Preliminary study of rodents using pellets of predatory birds in Iran

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Abstract:

Predatory birds feed mainly on small mammals. They usually swallow their prey and after digesting, the indigestible fur, bones and teeth are regurgitated as compact pellets. The investigation of pellet is an extremely valuable tool for mammalogists. In this study 351 pellets have been collected from the localities including north of khorasan, Zanjan, Yazd, Chahar Mahal va Bakhtiyari and Mazandaran Provinces, Iran. Results have revealed the most of pellets contain mainly the members of five families of rodents including Muridae, Dipodidae, Cricetidae, Sciuridae and Calomysidae, respectively. Although it is evident that dental morphology is a valuable tool to recognition the most genera, it is not enough for the specific identification in some cases such as *Meriones* and *Microtus*. Therefore, it would be essential employing additional approaches such as neontology and morphometrics geometric.

Keywords: Pellet, Rodent, Identification, Iran, Muridae

Introduction:

Our current understanding of small mammal distributions usually is based on museum specimens. Most museums holdings resulted from trapping surveys, scavenging of road-killed individuals, and owl pellet collections. Although these methods have provided information about what species might be present in an area, species with low abundance, narrow habitat preferences, cyclic population dynamics, or seasonal changes in activity might have been missed in some areas. In addition, some regions of the state have been rarely sampled (Brandon K. McDonald and Caire 2006). Therefore, pellets are one of the most crucial informative sources of predatory birds. They excrete the remains of prey bones and teeth from their mouth and drop them at the bottom of rocks and their nests. Owls usually produce one or two pellets per night. Two endings of each pellet usually are blunted and should be distinguished from the dropping of fox which has pointed endings. Dropping usually contains bones which have been broken by chewing and often fruit remains that is not found in owl pellets (Yalden D. W and. P. A. Moris 1993). The pellets could be significantly employed for faunistic studies as well as ecological investigation of hunting bird, density of rodents, the presence or absence of species, the relationship of two species and so on (Darvish 2000). They may also be used to survey seasonal changes in diet, or the age structure of prey taken and the

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general state of the ecosystem might be revealed by overgrazing (Yalden D. W and. P. A. Moris 1993). The archaeological records of pellets from hunting birds such as owls are also used for archaeological studies. One of the other aspects of these pellets in archeological studies is that it can represent the linkage between zoology and archaeology (Hashemi Narges 2006) .

There is very little English published information relating to the rodents of Iran; In addition, there are few ones in Persian. Darvish (1992) has investigated pellets of predatory birds in north of khorasan and concluded that the most prey of them were composed of rodents which belonging to Microtidae and Gerbiliidae. 228 pellets of hunting birds have been already studied by Darvish et al. (2000) and presented 10 species belonging seven genera of rodents in Robat Sharaf Khorassan. Obuch (2001) collected owl pellets samples from Middle East such as Syria ,Turkey and Iran to acquire faunal data on small mammals. Obuch and Kristin (2004) collected pellets of predatory birds from 17 areas of Iran and reported a number of rodents in collected samples.

Iran as an extensive country has quite a few various natural biomes such as lowland region, forest, mountain and desert. Because of discontinuity, complete sampling using live traps would be so difficult as well as time-consuming. Therefore, this kind of studies using pellets could be costly economized

The aim of this study is identification of rodents in collected pellets of sampling regions based on dental and cranial characters and preliminary survey of their distribution in sampling localities of Iran.

Material and Methods

351 pellets have been collected from fourteen localities (Table 1, and Figure 1). After transferring them to laboratory, the pellets preparing by soaking in 5% NaOH to decompose hair and feathers (Obuch, 2001), teasing apart with forceps and rotating the dissected pellet in a dish of water until the bone content sank and the fur floated (Denver W.Holt J. Lyon 1987). The shape of teeth and some parts of bones have been drawn by camera Lucida. Identification was aided using available identification keys (Darvish, 1992; Corbet, 1978), and also deposited materials at the Rodentology Research Department, Ferdowsi University of Mashhad, Mashhad, Iran. To avoid double counting, only crania were used to estimate number of individual prey. Map 1 illustrates the localities of sampling and Table 1 indicates global position of every locality and the number of pellets collected in different localities. In order to statistical study on genus *Meriones*, dental morphometric traits including the highest length of M/1 , the width of anterior, median and posterior lobes on first lower molar are measured and analyzed using SPSS version 16.

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	Localities	Latitude	Longitude	Number of Pellets
1	Abravan Sarakhs	N:36,06	E:59,51	56 pellets
2	Abravan Sarakhs	N:36,04	E:59,59	15 pellets
3	Abar koohe yazd	N:31,67	E:53,17	25 pellets
4	Share kord Hossein Abad	N:32,19	E:50,51	10 pellets
5	Ghazghan	N:36,14	E:59,53	23 pellets
6	Robat sharaf	N:36,17	E:60,40	4 pellets
7	Baghbaghu	N:36,02	E:60,33	13 pellets
8	Kish	N:26,31	E:53,57	11 pellets
9	Kushk , Kardeh	N:36,40	E:59,38	3 pellets
10	Kalat	N:36, 34	E:60 01	6 pellets
11	Shurak Maleki	N:36,02	E:60,11	5 pellets
12	Mayamey Chenarak	N:36 ,15	E:60,07	13 Pellets
13	Zanjan	N:36,41	E:48,31	15 Pellets
14	Tandure park	N:37,35	E:58,53	31 Pellets
15	Ali Abad Katul	N:36,54	E:54,50	4 pellets
	Yazd	N:31,37	E:54,04	89 pellets

TABLE 1: The coordinates of sampling localities and the sample size.

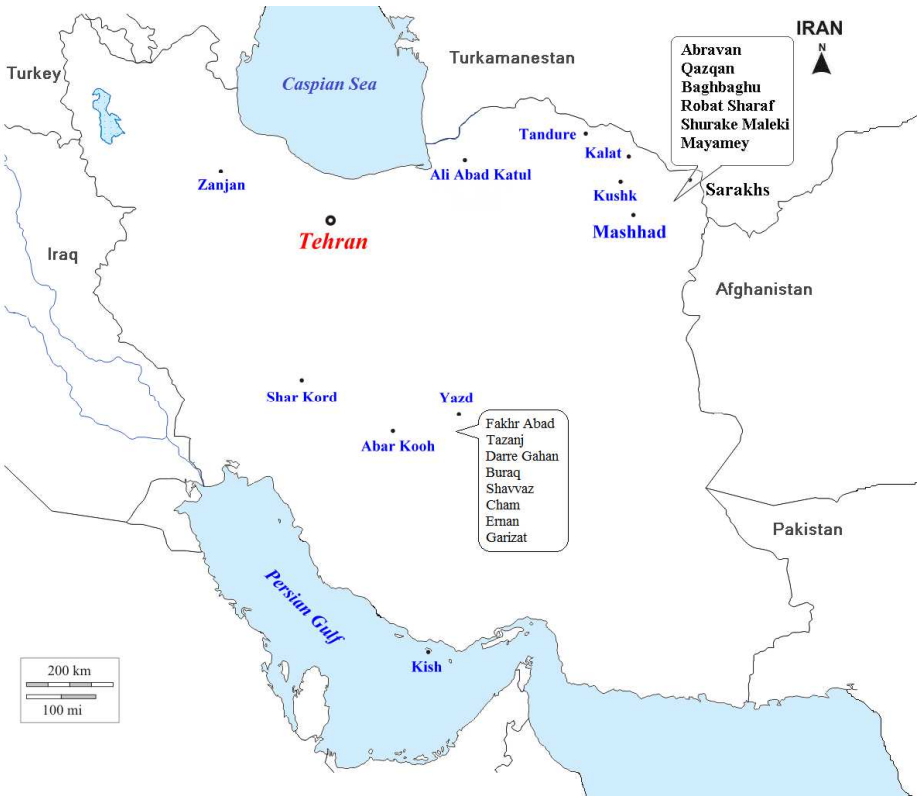

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FIGURE 1: Collecting sites of pellets in different parts of Iran.

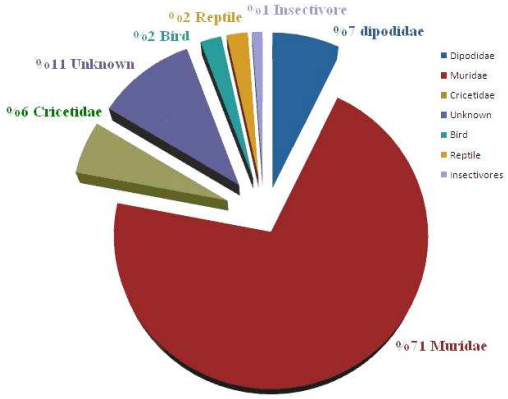
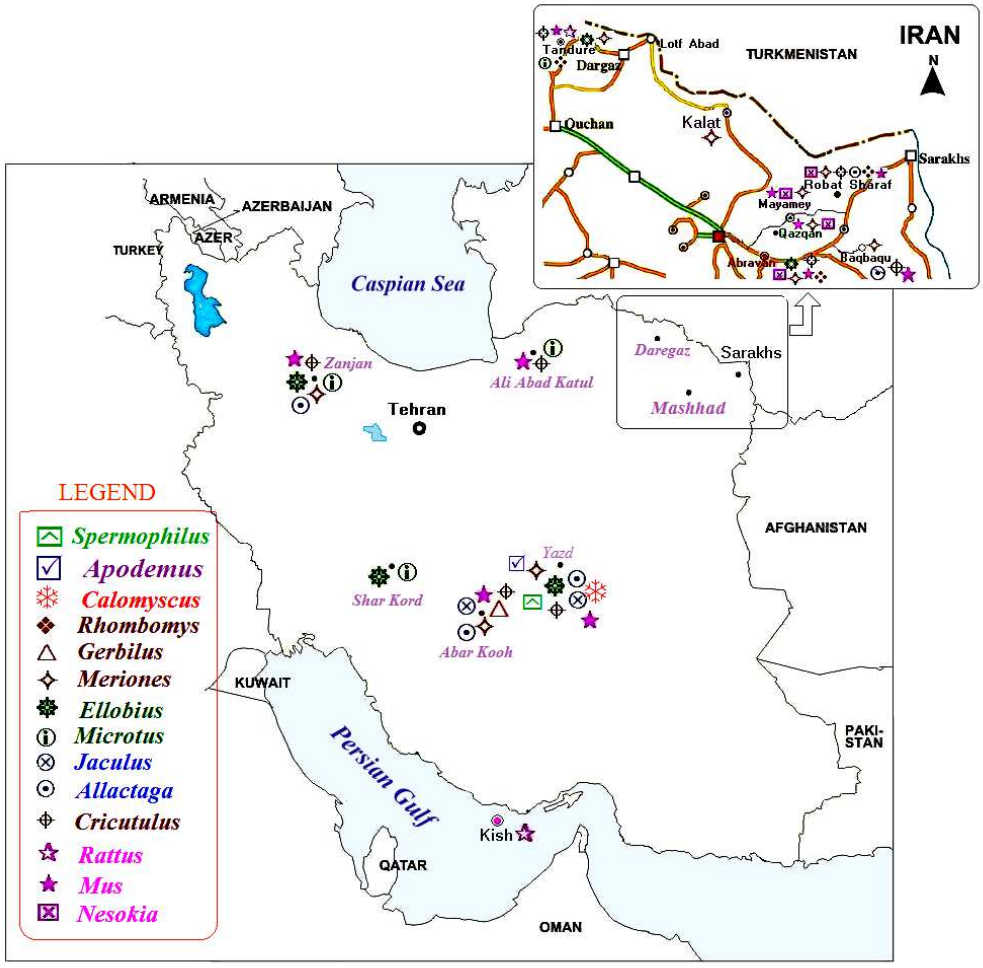


CHART 1: The percentage of each group of rodents based on collected 351 pellets from the localities of sampling.



MAP 2: Distribution map of the found specimens.

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Results

The collected material altogether comprised items, belonging to five families and fifteen genera. Map 2 illustrates distribution of fourteen localities and the identified genera in every locality. The identification was carried out according to keys. Chart 1 indicates percentage of rodents taxa in whole pellets. According to this chart, prey birds mainly feed on the members belonging to Muridae by %71 and the second most frequency for Dipodidae by %7 in selected localities. The other results have been arranged in the following groups:

List of the recognized species

Family Muridae Illiger, 1811**.**

The collected samples from different localities encompasses the some members of subfamily Gerbillinae as follow.

Subfamily Gerbillinae Gray, 1825.

Skull is specialized with tendency to great inflation of auditory bullae, enlarged braincase and weaken of rostrum (Corbet 1978).

Rhombomys Brandt and Wagner, 1855.

Diagnosis: Teeth are hypsodont and upper incisors have two longitudinal grooves on the front surface. Thickness of enamel and cementation in angles of dental lobes are diagnostic characters of the genus. There is only one species in Iran.

Rhombomys opimus Lichtenstein, 1823.

Diagnosis: Occlusal surface of molars are three transverse lobes which connect each other in the middle by right angle (Figure 1). Molars are hypsodont and each is located in a separated alveole. The species differs from *Meriones* in the rootless molars. The complicated structure of the last molar has a loop which is constricted in the middle. The presence of two longitudinal grooves on the anterior surface of the upper incisors and the form and size of the tympanic bullae are characteristic. The species has been found in Tandure, Abravan and Robat Sharaf. Darvish (2000) has found this species from Robat Sharaf pellets. (Darvish, 2000). This species has also captured from Sarakhs and Daregaz in 2006. (Darvish *et al*., 2006)

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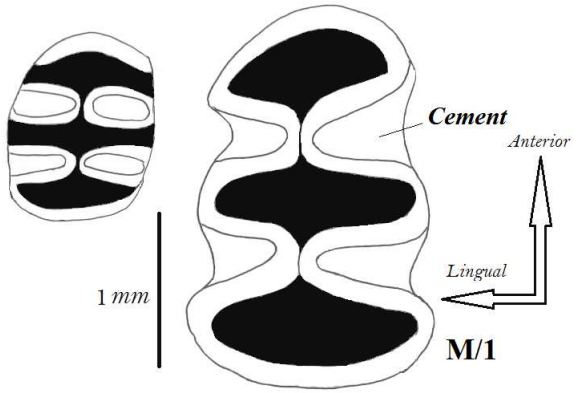

FIGURE 1: *Rhombomys* teeth.

Meriones Illiger, 1811.

Diagnosis: Anterior surface of upper incisors has one longitudinal groove. Molars of adult are well-developed roots. Last molar is very small with simple loop. In molars transverse lobes connected together and form dental loph (Figure 2). M1/ and M/1 have one lingual root and two labial roots while M2/ with two anterior and posterior roots and the last molar with one root. M3/ is simple and one lobed. The members of the genus were observed frequently in the pellets of Robat Sharaf, Zanjan, Ali Abad, Abar Kouh, Tandure, Abravan, Mayamey , Kalat-e-Nader as well as Cham, Garizat Shavvaz, Buraq, Ernan, Shirkooh and Tazanj in Yazd province. Obuch and Kristin have also reported *Meriones crassus* and from Robat Sharaf and Yazd (Obuch J. and A.Kristinn 2004).

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 (Darvish 2009). Identification of the species of this genus only based on teeth design is not possible and it is required to using of other characters such as skull ,and bulla and tympanic characters (Naseri Z. 2006; Momtazi 2009). Darvish in 2000 has presented and identified *M. meridianus* and *M. libycus* using discriminant analysis (Darvish, 2000) and has also captured *M. libycus* from Sarakhs (Darvish *et al*., 2006). *M. meridianus* has been reported by other researchers from Sarakhs (Karami M. 2008).

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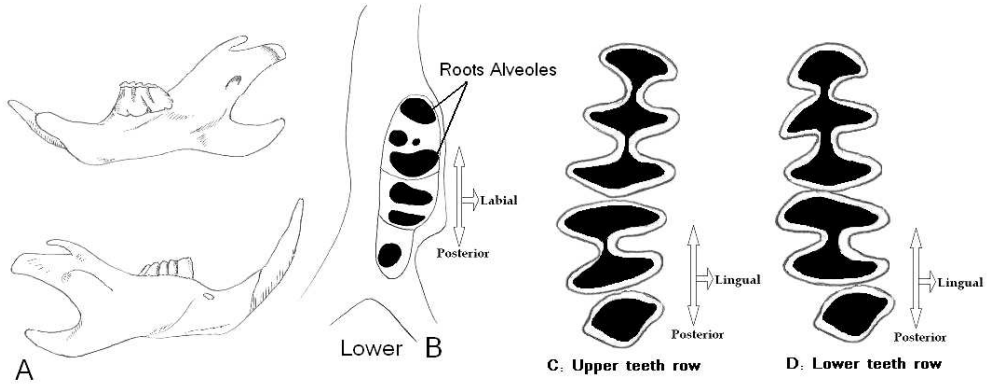

FIGURE 2: A) Mandible B) Lower mandible, root alveolus C) Upper D) lower teeth rows in *Meriones*.

Gerbillus Desmarest, 1804.

Diagnosis: The molars usually have roots. Their occlusal surface is flat, with oval or rhomboid enamel loops (Figure 3). Tympanic bullae inflated and mastoid is large (Kingdon 1974). Some of the pellets have been collected from Tandure confirme the presence members of the genus. Previously, it has been reported that there are four species of *Gerbillus* from Iran. However, Siahsarvie and Darvish (2007) present new record of *Gerbillus* from the Iranian Plateau (Siahsarvie R. and J. Darvish 2007). Obuch and Kristin (2004) have also reported *Gerbillus nanus* from Yazd.

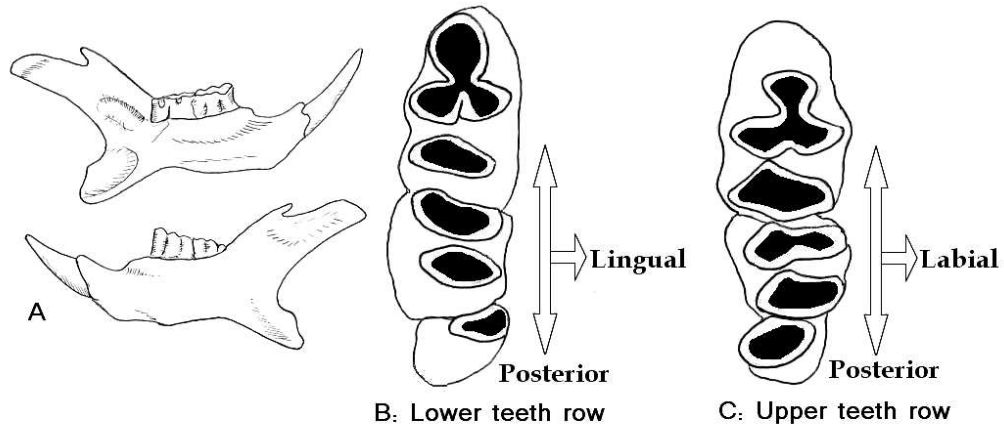

FIGURE 3: Mandible B and C, Lower and upper tooth row in *Gerbillus.*

Family Cricetidae Fischer, 1817.

Cusps of the upper molars arranged in two longitudinal rows. The collected materials consist of the members of two subfamily; Arvicolinae and Cricitiae as follow.

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Arvicolinae Gray, 1821.

Occlusal surface of cheek teeth are prismatic and alternating from left to right, and molars are usually rootless (Krystufek and Vohralik, 2005). Zygomatic plate completely tilted upwards. The arvicolinae differ from the other subfamilies of the cricetidae mainly in the structure of the molars in which the mastigatory surface is flat and consists of alternating triangles. The molars of most species of voles are rootless only in few groups of voles (such as *Ellobius*) the growth of the molars cease towards the end of life and each tooth forms two roots (Vinogradov 1935).

Ellobius Fischer, 1814.

Diagnosis: Anterior surface of upper incisors is white. Root of lower incisor forming a large projecting tubercle (Alveolar process) on the outer surface of the mandibular condyle. Enamel loops of molars not forming completely closed triangles. Front surface of upper incisors white and pro-odont. M3/ shorter than M2/ (Corbet 1978).

The remains of dental and cranial pieces of the taxon have found in the pellets collected from Daregahan (Shirkooh) in Yazd province.

Ellobius fuscocapilus Blyth, 1843.

Diagnosis: Incisive foramen is very small. Interparietal is absent (fused with occipital). Third upper molar has a more elongate crown than *E.talpinus*. There are three projecting angles on the outer side of this tooth. Premaxilar exceed from nasal. Posterior ridge of premaxilar doesn't enclosed incisive foramen. Anterior lobe of M2/ has labial notch while anterior lobe of M3/ with lingual notch. Well-developed coronoid. M3/ has three projecting angles on the outer side and three ones on the inner side (Figure 4) (Vinogradov 1935). One of pellet collected from Sarakhs was shown the presence of this specimen. The specimen has previously been reported from Daregaz (Darvish, 1991).

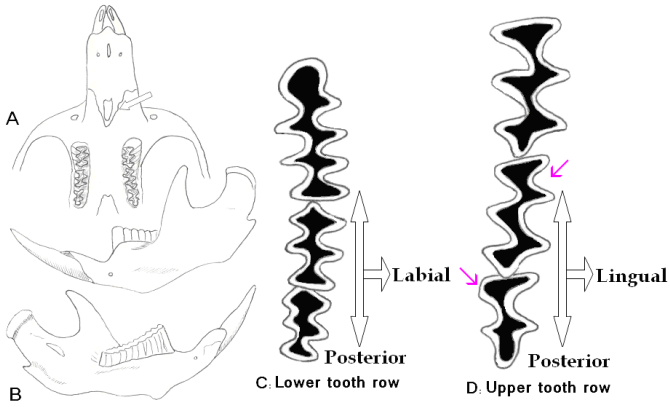

FIGURE 4: A) Skull B) Mandibles C and D) Lower and upper teeth rows in *E. fuscocapillus.*

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Ellobius talpinus Pallas, 1770**.**

Diagnosis: Third upper molar usually with only two rounded projecting angles on the outer and inner sides. M3/ has two internal and external projecting angles. Reduced coronoid. Interparietal is well-developed. Premaxilar is equal to nasal or smaller. Posterior ridge of premaxilar doesn't enclose incisive foramen (Figure 5). Only one of pellets which have been collected from Robat Sharaf shows the presence of this species. Obuch and Kristin have reported this species from Robat Sharaf (Obuch and Kristin 2004). This species has previously reported from Daregaz and Robat Sharaf (Darvish 2000). It has been reported *E.talpinus* exist as a parapatric species with *E. fuscocapillus* (Darvish *et al*., 2006).

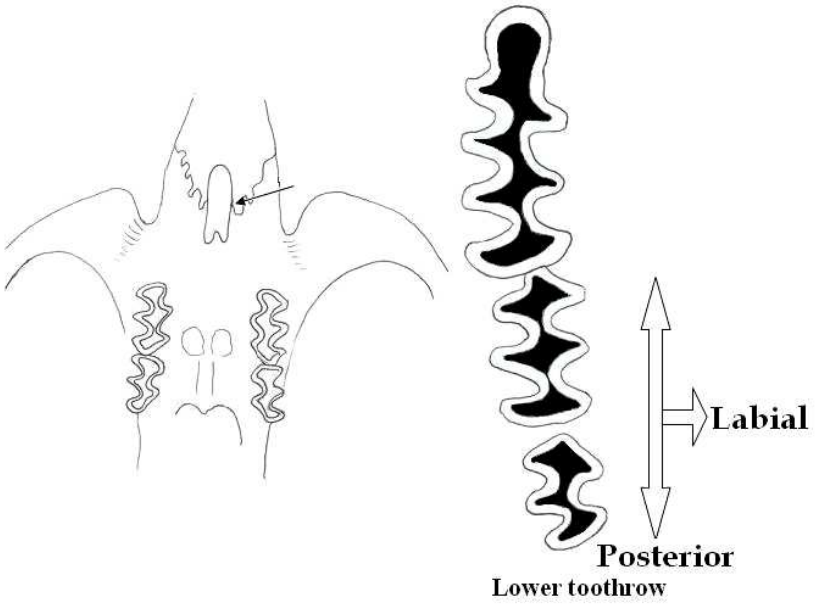

FIGURE 5: Ventral view the skull and lower tooth row in *E. talpinus*.

Ellobius lutescens Thomas, 1905.

Diagnosis: Resemble to *E. fuscocapilus*. Mandible has markedly developed alveolar process which forms sheath for the root of the lower incisors (Darvish J. and shakib 2006) . M3/ has one anterior notch, one labial and two lingual notches. M/3 has two labial and lingual notches. The well-developed coronoid, incisive foramen is small, interparietal is absent (Fused with the occipital), and third upper molar is as in *E. fuscocapilus* (Figure 6). Collected pellets from Zanjan represent this species.

It seems *E. talpinus* occurs in North East, *E. lutescens* in the central and west and *E. fuscocapilus* in variety regions of the country.

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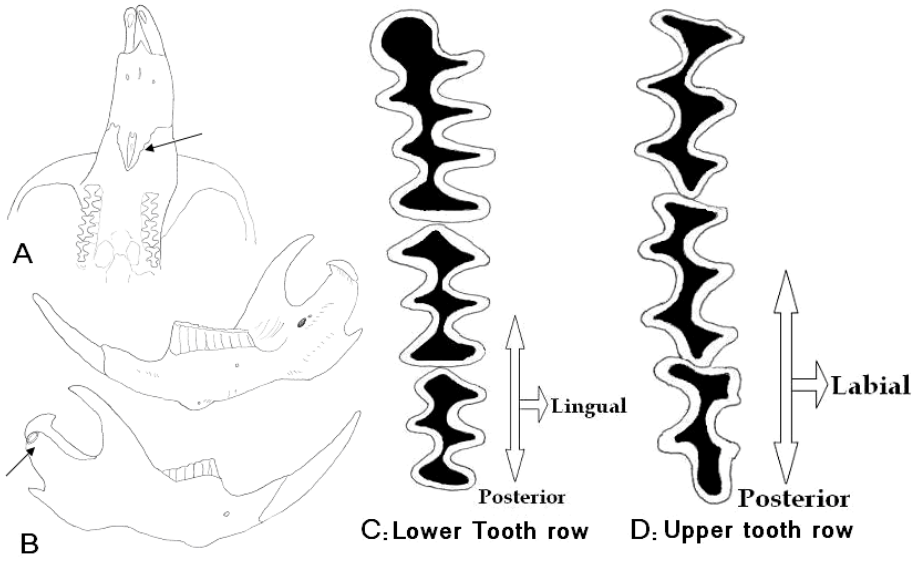

FIGURE 6: A) Skull B) Mandibles C and D) Tooth rows in *E. lutescens*.

Microtus Schrank, 1798.

Diagnosis: Recognition character for the genus is presence of M/1 with 4-5 closed triangles and M3/ with three closed triangles. Because of high Resemblance, specific identification is not possible just by dental design (Figure 7). The pellets have been collected from Kushk, Shahre Kord, Zanjan as well as Tandure shown which *Microtus* exist in these localities. A study on this specimen has shown it is high probable belonging to socialis group as reported *M. paradoxus* from Tandure (Darvish et al., 2006), and those from Zanjan are belong to *M. socialis* and *M. qazvinensis* (Mahmoudi *et al*., in press)

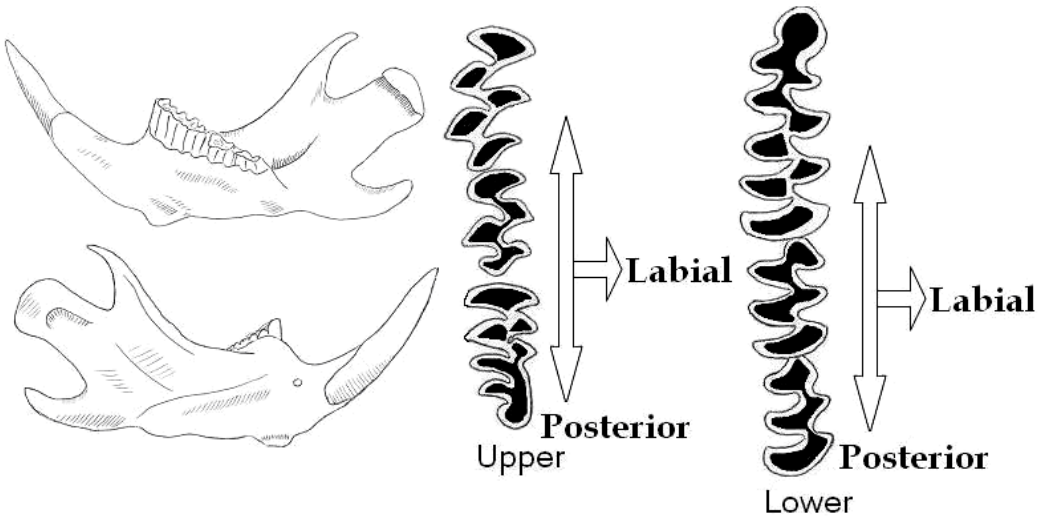

FIGURE 7: Mandibles and teeth rows in *Microtus*.

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Subfamily Cricetinae Fischer, 1817.
The tubercles on the upper molars are always arranged in two longitudinal rows. The crowns are low and roots are always present.

Cricetulus Milene-Edwards, 1867.
Diagnosis: Skull relatively narrow, interparietal broad about 3-3.5 times wider than long. There is just one species in Iran.

Cricetulus migratorius Pallas, 1773**.**
Diagnosis: In the first lower molar, lingual cusps are located more anterior than labial cusps (Darvish 2000). Supraorbital crest is absent. It has been found in Abar Kouh, Tandure, Baghbaghu, Robat Sharaf and Zanjan and also in Garizat, Ernan, Buraq and Shavvaz in Yazd province. Dental design is according to figure 8. Obuch and Kristin have also reported *Cricetulus migratorius* from Robat Sharaf (Obuch and Kristin, 2004). Moreover, it has been (Darvish *et al*., 2006) captured from Dargaz (37° 26´ N, 59 °35´ E) and Sarakhs (36° 20´ N, 60° 32´ E).

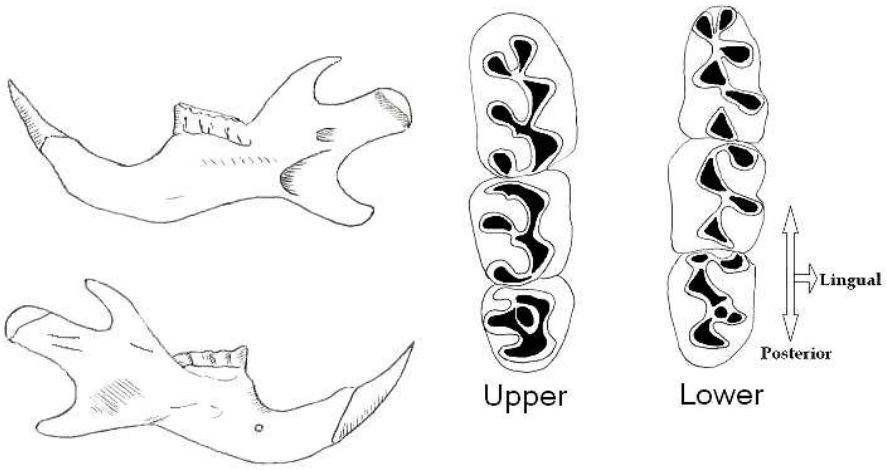

FIGURE 8: Mandibles and teeth rows in *Cricetulus.*

Subfamily Murinae Illiger, 1811.
Infraorbital foramen enlarged and usually specialized into a wider portion for muscle transmission and a lower narrower one for nerve transmission. Zygomatic plate always broadened and tilted upwards and located completely beneath infraorbital foramen. Molars are rooted, upper molars laminate or cuspidate. When is cuspidate, the cusps arranged in three longitudinal rows.

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Third Molar and tympanic bullae are small, teeth brachiodont. M1/ has 8-9 tubercles on three longitudinal rows.

Nesokia Gray, 1842.
The genus has one species in the Iran.
Nesokia indica Gray, 1830.
Diagnosis: Incisive foramina short, about 1/3 of the length of the diastema. Upper incisors are massive and large. Molars consisting of narrow transverse loops (3 loops on the first molar and 2 on the following). The tubercles are marked only in early youth. Root of lower incisor forming large alveolar tubercle at the base of the mandibular condyle. Supraorbital crest is present (Figure 9). Pellets of Qazqan, Robat Sharaf, Abravan and Mayamey showed the presence of it. Darvish *et al*. (2006) captured it from Zoshk (36° 20´ N, 59° 11´ E) and Sarakhs (36° 26´ N, 61° 06´ E).

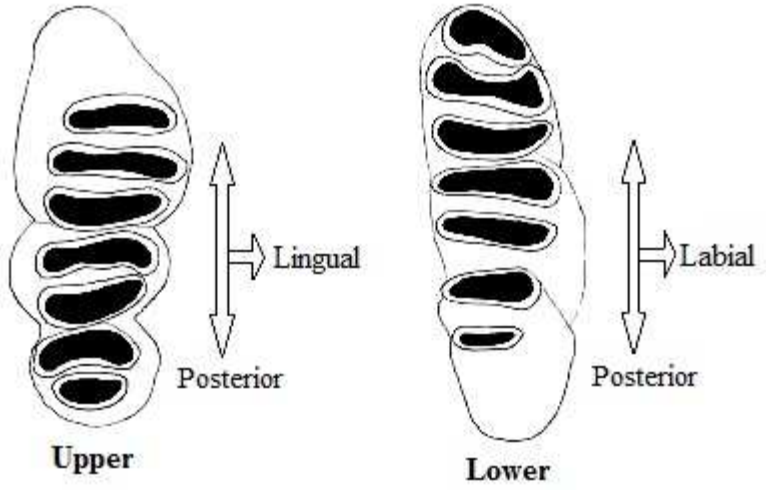

FIGURE 9: Teeth rows in *Nesokia***.**

Mus Linnaeus, 1758.
Diagnosis: First upper is molar as long as or longer than the last two molars together. M1/ has three roots. Posterior side of upper incisors has a notch. Anterior-outer corner of parietals forming pointed processes above the frontal. Interorbital space and parietals don't have lateral crests (Figure 10). Probable species is *Mus musculus* which have been collected from Abravan, Mayamey, Shurak Maleki, Qazqan, Baghbaghu, Robat Sharaf, Zanjan, Ali Abad, Tandure as well as Abar kooh, Cham, Garizat and Tazanj in Yazd province. Darvish (2000) reported *M. musculus* from Robat Sharaf pellets.

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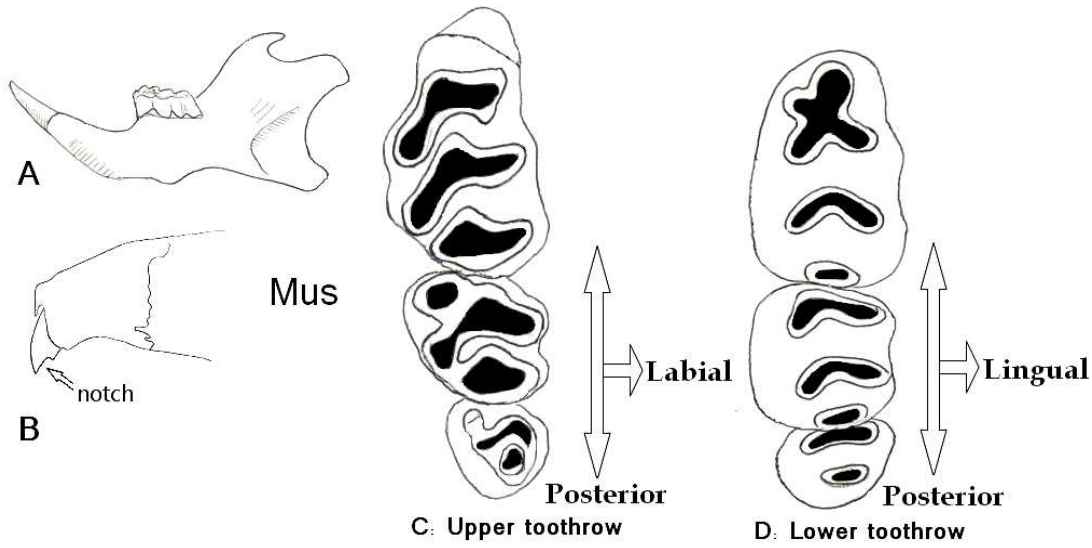

FIGURE 10 A) Mandible B) Notched upper incisor C and D) Teeth rows in *Mus*.

Rattus Fisher, 1803.

Diagnosis: First upper molar is shorter than the following two together. Crests on sides of interorbital space and on parietals always well developed. Teeth row is longer than *Mus*. M1/ has three roots (Figure 11). Pellets of Kish as well as Tandure show the presence of it. Harrison and Bates (1991) have also recorded *Rattus norvegicus* from Persian Gulf region. It is possible the specimen is belonging to the species.

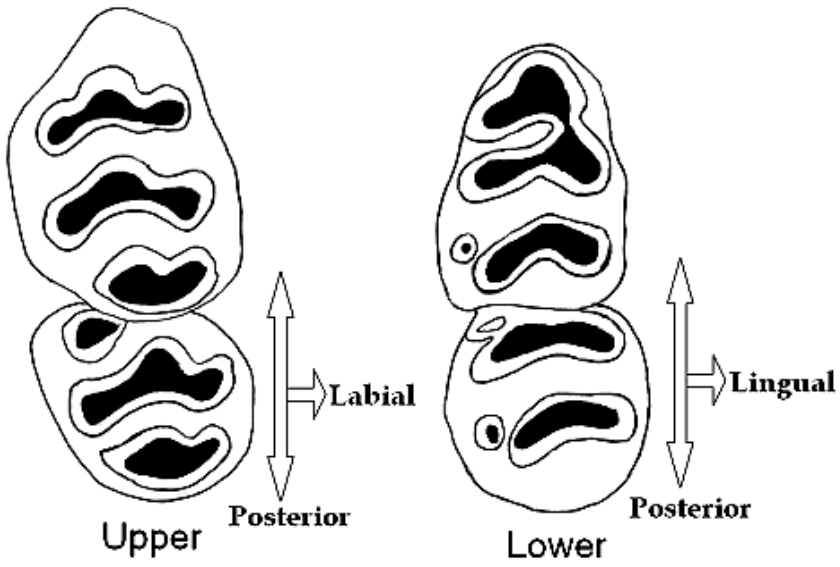

FIGURE 11: Teeth rows in *Rattus*.

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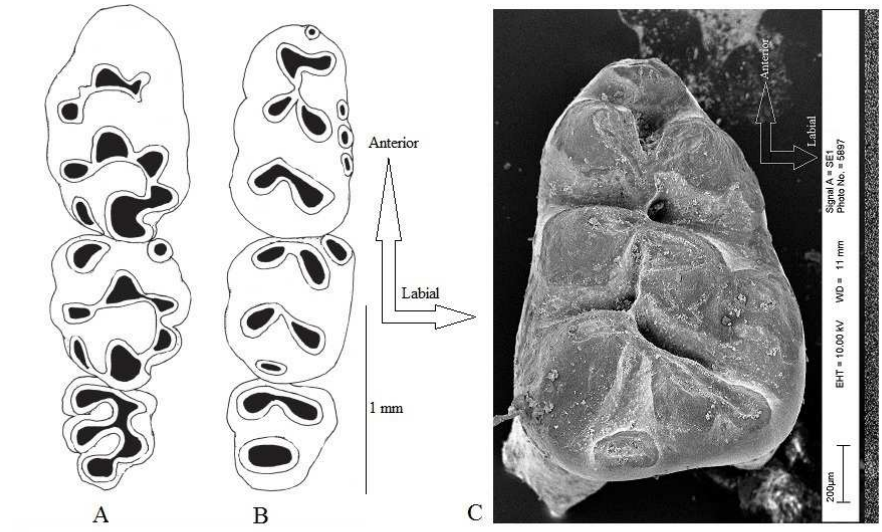
Apodemus Kaup, 1829

*Dignosis:*There are nine cusps on first upper molar and on the contrary of *Mus*, there are not any notch on the posterior edge of the upper incisive. There are several cingula at the labial side of the first lower molar. The anterior palatine fissure often does not arrive to the anterior border of first molar alveoli. The collected pellets from Shirkooh and Kor in the south of Yazd province have shown the presence of the genus (Figure 12).



A: Upper Molar teeth
B: Lower Molar teeth
C: Scanning electrom microscope image of first lower molar in *Apodemus*.

FIGURE 12: Teeth rows in *Apodemus*

Family Calomysidae Vorontsov and Potapova, 1979

This family consists of one genus with different species in Iran.

Calomyscus Thomas, 1905

Dignosis: The genus has several closely morphology species in different parts of Iran which could not be identified only based on dental morphology. The genus is characterized by having five cusps on the first upper molar. Arrangement of cusps is asymmetrical (symmetrical in Cricetinae). In the maxilla, 1st and 2nd molar have two lingual and three labial cusps; the labial row is shifted forward. In the mandible, 1st and 2nd molars have three cusps on each side; the lingual row is placed forward. Third lower molar has three cusps. Quite a few collected pellets from Shirkooh show the presence of it (Figure 13).

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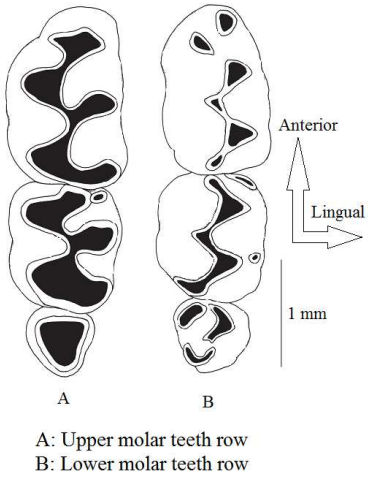

FIGURE 13: Teeth rows in *Calomyscus*

Superfamily Dipodoidae Fischer, 1817.
This superfamily consist of a family Dipodidae.

Family Dipodidae Fischer de Waldheim, 1817.
Infraorbital foramen greatly enlarged for muscle transmission. Lacrimal is large and frontal broad. Zygomatic plate is narrow and remaining completely below it, mandible weak. The angular process not distorted outwards. This part of the jaw frequently has a perforation. Cheek teeth rooted, usually cuspidate, with broad re-entrant folds. This family consists of two following subfamilies.

Subfamily Allactaginae Vinogradov, 1925.
Upper incisors pro-odont, mastoid and bullae little inflated. Infraorbital foramen is more widely open. Os penis is absent. *Allactaga* is the common genus in the group.

Allactaga Cuvier, 1836.
Diagnosis: Mandible with perforated angular process and root of lower incisor forms process on the external surface of condyle. P^4 present but small. M1/ and M2/ each with three external re-entrant folds, the middle one of which is small, and each tooth with one internal fold. M3/ has one inner, three outer folds. In the lower teeth row, M/1 has one small front fold, three inner folds and two outer ones. The middle inner one being small; M/2 is like M/1 but without the anterior fold. M/3 has one fold and one or two inner ones (Figure 14). In the pellets which have been collected from Baghbaghu, Robat Sharaf, Abar kooh and

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Shirkooh in Yazd and Zanjan, the members of the genus found. Obuch and Kristin have reported *A. elater* from Yazd. (Obuch and Kristin, 2004). In addition, Darvish (2000) has reported *A.elater* in Robat Sharaf pellets.

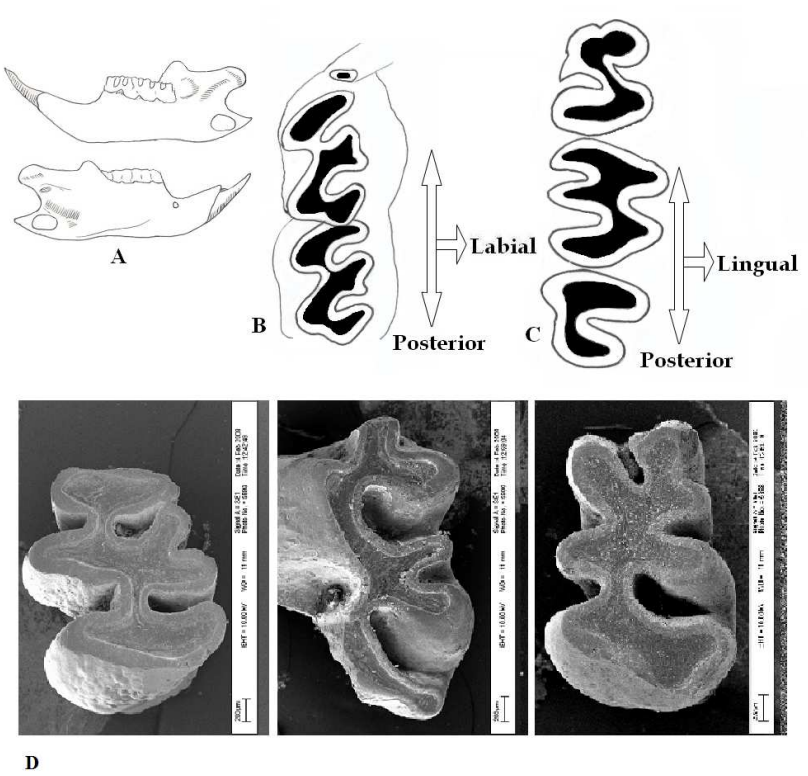

FIGURE 14: A) *Allactaga* mandibles B) Upper tooth row in *Allactaga* C) Lower tooth row in *Jaculus*. D) Electron microscope image of *Allactaga* molars.

Subfamily Dipodinae Fischer, 1817.
Mastoid and bullae extremely inflated and exceed from foramen magnum. Upper incisors are not pro-odont. Dental design is simpler than allactaginae. Infraorbital foramens less widely open. Reduced coronoid. Os penis is present. Dipus group such as *Jaculus (Ellerman 1940).*

Jaculus Erxleben, 1777.
Diagnosis: Mandible is perforated at the below of angular. Root of lower incisor make a process on the lateral surface of articular process. Upper incisor has a longitudinal groove on the front. Upper teeth row molars with one wide inner and one wide outer re-entrant fold. M1/ is the largest and M3/ the smallest. Lower cheek teeth with two outer folds in M/2 and one inner one, M/1 with a

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fold each side and an anterior notch. The pellets of Tandure and Darregahan in Shirkooh Mountain indicate the presence of the genus (Figure 14).

Family: Sciuridae Hemprich, 1820
Cheek teeth are brachyodont and rooted; there are 1-2 premolars in upper jaw and one in mandible. The family have two genera in Iran.

Spermophilus Blasius, 1884
Diagnosis: Cheek teeth are relatively hypsodont, with the lingual portion in the upper row being constricted thus giving teeth a triangular appearance. Dental formula: 1/1, 0/0, 2/1, 3/3. Some collected pellets from Shirkooh (Darregahan) show the presence of the genus (Figure 15).

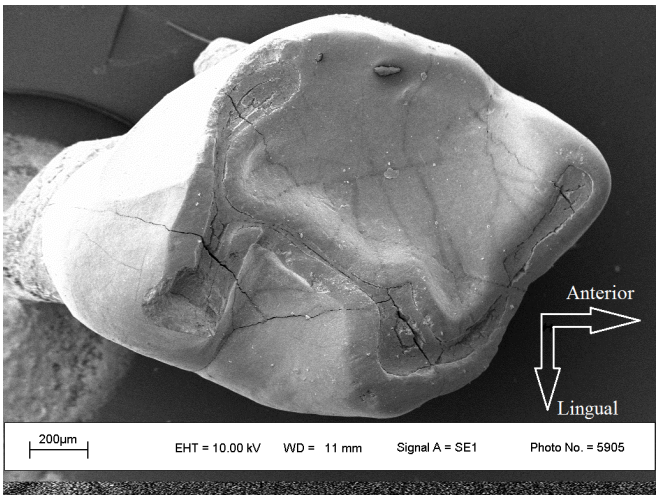

FIGURE 15: The scanning electron microscope image of first or second lower molar in *Spermophilus*.

Statistical studies

The discrimination species of the genus *Meriones* are not possible only by dental morphology (Darvish 1992). Momenzadeh et al. (2008) confirm the importance of molar size for determination of *Meriones* species. Therefore, in order to statistical examination of *Meriones* specimens, four characters of teeth have been measured including the highest length of M/1, the width of anterior, median and posterior lobes measured on 99 teeth collected in seven localities of Zanjan, Abravan, Qazqan, Mayamey, Robat Sharaf, Tandure, Abar Kouh. Figure 16 shows four measured dental characters. Measuring dental dimensions have

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been conducted using a measurescope and analyzed by SPSS version 16. Table 2 indicates the univariate statistical results. Box plot of the highest length of M/1 in *Meriones* specimens in sampling localities is shown in figure 17. *Meriones* specimens from Abar Kooh was separated from other localities with having the lowest length. In addition, the mean of M/1 length in Abravan, Zanjan, Robat Sharaf, Tandure are similar together and also the same similarity in samples Mayamey, Qazqan, Baghbaghu. In order to compare different among populations a Canonical Discrimainant Analysis (CDA) was conducted in SPSS. The first two functions explained 85.7% of the total variance that is suitable amount for showing the first molar size differences among populations.

The results of a CDA analysis indicates that there are significant differences between populations (Wilk`s Lambda= 0.257, P_{value} = 0.0001) The Abar kooh specimens are distinct based on the dental characters from others (Figure 18). Darvish in 2009 indicated the sizes of molars in some *Meriones* species are considerably smaller than others and showed that *M. crassus* and *M.meridianus* have small sizes specially in molar size (Darvish 2009). Therefore it seems the specimen of the Abar Kooh probably is belonging to *Meriones meridianus* or *Meriones crassus*.

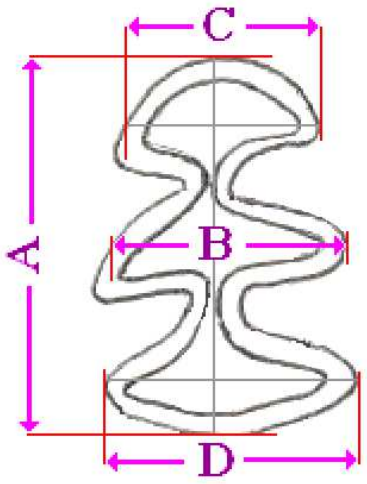

FIGURE 16: The definition of measured characters on M/1 in *Meriones*.

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	A	B	C	D
N	99	99	99	99
Min	1.625	0.965	0.961	0.924
Max	2.759	1.854	1.342	1.937
Mean	2.2708	1.4	1.0518	1.4439
Std.error	0.0188	0.01857	0.01289	0.02
Variance	0.0353	0.0341	0.0164	0.04

Table 2: Univariate statistical results from four measured characters on M/1.

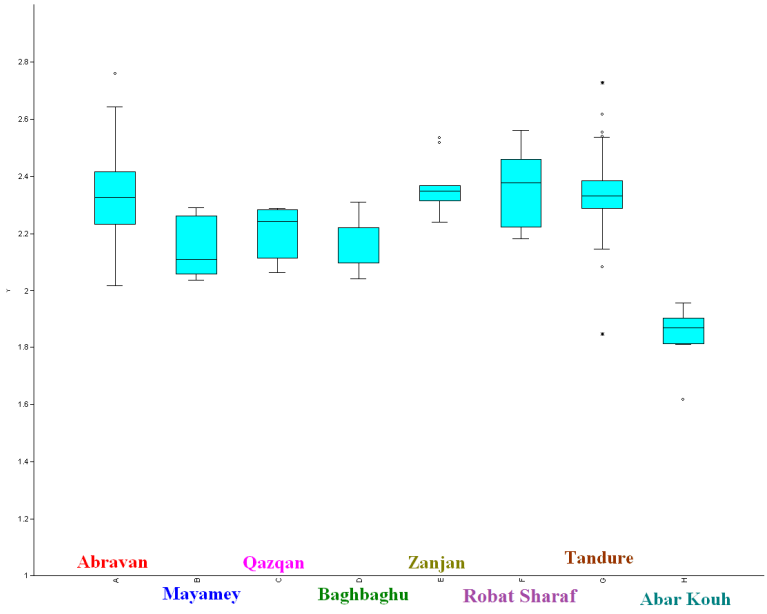

FIGURE 17: Mean and box plot variation of the length of M/1 in *Meriones* in different localities.

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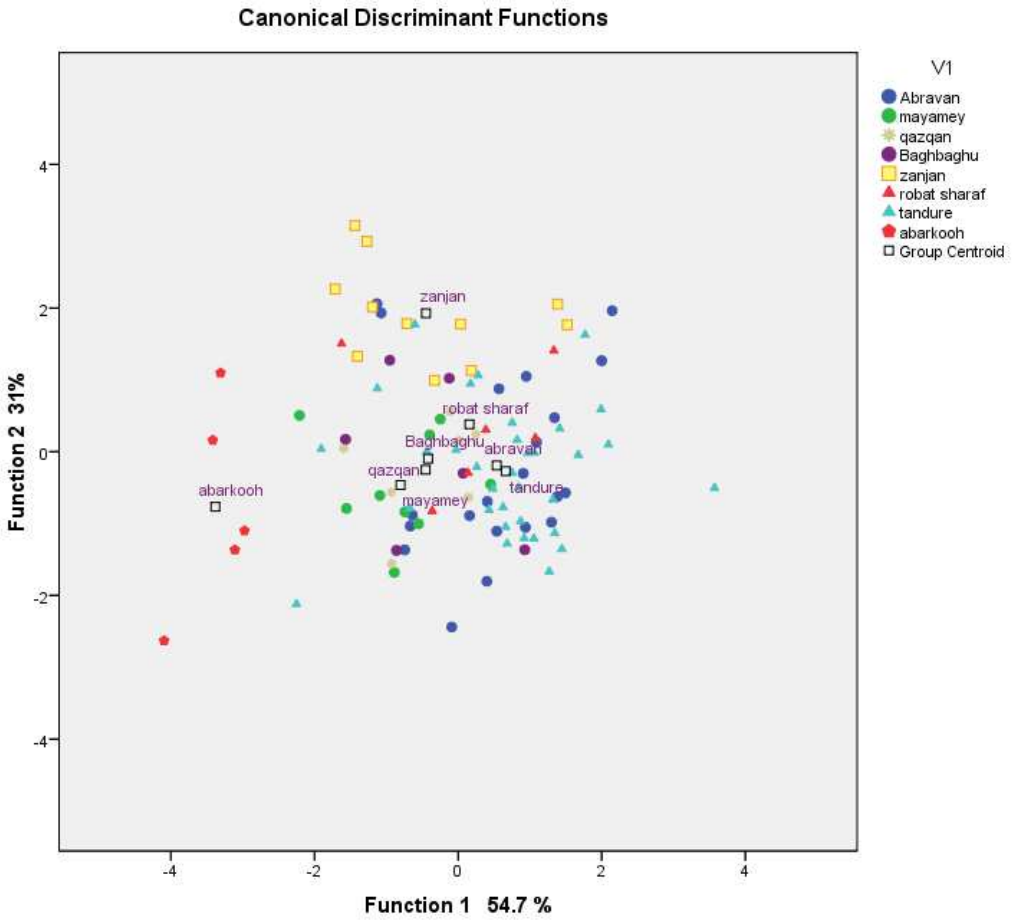

FIGURE 18: Scatter plot of CDA analysis on M/1 measured variables in *Meriones* .

Discussion

In the current study, fourteen genera of small mammals belonging to four families and six subfamilies were identified. This survey clearly indicates the pellets are crucial sources could be significantly employed for faunistic studies as well as ecological investigation of hunting bird, density of rodents, the presence or absence of species. According to results of the survey, diet of predatory birds mainly composes of small mammals (Chart 1). The results of the study are agreement with other studies (Obuch and Kristin, 2004, Darvish 1992, 2000). However, it might be differed as a result of different in temporal and spatial sampling. Obuch and Kristin (2004) have showed the movement of predatory birds from one place to another area result in we cannot find any pellets in the site.

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The northeastern Iran composed of two parallel mountain chains, Kopet Dag and Binaloud, in the north, and parts of Iranian central desert in the south and west. Eastwards it borders to the eastern part of the Iranian plateau (Afghanistan). Kopet Dag Mountains in the northern part of the Khorasan make an important ecologic barrier between these two zones. However, some species were able to circle the mountains eastward and enter to the Iranian plateau through Kushk crossing. The environment conditions especially humidity is the factors which play an important role in distribution of rodents. Some specimens such as *Nesokia* are very dependent on to humidity which has strictly limited their distribution but other specimens such as *Meriones*, *Rhombomys*, *Gerbillus* and dipodids are adapted to arid or semiarid areas (Misonne, 1959). Therefore, it could be observed *Meriones*, *Gerbillus* and dipodids in the arid areas such as Abar Kooh and the semi arid in some parts of northern Khorasan (Darvish *et al.*, 2006). According to these results, it seems species identification requires more studies to acquire discriminating characters in genera with high variety such as *Meriones*, *Microtus*, *Apodemus*. Therefore, it is necessary to use additional methods including geometric and morphometric, neontology as well as morphological analyses to realize relevant characters.

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Appendix

Key to recognize Glires

1.1 Each jaw with two upper incisors…….……Rodentia (2)
1.2 Each jaw with four upper incisors…… …….…….Lagomorpha
2.1 Angular process of mandible from ventral view is seen on the dental plate…….……..Sciurignathi (3)
2.2 Angular process of mandible from ventral view is seen toward internal of dental plate …….……..Hystrichognathi
3.1 Infraorbital foramen absent …….…….Sciurimorpha
3.2 Infraorbital foramen always enlarged……..……4
4.1 Zygomatic plate tilted upwards and broaded. The infraorbital never much enlarged. ……..….Muroidae

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4.2 Zygomatic plate never tilted upwards, always narrow and completely below the enlarged infraorbital foramen. The angular process of mandible has a perforation.

Key to recognize Muroidae

1.1 Cusps of the upper molars arranged in two longitudinal rows and M1/ with 5-6 cusps……..……3
1.2 Cusps of the upper molars arranged in three longitudinal rows and M1/ with 8-9cusps……Muridae (2)
2.1 Anterior surface of upper incisors with longitudinal groove…….Gerbillinae
2.2 Anterior surface of upper incisors without longitudinal groove……Murinae
3.1 The first upper molar with 5 cusps……....Calomysidae(Calomyscus)
3.2 The first upper molar with 6 cusps……..Cricetidae

Key to identify the genera of Murinae

1.1 Cheek teeth laminate and without traces of cusps…….……*Nesokia*
1.2 Cheek teeth cuspidate……..…….2
2.1 The first upper molar with 9 cusps ……...*Apodemus*
2.1 The first upper molar with 8 cusps …….3
3.1 Teeth row size is small, M1/ is longer than two last molar together…*Mus*
3.2 Teeth row size is large, M1/ is not longer than two last molar together……...Rattus

Key to identify subfamily Gerbillinae

1.1 Upper incisors with two grooves, space of between dental lobes fill by cement and molars are
hypsodont…….…….*Rhombomys*
1.2 Upper incisors with one groove …….……2
2.1 Molars hypsodont and dental lobes are symmetry each other…..……3
2.2 molars brachiodont and dental lobes are asymmetry. The size of teeth row is small……..……..…….*Gerbillus*
3.1 Molars fairly hypsodont, transverse lobes in upper molars usually separate ……..…….…….…….*Tatera*
3.2 More hypsodonty in molars, upper molars with lozoid shape lobes…….……..…*Meriones*

Key to recognize Cricetidae

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1.1 Teeth row cuspidate, there are 5-6 cusps on two longitudinal rows……Cricetinae 2
1.2 Teeth row prismatic with projecting angle in each side…….Arvicolinae3
2.1 Tooth row small size and dental design as Fig.8 ……..…….*Cricetulus*
2.2 Tooth row large size ……..……..…*Mesocricetus*
3.1 Enamel loops of molars forming closed triangles…….*Microtus*
3.2 Enamel loops of molars not forming closed triangles……*Ellobius*

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