

Morphological comparison of fourteen species of the genus *Meriones* Illiger, 1811 (Rodentia: Gerbillinae) from Asia and North Africa

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Genus *Meriones* is the dominant member of gerbils in the Palaearctic region, particularly in aride region of Asia. This is also one of the most typical genus of subfamily Gerbillinae with about 17 morphospecies namely: *M. persicus*, *M. hurrianae*, *M. zarudnyi*, *M. vinogradovi*, *M. meridianus*, *M. libycus*, *M. crassus*, *M. tristrami*, *M. rex*, *M. tamariscinus*, *M. unguiculatus*, *M. shawi*, *M. grandis*, *M. sacramenti*, *M. dahl*, *M. cbengi*, *M. arimalius*. Of which first eight species have been recorded from the Iranian Plateau. There are minor differences between some species and hence, interspecific discrimination of specimens from each species is not always possible, even by polytechnic methods using different taxonomic characters such as tympanic bullae, suprarectal triangle and external characters on material from museums and dental characters on archeozoological materials. Here, 26 morphological characters of 384 museum specimens belonging to 14 morphospecies of *Meriones* from North Africa, Iran and Central Asia were studied. This study review, 14 species of *Meriones* and based on the results, it seems that *M. libycus*, *M. crassus* and *M. meridianus* are complex species and need taxonomic revision. The cladistics analysis shows that *M. vinogradovi* could be forming ancestral species of genus *Meriones*, and west of Caspian Sea could be the center of origin for *Meriones*. Due to the presence of convergence regarding adaptation of different species of *Meriones* to similar environment, subgeneric morphological characters may cause homoplasies and paraphyletic subgenera the analysis of morphological character states matrix, using Mix program of Phylip shows different four clades that did not conform to the nominative subgenera and unveil probable homoplasy.

Key words: *Meriones* species, Morphology, phylogeny

INTRODUCTION

Genus *Meriones* is the most typical member of gerbils, dominant in the Palaearctic region, with large adaptive characteristics. This genus, as a member of Rhombomyina, by narrow interorbital constriction and braincase width, upper incisors with one groove and the nearly equal length of lacrimal bone is distinguishable from other genera. Molar is always with well developed root, unlike *Rhombomys*, with narrow longitudinal bridglets connecting lamina, with these bridglets are situated axially on upper M1 (Pavlinov, 2008). The genus itself is moderately stable in taxonomy (Corbet, 1987), but its monophyly and generic status was never seriously considered as disputable. *Meriones* is thought to have evolved from the extinct *Pseudomeriones*, the earliest known gerbilline, recorded from the early part of late Miocene in Turkey and Afghanistan, and later in late Miocene and Pliocene in those two countries and Spain, Greece, North Iran /Turkmenistan and China (Wessels, 1998). The comprehensive review of the genus by Chaworth- Musters and Ellerman (1947) and , Ellerman., Morrison-Scotte, 1951, Pavlinov et al.(1990) recognized four subgenera of *Meriones*:

I- *Meriones* Illiger, 1811: lower surface of hind feet completely haired, including: *M. tamariscinus* (Pallas, 1773),

II- *Parameriones* Heptner, 1937: Proximal pads of the hind feet are small, including: *M. persicus* (Blanford, 1875) and *M. rex* (Yerbury and Thomas, 1895). *M. rex* was not allocated to this subgenus by Pavlinov et al.(1990), who reviewed the species as a distinctive Jird that "has evolved in the special and peculiar environment of the Yemen highlands" (Harrison and Bates, 1991. Karyotype (2n= 38, FN= 74) was documented by Al-Saleh and Khan (1987).

III. *Chelions*: lower surface of hind feet are with small naked stripe and posterior palatal foramina not exceeded upper tooth row in length, check vibrissa is present, including *M. hurrianae* Jerdon, 1867.

IV. *Pallasiomes* Heptner, 1936, lower surface of hind feet with small naked stripe and posterior palatal foramina not shorter than upper toothrow in length, cheek vibrissa absent, including: *M. unguiculatus* (Milne-Edwards, 1867); *M. tristrami* (Thomas, 1892); *M. meridianus* (Pallas, 1773); *M. shami* (Duvernoy, 1842), *M. dabli* (Shidlovsky, 1962); *M. arimalius* (Cheesman and Hinton, 1924); *M. grandis* (Cabrera, 1907); *M. sacramenti* (Thomas, 1922); *M. vinogradovi* (Heptner, 1931); *M. zarudnyi* (Heptner 1937); *M. crassus* (Sundevall, 1842); *M. libycus* (Lichtenstein, 1823); *M. chengi* (Wang, 1964 in Wilson et al. 2005).

These sub-genera are not clearly distinguished based on molecular studies (Chevret and Dobigny, 2005) and cladistics analysis (Pavlinov, 2008). Members within this genus have many similar morphological, behavioral, and ecological features and the species are distributed in sympatric, allopatric, parapatric or stasipatric situation together (Fig. 1) that makes their taxonomic assignments difficult and on-going. *Meriones* species are inhabitant of different habitats as clay and sandy deserts, low plains, cultivated fields, grasslands, mountain valleys, slopes as patchy demes adapt to a wide range of temperature and humidity as extreme dry and warm to dry and cold temperature and humidity. As most of *Meriones* species are represented in the Iranian Plateau and Arabian region, the study of *Meriones* is important for these regional faunal studies. Therefore, in this study we assemble the taxonomic views of previous authors (Blanford, 1869; Petter, 1951, 1953, Legoux et al., 1954; Petter 1957, 1959 , 1961, 1974, 1987, 1987, 1989; Petter et al., 1984; Petter, 1988; Vinogradov and Argyropolo, 1964; Hassinger, 1968; Lay, 1967; Wilson et al., 2005; Darvish et al., 1991; Darvish, 2009) for reviewing 14 species of *Meriones* distributed in the Iranian Plateau, Arabian and Central Asian regions.

MATERIAL AND METHODS

The studied materials belong to the rodent collections at the Laboratory of Mammals and Birds in the Natural History Museum of Paris (MNHN) and in the Zoological Museum of the Ferdowsi University of Mashhad (FUMZM), Iran. The localities are presented in Figure 2 and Table 1(Annex I). The taxonomy follows Musser and Carleton's (Wilson and Reeder, 2005). External, skulls and molars studied characters are based on previous studies with modification and new characters states that defined by the author. Eleven external and 15 cranial and dental morphological characters were analyzed. The external and skull morphology adapted from Petter (1957, 1959), Corbet (1978), Zaim and Paskal (1988), Storch (1975, 1988) and the skull and dental nomenclature adapted from Tong (1989). The studied characters are: 1) Soles of hind feet.; 2) Heel hind feet ; 3) Claws of hind feet; 4) Terminal tuft of the tail; 5) Length of tuft; 6) Tail length compared to head and body ratio; 7) Ear length compared to head and body length; 8) Color of the upper part of the tail; 9) Color of the lower part of the tail; 10) Color of the dorsal part of body; 11) Color of the underbelly; 12) Bony auditory meatus; 13) Anteroventral side of the bony auditory meatus; 14) Mastoid portion of auditory chamber occipitals in dorsal view; 15) The bony part of upper auditory meatus (curtain); 16) Shape of suprameatal triangle; 17) Posterior suprimeatal triangle; 18) Emptiness of suprimeatal triangle space; 19) Stylomastoid foramen; 20)Suprimeatal apophysis of squamosal; 21) Inferior

masseteric ridge of mandible; 22) Dorsal ramus of zygomatic plate; 23) Supraorbital crest; 24) Shape of interparietal bone, 25) Upper molar (M1/); 26) Perikymatics of lower molars row. Skulls and molars were examined by stereomicroscope, and drawing was made using a Camera Lucida. All Species were described and their morphological characters were treated as a matrix using Mix program PHYLIP (Phylogeny inference package, version 3.67, Felsenstein, 2008) to construct rooted cladogram. (Appendix 3 and 4).

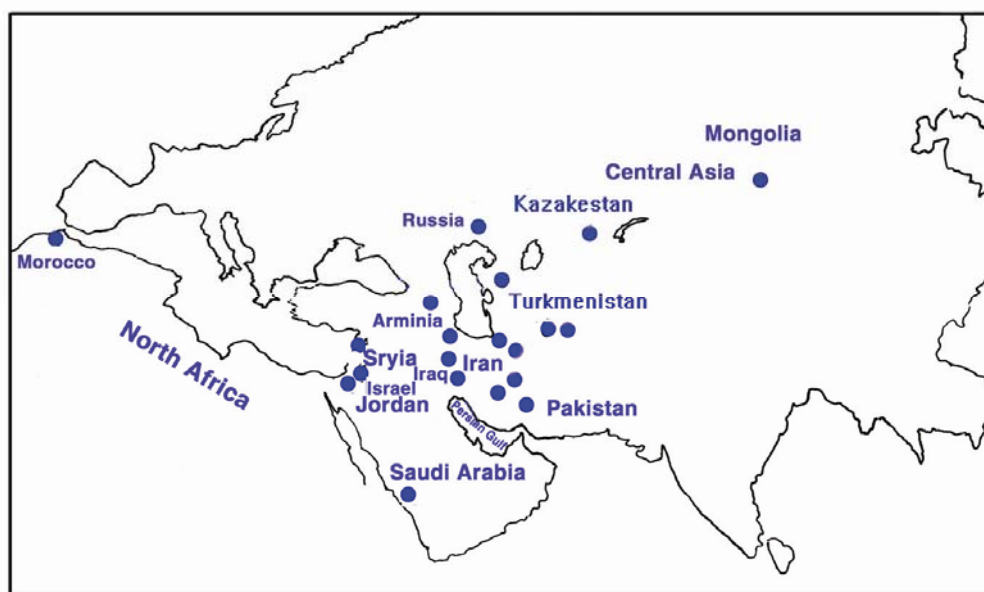


FIGURE 2. Localities of examined materials.

TABLE 1- localities of 14 *Meriones* material examined, from the MNHN and ZMFUM

| Location | Species | Acronym | Iran (ZMFUM) | France (MNHN) | Total |
|--------------------------------------|------------------------|------------|--------------|---------------|-------|
| Iran | <i>M. libycus</i> | <i>lib</i> | 70 | 33 | 103 |
| Iran | <i>M. persicus</i> | <i>per</i> | 12 | 24 | 36 |
| Iran, Syria, Israel, Northern Africa | <i>M. crassus</i> | <i>cra</i> | 4 | 47 | 51 |
| Iran, Russia, Armenia Mongolia | <i>M. meridianus</i> | <i>mer</i> | 3 | 17 | 20 |
| Iran, Israel, Iraq, Jordan | <i>M. tristrami</i> | <i>tri</i> | 1 | 69 | 70 |
| Iran | <i>M. vinogradovi</i> | <i>vin</i> | 2 | 25 | 27 |
| Saudi Arabia | <i>M. rex</i> | <i>rex</i> | - | 9 | 9 |
| Israel | <i>M. sacramenti</i> | <i>sac</i> | - | 14 | 14 |
| Morocco | <i>M. shawi</i> | <i>sha</i> | - | 28 | 28 |
| Morocco | <i>M. grandis</i> | <i>gra</i> | - | 16 | 16 |
| Iran | <i>M. hurrianae</i> | <i>hur</i> | - | 2 | 2 |
| Central Asia | <i>M. tamariscinus</i> | <i>tam</i> | - | 3 | 3 |
| Central Asia | <i>M. unguiculatus</i> | <i>ung</i> | - | 4 | 4 |
| Turkmenistan | <i>M. zarudnyi</i> | <i>zar</i> | - | 1 | 1 |
| Total | | | 92 | 292 | 384 |

TAXONOMIC ACCOUNT

SUPERORDER GLIRES LINNAEUS, 1758
ORDER : RODENTIA, BOWDICH, 1821
SUPERFAMILY: MUROIDEA ILLIGER, 1811
FAMILY: MURIDAE ILLIGER, 1811
SUBFAMILY: GERBILLINAE GRAY, 1826
GENUS: *MERIONES* ILLIGER, 1811

Diagnosics: These Jirds are rather robust, rat-like gerbils. The tail is fully haired and usually with black terminal tuft. The soles may be partly or completely haired. The braincase is inflated and the rostrum is slender Corbet, G.B., 1978. The upper incisor has a single groove on its anterior surface. The incisive foramina are long, but palatine foramina are relatively short or obsolete. The upper cheek teeth are usually hypsodont, especially in immature specimens; they are without trace of cusps, even when first erupted. The crown pattern is more or less prismatic (Ellerman 1966, Harrison et al., 1991). The geographic distribution of all species of *Meriones* presented in Fig. 2, Dravish (1991), Harrison, et al. 1991 Panteleyev (1998). Darvish et al. (2006), Karamy et al. (2008) Darvish et al. (2010).

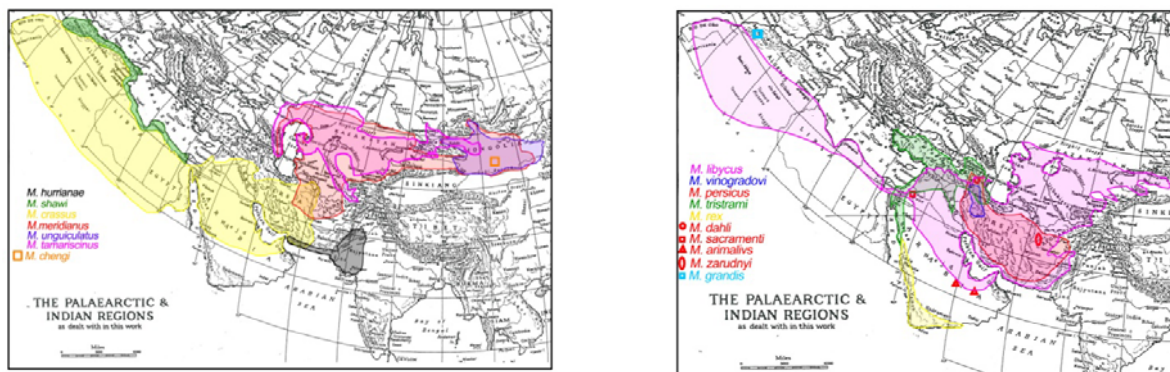


FIGURE 2. Geographic distribution of *Meriones* species, modified from Panteleyev (1998).

Subgenus *Meriones* Illiger, 1811

1- *Meriones tamariscinus* (Pallas, 1773).

Tamarisk Jird

Type locality: Kazakhstan, Saraitshikowski (= Saraichik).

Distribution: North Caucasus and Kazakhstan to the Altai Mountains, and through northern Sinkiang (Dzungaria) to the western extremity of Kansu. In the south, this species is distributed to Samarkand and Bokhara oasis and Forghana valley. Milne-Edwards (1867), (Fig. 2).

Material localities: Central Asia.

External characters: This is a large species. The body length is about 180 mm. The tail is nearly shorter than the head and body length (95%). The tail tuft is short with a light chestnut color. The sole of the hind feet is completely covered by brown hairs which reaches the heel zone in *M. t. texartensis* but absent in *M. t. siscaucasicus*. The hairs in sides and anterior part of soles are white, and in the middle of sole with a distinct dark brown stripe or triangle. The tail is without tuft of long hairs, with short hairs throughout, which are longer at the tip and forming a small tuft. The dorsal side of

feet is often with a dark oblong spot. The claws are yellowish brown. The back is light, the underbelly is off-white.

Cranial characters: This species has the small auditory bullae, without any hypertrophy and additional cavity in the anterior outer part. The external bony auditory meatus is simple, but the anterior edge of the meatus is crescent shaped. The curtain of bony auditory meatus is present. The suprameatal triangle is small and closed. The upper suprameatal triangle process is broad (Plate 1a).

Taxonomy: The restriction of this species to subgenus *Meriones* reflects the very distinctive male genital morphology of *M.tamaricinus* compared with other species of *Meriones* (Wilson and Reeder, 2005).

Subgenus *Parameriones* Heptner, 1937
2- *Meriones persicus* Blanford, 1875
Persian Jird

Type locality: Iran, Kohrud, 72 miles N. of Isfahan, Iran.

Distribution: Eastern Minor Asia and Transcaucasia through north-eastern Iraq and Iran, to south-western Turkmenistan, Afghanistan and Pakistan (West of Indus River) (Darvish et al. 2006), Karamy et al. (2008) (Fig. 2).

Material localities: Iran, Khorasan: Dargaz (Tandoureh), Bojnord (Espakho), Kerman Province (Sirjan), Kashmar, Birjand.

External characters: This is a robust and heavily built Jird of elegant appearance. The tail is bicolored and much longer than the head and body (136%) (Darvish, 2009). The tail tuft is well developed and is completely reddish gray. A band of light black or gray is present on the upper part of the tail. The sole of the hind feet is entirely naked. The ears are large and prominent and the claws are yellow. There is variation on the upper part of the body with dark brown and the underbelly is pure white. There is a supraorbital distinctive white spot between the eye and ear, this white spot completely covers the area around the eyes in *M. tristrami* that are generally sympatric with *M. persicus* in the west of Iran.

Cranial characters: The skull is slender and has a well-marked elongated rostrum. The anterior tip of the nasal bones projects beyond the incisors. The external bony auditory meatus does not come into contact with the posterior root of the zygoma (Yegit et al., 1999). The anterior edge of the meatus is not inflated. The tympanic bulla is without swelling and the size varies. The curtain is present (Yegit et al., 1999) and suprameatal space is small and closed posteriorly. The baculum consists of a distal and proximal baculum, the distal consists of the three cartilaginous parts and the proximal baculum is composed of the os part. The Baculum is composed of a pentagonal base and a stick-shaped shaft (Yegit et al., 1999). The zygomatic plates are less projected forwards and with anterior margins more strongly convex and cut back below. The pattern of the first upper molars is very similar to *M.vinogradovi*. The number of alveoli of the first lower molar is 3-4 (Plate 1m). In Iran, this species is usually found on barren rocky hills and mountain sides where it shares its habitat with long tailed hamsters of the genus *Calomyscus*.

Taxonomy:

The Iranian Plateau subspecies of *M. persicus* are as follows:

M. p. persicus Blanford, 1857.

Type locality: North of Esfahan, Kouhroud, distributed in the west part of Iran, probably limited to Zagross Mountain Chains.

M. p. baptistae Thomas, 1920.

Type locality: South East of Iran, Kerman, distributed probably from East of Zagros to South East of Iran in Baluchistan and South of Khorassan province.

M. p. gorganensis Goodwin, 1939.

Type locality: Dasht in the valley of Gorgan near Bojnord. It is distributed probably in the North East of Iran. The bulla of this subspecies is too larger than the *M. persicus* type specimen (Ellerman and Morrison-Scott, 1944).

M. p. rossicus Goodwin, 1939.

Type locality: Eriwan, probably distributed in the North West of Iran.

3-species: *Meriones rex* Yerbury and Thomas, 1895 King Jird

Type locality: Yemen, Lahej, near Aden.

Distribution: Yemen highlands in SW Arabian Peninsula, from Mecca in Saudi Arabia to near Aden in Yemen (Harrison et al. 1991), (Fig. 2).

Material locality: Taef, Saudi Arabia.

External characters: This is a robust Jird (Harrison et al., 1991). The tail is with a distinct dorsal crest of elongated hairs on the distal half and relatively shorter than the head and body (95%) Darvish (2009). The tail tuft is less developed than *M. persicus*. The soles of hind feet are hairless and of a dark ochre color. Claws are gray with yellow tips. The pelage is distinctly rougher in texture than is usual in the genus. The color of the upper part of the body is charcoal-gray, with a tendency to dark yellow with dark spots.

Cranial characters: The skull is robust and angular, with braincase heavily ridged. The external bony auditory meatus is not inflated, with the anterior edge slightly curved. A bone bar makes contact between the meatus and the lower process of suprimeatal triangle. The tympanic bullae are well inflated but not excessively so far this genus. The curtain is present. The suprimeatal triangle is relatively small and closed posteriorly. As the average size of the mastoid part of the tympanic bulla is medium, the suprimeatal triangle is in a half-full plate, and the anterior edge of the tympanic bullae is conspicuous. The coronoid process of each half mandible is very small. The dorsal ramus of the zygomatic plates is rounded off above. The tooth rows are longest in genus *Meriones* and upper molar length considerably exceeds the combined length of M2/ and M3, probably due to insularity (Plate 1c).

Comment: This species has evolved in the special and peculiar environment of the Yemen highlands. Specimens from the littoral plain of South Yemen are referred to as *M.r.rex* with large size. *M.r.burji* is found in the mountains of North and South Yemen (Harrison et al., 1991).

Subgenus *Cheliones* Thomas, 1919.

4- *Meriones hurrianae* Jordan, 1867

Indian desert gerbil

Type locality: India, Hurriana district.

Distribution: Semi-desert from Punjab and Kathiawar to S. Afghanistan and S.E. Iran (Darvish et al. 2006; Karamy et al., 2008).

Material locality: Bandar Abbas, Iran (Fig. 2).

External characters: This is a robust Jird with ears noticeably small. The tail is relatively the same length as the head and body length. On one-third distal part of the tail, a dorsal crest of longer black hairs is present which terminate in a pencil tuft. The body fur has a sandy grayish buff color with a sprinkling of black tipped hairs. The ventral fur is grayish or creamy color, the distal tips of the hairs being light fulvous-brown. The sole of the hind feet is completely furred with a restricted naked

patch around the region of the heel. The claws are dark brown or blackish and are noticeably longer in this species as compared with the claws of *M. persicus* or *M. libycus*.

Cranial characters: The tympanic bulla is small and the external bony auditory meatus is without an anterior bulge. The curtain is absent. The suprameatal triangle is small, irregular in shape and closed. The ramus of the suprameatal triangle is large and the exoccipital bone is prominent and visible in the lateral view (Plate 1d).

Taxonomy: This species has no subspecies.

Subgenus *Plassiomys*, Heptner 1933

5- *Meriones zarudnyi* Heptner, 1937

Zarudnyi's Jird

Type locality: Turkmenistan, Kushka (Afghanistan-Turkmenistan border). Afghan/ Turkmenistan border.

Distribution: North East Iran (Shirvan), North Afghanistan, and South Turkmenistan. Hassinger, (1968), Darvish et al. (2006), Karamy et al. (2008), Darvish et al. (2010). (Fig. 2).

Material locality: Iran, Turkmenistan.

External characters: The size is as *M. tristrami*. The tail is uniform in color, with a larger black brush than *M. tristrami*. The tail is longer than the head and body with long tuft. The sole of the hind feet is covered with hairs with a well marked stripe of bare skin, and the heel is hairless. Claws are yellow with a mixture of brown and chestnut color with a tendency towards a dark sand-like color in the upper part. The underbelly color is white (Darvish et al. 2010).

Cranial characters: The tympanic bulla is markedly larger than in *M. tristrami*, and the anterior wall of the auditory meatus does not form a long anterior process. The external bony auditory meatus is simple, and the anterior edge of the meatus is not curved. Tympanic bulla is not inflated. The curtain is absent and the suprameatal triangle is large, isosceles, and closed. The suprameatal space is large with an empty half. The upper suprameatal triangle process is equal to the lower one and the dorsal ramus of zygomatic plate is rectilinear (Plate 1e).

Taxonomy: This species has no subspecies.

6- *Meriones meridianus* (Pallas, 1773)

Midday Jird

Type locality: South East Russia, Astrakhanskaya Oblast, Dosang

Distribution: From Lower Don River and north of the Caucasus to Mongolia and N China, south to E Turkey, E Iran and N Afghanistan, (Darvish et al. 2006), Karamy et al. (2008).

Material localities: Iran, Russia, Armenia Mongolia.

External characters: This is a small species. The tail is relatively longer than the head and body or shorter (90%). It differs from *M. unguiculatus* in the less developed tuft of the tail; the tuft is sometimes absent. The dorsal part of the tail is yellowish brown and its ventral part is light yellow. The sole of the hind feet is covered with hairs. The claws are white with an upper part that is high red and the underbelly is white.

Cranial characters: Tympanic bullae are very large (larger than other species). The external bony auditory meatus is inflated and the curtain is present. The suprameatal triangle is large, isosceles, and always open. The upper process of the suprameatal triangle is larger than the inferior one. The dorsal ramus of zygomatic plate is rectilinear. Molars are weakly hypsodont, M/1, M2/2 bear two roots, M/3 and M3/ one root, and M1/ has three roots (Yigit et al., 1999) (Plate 1f).

The specimens of Turkmen –Sahra have rather yellowish claws and the fur is denser and with the chestnut color, whereas the specimens of Sarakhs have rather brownish claws with white at the tip.

The specimens of Russia have yellowish tuft tail (collection of Isabelle Komerovski in Natural History Museum of Philadelphia (NHMP), pioneer of breeding of this species. Here, the back becomes gray and belly sharp yellow. The molars are also smaller in these specimens (N2001-1890, 1889 MNHN). *M. m. penicillium* breed from Russia, the shape of the first upper molars closely approaches the form of M1 in *M. vinogradovi*.

In the specimens of *M. m. dabli* (specimen number 66 from Russia in Appendix) the tail length is smaller than the head and the body length (113/124).

The elongation of the tail increases in subspecies *nogaeorum* (thinnest), *penicilliger* (larger pale) and the longest tail is *in urionchairus* which is more colored.

The *M. m. negmet* of Mongolia (N1302 MNHN) from the Chan collection and N1917 MNHN, the sole of the hind foot is furry and of yellow color, the claws are white, and its upper part is completely yellow. The underbelly is white.

At the specimens N651 MNHN de Chrkalik Mongolia, the tail is yellow with dark-light spots, the claws are white, the sole of hind feet is furry and white, and the underbelly is also white. The chromosome number is $2N = 50$.

7- *Meriones crassus* Sundevall, 1842

Sundevall's Jird

Type locality: Egypt, Sinai, Fount of Moses (Ain Musa)

Distribution: Across North Africa from Morocco through Niger, Sudan, and Egypt to Israel, Jordan, Syria, SE Anatolia (Turkey), Saudi Arabia, Iraq, Iran, Afghanistan and southern Turkmenistan Petter, 9 19510; Hassinger, (1968), (Harrison et al., 1991), Darvish et al. (2006), Karamy et al. (2008),

Material localities: Iran, Pakistan, Saudi Arabia, Syria, Israel, Egypt, Libya.

External characters: This is a less robust Jird than *M. libycus*. The tail length increases from the western Iranian plateau towards Iraq and North Africa Darvish (2009). The tail tuft is gray-chestnut with a strong variation and less developed than that in *M. libycus*. The dorsal proximal part of the tail is off-white with a dark brown tuft at the end. The sole of the hind feet are partly hairy. The heel is hairless with a fine line of demarcation. The claws are ivory white. The color of the back is gray and the underbelly is white.

Cranial characters: The skull is less robust than *M. libycus*, but the braincase is in broader and the tympanic bullae are enormously enlarged and the supraorbital ridges are less pronounced. The external bony auditory meatus is very grossly inflated and developed downgrowth from the tympanic annulus which present in each ear. In addition, the curtain that conceals the bodies of the ossicles (Harrison et al., 1991). The suprimeatal triangle is large isosceles and open posterior and covered by the mastoid part. The upper suprimeatal triangle process is fine and equal to the lower process. The stylomastoid foramens are open and prominent. The dorsal ramus of zygomatic plates is low, rectilinear and less abruptly cut back below. Supraorbital crests are minimal and the interparietal bone is smooth and round. The descendant wing of the parietal bone is triangular (Plate 1g).

Taxonomy:

The Iranian Plateau subspecies of *M. crassus* are as follows:

M. crassus charon Thomas, 1919. Type locality: Mound of Siza, Ahwaz. This subspecies could be distributed in west of Zagross, Iraq and Turkey.

M. crassus swinsboei Scully, 1881. Type locality: Gatai between Kandahar and Kojak Pass, Afghanistan. This subspecies could be distributed in the East of Zagros in the Iranian Plateau.

In *M. crassus swinsboei* the auditory bulla is larger than *M. c. charon* and the external bony auditory meatus is greatly inflated, but the body and the tail length are shorter than *M. c. charon*.

8- *Meriones tristrami* Thomas, 1892 Tristram's Jird

Type locality: Dead Sea area, Palestine

Distribution: From Arabian Peninsula to Asia Minor, Transcaucasia and north western Iran (Darvish et al. 2006), Karamy et al. (2008), Fig.2.

Material localities: Iran, Iraq, Jordan, Syria, Israel.

External characters: This is a rather small Jird with mainly hairy soles of hind feet. The tail is longer than the head and body length (109%) Darvish (2009) and the tail tuft is scanty with yellowish fulvous above, lightly grizzled with black; the underside is lighter fulvous yellow, and the terminal tuft is black. The sole of the hind feet is mainly hairy; the heel is bare with an irregular black line of demarcation. The claws are white with light or yellowish brown in certain specimens (in Jordan). The dorsal color is light chestnut and the underbelly is white. There is four pair of mammae (Harrison et al., 1991).

Cranial characters: The skull and tympanic bullae are small. The bulla is usually about one third of the occipiti-nasal length, with the mastoid cavities slightly inflated. The external bony auditory meatus is not inflated and there is a well defined widening of the anterior edge, that is thin even in old specimens, the posterior face of bony auditory meatus is crescent-shaped. The curtain is present. The suprêmeatal triangles are small, with irregular elliptical shape and closed posteriorly. The suprêmeatal spaces are small and half covered by the mastoid part of the tympanic bulla. The upper process of the suprêmeatal triangles is equal to the lower process. The stylomastoid foramina are open and apparent. The lateral apophysis of the exoccipital is small and the exoccipital bone is visible from lateral view. The dorsal ramus of zygomatic plate are curved or tilted downwards. The supraorbital crest is minimal and the interparietal bone is smooth and round. The descendant wing of the parietal bone is square. The Perikymatias is present in the lower and upper molars row, and the dental lines are tilted relative to the axis of the mandible. Molar teeth as well as incisors, growing throughout life according to the findings of projecting and wearing stages of lateral folds (Chetbour and Tchernov., (1983), Yigit et al., (1999)). The mandible is rather small but with the angular processes prominent (Plate 1h).

Taxonomy

M. tristrami is a polytypic species. This species was documented by fossils, since at least 160000 years ago from Levent (In Wilson and Reeder, 2005). Aharoni thinks that this species is a derivative form of the oriental species *M. tamaricinus*, but Ellerman and Morrison-Scott (1951) declare that *M. tristrami* is a representant of occidental species *M. shawi*.

The subspecies of the Iranian Plateau is *M. t. blackleri*, recorded from north west of Iran.

9- *Meriones vinogradovi* Heptner, 1931 Vinogradov's Jird

Type locality: Iran, this species based on three specimens captured in Azerbaijan region of Iran.

Distribution: E Anatolian Turkey, N Syria, N Iran, and Armenia and Azerbaijan, Petter, (1955). (Darvish et al., 2006, Karamy et al. 2008), (Fig. 2)

Material locality: Iran,

External characters: This is a small Jird. Similar in size and features to *M. tristrami*. The tail length is relatively equal to the head and body length (100%). The tail tuft is well developed and is approximately one third of the length of the tail. Proximal superior part of the tail is sharp yellow and the lower part is light yellow. The ears are rather long, and ovate and much more hairy than those of *M. tristrami*. The sole of the hind feet is more hairy than *M. tristrami* and with much reduced naked patch on the heels. The hairs in the central part of the soles form a distinct reddish brown tuft which largely conceals the digital pads. The color of the claws varies from light chestnut to off-white. The coloration of the dorsal part of the body is yellow-gray to gray and the underbelly is uniformly white.

Cranial characters: The skull is small and the tympanic bullae are small, but generally more robust in appearance than the skull of *M. tristrami*. The external bony auditory meatus is not blown up, with a widening of the anterior borders and crescent-shaped posterior side. The bulge of the tympanic bulla is limited with visible anterior edge. The curtain is present, and this species is characterized by a visible apophysis of the ossicles of the hammer (Petter, 1955). The suprimeatal triangle is a regular ellipse with very thin superior and inferior processes. The inter-suprimeatal space is small and half covered by the mastoid part of the tympanic bulla. The upper edge of the suprimeatal triangle is equal in length to the lower process. The Stylomastoid foramen is conspicuous and open. The paroccipital apophysis of the exoccipital is short and pointed, and the occipital bone is less visible from the lateral side of the skull. The dorsal ramus of zygomatic plate is rectilinear and high. The supraorbital ridge (crest) is present. The interparietal bone is dentate in anterior and posterior. The descendant wing of parietal is large. Perikymatias in the upper and lower molars is strong, and the alignment between antroloph and neoloph of first lower molar is absent. The skull is remarkably curved at the upper part of interorbital part (Plate Ij).

Remarks: The specimen N1631 (*M. vinogradovi*) trapped in the town of Ahwaz, Khuzestan province (southern- west of Iran) shows the southern limit of the distribution of this species. However, this specimen has a lighter skin color compared to the other specimens of *M. vinogradovi* trapped in the area of Qasvin and in Iranian Azerbaijan, Iraq and Syria.

The specimens of *M. vinogradovi* which were born in the animal house have a shorter tail.

Taxonomy: This species has no subspecies.

10- *Meriones shawi* (Duvernoy, 1842) Shaw's Jird

Type locality: Algeria, Oran.

Distribution: Mediterranean littoral from E Morocco through N Algeria, Tunisia, Libya, and Egypt to N Sinai, never found more than about 240 km inland (Lay and Nadler, 1969).

Material locality: Agora, Morocco.

Exists in Moroccan Atlas, Algeria from the shore to the Hauts Plateaux, south of Tunisia Petter,(1951, 1957).

External characters: According to Dravish (2009), the tail length is relatively smaller than the head and body length (98%). The tail tuft is black and its size is half of the tail. The sole of the hind feet is half covered with very fine fur. The proximal superior part of the tail is gray and the lower part is light gray. The claws are yellow with white tips. The color of the back is maroon and the underbelly is white.

Cranial characters: The bony auditory meatus is with a bulge, and the anterior edge curved downward. The curtain is present. The tympanic bulla is small. The suprimeatal triangle is isosceles.

As the average size of the mastoid part of the tympanic bulla in the suprimeatal triangle is low, so the half part of its surface is empty and the anterior borders of the tympanic bulla is quite apparent. The dorsal ramus of the zygomatic plate is concave. The upper process of suprimeatal triangle is concave, and the stylomastoid foramen is large and open. The exoccipital bone is masked, but this is apparent in the lateral view. The upper M/1 is wide (Plate 1k). *Meriones shawi* resembles to *M. rex* in the shape of the tympanic bulla and its accessory structures. The analysis of the craniometrical data shows a strong sexual dimorphism on *M. shawi* (Zaim and Pascal, 1988).

Remark: *M. shawi* range is mostly defined north to that of *M. libycus* (Fig. 1) but is sympatric with this species in several regions such as in Haut Plateaux of Algeria. The interpopulational fecundity of Moroccan, Algerian and Tunisian population are confirmed in captivity (Petter, 1957).

11- *Meriones grandis* Cabrera, 1907 Moroccan Jird

Type locality: Morocco, Marakesh.

Distribution: Mediterranean littoral from Morocco through N Algeria to Tunisia Harrison, et al., 1991.

Material locality: Agora, Morocco.

External characters: The tail length is approximately smaller than the head and body length (96%), but greater than that of *M. shawi*.

Cranial characters: The bony auditory meatus is with a bulge but more remarkable than in *M. shawi*, with the anterior edge largely curved downward. The curtain is present. The tympanic bulla is small Darvish, J., 2009. The suprimeatal triangle is isosceles (Plate I).

The taxon *M. grandis* has traditionally been included in *M. shawi* but Pavlinov et al. (1990) reviewed *M. grandis* as a species and Pavlinov (2000) recorded the morphological traits distinguishing *M. grandis* from *M. shawi*; he also documented a broad overlap between the two species in E Morocco, N Algeria, and Tunisia.

12- *Meriones unguiculatus* (Milne-Edwards, 1867) Mongolian gerbil, Clawed Jird

Type locality: China, North Shanxi

Distribution: Mongolia, and adjacent regions of Siberia (Transbaikalia) and of China from East Gansu, North Ningxia, North Shanxi, and Hubei, through Center and North Nei Mongolia and Liaoning, Milne-Edwards (1867) (Fig. 2) This species is most frequently used as an experimental animal and as a pet.

Material localities: Central Asia.

External characters: This is a small species and the length of the body is usually less than 150 mm. The tail is shorter than the head and body length (85%). The tuft of the tail is short and is a quarter length of the tail. The upper and the lower parts of the tail are light gray and yellowish, respectively. The sole of the hind feet is completely covered with thick hairs. The claws are dark brown. The back is maroon gray, and the underbelly is off-white.

Cranial characters: Tympanic bullae is large, with additional cavities between the anterior wall of the auditory meatus and the anterior margin of the tympanic bullae, these are smaller than *M. meridianus* and *M. libycus*. The external bony auditory meatus is nearly simple with the anterior edge of the meatus concave. This characteristic must be viewed from the top of the skull. The tympanic bulla is slight and variable in size. The curtain of the bony auditory meatus is absent. The suprimeatal

triangle is small and slightly open. The suprameatal space is small and sometimes half empty. The upper portion of the suprameatal triangle has the same length as the lower portion and minimally separated from it. The dorsal ramus of zygomatic plate is curved with a sigmoid tendency (plate 1b).

13- *Meriones libycus* Lichtenstein, 1823

Libyan Jird

Type locality: Libyan Desert.

Distribution: North Africa from Western Sahara to Egypt and from Arabia to the Iranian Plateau and Turkmenistan to Sinkiang in West of China (Fig. 2) Hassinger, (1968), Darvish et al. (2006), Karamy et al. (2008), Material examined: The Iranian Plateau and North Africa.

Material localities: Iran.

External characters: This is a robust Jird. The tail is generally longer than the head and body (115%). The tail tuft is always black and well-developed. The ventral side of the tail is white but the base of the fur is always gray. The sole of the hind feet is partially hairy, with the dusky colored bare patches on the heels. The claws are pigmented and sometimes completely black on *M. l. syriacus*, but in *M. l. arimalius* the claws are not so deeply pigmented. The sole of the hind feet has white hairs that are gray at the base. Sub-adults possess a thin dorsal tail stripe.

Cranial characters:

The skull is robust. The squamosal root of the zygomatic arch is in contact with the anterior portion of the auditory bullae. In *M. l. syriacus*, the mastoid portions of the bullae just project beyond the supraoccipital and in *M. l. arimalius* the bullae project well beyond the occiput. The malleus is visible through the bony auditory meatus (Harrison and Bates, 1991) due to the absence of curtain. The posterior portion of the suprameatal triangle is either closed or nearly closed (Plate 1n). The analysis of craniometrical data shows a light sexual dimorphism on *M. libycus* (Zaim and Pascal, 1988). The number of alveoli of first lower molar is 3-4. The number of alveoli of second lower molar is 3. Petter, 1953; Momenzadeh et al. (2008)..

Taxonomy:

M. libycus is a complex species with several subspecies (Lay and Nadler, 1969). The subspecific status of *M. libycus* is not clear. But the different recorded subspecies from the Iranian Plateau are:

M. l. erythrourus Gray, 1842. Type locality: Sahlabad South-West of Kandehar, Afghanistan. This subspecies probably is distributed in Sistan and Baluchistan and the South of Khorassan in the East of Iran.

M. l. syrus Thomas, 1919. This subspecies probably is distributed in the South- West of Iran

M. l. maxeratis Heptner, 1933. Type locality: Taschkan, Turkman. This subspecies could be present in the South slop of Kopet Dag, in Dargaz region, the North East of Iran.

M. l. marginiae Heptner, 1933. Type locality: Turkmenistan, Bayram Ali Marve, *M. l. oxianus* (Heptner, 1933). Type locality: Bokhara and *M. l. soghdianus* Heptner, 1933. Type locality: Forghana vally. These subspecies could be revised and may be present in the North East part of the Iranian Plateau in Afghanistan.

M. l. iranensis Goodwin, 1940, Type locality Maravehtep in the North of Gorgan (Lay, 1967).

M. erythrourus farsi Schlitter and Setzer, 1973. Type locality: The North of Lar in the Fars province

M. l. caucasicus Brandt, 1955. Type locality: 27 Km. north of Abadeh is a problematic subspecies.

M. l. erythroura Gray, 1842. Type locality: The specimen from MNHN recorded from NW Iran. Very distinct for the shape of the first upper molars in which the bridglets are truncated and completely different from other specimens of *M. libycus* and genus *Meriones*. This subspecies need taxonomic revision.

14- *Meriones sacramenti* Thomas, 1922
Buxton's Jird

Type locality: Israel.

Distribution: A small range in Israel (on the coastal plain south of the Yarqon River and in the N Negev) and NE Sinai Peninsula of Egypt, Petter,(1957), Syria (Misonne, 1959), Harrison et al. (1991), (Fig. 2)

Material locality: Palestine.

External characters: This is a robust Jird which attained a larger size than *M. libycus*. The tail is relatively shorter than the head and body length (95%); the terminal tuft is well developed. The limbs are robust and the hind feet of adult are markedly larger than those of *M. crassus*. The soles of the hind feet are ivory white. The dorsal coloration is in general reddish sandy diffusely speckled with black.

Cranial characters: The skull is very robust. The superorbital ridge is robust. The tympanic bullae are very large but less inflated than those of *M. crassus*. The mastoid chambers are not projected prominently beyond the occipital. The mesopetryoid space is more widely V-shaped than *M. crassus* and the pterygoid fossae are larger. The antero-superior rim of each bony auditory meatus grossly inflated and coming into contact with the posterior root of zygoma and projecting laterally with it. The curtain is present. The mandible is extremely robust. The suprameatal triangle is large, isosceles, and not very open (Plate 10).

Taxonomy:

This species has no subspecies. Ellerman and Morrison-Scott (1951) considered *M. sacramenti* as a form of *M. crassus*. *M. sacramenti* is apparently most resembles to *M. libycus* on its external morphology, but more resembles to *M. crassus* based on skull morphology.

Phylogenetic study:

The Cladistic situation of 14 species of genus *Meriones* was observed using 26 morphological characters (external, skull and molars)(Appendix 3 and 4).

The Mix program was analyzed and the final cladogram with four monophyletic groups or clade was determined (fig. 3): The rooted tree shows that Clade1 is *M. vinogradovi* is a separated clade from all other species. Clade 2 is *M. tristrami* and *M. burrianae* Clade 3 *M. rex*, *M. zarudnyi* and *M. persicus*, clade 4 including *M. tamaricinus*, clade 5 including *M. crassus*, *M. meridianus*, *M. M. unguiculatus* and clade 6 includes *grandis*, *M. shawi*, *M. sacramenti* and *M. libycus*. This result does not confirm the subgeneric classification of genus *Meriones* (McKenna et al., 1997; Pavlinov, 2008) and is in accordance with molecular studies. Molecular analyses confirm that *M. unguiculatus* are more similar to *M. meridianus* and *M. crassus*. (Dobigny, 2005).

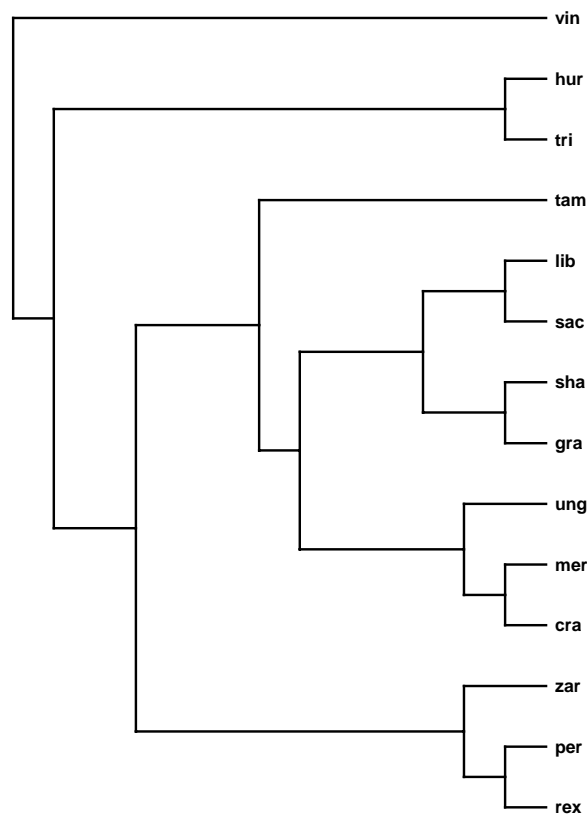

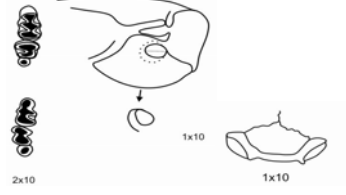

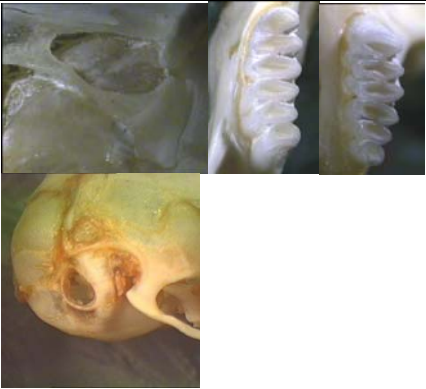
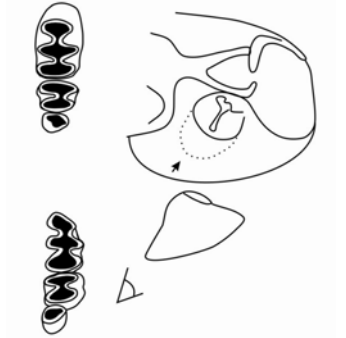
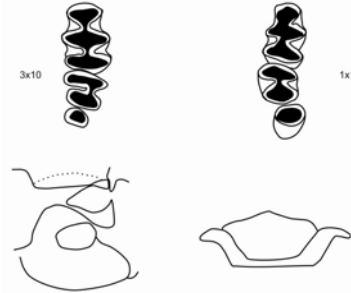
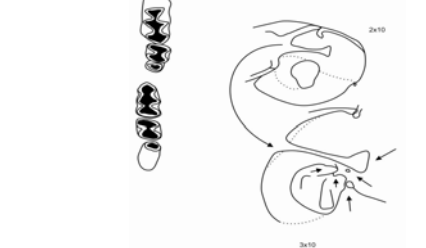
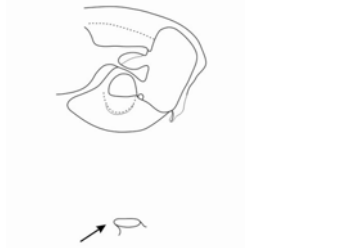
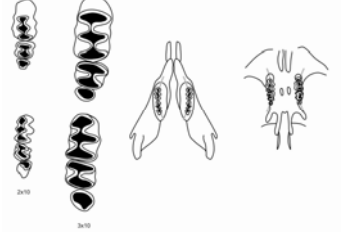


FIGURE 3. Rooted tree of *Meriones* species which shows phylogenetic relationship. Lib (*M. libycus*); per (*M. persicus*); cra (*M. crassus*); mer (*M. meridianus*); tri (*M. tristrami*); vin (*M. vinogradovi*); rex (*M. rex*); sac (*M. sacramenti*); sha (*M. shawi*); gra (*M. grandis*); hur (*M. burrianae*); tam (*M. tamariscinus*); ung (*M. unguiculatus*); zar (*M. zarudnyi*).

The rooted tree confirms that speciation in genus *Meriones* is vicariant and Africa, Arabian Peninsula, The Pamir Mountains, Zagros, Kopet-Dagh, the Bdkyz Plateau, Balkan and Caucasus Mountains, and the Caspian Sea Flood Plain, could be the barriers. The species *M. crassus*, *M. meridianus*, and *M. unguiculatus* belong to three separate geographic region of Far East Asia for *M. unguiculatus*, Central Asia for *M. meridianus* and North Africa for *M. crassus*. The two species *M. crassus* and *M. meridianus* have a secondary contact in the Iranian Plateau and East of Turkey that could be analysed by molecular study. The Iranian Plateau is a contact zone for different species as *M. libycus* and *M. crassus* in the central desert of the Iranian Plateau and between *M. zarudnyi* and *M. libysus* in the North East of Iran. North Africa is also the center of the origin of *M. shawi* and, *M. grandis* are the biggest species in size and probably have been present since late Pleistocene of Maghreb. *M. sacramenti*, *M. libycus* and *M. crassus* are remarkably similar in auditory bullae and bony auditory meatus seems to reflect the North African origin of these species.

PLATE 1- Auditory bullae and tooth row shape in different species of genus *Meriones*.

| | | |
|---|--|---|
| <p>a- <i>Meriones tamariscinus</i>, C. Asia</p> | <p>b- <i>Meriones unguiculatus</i> C. Asia</p> | <p>c- <i>Meriones rex</i> Arabian Peninsula</p> |
|  |  |  |
| <p>d- <i>Meriones burrianae</i></p> | <p>e- <i>Meriones zaruudnyi</i> Turkmenistan</p> | <p>f- <i>Meriones meridianus</i> Iran, Bardsir</p> |
|  |  |  |
| <p>g- <i>Meriones crassus</i>. Iran, Birjand</p> | <p>h- <i>Meriones tristrami</i>, Iran. Qazwin</p> | <p>i- <i>Meriones vinogradovi</i> Iran Saquez</p> |
|  |  |  |

DISCUSSION

This study is based on identified museums specimens of genus *Meriones*. Due to the presence of convergence regarding the adaptation of different species of *Meriones* to similar environment Petter, (1961), Chetbourn et al., (1983), subgeneric morphological characters may cause homoplasies and paraphyletic subgenera, McKenna et al. (1997). The characters applied to subgenera of *Meriones*, Pavlinov et al.(1990), as presence or absence of hair on lower surface of hind feet, presence, absence and size of proximal pads on hind feet, position of posterior palatine foramina, presence or absence of check vibrissa are not in congruence with molecular studies (Chevret and Dobigny, 2005). Meanwhile as the supraspecific morphological character states in definition are conservative and stable during successive speciation from ancestral species. They could be applicable for determination of "polarity" of characters. It is necessary to clarify the polarity in the absence and the presence of curtain, hypertrophy of auditory, posterior hypertrophy of auditory bull, hypertrophy of anterior part of auditory bulla, and hypertrophy of all part of auditory Petter, (1953), Legouix, et al. (1954), Momenzadeh et al.(2008).

Our cladistics analysis shows that *M. vinogradovi* could be forming ancestral species of genus *Meriones* and not *M. shawi*, in contrast to Tong's (1986) approach and Caucasus high land region could be the center of origin for *Meriones*. That is in concordance with recent paleontological studies (Wessels, 1998). This genus have evolved from the extinct *Pseudomeriones*, the earliest known gerbilline, recorded from the early part of late Miocene in Turkey and Afghanistan, and later in late Miocene and Pliocene in those two countries, North of Iran, Turkmenistan and China (Wessels, 1998).

It's conformed that *M. tristrami* appeared in South of Caucasus region and penetrated secondarily to the West of Iranian Plateau, Turkey, Syria, Mesopotamia and Palestine region, after latest glaciations (Misonne 1959). *M. vinogradovi* also appeared in South Caucasus region in the biotope with characteristics of humid valley beds and distributed in North West of Iran, Turkey and Iraq (Misonne 1959). Whereas *M. persicus* was appeared in the North East of Iranian plateau (Iranian tension zone of Misonne, 1959) and then progressed towards all different highland of Iranian Plateau and adjacent countries. The endemic species *M. grandis*, *M. shawi*, in North Africa, *M. rex* in Arabian Peninsula and *M. sacramenti* in Israel reflect their origin in these region.

Although it is generally possible to determine *Meriones* species by morphological characters, distinguishing unique samples is not always an easy task. This problem is intensified because of the age variation seen in morphological traits. Due to the fact that museum specimens are determined by other authors, we identified the specimens by determination key of Corbet 1978 and other authors (Annex II). As diagnostic traits are scarce, it is probable that species is defined imprecisely or their definition be done with redundancy. What has been defined here as morphological species in *Meriones* could be only pragmatic one, necessary for inventory (Darvish et al. 1991).

The interspecific variation in morphospecies of genus *Meriones* for the species as *M. crassus*, *M. meridianus*, *M. libycus* is considerable. *M. crassus* is also polytypic. The North African population are described as *M. c. crassus* from Sinai that is larger than the western Iranian subspecies *M. c. charon* Thomas, 1919 of western Iraq to the west of Zagross. The tympanic bullae is rather less inflated in *M. c. charon*. The population of west of Zagros belong to *M. crassus suinschoei* (type locality: Afghanistan), in which the external bony auditory meatus is greatly inflated, but the body and the tail are shorter compared to *M. c. charon* (Petter 1961). As the cline of tympanic bullae size probably disrupted in the south of Zagross between *M. c. charon* and *M. c. suinschoei* subspecies, the taxonomic value of Eastern populations of *M. crassus* need taxonomic consideration. *M. meridianus* is a species with considerable variation in size and proportions, and a complex species that has a considerable geographical variation Darvish (2009). The external characters as tuft of the tail and shape of molars have clear difference among the Siberian, Caucasus, Mongolian and Iranian populations. The volume of the body increases from the South towards the North of Russia showing Bergman rule,

and the color of the tail and the tail tuft and the back become yellowish. Therefore, *M. meridianus* of central Asia is remarkably different from the specimens of the Iranian Plateau that its subspecific status must be determined. *M. libycus* is a complex species with emblematic subspecies *M. l. erythrura* of the North West of Iran in which the first upper molars bridglets are truncated and never seen in genus *Meriones*. So, an integrative approach of molecular and morphological Cladistics analysis could clarify cladogenesis in the genus *Meriones*.

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APPENDIX I- List of material examined**Specimens from MNHN collections (Paris, France):**

M. tristrami (from collection of MNHN Paris; locality Jordan, Kirkouk, Iraq, Iran, TAlAbyaz Iran, Qasvin)

N206, N240, N286, N299, N457, N467, N505 Baltazard, Iran
N517, N521, N828, N1298, N1366, N1404, N1360, N1361, N1362, N1364
N1365, N1366, N1367, N1369, N1370, N1393, N1395, N1396, N1397, N1398
N1399, N1400, N1401, N1402, N1403, N1404, N1405, N1406, N1407, N1410
N1411, N1629

M. persicus (Iraq, Samaleh; Iran Mahallat, Qazvin, Bikas);

N14, N241, N420, N421, N426, N427, N442, N515, N848, N977, N978
N979, N981, N982, N986, N987, N988, N985, N990, 1026, N1034, 1069
N1297, N1034, N1351, N1628, N2071

Meriones rex (Taef, Saudi Arabia): N175, N286, N287, N288, N1919

N1921, N1922

Meriones libycus (Iran: Bojnourd, Robat Garabil, Dachbroune, Zahedan, Laguenay Paris Animalerie): N55, N82, N84, N85, N86, N90, N91

N330, N331, N329, N333, N336, N337, N338, N339, N341, N342, N345
N429, N335, N346, N349, N351, N352, N382, N508, N749, N750, N843, N88
N909, N994, N995, N996, N998, N999, N1000, N1330, N1331, N1332, N1333
N1334, N1335, N1336, N1337, N1338, N1505, N1803, N3777

M. sacramenti (Israel Richon Lezion).

N171, N173, N508, N509, N511, N512, N513, N648, N1423, N613, N171

M. crassus (Iran: Kasrshirin, Maine, Kouhak, Isfahan, Mahallatroum, Birjand, Tasuki, Zabol): N21, N103, N104, N105, N106, N107, N109, N412, N423, N530, N1036, N1037, N1038, N1040, N1041, N1042, N1043, N1354

M. burrianae (Iran: Bandar Abbas) N1328, N1329

M. meridianus (Iran: Chatagui N41, merid 121 NE Iran N1352, Sarakhs Iran N1353, NE Iran) Mongolia (N66, N132, N50568), Armenia (dahl N85973, Irvan), Russia (masagetes 6630, d5713 Astrakhan, Nogair. 15941, Siscaucasie, Penicil 15957)

M. vinogradovi (Elevage, in France, Iran, Nagadeh, Saggez, Qasvin): N95, N265, N457, N462, N468, N469, N522, N623, N624, N817, N976, N1631

M. tamariscinus (Central Asia): N121, N1302, N1532, N1848, N4866, N5758, N6105, N6630, N1849, N1887, N1889, N1890,

M. unguiculatus (Central Asia): N250, N485, N1455, N1546

M. shawi (North Africa) N32, N66, N67, N233, N241, N243, N311, N725, N724, N725, N747, N750, N756

M. grandis (Morocco): N65, N218, N263, N264, N514, N515, N516, N646, N672, N673, N674, N783, N821, N1427, N2070

Specimens from Ferdowsi University of Masshad museum (FMUZZM), (Iran):

(sampling localities) Birjand, Sabzevar, Gonabad, Ferdows, Bejestan, Torbat-Jam, Sarakhs, Mashhad, Kalat, Fariman, Shirvan, Dargaz, Khash, Kerman, Shahdad, Sirjan, Bardsir, Iranshahr)

M. libycus: FZM N36, N471, N563, N569, N570, N616, N659, N784, N838, N839, N840, N841, N842, N850, N474, N571, N572, N573, N574, N658, N785, N809, N810, N811, N524, N564, N565, N661, N662, N666, N667, N668, N670, N799, N568, N653, N576, N645, N853, N518, N795, N796, N1010, N554, N660, N664, N664, N667, N651, N652, N808, N797, N559, N552, N647, N245, N304, N1025, N335, N336, N1025, N337, N334, N343, N331, N6, N548, N213, N214, 216, N217, N218, N219, N221, N222, N206, N237, N239, N174, N394, N395, N498, N399, N646, N175, N176, N180, N181, N208, N209, N210, N211, N694, N1193, N303, M1, M17, M2, 8, M35, M36, M39(105), N34, M3, M6, M7, M10, M30, M31, M35, M20, M21, M34, M37, M39, M42, M2, M11, M12, M8, N17, N691, N106, N141, N111, N188, N196, N203, N432, N13, N14, N404, N1112, N432, M29.

Meriones persicus (Iran, dargaz: Tandoureh, Espakho, kashmar, Sirjan): N983, N991, N996, N1037, N1104, N1110, N1111, N1113, N1114, N1115, N1109, N1116, N110, N1, N2, N5.

APPENDIX 2- Identification key of morphospecies of *Meriones* Corbet (1978), Petter (1957 and 1959), Corbet (1978), Tong (1989), Darvish (2009) and this study.

- Soles of hind feet entirely naked.....(2)
 - Soles of hind feet at least partly haired.....(3)
 1. Ventral pelage entirely white: tail usually longer than head and body(133%), heavily tufted*M. persicus*
 - Ventral pelage tinged with buff; tail about equal
 2. Ears small, under 0.07 % of length of head and body (less than 13 mm) *M. hurrianae*
 - Ears longer, over 10% of head and body, usually over 13 mm.....(4)
 4- Bullae small, length in horizontal plane (excluding mastoid part) less than or equal to diastema 31%-41%..... (5)
 - Bullae larger, length in considerably exceeding that of diastema. Bulla length is 41%-51% condylobasal length..... (7)
 5- Sole of hind foot fully haired, with a darker central streak(6)
 - Sole of hind feet with a distinct naked patch near the heel, rest uniformly colored *M. tristrami*
 - Posterior feet are covered with hairs with a well marked stripe of bare skin and bullae is larger than in *M. tristrami*.....*M. zarudnyi*
 6- Tail sharply bicolor, dark above and pale below; sole of hind foot with central streak dark brown, tail smaller than head and body length (97%), upper part of nail yellow, *M. tamariscinus*
 - Tail not sharply bicolor, distal part entirely dark; centre of sole reddish brown, The most smaller mandible length*M. vinogradovi*
 7- Sole of hind foot fully haired; the greatest length of skull usually under 36 mm.....(8)
 - Sole of hind foot naked near the heel; the greatest length of skull usually over 36 mm.....(9)
 8- Ventral pelage wholly white; claws pale; bullae larger, mastoid chambers projecting behind occipital condyles. The smaller A and B length, condylobasal length and molars length*M. meridianus*
 - Ventral pelage grey with white tips; claws dark, bullae smaller, mastoid chambers usually level with condyles. The smallest tail length, 77% head and body length. The greatest molar length and, the smallest width of skull, auditory bulla, and occipitonasal length..... *M. unguiculatus*
 9- Bony auditory meatus with a curtain of bone in the upper part, obscuring the main bodies of the ossicles; claws usually pale. (10)
 - Bony auditory meatus without such a curtain so that the ossicles are clearly visible; claws usually dark (12)
 10- Bullae smaller, mastoid parts less swollen and not projecting much behind occipital condyles, suprêmeatal triangle (i.e. surface of anterior mastoid chamber) widely open behind; (tail rather lightly tufted). *M. shawi*
 - Bullae very large, mastoid parts greatly swollen and extending well behind condyles, suprêmeatal triangle closed behind or almost so (11)
 11- Tail heavily tufted with a black dorsal line on at least the distal half; larger: hind feet 36-41 mm, greatest length of skull 41-49 mm, auditory bulla and width of skull *M. sacramenti*
 - Tail less tufted, no black line on distal half; smaller: hind feet 25-35 mm, greatest length of skull 32-42 mm, smallest hind foot and interorbital length.....*M. crassus*
 12- Tail prominently tufted; process in front of bony auditory meatus greatly inflated, generally in contact with posterior process of zygomatic arch*M. libycus*

APPENDIX 3 - Variation in size, shape or position of the external character states extracted from different sources**1) Soles of hind feet.**

- A. hairless
- B. fur in the border of soles and sparse
- C. thickly furred

2) Heel of hairless hind feet

- A. Presence of a pronounced dark line
- B. Presence of a thin line
- C. Presence of a very thin line
- D. Presence of a black spot
- E. Presence of a red spot
- F. Presence of scaled pink spot

3) Claws of hind feet

- A. Top of claws is ivory white with a light base
- B. Top of claws brownish yellow with a light base
- C. Top of claws yellow with a dark red base

4) Terminal tuft of the tail

- A. Tufted without a black line
- B. Large tuft with a black demarcating line

5) Length of tuft

- A. Approximately half of the tail length
- C. Approximately one-third of tail length
- D. Approximately one-quarter of tail length

6) Tail length compared to head and body ratio

- A. Longer than head and body length (> 1)
- B. Equal to head and body length ($=1$)
- C. Shorter than head and body length (<1)

7) Ear length compared to head and body length

- A. Small ($< 0.08\%$)
- B. Medium, between (0.08 to 0.12%)
- C. Large, upper (12%)

8) Color of the upper part of the tail

- A. Brown,
- B. Lighter brown upper part
- C. Light red with a darker central line
- D. Yellow with a dark line extending towards tuft

9) Color of the lower part of the tail

- A. Light gray
- B. Red brown
- C. Light brown
- D. Dark yellow

10) Color of the dorsal part of body

- A. Orange
- B. Yellowish brown
- C. Consistent sand color

11) Color of the underbelly

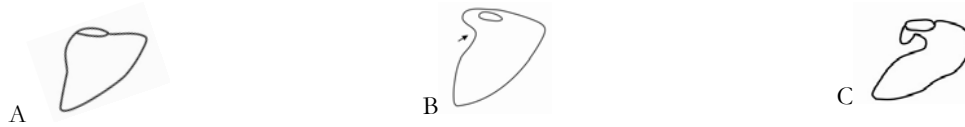
- A. White
- B. Yellowish white

APPENDIX 4- Variation in size, shape or position of the cranial and dental morphological character states.

1- Bony auditory meatus: A. Without any expansion, B. little expanded, C. Expanded, and D. Greatly inflated



2) Anteroventral side of the bony auditory meatus: A. Smooth, B. Concave, C. Crescent-shaped



3) Mastoid portion of auditory chamber: .A. Not expanded behind occipitals in dorsal view, B. expanded behind occipitals in dorsal view



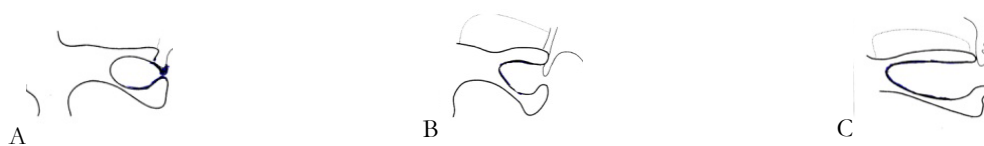
4) The upper part of tympanic membrane or bony part of upper part auditory meatus (curtain): A. Present, obscuring the middle ear ossicles, B. Absent, ossicles clearly visible



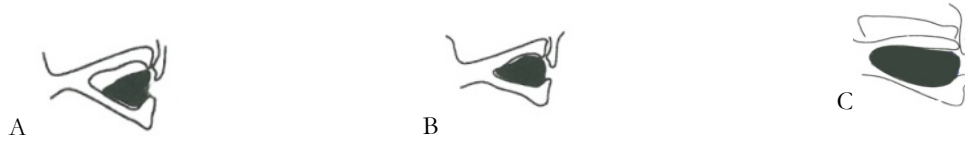
5) Shape of suprimeatal triangle: A. quilateral, B. Isosceles, C. Helicoids



6) Posterior suprimeatal triangle: A. Closed by hamular process, B. Small opening, C. Completely open



7) Emptiness of suprameatal triangle space: A. Half empty, B. a little empty, C. Completely covered



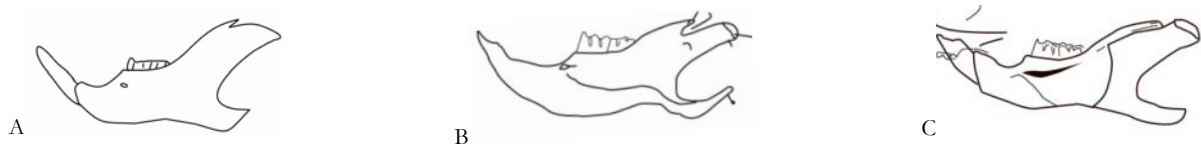
8) Stylomastoid foramen: A. open, B. closed



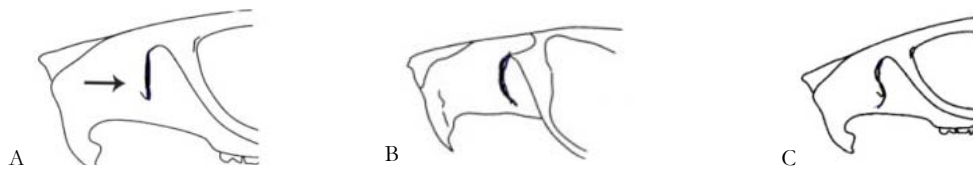
9) Suprameatal apophysis of squamosal: A. thin, B. thick, C. very thick and irregular



10) Inferior masseteric ridge of mandible: A. bass, B. medium, C. high



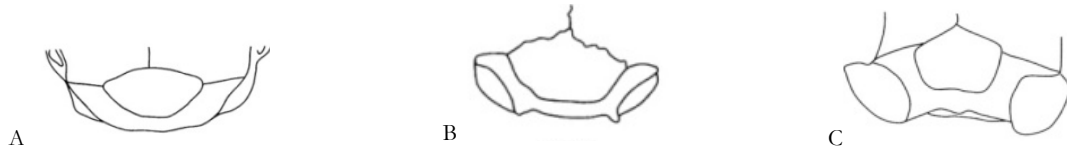
11) Dorsal ramus of zygomatic plate: A. rectilinear, B. rounded, C. sigmoid



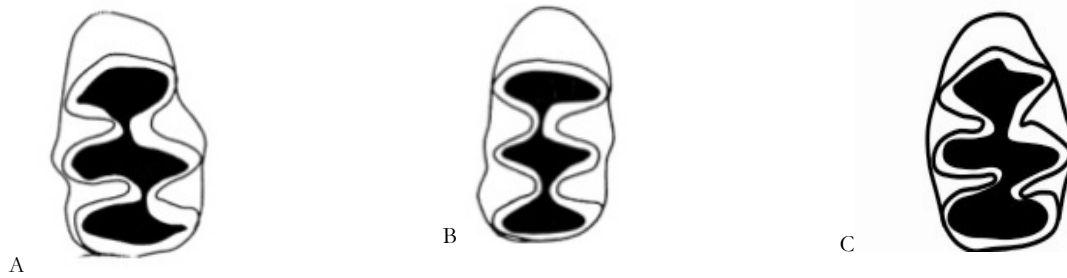
12) Supraorbital crest: A. Absent, B. Visible, C. pronounced



13) Shape of interparietal bone: A. Isosceles trapezoid, B. Long trapezoid, C. Equal sides



14) Upper molar (M1/): A. The longitudinal bridglets in two lines, B. The longitudinal bridglets in the same line, C. truncated



15) Perikymatics of lower molars row: A. Present, B. weakly developed, C. Absent

