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**UNIVERSITY OF DICLE**  
**INSTITUTE OF NATURAL AND APPLIED SCIENCES**

**KARYOLOGICAL PECULARITIES SPALACIDAE FAMILY  
(MAMMALIA:RODENTIA) SPECIES IN NORTH IRAQ  
(KURDISTAN REGION).**

**Zaitoon Ahmad HAMAD**

**M.Sc. THESIS**  
**DEPARTMENT OF BIOLOGY**

**DIYARBAKIR**


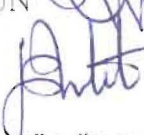

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*“Karyological Peculiarities Spalacidae Family (Mammalia: Rodentia) Species in North Iraq (Kurdistan Region) ,Submitted by Zaitoon Ahmad HAMAD in partial fulfillment of the requirements for the degree of Master of Science in Mammalian cytogenetic.*

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## ABSTRACT

### KARYOLOGICAL PECULIARITIES OF SPALACIDAE FAMILY (MAMMALIA: RODENTIA) SPECIES IN NORTH-IRAQ (KURDISTAN REGION)

M.Sc. THESIS

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Spalacidae (Mole Rat) are highly adapted for life underground and have limited movement. Morphologically, they are cylindrical, powerful, heavy-bodied animals with short limbs and claws, and projecting incisors. Spalacidae occur in southeastern Europe, Asia Minor, the Caucasus and Transcaucasia; through the chernozem belt of the Russian plain to the Caspian, Syria, Palestine, Egypt and Libya. Spalacids are good model for speciation and explain to chromosomal variation in biology science especially evolution of living and to understand the inadequacy of morphologic species (typology) concept because of they have chromosomal polymorphism, sibling species and active speciation. It was done dense studies on karyology and morphologic peculiarities of these animals at many countries. However it does not go beyond to limited studies that were carried out by some native and foreign researches for this family in Iraq. It need to do detail study because of it was not reveal the distribution range, morphologic and especially karyologic peculiarities of these animals. All samples have  $2n=52$  diploid chromosomes. Duhok (Bardarash), Mosul example commodity 11 pairs of meta / submetacentric, 14 pairs acrocentric, and large commodity X, and Y is small acrocentric  $2n = 52$ ,  $NF = 76$ , but; Erbil, Sulaymaniyah and Kirkuk samples  $NF=80$ , 13 pairs of meta/submetacentric, 11 pairs acrocentric and large commodity X, Y is small acrocentric  $2n = 52$ ,  $NF = 76$ , was found as  $NF = 80$ . In this study, two chromosomal forms of *Nannospalax ehrenbergi* are distributed in Iraq, which was emerged.

**Key Words:** Mammalia Rodentia, Spalacidae, *Nannospalax ehrenbergi* Karyology, Iraq.

## ÖZET

### KUZEY IRAK SPALACIDAE (KÖR FARE) (MAMMALIA: RODENTIA) TÜRLERİNİN KARYOLOJİK ÖZELLİKLERİ

YÜKSEK LİSANS TEZİ

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2016

Kör fareler yeraltı yaşamına uyum sağlamış ve hareket sınırları dar olan hayvanlardır. Morfolojik olarak kısa bacaklı, tırnaklı ve belirgin kesici dişlere sahip; silindirik, güçlü ve hantal hayvanlardır. Spalacidler Güneydoğu Avrupa, Orta Asya, Kafkaslar ve Transkafkaslardan Rusya, Suriye, Filistin, Mısır ve Libyaya kadar dağılışı gösterirler. Familyanın alt taksonları da dahil olmak üzere sistematiklerinde önemli ölçüde sorunlar bulunmaktadır. Bunların kromozomal polimorfizm göstermeleri sibling türlerinin bulunması ve aktif türleşmeleri nedeniyle, türlerinin tespitinde güçlükler bulunmaktadır. Birçok ülkede bu hayvanların karyolojik ve morfolojik özellikleri üzerinde yoğun çalışmalar yapılmaktadır. Ancak Irak'ta bu familyanın karyolojik durumu çok kısıtlı çalışmalardan öteye gitmemektedir. Bu hayvanların morfolojik, özellikle de karyolojik özelliklerinin ve dağılımlarının ortaya çıkarılmamış olması ayrıntılı bir araştırma yapılmasını gerektirmektedir. Bütün örnekler  $2n=52$  diploid kromozoma sahiptir. Duhok (Bardarash), Musul örnekleri 11 çift meta / submetasentrik, 14 çift akrosentrik ve büyük bir metasentrik X, ile küçük bir akrosentrik Y kromozomu taşımaktadır. Karyotipleri  $2n = 52$ ,  $NF = 76$  dir. Fakat Erbil, Süleymaniye ve Kerkük örnekleri  $NF=80$  olup, 13 çift meta-submetasentrik, 11 çift akrosentrik ve büyük metasentrik X, küçük akrosentrik Y kromozomludur. Bu çalışmada Irak'ta dağılışı gösteren *Nannospalax ehrenbergi* türünün farklı iki kromozomal formu belirlenmiştir.

**Anahtar Kelimeler:** Mammalia Rodentia, Spalacidae, *Nannospalax ehrenbergi* Karyoloji Irak.

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## SYMBOLS AND ABBREVIATIONS

F: Female ♀

Fm: Foramen magnum.

g : Gram

mg : Milligram

min: Minute

ml: mililitre

h: Hour

KCL: Potasium chloride

LC: Lambdoid crest.

LOR: Longitudinal ridges.

M: Male ♂

2n: Diploid Chromosome number.

NF: Fundamental number of chromosomal arms.

*N. ehrenbergi*: *Nannospalax ehrenbergi*.

NFa: Autosomes arm numbers.

OC: Occipital condyles.

Rpm: Round per minute

SC: Sagittal crest

SCF: Supracondyloid foramen

WWF: World Wildlife Fund

CLP: Conservation Leadership Programme

IUCN: International Union Conservation of Nature



### 1. INTRODUCTION

Palaearctic Realm involve different region, Iraq is part of them .The largest of the eight terrestrial ecozones that have been defined for the Earth is, Palaearctic Realm It includes the ecoregions covering the northern and central Arabian Peninsula, and Asia northern Africa Europe, north of the Himalaya foothills. Under the World Wildlife Fund (WWF, 2006) an ecosystem classification system of 26 biomes or major territory types was developed from which 867 terrestrial ecoregions were defined. Under the WWF system, there are 5 terrestrial biomes found in the Palaearctic realm of Iraq:

1. Mediterranean Forests, Woodlands, and Scrub.
2. Deserts and Xeric Shrub lands
- 3 Savannas and Flooded Grasslands.
- 4 Mixed Forests and Temperate Broadleaf
- 5 Shrub lands, Savannas and Temperate Grasslands (Abdulhassan et al .2011) .

The Palaearctic range includes Egypt, Lebanon, Morocco, Israel, Jordan, Iran ,Iraq SW Saudi Arabia, and Afghanistan (Harrison 1964, De Blasé 1980, Qumsiyeh 1985, Harrison and Bates 1991, Benda and Uhrin 1999).

Cytogenetic research depends up on the taxonomist to suggest problems and give the background to any problems, ecologists depends up on taxonomists for as identification and taxonomists are dependent on both for information on species limits and evolution (Agnew 1962).

The most important substance for the evolution is the chromosomes. Thus the chromosomes are to be the most important and requisite tool in the explanation of speciation and taxonomic problems. Chromosomal realization is particularly important in the establishment of phylogenetic relationship among related taxa including fossorial mammals (Yüksel and Gülkaç 1992).

Spalacidae is Mediterranean blind subterranean rodents. Morphologically they are power full; cylindrical; heavy bodied animals; with short limbs and claws and projecting incisors; the dental formula is  $1.0.0.3/1.0.0.3 = 16$  (Savic and Nevo, 1989).

The family Spalacidae is consists of fossorial mole rats which are highly adapted to subterranean life. The systematic and taxonomy of extant species of mole rats are still argumentative ( Gromov and Baranova ,1981).

The wonderful character of the blind mole rat together with its genomic and transcriptomic information enhance Our understanding of adaptation to excessive environments and will enable the utilization of blind mole rat models for biomedical research in the fight against cancer, stroke and cardiovascular diseases (Fang et al, 2014).

Chromosomal differentiation there is still uncertainty about taxonomy of this taxon (Topachevskii, 1969 ) renowned 2 genera: *Microspalax* and *Spalax*. Later (Gromov and Baranova, 1981) accepted 2, genera: *Nannospalax* and *Spalax*, and since *Microspalax* is a homonym among populations. Chromosomal differentiation among populations can be an preliminary step in speciation (Zima, 2000).

The systematic and phylogenetic associations of mole rats within the family Spalacidae have not yet been definitively resolved. Because of distinct convergent tendencies leading to a uniform phenotype of mole rat ,to adapted to their fossorial way of life traditionally difficult to be systematically studied on it (Nevo 1979; Savic 1982).

The genus *Nannospalax* is well known for its large variant in chromosome numbers, and the diploid chromosome number (2n) varies between 36 and 62 (reviewed by Nevo et al., 2001). However, the main center of chromosomal variety of *Nannospalax* in Anatolia which harbors just about 60% of the cytotype diversity (Nevo et al., 2001).

Up to now, more than 50 chromosomal forms have been qualified for the family Spalacidae spread in the Palearctic region, and 30 forms of them were only recorded from Turkey. Taxonomic books have established the generic name *Nannospalax* as applicable for blind mole rats in Turkey (Kryštufek et al, 2001; Yiğit et al., 2006).

However, the exact distribution areas of these chromosomal forms are still not known (Nevo et al.1995; Sözen 2004; Sözen et al. 2008).

A major goal of biodiversity research is to evaluate the number of present and past species in various taxonomic groups and to determine how to quantify the different degrees

## 1.INTRODUCTION

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of independent evolutionary history or taxonomic distinctiveness; in different species or groups (Mayr 1988).

In the analysis, in addition to the number of chromosomes, their morphology was also studied. The chromosomes are described on the basis of relative chromosome arms ratios (Patton 1967).

- Karyotyping is a picture of an individual's chromosomes arranged in homologous pairs. The study of karyotypes is important for :
- Study taxonomic relationships, and to gather information about past evolutionary events.
- Study cellular function Cell biology and genetics, and the results may be used in evolutionary biology (karyosystematics) and medicine.
- Karyotyping is important for Study chromosomal aberrations, when people want to find out if their children will have any genetic disorders that involve trisomy or monosomy.

*Nannospalax ehrenbergi*, which is found in Jordan, Egypt, Israel, and Turkey had values of  $NFa = 62-86$ ,  $2n = 48-62$  and Studies performed on Turkish mole rats exposed 12 cytotypes with different chromosomal sets ( $2n = 48, 52, 54, 56, 58$  and  $NFa = 62, 64, 68, 70, 72, 76, 78,$  ) (Nevo et al., 1995; Ivanitskaya et al., 1997; Coşkun et al., 2006).

(Wahrman et al) were carried out the first studies on the karyological peculiarities of *Nannospalax ehrenbergi* in 1969. *Nannospalax ehrenbergi* has a great variability of the number of chromosome arms and diploid chromosome numbers (Wahrman et al. (1969)).

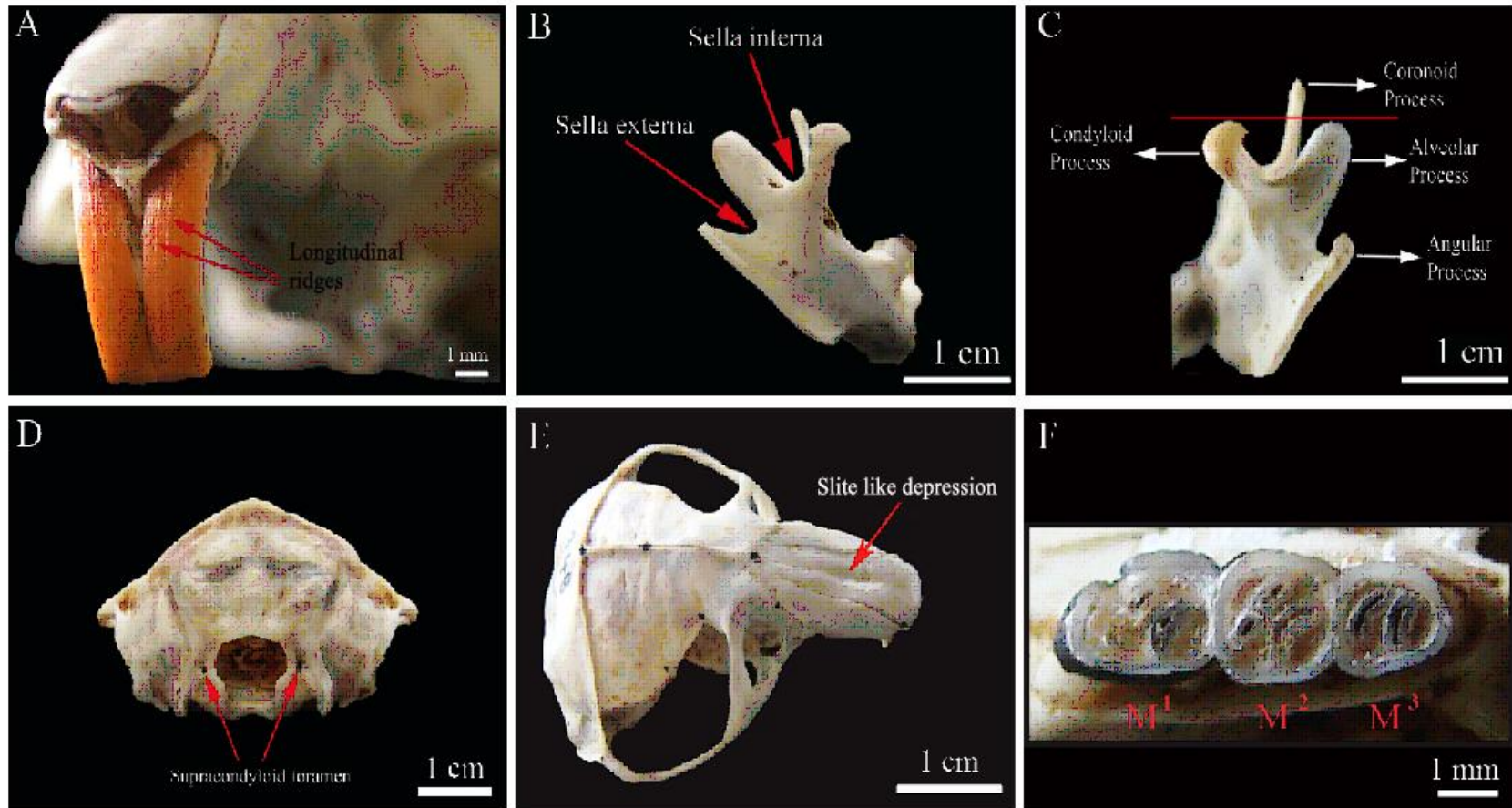
Anterior surface of the upper incisors have two longitudinal ridges (Fig 1-A); sella interna is placed above the sella externa on the mandible (Fig.1.B); coronoid process is higher as condyloid process (Fig.1.C) supracondyloid foramen present above both sides of the occipital condyles (Fig.1.D); there is a slit-like depression on nasals (Fig.1.E); and two enamel islands on the surface chewing of the third upper molar ( $m^3$ ) (Fig 1.F). All these characters accord with the diagnoses of *N. ehrenbergi* given by (Nehring 1898, Ellerman 1940, Topachevskii, 1969).

Mole rats belong to the species *N. ehrenbergi* are now known from Iraq that the most widely distributed. The cytotypes of mole chromosomal form is  $2n=52$  and  $NF=76$ ,  $NF=80$ .

Mole rats of this cytotype inhabit (Duhok, Mosul Population) in the north of great Zap NF=76, but (Erbil, Sulaymaniyah-Kirkuk populations) in the south of great Zap 2n=52, NF=80.

In this study, it is purposed to describe the cytotype characteristics of several *Nannospalax* populations from Iraq to fill at least small gaps in our knowledge about karyological forms, their distributional areas and evolutionary trends in the north of Iraq. Because distribution range and biological peculiarities have not yet been documented in detail or poorly studied.

## 1.INTRODUCTION



**Fig.1.1** Skull of *N.ehrenbergi* **A-** the anterior surface of the upper incisors had two longitudinal ridges; **B** sella interna is placed above the sella externa on the mandible, **C.** Coronoid process as higher as condyloid process, **D.** Supracondyloid foramen above both sides of the occipital condyles, **E.** longitudinal slit-like depression on nasals, **F.** Two enamel islands on the surface of the third upper molar (m<sup>3</sup>) (Yürümez, 2010).



## 2. LITERATURE REVIEW

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### 2. LITREATURE REVIEW

#### 2.1. Mammals of Iraq

Iraq is rich in wild life and has many territories from mountain, the mammalian fauna is basically Palearctic, and many genera and even species are shared with northern Europe, Indian and African elements (Hatt 1959). Kurdistan region in northern Iraq to the wet marsh lands in the south as of 2001, 7 of Iraq's mammal species are endanger, Iraq had lost all of its ( Asiatic cheetah- Asiatic Lion ) and the now extinct Caspian Tigers by the earlier years of the twentieth century. Cheesman (1920) listed 38 mammals' species/subspecies in Iraq, nine are new to science. The wild mammals which occurring in Iraq is belonging to eight orders and 28 families (Al Sheikhly and Haba, 2015b).

Harrison and Bates (1991) listed of bat is 16 bat species including three species of *Rhinolophus* and three species of *Myotis* within the geographical range of Iraq,

(Al-Sheikhly 2012) provided further notes on the bat fauna of steppes and desert habitats in central and western Iraq.

More newly (Al-Sheikhly and Haba, 2015a) has reported (16 species) of bats of Iraq (Table 2.1). The bat species including three species of *Rhinolophus* and three species of *Myotis*. In addition to this list, two further species were encountered during cave surveys in Akre district (Kurdistan region) in northern Iraq (Bjil village of Akre region Duhok Governorate, northern Iraq (Al-Sheikhly and Haba, 2015b).

In the northern of Iraq in two mountainous areas in Kurdistan Wild Goat (*Capra aegagrus*) was recorded in Barzan (Erbil Governorate) and Peramagroon and Qara Dagh (Sulaimaniyah Governorate) (Raza 2013) .The observation of the Least Weasel (*Mustela nivalis*) is another exciting finding was in Shirin Mountain of the Barzan area. The possibility of the presence of the Least Weasel in Iraq is mentioned in old literature but the Nature Iraq CLP team with the trainer Amir Hossein Khaleghi, were able to observe and photograph this species for the first time, making this the first record of the species established for Kurdistan, northern Iraq. Wild Boar (*Sus scrofa*), Cape Hare (*Lepus capensis*), and Red Fox (*Vulpes vulpes*) as well as hearing the calls of Striped Hyena (*Hyaena hyaena*), a near threatened species, during the night. In addition the team found

three Eurasian Otters (*Lutra lutra*), during the training for the CLP project, also a near threatened species, in the Rezan River of Barzan, which were sighted with flashlights at night (Raza 2013).

In Kurdistan of Iraq, by the camera traps in Qara-Dagh observed Persian Leopard (*Panthera pardus saxicolor*) is an endangered subspecies according to the IUCN Red List (Raza et al.2012) . The camera trap also documented Wild Boar (*Sus scrofa*), Wild Cat (*Felis silvestris*). Indian Crested Porcupine (*Hystrix indica*), Golden Jackal (*Canis aureus*), and Persian Squirrel (*Sciurus anomalus*) (Raza 2013) .

There are several documents indicating that the elephant was indeed common as a wild animal in the area west of present day Iraq and possibly along the Euphrates in this kingdom. In the Iraq Natural History Museum is a molar from Lake Habbaniya, Deraniyagala has identified as *E. maximus asurus* (Hatt 1959).

After 1990, some marshes of Iraq were dried; therefore many of the animals disappeared like *Lutra perspicillata* which was found in Iraq only, and the Bandicoot Rat *Erythronesokia bunnii* (Khajuria 1980).

## 2. LITERATURE REVIEW

**Table 2.1.** List of wild mammals recorded in Iraq including Sub-Species (Al-Sheikhly and Haba, 2015b) (continue).

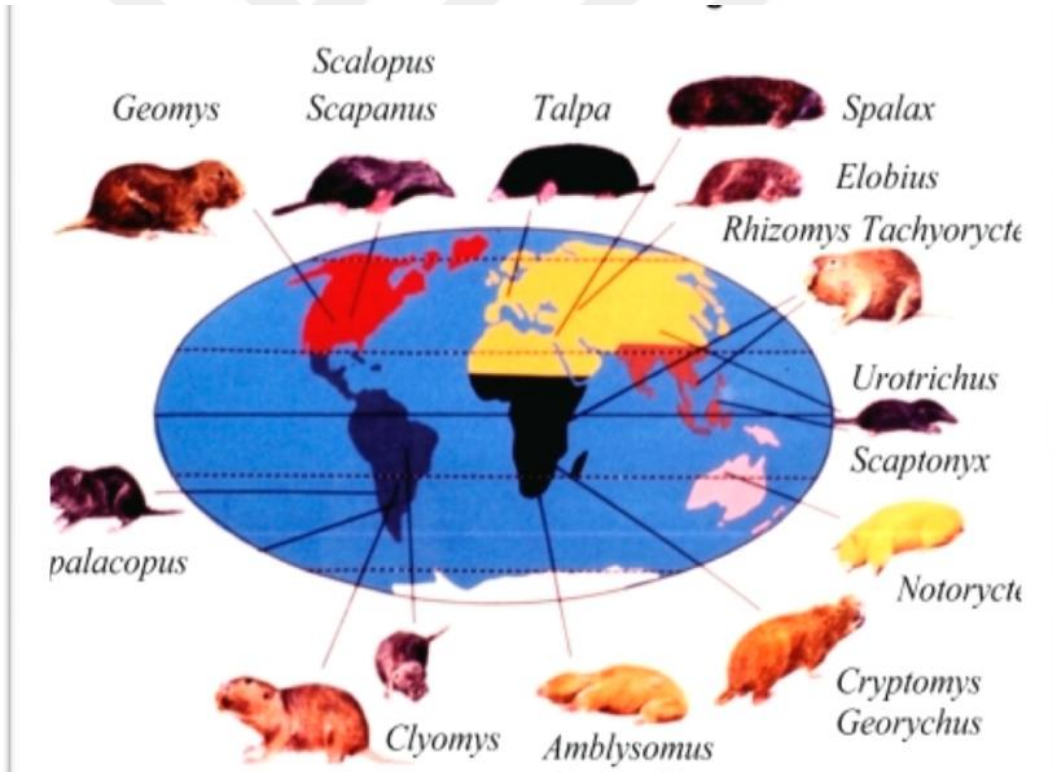
Order	Family	Species/Subspecies	AUTHORS
<b>Erinaceomorpha</b>	Erinaceidae	<i>Erinaceus concolor</i>	(Martin 1838)
		<i>Hemiechinus auritus calligoni</i>	(Satunin 1901)
		<i>Paraechinus aethiopicus ludlowi</i>	(Thomas1919)
<b>Soricomorpha</b>	Soricidae.	<i>Suncus etruscus</i>	(Savic1822)
		<i>Suncus murinus</i>	(Linnaeus, 1766)
		<i>Crocidura suaveolens portali</i>	(Thomas1920)
<b>Chiroptera</b>	Emballonuridae	<i>Taphozous nudiventris</i>	(Wettstein1913)
	Rhinolophidae	<i>Rhinolophus ferrumequinum irani</i>	(Cheesman1921)
		<i>R. hipposideros midas</i>	(Anderson1905)
		<i>R. mehelyi</i>	(Matschie 1901)
		<i>R. euryale</i>	(Blasius,1853)
	Hipposideridae	<i>Asellia tridens murraina</i>	(Anderson1881)
	Molossidae.	<i>Tadarida teniotis rueppelli</i>	(Temminck 1826)
	Rhinopomatidae	<i>Rhinopoma hardwickii</i>	(Gray 1831)
		<i>Rhinopoma microphyllum</i>	Kock et al. (2001).
	Vespertilionidae	<i>Myotis blythii omari</i>	(Thomas, 1906).
		<i>Myotis emarginatus</i>	(E. Geoffroy,1806)
		<i>Myotis nattereri</i>	(Kuhl, 1817)
		<i>M. capaccinii bureschi</i>	(Heinrich, 1936).
		<i>Eptesicus bottae hingstoni</i>	(Thomas, 1919)
		<i>Eptesicus anatolicus</i>	(Felten, 1971)
<i>Otonycteris hemprichii</i>		Peters, 1859	
<i>O. h. petersi</i>		Anderson & de Winton, 1902	
Vespertilionidae	<i>Rhyneptesicus nasutus pellucens</i>	(Thomas1906)	
	<i>Pipistrellus kuhlii ikhwanius</i>	(Cheesman &Hinton1924)	
	<i>Vansonia rueppellii coxi</i>	(Thomas 1919)	
Miniopteridae	<i>Miniopterus pallidus</i>	Anderson & de Winton 1902	
<b>Carnivora</b>	Canidae	<i>Canis aureus</i>	(Linnaeus 1758)
		<i>Canis lupus pallipes</i>	(Sykes 1831)
		<i>Vulpes vulpes arabica</i>	(Thomas 1902)
		<i>Vulpes rueppellii sabaea</i>	(Pocock 1934)
		<i>Vulpes zerda</i>	(Zimmermann 1780)
	Ursidae.	<i>Ursus arctos syriacus</i>	(Hemprich & Ehrenberg 1828)
	Mustelidae	<i>Martes foina syriaca</i>	(Nehring 1902)
		<i>Vormela peregusna syriaca</i>	(Pocock 1936)
		<i>Mustela nivalis boccamela</i>	(Bechstein 1800)
		<i>Mellivora capensis wilsoni</i>	( Cheesman 1920)
		<i>Lutra lutra seistanica</i>	(Birula 1912)
	Mustelidae	<i>Lutrogale perspicillata maxwelli.</i>	(Hayman 1956)
	Herpestidae	<i>Herpestes edwardsi ferrugineus</i>	(Blyth 1845)
<i>H. javanicus pallipes</i>		(Blanford 1874).	

	Hyaenidae	<i>Hyaena hyaena syriaca</i>	(Matschie 1900)
	Felidae	<i>Felis silvestris nesterovi</i>	(Birula 1916)
		<i>Felis chaus furax</i>	(Winton 1898)
		<i>Felis margarita harrisoni</i>	(Hemmer, Grubb & Groves 1976)
		<i>Caracal caracal schmit</i>	(Matschie 1912)
		<i>Lynx lynx dinniki</i>	(Satunin 1915)
		<i>Panthera pardus saxicolor</i>	(Pocock 1927)
		<i>Acinonyx jubatus venaticus</i>	(Griffith 1821)
Artiodactyla	Bovidae	<i>Capra aegagrus</i>	(Erxleben 1777)
		<i>Ovis orientalis gmelini</i>	(Blyth 1841)
		<i>Oryx leucoryx</i>	(Pallas 1777)
		<i>Gazella subgutturosa marica</i>	(Thomas 1897)
	Cervidae	<i>Dama dama mesopotamica</i>	(Brooke 1875).
Suidae	<i>Sus scrofa attila</i>	(Thomas 1912)	
Lagomorpha	Leporidae	<i>Lepus capensis arabicus</i> <i>Lepus europaeus connori</i>	(Ehrenberg 1833) (Robinson 1918)
Rodentia	Sciuridae	<i>Sciurus anomal pallescens</i>	(Gray 1867)
	Hystricidae	<i>Hystrix indica</i>	(Kerr 1792)
	Dipodidae	<i>Allactaga euphratica</i>	(Thomas 1881)
	Gliridae	<i>Eliomys melanurus</i>	(Wagner 1840)
		<i>Dryomys nitedula pictus</i>	(Blanford 1875)
	Spalacidae	<i>Nannospalax ehrenbergi</i>	Nehring 1898
	Muridae	<i>Apodemus mystacinus</i>	(Danford & Alston 1877)
		<i>Apodemus flavicollis argyropuloi</i>	(Heptner 1948)
		<i>Rattus rattus</i>	(Linnaeus 1758)
		<i>Rattus norvegicus</i>	Berkonhout 1769)
		<i>Mus musculus praetextus</i>	(Brants, 1827)
		<i>Nesokia indica boxtoni</i>	(Thomas 1919)
	Cricetidae	<i>Cricetulus migratorius cinerascens</i>	(Wagner 1848)
		<i>Gerbillus nanus</i>	(Blanford 1875)
		<i>Gerbillus dasyurus</i>	(Wagner 1842)
		<i>Gerbillus mesopotamiae</i>	(Harrison 1956)
		<i>Gerbillus cheesmani</i>	(Thomas 1919)
		<i>Tatera indica taeniura</i>	(Wagner 1843)
		<i>Meriones persicus</i>	(Blanford 1875)
		<i>Meriones tristrami lycaon</i>	(Thomas 1919)
		<i>Meriones libycus syrius</i>	(Thomas 1919)
		<i>Meriones crassus</i>	(Sundevall 1842)
		<i>Ellobius lutescens</i>	(Thomas 1897)
<i>Arvicola amphibius persicus</i>	(de Filippi 1865)		
<i>Microtus socialis guentheri</i>	(Harrison and Bates 1991)		
Cetacea	Delphinidae	<i>Sousa chinensis</i>	(Osbeck 1765)
		<i>Tursiops aduncus</i>	(Ehrenberg 1833)
		<i>Neophocaenan phocaenoide</i>	(Cuvier 1829)
Balaenopteridae	<i>Balaenoptera musculus</i>	(Linnaeus 1758)	
	<i>Balaenoptera edeni</i>	(Anderson 1879)	
	<i>Megaptera novaeangliae</i>	(Borowski 1781)	

## 2. LITERATURE REVIEW

### 2.2 Family: Spalacidae

The family Spalacidae are represented as subterranean rodents that at present wholly are spread in the Palearctic region (Figure 2.1). The distribution area of the family Spalacidae includes central Asia, north eastern Africa, Balkans, south eastern Europe, Middle East and Caucasia (Topachevski 1969, Savic and Nevo, 1990, Musser and Carleton, 1993). Also in (Hungary, Yugoslavia, Bosnia, Herzegovina, Dobruja, Romania and Greece); The Caucasus and Transcaucasus; through the chemozem belt of the Russian plain (Topachevski 1969).



**Figure 2.1** The Distribution of subterranean mammals across the planet. Palearctic region: *Spalax* (Spalacidae, rodents; SE Europe, Turkey, Near East, N. Africa) (Nevo 1999).

The species *Nannospalax ehrenbergi* initially described by Nehring (1898), on specimens which was collected from Yafa-Israel also occurs in Jordan, Palestine, Libya, Syria, Lebanon, Egypt, Israel, Iraq and Southeast Anatolia of Turkey (Lay and Nadler, 1972; Musser and Carleton, 1993)

*N. ehrenbergi* (Fig. 2.2) distributed in eastern Mediterranean region, this region which these mole rats are found in disjointed areas with appropriate soils for burrowing (Hutchins 2004; Scitteret et al., 2008).



**Figure 2.2.** *Nannospalax ehrenbergi* Shwan .sample .

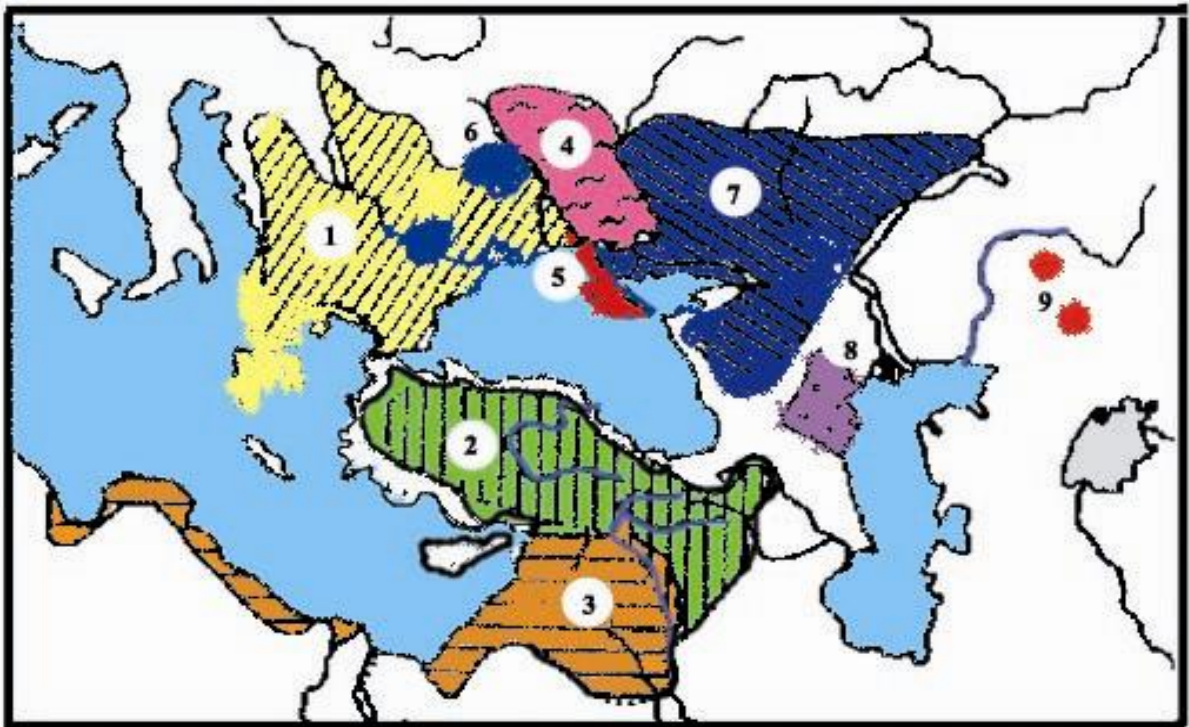
The blind mole rat (*Nannospalax*) spends its whole life underground, protecting itself from predators and climatic fluctuations while demanding it with multiple stressors such as darkness, hypoxia, hypercapnia, energetics and high pathogenicity (Fang et al., 2014).

## 2. LITERATURE REVIEW

### 2.2.1. Classification of Spalacidae

The systematic of blind mole rats (*Spalax*) has been stormily argument over the last century because of their rather identical external appearance and gross cranial, morphology (Németh 2013). The first inclusive work, a landmark in blind mole rat systematics, was published by (Méhely 1909).

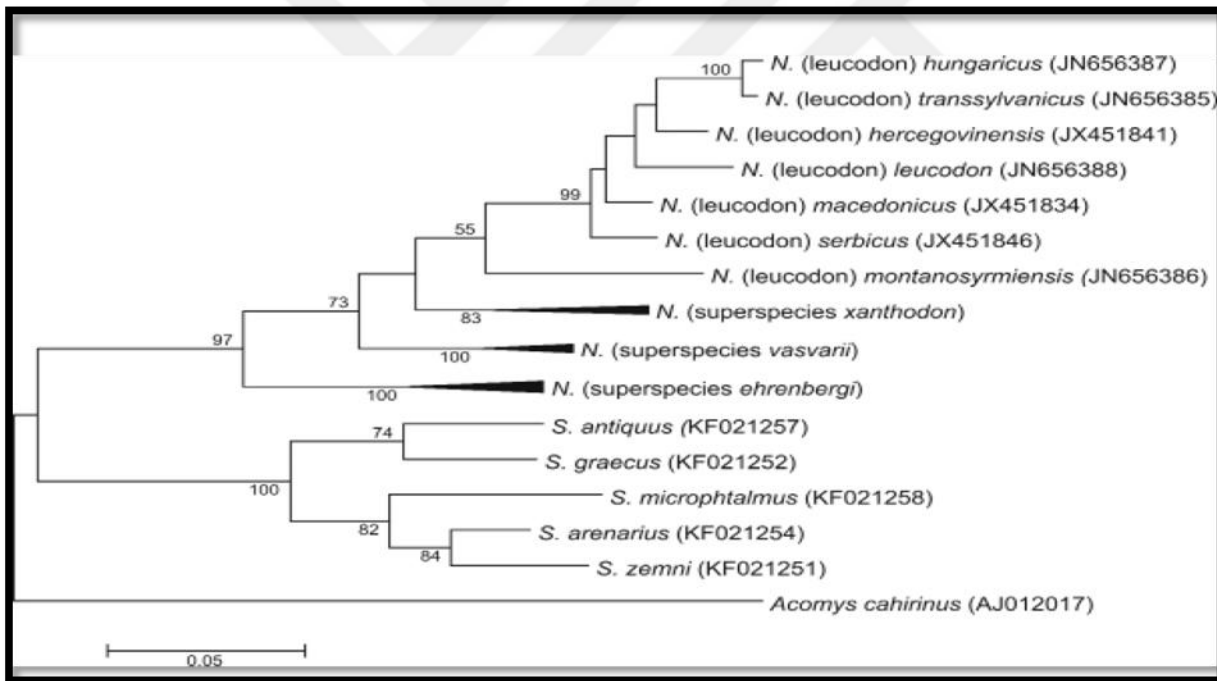
Using morphological traits: morphologically nine species distinguished, base up on biochemical data; the monotypic (Fig 2.3) *S. nehringi*, *S. leucodon*, and *S. graecus*, *S. microphthalmus*, *S. polanicus*, *S. arenarius*, and *S. giganteus* (Ognev 1947, Vorontsov et al.,1977 and Topachevski 1969).



**Figure 2.3** Distribution of Spalacidae species. 1. *Nannospalax leucodon* 2. *Nannospalax nehringi* 3. *Nannospalax ehrenbergi* 4. *Spalax zemni* 5. *Spalax arenarius* 6. *Spalax graecus* 7. *Spalax microphthalmus* 8. *Spalax giganteus* 9. *Spalax uralensis* (Pantalayev 1998).

The phylogenetic separation of the different bodied , large-bodied and small-bodied blind mole rats at the genus-group level (*Spalax* and *Nannospalax*), as optional earlier on morphological grounds (Méhely 1909; Ognev 1947; Topachevski 1969), and strongly supported by the recent molecular biological evidence (Hadid et al., 2012; Chisamera et al., 2014) is further corroborated by the results of the present investigation (Fig 2.4).

Based on the fossil records (Nevo and Bar-El, 1976; Catzefflis et al., 1989), the separation of *Spalax* and *Nannospalax* happened during the dry late Miocene and could be attributed to the establishment of a marine barrier between Asia Minor and the Balkan Peninsula during the Tortonian (Popov et al., 2006; Akkiraz et al., 2011).



**Figure 2.4** Phylogenetic tree showing evolutionary history of *Spalax* (S.) and *Nannospalax* (N.) species based on 870 bp long partial sequence of cytochrome b gene using the Maximum Likelihood method and the Tamura-Nei model (Tamura et al., 2013).

Factors which enable isolation are terrains where this animal cannot dig tunnels in the earth and where there are no conditions for its survival. These are mostly large forest complexes, large bodies of water or humid soil, as well as rocky deserts.

## 2. LITERATURE REVIEW

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### 2.2.2. Spalacidae in Iraq

Cheesman (1920) saw mounds and tunnels of a species of mole rats in Mosul province, which does not occur in South Iraq. Bate (1930) reported bones of *Spalax cf. ehrenbergi* from the Hazar Mard caves near Sulaymaniyah. The specimens from Sarsank seem to be the first complete specimens. The "mole-rat" *Spalax* location in Iraq is found in regions of grassy plains and foothills, and extends upward through forested areas of the Zagros Mts. to timberline (Reed, 1958). The subordinate limit of their distribution has apparently not been recorded (Fig. 2.5).

Jarmo in the Chemchamal Valley of eastern Kirkuk in the region of midway between Kirkuk and Sulymaniyah the species there is *S. leucodon* (Hatt, 1959). Harrison (1956) later obtained mole rats on Ser Amadiya and at Tinn near Bermaneh. The rodent fauna from Palegawra, in northeastern Iraq, is dominated by *Spalax* and *Meriones* (Turnbull and Reed, 1974).

*Nannospalax ehrenbergi* was found in Mosul-Jurn (Coşkun et al., 2012). Recently recorded as *Spalax leucodon* from Hawraman Mts. (Lahony et al. 2013). The absence of *Spalax* from true desert is in contrast to its ubiquitous presence in the Mediterranean region.

Although *N. ehrenbergi* species (Hadid et al., 2012), uncertainty remains about the taxonomic rank as well as the nomenclature of the Iraqi karyotype, which is widely distributed also in southeastern Anatolia.

Montagu (1924) observed *Spalax leucodon* in the high mountains region of the northern corner of Iraq within a few miles of the Iranian and Turkish borders and in Zagros Mountain that rise to the north and east.



**Figure 2.5.** Sampling localities and geographical range of *Nannospalax ehrenbergi* in Iraq (Old records, 1. Near Sulaymaniyah (Bate 1930), 2. Near Mosul (Cheesman 1920), 3. Sarsank (Hatt 1959), 4. Ser ‘Amadia and Tinn (Harrison 1956), 5. Jarmo, Chemchamal Valley (Reed 1958), 6. Jarmo, Palegawra Cave (Turnbull and Reed 1974) 7. Mosul (Coşkun et al., 2012).

## 2. LITERATURE REVIEW

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### 2.2.3 *Nannospalax ehrenbergi* (Palestinian Mole Rat)

The first description of species *Nannospalax ehrenbergi* done by Nehring (1898) on specimens which collected from Yafa-Israel. It also occurs in Palestin, Syria Libya, Jordan, Lebanon, Egypt, Iraq and Southeast Anatolia of Turkey (Lay and Nadler, 1972; Musser and Carleton, 1993).

*N. ehrenbergi* (Fig. 2.3.) distributed in eastern mediterranean region, this region which is these mole rats are found in disjointed areas with suitable soils for burrowing (Hutchins 2004; Schiltter et al., 2008). *N. ehrenbergi* is a primary consumer and through its diet of underground plant seeds, roots, and tubers. it shapes and defines that plant biodiversity and availability in an ecosystem (Fig 2.6) .The extensive burrowing and tunneling activitie of this species also effects the nutrient water and air composition of soils (Hutchins 2004; Schiltter et al. 2008) .



**Figure 2.6.** *Nannospalax ehrenbergi* location in Bardarash

The animal lives in a deep nest below a large mound and excavates deep burrows (Fig 2.7) In October one finds an entirely new and larger breeding mound in which copulation seems to take place in December and January. The female remains in the breeding mounds till term in January to March and the young begin to disperse from here during April and May, with the onset of the dry summer season. There is a renewed construction of resting mounds and deep tunnel system (Nevo 1961).



**Figure 2.7** Tunnel system of female *N. ehrenbergi* in Mughagh village.

## 2. LITERATURE REVIEW

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The common phenomenon in most subterranean rodents is Food storing (Nevo et al. 1999, Busch et al .2000). The amount of stored food may reflect either the food accessibility in a given habitat or the requirement to store food in less productive habitats.

The role of food storing for the blind mole rat survival should be deliberate under more stressful conditions, such as in the advanced dry season with hard soil and reduced above ground vegetation (Fig. 2.8, A and B).



**Figure 2.8.** A. Roots of plant in *Nannospalax ehrenbergi* tunnels from Mughagh village B. bulbs of plant (Xalephan region ) in *Nannospalax ehrenbergi* location.

## 2.3. STUDY AREA

### 2.3.1. General Information

The territory of Iraq is comprised between latitudes 29° to 38° N and longitudes 39° to 49° E (a small area lies west of 39°) and spans over 437,072 km<sup>2</sup>, with a total area of 438 320 km<sup>2</sup>. Iraq is a southwest Asian country that is surrounded by Turkey to the north, Iran to the east, Syria and Jordan to the west, and by Saudi Arabia and Kuwait to the south (Fig 2.9). The country has high rocky mountains along its border with Iran and Turkey. Iraq's elevation tapers to the south and west as it transitions through the fertile Tigris and Euphrates basins to the Syrian Desert and the red sand deserts of the An Nafud in northern Saudi Arabia.



Figure 2.9. Shaded Relief Map of Iraq.

## 2. LITERATURE REVIEW

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While the province of Iraq consists chiefly of lowlands that rarely exceed 300m in elevation (McFarlane et al , 2002), the country can be divided into four major geographic regions: rolling uplands between the Euphrates and Tigris rivers; highlands in the north and northeast; desert in the west and southwest and alluvial plain in the central and southern sections ( Zohary 1973).

In the north of Iraq is mountainous as the Zagros Mountains front its borders with Iran and the country's highest point is located there, an unnamed peak rising 3,611 m. The north and east of Iraq it is barred by the foothills of the Kurdistan mountains. This is in the main an undulating plain crossed diagonally by the Jabal Hamrin range. It is built mainly of chalks and marls covered by sand on blows; it rises up northwards to 300 m (n. Mosul) and there it is extensively dry farmed. A number of undrained basins are scattered at this point (Zohary 1973).

The landscape includes high mountains in the north (Kurdistan), desert, arid lands and sandy steppes in the western and south-western plateau (Al-Badiyah) and the Mesopotamian marshlands in the southern alluvial plain. This wide range of habitats awards Iraq with a noticeable biodiversity, the wild mammals being not an exception (Table 2.1) (Al-Sheikhly et al. 2015b).

### 2.3.2. Climate

The climate of Iraq is generally of the Mediterranean type, in the northernmost part mainly a hot desert climate or a hot semi-arid climate . Generally the averages high temperatures are above 40 °C at low elevations during summer months (June, July and August) while averages low temperatures can drop to below 0 °C during the coldest month of the year during winter (Table 2.2). The annual rainfall varies from 40.5 (Kirkuk) 42. 0 cm (Mosul), 43.0 cm (Erbil). Most of the rainfall occurs from December through April. The mountainous region of northern Iraq. receives appreciably more precipitation than the central or southern desert region. Also, winter snows are reported in Iraq (Fig. 2. 10).

The Kurdistan Region of Iraq has a separate continental interior climate of the Mediterranean type with hot and dry summer, while the winter is cold and wet (Fig 2.10) , The cold months are December, January and February while the hot months are June, July and August .



**Figure 2.10** Regional Köppen climate classification of Iraq

The region falls under the impact of the Mediterranean anticyclones and subtropical high pressure belts during the summer. But In the winter, the region is invaded by Mediterranean cyclones moving east to northeast through the region. The autumn and spring are very short with mild temperatures (Stevanovic and Markovic, 2004).

## 2. LITERATURE REVIEW

The indicate annual rainfall in the region which occurs mainly during winter and spring is about 500 mm, and it is extraordinary to have rainfall between June and September. As it is clarified here in after, this climate has affected mainly on the unevenness of the valleys. In Western Zagros Ranges of Iraqi Kurdistan is clear valley's asymmetry in cross section, which can be developed by lithological and structural contrast of the two sides of the valleys; in addition to the direction of the topographic slope with respect to geologic structures (Karim et al. 2014) .

The climate is characterized by warm summers and cold winters in the mountains of the north and northeast. Heavy snowfalls occur in the winter and rainfall occurs mainly in winter and spring, with minimal rainfall in summer. Above 1,500 m and there is some thunderstorm activity in the summer. Annual precipitation for the whole region ranges from 40 to 100 cm. few nights are cloudy in summer and about half of the days are cloudy in winter (Table (2.2)).

**Table 2.2** Iraqi Annual temperatures (° C) in different location according the seasons.

Region	Winter		Summer		Extremes	
	Min	Max	Min	Max	Min	Max
Mountains	-4°	5°	15°	25°	-30°	42°
Rolling Upland	3°	13°	25°	40°	-12°	49°
Tigris/Euphrates Delta	4°	18°	25°	40°	-7°	51°
Western/Southern Desert	9°	16°	20°	40°	-14°	49°

**Kirkuk Climate:**

The existing climate in Kirkuk is known as a local steppe climate. There is little rainfall in Kirkuk during the year, This location is classified as BSh by Köppen and Geiger. The average temperature in Kirkuk is 21.6 °C , The average annual rainfall is 365 mm (Figure 2.11.A).

**Erbil Climate:**

The climate in Erbil is mild, and generally warm and temperate. There is more rainfall in the winter than in the summer in Erbil. The Köppen-Geiger climate classification is Csa. The averages temperature is 20.2 °C. In a year, the average rainfall is 543 mm.

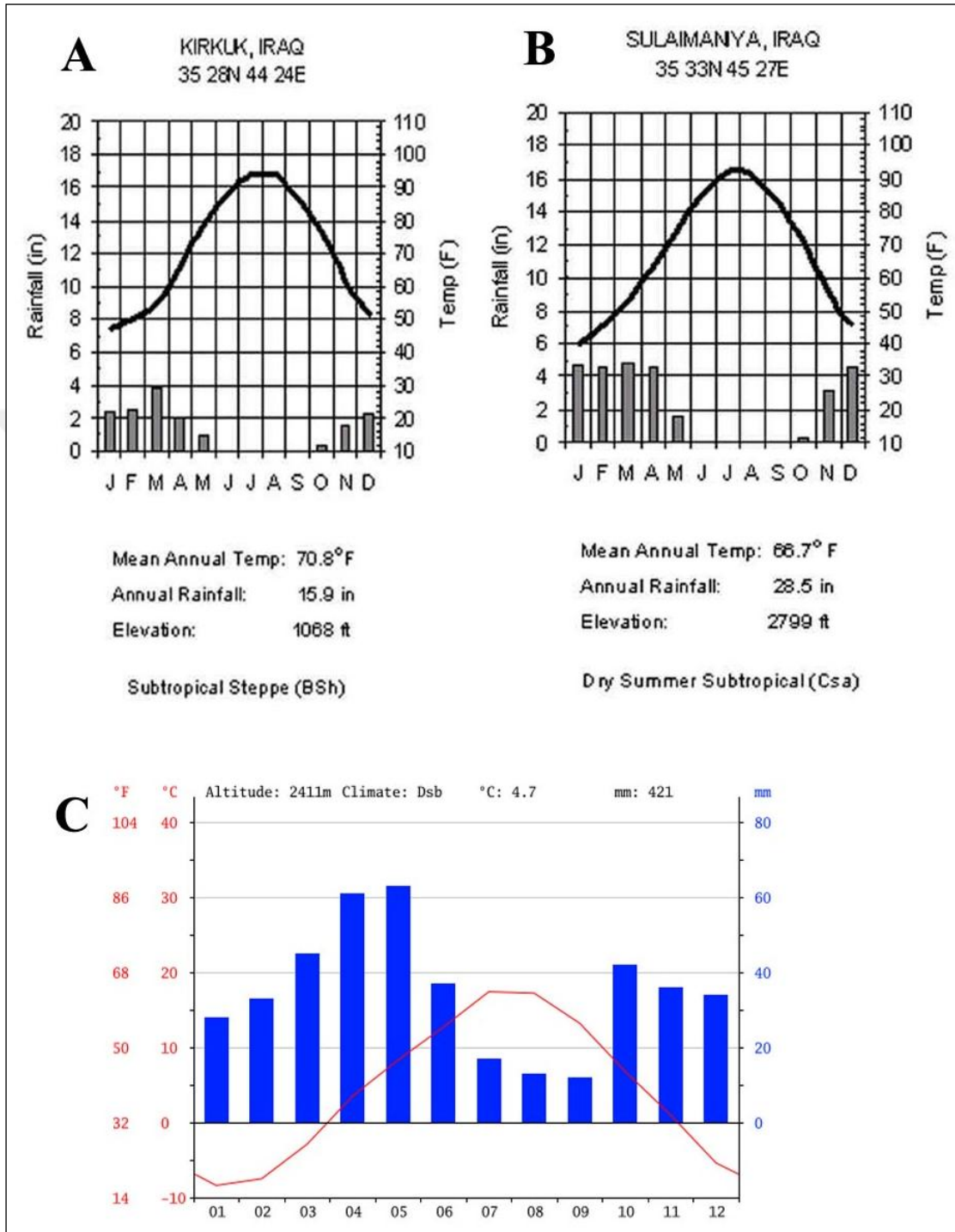
**Sulaymaniyah Climate:**

In January, the average temperature is 3.8 °C. It is the lowest average temperature of the whole year. The warmest month of the year is August with an average temperature of 31.4 °C. The driest month is June with which is precipitation 0 mm. Most precipitation falls in February, with an average of 146 mm. The difference in precipitation between the driest month and the wettest month is 146 mm. The average temperatures vary during the year by 27.6 °C (Figure 2.11.B).

**Bardarash Climate:**

In Bardarash-e Olya, the average annual temperature is 4.7 °C. About 421 mm of precipitation falls annually . Generally, it is cold and temperate. There is more rainfall in the winter than in the summer in Bardarash-e Olya. The Köppen-Geiger climate classification is Dsb. (Figure 2.11.C) .

## 2. LITERATURE REVIEW



**Figure 2.11** A- Climographs for Kanaqin and Kirkuk, B. Annual temperature in Sulaymaniyah region. C. Average rainfall in (Bardarash) the least amount of rainfall occurs in September.



### 3.MATERIALS AND METHODS

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### 3. MATERIAL AND METHODS

#### 3.1. Material collection

The study was carried out on 15 mole rats, (5 males and 10 female) collected from different location (4 samples from Mughagh village) about 55 km far from Sulaymaniyah (4 samples from Shwan city ) 50 km far from Kirkuk, (5 samples from New Erbil near Erbil), (1 sample male from Xalephan city was died) and (1 sample from Bardarash) 60 km far from Duhok (Fig 3.1). The coordination of each place is (Mughagh is 35°.47' N-45°.06' E. Elevation-775 m) and It is grassy place and the location is Valley. You can found the animals there all time of the year and in summer by the water which pass through this location. Shwan city (35°.45' N- 44°.27' E. Elevation 689 m), another location is (35°.43 N-44°.27 E. Elevation 610 m). Its land location and very hot no animals have been appear just after a heavy raining because the animals going to a deep part of the ground by the high temperature at about (40-43° C) , Erbil (36°.12 N-44°.3 E. Elevation 463), and Bardarash (36°.29 N-43°.35 E. Elevation 455 m).

The determination of location wich is *Spalax* present it by presence of this hills (mounds) which made by the animal (Fig 2.6) during removing the soil above the hole to make burrow under the ground.

#### 3.1.1. Catching animals

- ✓ At first it should be remove all soil which present above the hole
- ✓ discover the direction of the burrow. with a stick If there are more direction of borrow, open one hole it should close another and remains one of them after make sure of the direction for the tunnel,
- ✓ then thickness this one hole to burrow direction about 20-30 cm by close the way of the back side with hole designed for this purposes.
- ✓ wait until the animal start to work and cut the tunnel back side the animal with a hoe then remove more soil to outside the hole it's easy to catch It at this time (Fig 3.2).

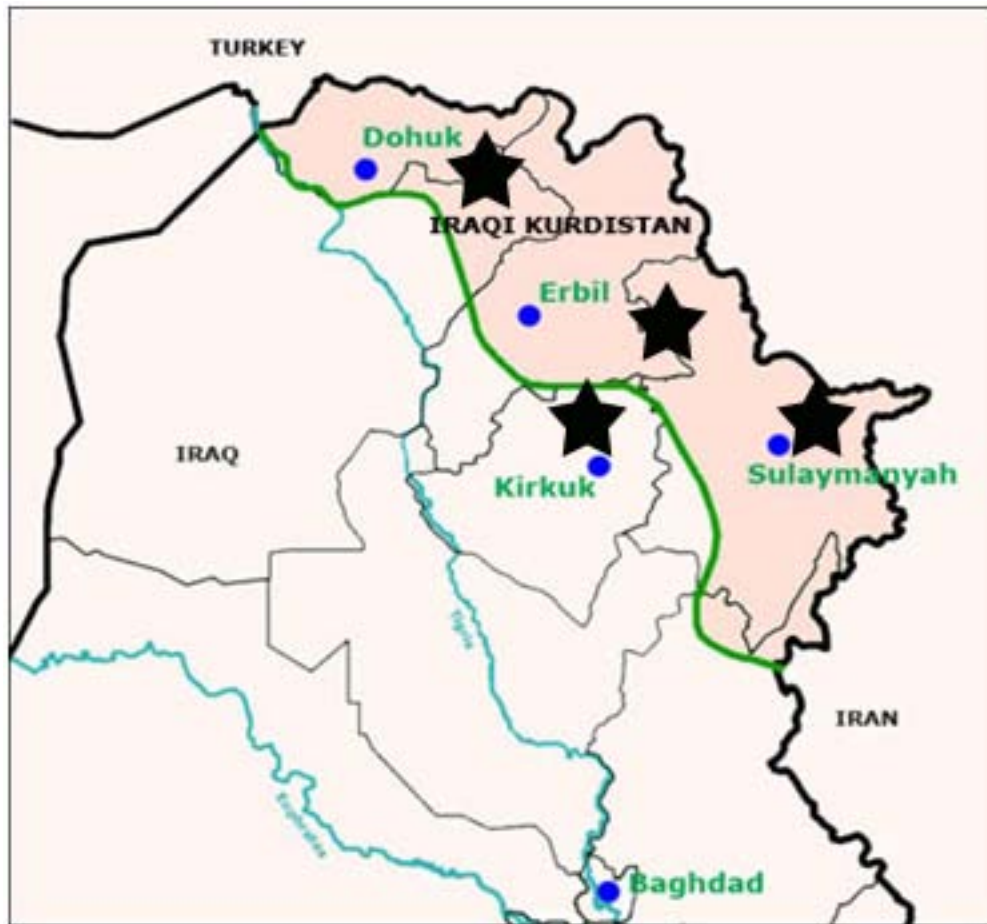


Figure 3.1 The location of sample collection in Iraqi Kurdistan region.

### 3.MATERIALS AND METHODS

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#### 3.2. Methods

##### 3.2.1. Karyotype Preparation

Karyotypes of animals in bone marrow metaphase chromosome obtained as described by (Lee and Elder, 1980). Slides were conservatively stained with 10% Giemsa solution well extend metaphase were recorded using a camera attached to a microscope. Karyotypes were prepared from the best metaphase; chromosomes were paired by eye using the position of centromere and chromosome size. To increase number of mitosis division (that's very important for obtaining good be result ) it would be better to inject the animals with yeast (2-3 g of dry yeast,5-6 g glucose and 25 ml of distilled water 2 days before sacrifice, water incubate at 40 for 20-40 min. This solution 0.5 ml for 25 g of most body inject under skin twice). Preparation procedure is following;

##### 3.2.2. Bone Marrow Preparation:

1. The 0.4% mg solutions of colchicines inject intra peritoneal for 30 minute. 1 ml for the solution for 100 g body mass.
2. The bone marrow cells remove by a syringes which 0.075 ml solution of KCl (560 mg KCl in 100 ml of distilled water into conical bottom tube, resuspend cells with syringe and incubate for 10 min at 37°C.
3. Spin the suspension for 5 min at 1000-1500 rpm.
4. Carefully remove the supernatant and very slowly add the fix solution (methanol and glacial acetic acid) in the proportion 3:1 and leave the tube with the suspension at 4 °C for 30 min.
5. Change the fix solution each 5 mint 4 times, store the fix and tube with fixed suspension at 4 °C keep the tube with the fixative solution, before preparing the slid at 4 °C for 12h.
6. The suspension with the last portion of fix resuspend the resulting suspension should be slightly cloudy.
7. Slide making; - Two drops of cell suspension from syringe is dropping in to the wet cooled slid and allowed to air dry.

8. Remember, the microscope slide must be very clean the hypotonic solution and fix must be made up immediately prior to use. The most important detail; for good banding results the age of the chromosomes slides must be not older than two weeks, it would be better to store the chromosome slides at the low temperature.



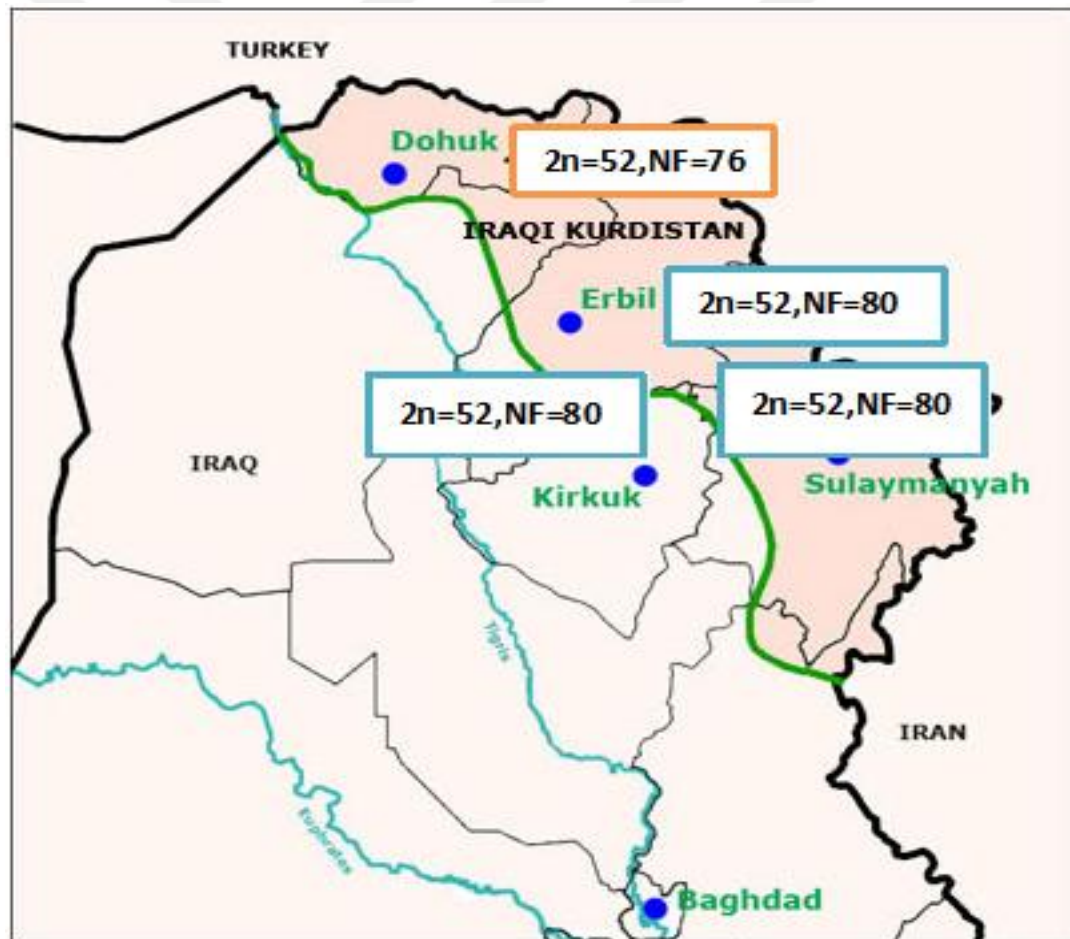
**Figure 3. 2.** Field work catching animals (*Nannospalax ehrenbergi*).

## 4.RESULTS AND DISCUSSION

### 4. RESULTS AND DISCUSSION

#### 4.1 Results

North Iraqi mole rats are morphologically similar and all samples have a supracondyloid foramen above both sides of the occipital condyles and two enamel islands on the chewing surface of the third upper molar ( $m^3$ ) and upper molars were three rooted (Topachivskii 1969, Ellerman 1940). The anterior surface of the upper incisors had two longitudinal ridges (Fig 1.1). All these character accord with the diagnoses of *Nannospalax ehrenbergi*, given by (Nehring 1898).



**Figure 4.1.**Chromosom number (2n) and fundamental number of chromosome arm (NF) of *N. ehrenbergi* in north Iraqi (Kurdistan region).

**Duhok Population:**

The karyotype of Bardarash locality was  $2n = 52$ ,  $NF = 76$ ,  $NFa = 72$  which consists of 11 pairs of metacentric/submetacentric autosomes, and 14 pairs of acrocentric autosomes. The X chromosome was large and metacentric (Figure 4.3). Mole rats of this locality (Duhok, Mosul Population) inhabit in the north of great Zap river (Table 4.1). The karyotype of Bardarash similar to Mosul sample  $2n=52$  . $NF=76$ . $NFa=72$  (Fig 4.2).

**Erbil Population:**

Male from Erbil has  $2n= 52$ ,  $NF= 80$ ,  $NFa= 76$ , Karyotype consist of 13 pairs metacentrics and submetacentric and 12 pairs acrocentric autosomes. X chromosome is big size and metacentric Y chromosome small and acrocentric. (Fig 4.4) The karyotype of Bardarash similar to Mosul sample  $2n=52$   $NF=76$ . $NFa=72$ . But karyotype of Kirkuk, Sulaimaniah, and Erbil are similar to each other which located south part of the Great Zap river (Table 4.1).

**Kirkuk Population:**

Diploid chromosome number  $2n=52$ ,  $NF=80$ ,  $NFa=76$  .Have the karyotypes of females specimens from Shwan (50 km north Kirkuk) 13 pairs had meta and submetacentric 12 pairs acrocentric, X chromosome large and metacentric (Fig 4.5) The karyotypes of mole rats *Nannospalax ehrenbergi* (Nehring 1898) from two closely located populations from Kirkuk province, Iraq, were investigated. The species occurrence in Iraq, based on literature overview and the present study, was up dated (Fig 4.2).

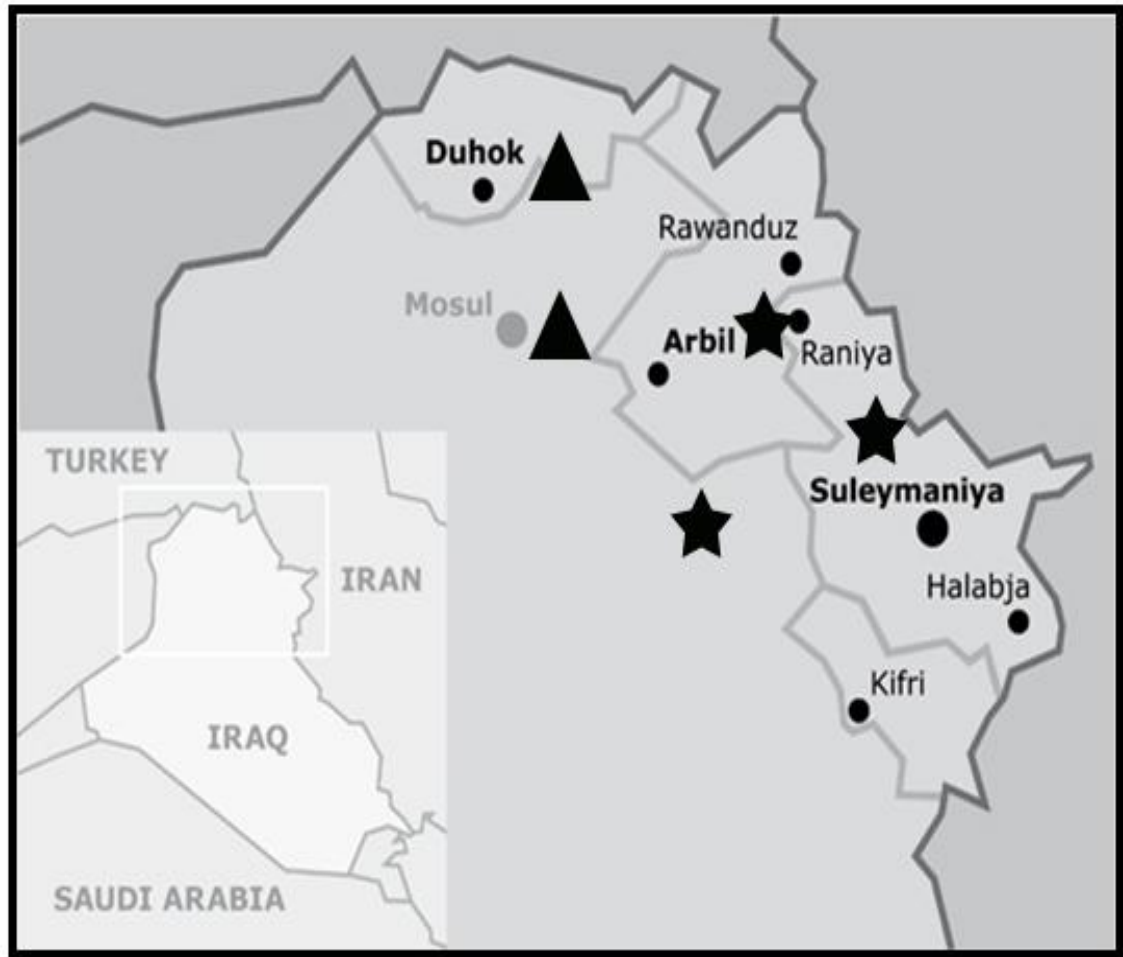
**Sulaymaniyah Population:**

The diploid number of chromosome is  $2n=52$ ,  $NF=80$ ,  $NFa=76$ , Males from Mughagh (55 km west Sulaymaniyah) 13 pairs metacentric and submetacentric, 12 pairs acrocentric, and X chromosome large and metacentric and Y chromosome small and acrocentric (Fig 4.6).

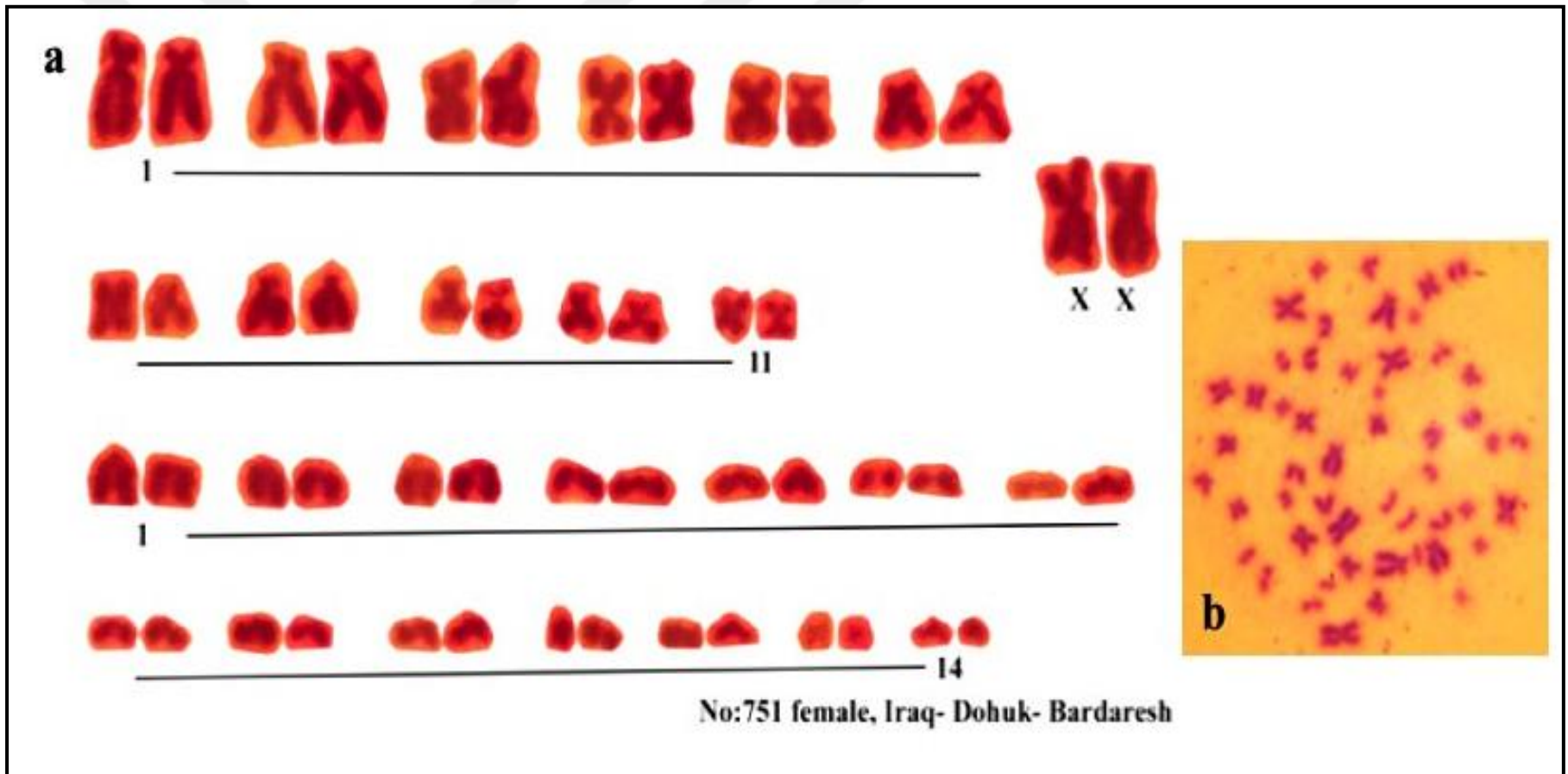
#### 4.RESULTS AND DISCUSSION

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The differences in arm number in mole rats the north Iraq can be explained by the changing of centromeric position or pericentric inversion in a small pair of autosome (Fig 4.1).



**Figure 4.2.**Chromosom number( $2n=52$ ) Iraq, Kurdistan region. Erbil- Sulymaniyah- Kirkuk, NF=80 (Star), Bardarash-Mosul, NF=76 (Triangle).



**Fig 4.3.** The karyotype of female *Nannospalax ehrenbergi* from the Duhok Bardarash, No: 751. **a.** Karyotype, **b.** Metaphase plate.  $2n= 52$ ,  $NF=76$ ,  $NFa= 72$ ).

#### 4.RESULTS AND DISCUSSION

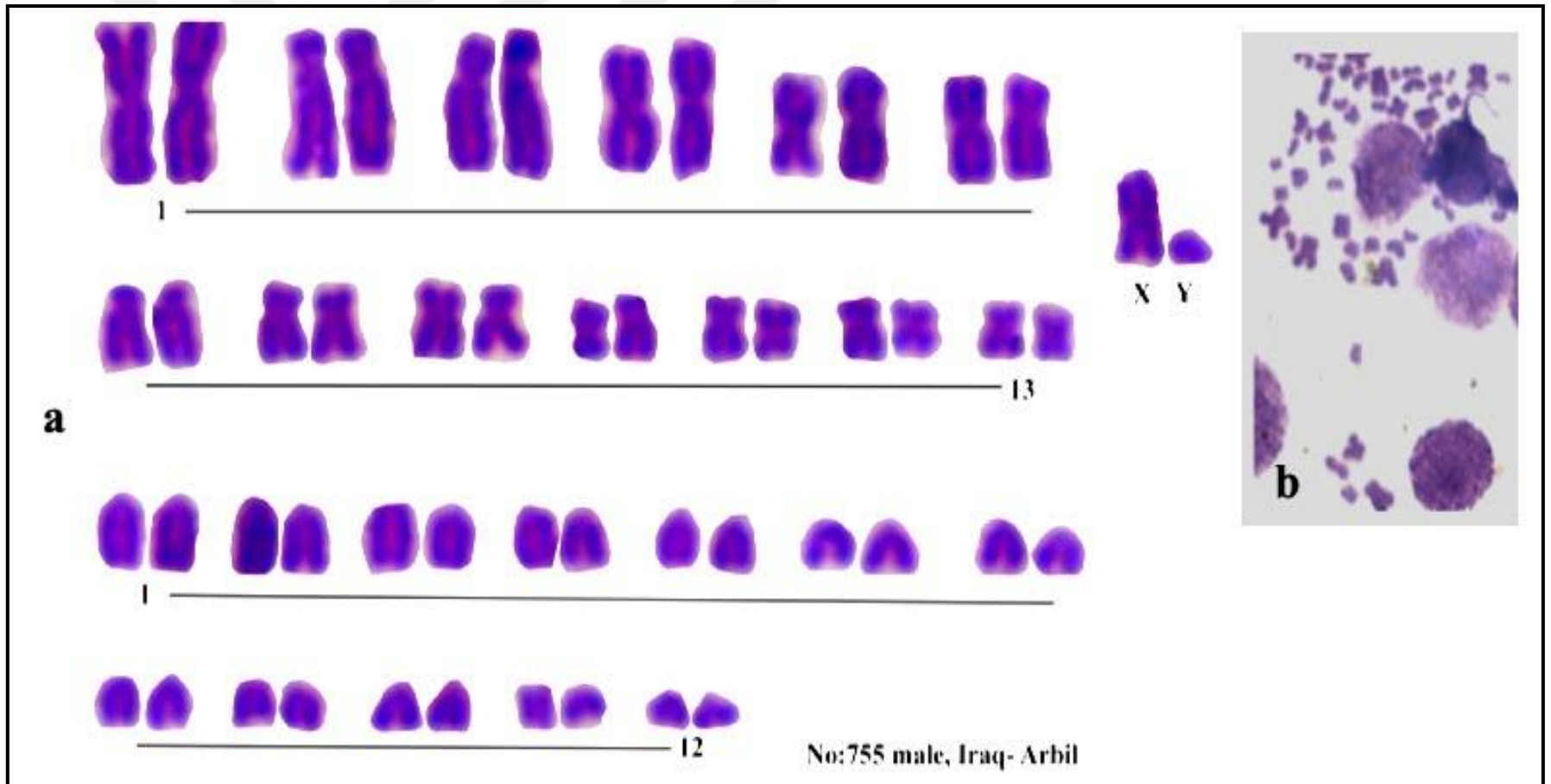
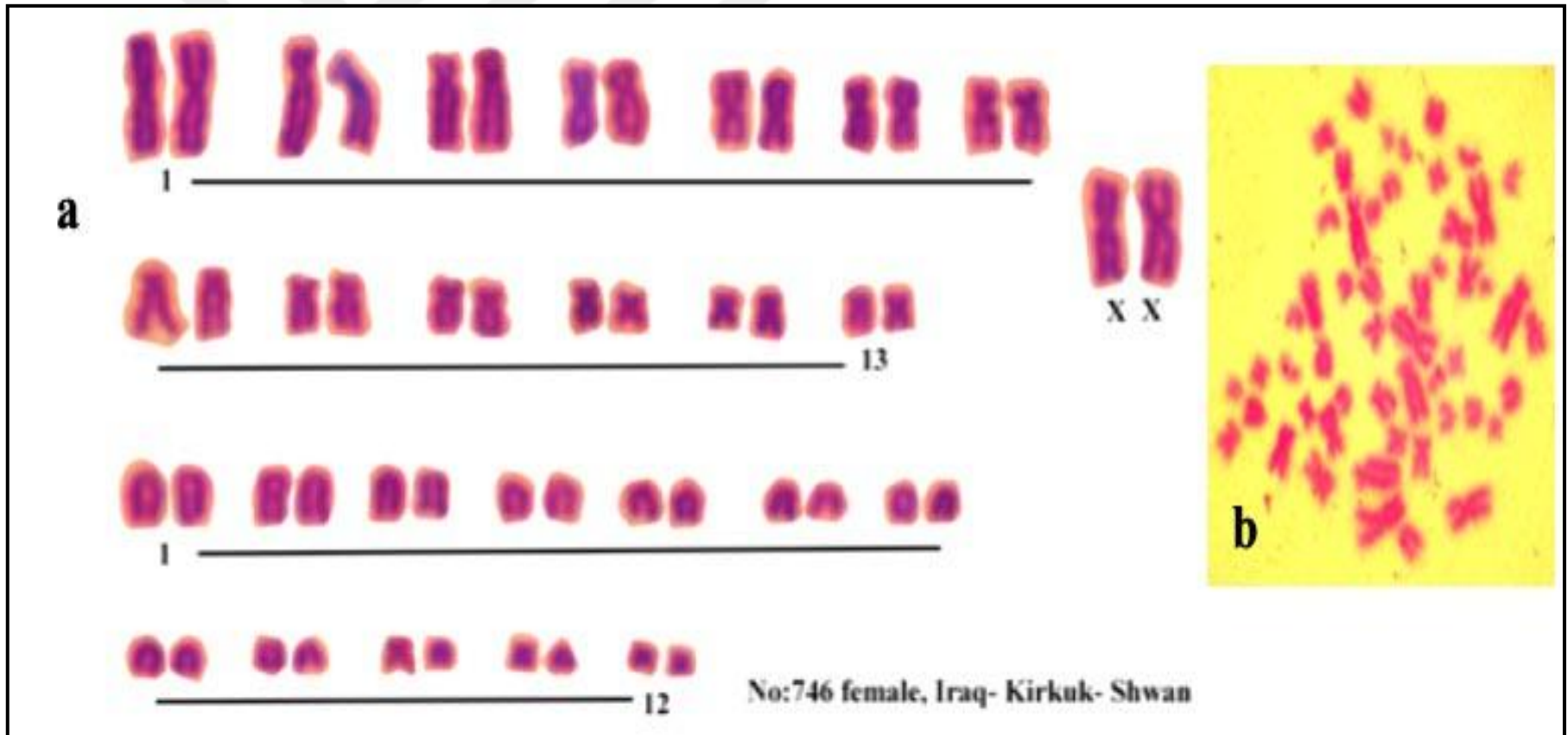
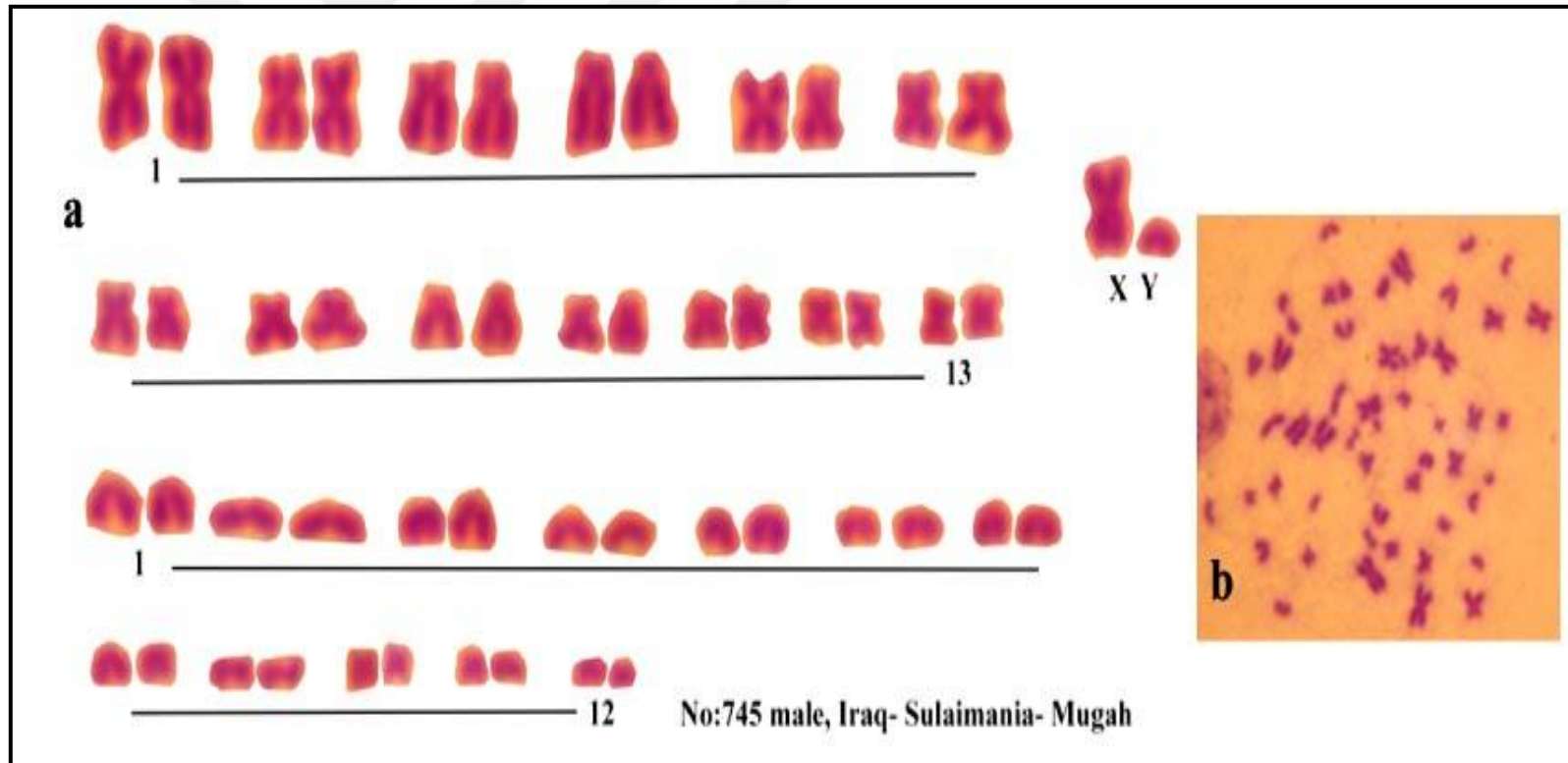


Fig 4.4. The karyotype of male *Nannospalax ehrenbergi* from the Erbil, New-Erbil No: 755. a. Karyotype, b. Metaphase plate.  $2n= 52$ ,  $NF=80$ ,  $NFa=76$ .



**Fig 4.5** The karyotype of a female *Nannospalax ehrenbergi* from Kirkuk –Shwan No: 746. **a.** Karyotype, **b.** Metaphase plate.  $2n= 52$ ,  $NF=80$ ,  $NFa=76$ ).

#### 4.RESULTS AND DISCUSSION



**Fig 4.6** The karyotype of a female *Nannospalax ehrenbergi* from Sulaimaniyah ,Mughagh No:745 , **a.** Karyotype, **b.** Metaphase plate.(  $2n= 52$  . NF=80, NFa=76)

**Table 4.1** Localities, sample size(N), diploid chromosome numbers (2n), and chromosomal arm numbers (NF), Autosomal arm number (NFa), Sex of animals. , **m**: metacentrics, **sm**: submetacentrics, **a**. acrocentric

City	Locations		N	2n	Autosomes		NF	NFa	Gonosomes		Reference
	Town	Village			m/sm	a			X	Y	
<b>Kirkuk</b>	Shwan		4 ♀	52	13	12	80	76	Sm	.	
<b>Sulaymaniyah</b>	Dukan	Mughagh	2 ♂, 2 ♀	52	13	12	80	76	Sm	a	<b>This study</b>
<b>Erbil</b>	New Arbil		2 ♂, 3 ♀	52	13	12	80	76	Sm	a	
<b>Duhok</b>	Bardarash	Zamzamok	1 ♀	52	11	14	76	72	Sm	-	
<b>Mosul</b>	Al Jurn		3 ♂	52	11	14	76	72	Sm	a	Coşkun et al. 2012
<b>Erbil</b>	<b>Xalephan</b>		1 ♂	death							

### 4.2. DISCUSSION

In the past studied karyotypes characterized from techniques ranging from classical staining and banding to molecular cytogenetic approaches from chromosome paints to cloned DNA will serve as basis for high decision maps construction for hundreds of mammalian and vertebrate species (Graphodatsky et al,2013).

Higher rates of karyotype evolution occur in placental mammals (Wilson et al, 1974), in small population (Lande 1979; 1985), in species rich genera (Bengtsson, 1980), and with limited mobility as in the Spalacidae (Wahrman et al, 1969).

The increase of acrocentrics occurs by Robertsonian fission, the divergence in the number of the chromosome arms happen by centromeric translocation (Savic & Soldatovic 1979, Yüksel 1984, Nevo et al. 1994, Lahony et al. 2013).

Mole rats belonging to the *Nannospalax ehrenbergi* are two chromosomal forms that widely distributed in Iraq. A chromosomal form is  $2n= 52$  and  $NF= 76$ ,  $NFa= 72$ . This chromosomal form inhabit (Duhok, Mosul Population) in the north of great Zap, and the other  $2n= 52$  and  $NF= 80$ ,  $NFa= 76$  (Erbil, Sulaymanyah-Kirkuk populations) in the south of great Zap.

The divergence in arm number in mole rats the north Iraq can be explained by the changing of centromeric position or pericentric inversion in a small pair of autosome.

Only (one) chromosomal form was presented by Coşkun et al. (2012) from Mosul, Iraq. Samples in Mosul are accepted as *N. ehrenbergi* (Coskun et al. 2012).

Reed (1958), Hatt (1959), Turnbull and Reed (1974) Harrison and Bates (1991), Lahony et al. (2013) said that mole rat samples in all Iraq are *S. leucodon* but our results show that all samples in the north of Iraq are *Nannospalax ehrenbergi* not *Spalax leucodon*.

Through Robertsonian variation two acrocentric chromosomes may fuse at the centromere to produce one bi-armed chromosome. Thus, this mechanism allows for the evolution of the karyotype in such a way that the diploid number is reduced but the fundamental number is kept constant.

On the other hand, may change by pericentric inversions through which some acrocentric chromosomes may be converted into a bi-armed chromosome without changing chromosome number (Patton 1967; Swanson 1965; Savic and Soldatovic, 1979).

The autosomes arm numbers have been explained by pericentric inversions (Wahrman et al., 1969) or by centromeric shift (Nevo et al., 1994). The main trend in the chromosomal evolution of *Nannospalax* is the process of Robertsonian rearrangements, and changes in the autosome arm numbers can be explained by pericentric inversions or centromeric shifts (Nevo et al., 1995; Ivanitskaya et al., 1997; Ivanitskaya and Nevo, 1998).

The change in chromosome numbers for *N. ehrenbergi* was an outcome of the Robertsonian rearrangements. According to the results, NF variation was the result of pericentric inversions.

Nevo et al. (1994) suggested that there was a trend, from lower chromosome number to higher number, correlated with aridity stress. Chromosomal changing mechanism is independent of climatic peculiarities.

There are 3 *Nannospalax* species distributed in Turkey: *N. leucodon*, *N. nehringi*, and *N. ehrenbergi* (Topachevskii, 1969; Wilson and Reder, 1993; Krystufek and Vohlarik, 2005; Yiğit et al., 2006). But in Iraq only one species *N. ehrenbergi* (Coşkun et al. 2012).

The taxonomic categories with a large number of acrocentric chromosomes are more primitive. New species have been formed during the speciation process through Robertson fusion of acrocentric chromosome. This leads to a decrease of the diploid number of chromosomes and at the same time to a decrease of a number of acrocentric pairs autosomes, and to the appearance of a greater number of meta and submetacentric autosomes (Harding 1950).

The sex chromosomes were the least susceptible to changes. The X chromosome is always submetacentric and of almost the same size, with a relative size of 50 % which corresponds to the size of this chromosome in most animals. Variations in size and type of the Y-chromosome are slightly higher. It appears most frequently as a small acrocentric to sub acrocentric chromosome (Ohno et al., 1966).

## 4.2 DISCUSSION

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Multiple adaptive systems (genetic, morphological, physiological, ecological, behavioral and biochemical) characterize each species, adapting it to its unique ecogeographical climatic region and stresses (Nevo and Cleve 1978).



## 5. CONCLUSION

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### 5. CONCLUSION

In conclusion, all samples have supracondyloid foramen above both sides of the occipital condyles; two enamel islands on the chewing surface of the third upper molar ( $m^3$ ); upper molars were three rooted; the anterior surface of the upper incisors had two longitudinal ridges. All these characters accord with the diagnoses of *N. ehrenbergi*, given by (Nehring 1898, Ellerman 1940, Topachivskii 1969).

All samples have  $2n=52$  diploid chromosomes. Duhok (Bardarash), Mosul populations (Coşkun et al, 2012) karyotypes have 11 pairs of meta/submetacentric, 14 pairs acrocentric, and large commodity X, and Y is small acrocentric. Diploid chromosome numbers are  $2n = 52$ ,  $NFa = 72$ ,  $NF = 76$ . But Erbil, Sulaymaniyah and Kirkuk samples have 13 pairs of meta-submetacentric, 11 pairs acrocentric and large commodity X, Y is small acrocentric. Diploid chromosome numbers are  $2n = 52$ ,  $NFa = 76$ , was found as  $NF = 80$ . In this study, two chromosomal forms of *Nannospalax ehrenbergi* are distributed in Iraq, which was emerged.

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### **Published Papers**

1. Coşkun Y. Hamad ZA , Kaya A,2016 . Morphological properties of *Nannospalax ehrenbergi* (Rodentia Spalacidae Distribution in North Iraq. Hacettepe J.Bio and Chem. Vol.43....(Accepted for publication).

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- 1.Coşkun Y. Hamad Z.A., Kaya A. 2015. Kuzey Irak'ta Dağılışı Gösteren *Nannospalax ehrenbergi* (Mammalia:Rodentia) Türünün Karyolojik Özellikleri. XII. Ulusal Ekoloji ve Çevre Kongresi, Sözlü Sunumu Bildiri Özet Kitapçığı p:64,13-17 Eylül 2015 Muğla.
- 2.Coşkun Y. Hamad Z.A., Kaya A. 2015. Kuzey Irak'ta Dağılışı Gösteren *Nannospalax ehrenbergi* (Rodentia: Spalacidae) Türünün Morfolojik Özellikleri. VI. Ekoloji Sempozyumu, Sözlü Sunumu Bildiri Özet Kitapçığı p:35, 6-9 Mayıs 2015 Sinop.





**Male mounds of *Nannospalax ehrenbergi* Kirkuk Shwan region ( December 2014).**