

KARYOTYPES OF *NANNOSPALAX* (PALMER 1903) POPULATIONS (RODENTIA: SPALACIDAE) FROM CENTRAL-EASTERN ANATOLIA, TURKEY

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RIASSUNTO - *Cariotipi di Nannospalax (Palmer 1903) (Rodentia, Spalacidae) dell'Anatolia centro-orientale, Turchia.* Sono stati analizzati i cariotipi di 20 (11 maschi e 9 femmine) *Nannospalax* catturati, nel periodo 2006-2009, in 11 località dell'Anatolia centro-orientale (Turchia). Sono state individuate sei diverse forme cromosomiche ($2n=49$; $2n=50$; $2n=52$; $2n=54$; $2n=60a$ e $2n=60b$), corrispondenti a *N. nehringi* ($N = 3$), *N. ehrenbergi*, *N. munzuri* e *N. tuncelicus*. Nella provincia di Malatya è stata confermata la presenza di due popolazioni ($2n=60a$ e $2n=60b$), separate dal fiume Thoma. La forma $2n = 49$, rinvenuta presso Pülümür, potrebbe essere un nuovo taxon.

Key words: *Spalax*, *Nannospalax*, autosomi, forme cromosomiche, Turchia

The subterranean mole rats (Family: Spalacidae) are exceptionally variable animals with respect to the morphology and karyology of their chromosomes. The genus *Nannospalax* underwent a rapid chromosomal evolutionary radiation that resulted in the 59 chromosomal form, widespread throughout the Palaearctic region (Musser and Carleton, 2005). In Turkey two species (*Spalax leucodon* and *S. ehrenbergi*) of mole rats have been defined in morphological terms (Mursaloğlu 1979; Kıvanç 1988 and Nevo *et al.*, 1995). Nonetheless, contrary to Musser and Carleton (2005), we agree with Gromov and Baranova (1981) in attributing all Turkish

spalacids to the genus *Nannospalax*, the species of the genus *Spalax* having no acrocentric chromosomes in their karyotypes (Lyapunova *et al.*, 1974; Zima and Kral, 1984). Two other species, *Nannospalax munzuri* from Tunceli - Ovacık and *N. tuncelicus* from Tunceli - Bingöl - Elazığ province, have been described by Coşkun (1996, 2004).

Karyological studies on Turkish mole rats were initiated by Soldatovic and Savic (1978). Currently, about 150 populations of mole rats have been karyotyped.

Since 1984, investigations on *Nannospalax* populations (Coşkun *et al.*, 2006 and references therein) showed that in Turkey there

are different allopatric chromosomal forms (without hybrid zones) of this genus (Nevo *et al.*, 1994, 1995; Tez *et al.*, 2001; Coşkun, 2003). Yüksel (1984) recorded $2n = 52$ for specimens from Elazığ, while $2n = 60$ was reported for Malatya province (Yüksel, 1984; Ivanitskaya *et al.*, 1997 and Nevo *et al.*, 1995). In the same province, Gülkaç and Yüksel (1989) found that the chromosome morphology of the specimens from Arguvan was different from that showed by individuals from other localities. Finally, $2n = 58$ *Nannospalax munzuri* and $2n = 54$ *N. tuncelicus* were reported by Coşkun (2004).

This study aimed to describe the *Nannospalax* karyotypes from the Central East Anatolian region, for which there still was lack of sound information.

Between 2006 and 2009, twenty mole rats were trapped in their burrows in 11 different locations of Central East Anatolia, a region characterized by high mountains (up to 3200 m a.s.l.) and large undulating plateaus between 900 and 2100 m a.s.l.. Chromosomes were extracted from bone marrow cell suspensions stained with a 4% Giemsa solution, by a standard air drying method modified from Lee and Elder (1980). Karyotypes were arranged in pairs according to their size and centromere position from the best metaphase spreads. The fundamental number of chromosome arms (NF) and autosomal number of chromosome arms (NFa) were computed by counting bi-armed autosomes as two arms and acrocentric autosomes as one arm. The morphology of the chromosomes was identified according to Levan *et al.* (1964).

Voucher specimens were deposited at the Department of Biology, Science and Art Faculty, University of Dicle.

Materials: (1) Sivas - Divriği - Hıdırlık village (39°23'N 37°54'E) 1♂♂; (2) Erzincan - Kemaliye - Dutluca village (39°08'N 38°36'E) 1♀♀; (3) Erzincan - Kemaliye - Çitköy village (39°06'N 38°34'E) 1♀♀; (4) Elazığ - Keban - Denizli village (38°50'N 38°50'E) 2♀♀, 1♂♂; (5) Malatya - Akçadağ - Kürecik Road (38°20'N 37°45'E) 1♂♂; (6) Malatya - Doğanşehir - Örnek village (38°06'N 37°53'E) 2♂♂; (7) Malatya - Kale - İzol (38°24'N 38°45'E) 2♂♂, 1♀♀; (8) Elazığ - Keban - Çirkan village (38°46'N 38°46'E); 1♀♀, 1♂♂; (9) Erzincan - Kemaliye - Esentepe village (39°16'N 38°29'E) 1♂♂; (10) Tunceli - Hozat - Akmezra village (39°05'N 39°13'E) 1♀♀, 1♂♂; (11) Tunceli - Pülümür - Kangallı village (39°27'N 39°51'E) 2♀♀, 1♂♂. On the whole six different chromosomal populations from the Central East Anatolian region were identified (Fig. 1) and their diagnostic features described (Tab. 1). Three belonged to *N. nehringi*, one to *N. ehrenbergi*, one to *N. munzuri* and one to *N. tuncelicus*. The presence of two chromosomal forms previously described in Malatya province, $2n = 60a$ (Gülkaç and Yüksel, 1989; Ulutürk *et al.*, 2009) and $2n = 60b$ (Yüksel, 1984) was confirmed. These two forms seem to be separated by the River Tohma.

The karyotypes of six specimens from four localities (1-4) belonged to the first form ($2n = 60a$) and showed NF = 82 and NFa = 78. Their karyotypes consisted of 10 pairs of meta- and submetacentric autosomes and

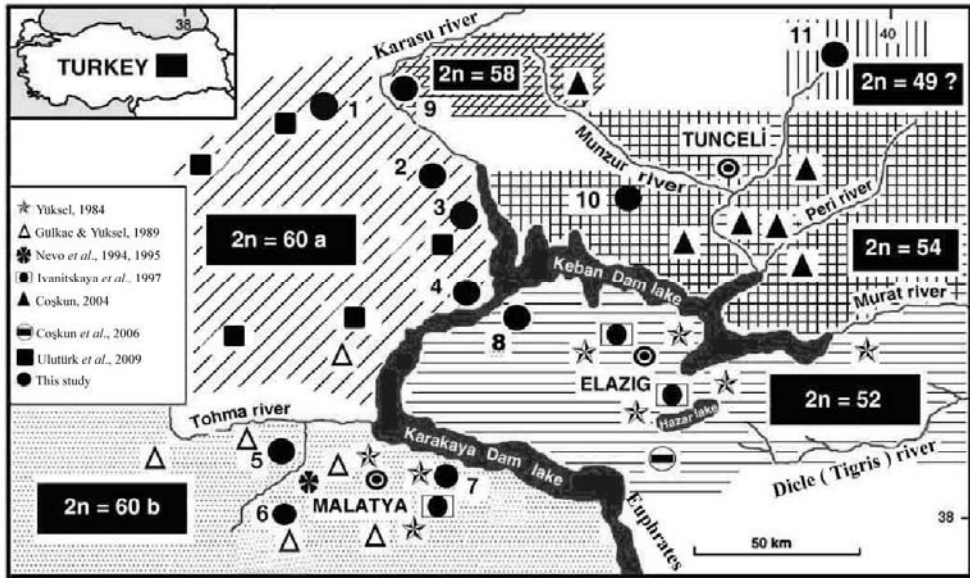


Figure 1 - Sampling localities and geographical distribution of chromosomal forms in the region. (1) Sivas - Divriği - Hıdırlık village, (2) Erzincan - Kemaliye - Dutluca village, (3) Erzincan - Kemaliye - Çitköy village, (4) Elazığ - Keban - Denizli village, (5) Malatya - Akçadağ - Kürecik Road, (6) Malatya - Doğanşehir - Örnek village, (7) Malatya - Kale - İzol, (8) Elazığ - Keban - Çirkan village, (9) Erzincan - Kemaliye - Esentepe village, (10) Tunceli - Hozat - Akmezra village, (11) Tunceli - Pülümür - Kangallı village.

19 pairs of acrocentric ones. The X chromosomes were large and submetacentric (Fig. 2A), whereas the Y chromosome was very small and acrocentric.

The karyotypes of six specimens from three localities (5-7) had $2n = 60b$, $NF = 78$ and $NFa = 74$. Their karyotypes consisted of 8 pairs of meta- and submetacentric autosomes and 21 pairs of acrocentric ones. The X chromosomes were small and submetacentric, whereas the Y chromosome was very small and acrocentric

(Fig. 2B).

Our results agreed with those of Nevo *et al.* (1995) and Ivanitskaya *et al.* (1997), whilst differed from the karyotypes ($2n = 60$, $NF = 80$ and $NFa = 76$) described by Yüksel (1984) and Gülkaç and Yüksel (1989).

Two specimens from Çirkan village (Elazığ-Keban province, locality 8) belonged to *N. ehrenbergi*, showing $2n = 52$, $NF = 76$ and $NFa = 72$ (Fig. 2C). The autosomal complement consisted of 11 meta- and submetacentric and 14 acrocentric pairs.

Table 1 - Chromosomal records of *Nannospalax* from the Central-Eastern Anatolia Region, Turkey (sm: submetacentric, st: subtelocentric, a: acrocentric, m: metacentric, 2n: diploid chromosome number, NF: chromosome arm number, NFa: fundamental (autosomal) number (♀♀)).

Population	Locality		2n	Autosome		NFa	NF	Gonosomes		References
				m/sm/st	a			X	Y	
2n=60a	Malatya	Arguvan	60	10	19	78	82	sm	st	Gülkaç & Yüksel, 1989
		Hekimhan							a	This study
		Arguvan								
		Arapgir								
	Elazığ	Keban-Denizli							a	This study
	Erzincan	Kemaliye								
										Dutluca
	Sivas	Divriği-Karasar							a	This study
		Kangal-Davutoğlu								
		Divriği-Hıdırlık								
2n=60b	Malatya	Yazıhan	60	9	20	76	80	sm	st	Yüksel, 1984
		Akçadağ	60	8	21	74	78	sm	a	Gülkaç & Yüksel, 1989
		30 km W of Malatya								Nevo <i>et al.</i> , 1995
		12 km E of Malatya	a	This study						
		Doğanşehir-Örnek								
		Kale-İzol								
		Akçadağ-Kürecik								
2n=52	Elazığ	Baskil	52	11	14	72	76	sm	st	Yüksel, 1984
		Sivrice							a	This study
		Gözeli								
		Keban-Çirkın								
2n=58	Tunceli	Ovacık	58	4	24	64	68	sm	a	Coşkun, 2004
	Erzincan	Kemaliye-Esentepe								This study
2n=54	Elazığ	Kovancılar	54	9	17	70	74	sm	a	Coşkun, 2004
		Palu								
	Tunceli	Kocakoç								
		Pertek								
		Nişantaşı								
Hozat-Akmezra	This study									
2n=49	Tunceli	Pülümür-Kangallı	49	12+1	11	72	76	sm	a	This study

Karyotypes of Nannospalax in Turkey

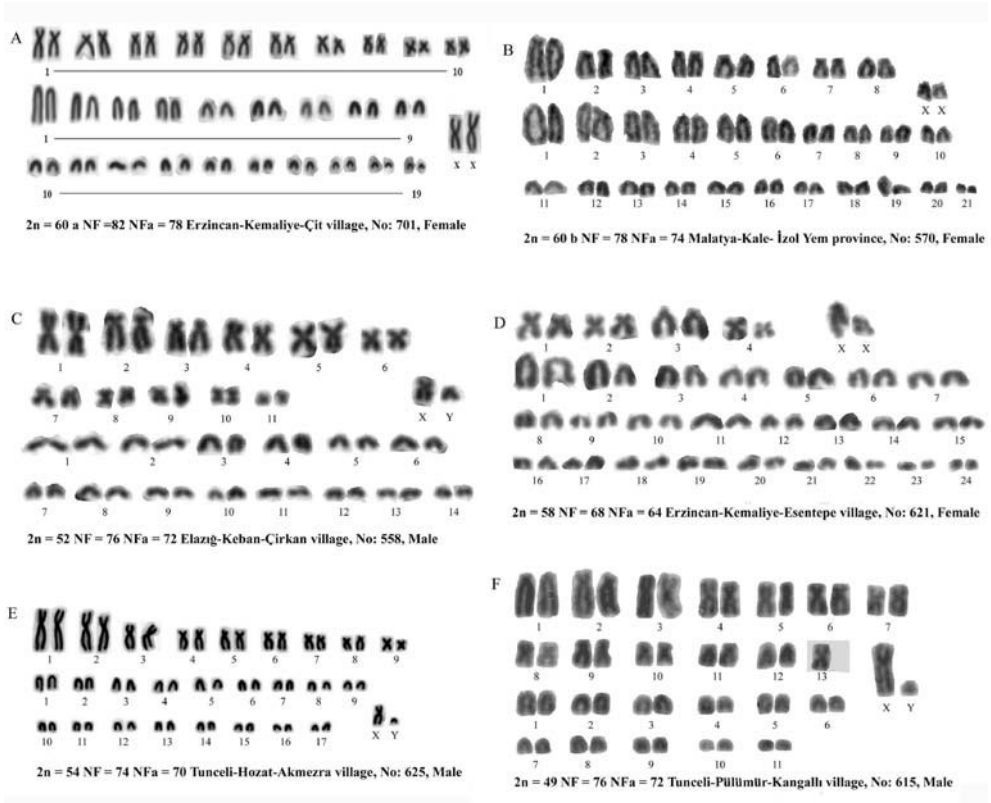


Figure 2 - Karyotypes of *Nannospalax* populations from central-eastern Anatolia. (A) $2n = 60a$, (B) $2n = 60b$, (C) $2n = 52$, (D) $2n = 58$, (E) $2n = 54$, (F) $2n = 49$.

The submetacentric X chromosomes and the acrocentric Y chromosome were both small-sized. The karyotypes resulted identical to those described by Yüksel (1984) and Coşkun *et al.* (2006) from Elazığ, Ivanitskaya *et al.* (1997) from Elazığ and Şanlıurfa, Gülkaç and Yüksel (1989) from Adıyaman and Hilvan, Nevo *et al.* (1995) from Diyarbakır, Coşkun (1998) from Şırnak, suggesting that the $2n = 52$ form of

N. ehrenbergi is widespread in Southeastern Anatolia.

N. munzuri ($2n = 58$, NF = 68, NFA = 64) was found on the eastern bank of the River Karasu, Esentepe village (Erzincan-Kemaliye province, locality 9). Till now this species had been described only from Tunceli – Ovacık (Coşkun, 2004). The river probably acts as a geographic barrier between $2n = 60a$ and $2n = 58$ chromoso-

mal forms (Fig. 1). The autosomal complement consisted of 4 meta- and submetacentric and 24 acrocentric pairs. The X chromosomes were small sized and metacentric, while the small Y chromosome was acrocentric (Fig. 2D).

The karyotypes of two specimens from Akmezra village (Tunceli-Hozat province, locality 10) belonged to *N. tuncelicus*, showing $2n = 54$, $NF = 74$ and $NFa = 70$. Their karyotypes consisted of 9 pairs of meta- submetacentric and 17 pairs of acrocentric autosomes (Fig. 2E). The X chromosomes were large and submetacentric, whereas the small Y chromosome was acrocentric.

The NF and NFa values of this population were different from those described by Nevo *et al.* (1995) from Bolu, whilst agreed with those reported by Coşkun (2004) from Bingöl, Elazığ and Tunceli and, except for the morphology of the Y chromosome, those recorded by Yüksel and Gülkaç (2001) from Kızılırmak Basin.

The karyotypes of three specimens from Kangallı village, 20 km south of Pülümür (Tunceli-Pülümür province, locality 11), showed $2n = 49$, $NF = 76$ and $NFa = 72$. Their karyotypes consisted of 12 pairs and 1 univalent meta- submetacentric autosomes and 11 pairs of acrocentric ones. The X chromosomes were large and submetacentric, whereas the Y chromosome was small and acrocentric (Fig. 2F). Considering that, to our knowledge, there is no contact between the current ranges of the two forms $2n = 50$ and $2n = 48$, the karyotype could represent a cytogenetically distinct taxon, characterised by a high percentage

of banded chromosomes. The results of this study expanded the range of the $2n = 52$ chromosomal form of *N. ehrenbergi* to the Keban Dam Lake and possibly extended the list of karyotypes of *Nannospalax* with one new form from Central East Anatolia, although further evidence needs to be collected. Nevo *et al.* (1988, 1995) pointed out that each chromosomal form could be assigned to a separate biological species, inhabiting a specific ecogeographical region. According to this hypothesis, there presumably are about 30 such species in Turkey. Our results suggest that adaptive differentiation and speciation are still in progress.

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