Mammalian Biology
Zeitschrift für Säugetierkunde
www.elsevier.de/mambio

Short communication

Chromosomal diversity in mole-rats of the species *Nannospalax ehrenbergi* (Rodentia: Spalacidae) from South Anatolia, Turkey

By Y. Coşkun, S. Ulutürk and G. Yürümez

Biology Department, Dicle University, Diyarbakır, Turkey

Receipt of Ms. 25.8.2005
Acceptance of Ms. 2.2.2006

Key words: *Nannospalax*, karyotype, chromosomal diversity, Turkey

The represents of the family Spalacidae are subterranean rodents that at present exclusively are distributed in the Palaearctic region. The distribution area of the family includes northeastern Africa, the Balkans, southeastern Europe, Central Asia, Middle East and Caucasia (Topachevskii 1969; Savic and Nevo 1990; Musser and Carleton 1993). Mole rats of the family Spalacidae range over Turkey (Asia Minor) and Turkish Thracia in two taxa; the ancestral *Spalax leucodon* (over most of Turkey) and the more descendant *Spalax ehrenbergi* in southeastern Turkey (Nevo et al. 1995). The mole rats of the genus *Nannospalax* (formerly *Spalax*) have been widely studied during recent years to clarify species boundaries and phylogenetic relationships. The wide chromosomal variability of the genus has been highlighted in several studies, with each accepted species characterized by its individual karyotypes and others being revealed as cryptic species (Nevo et al. 1994a). Therefore, taxonomic treatment of the genus remains a challenge, which is further complicated by high genetic variation in some taxa (Nevo et al. 1988).

The species, *Nannospalax ehrenbergi* originally described by Nehring (1898), on specimens collected from Yafa-Israel also occurs in Libya, Syria, Jordan, Lebanon, Israel, Egypt, Iraq, and Southeast Anatolia of Turkey (Lay and Nadler 1972; Musser and Carleton 1993). Nehring (1898) also described a new species, as *S. intermedius* in this region from İskenderun-Arsuz-Çengenköy, but no consensus is yet in sight on this species. Hitherto, classical morpho-taxonomic traits have not sufficed to diagnose the different species (Savic and Nevo 1990). Wahrman et al. (1969a, b) carried out the first studies on the karyological peculiarities of *N. ehrenbergi*. In these studies four different chromosomal forms were recorded in Israel with a diploid number of chromosomes of $2n = 52$, 54, 58 and 60. Also, Lay and Nadler (1972) confirmed the diploid number of chromosomes of Egyptian specimens of this species as $2n = 60$.

The first karyological analyses of Turkish *N. ehrenbergi* populations were made by Yüksel (1984) from the Elazığ population. Karyotype studies of *N. ehrenbergi* from across their distribution revealed obvious chromosome polymorphisms and several different karyotypes from this region have already been described (Yüksel and Gülkaç 1992; Nevo et al. 1994b, 1995; Ivanitskaya et al. 1997; Coşkun 2004a, b).

Thus, *N. ehrenbergi* has a great chromosomal polymorphism according to the diploid number

doi:10.1016/j.mambio.2006.02.005

of chromosomes and the number of chromosome arms.

The aim of this study therefore is to investigate the karyotypes of the five populations of *N. ehrenbergi* from 54 localities of southeast Anatolia, an area of the distribution range yet poorly studied.

A total of 150 (59 male, 75 female, 16 unknown) mole-rats were captured at 54 localities in the south and southeast of Anatolia (Fig. 1), during 12 expeditions between 2000 and 2004. The sampling area is characterized by substantial habitat and climatic diversity. Trapping mole rats involves the opening of a burrow system and catching an animal with a hoe when it comes to plug the opening. Voucher specimens are deposited at the Department of Biology, University of Dicle (Fig. 1).

Material investigated: Numbers are localities as indicated in figure 1 and numbers in paranthesis indicate sample sizes. Diyarbakır population: 1. Şırnak-Silopi-Çukurca village (3), 2. Şırnak-İdil- 10 km east (4), 3. Siirt-Pervari-Ormandağı village (5), 4. Siirt-Eruh 10 km west (4), 12. Batman -Gercüş-Akyar (1), 13. Mardin-Midyat 2 km east (2), 14. Mardin-Ömerli 4 km east (1) 15. Mardin-Ömerli-Alıçlı village (3), 16. Mardin-Nusaybin-Söğütlü village (3), 17. Mardin -Merkez 7 km west (7), 18. Mardin-Kızıltepe-İstasyon (1), 19. Mardin-Mazıdağı-Evciler village (7), 20. Diyarbakır-Bismil-Çöltepe (3), 21. Diyarbakır-Bismil-Yeniköy (2), 22. Diyarbakır-Silvan 20 km west (2), 23. Diyarbakır-Kulp (2), 24. Diyarbakır-Çermik (2), 25. Elazığ-Gözeli village (3), 26. Adıyaman-Kahta-Ballıköy (2), 27. Adıyaman-Şambayat 1 km west (3), 28- Adıyaman-Gölbaşı 2 km north (8), 29. Adıyaman-Gölbaşı-Çağlayancerit road junc. (3), 30. Şanlıurfa- Ceylanpınar- 15. km north (2), 31. Şanlıurfa- Viranşehir-Kocanezim village (3), 32. Şanlıurfa 40 km east- Düzenli village (1), 33. Şanlıurfa - Harran - Balgat village (1), 34. Şanlıurfa-Siverek-Küçükgöl village (1), 35. Şanlıurfa-Suruç-Payamlı (1), 36. Şanlıurfa- Suruç- Sasi village (4), 37. Şanlıurfa-Suruç- Mürşitpınar village (3), 38. Şanlıurfa- Bozova- Ördek village (4), 39. Şanlıurfa- Birecik-Kocaali village (2), 44. Kahramanmaraş-Pazarcık-Seyrantepe village (3).

Siirt population: 5. Siirt-Kurtalan-Bağlıca-Yeniköprü (1), 6. Siirt-Kurtalan-Baykan road junc. (2), 7. Siirt-Kurtalan-Yolbulan village (2), 8. Siirt-Kurtalan 15 km west (2), 9. Batman-Kozluk-Yeniçağlar village (2), 10. Batman-Beşiri-Yolkonak village (4), 11. Batman-Hasankeyf- Suçeken village (5). Hatay population: 40. Gaziantep-Karkamış-Karanfil village (2), 41. Gaziantep-Türkyurdu village (2), 42. Gaziantep-Nurdağı-Kömürler (3), 43. Gaziantep-Islahiye-Boğaziçi village (1), 45. Osmaniye-Bahçe 4 km west (2), 46. Osmaniye-Çona village (4), 48. Hatay-Arsuz-Çengenköy (5), (Type locality of *S. intermedius*).

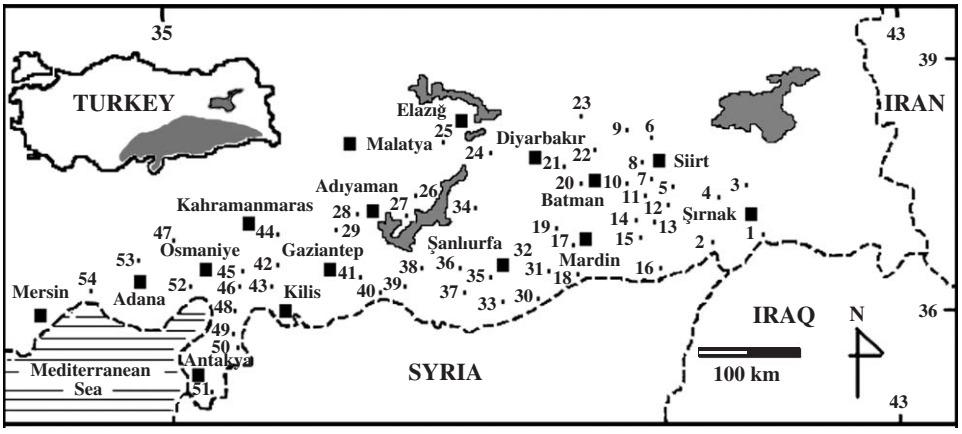

Fig. 1. Sampling localities of *Nannospalax ehrenbergi*. Locality numbers as in text.

49. Hatay-Kırıkhan-Muratpaşa village (1), 50. Hatay-Reyhanlı-Beşarslan village (1).
Tarsus population: 47. Osmaniye-Kadirli-Anberinarkı village (2), 52. Adana-Ceyhan-Yakapınar 3 km west (3), 53. Adana-Kozan-Pekmezci village (3), 54. Mersin-Tarsus-İbrişim village (5).
Yayladağı population: 51. Hatay-Yayladağı-Şenköy (2).
Karyotyping was performed in the laboratory. Mitotic chromosomes were obtained from bone marrow of long bones and preparations were made by means of the general air-drying technique (Lee and Elder 1980). Slides were conventionally stained with 4% Giemsa-solution. Well-spread metaphases were recorded using a camera attached to a microscope. Karyotypes were prepared from the best metaphases. Chromosomes were paired, using the position of the centromere and chromosome size. The diploid number ($2n$), the fundamental number (NF) and where possible the autosomal fundamental number (NFa) were scored in at least five metaphases per specimen. To allow comparison between the different karyotypes, the NF and NFa listed refer to the female karyotype.
According to the karyotype analyses, five different *N. ehrenbergi* populations were described from the south and southeast Anatolia. Diagnostic features for the different karyotypes are described below and summarized in table 1. This table gives a comparative survey of all populations of *N. ehrenbergi* (Nehring, 1898) from Turkey analysed to date. The approximate geographical distribution areas of each chromosomal form are shown in figure 3.
Diyarbakır population: The karyotypes of 96 specimens from all sites of this population studied comprised $2n = 52$ chromosomes. The autosomal complement consisted of 11 meta/submetacentric and 14 acrocentric pairs. The X chromosome was small sized metacentric, the Y chromosome was small acrocentric. The number of chromosomal arms is NF = 76 and number of autosomes NFa = 72 (Fig. 2A).
The karyotypes observed are identical with those described by Yüksel (1984) from Elazığ, Ivanitskaya et al. (1997) from Elazığ and Şanlıurfa, Yüksel and Gülkaç (1994) from Adıyaman and Hilvan, Nevo et al. (1995) from Diyarbakır, Coşkun (1998) from Şırnak (Tab. 1).
Yüksel and Gülkaç (1992) additionally reported $2n = 54$ chromosomal forms from Şanlıurfa-Suruç. But we could not find or observe $2n = 54$ chromosomal specimens from this area.
The most common chromosomal form is $2n = 52$, NF = 76, NFa = 72, which is known from Southeast Anatolia. This population occupies a wide range of the region (Fig. 3).
Siirt population: In all the samples of this population the diploid number of chromosomes is $2n = 56$, NF = 66 and NFa = 62. Their karyotypes consist of 4 pairs of metacentric/submetacentric and 23 pairs of acrocentric autosomes. The X chromosomes are medium sized and submetacentric; the Y chromosomes are small and acrocentrics (Fig. 2B).
The karyotype of this population was first defined by Coşkun (2004b) and the karyotypes observed here are identical with those. The geographical distribution of this chromosomal form is shown in figure 3.
Hatay population: Specimens were collected from the type locality of *S. intermedius* Nehring, 1898. The karyotypes of 21 specimens from Hatay populations have $2n = 52$, NF = 74, and NFa = 70. Their karyotype consist of 10 pairs meta/submetacentrics, and 15 pairs of acrocentric autosomes. The X chromosomes are large sized and submetacentric; Y chromosomes are small and acrocentric (Fig. 2C). According to the karyotype, *S. intermedius* occurs in the Hatay Province and should be considered a separate species. The geographical distribution of this chromosomal form is shown in figure 3. The karyotype observed is identical with those described by Coşkun (1999, 2004a).
Tarsus population: These specimens are asigned by a $2n = 56$, NF = 72 and NFa = 68. Their karyotype consist of 7 pairs meta/submetacentrics, and 22 pairs of acrocentric autosomes. The X chromosome is a medium-sized meta/submetacentric, while the Y is small and acrocentric (Fig. 2D). However, two specimens from Adana-Kozan Pekmezci village have five pairs of meta/submetacentric autosomes (NF = 68, NFa = 64).

Table 1. Chromosomal data for the species *Nannospalax ehrenbergi* from Turkey. 2*n*: diploid number; m/sm: number of pairs of metacentric and submetacentric chromosomes; a/st: number of pairs of acrocentric and subtelocentric chromosomes; X: X chromosome, Y: Y chromosome, NF(a): (autosomal) fundamental number (female)

		Autosomes		Sex chromosomes				References
Locality	2*n*	m/sm/st	a	X	Y	NFa	NF	
Elazığ	52	11	14	Sm	Sm	72	76	Yüksel (1984), Ivanitskaya et al. (1997)
Hilvan	52	3+2+6	14	M	St	72	76	Yüksel and Gülkaç (1992)
Suruç	54	3+3+4	16	M	St	76	72	Yüksel and Gülkaç (1992)
Şanlıurfa	52W	14	11	Sm	A	74	78	Nevo et al. (1995)
	52	13	12	Sm	A	76	80	Ivanitskaya et al. (1997)
Adıyaman	52	11	14	M	Sm	72	76	Yüksel and Gülkaç (1992)
Gaziantep	56	14	13	M	Sm	86	90	Yüksel and Gülkaç (1992)
	58	17	11	Sm	Sm	86	90	Nevo et al. (1995)
	56	12	15	Sm	A	78	82	Ivanitskaya et al. (1997)
Şırnak	52	11	14	Sm	A	72	76	Coşkun (1998)
Kilis	52	10	15	Sm	A	70	74	Coşkun (1999)
Tarsus	56	7	20	Sm	A	68	72	Nevo et al. (1995), Sözen (1999), Ivanitskaya et al. (1997)
Birecik, Siverek Diyarbakır	52	11	14	Sm	Sm	72	76	Ivanitskaya et al. (1997), Nevo et al. (1995)
Hatay	52	10	15	Sm	A	70	74	Coşkun (2004a)
Siirt	56	4	23	Sm	A	62	66	Coşkun (2004b)
Yayladağı	48	12	11	M	—	70	74	Coşkun (2004a)

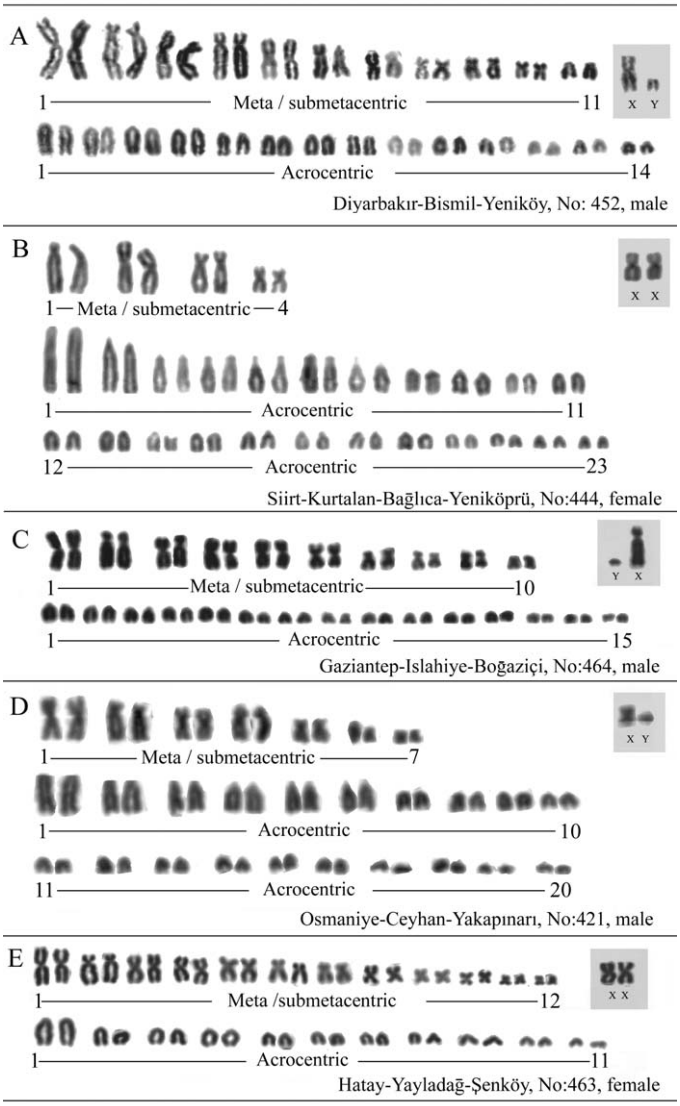

Fig. 2. Standard karyotypes of *Nannospalax ehrenbergi* (A) Diyarbakır population (male), with $2n = 52$; (B) Siirt population (female), with $2n = 56$ from Coşkun (2004b); (C) Hatay population (male), with $2n = 52$ from Coşkun (2004a); (D) Tarsus population (male), with $2n = 56$; (E) Yayladağı population (female), with $2n = 48$ from Coşkun (2004a).

The karyotype of mole rats from Tarsus does not differ from those that earlier described (Nevo et al. 1995; Ivanitskaya et al. 1997; Sözen 1999). The geographical distribution of this chromosomal form is shown in figure 3.

Yayladağı population: The karyotypes of two specimens from the Yayladağı population are $2n = 48$, NF = 74, and NFa = 70. It consists of 12 pairs of meta/submetacentrics, and 11 pairs of acrocentric autosomes. The X

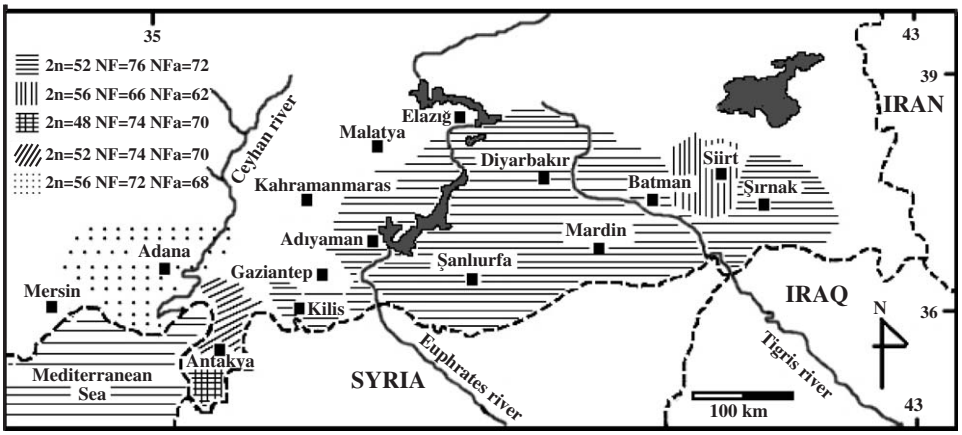

Fig. 3. Geographical distribution of *Nannospalax ehrenbergi* karyotypes.

chromosomes are large sized (Fig. 2E) (Coşkun 2004a). The karyotype of this population represents a cytogenetically distinct taxon, with a high percentage of metacentric chromosomes. The geographical distribution of this chromosomal form is shown in figure 3.

The present study extends the list of karyotypes of *N. ehrenbergi* with five karyotypes in the wide distribution area from south and southeast Anatolia. The data show that the Diyarbakır population has a broad distribution on both banks of the Euphrate (Fırat) and Tigris (Dicle) rivers.

Nevo et al. (1995) have pointed out that each chromosomal form must be assigned to a separate biological species and that there presumably are about 20 such species in Turkey. While the chromosomal diversity in Turkish *N. ehrenbergi* is rather great, it is difficult at the moment to decide whether or not a particular karyotype represents a separate species.

Acknowledgement

This study was supported by the Scientific and Technical Research Council of Turkey (TÜBİTAK-Project No. TBAG-2097).

References

Coşkun, Y. (1998): Morphological and karyological characteristics of the species, *Spalax ehrenbergi*, Nehring 1897 (Rodentia: Spalacidae) from Şırnak province. XIV. National Biological Congress. Vol. 3. Pp. 114–122 (in Turkish).

Coşkun, Y. (1999): New karyotype of the mole rat *Nannospalax ehrenbergi* from Turkey. Folia Zool **48,** 313–314.

Coşkun, Y. (2004a): Morphological and karyological characteristics of *Nannospalax ehrenbergi* (Nehring, 1898) (Rodentia: Spalacidae) from Hatay Province, Turkey. Turk. J. Zool **28,** 205–212.

Coşkun, Y. (2004b): A new chromosomal form of *Nannospalax ehrenbergi* from Turkey. Folia Zool **53,** 351–356.

Ivanitskaya, E.; Coşkun, Y.; Nevo, E. (1997): Banded karyotypes of mole rats (*Spalax*, Spalacidae, Rodentia) from Turkey: a comparative analysis. J. Zool. Syst. Evol. Res **35,** 171–177.

Lay, D. M.; Nadler, C. F. (1972): Cytogenetics and origin of North African *Spalax* (Rodentia: Spalacidae). Cytogenetics **11,** 279–285.

Lee, M. R.; Elder, F. F. (1980): Yeast stimulation of bone marrow mitosis for cytogenetic investigations. Cytogenet. Cell Genet. **26,** 36–40.

Musser, G. G.; Carleton, M. D. (1993): Mammal Species of the World: A taxonomic and geographic reference. Washington: Smithsonian Institute Press.

Nehring, A. (1898): Über mehrere neue *Spalax*-Arten. Sitzungsber Ges Naturforsch., Freunde Berlin **10,** 163–183.

Nevo, E.; Corti, M.; Heth, G.; Beiles, A.; Simson, S. (1988): Chromosomal polymorphisms in subterranean mole rats: origins and evolutionary significance. Biol. J. Linn. Soc **33,** 309–322.

Nevo, E.; Filippucci, M. G.; Beiles, A. (1994a): Genetic polymorphisms in subterranean mammals (*Spalax ehrenbergi* superspecies) in the Near East revisited: patterns and theory. Heredity **72,** 465–487.

Nevo, E.; Filippucci, M.; Redi, C.; Korol, A.; Beiles, A. (1994b): Chromosomal speciation and adaptive radiation of mole rats in Asia Minor correlated with increased ecological stress. Proc. Natl. Acad. Sci. USA **91,** 8160–8164.

Nevo, E.; Filippucci, M. G.; Redi, C.; Simson, S.; Heth, G.; Beiles, A. (1995): Karyotype and genetic evolution in speciation of subterranean mole rats of the genus *Spalax* in Turkey. Biol. J. Linn. Soc **54,** 203–229.

Savic, I.; Nevo, E. (1990): The Spalacidae: Evolutionary history, speciation and population biology. In: Evolution of Subterranean Mammals at the Organismal and Molecular Levels, Ed. by O. Reig. New York: Alan R. Liss, Inc., Pp. 129–153.

Sözen, M. (1999): Ulukışla (Niğde)-Tarsus (Mersin)-Adana Bölgesi *Spalax* Güldenstaedt, 1770 (Mammalia-Rodentia) Populasyonlarının Karyolojik ve Morfolojik Analizi. Diss. thesis. Ankara University Fen Bilimleri Enstitüsü.

Topachevskii, V.A. (1969): Fauna of the USSR: Mammals Mole-Rats, Spalacidae. Vol. 3. Leningrad: Nauka Publisher. Pp. 308.

Wahrman, J.; Goitein, R.; Nevo, E. (1969a): Geographic variation of chromosome forms in *Spalax*, a subterranean mammal of restricted mobility. Comp. Mamm. Cytogenet. 30–48.

Wahrman, J.; Goitein, R.; Nevo, E. (1969a): Mole rat *Spalax*: evolutionary significance of chromosome variation. Science **164,** 82–84.

Yüksel, E. (1984): Cytogenetic study in *Spalax* (Rodentia: Spalacidae) from Turkey. Communications C: Biologie **2,** 1–12.

Yüksel, E.; Gülkaç, M. D. (1992): On the karyotypes in some populations of the subterranean mole rats in the lower Euphrates-basin, Turkey. Caryologia **45,** 175–190.

Authors' address:
Yüksel Coşkun, Servet Ulutürk and Gökhan Yürümez, Department of Biology, University of Dicle, 21280 Diyarbakır, Turkey
(e-mail: yukselc@dicle.edu.tr)