



Spatial Variation in the Diet of the Barn Owl *Tyto alba* in Iran

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Abstract

We studied spatial variation in the diet of the Barn Owl *Tyto alba*. Pellets regurgitated by Barn Owls were collected from 20 sites mostly in southern Iran from 1996 to 2011. Pellet investigation yielded remains of 2,253 prey items representing 97 different species belonging to 53 bird species, 34 mammals, three reptiles, one fish and some classes of arthropods. Mammals comprised 1,741 prey items (77.3%), while birds comprised 452 (20.1%). The predominant species were mice (*Mus* sp.) (696; 30.9%), Indian Gerbil *Tatera indica* (246; 10.9%), Social Vole *Microtus socialis* (214; 9.5%) and House Sparrow *Passer domesticus* (198; 8.8%). Most prey items were found in Chahak (Genaveh) (383), Choqa-Zanbil (323) and Bisotun (280). Caspian Shrew *Crocidura suaveolens caspica* was dominant in Gilan Province, *Microtus socialis irani* was common in Kermanshah and Fars Provinces, *Mus* sp. dominated in Khuzestan Province, and Indian Gerbil and Baluchistan Gerbil *Gerbilus nanus* occurred mainly near the Persian Gulf and Gulf of Oman and in Baluchestan and Kerman provinces, while the Barn Owl preyed mainly on waders in the mangrove forests of Qeshm Island. Analysis of the data using a modified Marked Differences from the Mean method (MDFM) showed remarkable differences in 26 prey taxa identified by species or genus. According to the MDFM method, the four species of prey with the highest scores (+3) were: Black Rat *Rattus rattus* on Kish Island, Caspian Shrew in Anzali, Baluchistan Gerbil in Tiss and Indian Gerbil in Tujak. The occurrence, prey number and biomass of prey species demonstrate great variation in the diet of the Barn Owl in Iran.

1. Introduction

The Barn Owl *Tyto alba* is a nearly cosmopolitan bird species, distributed around the world. Food remains are a good source of information about the species composition of the diet in a particular area. Such information is essential for research and conservation purposes (Tores & Yom-Tov 2003). Food resources are one of the limiting factors influencing the distribution of a species, depending on its

feeding strategy (Schoener 1971). The Barn Owl predaes on a wide variety of prey species and can be considered as both an opportunistic (Taylor 1994) and a selective predator (Tores *et al.* 2005). Although Barn Owls select one prey species at a particular time, they also exhibit an opportunistic feature (Tores *et al.* 2005). There is an enormous literature on the diet of the Barn Owl in the Western Palearctic, based almost wholly on pellet examination (Cramp & Simmons 1988).

The objectives of some of these publications

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were to report on the diversity or distribution of prey species (Darvish 1991, Cramp & Simmons 1988). Published studies provide an overview of the diet of the Barn Owl, including the types of prey taken (Taylor 1994, Bruce 1999, Cramp & Simmons 1988), size of prey (Dickman *et al.* 1991, Ille 1991, Marti *et al.* 1993), prey biomass (Flikweert *et al.* 2007, Figuero *et al.* 2009), effect of season on diet (Campbell *et al.* 1987, Mahmood-ul-Hassan *et al.* 2000, 2007a), effect of landscape on diet (Burel *et al.* 1998, Lawler & Edwards 2002, Bond *et al.* 2004, Bontzorlos *et al.* 2005) and the influence of climate on diet (Avery 1999, Jaksic & Lazo 1999). Various statistical methods have been used to analyze the diet of the Barn Owl including Marked Differences from the Mean (MDFM). The MDFM was introduced to find marked differences in contingency tables with unexpected frequency of prey items among several specific locations (Obuch 2001a). This method has previously been used for the Barn Owl (Obuch 2001a, Obuch & Benda 2009) and Little Owl *Athene noctua* (Obuch & Kristin 2004).

Numerous studies relating to the diet of owls have been published around the world during the last few decades. However, in Western Asia and the Middle East, there have been rather few studies. These have included studies of the Barn Owl in Pakistan (Mushtaq-ul-Hassan *et al.* 2004, Mahmood-ul-Hassan *et al.* 2007a, b), Iraq (Nader 1968), Jordan (Rifai *et al.* 1998), Turkey (Hoppe 1986, Kasperek 1986), Syria (Shehab 2005, Shehab & Charabi 2006, Shehab *et al.* 2006), Palestine (Dor 1947) and Israel (Yom-Tov & Wool 1997, Rekasi & Hovel 1997, Tores & Yom-Tov 2003, Tores *et al.* 2005, Charter *et al.* 2009). The only one of these to include a comparative diet analysis was that of Obuch & Benda (2009), who compared the diet of the Barn Owl in eight different regions in the Eastern Mediterranean, including Israel, Syria, Lebanon and Turkey.

The Barn Owl has recently been found to occur widely across Iran (Osaei *et al.* 2007). This paper reveals new knowledge on the diet of the Barn Owl in Iran, and gives information on the diversity of prey species and geographical variation in the diet of the species across the country.

2. Materials and Methods

2.1. Characteristics of Barn Owl Pellets

The characteristics of Barn Owl pellets are different from those of other Iranian owls. They have a markedly oval shape which distinguishes them from the pellets of other owls. Barn Owl pellets are wider and have a harder and usually darker surface. Skulls are generally well-preserved in the pellets, usually with the mandibles still attached to the skull. The pellets are most likely to be found inside abandoned buildings, in caves and under rock overhangs, but they are also commonly found under trees. Barn Owl pellets are similar in size to those of the Long-eared Owl *Asio otus* and Tawny Owl *Strix aluco*.

The pellets from Long-eared Owls are characteristically cylindrical in shape. They are usually narrower than those of the Barn Owl and without an outer solid surface, while hair and feathers are usually well-preserved and keep their original color. These pellets also usually provide well-preserved skulls with the mandibles still attached. Long-eared Owl pellets are typically found under trees, and can occur in large numbers when over-wintering flocks are present.

The pellets from Tawny Owls usually have a shape similar to those of Long-eared Owls. Hair is usually grey in color and partially absorbed. Bones are usually more crushed, with mandibles separated from the skull and spread throughout the pellet. Places of occurrence include forested areas, under rocky overhangs and in caves, and more seldom in buildings and under trees in city parks.

2.2. Study sites (Fig. 1)

(1) Anzali, Gilan Province: 37°32'36" N, 49°14'59" E. Visited on 22–24 August 2007. About 25 pellets regurgitated by a breeding pair of Barn Owls were collected near Ali-Abad village in the district of Kapour-Chal. The pellets were found at six sites scattered around the barn where the owls were nesting.

(2) Bisotun, Kermanshah Province: 34°23'N, 47°26'E; 1,400 m asl. Visited on 7 October 1998 and in November 2002. Some old pellets were found 15 m inside a tunnel in a rock about 20 m above ground. Some fresh pellets of the Eurasian Eagle Owl *Bubo bubo* were also found near the entrance to the tunnel. No pellets were

found in the tunnel in November 2002, but a layer of bat dung was present.

(3) Haft-Tappeh, Dezful, Khuzestan Province: 32°11'N, 48°21'E. Visited on 18 October 2002 and again in autumn 2007 and early winter 2008. Pellets were found under palm trees near the archeological site.

(4) Choqa-Zanbil, Shushtar, Khuzestan Province: 32°01'N, 48°32'E, 50 m asl. Visited on 18 October 2002. A large number of pellets were collected under a rocky overhang about 1 km from the archeological site.

(5) Shushtar, Khuzestan Province: 32°03'N, 48°51'E, 150 m asl. Visited on 11 October 1998. Pellets were collected under rocky overhangs above the river.

(6) Simili, Masjed Soleyman, Khuzestan Province: 31°42'N, 49°24'E, 360 m asl. Visited on 12 October 1998. Pellets were found in the rocky walls close to the river Abe Shur.

(7) Chahak, Bandar Genaveh, Bushehr Province: 29°39'N, 50°27'E, 10 m asl. Visited on 4 May 1996, 14 October 1998, and 15 October 2002. Most of the pellets were found inside a cave situated in a rock tower near Chahak village and about 5 km from the sea shore.

(8) Kushkak, Fars Province: 30°05'N, 52°32'E, 1650 m asl. Collected by M. Uhrin on 5 October 2011.

(9) Sivand cave 1, Marvdasht, Fars Province (Figs. 2a, b): 30°04'N, 53° 01' E; 1,800 m asl. Visited on 13 October 2002. Pellets were found inside a cave in the rocky canyon between Sivand and Saadat-Shahr.

(9) Sivand cave 2, between Sivand and Rahmat-Abad, Fars Province (Fig. 2c): 15 km southwest of Saadat-Shahr, 29°55'78" N, 52°52'85" E; 1,812 m. Visited on 2 June 2009 and again on 12 June 2010. A batch of 25 pellets was collected during the first visit and a large batch during the second one.

(10) Persepolis, Marvdasht, Fars Province: 29°55'78" N, 52°52'85" E; 1,620 m asl. Visited on 13 October 2002. Pellets were collected under pine trees in the wood nearby the

archeological site.

(11) Atash-Kadeh, Firuz-Abad, Fars Province: 28°53'60"N, 52°32'08"E; 1,366 m asl. Visited on 20 April 2000, 2 June 2009, and 11 June 2010. Pellets were found inside the old mosque in Ardeshir village.

(12) Kish Island, Hormozgan Province: 26°30'02"N, 53°57'21"E, 1 m asl. Visited on 10 June 2010. A large batch of pellets, the largest found during 2009–2010, was collected from an abandoned hospital building.

(13) Qeshm, Hormozgan Province: 26°54'N, 55°45'E, 10 m asl. Visited on 17 April 2000. Pellets were found in the stone walls above the bay with mangrove trees near Laft village on Qeshm Island.

(14) Tujak, Minab, Hormozgan Province: 26°04'N, 57°18'E, 20 m asl. Visited on 15 April 2000. Pellets were collected in stone walls.

(15) Espakeh, Iran-Shahr, Sistan and Baluchestan Province: 26°48'N, 60°10'E, 700 m asl. Visited on 10 April 2000. Pellets were collected under trees in a village garden and in the surrounding rocks.

(16) Bampur, Iran-Shahr, Sistan and Baluchestan Province: 27°13'N, 60°23'E. Visited on 9 April 2000 and 18 February 2010. Pellets were found under the outer walls of the castle.

(17) Nok-e Gonab, Iran-Shahr, Sistan and Baluchestan Province: 27°29'N, 60°22'E, 700 m asl. Visited on 9 April 2000. Pellets were collected inside an abandoned guard tower near the road ~ 30 km north of the town.

(18) Tiss, Chahbahar, Sistan and Baluchestan Province: 25°22'N, 60°36'E, 10 m asl. Visited on 13 April 2000. Pellets were found by natural rocky cliffs close to the sea coast.

Small samples:

(19) Pasargad, Fars Province: 30°14'N, 53°01'E. Visited on 13 October 2002. Pellets were found near the archeological site.

(20) Manujan, Kerman Province: 27°24'N, 57°30'E, 350 m asl. Visited on 16 April 2000. Pellets were found in the old castle.

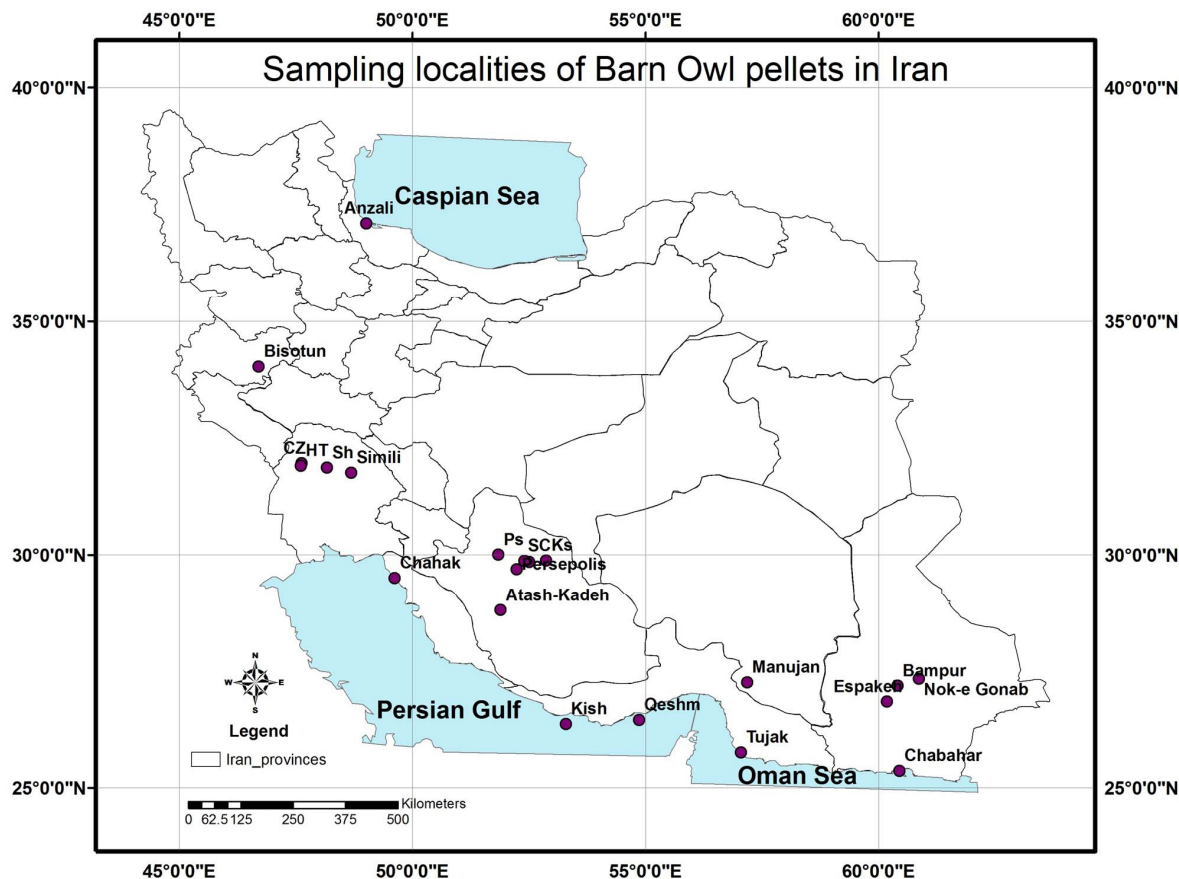


Fig. 1. Map of Iran showing sampling localities of Barn Owl pellets. Key to symbols: CZ= Choqa-Zanbil, HT=Haft-Tappeh, Ks= Kushkak, Ps= Pasargad, Sh= Shushtar, SC= Sivand caves.



Fig. 2. a) Canyon between Sivand and Saadat-Abad, b) the cave in the canyon, and c) the cave between Sivand and Rahmat-Abad.

2.3. Pellet analysis and prey identification

Pellets regurgitated by Barn Owls were collected from 18 localities in Iran during May 1996, October 1998, April 2000, October 2002, August 2007, autumn 2007, early winter 2008, June 2009, February and June 2010 and October 2011. Each pellet was soaked in 95% alcohol and then teased apart using a pair of forceps and a needle. The bones and skulls from each pellet were placed in separate containers. Specimens from 1996 to 2002 are kept in Comenius University in Bratislava, Slovakia and from 2007 to 2010 in the Iranian Research Institute of Plant Protection. The samples were treated in 5% NaOH to decompose hair and feathers.

The identification of prey was performed using the following bones and structures: skulls of mammals and reptiles, bill, humerus, metacarpus and tarso-metatarsus of birds, and heads of invertebrates. The identification of bones was carried out by comparison with skeletons in the collections at the Detached Unit of the Comenius University in Blatnica, Slovakia, and also based on information in Lay (1967), Etemad (1977), Harrison & Bates (1991), Gromov & Erbajeva (1995), Porter *et al.* (1996), Morowati *et al.* (2005), and Ziaie (2008).

2.4. Dietary diversity and prey biomass

The number of prey items and frequency of prey species were calculated for all sites. To estimate the biomass of each prey species represented in the pellets, we used Ziaie (2008) for mammalian prey, Perrins (1998) for avian prey, and various scientific references for other vertebrate and invertebrate prey. The biomass contribution of each species to the diet was calculated as the percent biomass; multiplying the number of individuals in the pellets by the estimated average body mass of each prey species divided by the total sum of biomass.

2.5. MDFM method

The quantitative analysis of the samples was performed using the Marked Differences from the Mean method (MDFM) (Obuch 2001a). By using this method, sites at which the diet of the Barn Owl is markedly different from its diet at other sites, and prey items that occur at some sites in markedly different proportions from their occurrence at most other sites will be

indicated. The taxa and samples were ranked based on the similarity of the (+) values of MDFM. It is based on looking for so-called diagnostic elements with plus (+) and minus (-) marked differences. The values of positive (+) and negative (-) MDFM are given together with values of absolute abundance (Table 2).

In this method, we first calculate theoretical values of each prey species using $a'_{ij} = [n_j \times m_j] / \Sigma n_j$ where n_j is the summation of total prey items of one particular species in all study sites, m_j the summation of all prey items of all species in a specific study area, and Σn_j the summation of all prey items in all study areas. To find positive values of real values (number of each particular prey species in a specific study area) from the theoretical values, we use the following formula: $S_{ij} = a'_{ij} \geq 1.2a'_{ij} + 4$ indicates one plus sign (1+), $S_{ij} \geq 2.4a'_{ij} + 8$ indicates two plus signs (2+), and $S_{ij} \geq 4.8a'_{ij} + 16$ indicates three plus signs (3+). Therefore, the difference of each cell from the theoretical mean will be indicated with plus signs and values 1+, 2+, 3+ indicate the degree of marked differences (Obuch 2001a). These will also apply similarly for minus signs (-).

In the arrangement of data (Table 2), the contents of columns which had similar prey species and were located geographically close to each other were combined. Prey species that occurred only in one column were then removed from this table. Prey species that occurred in more than one column were separated into two sections; the first part, prey species having at least one plus sign, and the second part, prey species with no plus sign (Table 2). For further information see Obuch (2001a). Biodiversity Index (H') was also calculated for each column (Table 2).

3. Results

3.1. Prey composition

A total of 2,253 prey items, representing 97 different species (predominantly 53 species of birds and 34 species of mammals), were found in the pellets of Barn Owls collected mostly in southern Iran. Mammalian species comprised 6 insectivores, 6 bats, 1 hare and 21 rodents. Other taxa consisted of 3 reptiles, 1 fish and 6 unidentified species of arthropods (4 insects, 1 solifuged and 1 scorpion). Mammals comprised

1,741 prey items (77.3%), while birds comprised 452 prey items (20.1%). Rodents were the main group in the diet (1,565 prey items, 69.5%). Sites with the largest number of prey items were Chahak (Genaveh) (383), Chogh-Zanbil (323), and Bisotun (280) (Table 1).

3.2. Main prey species

The predominant prey species were mice *Mus* sp. (696, 30.9% of prey items), Indian Gerbil *Tatera indica* (246, 10.9% of prey items), Social Vole *Microtus socialis irani* (214, 9.5% of prey items) and House Sparrow *Passer domesticus* (198, 8.8% of prey items) (Table 1). *Mus* sp. was the predominant prey species in Haft-Tappeh and Choqa-Zanbil; Social Vole in Sivand and Bisotun; and Indian Gerbil in Chahak (Genaveh) and Tujak. The Eurasian Water Vole *Arvicola amphibius* is a large rodent, which appeared as a rare food item in the pellets collected from Bisotun and Anzali. The House Sparrow was recovered from most of the localities, but it was important food only in Chahak (38.9%) and Kish (36.4%). The

Crested Lark *Galerida cristata* constituted 70% of the owl's diet in Chahak.

3.3. Marked prey

The MDFM method identified 26 taxa (21 identified to species) as differing markedly in their occurrence in the diet of the Barn Owl at different sites in Iran (Table 2). The species showing the greatest differences between sites (prey species with 3+) were Black Rat *Rattus rattus* on Kish Island, Caspian Shrew *Crocidura saveolens caspica* in Anzali, Baluchistan Gerbil *Gerbilus nanus* in Tiss, and Indian Gerbil in Tujak (Table 2). According to this method, mammals were markedly different only in Choqa-Zanbil; birds in Chahak, Kish and Qeshm; and other vertebrates in southeast Iran. No marked differences were observed among invertebrates (Table 2). The highest Biodiversity Index (H') was observed for Chahak (2.53) followed by Bisotun (2.45) and Bampur, Manujan, Espakeh and Nok-e Gonab (2.31) (Table 2).

Table 1. Prey composition of the Barn Owl *Tyto alba* based on pellets collected from 18 sites in Iran. **Key to site numbers:** 1- Anzali, 22. – 24.8.2007, 2- Bisotun, 7.10.1998, 3- Haft-Tappeh, 18.10.2002, 2007, 2008, 4- Choqa-Zanbil, 18.10.2002, 5- Shushtar, 11.10.1998, 6- Simili, 12.10.1998, 7- Chahak, Bandar-e Genaveh, 4.5.1996, 14.10.1998, 15.10.2002, 8- Kushkak, 5.10.2011, 9- Sivand, 13.10.2002, 2.6.2009, 12.6.2010, 10- Persepolis, 13.10.2002, 11- Atash-Kadeh, Firuz-Abad, 20.4.2000, 2.6.2009, 11.6.2010, 12- Kish, 10.6.2010, 13- Qeshm, Laft, 17.4.2000, 14- Tujak, 15.4.2000, 15- Espakeh, 10.4.2000, 16- Bampur, 9.4.2000, 18.2.2010, 17- Nok-e Gonab, 9.4.2000, 18- Tiss, 13.4.2000, 19- Pasargad, 13.10.2002, 20- Manujan.

Species \ Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Prey item(%)
<i>Paraechinus aethiopicus</i>													1								1	0.04
<i>Paraechinus hypomelas</i>							6														6	0.27
<i>Suncus etruscus</i>		1	3	7		3	4	2	11		2			2							35	1.55
<i>Crocidura leucodon</i>			3	4																	7	0.31
<i>Crocidura suaveolens</i>	2	30	3	9				4	4	1				8				1			62	2.75
<i>Crocidura s. caspica</i>	42																				42	1.86
<i>Crocidura</i> sp.														1							1	0.04
<i>Aselia tridens</i>				2																	2	0.09
<i>Myotis blythii</i>		3																			3	0.13
<i>Pipistrellus pipistrellus</i>	1																				1	0.04
<i>Pipistrellus kuhlii</i>	3	1	7																		11	0.49
<i>Otonycteris hemprichi</i>							1														1	0.04
<i>Taphozous nudiventris</i>				1			2														3	0.13
<i>Lepus capensis</i>							1														1	0.04
<i>Dryomys nitedula</i>		1																			1	0.04
<i>Myomimus</i> sp.		14																			14	0.62

Species \ Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Prey item(%)
<i>Jaculus jaculus</i>				2			9														11	0.49
<i>Mus sp.</i>	11	64	147	282	6	39	19	3	85	3	12	18		2	1	1		1	2		696	30.89
<i>Acomys dimidiatus</i>														2				2			4	0.18
<i>Rattus norvegicus</i>													2								2	0.09
<i>Rattus rattus</i>												70	1	2							73	3.24
<i>Nesokia indica</i>			2	2	4	3	1							5	1			1			19	0.84
<i>Cricetulus migratorius</i>		30						4	27	5	10										76	3.37
<i>Calomyscus bailwardi</i>		2							1												3	0.13
<i>Gerbillus nanus</i>							11						1	5	5	6	14	31		1	74	3.28
<i>Gerbillus mesopotamiae</i>			1	2																	3	0.13
<i>Meriones tristrami</i>		13																			13	0.58
<i>Meriones libycus</i>					7		4														11	0.49
<i>Meriones crassus</i>			2		12	15		1							2	2	4				38	1.69
<i>Meriones sp.</i>			2																		2	0.09
<i>Meriones persicus</i>								1	3							1			1		6	0.27
<i>Tatera indica</i>			1	2			123				1			97	1	1		18		2	246	10.92
<i>Ellobius lutescens</i>		12																			12	0.53
<i>Arvicola amphibius</i>	4	3																			7	0.31
<i>Microtus socialis irani</i>		57			1		38		14												214	9.50
<i>Chionomys nivalis</i>		18																			18	0.80
Rodentia sp.			7					8		2	4					1					22	0.98
Mammalia	63	249	176	315	10	65	192	56	244	23	27	92	5	124	10	12	18	54	3	3	1741	77.27
<i>Falco tinnunculus</i>							1														1	0.04
<i>Falco subbuteo</i>							1														1	0.04
<i>Alectoris chukar</i>							3														3	0.13
<i>Ammoperdix griseogularis</i>					1									1	1						3	0.13
<i>Coturnix coturnix</i>					3		1														4	0.18
<i>Francolinus francolinus</i>							1														1	0.04
<i>Rallus aquaticus</i>							1														1	0.04
<i>Porzana porzana</i>					1					1											2	0.09
<i>Porzana pusilla</i>					1																1	0.04
<i>Calidris sp.</i>													5								5	0.22
<i>Tringa sp.</i>													9								9	0.40
<i>Xenus cinereus</i>													8								8	0.36
<i>Actitis hypoleucos</i>							1						10								11	0.49
<i>Larus sp.</i>													1								1	0.04
<i>Columba livia</i>							1								2						3	0.13
<i>Columba oenas</i>							3														3	0.13
<i>Streptopelia turtur</i>							2														2	0.09
<i>Streptopelia senegalensis</i>			4				1		1			3			1	1				1	13	0.58
<i>Otus scops</i>							3														3	0.13
<i>Otus brucei</i>							1							1							2	0.09
<i>Athene noctua</i>					1		1														2	0.09
<i>Apus apus</i>				1																	1	0.04
<i>Merops apiaster</i>							2														2	0.09
<i>Merops orientalis</i>							2														2	0.09

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Species \ Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Prey item(%)	
<i>Coracias bengalensis</i>							2														2	0.09	
<i>Alauda arvensis</i>							3		1												4	0.18	
<i>Galerida cristata</i>		1	1		4	11	42			1											60	2.66	
Alaudidae sp.		1			1	1	2		1												6	0.27	
<i>Delichon urbica</i>		2																			2	0.09	
<i>Riparia riparia</i>		1	1																		2	0.09	
<i>Ptyonoprogne rupestris</i>		2																			2	0.09	
<i>Pycnonotus leucotis</i>							2					3									1	6	0.27
<i>Lanius senator</i>							2														2	0.09	
<i>Lanius collurio</i>							1														1	0.04	
<i>Hippolais pallida</i>									1												1	0.04	
<i>Phylloscopus sp.</i>												4									4	0.18	
Sylviidae sp.							3		3			6									12	0.53	
<i>Muscicapa striata</i>												4									4	0.18	
<i>Monticola sp.</i>							1														1	0.04	
<i>Oenanthe sp.</i>						1															1	0.04	
<i>Sitta tephronata</i>							1														1	0.04	
<i>Sitta neumayer</i>		1																			1	0.04	
<i>Nectarinia asiatica</i>														2							2	0.09	
Nectariniidae sp.				1																	1	0.04	
<i>Troglodytes troglodytes</i>							1														1	0.04	
<i>Emberiza calandra</i>			3			1															4	0.18	
<i>Emberiza sp.</i>														4							4	0.18	
<i>Carduelis cannabina</i>							4														4	0.18	
<i>Rhodospiza obsoleta</i>							3														3	0.13	
<i>Passer domesticus</i>		2	3	1	6		77	2	23	3		72	3	1	2	1					2	198	8.79
<i>Passer hispaniolensis</i>							1														1	0.04	
<i>Passer montanus</i>							1														1	0.04	
<i>Petronia petronia</i>			2																		2	0.09	
<i>Petronia xanthocollis</i>						1										1					2	0.09	
<i>Sturnus vulgaris</i>	1	1		1	3		1														7	0.31	
Passeriformes sp.		2	2	1	5	1	8										1	2			22	0.98	
Aves sp.juv.									4					1							5	0.22	
Aves	1	18	12	4	21	21	180	2	34	4	1	92	36	10	6	3	1	2	2	0	4	452	20.06
Lacertidae sp.					1							1		2				2	2			8	0.36
Agamidae sp.		1				1	4											3				9	0.40
Sauria sp.		1																				1	0.04
Cypriniformes sp.		2																				2	0.09
Amphibia, Reptilia, Pisces	0	4	0	0	1	1	4	0	0	0	0	1	0	2	0	0	5	2	0	0	0	20	0.89
Hymenoptera sp.												1				1						2	0.09
Coleoptera sp.		9	2			1	4							2		1		1				20	0.89
<i>Gryllotalpa sp.</i>				1			1		1						1							4	0.18
Orthoptera sp.				1								2						1				4	0.18
Solifugida sp.				1										1	1		1	1				5	0.22
Scorpionida sp.				1		2	2															5	0.22
Evertebrata	0	9	2	4	0	3	7	0	1	0	0	3	0	3	2	2	1	3	0	0	0	40	1.78
Total	64	280	190	323	32	90	383	58	279	27	28	188	41	139	18	17	25	61	3	7	2253	100.00	

Table 2. The marked differences in the samples of Barn Owl diet in Iran. **Key to site numbers:** 1- Anzali, 2007, 2- Bisotun, 1998, 3- Atash-Kadeh, 2000, 2009, 2010, Persepolis, 2002, Kushkak, 2011, Pasargad, 2002, 4- Sivand, 2 caves, 2002, 2009, 2010, 5- Shushtar, 1998, Haft-Tappeh, 2002, 2007, 2008, Simili, 1998, 6- Choqa-Zanbil, 2002, 7- Chahak, 1996, 1998, 2002, 8- Tujak, 2000, 9- Tiss, 2000, 10- Bampur, 2000, 2010, Manujan, 2000, Espakeh, 2000, Nok-e Gonab, 2000, 11- Kish, 2010, 12- Qeshm, 2000.

Species \ Site	1	2	3	4	6	5	7	8	9	10	11	12	Total	%		
<i>Crocidura s. caspica</i>	3+ 42	1-	0	1-	0 1-	0 1-	0						42	1.86		
<i>Crocidura suaveolens</i>	2+	30	5	4	9 1-	3 2-	0	8	1	1-	0		62	2.75		
<i>Myomimus sp.</i>	2+	14											14	0.62		
<i>Meriones tristrami</i>	2+	13											13	0.58		
<i>Ellobius lutescens</i>	2+	12											12	0.53		
<i>Chionomys nivalis</i>	2+	18											18	0.80		
Coleoptera sp.	1+	9				3	4	2	1	1			20	0.89		
<i>Cricetulus migratorius</i>	1+	30 2+	19 1+	27	2-	0 2-	0 2-	0 1-	0		1-	0	76	3.37		
<i>Microtus socialis irani</i>	1-	0 1+	57 2+	52 2+	104	3-	0 3-	1 4-	0 2-	0 1-	0 1-	0 3-	0	214	9.50	
<i>Suncus etruscus</i>			1	4 1+	11	7	6	4	2					35	1.55	
<i>Mus sp.</i>	1-	11 1-	64 1-	20	85	2+ 282	1+ 192	3-	19 3-	2 2-	1 2-	2 2-	18 2-	0	696	30.89
<i>Pipistrellus kuhlii</i>	3	1				2 1+	7							11	0.49	
<i>Nesokia indica</i>						2 1+	9	1	5	1	1			19	0.84	
<i>Meriones libycus</i>			4			1+	7							11	0.49	
<i>Meriones crassus</i>	1-	0		1		2 1+	12 1+	15		1+ 8				38	1.69	
<i>Galerida cristata</i>	1-	1	1 1-	0 2-	0	1+	16 2+	42			1-	0		60	2.66	
<i>Paraechinus hypomelas</i>							1+	6						6	0.27	
<i>Jaculus jaculus</i>						2	1+	9						11	0.49	
<i>Tatera indica</i>	1-	0 3-	0 2-	1 3-	0 3-	2 3-	1 2+	123 3+	97 1+	18	4 3-	0 1-	0	246	10.92	
<i>Gerbillus nanus</i>		2-	0	2-	0 2-	0 2-	0	11	5 3+	31 2+	26	1-	0	1	74	3.28
<i>Rattus rattus</i>	2-	0	2-	0 2-	0 2-	0 2-	0	2-	2		3+ 70			1	73	3.24
<i>Passer domesticus</i>	1-	0 2-	2 1-	5	23 3-	1 1-	9 1+	77	2-	1 1-	0	5 2+	72	3	198	8.79
<i>Actitis hypoleucos</i>								1				2+ 10		11	0.49	
<i>Tringa sp.</i>												2+ 9		9	0.40	
<i>Xenus cinereus</i>												1+ 8		8	0.36	
<i>Calidris sp.</i>												1+ 5		5	0.22	
<i>Streptopelia senegalensis</i>				1		4	1			3	3			12	0.53	
Agamidae sp.		1				1	4			3				9	0.40	
Lacertidae sp.						1		2	2	2	1			8	0.36	
<i>Crocidura leucodon</i>					4	3								7	0.31	
<i>Arvicola amphibius</i>	4	3												7	0.31	
<i>Sturnus vulgaris</i>	1	1			1	3	1							7	0.31	
<i>Meriones persicus</i>			2	3						1				6	0.27	
<i>Pycnonotus leucogenys</i>							2			1	3			6	0.27	
Solifugida sp.					1			1	1	2				5	0.22	
Scorpionida sp.					1	2	2							5	0.22	
Mammalia	63	249	109	244	1+ 315	251	1-	124	54	43	1-	92	2-	5	1741	77.27
Aves	2-	1 2-	18 1-	7 1-	34 3-	4	54 1+	180 1-	10 1-	2	14 1+	92 2+	36	452	20.06	
Amphibia, Reptilia, Pisces	0	4	0	0	0	0	2	4	2	2 1+	5	1	0	20	0.89	
Evertebrata	0	9	0	1	4	5	7	3	3	5	3	0	40	1.78		
Total	64	280	116	279	323	312	383	139	61	67	188	41	2253	100.00		
Biodiversity Index H'	1.13	2.45	1.73	1.75	0.71	1.84	2.53	1.40	1.44	2.31	1.55	1.95	2.90			

3.4. Geographic variation of prey within Iran

Samples of pellets from Kish Island in the Persian Gulf were characterized by the dominant occurrence of Black Rat, while the dominant species in samples from Anzali in the south Caspian region was Caspian Shrew (see Dubey *et al.* 2007). A large collection from rocks near Bisotun in Kermanshah Province is significant because of the number of species that do not occur in the other material. These included Tristram's Jird *Meriones tristrami*, European Snow Vole *Chinomys nivalis*, Transcaucasian Mole-vole *Elobius lutescens*, and an undescribed species of dormouse *Myomimus* sp. (Obuch 2001b). The rodents Social Vole and Grey Dwarf Hamster *Cricetulus migratorius* are common in humid parts of the Zagros Mountains, and dominated in samples of pellets from Fars Province (Bisotun, Kushkak and Sivand). A big collection of samples from Chahak (Bandar-e Genaveh) near the Persian Gulf was characterized by the largest species diversity and a high abundance of birds, particularly House Sparrow and Crested Lark (Table 1). The Indian Gerbil was present in significant numbers in samples originating from the coast of the Gulf of Oman (Chahak and Tujak). Samples from the dry and hot province of Baluchestan were dominated by the Baluchistan Gerbil. The genus *Mus* was the most abundant prey item in Khuzestan Province (the taxonomy of this genus is still not well resolved in Iran). Samples from Qeshm Island in the Persian Gulf were unique because of the dominance of waders, Family Scolopacidae (Table 1).

4. Discussion

4.1. Distribution of prey

The occurrence of the poorly known Caspian Shrew in Barn Owl pellets from Kapour-Chal, the Mouse-tailed Dormouse *Myomimus* sp. in pellets from Bisotun and Indian Gerbil in pellets from Chahak, Chabahar and Tujak was of considerable interest. The Caspian Shrew has a small global range, and the discovery of the bone and skull remains (Fig. 3) of 42 specimens in a total 63 prey items could give us valuable information on population levels, predation risk and conservation issues for this species which is categorised as Data Deficient (DD) in the IUCN Red List (Kryštufek & Tsytulina 2008). Some

prey species were found in only one or two sites, e.g. Mesopotamian Gerbil *Gerbilus mesopotamiae* at Haft-Tappeh and Choqa-Zanbil, and Tristram's Jird, Transcaucasian Mole-vole, and European Snow Vole at Bisotun. The record of European Snow Vole is particularly important as the only previous records of this species have been from Dizin in the Alborz Mountains and Zardkuh-e Bakhtiari in the Zagros Mountains (Ziaie 2008).



Fig. 3. Lower mandible of *Crocidura suaveolens caspica*.

4.2. Occurrence of prey species in the diet

Some of the mammalian prey species recorded during the present study were not included in the diet of the Barn Owl as listed by Cramp & Simmons (1988), namely Desert Hedgehog *Paraechinus aethiopicus*, Brandt's Hedgehog *P. hypomelas*, European Hare *Lepus europaeus*, Eastern Spiny Mouse *Acomys dimidiatus*, Zagros Mountain Calomyscus *Calomyscus bailwardi*, Baluchistan Gerbil, Mesopotamian Gerbil, Tristram's Jird, Libyan Jird *M. lybicus*, *M. crassus*, Persian Jird *M. persicus*, Indian Gerbil, Transcaucasian Mole-vole, and Social Vole.

Most bird species that are taken as prey by Barn Owls are relatively small species, many of which roost communally, e.g., thrushes *Turdus* sp., starlings *Sturnus* sp., sparrows *Passer* sp. and finches Fringillidae. According to Cramp & Simmons (1988), birds larger or smaller than these are seldom taken. However, in the present study, the remains of a number of relatively large predator species were found in pellets, including Common Kestrel *Falco tinnunculus*, Eurasian Hobby *F. subbuteo*, European Scops Owl *Otus scops*, Pallid Scops Owl *O. brucei* and Little Owl. Of these, only Common Kestrel was mentioned as a prey item by Cramp & Simmons (1988). The presence of several fast-flying species in the samples, notably Common Swift *Apus apus*, European Bee-eater *Merops apiaster*, Green Bee-eater *M. orientalis*, Indian

Roller *Coracias benghalensis*, Common House Martin *Delichon urbicum*, Sand Martin *Riparia riparia*, Woodchat Shrike *Lanius senator* and Purple Sunbird *Nectarinia asiatica*, is also another noticeable point. Whether or not the Barn Owls were predating chicks of these species, and how Barn Owls prey on them remain subjects for further study.

4.3. Regional variation in the diet of the Barn Owl in southwest Asia

Studies elsewhere in the region have revealed considerable variation in the predominant items of prey in the diet of the Barn Owl. In southern India, small mammals comprised 85.5% (with 37.2% Asian House Shrew *Suncus murinus* and 23.0% Black Rat as predominant prey) (Santhanakrishnan *et al.* 2010). In a study in Pakistan, Mushtaq-ul-Hassan *et al.* (2004) found that small mammals constituted 98.5% of the diet, while small birds made up only 1.5%. The Asian House Shrew was the dominant food item among the small mammals, constituting 63.0%, while Black Rat comprised 8.4% and Soft-furred Rat *Millardia meltada* 6.3% (Mushtaq-ul-Hassan *et al.* 2004). In Central Punjab, Pakistan, Asian House Shrew comprised 65% (of 407 prey items) and in Southern Punjab 59% (of 2,413 prey items), while in Southern Baluchistan, Soft-furred Rat comprised 53.6% (of 571 prey items) (Mahmood-ul-Hassan *et al.* 2007b). In Iraq, the diet consisted of 30.0% *Mus abboti/musculus*, 26.5% Kuhl's Pipistrelle *Pipistrellus kuhlii* and 17.3% Black Rat (Nader 1968); at Al-Sareeh in northern Jordan, it included 60.3% Tristram's Jird (Rifai *et al.* 1998). At Lake Bafa on the Aegean coast of Turkey, the diet consisted of 58.6% *Mus abboti/musculus* and 28% Lesser White-toothed Shrew *Crocidura suaveolens* (Kasperek 1986), while at Samandag in southern Turkey, it consisted of 23.6% Greater White-toothed Shrew *C. russula*, 42.2% *Mus cf. musculus* and 19.9% House Sparrow (Hoppe 1986). In a sample of 407 prey items from three localities in southern Syria, 91.4% (by number) were small rodents, including 47.2% House Mouse *Mus musculus* and 12.8% *Microtus socialis* (Shehab 2005). Shehab & Charabi (2006) found that the vole *Microtus socialis* was the main food of the Barn Owl in northern Syria, constituting 59.5% of prey items, while shrews made up 9.6% by frequency. Shehab *et*

al. (2006) recovered the remains of European Water Voles *Arvicola terrestris* [*amphibius*] from pellets of Barn Owls in northwestern Syria, but did not consider this to be an important prey species. In nine samples of Barn Owl pellets from Syria (Benda *et al.* 2006), bats comprised over 10% of the mammals. The most abundant species were *Pipistrellus kuhlii* (1,872 specimens), Hemprich's Desert Bat *Otonycteris hemprichii* (55), Geoffroy's Trident *Aselia tridens* (35), Naked-rumped Tomb Bat *Taphozous nudiventris* (33) and Long-fingered Bat *Myotis capaccinii* (33). In Palestine, 6,224 vertebrates included, by number, 46.1% Guenther's Vole *Microtus guentheri*, 17.7% *Mus*, 16.3% shrews, 14.2% *Meriones*, 1.9% *Rattus*, 1.6% mole rat *Spalax* and 1.2% *Cricetulus* (Dor 1947). In the Negev, Israel, 414 mammalian prey items found in 256 pellets comprised 41.1% Tristram's Jird, 9.2% Buxton's Jird *M. sacramenti*, 8.2% Anderson's Gerbil *Gerbillus andersoni*, 40.1% House Mouse *Mus musculus* and 1.4% *Crocidura suaveolens*. The pellets also contained some remains of insects, small specimens of the snake *Eryx jaculus* and two passerine birds (Yom-Tov & Wool 1997). In another study in Negev, Allenby's Gerbil *Gerbillus allenbyi* and Greater Egyptian Gerbil *G. pyramidum* constituted 33.2 and 26.7%, respectively (Tores & Yom-Tov 2003). In a study in the Kibbutz, *Mus*, *Microtus*, and *Meriones* comprised 37.5, 30.2, and 19.6%, respectively (Tores *et al.* 2005). In the Jordan Valley, small mammals, particularly three rodents (Levant Vole [*Microtus socialis guentheri*], House Mouse, and Tristram's Jird *Meriones tristrami tristrami*), comprised 73% to 88% of the 3,544 prey items taken by Barn Owls (Charter *et al.* 2009). Such big differences are to be expected in a species of predator with such a wide range as the Barn Owl, exposed to very different assortments of potential prey species in different parts of its range.

4.4. Food-niche breadth

Previous studies have found that the Barn Owl is an opportunistic predator (Cramp & Simmons 1988, Tores *et al.* 2005, Figuero *et al.* 2009). The results of the present study have shown that the Barn Owl in Iran is also an opportunistic predator dependent on a wide range of available prey items to ensure its food

requirements. A total of 97 prey species were identified during the study (Table 1). Similarly, Obuch & Benda (2009) found 44 mammal species and 64 bird species in the diet of the Barn Owl in seven countries in the Eastern Mediterranean. In temperate regions of Western Europe, Barn Owls have been found to have a stenophagous diet, feeding almost exclusively on small mammals, whereas in the southern Mediterranean region, the owls feed on more kinds of prey and thus have greater trophic diversity (Herrera 1974). On the Canary Islands, large spatial variations were seen in the composition of the diet from predominantly insectivorous to predominantly avian (Flikweert *et al.* 2007).

Small mammals dominate the diet of the Barn Owl in most parts of the species' range. In the Eastern Mediterranean, mammals constitute 90% of all prey items (Obuch & Benda 2009). Obuch (2001a) found that *Microtus arvalis* alone constituted 73.9% of 2,749 prey items in Slovakia. In the present study, small mammals constituted the main diet of the Barn Owl throughout the country (77.3%), and rodents were the staple food (1,565 prey items, 69.5%; Table 1). This suggests that the Barn Owl is a very important natural predator of harmful rodent pests.

There are very few publications that have used the MDFM method. Obuch (2001a) found that only Eurasian Harvest Mouse *Micromys minutus* gained a +3 in the Socovce area of Slovakia. Obuch & Benda (2009) found that in samples from eight different regions of the Eastern Mediterranean, Savi's Pine Vole *Microtus savii*, Apennine Shrew *Sorex samniticus*, Yellow-necked Mouse *Apodemus flavicollis*, Wood Mouse *A. sylvaticus*, House Sparrow, Lacertidae and Orthoptera gained a 3+ sign in at least one of the regions. In the eight regions, the highest plus signs were observed in Calabria (+15), western Crete (+14), Peloponnese (+13) and northern Egypt (+12) (Obuch & Benda 2009). In studies of the diet of the Little Owl, Iran was found to have a greater plus sign (+16) than Egypt and Syria (Obuch & Krištín 2004).

Although it has been demonstrated that there is a great degree of spatial variation in the diet of the Barn Owl across its wide distribution, this species also shows temporal variation in its diet. In a long-term study of the diet of the Barn

Owl in the UK, Love *et al.* (2000) showed a significant change from the 1970s to the 1990s. A widespread decrease occurred in the percentage of Common Shrew in the diet, while the proportion of Pygmy Shrew *Sorex minutus*, *Apodemus* spp. and Bank Vole *Clethrionomys glareolus* increased. They attributed changes in diet primarily to changing agricultural practices. Finally, Taylor (1994) reported that fluctuations in the prey consumed by Barn Owls were related to cyclical changes in small mammal populations.

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References

- Avery D.M. (1999). A preliminary assessment of the relationship between trophic variability in southern African Barn Owls *Tyto alba* and climate. *Ostrich*, 70, 179–186.
- Benda P., Andreas M., Kock D., Lučan R.K., Munclinger P., Nová P., Obuch J., Ochman K., Reiter A., Uhrin M. & Weinfurtoová D. (2006). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 4: Bat fauna of Syria: distribution, systematics, ecology. *Acta Soc. Zool. Bohem.* 70, 1–329.
- Bond G., Burnside N.G., Metcalfe D.J., Scott D.M., & Blamire J. (2004). The effects of land-use and landscape structure on barn owl (*Tyto alba*) breeding success in southern England, UK. *Landscape Ecology*, 20, 555–566.
- Bontzorlos V.A., Peris S.J., Vlachos C.G. & Bakaloudis D.E. (2005). The diet of barn owl in the agricultural landscapes of central Greece. *Folia Zool.*, 54(1-2), 99–110.
- Bruce M.D. (1999). Family Tytonidae (Barn-owls). *In*: del Hoyo J., Elliott A.J. & Sargatal J. (Eds.), *Handbook of the Birds of the World- vol. 5, Barn-owls to Hummingbirds*. Lynx Edicions, Barcelona, Spain, pp. 34–75.
- Burel F., Baudry J., Butet A., Clergeau F., Delettre Y., Le Coeur D., Dubs F., Morvan N., Paillat G., Petit S., Thenail C., Brunel E., Lefeuvre J.-C. (1998). Comparative biodiversity along a gradient of agricultural landscapes. *Acta Oecologica*, 19(1), 47–60.
- Campbell R.W., Manuwal D.A. & Harestad A.S. (1987). Food habits of the Common Barn-Owl in British Columbia. *Canadian Journal of Zoology*, 65, 578–586.
- Charter M., Izhaki I., Meyrom K., Motro Y. & Leshem

- Y. (2009). Diets of Barn Owls differ the same agricultural region. *Wilson Journal of Ornithology*, 121(2), 378–383.
- Cramp S. & Simmons K.E.L. (Eds.) (1985). *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Vol. IV*. Oxford University Press, Oxford.
- Dahmardeh B., Ghasempouri S.M., Habibi S., Salimi K. & Esmaili-Sari A. (2007). Pollution levels of total mercury in owls' feathers from different provinces of Iran. *The 2nd World Owl Conference, 1-4 November, Groningen, The Netherlands*.
- Darvish J. (1991). A preliminary survey of Rodents in North Khorasan using pellets of birds of prey. *Journal of Applied Entomology and Phytopathology*, 59(1/2), 33–43. [In Persian with English summary]
- Dor M. (1947). Observations sur les micromammifères trouves dans les pelotes de la chouette effraye (*Tyto alba*) en Palestine. *Mammalia*, 11, 49–54.
- Dubey S., Cosson J-F., Magnanou E., Vohralík V., Benda P., Frynta D., Hutterer R., Vogel V. & Vogel P. (2007). Mediterranean populations of the lesser white-toothed shrew (*Crocidura suaveolens* group): an unexpected puzzle of Pleistocene survivors and prehistoric introductions. *Molecular Ecology*, 16, 3438–3452.
- Etemad E. (1977). *Mammals of Iran*. Society of Natural Resources Conservation, Tehran. [In Persian]
- Figueroa R.A.M., Rau J.R., Martinez D.R., Soraya Corales S., Mayorga S., Mansilla A. & Figueroa R.M. (2009). Rodent prey of the barn owl *Tyto alba* and short-eared owl *Asio flammeus* during winter in agricultural lands of southern Chile. *Wildl. Biol.*, 15(2), 129–136.
- Flikweert M., Prins T.G., de Freitas J.A. & Nijman V. (2007). Spatial variation in the diet of the Barn Owl *Tyto alba* in the Caribbean. *Ardea*, 95(1), 75–82.
- Gromov I.M. & Erbajeva M.A. (1995). [The Mammals of Russia and adjacent territories, Lagomorphs and Rodents]. St. Petersburg. [In Russian].
- Harrison D.L. & Bates P.J. (1991). *The Mammals of Arabia – Second ed.* Harrison Zool. Mus. Publ., Sevenoaks, Kent, UK, 354 pp.
- Herrera C.M. (1974). Trophic diversity of the Barn Owl in continental Western Europe. *Ornis Scand.*, 5, 181–191.
- Hoppe N. (1986). Pellet contents of the Barn Owl, *Tyto alba*, near Samandag, Turkey. *Zoology in the Middle East*, 1, 29–31.
- Ille R. (1991). Preference of prey size and profitability in Barn Owls *Tyto alba guttata*. *Behaviour*, 116, 180–189.
- Jaksic F.M. & Lazo I. (1999). Response of a bird assemblage in semiarid Chile to the 1997–1998 El Niño. *Wilson Bulletin*, 111, 527–535.
- Kasperek M. (1988). *Der Bafasee. Nature und Geschichte in der türkischen Ägäis*. Kasperek Verlag, Hedelberg, Germany, 174 pp.
- Kryštufek B. & Tsytulina K. (2008). *Crocidura caspica*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <http://www.iucnredlist.org/apps/redlist/details/136444/0>. Accessed on 10 December 2010.
- Lawler J.J. & Edwards T.C., Jr. (2002). Composition of cavity-nesting bird communities in montane aspen woodland fragments: the roles of landscape context and forest structure. *Condor*, 104, 890–896.
- Lay D.M. (1967). A study of the mammals of Iran. *Fieldiana: Zoology*, No. 54, Chicago, Illinois, USA.
- Love R.A., Webbon C., Glue D.E. & Harris S. (2000). Changes in the food of British Barn Owls (*Tyto alba*) between 1974 and 1997. *Mammal Review*, 30(2), 107–129.
- Mahmood-ul-Hassan M., Beg M.A. & Ali H. (2000). Diet of the Barn Owl (*Tyto alba*) in Central Punjab, (Pakistan). *Pakistan Journal of Zoology*, 32(1), 33–39.
- Mahmood-ul-Hassan M., Beg M.A. & Ali H. (2007a). Seasonal variation in the diet of the Barn Owl *Tyto alba stertens* in Central Punjab, Pakistan. *Acta Zoologica Sinica*, 53(3), 62–69.
- Mahmood-ul-Hassan M., Beg M.A., Mushtaq-ul-Hassan M., Mirza H.A. & Siddique M. (2007b). Nestling and diet of the Barn Owl (*Tyto alba*) in Pakistan. *Journal of Raptor Research*, 41(2), 42–50.
- Marti C.D. (2010). Dietary trends of barn owls in an agricultural ecosystem in northern Utah. *The Wilson Bulletin of Ornithology*, 122(1), 60–67.
- Marti C.D., Steenhof K., Kochert M.N. & Marks J.S. (1993). Community trophic structure; the roles of diet, body size, and activity time in vertebrate predators. *Oikos*, 67, 6–18.
- Morowati M., Nazari F. & Malikov V. (2005). *A Guide to Identification of Harmful Rodents*. Iranian Research Institute of Plant Protection, Tehran, 136 pp. [In Persian]
- Mushtaq-ul-Hassan M., Raza M.N., Shahzadi B. & Ali A. (2004). The diet of Barn Owl (*Tyto alba*) from canal bank, canal rest house and graveyard of Gojra. *Journal of Research (Science)*, 15(3), 291–296.
- Nader I. (1968). Animal remains in pellets of the Barn Owl, *Tyto alba*, from the vicinity of An-Najaf, Iraq. *Bulletin of the Iraq Natural History Museum*, 4, 1–7.
- Obuch J. (2001a). Using marked differences from the mean (MDFM) method for evaluation of contingency tables. *Buteo*, 12, 37–46.
- Obuch J. (2001b). Dormice in the diet of owls in the Middle East. *Trakya University Journal of Scientific Research (Edirne), Ser. B*, 2, 145–150.
- Obuch J. & Benda P. (2009). Food of the Barn Owl (*Tyto alba*) in the Eastern Mediterranean. *Slovak Rapt. J.*, 3, 41–50.
- Obuch J. & Krištín A. (2004). Prey composition of the little owl *Athene noctua* in an arid zone (Egypt, Syria, Iran). *Folia Zoologica*, 53 (1), 65–79.
- Osaei A., Khaleghizadeh A. & Sehhatiasabet M.E. 2007. Range extension of the Barn Owl *Tyto alba* in Iran. *Podoces*, 2(2), 106–112.
- Perrins C.M. (Ed.) (1998). *The Complete Birds of the Western Palearctic on CD-ROM*. Oxford University Press, Oxford.
- Porter R.F., Christensen S. & Schiermacker-Hansen P. (1996). *Field Guide to the Birds of the Middle East*. T. & A.D. Poyser, London.
- Rekasi J. & Hovel H. (1997). Pellet contents of barn owls *Tyto alba erlangeri* from Be'erotayim, Israel. *Israel Journal of Zoology*, 43, 305–306.
- Rifai L.B., Al-Melhim W.N. & Amr Z.S. (1998). On the diet on the Barn Owl, *Tyto alba*, in northern Jordan. *Zoology in the Middle East*, 16, 31–34.
- Santhanakrishnan R., Samsoor Ali A.H.M. & Anbarasan U. (2010). Diet Variations of the Barn Owl *Tyto alba* (Scopoli, 1769) in Madurai District, Tamil Nadu,

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- Southern India. *Podoces*, 5(2), 95–103.
- Schoener T.W. (1971). Theory of feeding strategies. *Annual Review of Ecology and Systematics*, 2, 369–404.
- Shehab A.H. (2005). Food of the Barn owl *Tyto alba* in Southern Syria. *Acta Zoologica Crakov.*, 48A (1-2), 35–42.
- Shehab A.H. & Charabi M.S. (2006). Food of the Barn owl *Tyto alba* in Yahmol Area, Northern Syria. *Turkish Journal of Zoology*, 3(2), 175–179.
- Shehab A.H., Mamkhaier I.H. & Amr Z.S. (2006). Remains of the Water Vole, *Arvicola terrestris* (Linnaeus, 1758) (Microtinae, Rodentia), from north-western Syria. *Zoology in the Middle East*, 37, 111–113.
- Taylor I. (1994). *Barn Owls. Predator-prey Relationships and Conservation*. Cambridge University Press, Cambridge, U.K.
- Tores M., Motro Y., Motro U. & Yom-Tov Y. (2005). The Barn Owl - a selective opportunistic predator. *Israel Journal of Zoology*, 51, 349–360.
- Yom-Tov Y. & Wool D. (1997). Do the contents of Barn Owl pellets accurately represent the proportion of prey species in the field? *The Condor*, 99, 972–976.
- Ziaie H. (2008). *A Field Guide to the Mammals of Iran*. Iranian Wildlife Center, Tehran, 420 pp. [In Persian]