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A contribution on rodents fauna of the Jaz Murian depression, southeast Iran

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ABSTRACT The Jaz Murian depression in the southeast of Iran bounded by deserts and mountains is a special corridor for penetration of Arabian and Indian fauna. The region demonstrates harsh desert climate. This study was designed to reveal rodent diversity of the region in the light of geographic features. Totally, 127 specimens belonging to 5 families and 14 genera and 15 species were captured using live-traps and hand-net. As a result, the depression enjoys Oriental and Ethiopian elements (*Acomys dimidiatus* Cretzschemar, 1826, *Gerbillus nanus* Blanford, 1875 and *Meriones libycus* Lichtenstein, 1823) which could pass Arabian deserts penetrating Iran from northern shores of Persian Gulf. Also, the region is a penetration route for Oriental species such as *Tatera indica* Hardwicke, 1807, *Golunda ellioti* Gray, 1837, *Meriones hurrianae* (Jerdon, 1867) and *Mus musculus* Linnaeus, 1758. The Jaz Murian depression is considered as the southernmost boundary of distributional range of *Apodemus witherbyi* Thomas, 1902 in the world. The Jaz Murian depression is supposed as a cross road between Palaearctic, Ethiopian and Oriental realms.

KEY WORDS The Jaz Murian depression; Rodent's diversity; Palaearctic; Ethiopian and Oriental realms.

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INTRODUCTION

Knowledge about faunal composition of a region will aid in mantaining and controlling its biodiversity and clarifying the evolutionary history of the area. Also, it can provide information about communication routes of animals between realms and lead to postulate filters and barriers (Darvish et al., 2014). Specially, these kinds of explorations in combination with geographical and topographic information can help us to postulate the processes through which diversification of new lineages and endemicity occur. Small mammals such as rodents are first reaching mammals to isolated ecosystems and predecessors for establishing populations by dispersal after vicariance events (Lomolino et al., 2005). In addition, rodents play a key role in balancing the ecosystems as common members in food chains (Shuai et al., 2006).

Moreover, documentation of rodent's diversity can help preventing and controlling public health challenges (Stenseth et al., 2003).They are known as important pests and they are reservoirs of some zoontic diseases (Nateghpour et al., 2013). Besides, they may cause economic problems and damages to agricultural crops (Schiller et al., 1999). So, investi-

gations shedding light on diversity and species richness of rodents can provide valuable information from biogeographic, economic and medical aspects.

The Jaz Murian depression in the southeast of Iran is a special route for exchange between Arabian and Indian fauna (Wessels, 1955; Misonne, 1959). Because of hard accessibility to the region bounded by deserts and mountains and its harsh climate some limited studies had been focused on diversity of mammals of the region (Blanford, 1875, 1876, 1877; Zarudny, 1896, 1898; Lay, 1967). Etemad (1978), Firouz (1999) and Ziaie (2008) have also reported some species of rodents inhabiting the region in their checklists of mammals of Iran but, some of these literature were recently revised (Musser & Carleton, 2005) and some records were added based on studies accomplished in Rodentology Research Department of Ferdowsi University (Siahsarvie & Darvish, 2007; Karami et al., 2008; Dianat et al., 2010; Darvish et al., 2014; Darvish et al., 2015). In this study, rodent fauna of the Jaz Murian depression was investigated and its diversity was discussed in the light of biogeographic view.

MATERIAL AND METHODS

Study area

The Jaz Murian depression is a broad oval in the southeast Iran covering about 25000 to 30000 square miles (Fisher, 1968). East-west extension of Jebal Barez-Shah Savaran-Bazman Mountain chains separates this depression from Lut desert in the north. In addition, continuation of the Zagros through Bashagerd to Makran Mountains in the south isolated the region from coastal area of Persian Gulf (Fisher, 1968). In fact, the southern part of the region stands with mountainous range reaching 4000 feet but there is a corridor in northern Fanuj with highlands less than 2850 feet above sea level (Harrison, 1943). The region receives two seasonal streams, Halilrud (on the west) and Bampur River (on the east) (Fisher, 1968). The depression also receives discharge of temporary streams and drainage of the rainfall from surrounding highlands (Lay, 1967). Lay (1967) also described the region as a dry land with the lowest precipitation in Iran

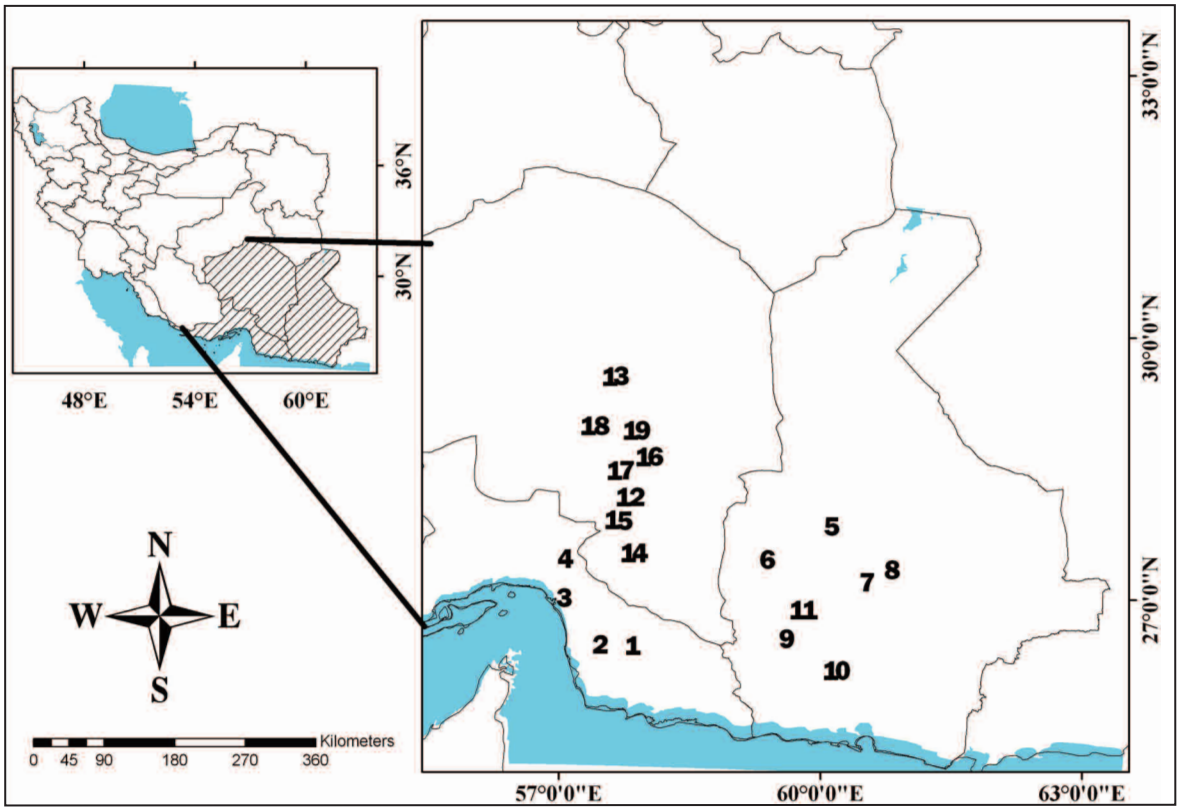

Figure 1. Maps of southeastern Iran with collecting sites for different specimens of rodents.

and abruptly falling temperature during nights with the main vegetation including *Acacia*, *Gymnocarpus*, *Tamarix* and *Haloxylon*. Based on Deblase (1980) it is part of the Baluchestan zoogeographic zone and Sahari-Sindi flora is the main vegetation cover of the region (Misonne, 1959). Madjdzadeh (2012) proposed the presence of three different zones in the region (desert and marginal desert, tropical zones and temperate mountainous zone). In fact, low plains reaching high mountainous range together provide magnificent paradoxical landscapes which can be seen in the region.

Sampling

The study was conducted in the Jaz Murian depression, southeast Iran (parts of Sistan & Baluchestan beside Kerman Provinces) from January 2014 to July 2015. Attributed geographical coordinates were recorded using GPS and ArcGIS ver. 9.3 software was applied for preparing the map of sampling localities (Fig. 1).

Rodents were collected using live-traps and snack or sausage bates. Since, jerboas are not trappable in live traps so we caught them with a hand net, using a searchlight at night and motorcycle. Collected specimens were subjected and prepared based on mammalogical procedure established by the American Society of mammalogists Animal Care and Use Committee (1998). Standard vouchers (skull, skin, tissues and karyotype idiograms) were preserved in Zoology Museum of Ferdowsi University (ZMFUM). In addition, specimens were identified based on identification keys (Corbet, 1978) with consideration to new revisions on rodent species of Iran (Musser & Carleton, 2005; Darvish et al., 2006b, Darvish, 2009; Dianat et al., 2010; Darvish et al., 2014; Darvish et al., 2015). Taxonomic arrangement followed Musser and Carleton (2005). Four external (Table 2) and eight cranial characters were measured (Table 4) applying a digital caliper to the nearest 0.01 mm (Instar Inc., Hangzhou, China). Fourteen dental characters (Table 3) were taken using a measuring microscope accurate to 0.001 mm. Mean and standard deviation of characters were estimated using SPSS 16 (SPSS Inc., Chicago, IL, USA).

ABBREVIATIONS. BL: body length, TL: tail length, FL: foot length, EL: ear length,M1/L: length of first upper molar, M2/L: length of second upper molar, M3/L: length of third upper molar, M1/W: width of first upper molar, M2/W: width of second upper molar, M3/W: width of third upper molar, M/1L: length of first lower molar, M/2L: length of second lower molar, M/3L: length of third lower molar, M/1W: width of first lower molar, M/2W: width of second lower molar, M/3W: width of third lower molar, UML: length of upper tooth row, LML: length of lower tooth row, BCH: braincase height, RH: rostral height, ZYGW: zygomatic breadth, RW: rostral width (maximum distance), IOW: interorbital constriction, BB: Breadth of braincase, CL: condylobasal length, BL: bulla length.

RESULTS

Totally, 127 specimens belonging to 5 families, 14 genera and 15 species were captured.

Family MURIDAE
Subfamily MURINAE

1. ***Mus musculus*** Linnaeus, 1758

Type locality. Uppsala, Sweden (Musser & Carleton, 2005).

Distribution. Worldwide distribution (except Antarctica) and commensally introduced by human to islands (Musser & Carleton, 2005).

Material localities. Sardasht, Biskove; Fariab; Bazman, Sefid Abad; Dalgan; Hudian; Bampur, Jafar Abad, Ali Abad; Iranshahr, Tigh Abad; Nikshahr; Fariab, Sardak-i-Sargorich; Kahnooj; Anbar Abad, Amjaz.

Diagnostic characters. The inner tubercle of the first loop of the first and second upper molars is markedly curved backwards; incisors with a denticle (Bonhomme et al., 1994; Din et al., 1996; Darvish et al., 2006b; Darvish, 2015).

2. ***Apodemus witherbyi*** Thomas, 1902

Type locality. Iran, Fars Province, Shul (Musser & Carleton, 2005).

Distribution. Plains, mountain and plateau steppes, and highland semi-deserts (not found in desert depressions) from southern Europe, Anatolia, the Middle East except Arabia, probably also occurs in Afghanistan (Musser & Carleton, 2005), Darvish et al. (2015) revealed its distributional range in Iran.

MATERIAL LOCALITIES. AnbarAbad, Amjaz.

DIAGNOSTIC CHARACTERS. Pectoral spot; stephanodont first upper molar; cusp-like t7 on 2nd upper molar; U-shaped fronto-parietal suture; posterior edge of the palatine is straight; large t7 on the first upper molar (Darvish et al., 2006a; Darvish et al., 2014).

3. ***Rattus rattus*** Linneaus, 1758

TYPE LOCALITY. Sweden, Uppsala County, Uppsala (Musser & Carleton, 2005).

DISTRIBUTION. Native to Indian Peninsula, and introduced worldwide in the temperate zone and parts of the tropical and subantarctic zones (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Minab, Tarom.

SPECIES	PREVIOUS REPORTS	THIS STUDY	NO.
Jaculus blanfordi	Jaz Murian (1)	Bazman, Shandak; Bampur, Jafar Abad; Kahnooj, Avaz Abad; Maskutan	5, 7, 11, 13
Mus musculus	IranShahr (4); Jaz Murian, Nikshahr, Kahnooj (3, 14); Jiroft, Anbar Abad (2, 9)	Sardasht, Biskove; Fariab; Bazman; Bazman, Sefid Abad; Dalgan; Hudian; Bampur, Jafar Abad, Ali Abad; Iranshahr, Tigh Abad; Nikshahr; Fariab, Sardak-i-Sargorich; Kahnooj; Anbar Abad, Amjaz	1, 4, 5, 6, 7, 8, 10, 12, 13
Apodemus witherbyi	Anbar Abad, Amjaz (2)	AnbarAbad, Amjaz	16
Nesokia indica	Iran Shahr (1); Bampur (5)	Bampur, Ali Abad; Kahnooj; Anbar Abad, Kesht-o-Sanat	7, 13, 17
Rattus rattus	Jiroft (2)	Minab, Tarom	3
Golunda ellioti	Jiroft, Kahnooj (11), (12); Anbar Abad, Amjaz (2, 10, 12)	AnbarAbad, Amjaz	16
Acomys dimidiatus	Jiroft (2, 13)	Sardasht, Biskove; Kohe Hidar village; Fanuj; Fariab	1, 2, 4, 11
Meriones persicus	Iran Shahr, Nikshahr (6); Jiroft (2); Amjaz (2)	Amjaz	16
Meriones libycus	Iran Shahr, Jaz Murian (1, 3)	Bazman, Kargokan, Cheshm-i-Abegarm; Hudian; Iranshahr, Tigh Abad; Maskutan	5, 6, 8, 11
Meriones hurrianae	Nik Shahr, Ghasreghand (7)	-	
Gerbillus nanus	Jaz Murian (1)	Minab, Tarom; Bazman, Kalgande; Jolgechah-i-Hashem; Bampur, Jafar Abad, Ali Abad; Iranshahr, TighAbad; Maskutan	3, 5, 6, 7, 8, 11
Tatera indica	Chah-i-Dadkhoda (7), Iranshahr; Jaz Murian, Nikshahr, Kahnooj (3, 14); Jiroft, Anbar Abad (2, 13)	Minab, Tarom; Roodan; Bazman; Dalgan; Jolgechah-i-Hashem; Hudian; Bampur, JafarAbad; Roodbar	3, 4, 5, 6, 7, 14
Calomyscus hotsoni	-	Kohe Hidar village; Fanuj; Anbar Abad	2, 9, 17
Cricetulus migratorius	Anbar Abad, Amjaz (2)	Anbar Abad	16
Micotus kermanesis	-	Anbar Abad	16
Ellobius fuscocapillus	Bashagerd (8)	-	
Hystrix indica	Jaz Murian (7); Iranshahr (3, 13)	Observed and colleceted its spines in Kohe Heidar village by the first author	2

Table 1. Sampling localities of previous reports and present study of rodents from the Jaz Murian depression. 1: Lay, 1967; 2: Amir Afzali et al., 2010; 3: Etemad, 1978; 4: Darvish, 2006c; 5: Zaree, 2013; 6: Missone, 1959; 7: Heptner, 1940; 8: Shenbrot & Krosnov, 2005; 9. Haddadian Shad et al., 2016.; 10: Darvish, 2012; 11: Nazari & Farid, 1991; 12: Madjdzadeh, 2012; 13: Firouz ,1999; 14: Ziaie, 2008.

DIAGNOSTIC CHARACTERS. Tail length longer than head and body length; ear reaches eye if pulled down; supraorbital ridges of the skull not parallel (Darvish, 2015).

4. ***Nesokia indica*** (Gray, 1830 in 1830–1835)

TYPE LOCALITY. India (Musser & Carleton, 2005).

DISTRIBUTION. Modern range covers Bangladesh, N-India, Pakistan, Afghanistan, Iran, Iraq, Syria, Saudi Arabia, Israel-Jordan, NE-Egypt, NW-China, and Central Asia (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Bampur, Ali Abad; Kahnooj; Anbar Abad, Kesht-o-Sanat.

DIAGNOSTIC CHARACTERS. Incisors are broad; breadth of zygomatic arcs is more than a half of the skull length; skull is with well developed crests (Darvish, 2015).

5. ***Acomys dimidiatus*** Cretzschemar, 1826

TYPE LOCALITY. Egypt, Sinai.

DISTRIBUTION. Sinai Peninsula of Egypt, Levant, Arabian Peninsula, S-Iraq, S-Iran, and S-Pakistan (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Sardasht, Biskove; Kohe Hidar village; Fanuj; Fariab.

DIAGNOSTIC CHARACTERS. Dorsal pledge is spiny; Tma is incorporated into the prelobe; on upper first molar t3 is posterior to t2; cusps linked with crests (Volobouev et al., 2007).

6. ***Golunda ellioti*** Gray, 1837

TYPE LOCALITY. India, Dharwar (Musser & Carleton, 2005).

DISTRIBUTION. SE-Iran, Pakistan, Nepal, N- and NE-India south through Indian peninsula to Sri Lanka (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Anbar Abad, Amjaz.

DIAGNOSTIC CHARACTERS. Upper incisors is grooved and upper molars have special columnar structure with high separated cusps (Darvish et al., 2012)

Taxa	N	BL	TL	FL	EL
MURIDAE					
Apodemus whiterbyi	6	88.50±7.81	102.00±3.84	21.00±1.09	16.16±0.75
Mus musculus	32	72.40±8.13	74.62±8.95	16.23±1.85	12.63±1.18
Meriones libycus	13	128.53±16.19	149.54±22.67	34.23±2.52	18.07±2.01
Meriones persicus	1	155.10	180.60	31.20	17.00
Tatera indica	13	151.80±13.64	173.22±12.44	37.10±2.99	25.30±3.59
Gerbillus nanus	15	75.53±4.35	118.00±8.67	23.23±1.09	12.07±0.86
Golunda ellioti	2	135±00	110.00±2.82	26.50±0.70	18.00±00
Nesokia indica	8	157.25±41.37	109.12±26.68	31.62±4.43	18.16±3.86
Rattus rattus	2	115.00±00	199.00±33.94	32.00±2.82	22.50±3.53
Acomys dimidiatus	21	90.50±10.24	106.18±9.80	19.38±0.50	20.00±1.60
CALOMYSCIDAE					
Calomyscus hotsoni	6	72.83±4.26	82.50±8.36	18.83±0.75	17.33±1.03
DIPODIDAE					
Jaculus blanfordi	6	123.16±7.73	205.33±49.57	67.16±3.18	25.33±1.36
CRICETIDAE					
Micotus kermanesis	1	140	54	23	16
Cricetulus migratorius	1	119	21	14	21

Table 2. Standard external measurements (Mean ± SD, in mm) of different species of rodents in southeast of Iran (see the text for abbreviations). BL: body length, TL: tail length, FL: foot length, EL: ear length.

Family MURIDAE
Subfamily GERBILINAE

7. ***Meriones persicus*** Blanford, 1875

TYPE LOCALITY. Iran, Kohrud, 116 km North of Isfahan (Musser & Carleton, 2005).

DISTRIBUTION. Iran, adjacent regions of Transcaucasia, Turkey (E-Anatolia), Iraq, Turkmenistan, Afghanistan and Pakistan (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Anbar Abad, Amjaz.

DIAGNOSTIC CHARACTERS. Each incisor have a groove; bullae enlarged; hind soles are bare; tail is longer than head and body (Corbet, 1978; Darvish, 2015).

8. ***Meriones libycus*** Lichtenstein, 1823

TYPE LOCALITY. Egypt, Alexandria (Musser & Carleton, 2005).

Taxa	N	M1/L	M2/L	M3/L	M1/W	M2/W	M3/W	M/1L	M/2L	M/3L	M/1W	M/2W	M/3W	LML	UML
Muridae															
Apodemus whiterbyi	6	1.81± 0.07	1.20± 0.04	0.93± 0.06	1.15± 0.06	1.06± 0.08	0.79± 0.03	1.56± 0.19	1.17± 0.03	1.05± 0.23	1.07± 0.07	1.04± 0.13	0.90± 0.06	4.12± 0.83	3.68± 0.06
Mus musculus	32	1.83± 0.8	1.03± 0.05	0.64± 0.05	1.11± 0.04	0.92± 0.06	0.63± 0.15	1.43± 0.11	0.94± 0.09	0.69± 0.09	1.04± 0.07	0.93± 0.08	0.59± 0.05	3.30± 0.17	3.07± 0.15
Meriones libycus	13	2.68± 0.41	1.50± 0.14	0.77± 0.08	1.75± 0.19	1.55± 0.18	0.86± 0.12	2.42± 0.24	1.56± 0.24	0.91± 0.20	1.80± 0.13	1.74± 0.11	1.02± 0.14	5.43± 0.50	5.39± 0.39
Meriones persicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tatera indica	13	3.18±. 26	1.75± 0.11	1.11± 0.12	2.39± 0.09	2.06± 0.19	1.42± 0.10	2.99± 0.13	1.92± 0.13	1.29± 0.18	2.27± 0.13	2.23± 0.15	1.40± 0.12	6.44± 0.26	6.19± 0.24
Gerbillus nanus	15	1.85± 0.10	1.00± 0.06	0.48± 0.04	1.27± 0.06	1.07± 0.07	0.61± 0.05	1.74± 0.09	1.15± 0.05	0.69± 0.09	1.23± 0.07	1.22± 0.07	0.67± 0.05	3.51± 0.31	3.48± 0.13
Golunda ellioti	12	2.68± 0.09	2.57± 0.06	2.39± 0.07	2.11± 00	2.28± 0.05	1.64± 0.04	2.95± 0.00	2.17± 0.32	1.73± 0.14	1.74± 0.12	1.76± 0.17	1.50± 0.24	6.80± 0.02	6.73± 0.11
Nesokia indica	8	3.41± 0.35	2.34± 0.29	2.00± 0.31	3.00± 0.27	2.79± 0.34	2.28± 0.30	3.51± 0.30	2.48± 0.30	2.13± 0.51	2.48± 0.22	2.67± 0.18	2.06± 0.24	8.64± 0.96	8.42± 0.71
Rattus rattus	2	3.08± 00	2.34± 0.24	1.60± 0.09	1.95± 0.14	1.83± 0.09	1.40± 0.12	2.68± 0.16	1.90± 0.11	1.84± 0.04	1.71± 0.06	1.79± 0.13	1.61± 0.14	6.44± 0.77	6.26± 0.73
Acomys dimidiatus	21	2.24± 0.04	1.51± 0.05	1.01± 0.04	1.53± 0.04	1.45± 0.07	0.92± 0.05	1.93± 0.05	1.39± 0.06	1.04± 0.05	1.37± 0.06	1.38± 0.06	0.99± 0.06	4.5± 0.09	4.1± 0.09
Calomyscidae															
Calomyscus hotsoni	6	1.55± 0.06	1.22± 0.08	0.60± 0.04	1.10± 0.05	1.05± 0.03	0.67± 0.03	1.46± 0.06	1.24± 0.05	0.78± 0.03	1.03± 0.02	1.13± 0.02	0.69± 0.02	3.39± 0.12	3.26± 0.15
Dipodidae															
Jaculus blanfordi	6	1.83± 0.10	1.72± 0.09	1.39± 0.08	1.76± 0.10	1.78± 0.04	1.31± 0.10	2.03± 0.10	2.05± 0.11	1.68± 0.16	1.67± 0.05	1.91± 0.09	1.40± 0.04	5.26± 0.19	5.46± 0.13
Cricetidae															
Micotus kermanesis	1	2.67	2.17	2.53	1.67	1.37	1.28	3.70	2.01	2.02	1.62	1.01	1.22	7.94	8.05
Cricetulus migratorius	1	1.91	1.42	-	1.40	1.27	-	1.73	1.41	1.39	1.24	1.26	0.96	4.23	4.40

Table 3. Dental measurements (Mean ± SD, in mm) of different species of rodents from the Jaz Murian depression, southeast Iran. (Data were not prepared for *Meriones persicus*). M1/L: length of first upper molar, M2/L: length of second upper molar, M3/L: length of third upper molar, M1/W: width of first upper molar, M2/W: width of second upper molar, M3/W: width of third upper molar, M/1L: length of first lower molar, M/2L: length of second lower molar, M/3L: length of third lower molar, M/1W: width of first lower molar, M/2W: width of second lower molar, M/3W: width of third lower molar, UML: length of upper tooth row, LML: length of lower tooth row.

DISTRIBUTION. North Africa through Saudi Arabia, Jordan, Iraq, Syria, Iran, Afghanistan, Central Asia to W-China; probably Anatolia (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Bazman, Kargokan, Cheshm-i-Abegarm; Hudian; Iranshahr, Tigh Abad; Maskutan.

DIAGNOSTIC CHARACTERS. Soles are not bare; claws are black (Darvish et al., 2006b).

9. ***Tatera indica*** Hardwicke, 1807

TYPE LOCALITY. Between Benares and Hardwar, north of India (Musser & Carleton, 2005).

DISTRIBUTION. An extensive range from SE-Anatolia in Syria, Iraq, and Kuwait through Iran, Afghanistan, and Pakistan into most of Indian Peninsula north to S-Nepal; also Sri Lanka (Musser & Carleton, 2005).

Taxa	N	BCH	RH	ZYGW	RW	IOW	BB	CL	BL
Muridae									
Apodemus whiterbyi	6	7.92±0.35	6.21±0.45	12.70±0.35	4.32±0.22	4.26±0.15	11.55±0.20	23.30±0.92	4.97±0.65
Mus musculus	32	7.01±0.31	4.84±0.38	10.97±0.59	3.24±0.24	3.48±0.16	9.33±0.27	19.49±1.23	3.56±0.32
Meriones libycus	13	13.31±0.97	8.77±0.67	20.56±0.96	4.90±0.26	6.64±0.59	17.97±0.80	33.74±2.43	15.04±0.87
Meriones persicus	-	-	-	-	-	-	-	-	-
Tatera indica	13	14.33±0.88	10.38±1.87 3	21.68±1.78	4.49±0.30	6.75±0.33	17.77±0.53	36.70±2.79	13.82±0.97
Gerbillus nanus	15	9.11±0.37	6.02±0.73	13.48±0.58	3.26±0.15	4.68±0.30	12.36±0.40	22.41±0.76	10.04±0.27
Golunda ellioti	2	10.00±0.24	8.30±0.24	15.98±0.07	5.23±0.16	4.41±0.32	12.84±0.27	30.73±0.38	6.52±0.12
Nesokia indica	8	14.59±1.85	12.59±2.16	25.00±3.96	7.29±1.08	6.20±0.66	17.04±1.31	40.05±6.84	7.86±0.99
Rattus rattus	2	11.31±0.43	8.86±1.39	18.03±1.95	5.71±0.65	5.65±0.77	15.44±1.51	35.18±4.76	6.25±0.51
Acomys dimidiatus	21	8.97±0.26	5.65±0.23	13.91±0.55	3.69±0.14	4.71±0.12	12.45±0.26	26.50±1.30	5.28±0.28
Calomyscidae									
Calomyscus hotsoni	6	7.42±0.31	5.01±0.21	12.16±0.39	3.83±0.18	4.05±0.24	10.89±0.44	20.78±1.22	5.44±0.32
Dipodidae									
Jaculus blanfordi	6	14.17±0.45	8.40±0.48	23.44±0.68	5.27±0.18	12.51±0.41	22.64±0.57	31.39±1.00	15.62±0.64
Cricetidae									
Micotus kermanesis	1	8.66	8.23	17.55	5.03	4.70	15.02	32.76	9.39
Cricetulus migratorius	1	9.18	7.37	15.10	5.53	4.58	11.77	22.07	5.50

Table 4. Cranial measurements (Mean ± SD, in mm) of different species of rodents from The Jaz Murian depression, southeast Iran. (Data were not prepared for *Meriones persicus*). BCH: braincase height, RH: rostral height, ZYGW: zygomatic breadth, RW: rostral width (maximum distance),IOW: interorbital constriction, BB: Breadth of braincase, CL: condylobasal length, BL: bulla length.

MATERIAL LOCALITIES. Minab, Tarom; Roodan; Bazman; Dalgan; Jolgechah-i-Hashem; Hudian; Bampur, Jafar Abad; Roodbar.

DIAGNOSTIC CHARACTERS. Bullae is rather small; transvers bands of molars are separate (Corbet, 1967; Mirshamsi et al., 2007; Darvish, 2015).

10. ***Gerbillus nanus*** Blanford, 1875

TYPE LOCALITY. Pakistan, Gedrosia (Musser & Carleton, 2005).

DISTRIBUTION. An extensive range from the Baluchistan region of NW-India, Pakistan, S-Afghanistan, and Iran through the Arabian Peninsula, Iraq, Levant, North Africa to Morocco, south in the Sahara to at least and NE-Mali (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Minab, Tarom; Bazman, Kalgande; Jolgechah-i-Hashem; Bampur, Jafar Abad, Ali Abad; Iranshahr, Tigh Abad; Maskutan.

DIAGNOSTIC CHARACTERS. Tail is longer than head and body; auditory meatus with anterodorsal rim inflated; no curtain within the meatus (Corbet, 1978; Darvish, 2015).

Family DIPODIDAE

11. ***Jaculus blanfordi*** Murray, 1884

TYPE LOCALITY. Bushire, Iran (Musser & Carleton, 2005).

DISTRIBUTION. SE coast of Caspian Sea through Turkmenistan to the Kyzylkum Desert, C-Uzbekistan, E- and S-Iran (Lay, 1967), S- and W-Afghanistan and SW Pakistan (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Bazman, Shandak; Bampur, Jafar Abad; Kahnooj, Avaz Abad; Maskutan.

DIAGNOSTIC CHARACTERS. Maxillary tooth row usually under 5 mm (Corbet, 1978; Darvish, 2015).

Family CALOMYSCIDAE

12. ***Calomyscus hotsoni*** Thomas, 1920

TYPE LOCALITY. W-Pakistan, W-Balochistan, Makran Dist., Gwambuk Kaul, 50 km SW-Panjgur.

DISTRIBUTION. Recorded from vicinity of type locality and Baluchistan Province of SE-Iran (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Kohe Heidar; Fanuj; Anbar Abad.

DIAGNOSTIC CHARACTERS. Nasal width is narrow; skull is high; diastema is long; intarorbital is narrow.

Family CRICETIDAE
Subfamily CRICETINAE

13. ***Cricetulus migratorius*** (Pallas, 1773)

TYPE LOCALITY. West Kazakhstan,Lower Ural River (Musser & Carleton, 2005).

DISTRIBUTION. SE-Europe to Romania and Bulgaria eastwards through Kazakhstan to S-Mongolia and N-China southwards through Turkey and Transcaucasia to Levant, Iraq, Iran (Lay, 1967), Afghanistan, Pakistan and N-India (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Anbar Abad, Amjaz.

DIAGNOSTIC CHARACTERS. Teeth are no-prismatic and with two rows; antero external angles of parietal is rounded (Corbet, 1978; Darvish, 2015).

Family CRICETIDAE
Subfamily ARVICOLLINAE

14. ***Micotus kermanesis***

TYPE LOCALITY.

DISTRIBUTION. Dry montane steppe habitats on isolated mountains from N slopes of Kopet-Dag Mtns in S-Turkmenistan (Meyer et al., 1996), mountains in E-Iran in the NE (Khorassan Prov., 5 km N-Kashmar, USNM) and S (Kuh-e Laleh-Zar and Kuh-e Hazar Mtns south of Kerman; Roguin, 1988), and the Hindu Kush of N-Afghanistan (Ellerman, 1948; Parvan Province, Shibar Pass, FMNH).

MATERIAL LOCALITIES. Anbar Abad.

Family HYSTRICIDAE

15. ***Hystrix indica*** Kerr, 1792

TYPE LOCALITY. India

DISTRIBUTION. Transcaucasus, Asia Minor, Israel, Arabia to S Kazakhstan and India, Sri Lanka, Tibet (China) (Musser & Carleton, 2005).

MATERIAL LOCALITIES. Kohe Heidar

DISCUSSION

The Jaz Murian depression was formed from the Early Tertiary during the southward movement of Makran, between continental margin of Makran and Lut basin (Berberian & King, 1981). It was part of Gondwana land mass possibly an extension of the Afro-Arabian continental platform (Stocklin, 1968; Berberian, 1976). From the biogeographic aspects, south of Iran was known as a bridge between oriental realm and African-Arabian region (known as Ethiopian realm; Frey & Probst, 1986; Coad & Vhlenkin, 2004; Madjnoonian et al., 2005). This dry land surrounded by mountains and desert range lacks endemic Iranian elements (Misonne, 1959) and was considered as a unique zoogeographic zone (Zarudny, 1911). Frey & Probst (1986) in their synopsis of the vegetation of Iran accounted the region as a Nubo-Sindian zone which was excluded from Palaearctic parts of Iran from the phytogeographic view. Conversely, the depression enjoys Oriental and Ethiopian elements which could pass the Sindian plains and Arabian deserts penetrating Iran from northern shores of Persian Gulf (Missone, 1959; Frey & Probst, 1986). In fact, during the late Early Miocene, decline in the sea level may have resulted in faunal exchange via some emerging islands (Wessels, 1955).

The penetration route of African (Ethiopian) elements (*Acomys* I. Geoffroy, 1838, *Gerbillus* Desmarest, 1804 and *Meriones* Illiger, 1811) into the region is not clear but Madjnoonian et al. (2005) proposed Bandar Abbas through Hormoz Strait as a paleo-corridor during Quaternary. Eastern spiny mouse (*Acomys dimidiatus*) was blocked in the southeast Iran while *Tatera indica* could pass the barriers into the central Plateau of Iran (Madjnoonian et al., 2005). *Acomys dimidiatus* entered south Iran from the west and passing northern margin of Persian Gulf (Fars, Bushehr, Hormozgan, Sistan and Baluchestan provinces) reaching southern Pakistan (Etemad, 1978; Firouz, 1999; Frynta et al., 2010). This study provided new records of the Eastern spiny mice from Kerman province. Mean value of tail length of the Jaz Murian specimens of *A. dimidiatus* is nearly similar to the Arabian specimens (Harrison, 1972).

Steppe field mouse (*A. witherbyi*) was previously reported from different localities of Iran (Hosseinpour Feizi et al., 2009; Darvish et al., 2015). Comparing to the specimens from northwest of Iran, mean value of head and body and tail length of the Jaz Murian specimens is longer (Darvish et al., 2014). Considering the fact that genus *Apodemus* Kaup, 1829 is a Palaearctic element (Michaux et al., 2002), the Jaz Murian depression can be interpreted as a boundary between Palaearctic and Oriental realms. It is supposed that the Jaz Murian depression is the southernmost boundary of distributional range of *A. witherbyi* in the world. The region might has also played a role as a corridor for entering *Mus musculus* from its origin (north Indian) to central Iranian Plateau (Bonhomme et al., 1994).

In *Mus musculus* and *Tatera indica* the head and body and tail length of the Jaz murian specimens were smaller than that of Pakistan specimens but tail lenght is longer than that of *Mus musculus* from northwest of Iran (Roberts, 1997; Darvish et al., 2014). The head and the body length of *Jaculus blanfordi* from the region are smaller than that of Pakistan and Turkmenistan specimens but the average tail length of the Jaz Murian specimens is longer than the tail length of Pakistan and Turkmenistan specimens (Shenbrot et al., 2008). The head and body length of *Cricetulus migratorius* from Jaz Murian is longer than the mean value of the head and body length of Pakistan, but the tail length is smaller. Also, it shows smaller head and body and tail length compared to specimens from the northwest of Iran and Arabia (Harrison, 1972; Roberts, 1997; Darvish et al., 2014). Mean value of head and body length of *Merion libycus* is smaller than that of Pakistan, but mean value of tail length is longer. Libyan jirds of the Jaz Murian show longer mean value of head and body and tail length comparing to the specimens from northwest of Iran (Roberts, 1997; Darvish et al., 2014). The head and body and tail length of the Jaz Murian specimens of *Nesokia indica* is smaller than the Pakistan and Arabian specimens (Harrison, 1972; Roberts, 1997). Also, the Jaz Murian specimens of *Calomy-*

scus hotsoni show smaller head and body length, but longer tail length comparing to the Pakistan specimens (Roberts, 1997).

Indian bush rat *Golunda ellioti* has been recorded from the Jaz Murian depression (Jiroft, Kerman) by different authors (Misonne, 1990; Nazari & Farid, 1991; Madjdzadeh 2012; Darvish et al., 2012). Actually, the genus *Golunda* occupied oriental realm from early Pliocene (Cheema et al., 1997, 2003) and it seems that the Jaz Murian is the westernmost boundary of this oriental species (Ziaie, 2008). The head and body and tail length of *Golunda ellioti* from Jaz Murian is longer than that of Pakistan specimens (Roberts, 1997).

Corbet (1978) mentioned that *Meriones hurrianae* (Jerdon, 1867) (Baluchestan, southeast Iran) and *Rattus niviventer* (Hodgson, 1836) (northern Pakistan) are oriental species which can be found in the boundary of Palaearctic realm; however, they were not captured in this study. The total head and body and the tail length of *Rattus rattus* from Jaz Murian specimens were smaller than that of Pakistan specimens (Roberts, 1997).

For most specimens, except *Gerbillus nanus*, and *Apodemus whiterbyi*, total length of the body is small, compared to that of their counterparts from northeast and northwest Iran (Darvish et al., 2006; Darvish et al., 2014). This pattern of nanism may be a response to lower precipitation and sparse vegetation cover in the region. In fact, high temperature and drought resulting in lower primary productivity and decline in food level, which in turn cause body size decline (Sheridan & Bickford, 2011).

CONCLUSION

The Jaz Murian depression is a crossroad between Palaearctic, Ethiopian and Oriental realms. Because of the conspicuous geographic and topographic features of this transition zone, a complex mixture of rodent species such as Oriental species i.e. *Golunda ellioti*, *Meriones hurrianae*, *Mus musculus*, *Tatera indica*, *Hystrix indica* and Ethiopian elements such as *Gerbillus nanus*, *Meriones libycus* and *Acomys dimidiatus* beside Palaearctic species i.e. *Apodemus witherbyi*, *Rattus rattus*, *Cricetulusmigratorius*, *Microtus* sp. can be found in the region. Although, the region is characterized by a low plains surrounded by high mountains, it is not strictly isolated. Thus, it can be considered as a corridor between three realms. The specific geographical condition and the unique topography and climatic situation of the Jaz Murian depression made the region favorite destination for zoogeographic and phylogeography studies. This study was just a preliminary investigation on the rodent's fauna of the Jaz Murian depression carried out to contribute to other studies aimed at revealing specific aspects of the region.

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