcheva et al. 1988, Zima et al. 1995 for review). The G- and C-banding patterns were reported by O'Brien et al. (2006) and Mitsainas et al. (2008).
The conventionally stained karyotype was investigated by Doğramacı & Tez (1991) in northern Anatolia and Civitelli et al. (1995) in the Istranca Mts. in European Turkey. The G- and C-banding pattern was studied by Şekeroğlu & Şekeroğlu (2011) in specimens from Giresun (north-eastern Anatolia). C-banding showed that most autosomes possessed at least faint dark C-bands in the pericentromeric region. Some chromosomes carried additional dark C-bands at varying positions on the long arm. The X chromosome had a centromeric dark band; the Y chromosome was partially C-positive. Arslan et al. (2013c) studied the AgNOR distribution in individuals from northern Anatolia. By using silver-nitrate staining, they localized the nucleolar organizer region in a secondary constrictions on an autosomal pair.

Hazel dormouse, *Muscardinus avellanarius* (Linnaeus, 1758)
2n = 46, NFa = 86-88, NF = 90-92; X = M, Y = A
The karyotype contains 18 pairs of meta- and submetacentric autosomes, three pairs of subtelocentric

autosomes and one pair of small acrocentric or subtelocentric autosomes. One of the autosomal pairs possesses a distinct secondary constriction. The X chromosome is a medium-sized metacentric; the Y chromosome is dot-like and acrocentric (see Zima & Král 1984b and Zima et al. 1995 for review, Belcheva et al. 1988). The G-banding pattern was described by O'Brien et al. (2006).
The karyotype of this species was investigated in the Trabzon area (Doğramacı & Kefelioğlu 1992), and these authors considered the small autosomal pair subtelocentric (NFa = 88). The G- and C-banding pattern was studied by Şekeroğlu et al. (2011b) in specimens from Ordu (north-eastern Anatolia) with a small acrocentric pair of autosomes (NFa = 86). All autosomes possessed dark C-bands in centromeric areas. The X chromosome had a distinct dark pericentromeric C-band; the Y chromosome had a C-positively stained centromeric region.

Forest dormouse, *Dryomys nitedula* (Pallas, 1778)
2n = 48, NFa = 92, NF = 96; X = SM/M, Y = A
All the autosomes are bi-armed and can be differentiated into five subtelocentric and 18 meta- or submetacentric pairs. One of the autosomal pairs possesses a distinct secondary constriction. The X chromosome is bi-armed and of medium size; the Y chromosome is a very small acrocentric (see Zima & Král 1984b and Zima et al. 1995 for review). The G- and C-banding patterns were reported by O'Brien et al. (2006) and Mitsainas et al. (2008).
The karyotype of Turkish populations was studied in the area of Trabzon (Doğramacı & Kefelioğlu 1990) and in the Istranca Mts. in south-eastern Europe (Civitelli et al. 1995). The G- and C-banding pattern was studied in specimens from Ordu (north-eastern Anatolia). Most of the autosomes possessed at least faint pericentromeric dark C-bands and some autosomes carried also interstitial dark C-bands. The X chromosome had two faintly stained pericentromeric bands and two additional bands in distal positions. The Y chromosome was partially C-positive (Şekeroğlu & Şekeroğlu 2011).

Woolly dormouse, *Dryomys laniger* Felten et Storch, 1968
2n = 46, NFa = 88, NF = 92; X = M, Y = M
All the autosomes are meta- and submetacentric, the X chromosome is a large metacentric and the Y chromosome is a small bi-armed element. The karyotype of this species, endemic to Turkey, was described by Kıvanç et al. (1997a).

Black-tailed garden dormouse, *Eliomys melanurus* Wagner, 1840
2n = 48, NFa = 86, NF = 90; X = M, Y not specified
The karyotype was examined in Israel (Filippucci et al. 1988, Sannier et al. 2004, 2011); examination from Turkey is not available.

Setzer's mouse-tailed dormouse, *Myomimus setzeri* Rossolimo, 1976
The karyotype is not known. The karyotype of a related species *M. personatus* from Turkmenistan includes 44 chromosomes and its G-banding pattern was reported (O'Brien et al. 2006).

Roach's mouse-tailed dormouse, *Myomimus roachi* (Bate, 1937)
2n = 44, NFa = 84, NF = 88; X = M, Y = D
The autosomal complement consists of bi-armed elements only. The X chromosome is a medium-sized metacentric; the Y chromosome is the smallest of the set. The karyotype was described by Civitelli et al. (1995) from Thrace in European Turkey.

Eurasian beaver, *Castor fiber* Linnaeus, 1758
2n = 48, NFa = 76, NF = 80; X = M, Y = M
The autosomal set contains 15 bi-armed and eight acrocentric pairs. Both the sex chromosomes are metacentric; the Y chromosome is the smallest in the complement (Zima & Král 1984b for review, Bulatova & Lavrov 1990). The karyotype of the Eurasian beaver is distinctly different from that recorded in the Canadian beaver as revealed by chromosome banding studies (Graphodatsky et al. 1991, Ward et al. 1991).
The species has become recently extinct in Turkey (Kryštufek & Vohralík 2009), and the karyological records from this country are therefore not available.

Transcaucasian mole-vole, *Ellobius lutescens* Thomas, 1897
2n = 17, NFa = 32, NF = 34; X = SM
This species is cytogenetically unique because it lacks obvious sex chromosome determining system. The karyotype contains eight bi-armed pairs and a single submetacentric chromosome (no. 9) is supposed to represent the X chromosome. The constitution X0 thus occurs in both sexes (see Zima & Král 1984b for review). The chromosome banding and painting pattern was reported by Djalali et al. (1986), Vogel et al. (1988), Kolomiets et al. (1991), O'Brien et al. (2006), and Romanenko et al. (2007a). The NOR occurred on the short arm of the largest submetacentric pair.

This karyotype was assessed also in eastern Turkey (Coşkun 1997, 2001) and the same complement was reported in a geographically close area in western Iran (Gharkheloo & Kıvanç 2003).

Long-clawed mole-vole, *Prometheomys schaposchnikovi* Satunin, 1901
2n = 56, NFa = 100, NF = 104; X = SM, Y = M/SM
The autosomal set comprises 11 meta- and submetacentric, 12 subtelocentric and four acrocentric pairs. The X chromosome is submetacentric and the largest element in the set; the Y chromosome is a small meta- or submetacentric. The complement includes autosomes which may possess distinct short arms and there are varying opinions in the literature about the correct number of autosomal arms. Similarly, the centromeric position on the Y chromosome has been interpreted either as acrocentric or metacentric (see Zima & Král 1984b for review). The G-banding pattern was reported by O'Brien et al. (2006).
The karyotype of Turkish populations was reported by Çolak et al. (1999b, c) from Kutul plateau (Ardanuç) in Artvin province and from a site 15 km north of Ardahan.

Bank vole, *Clethrionomys glareolus* (Schreber, 1780)
2n = 56, NFa = 56, NF = 60; X = A, Y = A/M
The autosomal complement consists of a small metacentric pair and 26 acrocentric pairs of diminishing size. The X chromosome is a medium-sized acrocentric; the Y chromosome is acrocentric in Turkish populations but it was reported as bi-armed in some other geographic areas (see Zima & Král 1984b for review, Radosavljević et al. 1990, Vujošević & Blagojević 1997, O'Brien et al. 2006, Mitsainas et al. 2008; Fig. 37).

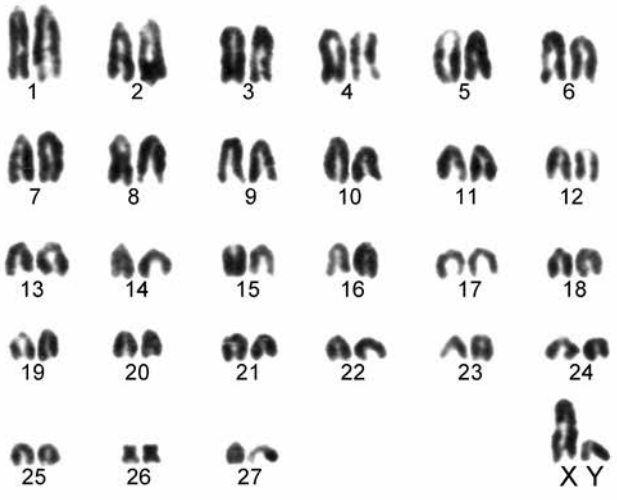

Fig. 37. Karyotype of *Clethrionomys glareolus* (Czech Republic).

The conventional karyotype of this species was described in Turkey by Çolak & Kıvanç (1991) and Çolak et al. (1997c), the C-banding pattern and the distribution of NORs were studied by Arslan et al. (2013c). All the autosomes and the X chromosome possessed distinct C-positive bands in pericentromeric areas, except of one of the larger acrocentric pairs. The Ag-NOR regions were found in seven acrocentric autosomal pairs, usually in telomeric regions of the short arms.

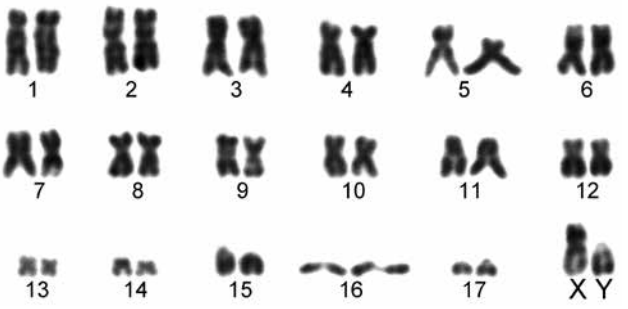

Fig. 38. Karyotype of *Arvicola terrestris* (Anatolia).

Water vole, *Arvicola terrestris* (Linnaeus, 1758)
2n = 36, NFa = 62, NF = 66, X = SM, Y = A
The autosomal complement consists of 12 meta- and submetacentric pairs, two large or medium-sized subtelocentric pairs, and three small acrocentric pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome is a small acrocentric with a distinct short arm (Fig. 38). Variation in the presence or absence of short heterochromatic arms in some acrocentric chromosomes has been reported within the species (see Zima & Král 1984b for review, O'Brien et al. 2006).
In Turkey, the conventionally stained karyotype was investigated by Özkurt et al. (1999a) in Central Anatolia (Kırşehir) and by Gözcelioğlu et al. (2006) in Thrace (Kırklareli). Arslan et al. (2011c) studied the chromosome banding pattern in water voles from Anatolia. All the chromosomes could be reliably identified by their unique G-banding patterns. The amount of constitutive heterochromatin in centromeric regions and in short arms of certain autosomes may vary. A unique feature of the C-banded karyotype of Turkish individuals was the absence of dark positive centromeric regions in most chromosomes. Populations of water vole from Anatolia resembled in their C-band pattern those studied previously in Azerbaijan (Kulijev et al. 1978), and they are different in this respect from populations in Central Europe and in other parts of the species range. The X chromosome stained uniformly and C-negatively,

whereas the Y chromosome stained C-positively. The active nucleolar organizer regions (NORs) were localized in one pair of small metacentric and two acrocentric autosomal pairs.

Common pine vole, *Microtus subterraneus* (de Sélys Longchamps, 1836)
2n = 52-54, NFa = 56, NF = 60; X = M/SM, Y = A/M
This species has a polytypic karyotype with two alternative diploid numbers, 2n = 52 or 2n = 54 (e.g. Belcheva et al. 1988, Zagorodnyuk 1988, Zima 2004; Figs. 39-40). The difference between the two races originated after a centric fusion of two acrocentric autosomes which resulted in a large submetacentric pair occurring in the 2n = 52 complement. The other autosomes are represented by a large subtelocentric and a small metacentric pair, and 22 acrocentric pairs. Polymorphism of the centromeric position was observed in some autosomal pairs (see Zima & Král 1984b for review). The X chromosome is a medium sized bi-armed element; the Y chromosome is of smaller size and was identified as acrocentric or metacentric. The chromosomal banding patterns were described by Zima (1984), Radosavljević et al. (1990), Baskevich (1997), Baskevich et al. (2000), Macholán et al. (2001), and O'Brien et al. (2006). Mitsainas et al. (2009a) described the C-banding pattern in Greek populations.
Both karyotypic races have been reported from Turkey. The 52 chromosome race was recorded in the Istranca Mts. in European Turkey whereas the 54 chromosome race in northern Anatolia (Çolak et al. 1997d, Baskevich et al. 2000, Macholán et al. 2001).

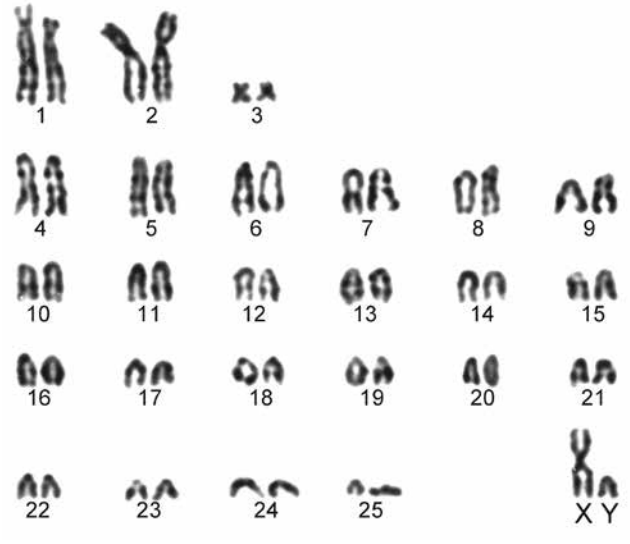

Fig. 39. Karyotype of *Microtus subterraneus* with 52 chromosomes (Slovakia).

The amount of C-positively stained regions was very low in the complement, and restricted mainly to the sex chromosomes. The C-heterochromatin content was the lowest in *M. subterraneus* among the three pine vole species occurring in Turkey (Baskevich et al. 2000). The X chromosome in the 54 chromosome race from Anatolia had amplification of C-heterochromatin in the long arm, and it was submetacentric (Macholán et al. 2001). The Y chromosome was completely heterochromatic and it was described as large and metacentric in samples studied by Çolak et al. (1997d) in the Istranca Mts., and smaller and acrocentric in samples studied by Macholán et al. (2001) from the same site.

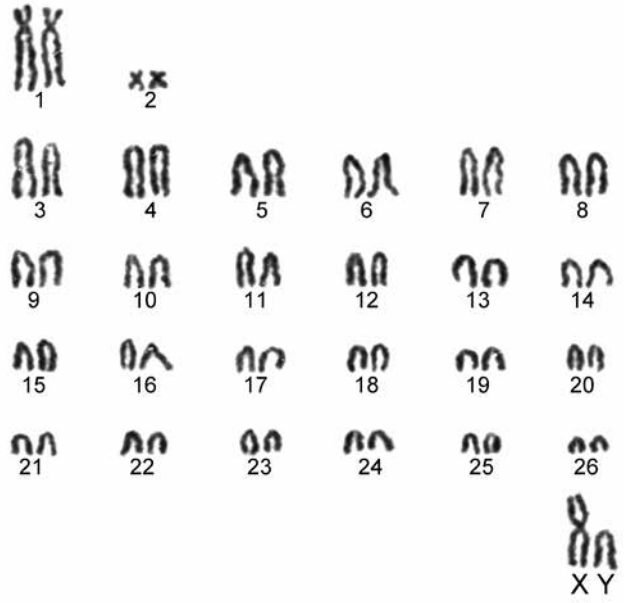

Fig. 40. Karyotype of *Microtus subterraneus* with 54 chromosomes (Anatolia).

Major's pine vole, *Microtus majori* Thomas, 1906
2n = 54, NFa = 56, NF = 60; X = SM/ST, Y = A
The autosomal complement includes one metacentric and one subtelocentric pair (these pairs are the largest among the autosomes), and 24 acrocentric pairs. The X chromosome is submetacentric, and there is a large block of C-heterochromatin in the long arm. The Y chromosome is of medium-size and acrocentric (see Zima & Král 1984b for review, Macholán et al. 2001, O'Brien et al. 2006; Fig. 41).
Karyological and other data showed that the range of this species is restricted to the wider Caucasus area and it does not occur in Europe (Kryštufek et al. 1994). The phylogenetic relationships within the genus *Microtus* and subgenus *Terricola* were proposed by Jaarola et al. (2004), Martínková et al. (2007) and Martínková & Moravec (2012).

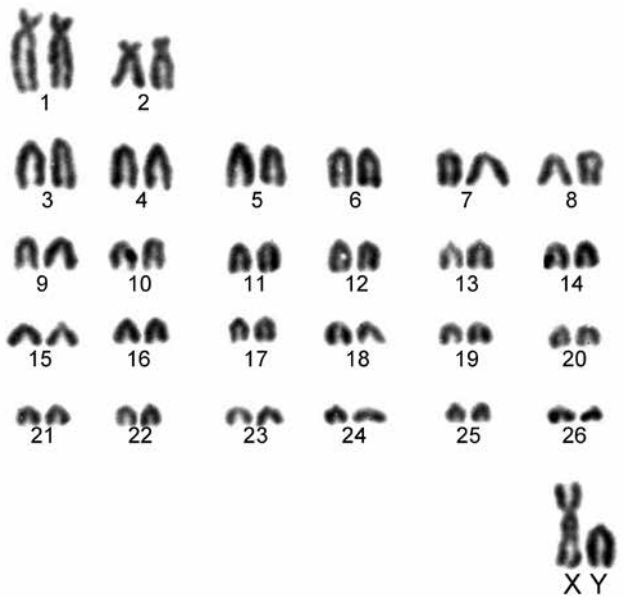

Fig. 41. Karyotype of *Microtus majori* (Anatolia).

The karyological data from Turkey were reported by Çolak et al. (1997d) and Macholán et al. (2001). The complement seems to be similar as in the populations studied in the Caucasus (Akhverdian et al. 1992, Baskevich 1997, Baskevich et al. 2000). The X chromosome was identified as subtelocentric by Çolak et al. (1997d).

Caucasus pine vole, *Microtus daghestanicus* Shidlovsky, 1919
2n = 54, NFa = 54, NF = 58; X = SM, Y = A
The karyotype consists of one small metacentric autosomal pair and 25 acrocentric autosomal pairs. The X chromosome is a medium-sized submetacentric; the Y chromosome an acrocentric. Except of this standard complement other variants of the diploid number were reported, e.g. 2n = 52, 46, 44, 42, 38 (see Akhverdian et al. 1992, Kryštufek & Vohralík 2005 for review, O'Brien et al. 2006) and some of these Caucasian races were previously proposed to represent separate species. The G-banding and cross-species chromosome painting pattern was described by Lemskaya et al. (2010). In Turkey, records from Bağdasan and Handere in eastern Turkey showed the presence of the standard 54 chromosome form (Kryštufek & Vohralík 2005).

Social vole, *Microtus socialis* (Pallas, 1773)
2n = 62, NFa = 60, NF = 62; X = A, Y = A
The complement includes acrocentric chromosomes only. The X chromosome is usually identified as the largest element; the Y chromosome as one of the smallest elements (see Zima & Král 1984b for review). The G-banding and cross-species chromosome painting pattern was described by O'Brien et al. (2006) and Lemskaya et al. (2010). The centromeric dark C-bands were present in all the autosomes, however, they were not distinctly apparent in the X chromosomes in the karyotype of individuals originated from Armenia (Zima et al. 2013). In the Armenian individuals examined, up to 16 NOR sites were observed in the centromeric region of the long autosomal arms. The karyotype in Turkey was studied by Kefelioğlu (1995) and Kefelioğlu & Kryštufek (1999). The same standard karyotype was found in specimens from Iran (Yiğit et al. 2006b).

Iranian vole, *Microtus irani* Thomas, 1921
2n = 60, NFa = 58, NF = 60; X = A, Y = A or
2n = 46, NFa = 46, NF = 50; X = M, Y = M
The karyotype of *M. irani* from the type site is not known with certainty due to taxonomic confusion in social voles and three distinct diploid numbers (2n = 60, 62 and 64) were reported in Iran (Matthey 1954, Golenishchev et al. 1999). The chromosomes of the complement with 60 chromosomes were acrocentric and their size was successively decreasing. Varying number of the chromosomes (1-7) possessed secondary constrictions in the centromeric region. Tiny short arms were visible in some acrocentric chromosomes. The sex chromosomes were also acrocentric but they could not be reliably differentiated in the conventionally stained karyotype (see Zima & Král 1984b for review).
The karyotypic data may be biased because of taxonomic problems in identification of the specimens under study. In Turkey, the karyotype was examined in a supposedly allopatric subspecies *M. irani karamani* from Balkusan (Kryštufek et al. 2010) and the karyotype containing 60 chromosomes was found. A different diploid number of 2n = 46 was ascertained in a population from Kilis, which was also ascribed to *M. irani* (Çolak et al. 1997e). However this population is believed to belong to social voles with an unresolved taxonomic affiliation (Kryštufek & Kefelioğlu 2001, Kryštufek & Vohralík 2005). Molecular phylogeny of the social voles was proposed by Kryštufek et al. (2009a) and Martínková & Moravec (2012).

Schidlovsky's vole, *Microtus schidlovskii* Argyropulo, 1933
2n = 60, NFa = 58, NF = 60; X = A, Y = A
The karyotype includes acrocentric chromosomes only and the X chromosome is identified as the largest element, the Y chromosome as a smaller one. The G-banding pattern was shown by O'Brien et al. (2006).

Cytogenetic investigations were performed by Yiğit et al. (2006b) in samples from Özalp (Van) and Yüksekova (Hakkari) in eastern Turkey. The complements with 2n = 60 or 2n = 62 were reported from Transcaucasia (Ajrumjan et al. 1986).

Guenther's vole, *Microtus guentheri* (Danford et Alston, 1880)
2n = 54, NFa = 52-54, NF = 56-58; X = SM/A, Y = A
Most of autosomes appear acrocentric, with short arms prominent in varying degree. The X chromosome has always a distinct short arm and can be evaluated as subtelocentric, however, the size of the short arm may vary in individuals from various geographic populations. The Y chromosome is small and the short arm is usually distinct (see Zima & Král 1984b for review, O'Brien et al. 2006; Fig. 42). The G-banding and cross-species chromosome painting pattern was described by Lemskaya et al. (2010).
In Turkey, the karyotype was reported from a number of sites (Kefelioğlu 1995, Çolak et al. 1997e, Kefelioğlu & Kryštufek 1999, Yiğit & Çolak 2002, Gözütok & Albayrak 2009). A standard karyotype was usually found but Çolak et al. (1997e) reported a pair of bi-armed small autosomes in some specimens (NFa = 54). Some of the authors recognized populations originating from western and central Anatolia as a separate species, *M. lydius*. The karyotype was described also from regions geographically close to Turkey (Golenishchev et al. 2002a, b).
Variations between populations were found in the amount and distribution of C-heterochromatin in certain autosomes and the sex chromosomes (Zima et al. 2013). C-banding showed distinct centromeric dark bands in all the chromosomes but the extent of the C-positively stained centromeric regions varied between populations. The difference was particularly prominent in the second largest autosome and the X chromosome. The distinct short arm of the X chromosome from the complement of the individuals from Harput was completely heterochromatic but the X chromosome in the Konya specimens possessed only pericentromeric dark C-band. The Y chromosomes in males from Konya and Harput were of similar size but the Y from complements of Konya specimens had only a pericentromeric dark C-band whereas the Y was completely C-heterochromatic in males from Harput. Furthermore, a specific pattern of the AgNORs distribution was recorded in individual geographic populations. In the karyotype of individuals from Harput, the NOR-carrier chromosomes were identified in six pairs. A medium-sized autosomal pair possessed a NOR site near the centromere on the long arm. No active NORs were observed in the two largest autosomal pairs but the two largest autosomes possessed active NORs in individuals from Konya, resembling thus the pattern recorded in *M. hartingi*. A heterozygous centromeric fusion (2n = 53) was recorded in individuals from a population at Harput (Zima et al. 2013).
Aşan Baydemir et al. (2011a) found an acrocentric X chromosome in specimens collected in Kahramanmaraş and Gaziantep provinces, whereas a submetacentric X chromosome was recorded in specimens from Kırıkkale and Nevşehir provinces. These authors studied C-banding pattern in the karyotype and recorded NORs at telomeric areas of the short arms of five acrocentric pairs and in centromeric areas of two telocentric pairs.

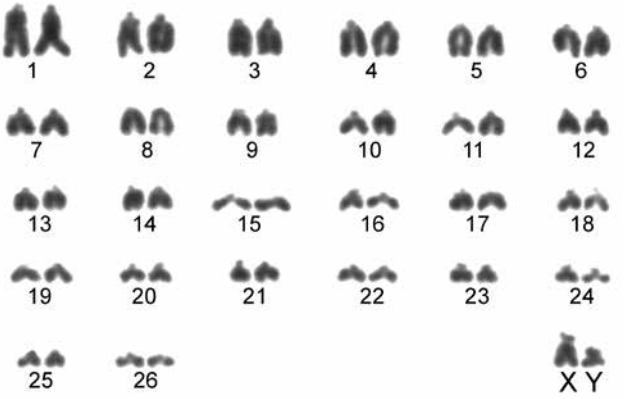

Fig. 42. Karyotype of *Microtus guentheri* (Anatolia).

European Günther's vole, *Microtus hartingi* Barret-Hamilton, 1903
2n = 54, NFa = 52, NF = 56; X = M/A, Y = A
The karyotype is quite similar to *M. guentheri* (Zima 2004 for review), with minor differences that can be observed in the distribution of C-heterochromatin and NORs (Zima et al. 2013).
The conventionally stained karyotype of populations from Turkish Thrace was studied by Kefelioğlu (1995). Belcheva et al. (1980) described the G- and C-banding patterns in populations from Bulgaria. Mitsainas et al. (2009a) studied the C-banding pattern in Greek populations, and Chassovnikarova et al. (2008) reported variation in the centromeric position in the sex chromosomes in samples from Bulgaria.

Doğramaci's vole, *Microtus dogramacii* Kefelioglu et Kryštufek, 1999
2n = 48, NFa = 46-48-50, NF = 50-52-54; X = M, Y = SM/A
The autosomal complement is all-acrocentric (NFa = 46) and/or it contains one (NFa = 48) or two

(NFa = 50) metacentric pairs. The X chromosome is a large metacentric; the Y chromosome is usually submetacentric but an acrocentric position of the centromere was recognized in some individuals. The karyotype was studied by Kefelioğlu & Kryštufek (1999), the G-banding and cross-species chromosome painting pattern was described by Lemskaya et al. (2010).

The lowest number of autosomal arms (NFa = 46) was found in a population from Konya while a population from Amasya was polymorphic (NFa = 46, 48, 50). The Y chromosome is submetacentric in specimens collected at Konya, whereas both the submetacentric and acrocentric Y chromosomes were recorded in the sample from Amasya. The G- and C-banding patterns were described by Albayrak et al. (2012). Şekeroğlu et al. (2011a) performed G-, C- banding and AgNOR staining in a large sample of 74 individuals from the type locality at Boyalı (Amasya, northern Anatolia). Only two distinct karyotypes were found. The prevailing complement, found in 70 % of specimens examined, contained only acrocentric autosomes (NFa = 46). The other complement included one medium-sized metacentric and 22 acrocentric autosomal pairs (NFa = 48). No hybrid individual was recorded in sites of syntopic occurrence of both races. A pericentric inversion was assumed a mechanism responsible for the changed centromeric position in one autosome. All the autosomes had large dark centromeric C-bands in centromeric areas and one pair displayed an interstitial dark C-band. The centromeric dark C-bands were present also on the sex chromosomes. The Y chromosome was always a small acrocentric. The number of active NORs varied from six to ten per cell. The NORs were located in centromeric regions of acrocentric autosomes. Albayrak et al. (2012) observed NORs in centromeric regions of four acrocentric pairs.

Anatolian vole, *Microtus anatolicus* Kryštufek et Kefelioglu, 2001

2n = 60, NFa = 58-60, NF = 60-62; X = A, Y = SM

The standard autosomal complement includes 28 acrocentric pairs and a single bi-armed pair (NFa = 60). The X chromosome is a large acrocentric; the Y chromosome is a small submetacentric. The karyotype was described by Kryštufek & Kefelioğlu (2001) from Yapalı, Cihanbeyli (Konya). Yavuz et al. (2009) extended the known range of distribution of *M. anatolicus* into the Taurus Mts. in the Antalya province (Bozdoğan, Kozan). These authors recorded slightly different karyotype with all acrocentric chromosomes (NFa = 58). C-banding showed extensive dark bands in the pericentromeric areas of all chromosomes (Yavuz et al. 2009).

Altai vole, *Microtus obscurus* Eversmann, 1845

2n = 46, NFa = 68, NF = 72; X = M, Y = M/A

The autosomal complement contains four pairs of large meta- and submetacentrics, one pair of large subtelocentrics, seven pairs of small bi-armed elements, and ten pairs of small acrocentrics. The X chromosome is a medium-sized metacentric and position of the centromere in the Y chromosome may vary (see Zima & Král 1984b for review). The centromeric shifts or pericentric inversions may occur in the large subtelocentric autosome which possesses a secondary constriction (Kozlovskii et al. 1988, Baskevich 1996b, Akhverdian et al. 1999). The chromosomal banding patterns were described by Mazurok et al. (1996) (Fig. 43). The separate status of this species seems dubious because of extensive hybridization with *Microtus arvalis* recorded in eastern European Russia (Lavrenchenko et al. 2009, Bulatova et al. 2010). *M. arvalis* has a similar karyotype with only four small acrocentric pairs (see Zima & Král 1984b for review).

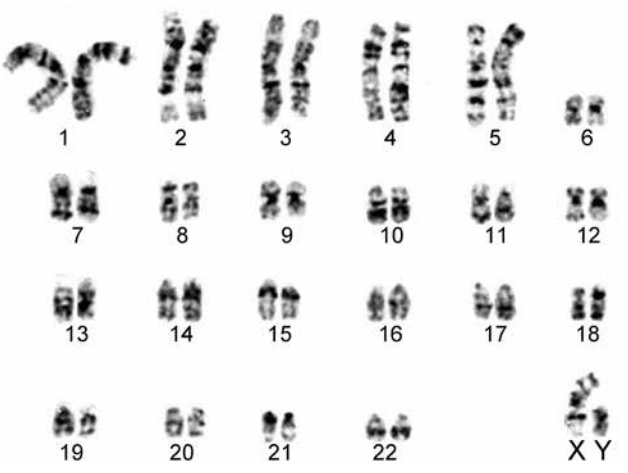

Fig. 43. G-banded karyotype of *Microtus obscurus* (Armenia).

The karyotype in Turkey was investigated by Kefelioğlu (1995). The distribution pattern of C-heterochromatin and AgNORs was described by Yorulmaz et al. (2013) in three females from Şavşat, Artvin Province. Certain small bi-armed and acrocentric autosomes possessed distinct C-positive bands in centromeric areas. A distinct dark C-band was observed also in a large bi-armed autosome. The X chromosome had a distinct pericentromeric dark C-band. A large autosomal pair was heteromorphic and consisted of a subtelocentric and acrocentric element. Only the acrocentric homologue

possesed dark C-staining in the centromeric region but no positive AgNOR staining was observed contrary to the results reported by Kozlovskii et al. (1988). The nucleolar organizer regions were localized in the secondary constrictions in four autosomal pairs. The Y chromosome was reported as acrocentric from Turkey (Kefelioğlu 1995) but variation in the centromeric position was found in the Caucasus (Baskevich 1996b).

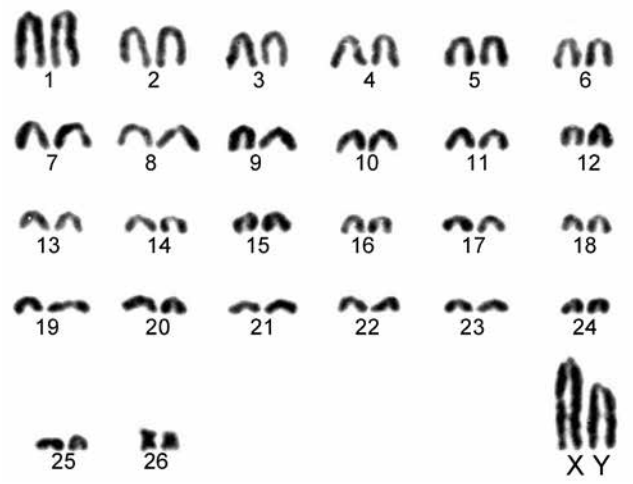

Fig. 44. Karyotype of *Microtus levis* (Anatolia).

East European vole, *Microtus levis* Miller, 1908
2n = 54, NFa = 54, NF = 56; X = A, Y = A
The autosomal complement consists of a single pair of small metacentrics and the remaining elements are acrocentric with successively diminishing size. The sex chromosomes are the largest elements in the set and both of them possess large blocks of C- heterochromatin (one third of the X chromosome and the whole Y chromosome are C-heterochromatic; see Zima & Král 1984b for review; Fig. 44). The chromosomal banding patterns were reported by Radosavljević et al. (1990), Mazurok et al. (1995), Zima (2004), O'Brien et al. (2006), Mitsainas et al. (2009a), Lemskaya et al. (2010) and Trifonov et al. (2010).
The karyotype of Turkish populations was examined by Kefelioğlu (1995) who found the standard complement. We studied the karyotype at other sites in Anatolia (province of Kırklareli, Kürtler – Samsun, Doğanköy, Eber Gölü – Afyon, Karabulut, Akşehir Gölü – Konya) and the same results were achieved.

Snow vole, *Chionomys nivalis* (Martins, 1842)
2n = 54, NFa = 52, NF = 56; X = SM, Y = A
All the autosomes are acrocentrics with decreasing size, the X chromosome is a large submetacentric; the Y chromosome is a small acrocentric. The chromosomal banding patterns were reported by Sablina et al. (1988), Radosavljević et al. (1990), Kulijev (1979, 1990), Malikov et al. (1990), and O'Brien et al. (2006).
The karyotype in Turkey was investigated by Kefelioğlu (1995) who examined also samples from the type localities of the subspecies *olympius*, *pontius*, and *cedrorum*. We found the same karyotype in a female from Harput (Elazığ). A similar karyotype was reported also from other areas of the range (Zima & Král 1984b for review).

Caucasian snow vole, *Chinomys gud* (Satunin, 1909)
2n = 54, NFa = 54, NF = 58; X = SM, Y = A
The karyotype contains 25 acrocentric autosomal pairs of diminishing size and the smallest autosomal pair is bi-armed. The X chromosome is a large submetacentric; the Y chromosome is acrocentric of varying size (see Zima & Král 1984b for review, O'Brien et al. 2006).
The karyotype was investigated in north-eastern Turkey by Sözen et al. (2009). The autosomal set consisted of one small pair of metacentric and 25 pairs of acrocentric chromosomes. The X chromosome was submetacentric and the largest chromosome in the set. The Y chromosome was acrocentric. The chromosomal complement was the same as reported from the Caucasus and Transcaucasia (Sablina et al. 1988, Kulijev 1979, 1990).

Robert's snow vole, *Chionomys roberti* (Thomas, 1906)
2n = 54, NFa = 54, NF = 58; X = SM, Y = A
The autosomal complement contains one small bi-armed pair and 25 acrocentric pairs of diminishing

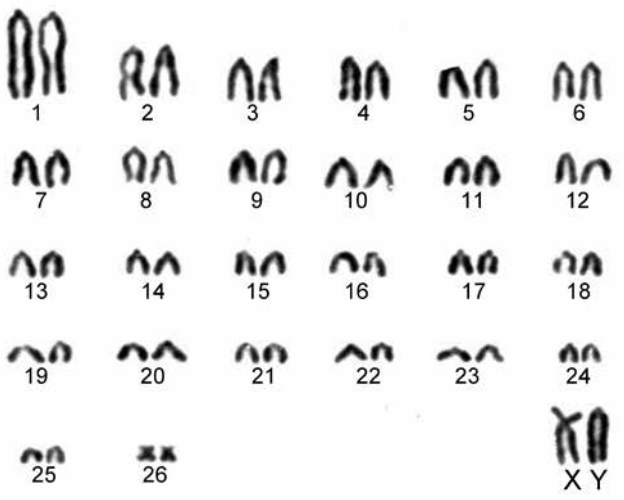

Fig. 45. Karyotype of *Chionomys roberti* (Anatolia).

size. The X chromosome is a large submetacentric; the Y chromosome is an acrocentric (Fig. 45). The chromosomal banding patterns were reported by Sablina et al. (1988), Kulijev (1979, 1990), and O'Brien et al. (2006).

The karyotype was described from Turkey by Kefelioğlu (1995). We have examined chromosomes of individuals from Meryemana (Trabzon Province) and found a large Y chromosome (Fig. 46). The

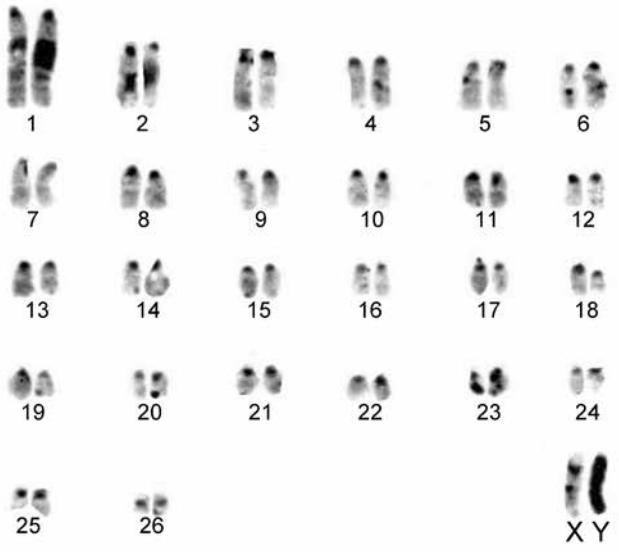

Fig. 46. C-banded karyotype of *Chionomys roberti* (Anatolia).

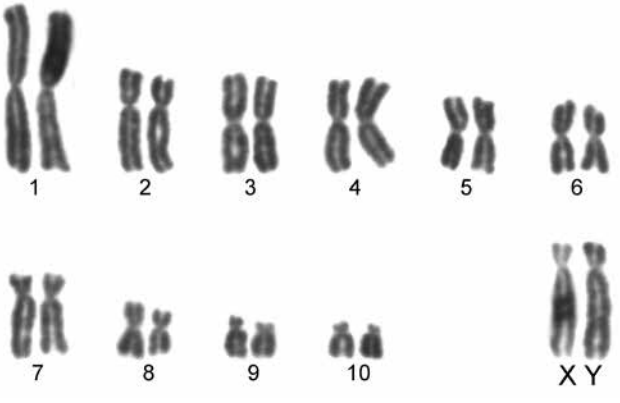

Fig. 47. Karyotype of *Cricetulus migratorius* (Turkmenistan).

karyotypes reported from the Caucasus were similar but the size of the Y chromosome may vary (Sablina et al. 1988).

Grey hamster, *Cricetulus migratorius* (Pallas, 1773)
2n = 22, NFa = 40, NF = 44; X = ST, Y = ST

The autosomal complement includes five metacentric and five subtelocentric pairs. The sex chromosomes were in the conventionall stained preparations reported as isomorphic large subtelocentric elements (see Zima & Král 1984b for review). The chromosome banding showed, however, that the internal structure of both the sex chromosomes is distictly different, and the sex chromosomes can slightly differ in size and the centromere position (O'Brien et al. 2006; Fig. 47). Karyotypic variation, the chromosome banding and painting pattern and the meiotic behaviour of chromosomes were reported by various authors (Zagorodnyuk 1986, Akhverdian 1993, Romanenko et al. 2007b, Arslan & Akan 2008). The whole C-heterochromatic arms were observed in 10-11 autosomal pairs.

The conventionally stained karyotype was reported by Doğramacı & Kefelioğlu (1991b) from northern Anatolia (Ordu). We examined a female from Harput (Elazığ) and a male from Karabulut (Afyon). The karyotype was similar as in other studies from the Caucasus (e.g. Akhverdian 1993), however, the size and centromere position in one small autosomal pair were different compared to reports from central Asia (Zima & Král 1984b for review). The banding pattern was examined by Arslan & Akan (2008) in central Anatolia. Most of autosomes were C-negatively stained. The pair no. 4 had a tiny dark centromeric band, the pair no. 8 a dark pericentromeric band, and the pair no. 9 a dark band in the distal part. The long arm of the Y chromosome was entirely C-heterochromatic; the X chromosome possessed a large dark pericentromeric C-band. The sex chromosomes clearly differed also in their G-banding pattern. Aşan et al. (2010) studied the distribution of nucleolar organizer regions. The NORs occurred in telomeric areas of two metacentric and three subtelocentric autosomes. One of the metacentric autosomes bore the NORs at telomeric ends of both the arms. Gharkheloo (2006) recorded a karyotype with a lower number of autosomal arms (NFa = 38) in Zanjan (Iran).

Golden hamster, *Mesocricetus auratus* (Waterhouse, 1839)
2n = 44, NFa = 78, NF = 82; X = M, Y = M

The autosomal set contains 18 bi-armed and three acrocentric pairs. The X chromosome is the largest metacentric in the complement; the Y chromosome is a large metacentric. The karyotype has been examined in many studies dealing with both natural and captive populations (Zima & Král 1984b for review). The banding and chromosomal painting patterns were examined by Pavia et al. (1977), O'Brien et al. (2006), Romanenko et al. (2006, 2007a, b), Sitnikova et al. (2007) and Trifonov et al. (2010). The whole

C-heterochromatic arms were observed in some autosomes. The conventionally stained karyotype was studied in Turkey by Doğramacı et al. (1994a) and Yiğit et al. (2000a).

Brandt's hamster, *Mesocricetus brandti* (Nehring, 1898)
2n = 42-44, NFa = 76-78-80, NF = 80-82-84;
X = SM, Y = SM
All the chromosomes are usually characterized as bi-armed (NFa = 80) but the centromere position on smaller autosomes was determined also as acrocentric (NFa = 76, 78). The X chromosome is a medium-sized submetacentric; the Y chromosome is a medium-sized small submetacentric or subtelocentric (Zima & Král 1984b). The chromosome banding pattern and the NORs distribution were reported by Popescu & Di Paolo (1980), O'Brien et al. (2006), Romanenko et al. (2007b), Aşan (2012) and others. NORs were located at telomeric areas of seven biarmed autosomes and at the centromeric area of one acrocentric autosome (Aşan 2012).
The karyological studies of Turkish populations were published by Todd et al. (1972), Lyman & O'Brien (1977), Popescu & Di Paolo (1980), Doğramacı et al. (1994a), Yiğit et al. (2000a), and Aşan (2012). The individual descriptions may differ in evaluation of the centromere position in two smaller pairs of autosomes (NFa = 76, 78, 80). Popescu & Di Paolo (1980) reported 2n = 42 and NFa = 78 in animals collected at Malya, and 2n = 44 and NFa = 80 in animals from Ankara. The difference bettween the two karyotypes probably resulted from a Robertsonian rearrangement. Yiğit et al. (2006a) recorded 2n = 42 and NFa = 78 in specimens from Iran.

Iranian mouse-like hamster, *Calomyscus bailwardi* Thomas, 1905
The karyotype of the rare Turkish populations is not known. Considerable chromosomal variation exists within the species and the genus (Graphodatsky et al. 2000a) and a specific karyotype may be expected in the supposedly isolated populations from Turkey. Graphodatsky et al. (1989) examined animals from Djulfa in Nachichevan and recorded 32 chromosomes in the diploid complement. O'Brien et al. (2006) reported the karyotype of *C. bailwardi* including 44 chromosomes. Somayeh et al. (2008) examined a sample of specimens from the Khorasan province in Iran and found the karyotype with 2N = 44, NFa = 60, NF = 64. The X chromosome was a small subtelocentric with a C-heterochromatic short arm; the Y chromosome was a small telocentric (acrocentric). We have examined animals originating from a site located about 100 km from the type locality of *C. bailwardi* in Iran and found a karyotype with 2n = 50. It can be assumed that the available records from regions neighbouring Turkey are related to distinct species. The chromosome banding and painting patterns in various *Calomyscus* species were shown in O'Brien et al. (2006) and Romanenko (2007b).

Indian gerbil, *Tatera indica* (Hardwicke, 1807)
2n = 68, NFa = 82, NF = 86; X = M, Y = A
The autosomal complement consists of eight bi-armed and 25 acrocentric pairs of diminishing size. The X chromosome is the largest metacentric; the Y chromosome is the smallest acrocentric (Fig. 48). Differences between published data may be caused by variable proportion of the bi-armed and uni-armed autosomes (NF = 80-86) reported in individual papers (Bates 1988, Arslan et al. 2013b for review).
The conventionally stained karyotype was studied in Turkey by Yiğit et al. (2001) at Ceylanpınar (NFa = 80). The C-banding pattern and the NORs distribution were investigated by Arslan et al. (2013b). The C-band positive regions were distributed in centromeric areas of all the autosomal pairs and the X chromosome. The Y chromosome was stained uniformly and C-positively. Active NORs were localized in

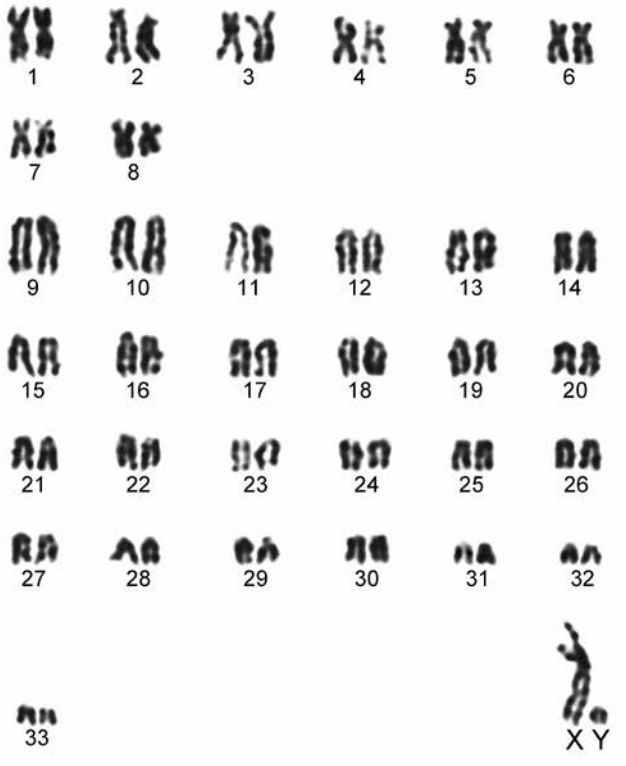

Fig. 48. Karyotype of *Tatera indica* (Anatolia).

secondary constrictions on the short arms of three pairs of bi-armed autosomes.

Persian jird, *Meriones persicus* (Blanford, 1875)
2n = 42, NFa = 74, NF = 78; X = SM, Y = SM
The autosomal set consists of 17 bi-armed and three acrocentric pairs. Both the sex chromosomes are submetacentric. The karyotype was investigated in Turkey by Yiğit & Çolak (1999). Similar karyotypes were reported from the Transcaucasus area and Iran (reviewed by Zima & Král 1984b).

Vinogradov's jird, *Meriones vinogradovi* Heptner, 1931
2n = 44, NFa = 74, NF = 78; X = M, Y = A
The autosomal complement includes 16 bi-armed and five acrocentric pairs. The X chromosome is the largest metacentric; the Y chromosome is usually described as a small metacentric (see Zima & Král 1984b for review).
The conventionally stained karyotype was reported from Turkey by Yiğit et al. (2006b). They found a standard karyotype of the species but the Y chromosome was identified as a small acrocentric. Different numbers of chromosomal arms were reported in papers studying populations from other regions.

Tristram's jird, *Meriones tristrami* Thomas, 1892
2n = 72, NFa = 72-82, NF = 76-84; X = SM/A, Y = SM/A
The diploid number of 72 chromosomes seems stable in various populations studied but the number of bi-armed chromosomes is varying and extensive variation in NF was reported (Zima & Král 1984b for review, Qumsiyeh et al. 1986, Wahrman et al. 1988, Chelomina et al. 1990, Qumsiyeh 1996; Fig. 49). This variation is assumed to originate from the alternative presence or absence of C-heterochromatic short arms in some acrocentric autosomes (Korobitsyna & Korablev 1980).
Variations in proportion of the bi-armed and uni-armed autosomes as well as in the size and the centromere position in the sex chromosomes were reported from Turkey (Kefelioğlu 1997b, Yiğit et al. 1997b, 1998d, Yiğit & Çolak 1998, Yiğit et al. 2006b, Demirbaş & Pamukoğlu 2008, Sözen et al. 2008). Five chromosomal forms were recognized with NFa varying from 72 to 82. The most distinct population with the acrocentric sex chromosomes was found at Doğubayazıt in eastern Anatolia (Yiğit et al. 2006b). In other populations the submetacentric sex chromosomes were identified and the number of autosomal arms was lower. NORs were located in telomeric areas of the long or short arm of three metacentric and seven acrocentric pairs (Aşan et al. 2010).

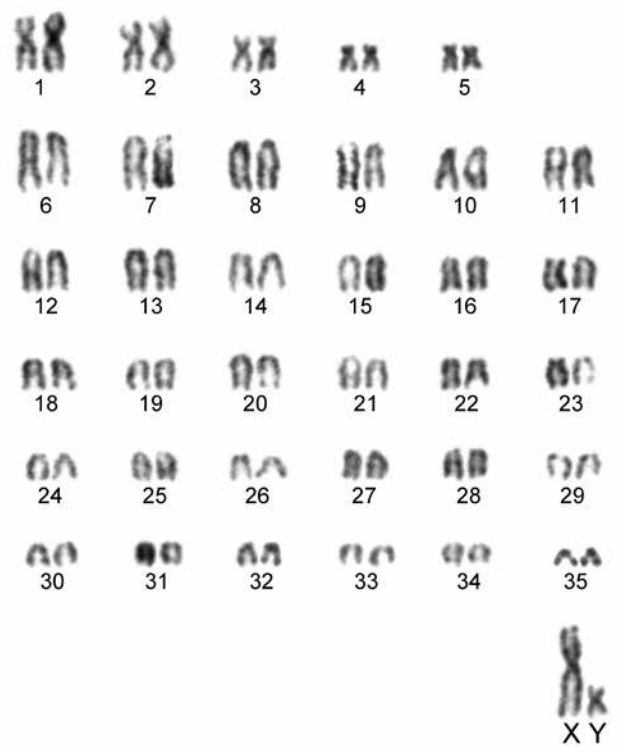

Fig. 49. Karyotype of *Meriones tristrami* (Anatolia).

Libyan jird, *Meriones libycus* Lichtenstein, 1823
2n = 44, NFa = 72-76, NF = 76-80; X = M, Y = SM/A
The autosomal set includes 15 or 17 bi-armed and six or four acrocentric pairs. The X chromosome is a large metacentric; the Y chromosome is a small submetacentric or acrocentric (see Zima & Král 1984b for review, Kulijev & Nadjafova 1986).
The karyological investigations of Turkish populations are still missing but the karyotype has been reported from some neighbouring countries, for instance from Iran (Yiğit et al. 2006b). Al-Saleh & Khan (1984) studied the karyotype in populations from Saudi Arabia with the use of G-banding and found a complement with 2n = 48 and NF = 96. Kartavtseva et al. (1987) described geographical variation in the C-banding pattern among populations from Azerbaijan.

Dahl's jird, *Meriones dahli* Shidlovsky, 1962
2n = 50, NFa = 74, NF = 78; X = SM, Y = SM
The autosomal complement includes 13 meta- and submetacentric and eleven acrocentric pairs. The sex chromosomes are large and submetacentric. The

complement is similar as in a related and wide-spread species *M. meridianus* (see Zima & Král 1984b for review). The Y chromosome was reported as acrocentric in some of populations of *M. meridianus* from eastern Europe (Korobitsyna 1974).
The standard karyotype was described from Turkey by Yiğit et al. (1997b, 1998c) (under the name *M. meridianus*) and Aşan Baydemir et al. (2011b). Interstitial dark C-bands were observed in the long arm of one of the large acrocentric autosomal pairs. NORs were located at telomeric areas of the short arm of three submetacentric and two acrocentric autosomes (Aşan Baydemir et al. 2011b).

Sundevall's jird, *Meriones crassus* Sundevall, 1842
2n = 60, NFa = 72, NF = 76; X = SM, Y = SM
The autosomal set consists of seven bi-armed and 22 acrocentric pairs. Both the sex chromosomes are bi-armed; the Y chromosome is approximately three-quarters of the size of the X chromosome.
The karyotype of the Turkish population was studied by Yiğit et al. (1998c). Lower numbers of autosomal arms were reported from other countries, e.g. NFa = 68 in Egypt (Nadler & Lay 1968) or NFa = 70 in Jordan (Qumsiyeh et al. 1986, Benda & Sádlová 1999) and Israel (Wahrman et al. 1988).

Wagner's gerbil, *Dipodillus dasyurus* (Wagner, 1842)
2n = 60, NFa = 66, NF = 70; X = M, Y = A
The autosomal complement consists of four bi-armed and 25 acrocentric pairs. The X chromosome is the largest metacentric; the Y chromosome is the smallest acrocentric.
The karyotype of Turkish populations was investigated by Yiğit et al. (1997a). A similar karyotype showing variation in the number of autosomal arms (NFa = 66, 68, 70) was reported from Jordan (Qumsiyeh et al. 1986).

Harvest mouse, *Micromys minutus* (Pallas, 1771)
2n = 68, NFa = 132, NF = 136; X = ST, Y = ST
The autosomal set includes one strikingly large submetacentric pair, three metacentric pairs and 29 subtelocentric pairs. The subtelocentric autosomes may be occasionally considered acrocentric, similarly as the sex chromosomes with rather short second arm. Distinct dark centromeric C-bands occur on all chromosomes, and some of them possess the C-heterochromatic short arms (see Zima 1983a, Zima & Král 1984b, Lungeanu et al. 1986 and Schmid et al. 1984 for review of chromosome banding studies). Cross-species chromosome painting was applied in this species by Nakamura et al. (2007) and Lin et al. (2013). The conventionally stained karyotype of the Turkish population was studied by Özkan et al. (2003) in Thrace and a standard complement was found.

Eastern rock mouse, *Apodemus mystacinus* (Danford et Alston, 1877)
2n = 48, NFa = 50, NF = 52; X = A, Y = A
The autosomal complement comprises 21 acrocentric and two metacentric pairs. Both the sex chromosomes are acrocentric (see Zima & Král 1984b for review). The karyotype of a related allopatric species, *A. epimelas*, is similar, but the presence of supernumerary chromosomes was recorded in a population in Bulgaria (Belcheva et al. 1988).
The standard karyotype of the species was reported in Turkey by Doğramacı & Kefelioğlu (1991a) and Çolak et al. (2004). Similar results were obtained also in neighbouring regions (Zima & Macholán 1995, Sözen et al. 2008).

Yellow-necked mouse, *Apodemus flavicollis* (Melchior, 1834)
2n = 48 + Bs, NFa = 46, NF = 48; X = A, Y = A
All the chromosomes are acrocentric, and the X chromosome is usually identified as the largest one whereas the Y chromosome as a smaller one. Incidence of the supernumerary chromosomes (Bs) is common in European populations (Giagia et al. 1985, Zima & Macholán 1995, Wójcik et al. 2004).
The chromosome banding pattern was described in several papers (Vujoševic et al. 1984, Zima & Král 1984b for review, Belcheva et al. 1987, Hirning et al. 1989, Boyeskorov et al. 1995, Orlov et al. 1996). Distinct pericentromeric dark C-bands occurred in all the chromosomes, the Y chromosome was completely C-heterochromatic but with lower intensity of staining compared to the autosomal centromeric areas. NORs were localized in telomeric regions of 4-9 autosomal pairs.
The karyotype of Turkish populations was reported by Doğramacı & Kefelioğlu (1991a) and Çolak et al. (2005). Zima & Macholán (1995) recorded 1-3 supernumerary chromosomes in approximately one quarter of animals examined in the sample from the Istranca Mts. in Turkish Thrace, however, no supernumerary chromosomes were found in karyotypes of the animals from northern Anatolia (Macholán & Zima 1997). The standard karyotype with 48 chromosomes was reported also from Jordan (Sözen et al. 2008).

Wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758)
2n = 48, NFa = 46, NF = 48; X = A, Y = A
The karyotype is all-acrocentric. The X chromosome is usually identified as the largest one whereas the size of the Y chromosome may be variable (Nová et al. 2002). The supernumerary chromosomes appear only occasionally in the karyotype of this species (Zima et al. 1997a).
The chromosome banding and painting patterns were studied by Vujoševic et al. (1984), Hirning et al. (1989), Boyeskorov et al. (1995), Orlov et al. (1996), Matsubara et al. (2004), Stanyon et al. (2004) and O'Brien et al. (2006). The amount of C-heterochromatin was rather high. The pericentromeric dark bands occurred on all the chromosomes and there were distinct telomeric dark bands on five autosomal pairs. The X chromosome usually contained a large block of C-heterochromatin, the Y chromosome stained entirely C-positively. NORs were localized in the telomeric areas of three to five autosomal pairs.
The karyotype was studied in Thrace by Çolak et al. (2005), and the Y chromosome was identified as a small acrocentric. The chromosomal complement found in Turkish populations was similar to that reported from neighbouring countries (Giagia et al. 1985, Kulijev & Nadjafova 1986, Belcheva et al. 1987, Nadjafova 1990, Nadjafova et al. 1993).

Pygmy field mouse, *Apodemus uralensis* (Pallas, 1811)
2n = 48, NFa = 46, NF = 48; X = A, Y = A
The karyotype consists of acrocentric chromosomes. The X chromosome is one of the largest elements; the size of the Y chromosome corresponds approximately to 10^{th}-12^{th} autosomal pair (see Zima & Král 1984b for review).
The banding pattern (G-, C-, AgNOR-staining) was described by Reutter et al. (2001) under the name *A. microps*. Distinct C-positive centromeric bands occurred on seven larger pairs of autosomes and tiny dark centromeric bands could be observed in some of smaller autosomes. A faint dark centromeric band was present in the X chromosome, and the Y chromosome stained C-positively, but the intensity of staining was lower than in the large autosomes. NORs were located in the telomeric area of three or four autosomal pairs, and in the pericentromeric area of another autosomal pair. All the NORs bearing autosomes were of medium size. In Turkey, the standard karyotype was reported from several sites in north-western Anatolia (Zima & Macholán 1995).

Steppe field mouse, *Apodemus witherbyi* (Thomas, 1902)
2n = 48, NFa = 46, NF = 48; X = A, Y = A
The conventionally stained karyotype is similar to previous *Apodemus* species. The karyotypic studies might be biased by erroneous species identification.
In Turkey, the karyotype was studied by Macholán & Zima (1997) and Çolak (2003) in the Ankara, Artvin, Bolu, Bursa, Samsun, Konya, and Muş provinces under the species names *A. hermonensis* and *A. iconicus*, respectively. The results of these studies were similar to the findings from neighbouring countries (Zima & Macholán 1995, Yiğit et al. 2006b).

Striped field mouse, *Apodemus agrarius* (Pallas, 1771)
2n = 48, NFa = 54-56, NF = 56-58; X = A, Y = A
The autosomal complement consists of 19 acrocentric pairs and four bi-armed pairs of smaller size (Fig. 50). The sex chromosomes are acrocentric, the X is among the largest elements, the Y is small. The incidence of supernumerary chromosomes was recorded in populations from the Far East (Kartavtseva 2002). Chromosome painting was applied in this species by Matsubara et al. (2004).
The data on chromosome banding pattern were summarized by Zima & Král (1984b), Vujoševic et al. (1984) and Lungeanu et al. (1984). Most of chromosomes had dark pericentromeric C-bands; the Y chromosome was entirely C-positive.
The standard karyotype of Turkish populations from Thrace was reported by Zima & Macholán (1995), Yiğit et al. (2000b) and Kefelioğlu et al. (2003). Yiğit et al. (2000b) recognized one of the autosomal pairs as subtelocentric and the number of autosomal arms increased accordingly (NFa = 56). Karyotypic

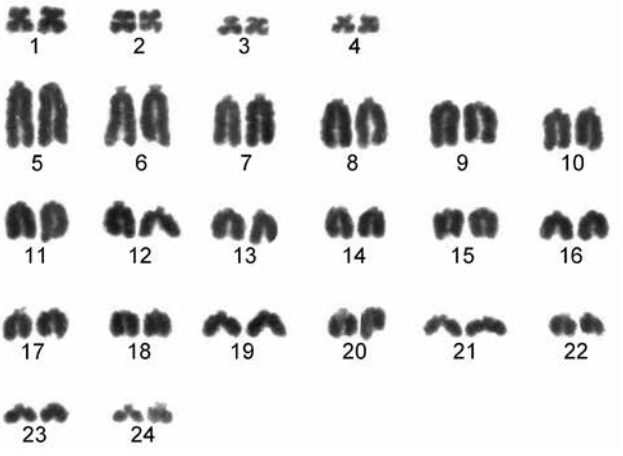

Fig. 50. Karyotype of *Apodemus agrarius* (Serbia).

data from the Balkans were reported by Belcheva et al. (1987); records from Azerbaijan by Kulijev & Nadjafova (1986).

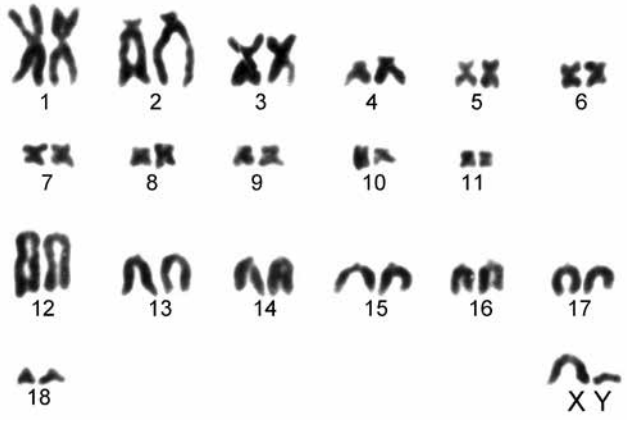

Fig. 51. Karyotype of *Rattus rattus* (Bulgaria).

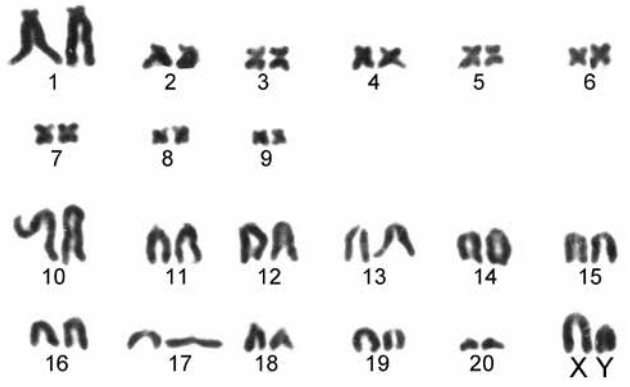

Fig. 52. Karyotype of *Rattus norvegicus* (Czech Republic).

Black rat, *Rattus rattus* (Linnaeus, 1758)
2n = 38 + Bs, NFa = 58-62, NF = 60-64; X = A, Y = A
Considerable karyotypic variations have been revealed within the whole distribution range of the nominal taxon. These variations result in changes of both the diploid chromosome number and the number of chromosomal arms (Yosida 1985).
The standard karyotype with 38 chromosomes contains nine metacentric, two subtelocentric, and seven acrocentric autosomal pairs (Fig. 51). Both sex chromosomes are acrocentric. The chromosome banding pattern was studied in various papers (see Zima & Král 1984b for review, O'Brien et al. 2006). Most of the autosomes and the X chromosome possessed distinct C-positive blocks in pericentromeric area. The Y chromosome was completely C-positive. NORs occurred at three autosomal pairs. Chromosome painting studies were reviewed by Romanenko et al. (2012).

The karyotype of Turkish populations was studied from Demirköy in Thrace, and from Ankara, Çankırı, and Antalya in Anatolia (Yiğit et al. 1998a, Aşan Baydemir 2011) and the standard complement was found. Kankılıç et al. (2006) reported polymorphic populations from three sites in Thrace. Variation resulted from supposed pericentric inversions at three autosomal pairs (NFa = 58-62) and from the presence of one or two small metacentric B chromosomes (2n = 39, 40). The B chromosomes were similar to the small metacentric autosomal pairs in the standard complement and they were found in populations from Gelibolu and Pınarhisar. Aşan Baydemir (2011) reported a heteromorphism in the centromere position in one pair of small autosomes (NFa = 59) in specimens from the Kırıkkale province in central Anatolia. Chromosomal findings are also available from Egypt (De Hondt et al. 1980), Azerbaijan (Kulijev 1984, Bulatova et al. 1991) and Bulgaria (Belcheva & Bisserkov 1984).

Brown rat, *Rattus norvegicus* (Berkenhout, 1769)
2n = 42, NFa = 62, NF = 64; X = A, Y = A
The autosomal complement includes seven metacentric and 13 subtelocentric and acrocentric pairs. The sex chromosomes are acrocentric (Fig. 52). Variations were reported in the centromeric position in certain autosomes and the X chromosome. The review of published data on conventionally stained and banded chromosomes was given by Zima & Král (1984b), De Lucca et al. (1990), and O'Brien et al. (2006). Dark centromeric C-bands, interstitial C-bands and C-heterochromatic short arms were detected on some chromosomal pairs. The X chromosome was C-negative whereas the Y chromosome was entirely C-heterochromatic. NORs were localized at three autosomal pairs. Chromosome painting studies were reviewed by Badenhorst et al. (2011) and Romanenko et al. (2012).
The standard karyotype was found in Turkish populations examined from Ankara and Samsun in Anatolia (Yiğit et al. 1998a). The same complement was reported in Armenia (Král 1971) and Azerbaijan (Kulijev 1984, Bulatova et al. 1991).

Short-tailed nesokia, *Nesokia indica* (Gray, 1830)
2n = 42, NFa = 52, NF = 56; X = SM, Y = M/SM
The autosomal set consists of six metacentric and 14 acrocentric pairs. Both the sex chromosomes are very large metacentrics (Fig. 53). The C-banding pattern was examined by Tewari et al. (1987), Dubey & Raman (1992), and O'Brien et al. (2006) and a varying amount of C-heterochromatin was found particularly on the sex

chromosomes. This species has not yet been studied in Turkey; data from neighbouring regions are available from Iran (Kamali 1975) and Tadjikistan (Král 1971).

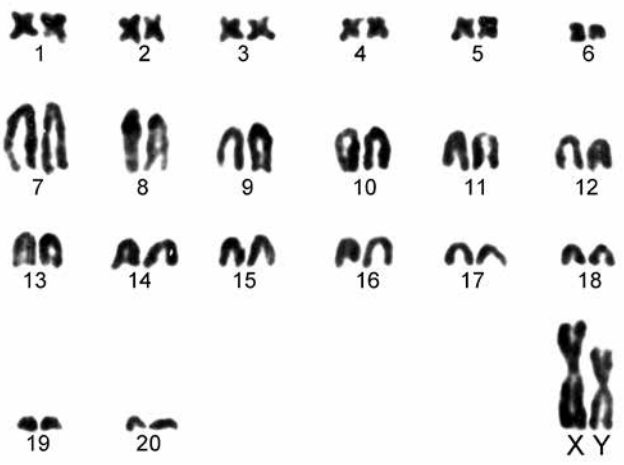

Fig. 53. Karyotype of *Nesokia indica* (Tadzhikistan).

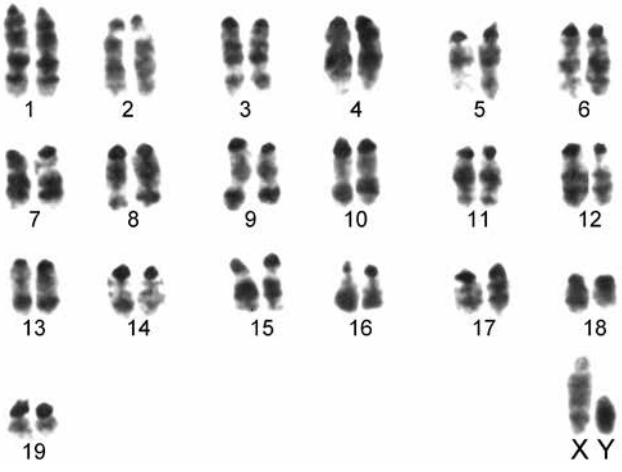

Fig. 54. G-banded karyotype of *Mus musculus* (Romania).

House mouse, *Mus musculus* Linnaeus, 1758
2n = 40, NFa = 38, NF = 40; X = A, Y = A
Populations of the house mouse in Turkey and surrounding areas of the Middle East belong to the subspecies *M. m. domesticus* (see Macholán et al. 2012 for genetic characterization). The standard complement includes only acrocentric chromosomes. The X chromosome is a large element; the Y chromosome is among the smallest ones (Zima & Král 1984b for review; Fig. 54).
This species is remarkable by extensive Robertsonian variation in the diploid number of chromosomes which is produced by autosomal centric fusions (e.g. Giagia et al. 1987, Tichy & Vucak 1987, Piálek et al. 2005, Hauffe et al. 2012). This variation was only quite exceptionally recorded in the related subspecies *M. m. musculus* (Zima et al. 1990). The banding data were reviewed by Zima & Král (1984b) and Sawyer & Hozier (1986). All the chromosomes had extensive dark pericentromeric C-bands; the Y chromosome was entirely C-heterochromatic (Garagna et al. 1993). Some of autosomes bore secondary constrictions containing NORs. Chromosome painting studies in the house mouse were reviewed by Romanenko et al. (2012).
Only the standard karyotype with 40 chromosomes was found in Turkey in Kayseri and Samsun (Gündüz et al. 2000), Zonguldak (Gözcelioğlu et al. 2005), and Doğubayazıt (Yiğit et al. 2006b), and the same results were reported from Cyprus (Cucchi et al. 2006). We found the standard karyotype also in two individuals examined from Çayır (Zonguldak).
The same karyotype was recorded also in Azerbaijan (Kulijev 1984, Korobitsyna et al. 1990, Bulatova et al. 1991), Iran and Levant (Qumsiyeh 1996, Gündüz et al. 2000, Yiğit et al. 2006b). Robertsonian populations and the occurrence of HSR regions found in Greek populations (Mitsainas et al. 2009b) have thus not been recorded in house mice from Turkey and the neighbouring countries in the Middle East.

Balkan short-tailed mouse, *Mus macedonicus* Petrov et Ružić, 1983
2n = 40, NFa = 38, NF = 40; X = A, Y = A
All chromosomes in the karyotype are acrocentric, and the complement is quite similar to the previous species (Zima & Král 1984b for review). However, the amount of C-heterochromatin is lower than in *M. domesticus* and other species of the genus (Redi et al. 1990, Garagna et al. 1993). The X chromosome possesses an enlarged centromeric C-positive band, and the size of the Y chromosome is distinctly small. NORs are localized on six autosomal pairs (Ivanitskaya et al. 1996a).
In Turkey, the karyological investigations were performed in populations from Kayseri and Samsun (Gündüz et al. 2000) and Ankara (Gözcelioğlu et al. 2005). We found the standard 2n = 40 karyotype in 20 individuals examined from Kürtler (Samsun), Kızkalesi (Icel), Suludere (Burdur). Akçaçile (Urfa), Konacık Köyü (south of Uluçınar), Karabulut (Afyon), Bardakçı (Manisa), Devecişağı, Aknurun, Beyşehir Gölü, Harran, and Çevlik. The standard karyotype was also recorded in Azerbaijan (Kulijev & Nadjafova 1986) and Israel (Ivanitskaya et al. 1996a).

Cyprus short-tailed mouse, *Mus cypriacus*
Cucchi, Orth, Auffray, Renaud, Fabre, Catalan, Hadjisterkotis, Bonhomme et Vigne, 2006
2n = 40, NFa = 38, NF = 40; X = A, Y = A

The standard karyotype is identical with the other two species of the genus *Mus* occurring in Turkey. The study of animals from Cyprus was performed by Cucchi et al. (2006).

Cyprus spiny mouse, *Acomys nesiotes* Bate, 1903
2n = 38, NFa = 66, NF = 68; X = A, Y = A
The autosomal complement includes 15 bi-armed pairs and three acrocentric pairs. The X chromosome is a large acrocentric with an apparent short arm; the Y chromosome is the smallest acrocentric (Zahavi & Wahrman 1956).
The G- and C-banding pattern was investigated by Zima et al. (1999). C-heterochromatin was localized in centromeric areas only. Distinct dark C-bands were apparent in the acrocentric autosomal pairs and in four or five metacentric autosomal pairs. The short arm and the centromeric region of the X chromosome were also C-positive. The G-banding pattern suggested that the karyotype of *A. cilicicus* can be derived from that of *A. nesiotes* after a single centric fusion of acrocentric autosomes.

Asia Minor spiny mouse, *Acomys cilicicus* Spitzenberger, 1978
2n = 36, NFa = 66, NF = 68; X = ST, Y = A
The karyotype consists of 16 pairs of meta- and submetacentrics and one pair of acrocentric autosomes. The X chromosome is large and subtelocentric whereas the Y chromosome is the smallest acrocentric (Fig. 55). Most autosomes display small centromeric blocks of C-heterochromatin and the first autosomal pair bears a larger C-positive band located in the pericentromeric area of the small arm. The acrocentric autosome has a small C-heterochromatic arm. In the X chromosome, C-heterochromatin constitutes the whole short arm as well as the pericentromeric part of the long arm. The Y chromosome is completely C-positive. Ag-NORs are located in terminal areas of the long arm of the pair no. 5 and in the pericentromeric area of the long arm of the pair no. 6.
The karyotype and chromosomal banding patterns were studied by Macholán et al. (1995), Kivanç et al. (1997b) and Arslan et al. (2008b) in Silifke (Mersin). *Acomys nesiotes* and *A. cilicicus* were lumped in the single species, *A. cahirinus*, by Kryštufek & Vohralík (2009). The karyotype of this chromosomally polytypic species was studied on various areas of the Middle East including some Mediterranean islands (Zima & Král 1984b for review, Qumsiyeh et al. 1986, Al-Saleh 1988, Volobouev et al. 1991, Benda & Sádlová 1999, Sözen et al. 2008).

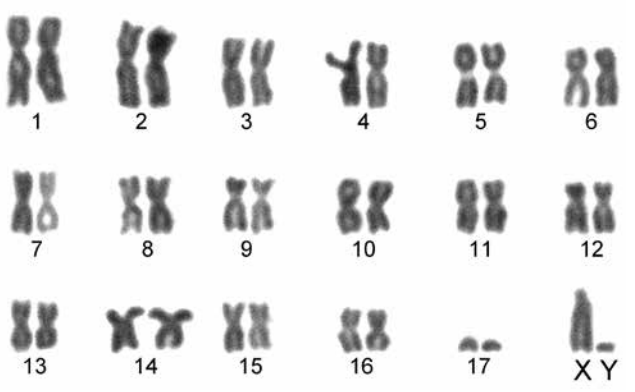

Fig. 55. Karyotype of *Acomys cilicicus* (Anatolia).

Nehring's mole rat, *Nannospalax xanthodon* Nordmann, 1840
The systematics and phylogenetic relationships of mole rats have not yet been definitively resolved, and the currently recognized species are often considered as superspecies presumably including separate cryptic species. The most important reason for the taxonomic uncertainties is remarkable karyotypic variation within and between the *Nannospalax* populations and species. About 50 distinct chromosomal races or cytotypes have been recorded within the three formally recognized *Nannospalax* species (e.g. Savić 1982, Nevo et al. 1994, 1995), and some authors believe that the individual cytotypes should be considered as presumptively good biological species (Nevo et al. 2001). It is thus obvious that the application of the Genetic Species Concept (Baker & Bradley 2006) will probably lead to systematic splitting of mole rats into many independent species. Molecular analyses of the cytochrome *b* sequences suggested, however, that associations between genetic and chromosomal variation are not widespread and common in mole rats, and therefore refuted the generalization of a "cytotype-equals-species" approach (Arslan et al. 2010, Kandemir et al. 2012, Kryštufek et al. 2012). The extent of chromosomal variation in mole rat populations in Turkey is impressive (e.g. Nevo et al. 1995, Sözen 2004, Sözen et al. 2006a) and the country can be considered a core area of differentiation processes in chromosomal evolution within this taxon. Nevo et al. (1994, 1995) proposed that chromosomal speciation of mole rats in Turkey is centripetal. The diploid numbers (2n) established in individual populations were suggested to be correlated with aridity stress and climatic unpredictability, and they increase towards central Anatolian Plateau from all directions. The mole rat populations with the highest diploid chromosome number (2n = 60) are actually

distributed mainly in central Anatolia, in accordance with the above hypothesis. Populations with lower diploid numbers occur in other areas and/or are interspersed in a mosaic pattern within areas of the 60 chromosome populations. However, the same diploid number may be found in geographically distant allopatric populations. When such populations at extreme edges of the range display identical diploid numbers, they can be designated by their 2n plus a letter such an E for eastern, C for central or W for western (Nevo et al. 1995, Sözen 2004, Sözen et al. 2006a). Effects of geographical isolation on the evolution of mole rat populations were discussed by Gülkaç & Yüksel (1999). Matur et al. (2013) attempted to analyse the phylogenetic relationships among the chromosomal races of mole rats from western Turkey. Continuing karyological studies of local populations of mole rats are therefore quite important for mapping of distribution of chromosome races and better understanding of mechanisms of their karyotype evolution. Because of the extreme extent of variation in karyotypes of mole-rats we include here only a brief list of individual karyotypes found in Turkey with their assumed distribution areas and relevant references. Only variation in autosomal complement is reported but certain variability exists also in size and morphology of the sex chromosomes. The X chromosome is a large or medium-sized element, the Y chromosome is usually small with varied position of the centromere.

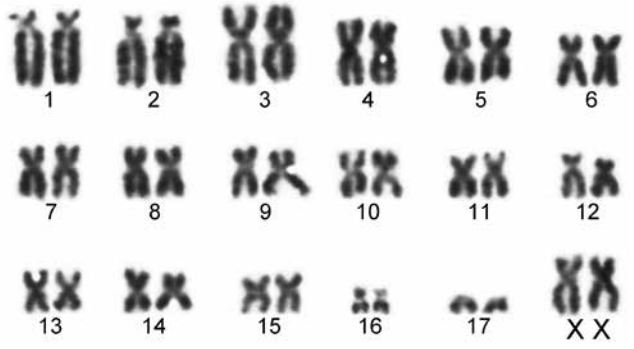

Fig. 56. Karyotype of *Nannospalax xanthodon* with 2n = 36 (Anatolia).

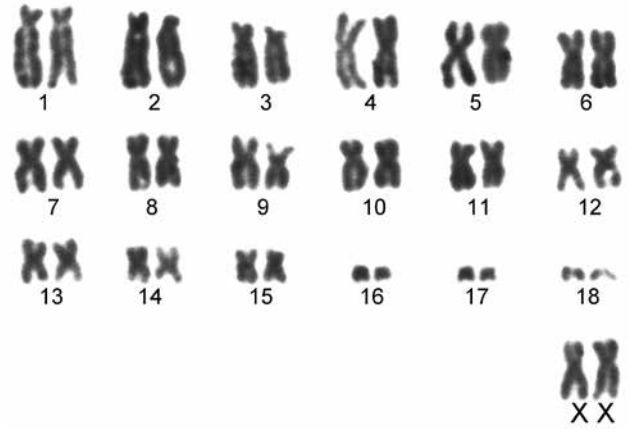

Fig. 57. Karyotype of *Nannospalax xanthodon* with 2n = 38 (Anatolia).

2n = 36, NFa = 64-66, NF = 68-70
Bayındır near İzmir, Haydarlı-Bağarası, Koçarlı, Ortaklar, Kemer cemetery (Aydın), Yatağan (Muğla) in western Anatolia (Sözen et al. 1999, 2013, Kankılıç et al. 2010, Matur et al. 2013, Arslan et al. 2013a; Fig. 56).

2n = 38, NFa = 70, NF = 74
North-western parts of Asia Minor up to the coast of the Marmara sea in the areas of Havran, Çanakkale, Balıkesir, Manisa, Selçuk and Ephes; Lesbos Island, Greece (Savić & Soldatović 1979, Giagia et al. 1982, Nevo et al. 1994, 1995, Tez et al. 2002, Sözen 2004, Kankılıç et al. 2009, Matur et al. 2013, Sözen et al. 2013, Arslan et al. 2013a; Fig. 57). This race occurs also on the islands of Bozcaada and Gökçeada in the Aegean sea (Sözen et al. 2013) and it was recognized as *Nannospalax nehringi anatolicus* (Méhely, 1909) by Savić & Soldatović (1984).

2n = 40, NFa = 68, NF = 72
Beyşehir and Konya provinces in central Anatolia (Nevo et al. 1994, 1995, Kankılıç et al. 2007b, 2010, Arslan et al. 2011a, Matur et al. 2013, Sözen et al. 2013).

2n = 48, NFa = 64, NF = 68
Lake Van in eastern Turkey, Ağrı and Van provinces (Coşkun 2003, Coşkun et al. 2009).

2n = 48, NFa = 67, NF = 71
Şamanlı plateau, 35 km E of Gümüşhane, north-eastern Anatolia (Sözen et al. 2006b).

2n = 50, NFa = 66, NF = 70 (50E, 50N)
Erzurum, Kars and Karabük provinces in Anatolia (Nevo et al. 1994, 1995, Sözen et al. 2000a, Coşkun 2003, Sözen 2004, Sözen et al. 2006b, 2013, Kankılıç et al. 2007a, b, Ulutürk et al. 2009, Matur et al. 2011).

2n = 50, NFa = 66, NF = 70 (50S)
Andırın (Kahramanmaraş) (Matur et al. 2011).

2n = 50, NFa = 68, NF = 72
Armenia (Pambak, Maralik) and Erzurum, Erzican, Susuz, Ardahan, Rize, Giresun, and Bayburt provinces

in eastern Turkey (Lyapunova et al. 1974, Sözen et al. 2000a, 2006b, Kankılıç et al. 2007b).

2n = 50, NFa = 70, NF = 74
Alaşehir (Manisa), Ovacık, Pamukören (Aydın) in western Anatolia (Nevo et al. 1994, 1995, Matur et al. 2011, 2013, Sözen et al. 2013).

2n = 50, NFa = 70, NF = 74 (50N)
Keltepe (Karabük) in northern Anatolia (Sözen 2004, Sözen et al. 2006b, Matur et al. 2011).

2n = 52, NFa = 66, NF = 70
Bilecik, Sakarya and Bolu provinces in northern Anatolia (Sözen 2004, Matur & Sözen 2005, Kankılıç et al. 2007b, Sözen et al. 2013).

2n = 52, NFa = 68, NF = 72 (52N)
Yalova (Matur 2009, Matur et al. 2013).

2n = 52, NFa = 68, NF = 72
Sebil (Mersin) (Sözen & Kıvanç 1998a, Sözen et al. 2000b, Kankılıç et al. 2007b).

2n = 54, NFa = 68, NF = 72
Eflani (Zonguldak), Tokat, north-western Anatolia (Sözen 2004, Sözen et al. 2006a, Matur et al. 2013).

2n = 54, NFa = 70, NF = 74
Bingől, Elazığ and Tunceli provinces (Nevo et al. 1994, 1995, Yüksel & Gülkaç 2001, Coşkun et al. 2009, 2010). Coşkun (2004a, c) recognized this race as a separate species *Nannospalax tuncelicus*.

2n = 54, NFa = 70-71, NF = 74-75
Kırıkkale (middle Kızılırmak basin), Yozgat and Tokat area in northern Anatolia, Çankırı and Çorum provinces (Yüksel & Gülkaç 2001, Sözen et al. 2006b, Kankılıç et al. 2007b, Aşan & Yağcı 2008, Arslan et al. 2011b, Sözen et al. 2011).

2n = 54, NFa = 78, NF = 82
Bolu, Anatolia (Nevo et al. 1994, 1995).

2n = 56, NFa = 68, NF = 72
Mersin, Isparta, Manisa, Uşak, Karabük and Adana provinces in Anatolia (Sözen & Kıvanç 1998b, Sözen 2004, Sözen et al. 2000b, 2006b, 2013, Kankılıç et al. 2007b, 2009, 2010), Çankırı and Çorum – 56N (Sözen et al. 2011).

2n = 56, NFa = 70, NF = 74
Kastamonu, Tosya, Safranbolu in Karabük province, north-western Anatolia (Sözen 2004, Sözen et al. 2006b, Matur et al. 2013).

2n = 58, NFa = 62-64, NF = 66-68
Ovacık (Tunceli), Kemaliye (Erzincan), south-eastern Anatolia (Coşkun 2004a, Arslan & Zima 2013a). Coşkun (2004a) recognized this race as a separate species *Nannospalax munzuri*.

2n = 58, NFa = 68, NF = 72
Konya, Niğde, Ereğli, and Adana provinces in Anatolia (Sözen & Kıvanç 1998b, Sözen et al. 2000b, 2006b, Arslan et al. 2011a).

2n = 58, NFa = 70-71, NF = 74-75
Vicinity of Kastamonu in northern Anatolia, Eregli in central Anatolia, Çankırı and Çorum provinces (Sözen et al. 2006a, 2011, Arslan et al. 2011a, Matur et al. 2013).

2n = 58, NFa = 74, NF = 78
Sarıkavak, Ankara Province, central Anatolia (Sözen 2004).

2n = 60, NFa = 68, NF = 72
Ulukışla (Niğde), Anatolia (Sözen et al. 2000b, Ivanitskaya et al. 2008).

2n = 60, NFa = 70, NF = 74
Aksaray, Kastamonu, Antalya, Kahramanmaraş, Burdur and Konya provinces in Anatolia (Sözen et al. 2000b, 2006a, b, 2013, Ivanitskaya et al. 2008, Kankılıç et al. 2009, Arslan et al. 2011a).

2n = 60, NFa = 72, NF = 76
Manisa, Akşehir, Aksaray, Beyşehir (Konya), Kütahya province (Sözen et al. 1999, 2000b, 2006b, 2013, Kankılıç et al. 2007b, 2009, Arslan & Bölükbaş 2010).

2n = 60, NFa = 74-75, NF = 78
Amasya and Samsun provinces (Sözen et al. 2006b), Aksaray province (Arslan & Bölükbaş 2010).

2n = 60, NFa = 74, NF = 78
Çankırı, Çorum, Malatya, Kastamonu, Kayseri, Sivas, Bilçcik, Bursa, Amasya, Uşak, Eskişehir, Karabük, Bolu, Aksaray, Kütahya, Isparta, Ankara, Konya, and Samsun provinces in Anatolia (Nevo et al. 1994, 1995, Ivanitskaya et al. 1997, Tez et al. 2001, Sözen

2004, Matur & Sözen 2005, Kankılıç et al. 2007b, 2010, Ivanitskaya et al. 2008, Arslan & Bölükbaş 2010, Arslan et al. 2011a, Sözen et al. 2011, 2013). Ivanitskaya et al. (2008) designated this cytotype as 60W (widely distributed).

2n = 60, NFa = 74-76, NF = 78-80
Küre (Kastamonu), northern Anatolia (Sözen et al. 2006b, Ivanitskaya et al. 2008). Ivanitskaya et al. (2008) designated this race as 60R (cytotype with restricted distribution).

2n = 60, NFa = 76, NF = 80
Bursa, Kütahya, Denizli, Ankara, Konya, Central Euphrates basin, Malatya, Kırşehir, Nevşehir, Kayseri, Yozgat, Erzincan, Sivas provinces in Anatolia (Yüksel 1984, Gülkaç & Yüksel 1989, Gülkaç & Küçükdumlu 1999, Yüksel & Gülkaç 2001, Sözen 2004, Kankılıç et al. 2007b, Ivanitskaya et al. 2008, Arslan et al. 2011a, Sözen et al. 2013).

2n = 60, NFa = 78, NF = 82
Antalya, Malatya, Ankara, Afyon, Sivas, Çankırı and Çorum provinces in Anatolia (Gülkaç & Yüksel 1989, Sözen et al. 1999, 2011, 2013, Kankılıç et al. 2009; Fig. 58).

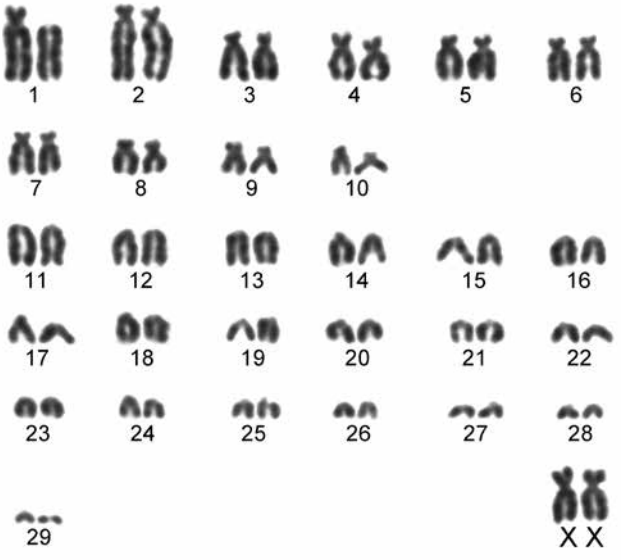

Fig. 58. Karyotype of *Nannospalax xanthodon* with 2n = 60 (Anatolia).

2n = 60, NFa = 80, NF = 84
Vicinity of Burdur and Denizli in Anatolia (Sözen et al. 1999, 2013, Kankılıç et al. 2010).

2n = 62, NFa = 86, NF = 90
Afyon, Konya, Ankara, Kayseri, Sivas provinces in Anatolia (Nevo et al. 1994, 1995). Complements with this diploid number have never been recorded again after the first description (see Sözen et al. 2006b), and the existence of this race is doubtful.

Lesser mole-rat, *Nannospalax leucodon* Nordmann, 1840
2n = 56, NFa = 72, NF = 76
Eceabat, Thrace (Sözen 2004).

2n = 56, NFa = 74, NF = 78
Çorlu, Hayarbolu (Kırklareli), Lower Thrace (Soldatović & Savić 1978, Savić & Soldatović 1979, Giagia et al. 1982, Sözen et al. 2006b, Matur et al. 2013, Arslan et al. 2014). This chromosomal race was recognized as *Nannospalax turcicus* (Méhely, 1909) by Savić & Soldatović (1984).

Palestine mole-rat, *Nannospalax ehrenbergi* Nehring, 1898
2n = 48, NFa = 70, NF = 74
Balada, Yayladağı Coşkun (2004b).

2n = 52, NFa = 70, NF = 74
Hatay and Kilis (Coşkun 1999, 2004b, Sözen et al. 1999, 2006b).

2n = 52, NFa = 72, NF = 76
Diyarbakır, Şırnak, Birecik, Hilvan, Siverek, Adıyaman, Elazığ (Yüksel 1984, Yüksel & Gülkaç 1992, Nevo et al. 1994, 1995, Ivanitskaya et al. 1997, Gülkaç & Küçükdumlu 1999, Coşkun 1998, 2004c). Mosul, Iraq (Coşkun et al. 2012, 2014).

2n = 52, NFa = 76, NF = 80
Şanlıurfa (Ivanitskaya et al. 1997).

2n = 54, NFa = 72, NF = 76
Suruç (Yüksel & Gülkaç 1992).

2n = 56, NFa = 62, NF = 66
Siirt (Coşkun 2004c).

2n = 56, NFa = 64, NF = 68
Kozan Pekmezci (Coşkun et al. 2006).

2n = 56, NFa = 68, NF = 72
Tarsus, Anberinarkı, Yakapınar, Adana, İbrişim, Şeyhmurat (Nevo et al. 1994, 1995).

2n = 56, NFa = 78, NF = 82
Gaziantep (Ivanitskaya et al. 1997).

2n = 56, NFa = 82, NF = 86
Gaziantep (Yüksel & Gülkaç 1992).

2n = 58, NFa = 78, NF = 82
Northern vicinity of Gaziantep (Nevo et al. 1994, 1995).

Williams's jerboa, *Allactaga williamsi* Thomas, 1897
2n = 48, NFa = 92, NF = 96, X = SM, Y = A
The karyotype includes 48 mostly bi-armed chromosomes. The conventionally stained chromosomes of this species were studied in Turkey by Çolak et al. (1994, 1997a) and Çolak & Yiğit (1998b). The chromosomal banding pattern was reported by Arslan & Zima (2010). All the chromosomes except the Y sex chromosome were bi-armed (Fig. 59) and could be identified by unique G-banding patterns. The complement included six metacentric pairs, twelve submetacentric pairs and five subtelocentric pairs of autosomes. The largest submetacentric autosomal pair was distinctly bigger than the other five pairs of the same morphological group. This largest autosome was identified as subtelocentric by Çolak et al. (1994). The C-banding analysis revealed considerable amount of constitutive heterochromatin in all the chromosomes. C-band positive regions were distributed mainly in centromeric areas, whereas the Y chromosome was stained uniformly and C-negatively. Active NORs were localized in two pairs of small metacentric and submetacentric autosomes.

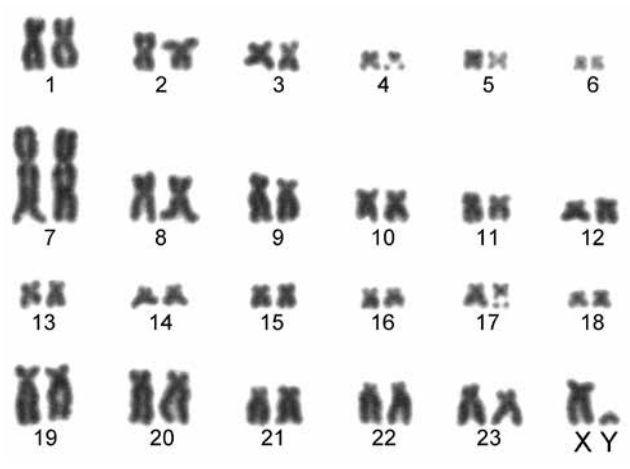

Fig. 59. Karyotype of *Allactaga williamsi* (Anatolia).

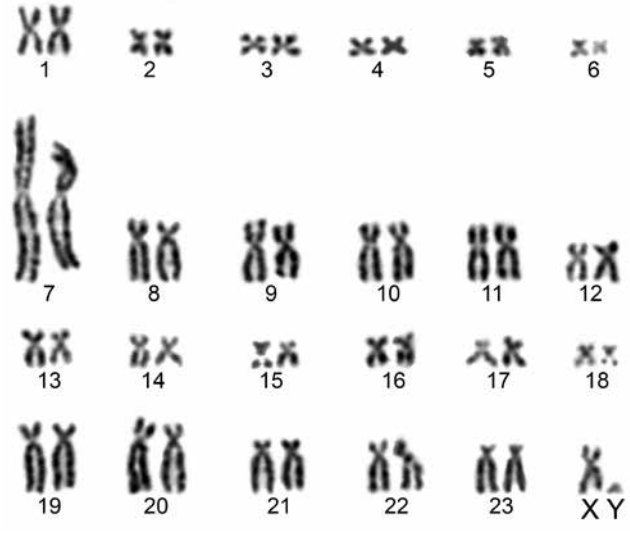

Fig. 60. Karyotype of *Allactaga euphratica* (Anatolia).

Euphrates jerboa, *Allactaga euphratica* Thomas, 1881
2n = 48, NFa = 92, NF = 96, X = SM, Y = A
The conventionally stained karyotype is similar to that of *A. williamsi* (Fig. 60) but the largest autosome was identified as submetacentric (Çolak et al. 1994, Çolak & Yiğit 1998a, b). The C-heterochromatin distribution and localization of NORs apparently differ between karyotypes of these related jerboa species (Arslan et al. 2012). Distinct differences were found in the distribution of C-heterochromatin. Extensive C-heterochromatic intercalary blocks were observed in the largest pair of autosomes of *A. euphratica* which were absent in the complement of *A. williamsi*. The Y chromosome was stained uniformly and C-negatively. Active nucleolar organizers were localized in two pairs of small biarmed autosomes, but their homology with the NOR-bearing autosomes from the karyotype of *A. williamsi* was not sure. The same karyotype of as in Turkey was found in *A. euphratica* also in Jordan (Sözen et al. 2008).

Small five-toed jerboa, *Allactaga elater* (Lichtenstein, 1825)
2n = 48, NFa = 92, NF = 96, X = SM, Y = A
The conventionally stained karyotype seems similar as in the other two Turkish jerboa species (Çolak et al. 1997b, Çolak & Yiğit 1998b).

Caucasian birch mouse, *Sicista caucasica* Vinogradov, 1925
2n = 32, NFa = 46, X = A, Y = A
The autosomal complement comprises eight pairs of meta- and submetacentric and seven pairs of acrocentric elements; both the sex chromosomes are acrocentric (for review see Sokolov et al. 1980, 1987, Zima & Král 1984b, Dzujev 1988, Baskevich 1996a). Other sibling species of birch mice from the Caucasus (*Sicista armenica* – Baskevich 1990, *S. kazbegica* – Sokolov et al. 1987 and *S. kluchorica* – Sokolov et al.

1981) have specific karyotypes different from that of *S. caucasica*. The karyotype of the *Sicista* species has not been studied in Turkey.

Indian crested porcupine, *Hystrix indica* Kerr, 1792
2n = 66, NFa = 128, NF = 132; X = M, Y not reported
The karyotype was examined by Arslan (2006) in two females from Bozyazı (Içel) in Turkey. The karyotype included bi-armed chromosomes only; the X chromosome was tentatively identified as the largest element.
The karyotype of *H. indica* was reported by Raman & Sharma (1971). The finding from Turkey differed from findings in *H. cristata* made in Italy (2n = 60, NFa = 114) and Kenya (2n = 60, NFa = 116) (see Zima & Král 1984b for review). However, George & Weir (1974) mentioned an unpublished record of 2n = 66 in individuals identified as *H. cristata*.

Coypu, *Myocastor coypus* (Molina, 1782)
2n = 42, NFa = 80, X = M/SM, Y = A
The autosomal complement consists of bi-armed chromosomes. One pair bears the secondary constriction. The X chromosome is meta- or submetacentric; the Y chromosome is a smaller acrocentric. Distinct centromeric and telomeric dark C-bands occur in most of the chromosomes. The karyotype has been described mostly in captive populations (see Zima & Král 1984b for review).
The karyotype of Turkish populations was studied in Iğdır province in Anatolia (Iliker et al. 2009). Some metacentric and submetacentric autosomal chromosomes had large centromeric C-bands and some of the submetacentric, medium-sized and small metacentric chromosomes had telomeric C-bands. These telomeric bands occurred either on one arm or on both arms. The X chromosome had centromeric heterochromatin, while the Y chromosome was entirely C-heterochromatic.

Conclusions

Altogether, 156 species occurring in the region concerned were included in this review. The karyotype was studied in 109 species in Turkey. In most other species findings are available from other geographic regions, and only three species (*Crocidura arispa*, *Monachus monachus*, *Myomimus setzeri*) remain unstudied cytogenetically. Within Turkey, the most studied taxonomic groups belong to small mammals (insectivores, bats, and rodents), whereas the large mammals, particularly carnivores, were studied with less intensity. Most of the mammals which were not studied karyologically in Turkey belong to marginal, rare or recently extinct species.
In this review, previously unpublished findings are reported in 20 species (*Neomys anomalus*, *Crocidura leucodon*, *C. suaveolens*, *Rhinolophus ferrumequinum*, *R. hipposideros*, *R. mehelyi*, *R. blasii*,

Table 1. The Turkish species revealing karyotypic variation between and/or within populations.

Species	Characteristic of variation
Hemiechinus auritus	NFa = 90 or 92
Taphozous nudiventris	X = M or SM, Y = A or dot-like
Rhinolophus hipposideros	2n = 54 or 58
Eptesicus serotinus	NFa = 48 or 50
Nyctalus leisleri	B chromosomes
Pipistrellus pipistrellus	2n = 42 or 44
Vormela peregusna	NFa = 72 or 74
Lepus europeaus	duplication on the long arm of a subtelocentric autosome
Microtus subterraneus	2n = 52 or 54, X = M or SM, Y = A or M
Microtus irani	2n = 46 or 60
Microtus guentheri	2n = 53 or 54, NFa = 52-54, X = A/SM, C-heterochromatin and AgNOR distribution
Microtus dogramacii	NFa = 46, 48 or 50
Microtus anatolicus	NFa = 58 or 60
Microtus obscurus	heteromorphic autosomal pair (A or ST)
Mesocricetus brandti	2n = 42 or 44, NFa = 76, 78 or 80
Meriones tristrami	NFa = 72-82
Apodemus flavicollis	B chromosomes
Apodemus agrarius	NFa = 54 or 56
Rattus rattus	B chromosomes, NFa = 58-62
Nannospalax xanthodon	multiple rearrangements, 2n = 36-60, NFa = 62-80
Nannospalax ehrenbergi	multiple rearrangements, 2n = 48-58, NFa = 62-82
Nannospalax leucodon	NFa = 72 or 74

Myotis capaccinii, *Nyctalus leisleri*, *Pipistrellus kuhlii*, *Spermophilus xanthoprymnus*, *Microtus levis*, *Chionomys nivalis*, *Ch. roberti*, *Cricetulus migratorius*, *Calomyscus bailwardi*, *Rattus rattus*, *R. norvegicus*, *Mus musculus*, *M. macedonicus*).

A karyotype different from the results of studies made in other regions was reported in Turkish populations of 17 species (*Hemiechinus auritus*, *Sorex araneus*, *Talpa caucasica*, *Taphozous nudiventris*, *Rhinolophus hipposideros*, *Myotis aurascens*, *Martes foina*, *Vormela peregusna*, *Arvicola terrestris*, *Microtus irani*, *Microtus obscurus*, *Cricetulus migratorius*, *Meriones vinogradovi*, *M. crassus*, *Nannospalax* spp.). Intraspecific chromosomal variation (polymorphism or polytypy) was recorded in 22 species (Table 1). This variation should be further studied in details, and it is desirable to investigate the chromosomal relationships between and within species with the use of banding techniques and fluorescence *in situ* hybridization approach. There are various challenges to the taxonomy and evolution of Turkish mammals that could be approached using cytogenetic techniques. In individual species or other taxa following topics can be highlighted.

Additional data on possible karyotypic variation of the common shrew (*Sorex araneus*) in European Turkey will be useful. The karyotype of the Caucasian shrew (*S. satunini*) is insufficiently known in Turkey and isolated populations in northern Anatolia (e.g. Mt. Ulu Dag) are of particular interest.

The karyotypes of the bicoloured white-toothed shrews (*Crocidura leucodon*) examined in Europe and the Caucasus differed in the arm composition of several bi-armed autosomes. It is quite topical to know the G-banded karyotype of Turkish populations and to assess the combinations of autosomal arms. Island populations may be of particular interest. The karyotype of the endemic jackass shrew (*Crocidura arispa*) remains unknown. Its description is highly desirable and may significantly contribute to the knowledge of the systematic status of the species.

The lesser horseshoe bat, *Rhinolophus hipposideros*, is obviously a chromosomally polytypic species including several distinct karyotype races. Data from Turkey are rather inconsistent, with reports of unexpected and unique complements. The mapping of the actual situation in Turkey is highly desirable.

The occurrence of the karyotype with 42 chromosomes in the common pipistrelle (*Pipistrellus pipistrellus*) in Turkey should be confirmed and the distribution of this form mapped, also in respect of the sibling species, the soprano bat (*P. pygmaeus*). Similarly, further data are desirable to reveal geographic distribution of the karyotype with 42 chromosomes recorded in *Myotis aurascens*.

There are relatively few cytogenetic data for large carnivores occurring in Turkey. Their knowledge could improve understanding of the taxonomic status in some species (e.g. *Vulpes vulpes*, *Mustela putorius*, *Hyaena hyaena*). Studies of the C-banded karyotype with the assessment of the number of large C-heterochromatic arms are desirable in Anatolian populations of the weasel (*Mustela nivalis*).

Large ungulates have been studied only exceptionally in Turkey and karyological data may contribute to better knowledge of some species (e.g. in *Gazella gazella* in respect of the recent molecular findings in the genus *Gazella* in Turkey – Kankılıç et al. 2012).

The knowledge of the karyotype of the Setzer's mouse-tailed domouse (*Myomimus setzeri*) may considerably contribute to the taxonomic assessment of the status of this species.

The ranges of the common pine vole (*Microtus subterraneus*) and the Major's pine vole (*M. majori*) could be precised in more details using chromosomal identification. It would be interesting if a hybrid zone between these species can be found. Certain isolated populations of pine voles in south-western Anatolia (e.g. Çığlıkara) are of particular interest. A possible occurrence of Robertsonian populations with lowered diploid chromosome numbers in the Caucasus pine vole (*Microtus daghestanicus*) in eastern Anatolia presents another attractive problem.

The systematic status of the Iranian vole (*Microtus irani*) has not yet been definitively resolved and cytogenetic investigations may be useful in such research along with molecular studies. The distribution ranges of the Altai vole (*Microtus obscurus*) and the East European vole (*M. levis*) may be precised based on cytogenetic identification.

Some contradictory reports on the karyotypes of the golden and Brandt's hamsters were published from Turkey and this problem deserves further research. Any chromosomal data concerning the mouse-like hamsters of the genus *Calomyscus* from Turkey will be very interesting as well as data for Turkish populations of the birch mice (*Sicista caucasica*).

A comparative banding study of individual species of the genus *Apodemus* occurring in Turkey could reveal new information about their relationships. Detailed population survey based on large samples of specimens could confirm or reject the absence of Robertsonian and other variation in the karyotype of the house mouse (*Mus domesticus*) in Turkey.

The mole rats of the genus *Nannospalax* represent obviously the highlight of chromosomal studies on Turkish mammals and much work could be done in this respect. Chromosomal research should involve advanced cytogenetic techniques and combination of the results with various molecular studies is desirable (see Graphodatsky et al. 2011).

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