Systematics and Phylogenetics
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 66 (4), 2014: 461-468

Morphological Morphometric Characterisation of the Eastern Broad-toothed Field Mouse *Apodemus mystacinus* (Rodentia: Muridae) from Zagros Mountains, north-western Iran

Jamshid Darvish[1,2], Zeinolabedin Mohammadi[1*], Fatemeh Ghorbani[1], Ehsan Mostafavi[3,4]

[1]Department of Biology, Faculty of Sciences, Ferdowsi University of Mashhad, Mashhad, Iran;
E-mail: Mohammadi.zeinal@gmail.com
[2]Applied Animal Institute, Rodentology Research Department, Ferdowsi University of Mashhad, Mashhad, Iran
[3]Department of Epidemiology, Pasteur Institute of Iran, Tehran, Iran
[4]Research Centre for Emerging and Reemerging infectious diseases, Pasteur Institute of Iran, Akanlu, Kabudar Ahang, Hamadan, Iran

Abstract: The eastern broad-toothed field mouse *Apodemus mystacinus* (Danford and Alston, 1877) has been reported from the Levant, some Aegean islands, Anatolia, the southern Caucasus and North Iraq. In this study, 15 specimens of *A. mystacinus* were recorded from the Zagros Mountains, north-western Iran. Four external features, 13 linear measurements of the skull and 14 dental characters were measured. Dental and cranial characters were evaluated based on the frequencies of 27 character states for 12 morphological characters. The oak forests of the north-western slopes of the Zagros Mountains are known as the easternmost range boundary of *A. mystacinus,* and the species has been blocked by the north-south extension of the Zagros Mountains. Based on morphological and morphometric characters, we suggest that the population of *A. mystacinus* from the Zagros Mountains possibly belongs to a new subspecies but this issue requires further analyses.

Keywords: *Apodemus mystacinus*, Zagros Mountains, morphometrics, Iran, subspecies

Introduction

The Eastern broad-toothed field mouse *Apodemus mystacinus* (Danford and Alston, 1877) was originally described as *Mus mystacinus* from Zebil, Bulgar Dagh, southern Turkey. This species is distributed in the Eastern Mediterranean through Anatolia, the Levant and the northern part of Iraq. Its range also extends westward to some Aegean islands and the easternmost boundary of its range is known to be North Iraq. It occurs in the South Caucaususin Georgia (Corbet 1978, Musser, Carleton 2005). *A. mystacinus* was accounted from morphological point of view as the most primitive species of the genus *Apodemus* (Ellerman, Morrison-Scott 1951). It was also recognised as the ancestral member of the subgenus *Sylvaemus* in the Western Palaearctic based on molecular phylogeny (Chelomina, Atopkin 2010). However, the inclusion of *A. mystacinus* in the subgenus *Sylvaemus* was not accepted by some authors (Çolak *et al*. 2007). Mezhzherin (1997) and Pavlinov *et al.* (1995) assigned this species to the subgenus *Karstomys* as a member of the genus *Sylvaemus*.

Ellerman, Morrison-Scott (1951) revised the taxonomic status of the subspecies of *A. mystacinus* and accepted two valid subspecies: *A. m. mystacinus* and *A. m. euxinus*. Vohralik *et al.* (2002) considered the Asian populations of *A. mystacinus* as a homogenous species based on colouration and morphometric analyses, with no distinct subspecies. *A. m. mystacinus* and *A. m. euxinus* were validated by Colak *et al.* (2004). The related form occurring in the Balkan Peninsula *A. epimelas* Nehring, 1902 has been synonymised with *A. mystacinus* or recognised as its subspecies (Ellerman 1941, Ellerman, Morrison-

*Corresponding author: Mohammadi.zeinal@gmail.com

Scott 1966, Corbet 1978, Niethammer 1978, Musser, Carleton 1993). Currently, *A. epimelas* is treated as a distinct species based on morphology and morphometrics (Mezhzherin 1997) or molecular studies (Filippucci *et al*. 2002, Bellinvia 2004, Michaux *et al.* 2005).

Until recently, four species of wood mice of the genus *Apodemus* have been known from Iran, i.e. *A. witherbyi* (Thomas, 1902), *A. uralensis* (Pallas, 1811), *A. hyrcanicus* Vorontsov, Boyeskorov and Mezhzherin, 1992 and *A. flavicollis* (Melchior, 1834) (Javidkar *et al*. 2005, Krystufek, Hutterer 2006, Darvish *et al.* 2010, Karami *et al*. 2008). In addition, *A. avicennicus* Darvish, Javidkar & Siahsarvie, 2006 was described by Darvish *et al*. (2006) from Iran. Firouz (2008) mentioned *A. mystacinus* as a probable member of the fauna of Iran and considered its possible presence in the Azarbaijan provinces, north-western Iran.

By the present study, the first records of *A. mystacinus* from the Zagros Mountains are added to the list of the rodents of Iran.

Material and Methods

In total, 15 specimens of *A. mystacinus* and 38 specimens of *A. witherbyi* were collected from Kordestan Province, western Iran, in June – July 2013, using live-traps and snack baits (Fig. 1). The specimens were determined based on cranial and external morphological and morphometric features, referring to Corbet (1978), Etemad (1978),Vorontsov *et al*. (1992), Colak *et al*. (2004) and Kryštufek, Vohralik (2005). The standard voucher specimens (skins, skulls, tissue samples) were deposited in the Zoology Museum of the Ferdowsi University of Mashhad (ZMFUM). The specimens were weighted, sexed and scored for four external dimensions; further, 13 linear measurements on the skull were taken using a vernier calliper accurate to the nearest 0.05 mm (Table 1 and Appendix 1). 14 dental measurements were performed with a measuring microscope to 0.001 mm (Table 2 and Appendix 1). Nomenclature of the dental characters followed Missone (1969) and Javidkar *et al*. (2007). The skulls were observed under a stereomicroscope (magnification 40x) and drawings were done using a camera lucida (Fig. 1).

Results

Diagnostic characters

Dorsal fur smoky grey, ventral fur pure white in chest and white with grayish base near thighs. Pectoral spot lacking. Tail distinctly bi-coloured. Demarcation line of body present but not clearly visible from lateral view. This is the largest *Apodemus* species in Iran, with the longest tail (Mean=114.21±8.67) and head-body length (Mean=97.00±7.95). Hind foot long, mean=24.52±3.22 (longer than that in the sympatric species *A. witherbyi*, mean=21.80±0.83) (Table 1). Skull large. Zygomatic arches weak. Brain-case relatively large and rounded. Condylobasal length

Table 1. External and cranial dimensions (in mm) of *A. mystacinus* and *A.witherbyi* from north-western Iran

Variables	***A.mystacinus* N=15**			***A.witherbyi* N=38**		
	Mean ± SE	Min	Max	Mean ± SE	Min	Max
HBL	97.00±7.95	90	118	90.40±1.18	77	103
TL	114.21±8.67	105	142	99.56±1.17	78	117
HFL	24.52±3.22	20	33	21.37±0.24	15	24
EL	17.58±1.41	16	20	15.79±0.08	11	26
CBL	26.75±0.29	24.82	29.26	23.31±0.10	21.24	24.72
FL	14.41±0.12	13.42	15.60	12.28±0.05	11.32	12.90
PAL	5.90±0.10	5.02	6.70	4.79±0.05	4.12	5.46
ZYGB	14.55±0.18	13.76	16.16	12.72±0.08	11.40	13.88
RW	4.69±0.050	4.34	5.24	4.43±0.04	3.66	4.84
IOC	4.75±0.050	4.26	5.08	4.33±0.02	4.10	4.66
BCW	13.27±0.13	12.06	14.40	11.70±0.04	11.23	12.32
IBW	12.16±0.11	11.16	12.88	10.98±0.50	10.44	12
RH	6.72±.09	6.32	7.46	5.94±0.04	5.40	6.38
BCBH	10.29±0.08	9.86	10.82	8.93±0.04	8.34	9.46
TBL	6.62±.08	6.10	7.16	5.91±0.05	5.32	6.82
TBW	4.99±0.03	4.68	5.22	4.40±0.02	4.08	4.76
ML	13.67±0.14	12.92	15.02	11.57±0.07	10.34	12.52

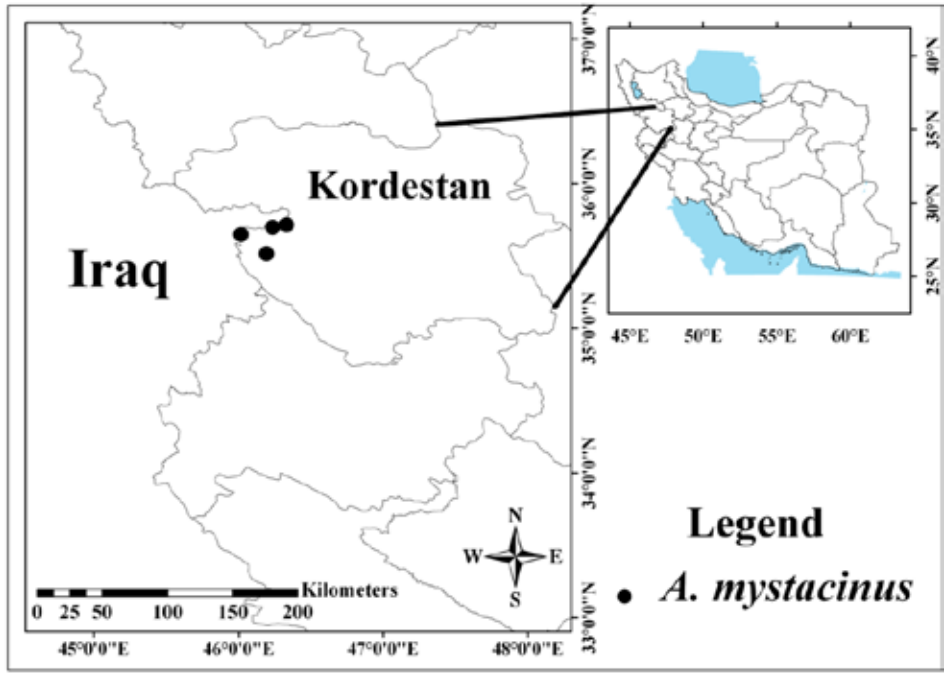


Fig. 1. Sampling localities of A. mystacinus from the north western Iran

Table 2. Dental measurements of *A. mystacinus* and *A.witherbyi* from north-western Iran; measurements are in millimetres

Variables	*A.mystacinus* N=15			*A.witherbyi* N=38		
	Mean ± SE	Min	Max	Mean ± SE	Min	Max
M1.L	2.28±.04	1.83	2.45	1.85±.01	1.69	1.96
M1.W	1.39±0.02	1.16	1.47	1.16±.01	1.02	1.26
M2.L	1.34±0.01	1.19	1.44	1.13±.01	1.03	1.20
M2.W	1.32±0.02	1.13	1.43	1.11±.01	1.01	1.22
M3.L	1.04±0.02	0.87	1.14	0.84±0.01	0.76	0.98
M3.W	1.07±0.02	0.79	1.21	0.81±.01	0.67	0.93
M.1L	2.14±0.02	1.90	2.22	1.66±0.01	1.17	1.78
M.1W	1.27±0.01	1.12	1.38	1.03±0.01	0.88	1.12
M.2L	1.40±0.01	1.24	1.54	1.14±0.01	1.04	1.25
M.2W	1.28±0.01	1.11	1.36	1.04±0.01	0.90	1.19
M.3L	1.20±0.02	0.98	1.31	0.97±.01	0.88	1.06
M.3W	1.12±0.10	0.84	1.33	0.89±0.04	0.80	1.0
MxTR	4.59±0.05	4.02	4.87	3.78±0.01	3.54	3.95
MnTR	4.73±0.05	4.09	4.93	3.76±.01	3.37	3.94

large, mean=26.75±0.29 mm (compared to that of *A. witherbyi*, mean=23.31±0.10). Mean length of maxillary tooth row 4.59±0.05 mm (compared to 3.78±0.01 mm in *A. witherbyi*).

All specimens of *A. mystacinus* except one have tubercle t12 on second upper molar (Table 3). Number of cingula on first lower molar ranges from 4 to 5, while on second lower molar 2, 3 and 4 cingula present (Table 3). Fronto-parietal sutures wide-V-shaped (49.98%), accolade-shaped (35.7%) or U-shaped (14.28%). Cusps t1 and t5 in all specimens separated; interpterygoid sinus straight in seven specimens (49.98%), U-shaped in three (21.42%) and with dens in four (28.56%) (Table 3). Posterior margin of incisive foramina reaching line connecting anterior parts of upper tooth rows in 64.26%, while in 35.7% (n=5) same margin not reaching this line (Table 3).

Molars relatively broad. Upper molars with labial antrocone (t3) and lingual antrostyle (t1) to protocone (t5) on upper M1 not connected in 100% of specimens. In lower molars, half of specimens show 4 and the other half 5 labial cingula on lower M.1. Number of labial cingula on lower M.2 is 2 in

Table 3. Variation in size, shape and position of the 12 parameters analysed in 15 specimens of *A. mystacinus*

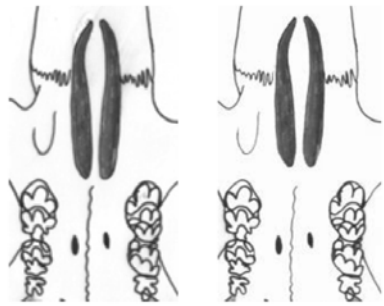
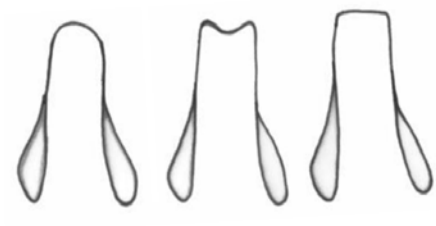
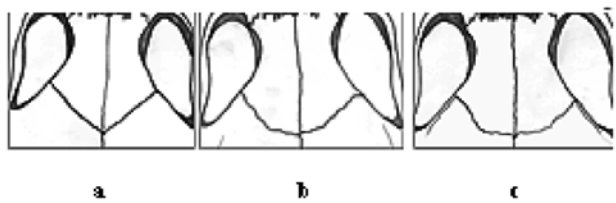
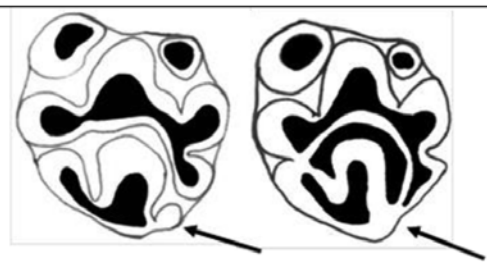
1. Position of posterior margin of incisive foramens relative to first upper molars		
a: Passing the line connecting anterior part of the tooth row	64.26	
b: Not passing the line connecting anterior part of tooth row	35.7	a b
2. Shape of interpterygoid vacuity		
a: U shape	21.42	
b: with a dens	28.56	
c: Straight	49.98	a b c
3. Shape of fronto-parietal suture		
a: Wide V shape	49.98	
b: U shape	14.28	a b c
c: Accolade shape ({)	35.7	
4. The postero-labial cusp t12 on the upper M2		
a: Present	92.95	
b: Absent	7.14	a b
5. Connective of the Anterostyle (t1) to the protocone (t5) on the upper M1		
a: Connected	0	
b: With no connection	100	a b

Table 3. Continued

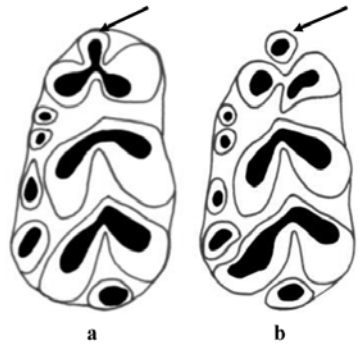
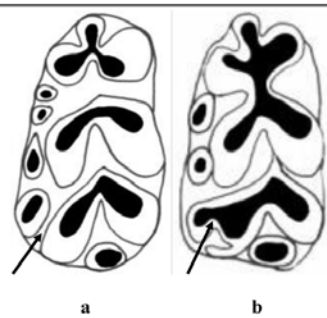
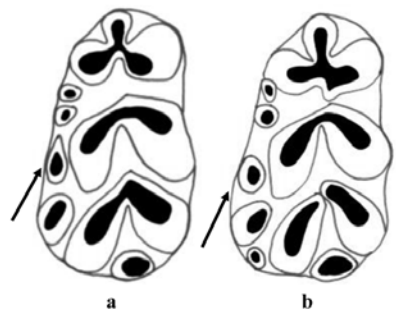
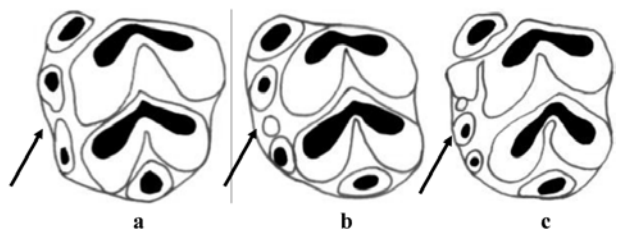
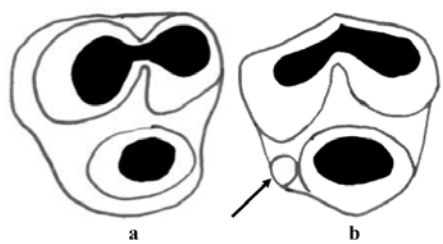
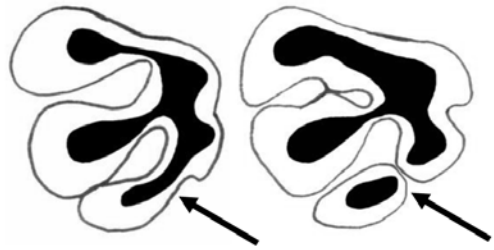
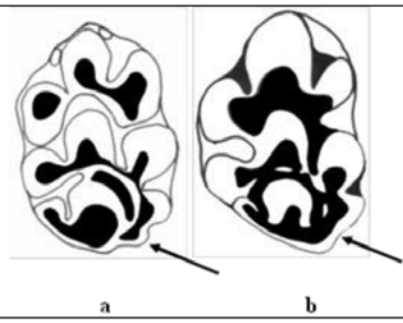
6. Position of median anteroconid on the lower M.1		
a: connected	85.68	
b: Isolated	14.28	
7. Position of dla on the lower M.1		
a: Connected to cingulum	0	
b: Isolated	100	
8. Number of Cingula on the lower M.1		
a: 4	49.98	
b: 5	49.98	
9. Number of Cingula on the lower M.2		
a: 2	35.7	
b: 3	35.7	
c: 4	28.56	
10. Cingula on the lower M.3		
a: Absent	85.68	
b: Present	14.28	

Table 3. Continued

11. Position of the t7 to t9 on the upper M3		
a: Connected	57.12	
b: Isolated	42.84	a b
12. The postero-labial cusp t12 on the upper M1		
a: Present	100	
b: Absent	0	a b

35.7%, 3 in 35.7% and 4 in 28.56% of specimens. Only two specimens have cingulum on third upper molar (Table 3).

In the sympatric species *A. witherbyi*, dorsal fur brown, with red tint and ventral fur completely pure white. Pectoral spot present in 100% of specimens. Demarcation line of body distinct. Fronto-parietal suture U-shaped (100%); posterior edge of palatine straight; first upper molar clearly stephanodont (cusps t1 and t5 connected by a ridge). The first incisive foramen passing line connecting anterior part of tooth rows in 100% of specimens. Cusp t7 on the first upper M/1 is large. Tubercle t12 on the second upper molar not present. The number of cingula on first lower molar 3, while in the second lower molar is 2 (Table 3).

Discussion

In spite of some efforts undertaken so far for elucidating the biodiversity of Iran (Darvish *et al*. 2006, Shahabi *et al*. 2011, Ghorbani *et al*. 2010, Karami *et al*. 2008, Darvish *et al.* 2012), there are still gaps in the studies that address the species diversity in the country as a whole. The north-west Iran is a part of the Irano-Anatolian hotspot, which is one of the most priorities for conservation in Asia (Mittermeier *et al*. 2012). The region was described as Armano-Kord area by Missone (1959) and is characterised by high level of endemicity of its fauna and flora (Rechinger, Lack 1991, Noroozi 2008, Mohammadi *et al*. in press).

The Eastern broad-toothed field mice inhabit in the mountainous area or clay foothills with an altitude of more than 1400 m in north-western Iran. The highland oak forests of the Zagros Mountains emerged gradually from 6700 to 5500 years ago (Van Zeist, Bottema 1977, Wasylikowa *et al*. 2008) and provided suitable ecological habitats for *A. mystacinus* in Iran. This species was found in the rocks and bushy foothills of the Zagros Mountains where this mouse feeds on seeds and seedlings, nuts and acorns of the most abundant plant species of these forests, including *Quercus infectoria, Quercus brantii, Quercus libani, Prunus orientalis, Prunus scoparia, Crataegus azarolus, Pyrus glabra* and *Cerasus microcarpa* (Haidari *et al.* 2013). In addition, the Zagros forests are the easternmost boundary of the distributional range of *A. mystacinus* and the species does not penetrate the Central Plateau of Iran. Vereshchagin (1959) described the presence of *A. mystacinus euxinus* in the Great and the Lesser Caucasus and western Transcaucasia but it has never been reported from the Iranian part of the Caucasus. Missone (1959) mentioned that valleys are the only corridors for the penetration of terrestrial species into the Iranian Plateau. In this sense, the Shiller valley in Kordestan, located on the boundary between North Iraq and Iran may serve as such a corridor for eastward expansion of *A. mystacinus* because the species was not collected in the other parts of the Zagros.

Our data confirmed the west-east decrease in the molar size comparing to that in Turkey's specimens,

which was previously described by some authors (Spitzenberger 1973, Vohralik *et al*. 2002). The specimens of *A. mystacinus* from the west of Iran also demonstrate lower average values in all measurements comparing to the specimens from Turkey. For instance, the average value of the condylobasal length in the Iranian population of *A. mystacinus* is smaller (Mean = 26.75 mm) in comparison with that from Turkey (Mean = more than 26.9 mm, Kryštufek, Vohralik 2005). Colak *et al*. (2004) reported average values of the condylobasal lengths 26.8 mm for *A. m. mystacinus* and *A. m. euxinus,* 27.8 mm for *A. m. smyrnensis* and *A. m. rhodius*. However, this measurement are greater than those in the Transcaucasian specimens (Mean = 26.5 mm) as reported by Shidlovskii (1953). Therefore, the population of *A. mystacinus* from the Zagros Mountains might be recognised as a new subspecies after implementing some further studies.

Funding: We appreciate the financial support of the Center for Disease Control and Prevention of the Iranian Ministry of Health and Pasteur institute of Iran [Grants no. 582] for the sampling of the study.

Appendix 1. Abbreviations

HBL	Head and body length
TL	Tail length
HFL	Hind foot length
EL	Ear length
CBL	Condylobasal length
FL	Facial length
PAL	Palatal length
ZYGB	Zygomatic breadth
RW	Rostrum width
IOC	Interorbital constriction
BCW	Braincase width
IBW	Interbulla width
RH	Height of rostrum
BCBH	Height of braincase with tympanic bulla
TBL	Tympanic bulla length
TBW	Tympanic bulla width

ML	Mandible length
M1.L	First upper molar length
M1.W	First upper molar width
M2.L	Second upper molar length
M2.W	Second upper molar width
M3.L	Third upper molar length
M3.W	Third upper molar width
M.1L	First lower molar length
M.1W	First lower molar width
M.2L	Second lower molar length
M.2W	Second lower molar width
M.3L	Third lower molar length
M.3W	Third lower molar width
MxTR	Maxillary tooth row length
MnTR	Mandibular tooth row length

References

Bellinvia E. 2004. A phylogenetic study of the genus *Apodemus* by sequencing the mitochondrial DNA control region. – *Journal of Zoological Systematics and Evolutionary Research*, **42**: 289-297.

Chelomina G.N., D.M. Atopkin, 2010. Molecular Genetic Evidence of a Deep Phylogenetic Discontinuity between the Asian and European Races of Pygmy Wood Mouse Based on the Mitochondrial Cytochrome b Gene Variation. – *Molecular Biology*, **44**: 699-708.

Çolak E., N. Yiğit, R. Çolak, M. Sözen, Ş. Özkurt, T. Kankiliç 2004. Taxonomic status and distribution of *Apodemus mystacinus* (Danford and Alston, 1877) (Mammalia: Rodentia) in Turkey. – *Turkish Journal of Zoology,* **28**: 285-294.

Çolak R., İ. Kandemir, E. Çolak, N. Yiğit 2007. Esterase variation in rocky mouse, *Apodemus mystacinus* (Danford& Alston, 1877) (Mammalia: Rodentia). – *Acta zoologica bulgarica*, **59**: 47-52.

Corbet G. B. 1978. The Mammals of the Palaearctic Region: a Taxonomic Review. British Museum (Natural History) and Cornell University Press, London and Ithaca., 314 pp.

Darvish J., E. Rastegar-Pouyani 2012. Biodiversity Conservation of Reptiles and Mammals in the Khorasan Provinces, Northeast of Iran. *Progress in Biological Sciences*, **2**: 95-109.

Darvish J., M. Javidkar, R. Siahsarvie 2006. New species of wood mouse of genus *Apodemus* (Rodentia: Muridae) from Iran. – *Zoology in the Middle East*, **38**: 5-16.

Darvish J., M. Javidkar, R. Siahsarvie, O. Mirshamsi 2006. New Records of the Hotson's Jerboa *Allactaga hotsoni*, Thomas, 1920 (Rodentia: Dipodidae) from Khorasan and Yazd Provinces, Iran. – *Journal of Science, Islamic Republic of Iran*.

Darvish J., S. Akbary Rad, R. Siahsarvieh, M.A. Hossein Pour Feizi, F. Ghorbani 2010. New record on pigmy field mouse (Muridae, Rodentia) from Northeast Iran. – *Hystrix*, *Italian Journal of Mammalogy*, **21**: 115-126.

Ellerman J. R. 1941. The families and genera of living rodents. Vol. II. Family Muridae. British Museum (Natural History), London., 690 pp.

Ellerman J. R., T. C.S. Morrison-Scott 1951. Checklist of Palaearctic and Indian mammals 1758 to 1946. Trustees of the British Museum (Natural History), London., 810 pp.

Ellerman J. R., T. C.S. Morrison-Scott 1966. Checklist of Palaearctic and Indian mammals 1758 to 1946. 2nd ed. British Museum (Natural History), London.

Etemad E. 1978. The Mammals of Iran. Volume 1. Rodents and Key to Their Classification. National Society for Protection

of Natural Resources and Human Environment, Teheran., 288 p. (In Farsi, with English summary).

Filippucci M. G., M. Macholan, J. R. Michaux 2002. Genetic variation and evolution in the genus *Apodemus* (Muridae,Rodentia). – *The Biological Journal of the Linnean Society*, **75**: 395-419.

Firouz E., 2008: A Guide to the Fauna of Iran (Vertebrates). Iran University Press, Tehran, 508 pp (in Farsi).

Ghorbani F., J. Darvish, H.G. Kami, O. Mirshamsi 2010. Rodent fauna of the western Golestan Province in northeast Iran. – *Iranian Journal of Animal Biosystematics,* **6**: 37-48.

Haidari M., M. Namiranian, L. Gahramani, M. Zobeiri, N. Shabanian 2013. Study of vertical and horizontal forest structure in Northern Zagros Forest (Case study: West of Iran, Oak forest). – *European Journal of Experimental Biology*, **3**: 268-278.

Javidkar M., J. Darvish, A. Riahi-Bakhtiari 2005. Discriminant analysis of dental and cranial characteristics in *Apodemus hyrcanicus* and *A. hermonensis* (Rodentia, Muridae) from Iran. – *Zoology in the Middle East*, **35**: 5-12.

Javidkar M., J. Darvish, A. Riahi Bakhtiari 2007. Morphological and morphometric analyses of dental and cranial characters in *Apodemus hyrcanicus* and *A. witherbyi* (Rodentia: Muridae) from Iran.-*Mammalia*: 56-62.

Karami M., R. Hutterer, P. Benda, R. Siahsarvie, B. Kryštufek 2008. Annotated check-list of the mammals of Iran. – *Lynx*, **39**: 63-201.

Kryštufek B., R. Hutt Erer 2006. The Ural field mouse *Apodemus uralensis* – a mammal species new to Iran. – *Zoology in the Middle East*, **38**: 111-112.

Kryštufek B., V. Vohralik 2005. Mammals of Turkey and Cyprus. Rodentia II: cricetinae, muridae, spalacidae, calomyscidae, capromyidae, hystricidae, castoridae. KnjižnicaAnnalesMajora, Koper, 292 p.

Mezhzherin S.V. 1997. Revision of mice genus *Apodemus* (Rodentia, Muridae) of Northern Eurasia. – *Vestnik Zoologii, Kiev*, **31**: 29-41 (in Russian, English summary).

Michaux J., E. Bellinvia, P. Lymberakis 2005. Taxonomy, evolutionary history and biogeography of the broad-toothed field mouse (*Apodemus mystacinus*) in the eastern Mediterranean area based on mitochondrial and nuclear genes. – *Biological Journal of the Linnean Society*, **85**: 53-63.

Michaux J., P. Chevret, M.G.Filippucci, M. Macholán 2002. Phylogeny of the genus *Apodemus* with a special emphasis on the subgenus *Sylvaemus* using the nuclear IRBP gene and two mitochondrial markers: Cytochrome b and 12S rRNA. – *Molecular Phylogenetics and Evolution*, **23**: 123-136.

Miller G. S. 1912. Catalogue of the mammals of Western Europe (Europe exclusive of Russia) in the collection of the British Museum. British Museum, London.

Misonne X. 1959. Analyse zoogeographique des mammiferes de l'Iran. – *Mémoiresd'Institut Royal des Sciences Naturelles de Belgique, deuxiemeserie*, **59**: 1-157.

Misonne X. 1969. African and Indo-Australian Muridae, Evolutionary trends. Institute Royal des Sciences Naturelles de Belgique, Bruxelles.

Mittermeier R. A., W. R. Turner, F. W. Larsen, T. M. Brooks, C. Gascon 2012. Global biodiversity conservation? the critical role of hotspots. Biodiversity hotspots distribution and protection of conservation priority areas (ed. by F.E. Zachos and J.C. Habel), pp. 3–22. Springer-Verlag Berlin, Heidelberg, Berlin.

Mohammadi Z., A. Mahmoudi, F. Ghorbani, J. Darvish, R. Siahsarvie 2014. A revision on Rodents of the Northwest Iran. *Iranian Journal of Animal Biosystematics.* In press.

Musser G. G., M. D. Carleton 2005.vol. II: Subfamily Murinae. (third ed.): – In: Wilson D. E., Reeder, D. M., Mammal species of the world, A taxonomic and geographic reference. The Johns Hopkins University Press, Baltimore., 1247-1252.

Musser G. G., M. D. Carleton 1993. Family Muridae. *in*: Mammal species of the world, a taxonomic and geographic reference, Second ed. (D. E. Wilson and D. M. Reeder, eds.). Pp. 501-755. Smithsonian Institution Press, Washington D.C., xviii + 1206 p.

Niethammer J. 1978. *Apodemus mystacinus* (Danford and Alston, 1877) – Felsenmaus. In: Niethammer, J., Krapp F. (eds.) Handbuch der Säugetiere Europas. Bd. 1, Nagetiere I. (Sciuridae, Castoridae, Gliridae, Muridae). Akad. Verlagsgesellschaft, Wiesbaden, 306-324.

Noroozi J., H. Akhani, S. W. Breckle 2008.Biodiversity and phytogeography of the alpine flora of Iran. – *Biodiversity and Conservation*, **17**: 493-521.

Pavlinov I.Ya., E. L.Yakhontov, A. K. Agadzhanyan1995. [Mammals of Eurasia. I. Rodentia. Taxonomic and geographic guide.]Archives of the Zoological Museum, Moscow State University, **32**: 289 p. (In Russian).

Rechinger K. H., W. Lack 1991. Dipsacaceae.In K. H. Rechinger (ed.): Flora Iranica 168. Graz: AkademischeDruck-u.-Verlagsanstalt.

Shahabi S., J. Darvish, M. Aliabadian, O. Mirshamsi, Z. Mohammadi 2011. Cranial and dental analysis of mouse-like hamsters of the genus *Calomyscus* (Rodentia: Calomyscidae) from plateau of Iran. – *Hystrix, the Italian Journal of Mammalogy*, **22**: 311-323.

Shidlovskii M.V. 1953. Maloaziiskaya gornaya mysh' (*Silvimus mystacinus* Danf. et Alst.) v rodentofaune Gruzii (Rodentia, Muridae) (Asia Minor *Silvimus mystacinus* Danf. et Alst. in Georgian Rodent Fauna (Rodentia, Muridae)). – *Trudy Instituta Zoologii Akademiia Nauk Gruzinskoi SSR*, **11**:135-168.

Spitzenberger F. 1973. In: Felten. H., Spitzenberger. F. Storch. G., eds.ZurKleinsaugerfauna West-Anatatoliens. Teil II. – *Senckenbergiana biologica*, **54**: 227-290.

Suzuki H., M. G. Filippucci, G.N. Chelomina, J. J. Sato, K. Serizawa, E. Nevo 2008. A biogeographic view of *Apodemus* in Asia and Europe inferred from nuclear and mitochondrial gene sequences. – *Biochemical Genetics***, 46**: 329-346.

Van Zeist W., S. Bottema 1977. Palynological investigations in western Iran. – *Palaeohistoria*, **19**: 19-85.

Vereshchagin N.K. 1959. The Mammals of the Caucasus – A History of the Evolution of the Fauna (translated from Russian). Published for the Smithsonian Institution, U.S.A and the National Science Foundation, Washington, D.C by the Israel Program for Scientific Translator, 816 p.

Vohralik V., D. Frynta, P. Mikulova, P. Benda, P. Nova 2002. Multivariate morphometrics of *Apodemus mystacinus* in the Near east and its divergence from European *A. m. epimelas* (Mammalia: Rodentia). *Israel Journal of Zoology*, **48**: 135-148.

Vorontsov N. N., G. G. Boyeskorov, S. V. Mezhzherin, E. A. Lyapunova, A. S. Kandaurov 1992. [Systematics of the Caucasian wood mice of the subgenus *Sylvaemus* (Mammalia, Rodentia, *Apodemus*).] *Zoologicheskii Zhurnal*, **71**:119-131. (In Russian with English summary).

Wasylikowa K., W. Van Zeist, H.E. Jr. Wright, L. Stevens, , A. Witkowski, A. Walanus, A. Hutorowicz, S.W. Alexandrowicz, J. J. Langer 2008. The Lake Zeribarpalaeoecology: a synthesis. – In: Wasylikowa, K., A. Witkowski (eds.): The 192 palaeoecology of Lake Zeribar and surrounding areas, Western Iran, during the last 48,000 years. Diatom Monographs 8, A.R.G. GantnerVerlag K.G., Ruggel, 303-321.

Received: 09.04.2014
Accepted: 27.06.2014