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Morphological and Karyological Characteristics of *Nannospalax ehrenbergi* (Nehring, 1898) (Rodentia: Spalacidae) from Hatay Province, Turkey

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Abstract: The material of 31 specimens of *Nannospalax ehrenbergi* was collected from 11 different localities in the Hatay region in south Anatolia. The specimens were studied in respect to their morphological and karyological characteristics in detail. Some taxonomic characteristics and measurements of the body and skull were investigated. The data obtained from the specimens were compared with the results of previously published accounts and with samples collected from more than 16 other localities in Turkey, Israel, Jordan and Egypt. The karyotypes of the Yayladağ populations have 2n = 48, NF = 74 and NFa = 70, whereas the karyotypes of the other Hatay populations have 2n = 52, NF = 74, and NFa = 70. The results show that this region's mole rat populations have morphological and karyological features different to those of other populations.

Key Words: Rodentia, Spalax, *Nannospalax ehrenbergi*, Morphology, Karyology, Turkey

Hatay Yöresi *Nannospalax ehrenbergi* (Nehring,1898) (Rodentia: Spalacidae) Türünün Morfolojik ve Karyolojik Özellikleri

Özet: Hatay bölgesinden 11 farklı lokaliteden toplanan 31 *Nannospalax ehrenbergi* örneği üzerinde ayrıntılı olarak morfolojik özellikleri çalışılmıştır. Bazı taksonomik özellikleri, dış vücut ve baş iskeleti ölçüleri araştırılmıştır. Örneklerden elde edilen bilgiler literatür bilgileri ve bu türün dağılış gösterdiği Türkiye, İsrail, Mısır ve Ürdün'den toplanan 16 farklı lokalite örnekleriyle karşılaştırılmıştır. Yayladağ populasyonunun diploid kromozom sayısı 2n = 48, kromozomal kol sayısı NF = 74 ve otozomal kol sayısı NFa = 70 iken diğer Hatay populasyonlarında 2n = 52, kromozomal kol sayısı NF = 74, ve otozomal kol sayısı NFa = 70' tir. Sonuçlar bu bölge Körfare'lerinin diğer populasyonlardan farklı morfolojik ve karyolojik özelliklere sahip olduklarını göstermektedir.

Anahtar Sözcükler: Rodentia, Spalax, *Nannospalax ehrenbergi*, Morfoloji, Karyoloji, Türkiye

Introduction

The family Spalacidae is at present exclusively distributed in the Palearctic region. The distribution area of the family includes northeastern Africa, the Balkans, southeastern Europe, Central Asia, the Middle East and Caucasia (Mehely, 1909; Miller, 1912; Ellerman, 1940; Ognev, 1947; Ellerman and Morrison-Scott, 1951; Topachevskii, 1969; Lay and Nadler, 1972; Corbet, 1978; Savic and Nevo, 1990; Musser and Carleton, 1993). The Spalacidae are southeast European and east Mediterranean blind rodents, highly adapted for life underground. Their taxonomy needs a modern revision including chromosomal and molecular-genetic data as well as morphology, physiology and behavior. Mole rats of the family Spalacidae range over Turkey (Asia Minor) and Turkish Thrace in 2 taxa: the ancestral *Spalax leucodon* (over most of Turkey) and the descendant *Spalax ehrenbergi* in southeastern Turkey (Nevo *et al.,* 1995).

Nannospalax ehrenbergi was originally described by Nehring (1898) on the specimens collected from Yafa, Israel. The species *Nannospalax ehrenbergi* is distributed in Libya, Syria, Jordan, Lebanon, Israel, Egypt, Iraq, and southeast Anatolia in Turkey (Ellerman and Morrison-Scott, 1951; Topachevskii, 1969; Mursaloğlu, 1979; Musser and Carleton, 1993).

There are many morphological studies on this species (Mehely, 1909; Topachevskii, 1969; Atallah, 1978; Mursaloğlu, 1979; Kıvanç 1988; Coşkun and Bilgin, 1988; Coşkun, 1994, 1998), as well as some

karyological studies (Nevo *et al.*, 1994a, 1994b; Nevo *et al.*, 1995; Ivanitskaya *et al.*, 1997; Coşkun 1997, 1999).

Nehring (1898) described a new species *Spalax intermedius* in this region from İskenderun-Arsuz-Çengenköy, but no consensus is yet in sight on this species. According to Harrison and Bates (1991), *Spalax leucodon (Synonym: Spalax ehrenbergi*); and according to Mehely (1909) and Mursaloğlu (1979) *Spalax ehrenbergi* have been living in this region. However, Topachevskii (1969) pointed out that the nominate subspecies *S. e. ehrenbergi* is distributed in this region, whereas Kıvanç (1988) indicated that the subspecies *Spalax e. intermedius* has been living in Hatay province. Savic and Nevo (1990), Nevo *et al.* (1994a) and Nevo *et al.*, (1995) called this region's mole rats a superspecies, *Spalax ehrenbergi*.

Most *Nannospalax ehrenbergi* populations are morphologically very similar, although their morphology has not been yet documented in detail. However, *Nannospalax ehrenbergi* has some morphological variations according to its skull and teeth structures (Nevo *et al.*, 1988).

The first studies on the karyological characteristics of *Nannospalax ehrenbergi* were carried out in 1969 by Wahrman *et al.*, (1969a, 1969b). In this study 4 different chromosomal forms were recorded in Israel with a diploid number of chromosomes of 2n = 52, 54, 58 and 60. Furthermore, 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 *Nannospalax ehrenbergi* populations were performed by Yüksel (1984) on the Elazığ population, and it was determined that this population has a karyotype of 2n= 52, NFa= 72 and NF= 76. Yüksel and Gülkaç (1992) identified the population of mole rats from Şanlıurfa as *Spalax ehrenbergi kirgisorum* from studies of specimens from Şanlıurfa, Adıyaman and Gaziantep; their karyotype was 2n = 52, NF = 76 and NFa = 72. They also concluded that populations from Adıyaman and Gaziantep are *Spalax ehrenbergi intermedius,* with karyotypes of 2n = 52, NF = 76 and 2n = 56, NF = 90. Nevo *et al.*, (1994b, 1995) determined that specimens from Tarsus, Gaziantep, Urfa and Diyarbakır had karyotypes of 2n = 56, 58, 52W and 52E in range, respectively. Ivanitskaya *et al.*, (1997) studied the karyological characteristics of populations from Tarsus, Gaziantep, Birecik, Şanlıurfa, Siverek, Diyarbakır and Elazığ. The diploid chromosome number of Diyarbakır, Elazığ, Siverek and Birecik specimens is 2n = 52, NFa = 72; of Tarsus specimens is 2n = 56, NFa = 68; of Şanlıurfa specimens is 2n = 52, NFa = 78 and of Gaziantep specimens is 2n = 56, NFa = 78.

As mentioned above, *Nannospalax ehrenbergi* has a great chromosomal polymorphism according to its diploid number of chromosomes and the number of chromosome arms. The analyses of the Hatay population's karyotype, whose results are shown here, represent a contribution to our knowledge of the karyotype. The current study of the Hatay populations provides a further contribution to the knowledge of karyotypic and morphological characteristics throughoud the range of this species. This study is intended to evaluate the chromosomal forms and the distribution of the populations of *N. ehrenbergi* in this region.

Materials and Methods

The study was conducted in Hatay province in south Anatolia. The area covers a region of approximately 11,300 km^2. It is characterized by high, angular peaks and lowland areas, mostly covered with oak forest; the elevation ranges from 10 to 1800 m. The study area is climatically rainy and cool.

The samples (13 males, 18 females) were collected from 8 different localities in the Hatay region between April 1998 and October 2003, and sample sizes of localities and sexes are given in brackets (Figure 1). The animals were sexed, measured and weighed. Twenty-three linear measurements were obtained from the skulls using slide calipers with an accurarcy of 0.1 mm according to Niethammer and Krapp (1978) and Nevo *et al.* (1988). Age determination was based on molar crest patterns. Karyotypes were prepared from the bone marrow. Preparations of mitotic chromosomes were obtained from the bone marrow by means of the general air-drying technique (Lee and Elder, 1980). The data obtained from the specimens were compared with the results of previously published accounts. Slides and voucher specimens (skins and skulls) are stored in the Biology Department, Science and Arts Faculty, Dicle University, Turkey.

The specimens were studied in detail with respect to their morphological and karyological characteristics.

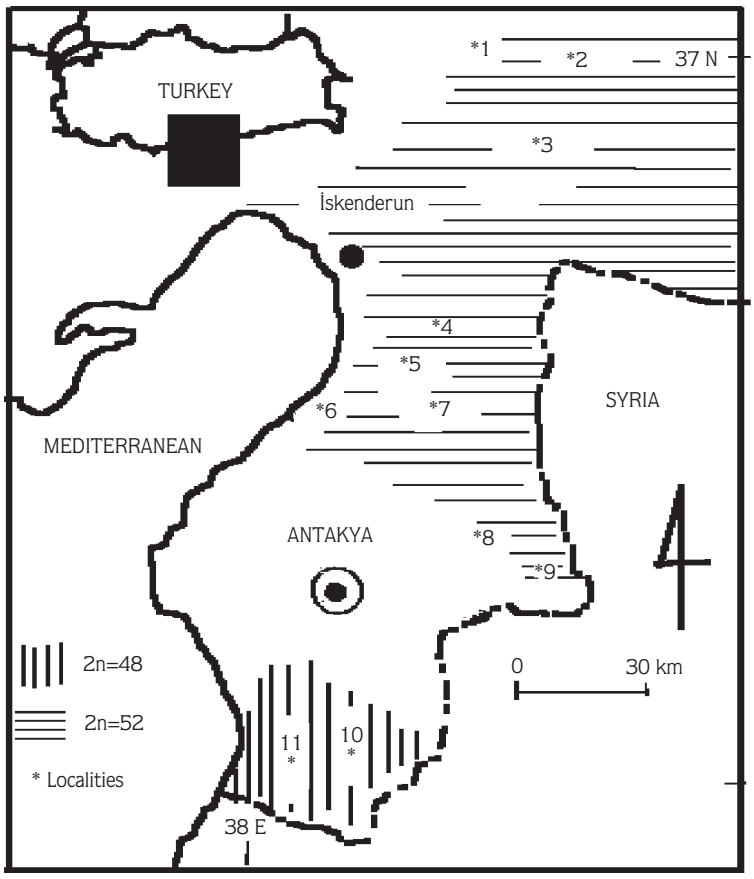

Figure 1. Localities of the collection places; 1. Bahçe (4♀, 1♂), 2. Fevzipaşa (1 ♀), 3. Islahiye (2♀, 2♂), 4. Kırıkhan (2♀, 2♂), 5. Belen (1♀), 6. Arsuz (2♀, 1♂) (close to type locality of *Spalax intermedius* Nehring 1898), 7.Kırıkhan-Muratpaşa (1♂) 8. Reyhanlı-Beşarslan (1♂), 9. Reyhanlı (3♀, 2♂), 10. Yayladağ 10 km N, (2♀, 2♂), 11. Yayladağ-Şenköy (1♀, 1♂).

Some taxonomic characteristics and measurements from the body and skull were investigated. The data obtained from the specimens were compared with the results of previously published accounts and with samples collected from more than 16 different localities in Turkey, Israel, Jordan and Egypt.

Results

All specimens examined have a supracondyloid foramen above both sides of the occipital condyles; the sella externa is placed below the sella interna on the mandible; and the anterior surface of the upper incisors is orange, and has 2 longitudinal ridges, whereas the lower incisors are yellow-orange and have at least 3 longitudinal ridges. Lambdoid and sagital ridges are weakly developed in mature and old samples. The parietals are uniform and their lengths are less than their widths. Foramen post palatines are located on the front of the line between M^2 and M^3 (Figure 2). The palate is not extended behind the line connecting the rear edges of the alveoli of the last upper molars in young specimens but is extended and passes through the back in mature and old specimens, and posseses a well developed styloid process (Figure 2). Body and some skull measurements are given in Table 1.

Enamel folds on the chewing surface of the molars vary in form according to age, and therefore structural differences are seen between young and old individuals (Figure 3). In young specimens the first upper molar (M^1) has 2 labial and 1 lingual folds. The second upper molar

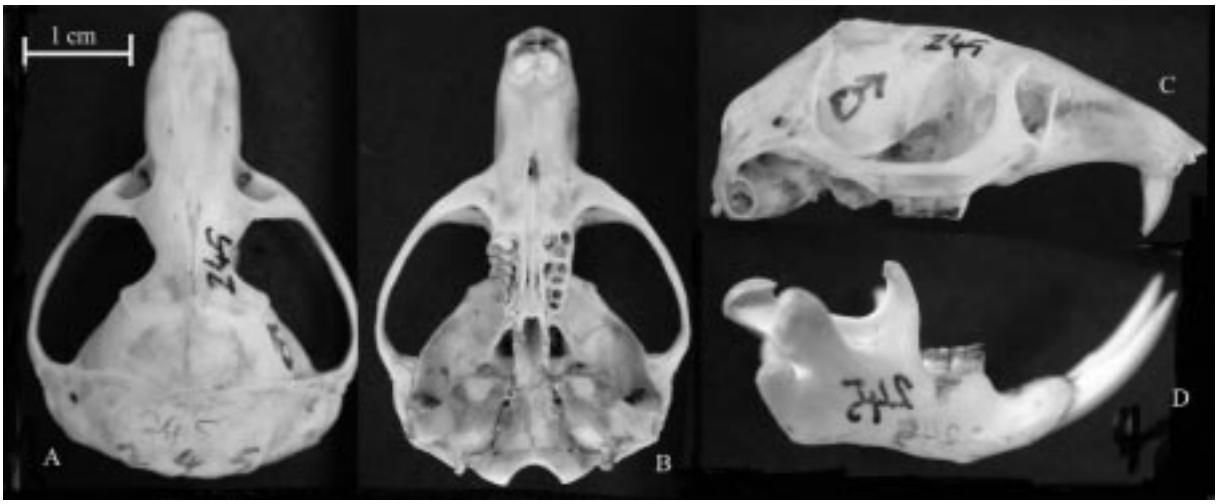

Figure 2. Skull of *Nannospalax ehrenbergi* from Hatay province (A. dorsal, B. ventral, C. lateral, and D. mandibule).

Table 1. Body and skull measurements of *Nannospalax ehrenbergi* from Hatay province (in mm). N: sample size, R: Range, X: Average, Sd: standard deviation.

Characters	FEMALES				MALES			
	N	R	X	Sd	N	R	X	Sd
Head + Body length	15	157-194	174.2	11.3	5	158-205	180.4	18.3
Hind foot length	15	21-26	24.1	1.46	6	24-29	26.0	1.89
Weight (g)	15	84-176	134.2	21.2	6	110-180	159.0	25.8
Condylonasal length	17	37.4-43	40.5	1.52	9	35.6-45.7	42.0	3.24
Zygomatic breadth	17	26-31.4	28.3	1.31	9	25.1-32	29.1	2.25
Supraoccipital height	17	11.3-14.5	13.2	0.79	9	11.0-15.1	13.4	1.17
Maximum skull height	17	15.9-18.8	17.5	0.76	9	16.6-19.6	17.9	0.98
Interorbital breadth	17	6.5-7.7	7.13	0.28	9	6.6-7.7	7.03	0.38
Nasal length	17	14.2-17.6	16.2	0.71	9	14.8-17.7	16.5	0.93
Rostrum breadth	17	7.2-9.0	8.25	0.43	9	6.9-9.4	8.28	0.78
Palatal length	17	7.2-8.9	8.0	0.38	9	6.5-9.5	8.41	1.02
Frontal + Parietal	17	14-17.5	16.1	0.86	9	14.9-20.0	17.4	1.71
Incisive foramen length	17	1.8-3.9	2.78	0.54	9	1.9-3.3	2.73	0.44
Upper incisor width	17	1.4-1.9	1.79	0.14	9	1.6-2.2	1.90	0.22
Up.incisor A-P cross section	17	1.8-2.6	2.14	0.17	9	1.8-2.4	2.26	0.20
Upper incisor width/A-P (%)	17	73.1-95.0	84.3	5.62	9	75.0-95.6	84.4	7.19
Upper molar length	17	6.1-7.1	6.49	0.32	9	6.2-7.9	6.64	0.53
Upper alveoli length	17	6.5-7.6	7.12	0.33	9	6.9-8.2	7.51	0.42
Upper diastema length	17	12.0-15.3	13.8	0.89	9	11.4-16.0	14.3	1.57
Mandible length	17	20.0-24.1	21.7	1.18	9	19.5-24.8	22.3	1.93
Lower Incisor width	17	1.6-2.2	1.92	0.16	9	1.6-2.1	1.92	0.18
Low. inc. A-P cross section	17	2.1-2.7	2.46	0.15	9	2-2.8	2.56	0.19
Lower inc. width/A-P (%)	17	70.4-95.6	78.2	7.36	9	69.6-80.8	74.9	3.56
Lower molar length	17	6.2-7.2	6.69	0.28	9	6.0-7.2	6.74	0.40
Lower alveoli length	17	6.5-8.3	7.24	0.40	9	7.1-7.8	7.58	0.24
Lower diastema length	17	4.7-6.5	5.54	0.51	9	4.6-6.5	5.81	0.64
Mandible height	17	6.2-7.4	6.7	0.36	9	5.9-7.4	6.84	0.45
Coronoid process height	17	12.2-14.8	13.4	0.69	9	12.5-14.9	13.7	0.98

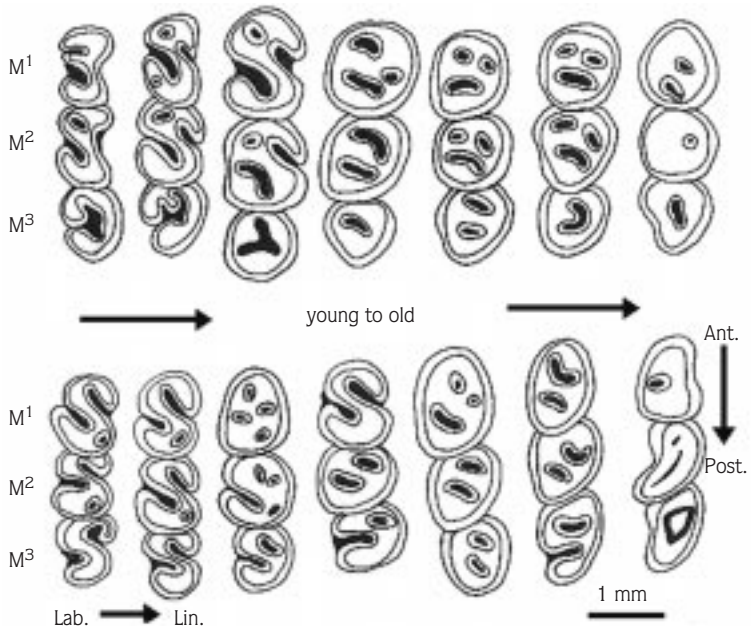

Figure 3. Chewing surface variations of upper (above) and lower (below) molar teeth of *Nannospalax ehrenbergi*. (Ant. Anterior, Post. posterior, lab. labial, lin. lingual side).

(M^2) has a deep intruding fold on each side; therefore the chewing surface in the majority of cases is "S" shaped, and bears an additional inlet. The third upper molar (M^3) is the most variable tooth. Most commonly there are 2 loops. M^3 bears 2 converging folds on the chewing surface in young specimens. In mature and old individuals these folds become 1-3 inlets and disappear in the oldest specimens. In mature specimens M^3 generally has 2 enamel islands on the chewing surface (Figure 3). $M^{1,2,3}$ have 3 roots in young specimens, and the antero-palatal and posterior roots of M^3 are welded together in old samples, while $M_{1,2,3}$ have 2 roots. The anterior root of M_3 is bifurcated. The alveoli of all molar teeth are completely separated by septa. The alveolar process is about the same height as the condyloid process on the mandible in Yayladağ, Arsuz, Reyhanlı and Fevzipaşa populations but the alveolar process is higher than the condyloid process in Bahçe, Kırıkhan, Islahiye and Belen populations. Body and skull dimensions of males are in average larger than those of females (Table 1).

The karyotypes of 6 specimens from Yayladağ populations have 2n = 48, NF = 74, and NFa = 70. Their karyotype consists of 12 pairs of meta/submetacentrics, and 11 pairs of acrocentric autosomes. The X chromosomes are large sized and metacentric (Figure 4A).

The karyotypes of 25 specimens from other Hatay populations have 2n = 52, NF = 74, and NFa = 70. Their karyotype consists of 10 pairs of meta/submetacentrics, and 15 pairs of acrocentric autosomes. The X chromosomes are large and submetacentric; Y chromosomes are small and acrocentric (Figure 4B).

Chromosome types and the number of arms are shown in Table 2. The table gives a comparative survey of all populations analyzed to date of the species *Nannopalax ehrenbergi* (Nehring, 1898) from Turkey.

Discussion

According to Gromov and Baranova (1981), Spalacidae has 2 distinct genera, *Nannospalax* and *Spalax*; and Turkish spalacids belong to the genus *Nannospalax*. The genus name *Nannospalax* is used in this paper.

The anterior surface of the upper incisors has 2 longitudinal ridges; the third upper molar bears 2 enamel islands on the chewing surface; which are of taxonomic value in determining *S. ehrenbergi* (Nehring, 1898;

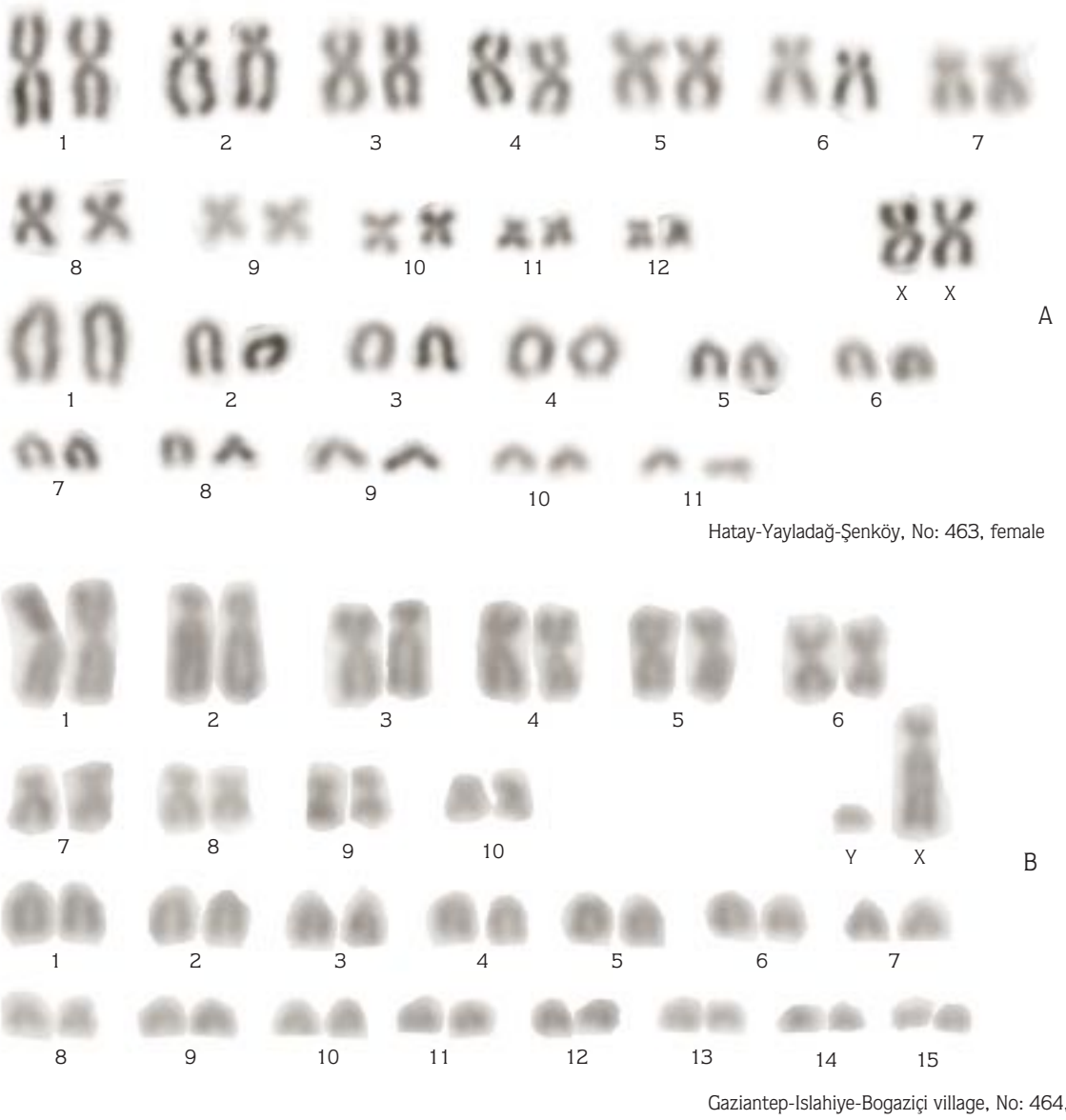

Figure 4. Karyotype of Yayladağ population (A), and the other Hatay populations (B).

Ellerman and Morrison-Scott, 1951; Topachevskii, 1969; Mursaloğlu, 1979; Nevo *et al.*, 1988; Coşkun, 1994). According to Topachevskii (1969), *Microspalax ehrenbergi* (*S. ehrenbergi*) have 3 rooted upper molars; the anterior surface of the lower molars has 3 longitudinal ridges and gives the ratio of the upper and lower molars width to the antero-posterior cross section. These characters are partly the same in the Hatay population. The measurements given by Nehring (1898) for *S. ehrenbergi*, such as zygomatic breadth (26-27 mm), rostrum breadth (7.5-7.6 mm), diastema length (12-12.3 mm) and upper alveolar length (7.3-7.5 mm), are higher in the Hatay population except for upper alveolar length (Table 1). Also, the skull measurements given for one female *S. intermedius* specimen by Nehring 1898, such as total length (45.0), zygomatic breadth (30.5), rostrum breadth (8.7), nasal length (17.3), diastema length (15.8) and upper alveolar length (6.0), are in the same range in the Hatay population.

Table 2. Comparative survey of the karyotypes of *Nannospalax ehrenbergi* from Turkey. 2n: diploid number, m/sm: meta-submetacentric, A: acrocentric, X: X chromosome, Y: Y chromosome, NF: chromosome arms number, NFa: autosome arm numbers.

Population	2n	m/sm.	A	X	Y	NF	NFa	Literature
Diyarbakır	52	11	14	Sm	Sm	76	72	Ivanitskaya et al. (1997)
Elazığ	52	11	14	Sm	Sm	76	72	Yüksel (1984), Ivanitskaya et al. (1997)
	52/54	11/10	14/16	m	sm	76	72	Yüksel and Gülkaç (1992)
Şanlıurfa	52	14	11	Sm	A	78	74	Nevo et al. (1994a)
	52	13	12	Sm	A	80	76	Ivanitskaya et al. (1997)
	56	14	13	m	Sm	90(?)	86	Yüksel and Gülkaç (1992)
Gaziantep	58	17	11	Sm	Sm	90	86	Nevo et al. (1994a)
	56	12	15	Sm	A	82	78	Ivanitskaya et al. (1997)
Adıyaman	52	11	14	m	sm	76	72	Yüksel and Gülkaç (1992)
Tarsus	56	7	20	Sm	A	72	68	Nevo et al. (1994a), Ivanitskaya et al. (1997)
Şırnak	52	11	14	Sm	A	76	72	Coşkun (1998)
Kilis	52	10	15	Sm	A	74	70	Coşkun (1997)
Yayladağ	48	12	11	m	-	74	70	This study
Hatay	52	10	15	Sm	A	74	70	This study

Kıvanç (1988) points out that the subspecies *S. e. intermedius* is distributed in this region, that this subspecies is distinguished from the other subspecies by the nasobasalis crest, which does not pass the median level of the foramen infraorbitalia. The palatines reach the posterior edge of M^3 and foramen post palatines are located on the same level of the line between M^2 and M^3. In all examined specimens from the Hatay population, the results show that the palatines are not extended behind the line connecting the rear edges of the alveoli of the upper molars in young samples but are extended or pass through the back in mature and old specimens; foramen post palatines are located in front of the line between M^2 and M^3. These results are not supported by those of Kıvanç (1988). As in Mehely's (1909) description of *S. ehrenbergi*, the palate ends with long and weak styloid process, and the upper molars have 3 roots in all examined samples. The pattern of the occlusal surface changes as the teeth wear down.

In this study the diploid chromosome number of Yayladağ specimens is 2n = 48 and NFa = 70. By these characteristics the specimens of Yayladağ differ from the other Hatay populations. This result is a new record for the Turkish *Spalax* (Table 2).

On the basis of comparative analysis of karyotypes, it can be concluded that there are 2 different chromosomal forms in this region, which is manifested in the differences in respect of the number and morphology of the chromosome.

The results show that this region's *Spalax* population has morphological and karyological features different from those of other populations. These differences indicate that the Hatay population needs a taxonomic revision based on karyological, ethological, physiological and cytogenetis studies.

Acknowledgments

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References

Atallah, S.I. 1978. Mammals of the eastern Mediterranean region; their ecology, systematics and zoogeographical relationships. Part 2. Saugetierkundliche Mitt., 26: 1-50.

Corbet, G.B. 1978. The mammals of the Palearctic region: A taxonomic review. Brit. Mus. (Nat. Hist.), London: 1-314.

Coşkun, Y. 1994. Türkiye Spalax'larının Taksonomik Durumu. XII. Ulusal Biyoloji Kongresi Tebliğleri, Zooloji Seksiyonu, Edirne, Cilt VI: 277-283.

Coşkun, Y. 1997. Kilis Yöresi *Spalax ehrenbergi* Nehring,1898 (Rodentia: Spalacidae) Türünün Karyolojik Özellikleri. III. Ulusal Ekoloji ve Çevre Kongresi, Kırşehir 3-5 Eylül 1997, Kırşehir, Kongre Kitabı, 1-7.

Coşkun, Y. 1998. Şırnak Yöresi *Spalax ehrenbergi* Nehring 1898 (Rodentia: Spalacidae) Türünün Morfolojik ve Karyolojik Özellikleri. XIV. Ulusal Biyoloji Kongresi Tebliğleri, Zooloji Seksiyonu, Samsun, Cilt III, 114-122.

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

Coşkun, Y. and Bilgin, F.H. 1988. Diyarbakır İli Sınırları İçerisinde Yaşayan *Microspalax (Microspalax) ehrenbergi* (Nehring 1898) (Rodentia: Spalacidae) Üzerine Taksonomik Bir Araştırma. IX. Ulusal Biyoloji Kongresi Tebliğleri, Sivas, Cilt 2: 143-150.

Ellerman, J.R. 1940. The families and genera of living rodents. Vol. 1. Rodents other than Muridae. Brit. Mus. (Nat. Hist.) London, IX+651.

Ellerman, J.R. and Morrison-Scott, T.C.S., 1951. Checklist of Palearctic and Indian Mammals 1758 to 1946. Brit. Mus. (Nat. Hist.) London, 1-810.

Gromov, I.M. and Baranova G.I. 1981. Catalogue of Mammals in USSR. Nauka, Leningrad.

Harrison, D.L. and Bates, P.J.J. 1991. The Mammals of Arabia. 2nd Edition. Harrison Zool. Museum Pub.

Ivanitskaya, E. Coşkun, Y. and Nevo, E. 1997. Banded Karyotypes of Mole Rats (*Spalax, Spalacidae, Rodentia*) from Turkey: A Comparative Analysis. J. Zool. Syst. Evol. Research, 35: 171-177.

Kıvanç, E. 1988. Türkiye Spalax'larının Coğrafik Varyasyonları *(Mammalia: Rodentia)*. PhD thesis, Ankara Univ. Ankara, 1-88.

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

Lee, M.R. and Elder, F.F. 1980. Yeast stimulation of bone marrow mitosis for cytogenetic investigations. Cytogenetics and Cell Genetics, 26: 36-40.

Mehely L. 1909. Species generis *Spalax*, A Földi Kutyak Fajai, Budapest: 1-334.

Miller G. S. 1912. Catalogue of the mammals of western Europe in the collection of the British Museum. Brit. Mus: (Nat. Hist.), London: 1-1019.

Mursaloğlu, B.1979.Türkiye *Spalax*'larında (Mammalia: Rodentia) Sistematik Problemler. TÜBİTAK VI. Bilim Kongresi Tebliğleri, 83-92.

Musser G. G. and Carleton M. D. 1993. Mammal species of the World. A taxonomic and geographic reference. Smithsonian Institute Press, Washington and London. 753-755.

Nehring, A. 1898. Über mehrere neue *Spalax* Arten. Sitzungsber, d. Gesellsch. Naturforsch., Freunde z. Berlin, 10: 163-183.

Nevo, E., Tchernov, E. and Beiles, A. 1988. Morphometrics of speciating mole rats: Adaptive differentiation in ecological speciation. Z. Zool. Syst.-forsch. 26: 286-314.

Nevo, E., Filippucci, M.G. and Belies, A. 1994a. Genetic polymorphisms in subterranean mammals (*Spalax ehrenbergi* superspecies) in the neaereast revisited. Patterns and Thoery. Heredity 72: 465-487.

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

Nevo, E., Filippucci, M.G., Redi, C., Simson, S., Heth, G. and Beiles, A. 1995. Karyotype and genetic evolution in speciation of subterranean mole rats of the genus *Spalax* in Turkey. Biological Journal of the Linnean Society, 54: 203-229.

Niethammer, J. und Krapp, F. 1978. Handbuch der Saugetiere Europas. Band 1. Rodentia I. Akademische Verlagsgesellschaft- Wiesbaden.

Ognev S. I. 1947. Mammals of the USSR and adjacent countries, Rodents. Vol. 5. (ISPT, English Translation), Jerusalem: 1-809.

Savic I. and Nevo E. 1990. The Spalacidae: Evolutionary history, speciation, and population biology. [In: Evolution of subterranean mammals at the organismal and molecular levels. Nevo E. and Reig O. A., eds.] Alan R. Liss, Inc. New York, 129-143.

Topachevskii V. A. 1969. The fauna of the USSR: Mammals, mole rats, Spalacidae. Vol. III, No.3, Akademia Nauka Leningrad: 1-308 (English Translation).

Wahrman, J. Goitein, R. and Nevo, E. 1969a. Mole rat Spalax: Evolutionary significance of chromosome variation. Science, 164: 82-84.

Wahrman, J., Goitein, R. and Nevo, E. 1969b. Geographic variation of chromosome forms in Spalax, a subterranean rodent of restricted mobility. In: Benirschke E, ed. Comparative Mammalian Cytogenetics. New York: Springer Verlag, 30-48.

Yüksel, E. 1984. Cytogenetic Study in Spalax (Rodentia: Spalacidae) from Turkey. Communications, de la Faculte des Sciences de l'Universite d'Ankara, Serie C: Biologie Tome 2: 1-12.

Yüksel, E. and 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.