Iranian Journal of Animal Biosystematics(IJAB)
Vol.5, No.1, 59-77, 2009
ISSN: 1735-434X

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

JAMSHID DARVISH

Rodents Research Department, Ferdowsi University of Mashhad, Iran

In order to determine the interspecific differences, morphometric characters of external, skull and tooth row variables- of different populations of fourteen species of Jird: *Meriones persicus*; *M. rex; M. hurrianae*; *M. tristrami*; *M. tamariscinus; M. vinogradovi; M. meridianus; M. unguiculatus; M.crassus*; *M. shawi; M. sacramenti*; *M. libycus*. *M. zarudnyi* and *M. grandis* were investigated in a wide range from North Africa to Central Asia. The material came from Iran, Saudi Arabia, Syria, Israel, Morocco, Jordan, Russia, Mongolia, and Turkmenistan.

Univariate and multivariate analyses were performed, euclidian distance between samples was computed and the corresponding distance matrix was used to represent a dendrogram and unrooted tree using the Minimum Spanning Tree algorithm.

The length of hind foot, ear, mandible and auditory bulla are highly important in making distinction between the species. The ratio of tympanic bulla length to the length of skull shows the presence of two adaptive groups: One with relatively small tympanic bulla which include *M. persicus*, *M. tristrami*, *M. vinogradovi*, *M. shawi, M. grandis,* M. *zarudnyi*, *M. rex*, *M. sacramenti* and *M. hurrianae* and the other with relatively large bulla which include *M. crassus*, *M. libycus*, *M. tamariscinus*, *M. meridianus* and *M. unguiculatus*. The Minimum Spanning Tree method showed that all species of Jird could be regrouped into two branches: one with small, and the other with medium and large overall size. This difference may reflect geographic and adaptive statue of different species of Jirds.

Key words: *Meriones*, morphometry, North Africa, Asia, Iran, MST, Adaptive Geographic variation.

INTRODUCTION

The Jirds of the genus *Meriones* are dominant in the Palaearctic region, especially in the Middle East and Central Asia (Wilson and Reeder 2005). The morphological differences between species are slight, especially in molar characteristics. The classification of this genus is inconclusive and the range of interspecific and intraspecific variations is not clearly known for each species. Most of the Jird species inhabit the arid belt of North Africa, Middle East and Central Asia and have been described by Blanford (1869), Petter (1951, 1953, 1955, 1957, 1959, 1961, 1984, 1987,1988 and 1989), Vinogradov and Argyropolo (1941), Hassinger (1968), Lay(1967), Harrison et al.(1991) , and Darvish et al. (1991). The comprehensive revision of this genus by different authors requires considerable modifications and a conclusive

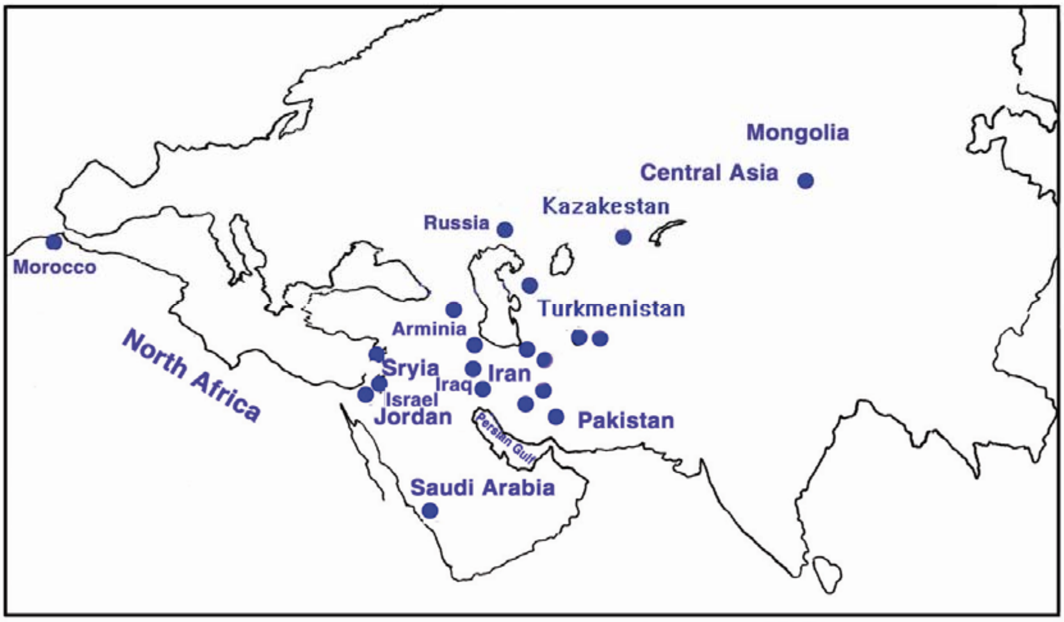


FIG. 1.- Distribution map of studied samples.

and up to date revision of the entire genus is not available (Corbet, 1978). The African forms of this genus are confusing taxonomically and their diagnostic features are not reliable (Corbet, 1978). Ellerman and Morrison-Scotte (1946) divided the different species of genus *Meriones* into 4 sub-genera and 12 species as following: 1- *Parameriones* Heptner, 1937; with *M. persicus* Blanford, 1875; *M. rex* Yerbury & Thomas, 1895. 2- *Chelions* Thomas, 1919; with *M. hurrianae* Jerdon, 1867. 3- *Meriones* with*: M. vinogradovi* Heptner, 1931; *M. tamariscinus* Pallas, 1773; *M. blackleri* Thomas, 1903. 4- *Pallasiomes* Heptner, 1936; with *M. unguiculatus* Miln-Edward, 1867; *M. meridianus* Pallas, 1773; *M. shawi* Duvernoy, 1842; *M. arimalius* Cheesman & Hinton, 1924; *M. libycus* Lichtenstein, 1823; *M. crassus* Sundevall, 1842. This subdivision of genus *Meriones* is discordant with the study of recent authors (Chevret and Dobigny 2005). Therefore, the taxonomic validity of different subgenera and species of *Meriones* is not clear. McKenna and Bell (1997) use the subtribe name Merionina (presumably arguing that it has priority) for the same group. According to Pavlinov (1990) *Meriones* is considered as a sister group (cladistically closest) of the genus *Brachiones*. Tong (1989), however, suggests that *Psammomys* is its sister taxon.

There are eight species of *Meriones* in Iranian Plateau with different kind of distribution from each other: *M. persicus* and *M. libycus* are distributed in all parts of Iran; *M. crassus* distributed in warm and lowlands of both sides of Zagros Mountains, central Kavir and Dashte Lout; *M. meridianus* is in sandy regions of central Kavir of Kerman and Khorasan provinces; *M. hurrianae* is distributed in the southeast Iran from Baluchistan to Bandar Abbas near Persian Gulf. *M. tristrami* and *M. vinogradovi* are distributed from northwest to southwest of Iran in Zagros Mountains chains. Till now, there have been a few comprehensive geographical studies on the species of the genus *Meriones* in Asia and North Africa. Consequently, in this study we tried to verify the interspecific and geographic variation of fourteen species of the genus *Meriones* in North Africa, Iranian Plateau, and Central Asia.

MATERIAL AND METHODS

The numbers of Jirds examined in this study are listed in the appendices. The specimens were provided by sampling in the east of Iran. All samples are deposited at the collection of rodents in Zoological Museum of Ferdowsi University of Mashhad (ZMFUM). The other part of the

TABLE 1. - Geographic origin of the *Meriones* samples, according to MNHN of Paris and ZMFUM of Mashad.

Number	Locality	Species	ZMFUM specimens Iran	MNHN specimens France	Total
1	Iran	*M. libycus*	70	33	103
2	Iran	*M. persicus*	12	24	36
3	Iran, Syria, Israel, North Africa	*M. crassus*	4	47	51
4	Iran, Russia, Arminia, Mongolia	*M. meridianus*	3	17	20
5	Iran, Israel, Iraq, Jordan,	*M. tristrami*	1	69	70
6	Iran	*M. vinogradovi*	2	25	27
7	Saudi Arabia	*M. rex*	-	9	9
8	Israel	*M. sacramenti*	-	14	14
9	Morocco	*M. shawi*	-	28	28
10	Morocco	*M. grandis*	-	16	16
11	Iran	*M. hurrianae*	-	2	2
12	Central Asia	*M. tamariscinus*	-	3	3
13	Central Asia	*M. unguiculatus*	-	4	4
14	Turkmenistan	*M. zarudnyi*	-	1	1
	Total		92	292	384

materials belongs to the Natural History Museum of Paris (MNHN) collected from North Africa, Middle East, Iran and Central Asia (tab.1 and Fig 1).

Measurements are in millimeters and consist of the mean and SD. For brevity, several abbreviation for measurement variables were defined: (A) width of the dorsal ramous of the plate zygomatic; B: width of zygomatic arc; CB: condylobasale length; ON: occipitonasale length; BL: The length of the tympanic bulla; WS: Width of cranium in the area of the tympanic bulla; IO: interorbital distance; UML: The length of upper molars tooth row; LML: The length of lower molars tooth row (fig 2). Standard external measurements are abbreviated as follows: BL: body length, (TL): tail length, (FL): foot length, (EL): ear length. The external morphometric data of specimens from the collection of MNHN of Paris were obtained from the data on the identification card of specimens and ZMFUM specimens were measured by a ruler to the nearest millimeter.

In order to evaluate differences in various external and cranial variables among species, several statistical techniques were applied: Univariate analysis and bivariate scatter plot were performed for various external and skull variables in order to determine and define univariate and bivariate separation of different species. The one-way analysis of variance (ANOVA) and pair-wise comparisons were carried out to check for statistically significant difference between groups. For this purpose, data were first checked for normality (Shapiro-Wilk test) and homogeneity of variances (Levene's test). The significance for all statistical test was set at P=0.05. Principle component analysis (PCA) was performed in order to visualize the overall differences using the four morphometric characters. Canonical analysis of all species was performed for skull and all variables separately. Euclidian distance between samples was computed by UPGMA method (Unweighted Pair- Group Arithmetic Average) and the corresponding distance matrix represented as phenogram and unrooted tree using Minimum Spanning Tree Method (MSTM). All the analysis was run by the SPSS version 15 and PAST packages.

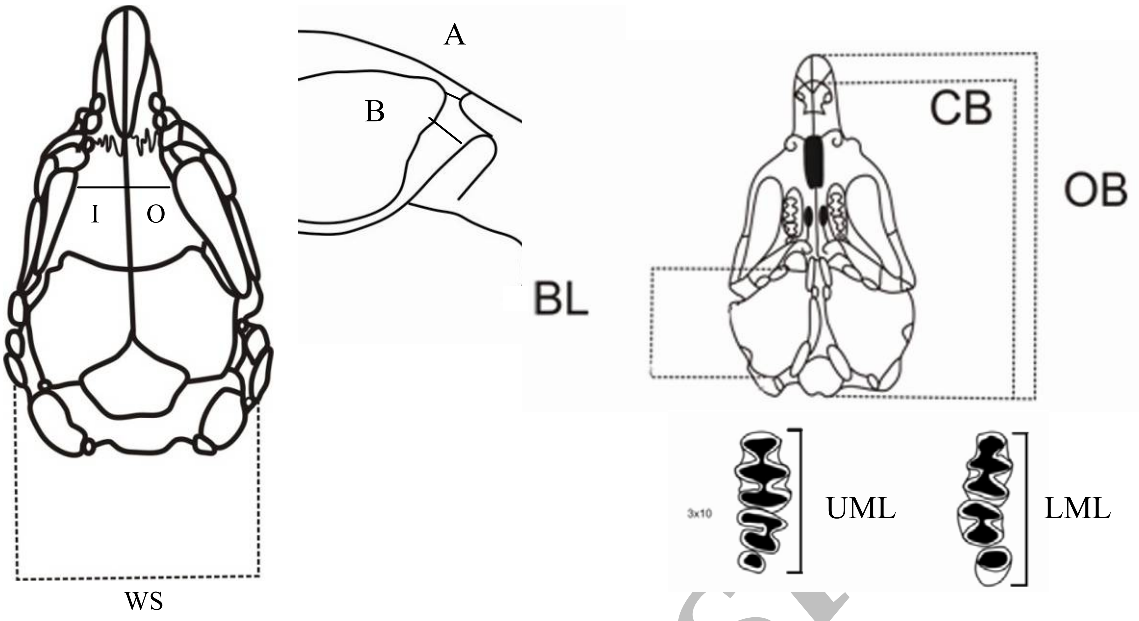
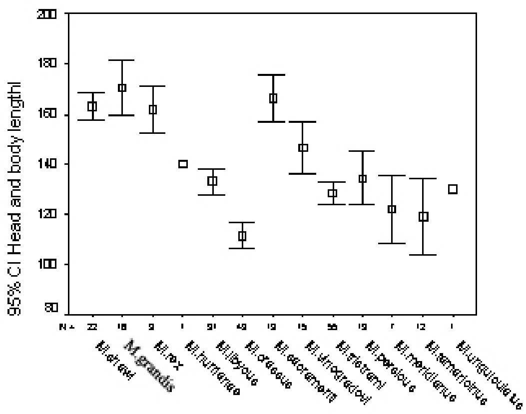


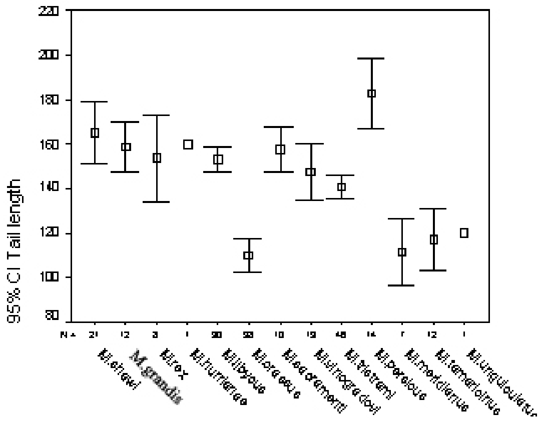
FIG. 2.- Abbreviation used for cranial variables: A width of the dorsal ramous of the plate zygomatic; B: width of zygomatic arc; CB: condylobasale length; ON: occipitonasale length; BL: The length of the tympanic bulla; WS: Width of cranium in the area of the tympanic bulla; IO: interorbital distance UML: The length of upper molars tooth row; LML: The length of lower molars tooth row. Standard external measurements are BL: body length, TL: tail length, Fl: foot length, EL: ear length

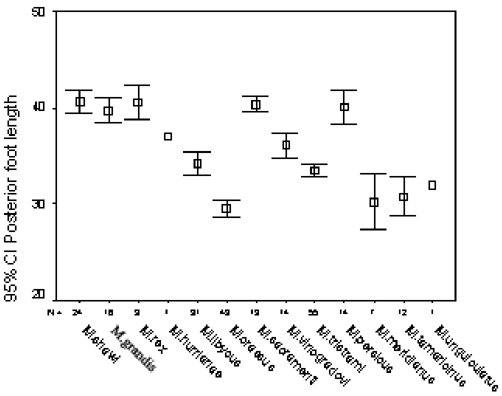
RESULTS

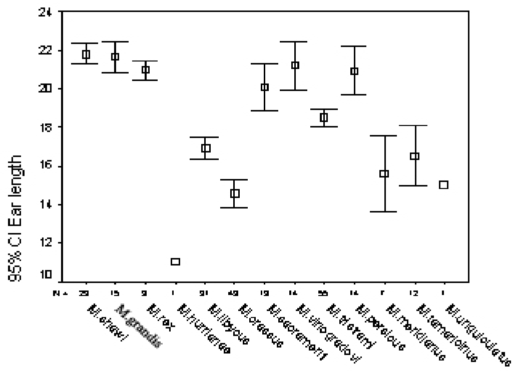
The analysis of 384 specimens of Jirds for 4 external and 9 cranial variables in 14 species was done and the values for mean and Standard Deviations are shown in table 2. The univariate analysis indicates that there are no significant sexual differences in external and cranial measurements. Therefore, we combined males and females for the purposes of statistical analysis. Measurements were done only for adult specimens who had complete maxillary teeth.

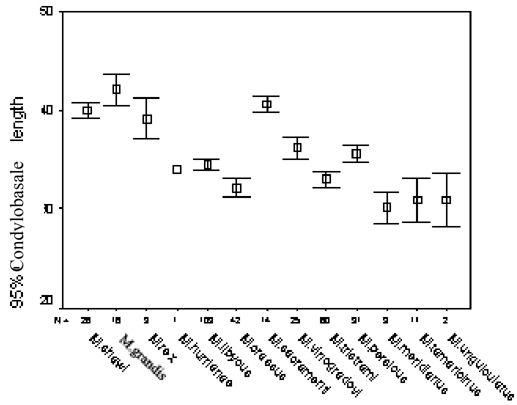
The analysis of variance also was done for extracting the meaningful variables for the analysis and indicated that all variable are statistically significant (p-value <0.05) and we do not need to eliminate some variable which can be included in the analysis (Table 3). The test of normality of Shapiro-Wilks for the samples was done and showed that the samples are normal and do not needed to be eliminated as nonsense data. There was not any difference between the sexes. The length of diastema was removed from the analysis because of missing values. The results of Kolmogoroff-Smirnoff normal distribution tests show that most of variables have a normal distribution. The descriptive data for all species are presented in table 2 and the comparison of means and standard error of all species presented in Fig 3. Geographic attention to the variation of external variable shows that in North Africa and Asia the size of external variable diminishes from *M. shawi* and *M. grandis* to *M. libycus* and *M. crassus* and from *M. sacramenti* to *M. unguiculatus* and *M. tamariscinus* .(Fig. 3)

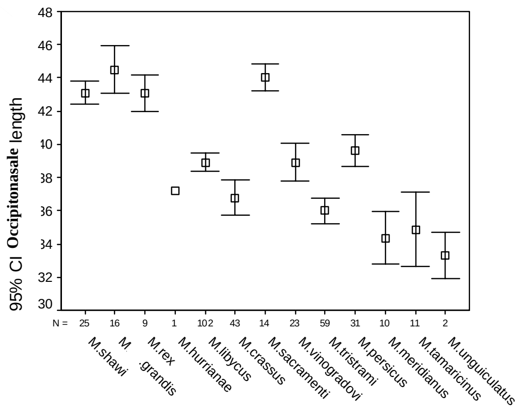

95% CI Head and body lengthl

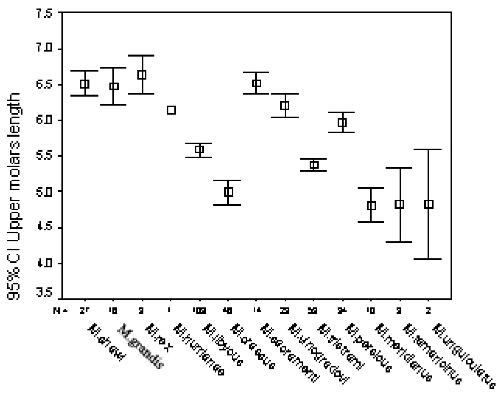

95% CI Tail length

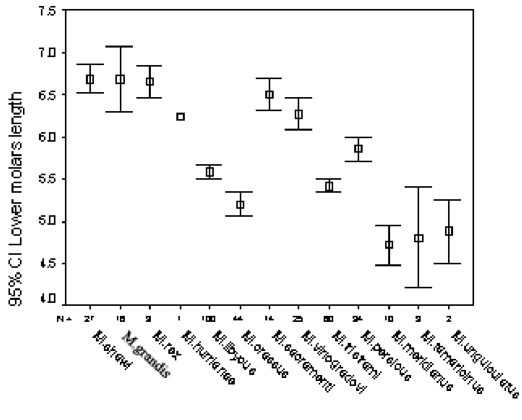

95% CI Posterior foot length


95% CI Ear length


95% Condylobasale length


95% CI Occipitonasale length


95% CI Upper molars length


95% CI Lower molars length

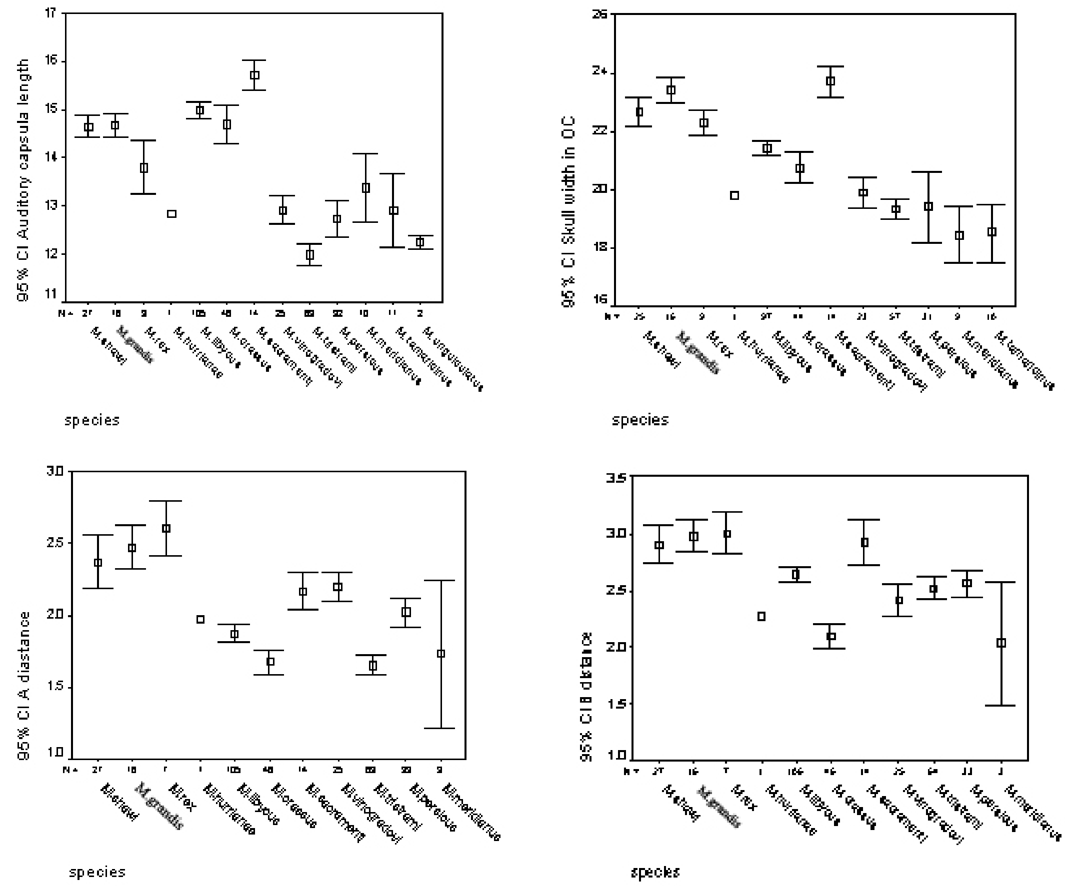
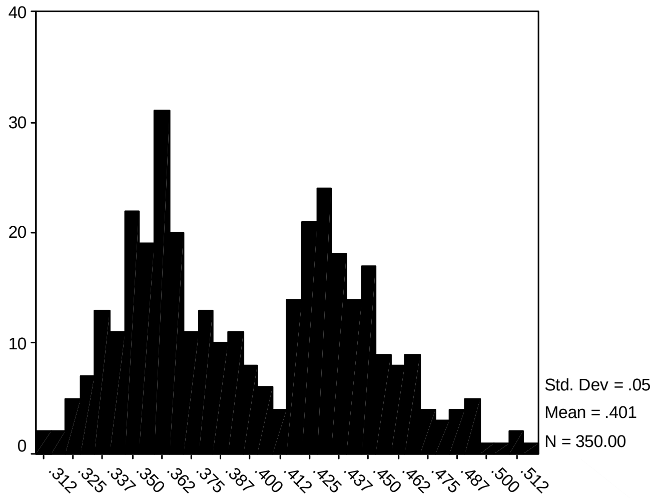


FIG. 3.- Error bar diagrams of variation in length of some external and cranial characters in different species of *Meriones*.

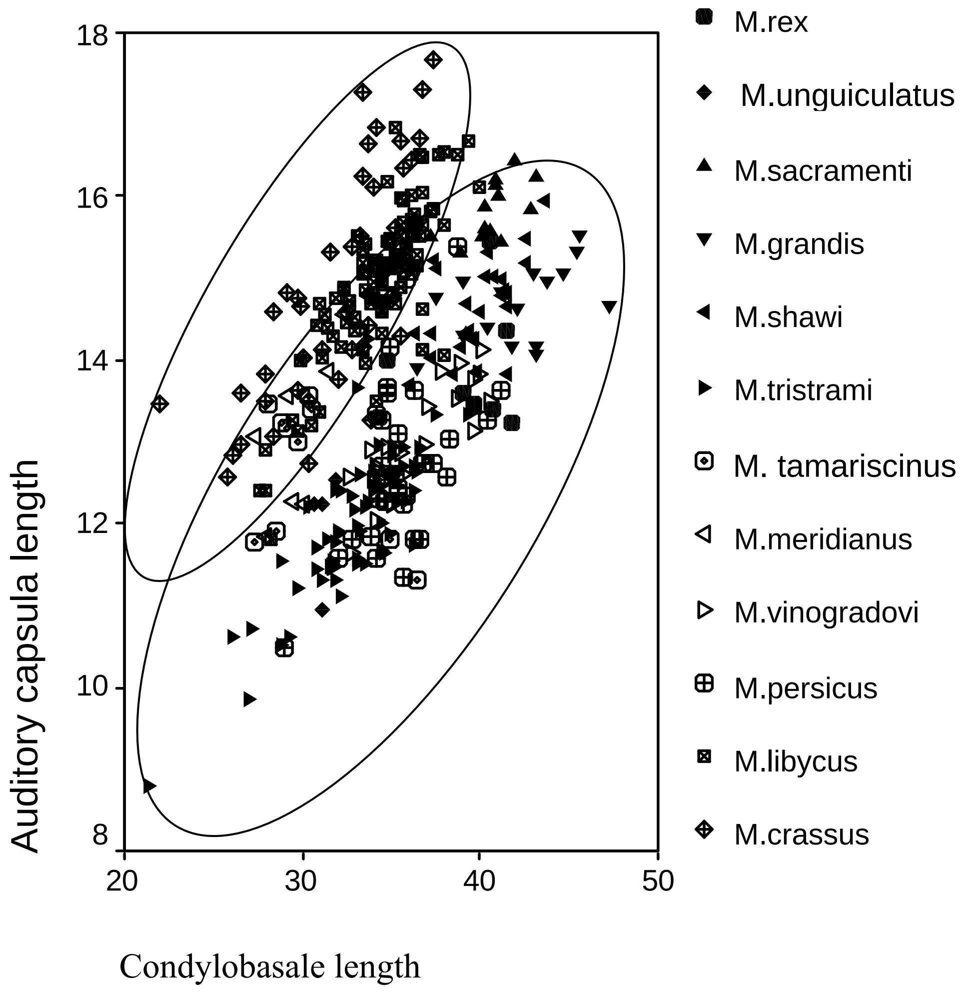
The variation of tympanic bulla/ condylobasale length shows the presence of two groups and two directions of anagenesis and probably cladogenesis (fig. 4A, B). Also, the scatter plot of upper tooth row compared to lower tooth row (Fig. 5) confirms the importance of molar size for determination of *Meriones* species (Momenzadeh et al. 2008).

The principal components analysis (PCA) of external data shows that *M. crassus* is the smallest species in respect to external size and *M. persicus* is the biggest (fig. 6). The first principal component accounts for 80.6 % of total variance and the second component accounts for 8.9% variance (Tab. 5). The head and body have 81% influences on component 1 and 5% on component 2. The tail length has 77% influence of component 1 and 18% on component 2 and the ear length has 87% influences on component 1 and 2% on component 2. The posterior foot length has negative influence on component 1 and positive influence on component 2. The scatter diagram suggests that some characters have positive loadings on the first PC and that these are of greatest value in the separation of species of *Meriones*.

The canonical discriminant analysis of skull variables showed that The test of Wilks' Lambda is significant and the first two component have respectively 57% and 24% of all variation and the length of upper molars tooth row (o.48) and lower molars(0.45), and auditory bulla (-0.37) respectively have the most correlation with the first component. For the second component, the size of auditory bulla (0.85) and the width of skull and the length of condylobasale (0.73) respectively have the biggest contribution.



A



B

FIG. 4. - A - Variation of tympanic bulla/condylobasale length ratio shows the presence of two groups: small tympanic bulla with variation between 0.31 to 0.4 including *M. persicus*, *M. tristrami*, *M. shawi, M. grandis* *M. rex*, *M. sacramenti*, *M. hurrianae* and *M. unguiculatus* and large tympanic bulla with variation between 0.4 and 0.51 including M. *crassus*, *M. libycus*, *M. tamariscinus*, *M. meridianus* and *M. unguiculatus* (Fig. 4B).

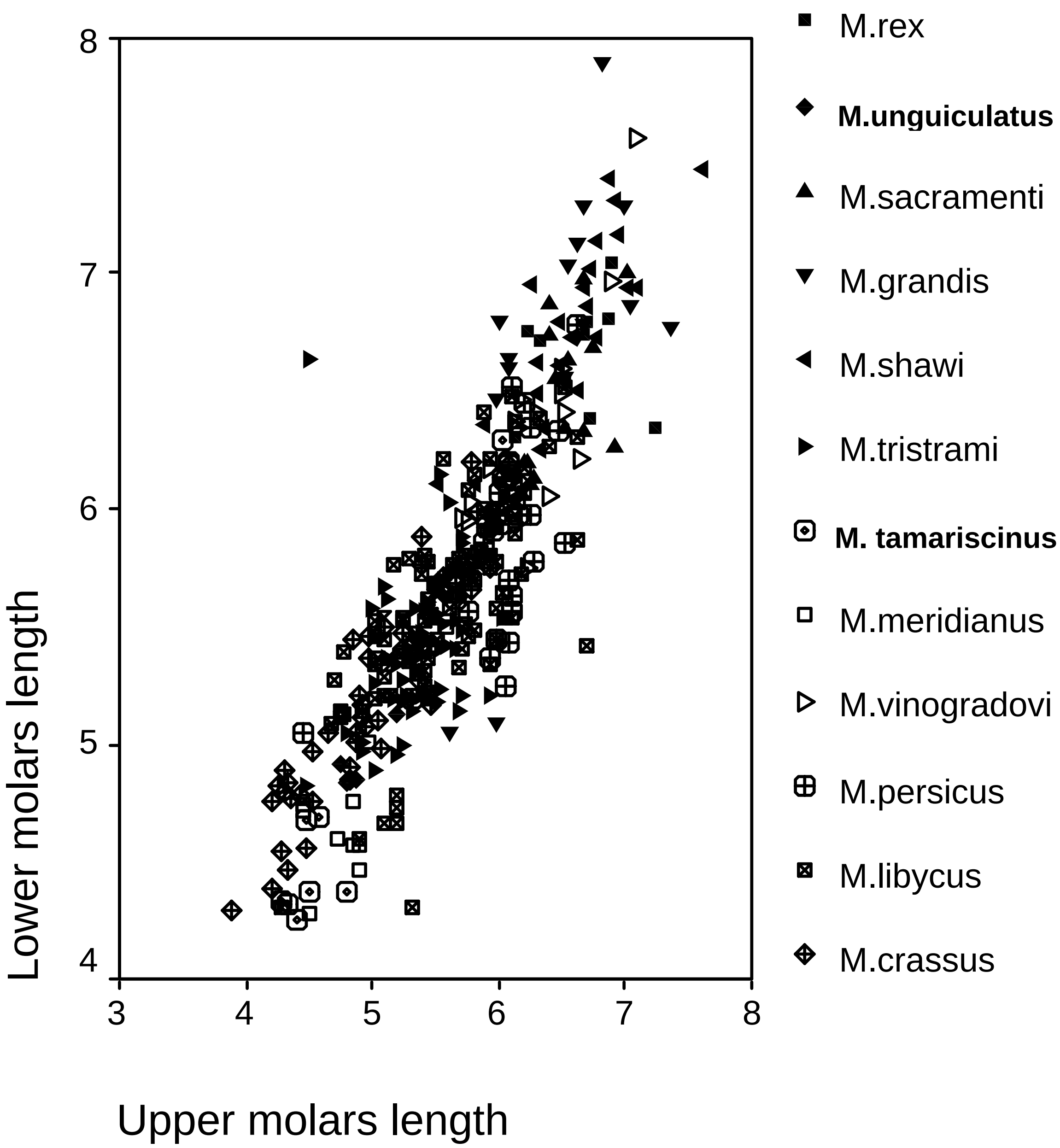


FIG. 5.- Scatter plot of lower molars length compared to upper molars length in Genus *Merions* species that show *M.crassus*, *M.meridianus, M.tamariscinus* have the smallest tooth row length and *M.shawi* and *M.grandis* the largest tooth row length.

TABLE 5.- Eigenvalue, percentage of total variance, and cumulative percentage of Principal component loadings in *Meriones* species (A). The first principal component of *Meriones* species has 80.6 % of total variance and the second component has 8.99% variance.

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.225	80.620	80.620	3.225	80.620	80.620
2	.360	8.995	89.615	.360	8.995	89.615
3	.249	6.229	95.844			
4	.166	4.156	100.000			

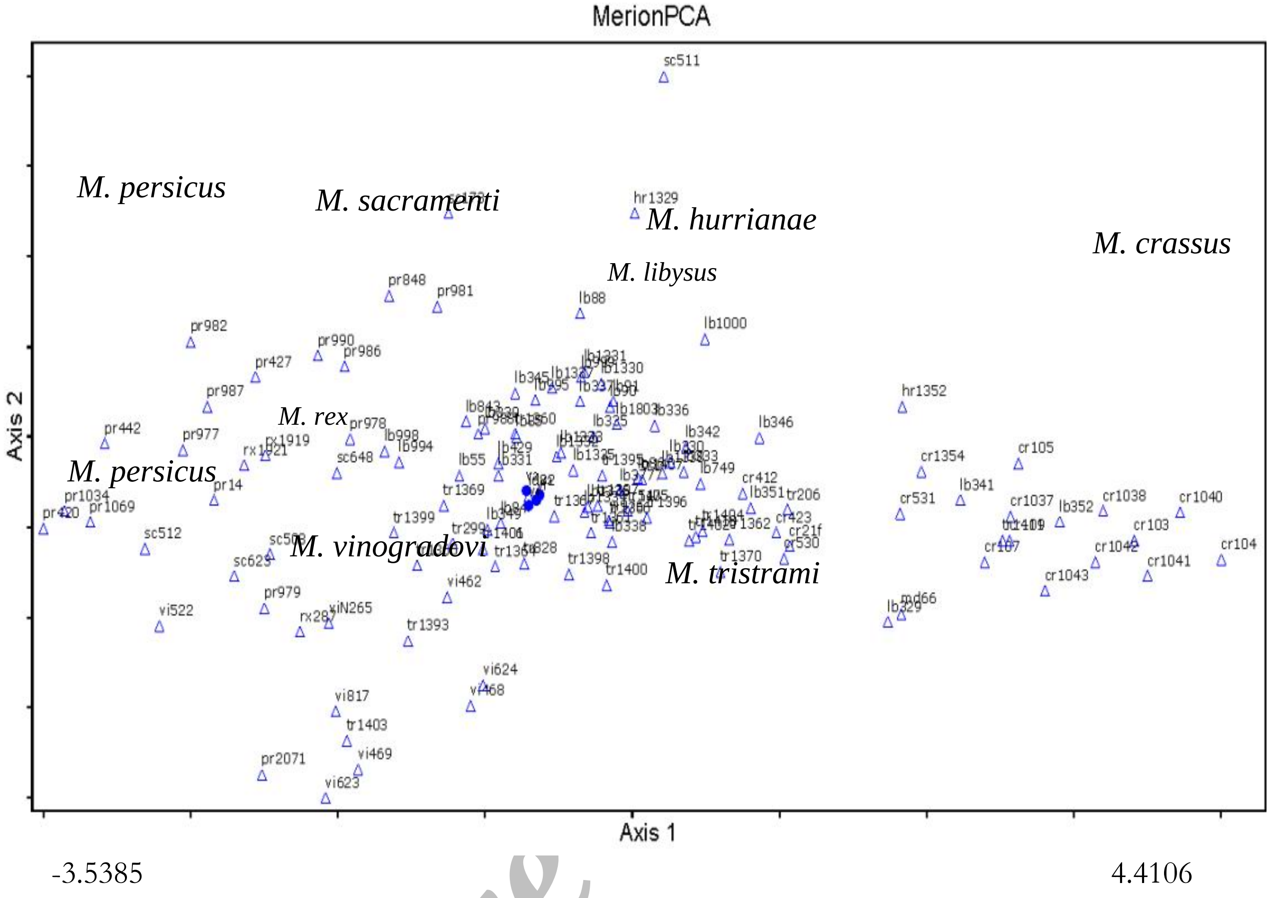


FIG. 6. - Principal component analysis of external size variables. On the axis 1, the smallest species is M. *crassus* and the largest is *M. persicus.* On the axis 2, *M. vinogradovi and M. sacramenti* are different from other species. Acronymes are : (rx): *M. rex;* (hr): *M. hurrianae*; (tr): *M. tristrami*; (tm): *M. tamariscinus; (vi): M. vinogradovi;* (mr): *M. meridianus;* (un): *M. unguiculatus;* (sh): *M. shawi;* (sc): *M.sacramenti*; (lb): *M. libycus. (mz): M.zarudnyi;* (mg): *M.grandis;* (pr): *M. persicus.*

Figure 7 shows that *M. Crassus, M.meridianus, M.tamariscinus* and *M. libycus* are separated by first component. But the other species are separated by second component. Therefore, the species *M. shawi*, *M. grandis*, *M. rex*, *M. vinogradovi*, *M. persicus*, and *M. tristrami* respectively have the longest auditory bulla, width of skull and condylobasale length. The Eigenvalues, standard canonical discriminant function coefficients and structure matrix of discriminant analysis and functions at group centroids are presented in table 7.

TABLE 6. - The test of Wilks' Lambda table of the significance of test of functions and the Eigenvalues with relatie variances.

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 6	,031	1069,484	66	,000
2 through 6	,145	593,499	50	,000
3 through 6	,374	302,147	36	,000
4 through 6	,626	143,718	24	,000
5 through 6	,840	53,409	14	,000
6	,949	16,024	6	,014

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3,714[a]	57,2	57,2	,888
2	1,583[a]	24,4	81,5	,783
3	,675[a]	10,4	91,9	,635
4	,342[a]	5,3	97,2	,505
5	,130[a]	2,0	99,2	,339
6	,054[a]	,8	100,0	,226

a. First 6 canonical discriminant functions were used in the analysis.

Table 7.- Discriminant function coefficients and structure matrix of discriminant anlysis.

	Function					
	1	2	3	4	5	6
Auditory capsula length	-,370	,857*	-,099	,135	,223	-,225
Condylobasal length	,382	,735*	-,126	,156	,447	-,270
Occipitonasal length	,236	,718*	-,073	,409	,449	-,233
Lower molars length	,451	,706*	-,107	,291	-,146	,425
Upper molars length	,480	,655*	,062	,422	-,263	-,299
Skull width in OC[a]	,053	,621*	-,083	,185	,270	-,173
Interorbital length	,247	,519	,652*	,163	,463	-,067

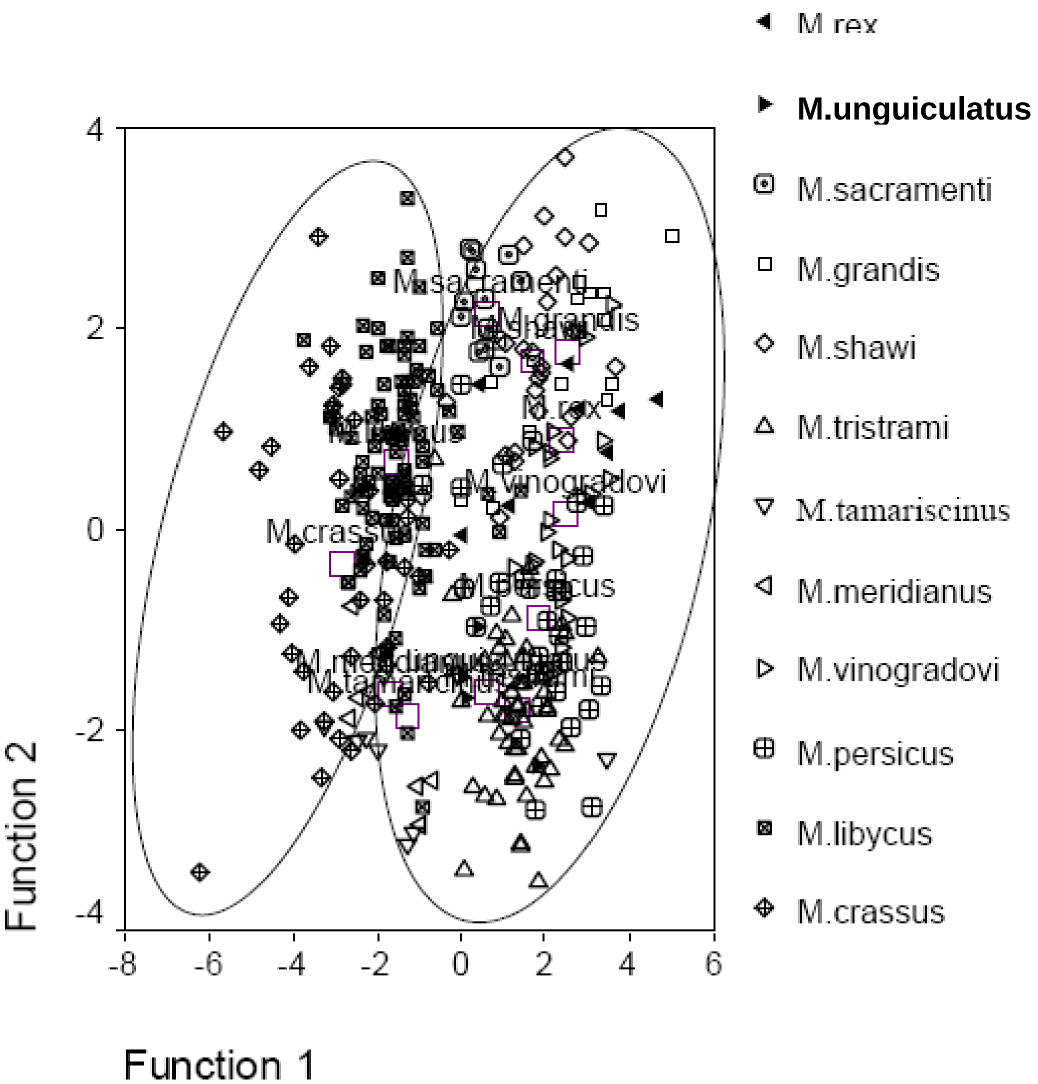
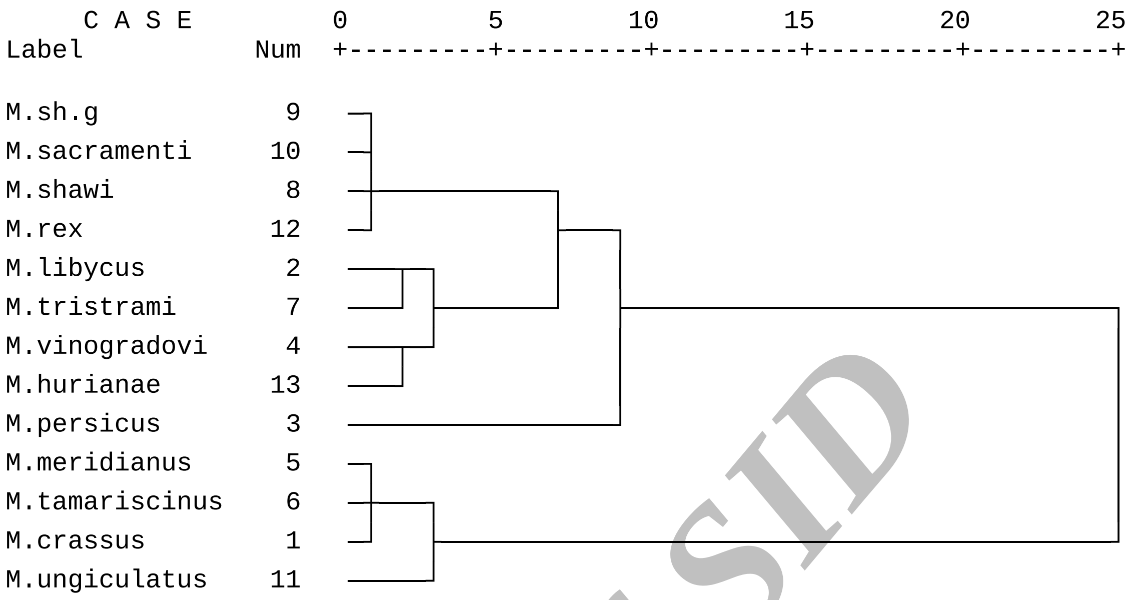


FIG.7.- Ordination of *Meriones* species on the discriminant functions1 and2 for skull. *M. crassus, M. meridianus, M. tamariscinus* and *M. libycus* are separated by first component.

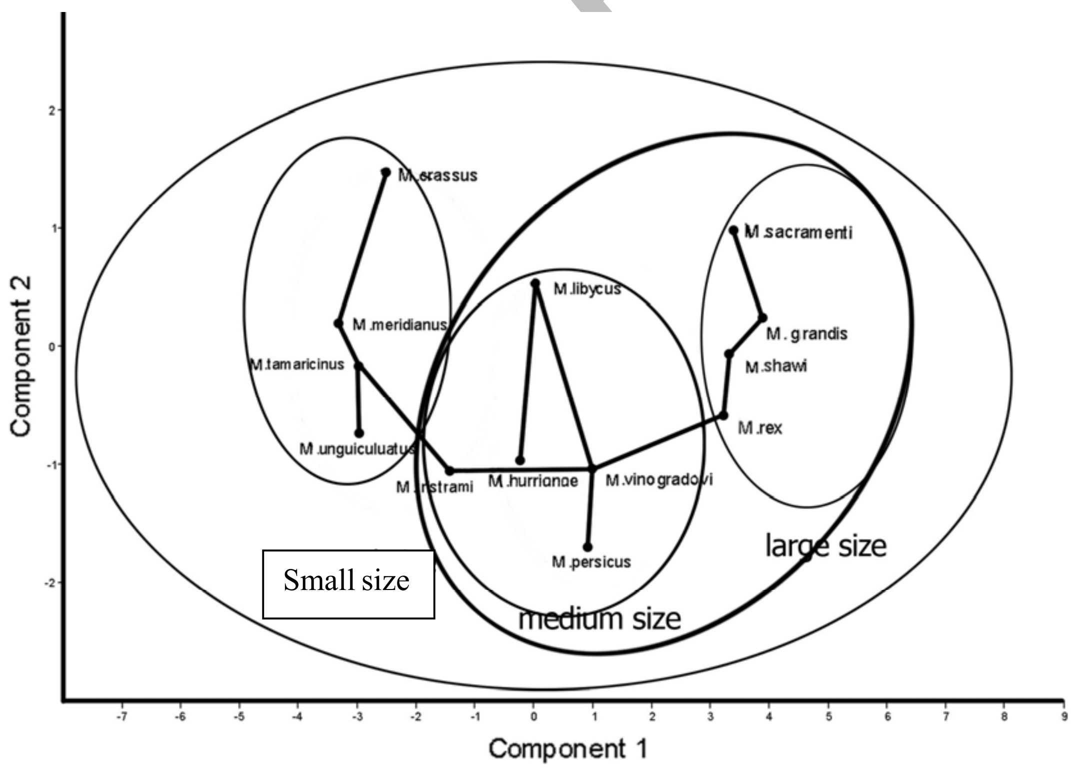
The phenetic dendrogram of samples by UPGMA method (Unweighted pair group method with Arithmetic mean) built from the Euclidean distances between the averages of the 13 external and skull variable (aggregative method "Paired Group Algorithm") shows that different species are grouped in two big branches by the size characters. One branch is composed of *M. meridianus, M. craassus*, *M. tamariscinus* and *M. unguiculatus* and the other branch is composed of two subgroups. The first group comprises the species of North Africa, Arabian peninsula and Israel including M. *shawi*, *M. grandis*, M. *rex* and *M. sacramenti*; the other subgroup is composed of *M. libycus , M. tristrami, M. vinogradovi* and *M. hurrianae*. The Minimum Spanning Tree Method shows that all species of *Meriones* could be regrouped in three groups of small, medium and large species by their overall size probably reflecting the way of their geographic distribution and an image of anagenesis (Fig 8).

TABLE 2.- Number of specimens, mean and standard deviation of external and cranial characters in different species of genus *Meriones* . The acronyms are (CB) condylobasale length; (ON): occipitonasale length; (BL): The length of the tympanic bulla ;(WS): Width of cranium in the area of the tympanic bulla; (IO): interorbitale distance (UM): The length of upper molars tooth row; (LM): The length of lower molars tooth row. Standard external measurements (BL): body length, (TL): tail length, (FL): foot length, (EL): Ear length. Due to missing values and the low number of specimens for some species, the number of specimens in this table is different from the table number 1 and *M. hurrianae* and *M. unguiculatus* are not mentioned in this table.

Chara cters	*M. crassus*			*M. libycus*			*M. persicus*			*M. vinogradovi*			*M. meridianus*			*M. tamariscinus*			*M. tristrami*			*M. shawi*			*M. .grandis*			*M. sacramenti*			*M. rex*			ANOVA	
	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	F	Sig
CB	44	31.9	3.5	103	34.5	2.5	32	35.6	2.3	25	36.2	2.6	7	30.2	2.1	12	30.9	3.3	55	33.0	3.0	23	39.8	2.0	16	42.1	3.0	13	40.6	1.5	9	39.1	2.8	36.5	0.0
ON	44	36.7	3.5	102	38.9	2.8	32	39.6	2.5	25	38.9	2.7	7	34.4	2.2	12	34.9	3.4	55	36.0	3.0	23	43.1	1.7	16	44.5	2.7	13	44.0	1.4	9	43.1	1.4	28.7	0.0
BL	44	14.7	1.4	103	15.0	0.9	32	12.7	1.0	25	12.9	0.7	7	13.4	1.0	12	12.9	1.1	55	12.0	0.9	23	14.7	0.6	16	14.7	0.5	13	15.7	0.5	9	13.8	0.7	50.6	0.0
SW	44	20.7	1.8	103	21.4	1.2	32	19.4	3.3	25	19.9	1.2	7	18.5	1.2	12	18.6	1.3	55	19.2	1.6	23	22.7	1.2	16	23.5	0.8	13	23.7	0.9	9	22.3	0.6	22.8	0.0
IO	44	5.9	0.3	103	6.9	0.5	32	6.9	0.5	25	6.7	0.4	7	6.1	0.4	12	6.2	0.7	55	6.3	0.5	23	7.3	0.5	16	7.3	0.6	13	6.7	0.2	9	7.6	0.4	26.1	0.0
UM	44	0.6	0.1	103	0.5	0.1	32	0.4	0.1	25	0.4	0.1	7	0.3	0.1	12	0.7	0.2	55	0.3	0.0	23	0.5	0.1	16	0.5	0.1	13	0.3	0.1	9	0.4	0.1	42.2	0.0
LM	44	5.2	0.5	100	5.6	0.5	32	5.9	0.4	25	6.3	0.4	7	4.7	0.3	12	4.8	0.8	55	5.4	0.3	23	6.7	0.5	16	6.7	0.7	13	6.5	0.3	9	6.7	0.3	26.1	0.0
HB	44	111.2	17.2	31	133.3	14.0	13	134.5	17.3	15	146.7	18.3	7	122.0	14.9	12	119.1	23.8	55	128.3	16.3	22	162.3	13.3	16	170.7	19.9	13	166.3	15.7	9	161.8	11.9	27.2	0.0
T	44	110.0	22.9	30	153.0	15.0	13	183.0	27.8	13	147.0	20.8	7	111.0	16.2	12	117.0	21.7	55	141.0	16.8	21	159.0	17.9	16	164.0	30.5	13	158.0	14.1	9	154.0	23.8	18.9	0.0
HF	44	29.5	2.9	31	34.2	3.3	13	40.1	3.1	14	36.1	2.2	7	30.2	3.1	12	30.8	3.2	55	33.5	2.4	24	39.2	8.1	16	39.8	2.4	13	40.4	1.3	9	40.6	2.2	23.1	0.0
E	44	14.5	2.3	31	16.9	1.6	13	20.9	2.2	15	21.2	2.2	7	15.6	2.2	12	16.5	2.5	55	18.5	1.7	23	21.6	1.6	16	21.6	1.5	13	20.1	2.1	9	20.9	0.6	37.3	0.0



A



B

FIG. 8. – A) Dendrogram of four external and seven cranial variables. B) The unrooted tree phenogram presented by MST (minimum spanning tree) presents two images of postulated divergence of different species.

DISCUSSION

This study showed the importance of external and skull characters for determination and classification of different species of Jirds. For example the length of hind foot, ear and auditory bulla are highly important for identification of species. Meanwhile, all these characters are adaptive values (Petter 1961) then may be used for evolutionary biology studies (Chetboun et al., 1983). In contrast to morphological studies in which the shape of molars are not important for distinction of species of Jirds , in morphometric studies the length of the upper and lower tooth rows and molars are important. Consequently, *M. shawi* , *M. grandis* and *M. sacramenti* have the longest tooth row and *M. crassus, M. meridianus, M. tamariscinus* and have the smallest. This result can be applied for determination of isolated teeth materials in paleontological, archaeozoological and neotological studies.

The studied species could be divided into two large groups of small, medium to large sized species that show the possibility of decreasing of size during the settlement of new populations in different localities. The smallest species are M. *crassus* from north Africa to Iranian Plateau , *M. tamariscinus* and *M. unguiculatus* in Central Asia and *M. meridianus* from Central Asia to Iranian Plateau . The species distributed in Iranian Plateau and adjacent countries are variable in size between north African and Central Asian species of Jirds.

Species like *M . persicus*, *M. tristrami*, *M. shaw*, *M. grandis, M. rex*, *M. sacramenti* which are adapted to highlands, have a simple tympanic bulla . The species adapted to arid lowlands like central Iranian basin, the tympanic bulla is hypertrophic as in: *M. crassus*, *M. libycus*, , *M. meridianus* and *M. unguiculatus.* We remark that the size of tympanic bulla is positively correlated with aridity and density and can be regarded as a limit for the distribution of each species (Petter, 1953) and can be used in integrative zoological studies.

The *Meriones* species are very interesting taxa for the study of interspecific and intraspecific variation of size and also mechanism of speciation and adaptation. These species is distributed in the arid belt of North Africa, Middle East and Asia and have relatively homogenous distribution in all part of its distribution reflecting different kind of distributions (sympatric, parapatric and allopatric). Nevertheless, the center of distribution of each species is not determined , meanwhile, *M. grandis, M. shawi*, *M. sacramenti*, and *M. rex* distributing in North Africa, Arabian peninsula and Palestine region which probably may be in accordance with the center of origin proposed by Cains's(1944). Also, the oldest species of genus *Meriones* is probably as *M. shawi* which appeared in the North Africa (Tong, 1986). *M. shawi* is limited in the south of its range of distribution in North Africa by aridity. Geographic distribution of species such as*M. grandis* and *M.shawi* in North West of Africa is replaced by *M. tristrami* in the east showing that the speciation in this group could be ecological and vicariant. *M. tristrami* appeared and distributed in the South of Caucasus region and penetrated secondarily to the West of Iranian plateau.us, Turkey, Syria, Mesopotamia and Palestine region, after the 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. Whereas *M. persicus* was appeared in the North East of Iranian plateau (Iranian tension zone of Misonne) and then progressed towards all different highland of Iranian Plateau and adjacent countries (Misonne 1959). Evidently, climate is the most important factor limiting penetration and distribution of different population. Some species penetrated Iranian plateau probably via Mesopotamia: *M. crassus*, *M. libycus* ; and one species penetrated Via Kushka in North east of Iranian Plateau : *M. meridianus* . *M. hurrianae* penetrated Persian Gulf border via South West of Indian Subcontinent. *M. libycus* is present in Sahara of North Africa, desert of Syria and through Mesopotamia, Iran and central Asia to china. *M.tamariscinus,* and *M.unguicultus* are two species of Jird distributed in central Asia with the large of distribution and *M.zarudnyi* is an endemic species presented in Badkhiz region in South of Turkmenistan. *M. crassus* has at least two distinct subspecies in Zagros Mountains: the south west lowland subspecies by the name of *M. crassus*

charon with smaller tympanic bulla and the other in the south eastern parts of Zagros and Central Iran by the name of *M. crassus swinshoei* with a hypertrophic bulla (Petter 1961).
M. meridianus is other species with considerable variation in size and proportions of external and skull variables. Also, the introduction of many subspecies for this species is emblematic, causing taxonomic confusion and a revision is highly demanded.

ACKNOWLEDGMENTS
I like to express my gratitude to Professor Ch. Denys Director of Birds and Mammals in Natural History Museum of Paris who made it possible for me to examine the specimens of Jird. I also thank Professor F. Petter for his remarks on taxonomic problems of *Meriones* species and also Mr.V. Akmaly and Mr. S. Taravati for reviewing the manuscript.

LITERATURE CITED

BLANFORD W.T 1869, Eastern Persia: 1870-71-72, Macmillan and Co., 1876, 443 pages

CAINS S.A 1944 . Foundation of Plant Geography. Harper and Brother . NY. London

CHEESMAN AND HINTON, 1924. On the Mammals collected in the desert of central Arabia by Major R.A.Cheesman, *Annals and Magazine of Natural History*(9)14 548-558

CHETBOUN, R. AND TCHERNOV, 1983, Temporal and spatial morphological variation in *M.tristrami* (Rodentia, Gerbillidae) from Israel, 32:63-90.

CHEVRET P. AND GAUTIER DOBIGNY. 2005. Systematics and evolution of the subfamily Gerbillinae (Mammalia, Rodentia, Muridae), *Mol.Phyl.Evol.* Vol.25- pp:674-688.

CORBET, G.B.1978. The mammals of the palearctic region.Bro. Mus. (W.H.) London

DARVISH ET AL. 1991. Preliminary study of the Fauna of Rodents in the Northern Khorasan with the aid of pellets from the prey birds. *Ent. & Phytopath.* Vol. 59. N: 1 & 2

ELLERMAN J. R. AND T.C.S. MORRISON-SCOTTE 1946. Checklist of Palaearctic and Indian mmammals 1758 to 1946 . Trustees of the British Museum (Natural History), London,810 pp.

HARRISON D.L.; AND P.J.J. BATES 1991.The mammals of Arabia, Harrison Zoological Museum, Sevenoaks, United Kingdom, 345 pp.

HASSINGER J.P. 1968. A survey on mammals of Afghanistan resulting from 1965 street expedition (excluding bats) *Fildiana(zoology)* 60:1-195

HEPTNER W.G. 1957. Note sur les Gerbillidae (Mammalia, Glires). Sur les relations réciproque de certains Gerbilles de l'Afrique du Nord et de l'Asie. *Mammalia*. . XI

LAY, D. M., 1967. A study of the mammals of Iran. Fieldiana Zool. 54, 1-282.,
Legouix J.P.; F.Petter et A.Wisner 1954. Etude de l'audition chez des mammifères à bulles tympaniques hypertrophiées. *Mammalia* t.° 18,(262-271).

MCKENNA M.C. AND BELL S.K.1997. Classification of mammals above species level Columbia University Press, New York 631pp.

MISONNE X. 1959. Zoogeography des Mammiferes de l'Iran. Academy Royal de Sciences Naturelle de Belgique.

MISONNE X., 1957. Mammifères de la Turquie sud-orientale et du nord de la Syrie. *Mammalia* T.21. n° 1.

MOMENZADEH M., J. DARVISH , F.TOUTOUNCHIYAN, M.SARMAD. F. SADEGHI SHAKIB. 2008. Investigation of climatic effects on the shape and volume of tympanic bulla of Meriones libycus and Meriones persicuss (Muridae: Rodentia) from northeastern Iran: an Evolutionary approach. *Iranian Journal of Animal Biosystematics* Volume 4. No.1.

PAVLINOV I., 1990. Curent concepts of Gerbillid phylogeny and classification. African Small mammals.

PETTER F. 1951. Etude d'une collection de rongeurs du Sahara nord-occidental. Bulletin du museum, 2 éme serie t. 23, n°5.

PETTER F.1953. Ecologie.- Remarques sur la signification des bulles tympaniques chez les Mammifères. Comptes rendus des séances de l'Académie des Sciences, t. 237, p.848-849.

PETTER F. 1953. Note préliminaire sur l'ethologie et écologie de *Meriones libycus* (Rongeurs, Gerbillidés). Mammalia, t. 17, n°4.

PETTER F.1955. Contribution à l'etude de *Meriones vinogradovi* Heptner 1931 (Rongeurs, Gerbillidae). *Mammalia* T.19.

PETTER F.1957. Liste commentée des espèces de Gerbillidaes de Palestine. *Mammalia* ; T. 21, n° 3

PETTER F.1959. Evolution du dessin de la surface d'usure des molaires des Gerbillides. *Mammalia* t° 23. n° 3.(304-315).

PETTER F.1961. Repartition geographique et ecologique des rongeurs désertiques (du Sahara occidental à l'Iran oriental). N° spécial. T.25

PETTER F. 1974. Recherches ecologiques relatives au développement des zones arides (desert méditerranéens) à precipitations hivernales. Symposium Israel-France, Publication spéciale 39; Département des publicatiobns scientifiques , organisation de la recherche agronomique , centre volcanie, Bet-Dagan, Israel.

PETTER F.,1987. Communications : Particularités écologiques et physiologiques des rongeurs désertiques. Bull.Acad. Vét. De France, 1987, 60, 159-163.

PETTER F.,1987. Origine, modalités et consequences de la domestication. Bull. Acad.Vér. de France, 1987, 60, 423-427.

PETTER F., 1989 . Some ecological and physiological problems of rodents of the Arabian Peninsula. In Wildlife conservation and devlopment in Saudi Arabia. Proceedings of the first symposium Riyadh, February, 1987. Publication No. 3 Riyadh, 1989.

PETTER F., F.LACHIVER ET R.CHEKIR 1984. Les adaptations des rongeurs Gerbillidés à la vie dans led régions arides. *Bull. Soc. Bot. Fr.,* 131, Actual.bot., 1984(2/3/4), 365-373.

PETTER F.'1988. Communications: Epidémiologie de la leishmaniose cutanée dans le sud du Maroc et dans le sud-est de l'Arabie. Bull.Acad.Vét. de France, 1988, 61, 113-117.

ROBERTS , T.J. , 1997 , The mammals of Pakistan , Oxford University Press , pp.415- 418 .

TONG . 1986. Origine et Evolution des Gerbillidae (Mammalia, Rodentia) en Afrique du Nord. Thèse de Doctorat.

VINOGRADOV , B.S. , AND, A.I. ARGYROPULO, 1941 , Fauna of the USSR , Mammals ,Key to the rodents , Moscow , Leningrad .

WILSON D.E AND D.M.REEDER . 2005. Mammal species of the world. Ataxonomic and geographic reference. Third Edition.John Hopkins University Press. Baltimore.

YIGIT , N. ; , E. COLAK. AND SOZEN. 1999. The tooth development , tooth wearing and age determination of *Meriones* tristrami (Mammalia : Rodenti).

YIGIT, N., E. COLAK. 1999. Study of the Taxonomy and Karyology of *Meriones persicus* (Blanford, 1875)(Mammalia: Rodentia) in Turky. *Tr.J.Zoology* 23(1999) 269-274.

Appendix 1. List of the specimens examinined

Specimens from MNHN collections (Paris):
M. tristrami (from collection of MNHN of Paris; locality Jordan, Kirkouk Iraq Irak, Iran TAl Abyaz Iran, Kasvin) 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, Kazvin , Bikas;**
N14, N241, N420, N421, N426, N427, N442, N515,v N848 , N977 , N978
N979 , N981, N982, N986, N987, N988, N985, N990, 1026 , N1034, 1069
N1297, N1034, N1351, N1628, N2071
Meriones rex (Arabie Saudit Taef): 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 Lezian(endemic).

N171,N173,N508,N509,N511,N512,N513,N648,N1423,N613,N171
M.crassus (Iran : Kasr shirin, Maine, Kouhak, Isfahan, Mahallat roum , Birjandm Tasuki, Zabol) :N21, N103, N104, N105, N106, N107, N109, N412, N423, N530 N1036, N1037 , N1038, N1040, N1041, N1042 , N1043, N1354

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

M.meridianus Iran(Chatagui N41merid121 NEIran N1352 Sarakhs Iran N1353NEIran) Mongolia (N66 N 1302 , N50568,), Armenia(dahli N85973 Irvan) , Russia (masagetes6630,, d5713 Astrakhan , nogair. 15941, siscaucasie, .penicil15957)

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

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

Ferdowsi University of Mashhad collection:

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

M.libycus: FZM N36, N471, N563, N569, N570, N616, N659, N784, N 838, 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 N,548, N213, N214 216, N217, N218, N219, N221 N222, N206, N237, N239, N174, N394, N395, N498, N399,N646, N175, N176, N180 N181,N208, N209, N210, N21,1 N694, N1193, N303,M1, M17, M2,8 M35, M 36 , 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 ,

TABLE 3.- Phenetics distance between 14 species of Meriones genus in North Africa and Asia. (per): *Meriones persicus*; (rex): *M. rex;* (hur): *M. hurrianae*; (tri): *M. tristrami*; (tam)*M. tamariscinus;* (vin): *M. vinogradovi;* (mer):*M. meridianus;* (ung):*M. unguiculatus;* (cra):*M.crassus*; (sawi):*M. shawi;* (sac):*M. sacramenti*; (liby):*M. libycus. (zar): M. zarudnyi* and (g): *M. grandis*

1:vin	0	0,34	0,33	0,31	0,210	0,17	0,348178	0,425101	0,276653	0,385965	0,242915	0,348178	0,218294	0,276653
2:zar	0,34	0	0,37	0,34	0,34	0,24	0,210526	0,348178	0,242915	0,385965	0,179487	0,242915	0,186232	0,276653
3:tam	0,33	0,37	0	0,41	0,37	0,41	0,267214	0,33669	0,267214	0,267214	0,234481	0,33669	0,34849	0,267214
4:ung	0,31	0,34	0,41	0	0,21	0,34	0,348178	0,276653	0,311741	0,210526	0,242915	0,311741	0,25172	0,425101
5:rex	0,21	0,34	0,37	0,21	0	0,276653	0,210526	0,276653	0,149798	0,348178	0,276653	0,311741	0,286511	0,311741
6:.g	0,17	0,24	0,41	0,34	0,27	0	0,311741	0,276653	0,121457	0,311741	0,465587	0,311741	0,399069	0,385965
7:cra	0,34	0,21	0,26	0,34	0,21	0,311741	0	0,311741	0,425101	0,348178	0,385965	0,242915	0,098232	0,425101
8:tri	0,42	0,34	0,33	0,27	0,27	0,276653	0,311741	0	0,242915	0,179487	0,276653	0,507422	0,322666	0,276653
9:mer	0,27	0,24	0,26	0,31	0,14	0,121457	0,425101	0,242915	0	0,210526	0,242915	0,425101	0,155535	0,179487
10:per	0,38	0,38	0,26	0,21	0,34	0,311741	0,348178	0,179487	0,210526	0	0,242915	0,149798	0,186232	0,276653
11:sac	0,24	0,17	0,23	0,24	0,27	0,465587	0,385965	0,276653	0,242915	0,242915	0	0,348178	0,322666	0,550607
12:hur	0,34	0,24	0,33	0,31	0,31	0,311741	0,242915	0,507422	0,425101	0,149798	0,348178	0	0,322666	0,242915
13:shawi	0,21	0,18	0,34	0,25	0,28	0,399069	0,098232	0,322666	0,155535	0,186232	0,322666	0,322666	0	0,286511
14:liby	0,27	0,27	0,26	0,425	0,31	0,385965	0,425101	0,276653	0,179487	0,276653	0,550607	0,242915	0,286511	0