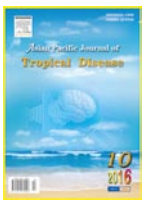
HOSTED BY
ELSEVIER

Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd



Faunal research doi: 10.1016/S2222-1808(16)61134-9

Evaluation of biological control of rattus population by mongoose (Herpestidae, Carnivora) in Abu-Musa Island, Iran

Mehdi Khoobdel[1*], Hossain Jafari[2], Fateme Firouzi[3]

[1]*Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran*

[2]*Marine Medicine Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran*

[3]*Department of Zoology, Faculty of Biological Science, Shahid Beheshti University, Tehran, Iran*

ARTICLE INFO

Article history:
Received 31 May 2016
Received in revised form 14 Jun, 2nd revised form 21 Jun 2016
Accepted 24 Jul 2016
Available online 30 Aug 2016

Keywords:
Biological control
Herpestes edwardsii
Persian Gulf
Rats
Mongoose

ABSTRACT

Objective: To evaluate the rattus biological control program in Iranian Persian Gulf Island, Abu-Musa.

Methods: This study was conducted on the Iranian island of Abu-Musa during April 2012 to March 2013. The rattus trapping was done using commercial live and baited rat trap, in different parts of the island. Also the island of Qeshm, with a similar weather and climatic conditions in the Persian Gulf was considered as a control area, which any comprehensive rattus control plan has not been implemented during the implementation of rattus biological control program on Abu-Musa Island. All ectoparasites were collected and stored at 70% ethanol. Ectoparasites, including fleas, lice and mites were identified using identification keys. In addition, a number of released mongooses were captured and identified.

Results: Despite a year of trapping on the island, no rattus were caught in the traps. While on the island of Qeshm, as a control location, rate of rat trappings was estimated 33.3%. Among the 27 captured rodents in two islands, a total of 89 ectoparasites including fleas, *Xenopsylla astia* (32 females, 18 males) and *Cetenocephalides felis* (9 females, 7 males), louse, *Polyplax spinulosa* (8 females, 2 males) and mite, *Laelaps nuttalli* (13 females and males) were collected.

In this study, the introduced mongoose on the island of Abu-Musa, which has established and increased their population and been distributed in all parts of the island, was identified as Indian gray mongoose, *Herpestes edwardsii*.

Conclusions: The introduced Indian gray mongoosehas successfully eradicated the rattus population in island of Abu-Musa, but we have no information about its direct and indirect impacts on other native faunal elements of this island.

1. Introduction

The common commensal species of *Rattus* (Fischer de Waldheim, 1803) including Norway or brown rat, *Rattus norvegicus* (*R. norvegicus*) (Berkenhout, 1769) and roof or black rat, *Rattus rattus* (L, 1758) are important reservoirs or vectors of pathogens and threat public health[1]. These harmful rodents are among the main agricultural pests and have destructive impact on urban environment and also food crops[1,2].

The biological control of rats using their natural enemies such as predators and pathogens is carried out in many parts of the world[3]. In the past, the pathogens such as *Salmonella* and some predatory animals including the monitor lizard, mongoose, ferret, weasel, barn owl and also domestic and feral cats were used as the main agents for the biological control of rodents. Among them, mongoose is the most common biological control agent that has been used for rat control[4,5].

The mongooses are the small invasive carnivorous belonging to the family of Herpestidae, with 17–18 genera and 35–37 species[6-7]. The *Herpestes* is a genus of the mongoose with ten species that are usually distributed in the old world[8]. Mainly 8 species of these mongooses including Indian grey mongoose [*Herpestes edwardsii* (*H. edwardsii*)], small Asian mongoose or Javan mongoose [*Herpestes javanicus* (*H. javanicus*)], small Indian brown mongoose

*Corresponding author: Mehdi Khoobdel, Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran.
E-mail: khoobdel@yahoo.com

Foundation Project: Supported by Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran (Project No BMSU/HRC-91.101/1).
The journal implements double-blind peer review practiced by specially invited international editorial board members.

(*Herpestes fuscus*), crab-eating mongoose (*Herpestes urva*), small Indian mongoose [*Herpestes auropunctatus* (*H. auropunctatus*)], small short tailed mongoose (*Herpestes brachyurus*), ruddy mongoose (*Herpestes smithii*) and striped-necked mongoose (*Herpestes vitticollis*) are distributed in Asia[6,7,9]. In some cases, the small Asian mongooses and the small Indian mongoose are mistakenly considered as a single or sympatric species[6,8,10]. Two mentioned species and *H. edwardsii* are native to the Middle East and much of Southern Asia[8,9].

The *Rattus* biological control (RBC) using mongoose has been done for about 100 years during 1872 to 1979 in many parts of the world[5]. The mongooses, mainly *H. javanicus* and *H. auropunctatus*, were widely introduced in new areas including the islands in the Pacific and Indian Oceans, the Caribbean and Atlantic Seas, Japan and some other regions of the world for biological control of rats and snakes[5,11]. The first introduction of mongooses to an island was occurred in 1872, when four males and five females were transferred from Calcutta of India to Jamaica[12]. Subsequent generations of breeding mongooses were moved to Cuba, Puerto Rico, Grenada, Barbados and Trinidad, also in 1883–1885, a relatively large number of mongooses were released on Hawaiian Islands[12,13]. Also during 1883–1910 a number of mongooses were released from India and Bangladesh on Fiji, Mauritius and Okinawa Islands, respectively. The latest instance of release on an island was occurred in 1979 on Amami-Ohshima in Japan[12,13]. Today these mongooses are found in a large number of islands and a wide variety of habitats[5,7].

Also the Indian gray mongoose, *H. edwardsii*, which is mainly found in Southern Asia has been introduced on Japan and also probably on Adriatic islands, but is reported with another name, *Herpestes griseus*, synonym of *H. edwardsii*[8,11].

The southern ports of Iran and the Persian Gulf islands are highly infected by rats due to many ship traffic[14]. Therefore biological control of *Rattus* was conducted in the Iranian strategic island of Abu-Musa in the Persian Gulf by using mongoose (unpublished report). It is not well understood that which species of mongoose properly were introduced in this island.

The aim of this study was evaluation of RBC program on the island of Abu-Musa.

2. Materials and methods

2.1. Study site

This study was conducted on the island of Abu-Musa during April 2012 to March 2013. Abu-Musa with 25°51'–26°19' N, 54°26'–55°19' E and an area of 12.8 km^2, is located in the Persian Gulf in Southeastern of Iran (Figure 1). Halva Mountain with an altitude of 110 m is the highest point of the island. The climate is warm and humid on this subtropical island[15]. Abu Musa and Greater and Lesser Tunbs are the Iranian strategic islands in the Persian Gulf. The oil tankers and merchant big ships have to pass between these islands, due to the depth of sea in this area[15,16](Figure 1).

2.2. RBC program

According to the official statements of Abu-Musa Island and the documentation of military health departments in this island, RBC program was conducted in Abu-Musa during 2005–2006 by island authorities and with the help and under the supervision of Department of Environmental Protection of Hormozgan Province, in south of Iran. In this program, more probably three pairs of the mongoose, 3 males and 3 females, were released in the island of Abu-Musa. We didn't found further details of the RBC plan implementation. According to residents and military health documentation, the *Rattus* widely distributed on Abu-Musa such as other Persian Gulf Islands before the RBC program implementation, but there was no more scientific information about the abundance of *Rattus* on the island.

2.3. Rattus trapping

The *Rattus* trapping was done by the use of commercial live and baited rat trap, similar to Sherman rat trap, in size to 12 cm × 14 cm × 23 cm (Figure 2). Fresh cucumber, coconut and fish were also used as bait in traps[17]. The traps were placed in the evening and before sunset in high-activity areas of the rat or in places where rodent activity is more likely to happen including darkened corners, along

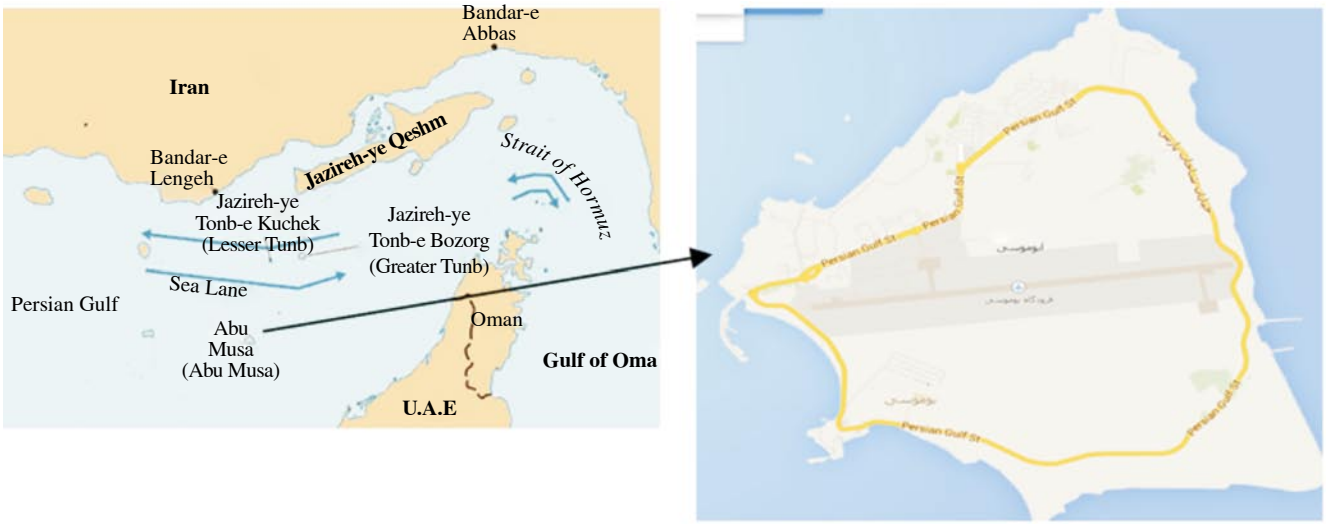


Figure 1. Location of Abu-Musa Island in Persian Gulf.

walls, behind appliances and objects. Traps were set in food storage and around, vegetable garden and greenhouses, as well as the landfill and near the military kitchen and also around tree sat different parts of the islands. The traps were checked each morning for rat trapping and if needed, were replaced with fresh baits.

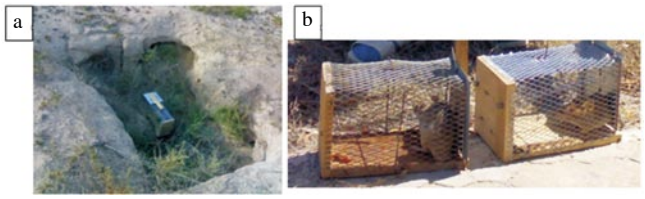


Figure 2. Rattus trapping in islands.
a: Abu-Musa; b: Qeshm.

Rat capturing was performed for one year during April 2012 to March 2013. The trappings were done every 15 days and 10 traps were used at each time. For the adaptation and acceptance of traps by *Rattus*, traps stayed 3 day at each location. The disposable gloves were used to work with traps and baiting. In total, during the 12-month and 24-turn trapping, 240 traps were set.

The island of Qeshm was considered as a control location, which has not been implemented any comprehensive *Rattus* control plan, during the implementation of RBC program on Abu-Musa island. The island of Qeshm with 26°32'–27°06' N, 55°15'–56°30' E, and an area of 1491 km^2 is located 65 km away from the north east of Abu Musa in Persian Gulf (Figure 1). The two islands have similar weather and climatic conditions[15]. Rat trapping was conducted in this control island for three months during April to June 2012 by using 60 times live baited rat traps.

The caught rats were transferred to the laboratory and their ectoparasites were picked up using brushing against the fur of rodent. All ectoparasites were collected and stored at 70% ethanol. Ectoparasites, including fleas, lice and mites were identified using identification keys[14]. Ectoparasites identification was confirmed by Dr. M. Abdi Goudarzi in Razi, from Vaccine and Serum Research Institute-Karaj Branch, Iran.

Also, rodents were identified after recording their different morphological characteristics.

2.4. Identification of the mongoose in Abu-Musa

A number of the mongooses (n = 3, including 2 males and 1 female) were captured by using live and baited mammals trap. The mongooses were identified according to their morphological characteristics and illustrations[18]. The confirmation of mongoose identification was done by Dr. T Gadirian in Department of Zoology, Shahid Beheshti University, Tehran, Iran.

In this study, the scientific estimation of the mongoose population on the island was not made but the researcher's observation in the field on mongoose population and their activities were recorded.

Average temperature and relative humidity of Abu-Musa Island were recorded during the study, March 2012 to February 2013 (Table 1).

2.5. Data analysis

The rate of *Rattus* trapping was defined by the number of traps that has been captured *Rattus* divided to total traps. The rate of rats trappings in two islands were compared by using of Fisher's Exact Test.

3. Results

In this study, totally 240 traps (monthly 20 traps) were used to *Rattus* trapping during the year in different parts of Abu-Musa Island, but did not catch any *Rattus*. The traps collected only 5 mice, *Musmusculus* from indoors such as food storages. These findings indicated that RBC program has been successful and *Rattus* have been eradicated from Abu Musa Island (Table 2).

In Qeshm Island, which was chosen as a control location, during 6 times of trappings by using 60 traps, a total of 22 rodents including *Rattus* and mice were captured. The rate of trappings was estimated 33.3%. The relative abundance of commensal rodents captured, including *R. norvegicus*, *R. rattus* and the *Musmusculus* were determined 63.6%, 27.3% and 10.1%, respectively (Table 1). The rate of rat trapping in treatment island, Abu-Musa was significantly less than control island, Qeshm ($P < 0.05$).

Among the 27 captured rodents in two islands, a total of 89 ectoparasites including four species of fleas, lice and mite were collected. All *Rattus* were infected with at least one species of ectoparasites (Table 2).

In this study, the introduced mongoose on the island of Abu-Musa was identified as Indian gray mongoose, *H. edwardsii* (Figure 3).

According to researchers observations, the population of this mongoose was increase and widely distributed in Abu-Musa City and all part of this island. The Indian gray mongoose eat most times of the day and early night, even sometimes until the middle of the night can be seen on the island. It seems that a large population of this mongoose was established on the island of Abu-Musa.

Figure 3. The Indian gray mongoose, *H. edwardsii* on the Abu-Musa Island.

Table 1
The monthly mean temperature and relative humidity of Abu-Musa Island during March 2012 to February 2013.

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Jan	Feb
Mean temperature (°C)	26	31	34	34	35	36	30	25	20	18	20	25
Relative humidity (%)	62	60	65	70	68	72	70	45	38	66	78	71

Table 2
The captured rodents and their ectoparasites in Abu-Musa and Qeshm islands.

Rodents	Catch number in Islands (relative abundance %)		Ectoparasites			
			Flea		Louse	Mites
	Abu-Musa	Qeshm	*Xenopsylla astia*	*Cetenocephalides felis*	*Polyplax spinulosa*	*Laelaps nuttalli*
R. rattus	0 (0.0%)	6 (27.3%)	0	8 (5 males, 3 females)	0	2
R. norvegicus	0 (0.0%)	14 (63.6%)	50 (32 males, 18 females)	8 (4 males, 4 females)	10 (8 males, 2 females)	8
Musmusculus	5 (100%)	2 (10.1%)	0	0	0	3
Total	5 (100%)	22 (100.0%)	50 (32 males, 18 females)	16 (9 males, 7 females)	10 (8 males, 2 females)	13

4. Discussion

The introduced Indian gray mongoose, *H. edwardsii* (É. Geoffroy Saint-Hilaire, 1818) has successfully eradicated the *Rattus* population in the island of Abu-Musa. This is the first successful biological control of rodent by using the mongoose in Iran and Middle East region. No capturing of *Rattus* on the island of Abu-Musa and the subsequent relatively high catches in the island of Qeshm suggested that rats have been eradicated, most probably only by introducing mongoose.

Unfortunately, we have no scientific information about the abundance of rats on the island of Abu-Musa, before implementation of RBC program. However, it has been done due to the high abundance of rodents in this island.

Another effort to control the great gerbil, *Rhombomys opimus* (Lichtenstein, 1823) as a main reservoir of zoonotic cutaneous leishmaniasis by using the Indian gray mongoose in Esfahan Province in central of Iran has been failed[19]. This unsuccessfully introduction is probably due to the release of mongoose in an open area, because most of successful rodent's biological control operations by using of mongoose, have occurred in insular areas such as islands, where native species have often evolved in the absence of strong competition, parasitism or predation[5,20].

In the late 19th and 20th centuries, the mongoose, mainly *H. javanicus* and *H. auropunctatus*, have been introduced successfully to control rats on the islands in the Pacific and Indian Oceans, the Caribbean and Adriatic Seas, South America, South Europe and almost Japan. But their introduction to North America and Australia for rat and more probably rabbit control was unsuccessful[4,12].

The small Indian mongoose introduced on Trinidad, were reduced the rats in cane fields, though they had been a major pest before the introduction of the mongoose[4], but in Hawaii failed to control rats[11]. Also in Puerto Rico, the Polynesian or Pacific rat, *Rattus exulans* are common only in mongoose-free urban areas, whereas roof rats, *R. rattus* are found in mongoose habitat[4].

Small Asian mongoose, *H. javanicus* was released on the island of Amami-Oshima in Japan to control snake and *R. rattus*. Pest control by biological means was also employed to reduce the snake population and the black rat. However, the mongoose has had a major negative impact on agriculture and the native animals in mountainous areas[5,13,21].

Also in another study, the mongoose was successfully introduced to the island of Jamaica to control the rats on sugar cane plantations[11].

In the Adriatic Sea in Croatia, investigation has shown that the *H. auropunctatus* has failed to reduce high abundances of *R. rattus*. They provide some evidence that black rat has changed its activity time to become more nocturnal on mongoose-infested islands, possibly to avoid predation by the mongoose. The mongoose may have become the main predator on other small native vertebrates[4,11].

Most of the biological control of rodent in the world has been done by using the Javan mongoose, *H. javanicus* and small Indian mongoose, *H. auropunctatus*. There is no information about of the few introduction of Indian gray mongoose, *H. edwardsii* on Japan and Adriatic islands[8,11,22]. This is the first report of successful RBC by using the Indian gray mongoose, *H. edwardsii*.

As above mentioned, the mongooses in the past often have been introduced for biological control of rodent pests on agricultural lands in many parts of the world. Apart from a few, most of these operations have been successful[11,12]. Long-term use of this biological control agent in the various islands of the world also indicates the success of this large and long-time rat biological control plan.

It should be noted that each biological control plan may have unintended and adverse side effects on non-target native species and populations, especially on islands insular ecosystem[20,23-25]. By the way, mongooses are among the worst invasive species that declines and extirpations of small vertebrates and native susceptible species of islands[11,23,26], because it also preys on a variety of non-target indigenous species including insects, spiders, scorpions and other invertebrates, as well as frogs, lizards, rodents, land nesting birds, snakes and all small animals[27]. Therefore we suggested that the impact of introduced mongoose on native fauna includes snakes, lizards and also some of invertebrate on the island of Abu-Musa to be investigated.

Also it is necessary to indicate that some studies have suggested that these mongooses can be important reservoirs and vectors for human, livestock and wildlife pathogens[28,29].

To determination of alien Indian grey mongoose impacts on biodiversity, food web and sensitive ecosystem of the island of Abu-Musa and also health islanders, further study are needed.

The introduction of Indian gray mongoose, *H. edwardsii* has successfully been eradicated the *Rattus* population in the island of Abu-Musa. In general, with the exception of some cases, biological control of rats by using the introduced mongoose has been successful in the world. But it's adverse effects on native fauna and biodiversity of island may affect RBC program. To understand the direct and indirect effect of introduced Indian gray monsoons on native species, further investigations are needed.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

This study was financially supported by Health Research Center,

Baqiyatallah University of Medical Sciences, Tehran, Iran (Project No BMSU/HRC-91.101/1). We must thank Dr. M. AbdiGoudarzi in Razi Vaccine and Serum Research Institute to confirm and identifications of some species of ectoparasites. We also wish to thank Dr. T. Gadirian in Department of Zoology, Shahid Beheshti University, Tehran, Iran for confirmation of mongoose identification and to provide scientific resource and articles. We also thank the following persons for their contribution and kind cooperation in the project and rat trapping: Messrs. H. vatani, M. Rahimi, MM. Bahmani, AA Esfahani. Thanks so much of Mrs. H. Salehi for editing the entire of the manuscript.

References

[1] Himsworth CG, Parsons KL, Jardine C, Patrick DM. Rats, cities, people, and pathogens: a systematic review and narrative synthesis of literature regarding the ecology of rat-associated zoonoses in urban centers. *Vector Borne Zoonotic Dis* 2013; **13**(6): 349-59.

[2] Banks PB, Hughes NK. A review of the evidence for potential impacts of black rats (*Rattus rattus*) on wildlife and humans in Australia. *Wildl Res* 2012; **39**(1): 78-88.

[3] Buckle AP, Smith R, editors. *Rodent pests and their control*. 2nd ed. London: CABI; 2015;

[4] Wodzicki K. Prospects for biological control of rodent populations. *Bull World Health Organ* 1973; **48**(4): 461-7.

[5] Funakoshi K, Okada S, Nagasato A, Arai A. Probable achievement of eradication of the small Indian mongoose *Herpestes auropunctatus* and survival state of native animals in Kagoshima prefecture mainland, Japan. *Mammalian Sci (Honyuryu Kagaku)* 2015; **55**(2): 167-81.

[6] Veron G, Colyn M, Dunham AE, Taylor P, Gaubert P. Molecular systematics and origin of sociality in mongooses (Herpestidae, Carnivora). *Mol Phylogenet Evol* 2004; **30**(3): 582-98.

[7] Schneider TC, Kappeler PM. Social systems and life-history characteristics of mongooses. *Biol Rev Camb Philos Soc* 2014; **89**(1): 173-98.

[8] Veron G, Patou ML, Pothet G, Simberloff D, Jennings AP. Systematic status and biogeography of the Javan and small Indian mongooses (Herpestidae, Carnivora). *Zool Scr* 2007; **36**: 1-10.

[9] Veron G, Patou ML, Debruyne R, Couloux A, Fernandez DAP, Wong ST, et al. Systematics of the Southeast Asian mongooses (Herpestidae, Carnivora): solving the mystery of the elusive collared mongoose and Palawan mongoose. *Zool J Linnean Soc* 2015; **173**(1): 236-48.

[10] Kalle R, Ramesh T, Sankar K, Qureshi Q. Observations of sympatric small carnivores in Mudumalai Tiger Reserve, Western Ghats, India. *Small Carnivore Conserv* 2013; **49**: 53-9.

[11] Barun A, Hanson CC, Campbell KJ, Simberloff D. A review of small Indian mongoose management and eradications on islands. Gland: IUCN; 2011, p. 17-25. [Online] Available from: http://www.issg.org/pdf/publications/Island_Invasives/pdfHQprint/1Barun.pdf [Accessed on 28 May, 2016]

[12] Brown P, Daigneault A. Managing the invasive small Indian mongoose in Fiji. *Agric Resour Econ Rev* 2015; **44**: 275-90.

[13] Sugimura K, Ishida K, Abe S, Nagai Y, Watari Y, Tatara M, et al. Monitoring the effects of forest clear-cutting and mongoose *Herpestes auropunctatus* invasion on wildlife diversity on Amami Island, Japan. *Oryx* 2014; **48**(2): 241-9.

[14] Kia EB, Moghddas-Sani H, Hassanpoor H, Vatandoost H, Zahabiun F, Akhavan AA, et al. Ectoparasites of rodents captured in Bandar Abbas, southern Iran. *Iran J Arthropod Borne Dis* 2009; **3**(2): 44-9.

[15] Khoobdel M, Tavassoli M, Salari M, Firozi F. The stinging Apidae and Vespidae (Hymenoptera: Apocrita) in Iranian islands, Qeshm, Abu-Musa, Great Tunb and Lesser Tunb on the Persian Gulf. *Asian Pac J Trop Biomed* 2014; **4**(Suppl 1): S258-62.

[16] Khoobdel M, Akbarzadeh K, Jafari H, Mehrabi Tavana A, Izadi M, Mosavo Jazayeri A, et al. Diversity and abundance of medically-importance flies in Iranian islands; the Greater Tonb, Lesser Tonb and Abu-Muosa. *Iran J Military Med* 2013; **14**(4): 259-68.

[17] Singla N, Kanwar D. Poultry egg components as cereal bait additives for enhancing rodenticide based control success and trap index of house rat, *Rattus rattus*. *Asian Pac J Trop Biomed* 2014; **4**(Suppl 1): S341-7.

[18] Firouz E. *The complete fauna of Iran.* London: I.B. Tauris Publishers; 2005, p. 352.

[19] Khoobdel M, Jafari H, Akhoond MR. The impacts of the introduced Indian gray mongoose *Herpestes edwardsii* (Mammalia, Carnivora) on the non-target native species of Abu-Musa Island, Iran. *Iran J Military Med* 2016; **18**(1): 371-9.

[20] Lewis DS, van Veen R, Wilson BS. Conservation implications of small Indian mongoose (*Herpestes auropunctatus*) predation in a hotspot within a hotspot: the Hellshire Hills, Jamaica. *Biol Invasions* 2011; **13**(1): 25-33.

[21] Watari Y, Takatsuki S, Miyashita T. Effects of exotic mongoose (*Herpestes javanicus*) on the native fauna of Amami-Oshima Island, southern Japan, estimated by distribution patterns along the historical gradient of mongoose invasion. *Biol Invasions* 2008; **10**(1): 7-17.

[22] Barun A, Simberloff D, Meiri S, Tvrtkovi N, Tadi Z. Possible character displacement of an introduced mongoose and native marten on Adriatic Islands, Croatia. *J Biogeogr* 2015; **42**(12): 2257-69.

[23] Evans EW. Biodiversity, ecosystem functioning, and classical biological control. *Appl Entomol Zool (Jpn)* 2016; **51**(2): 173-84.

[24] Morley CG, Winder L. The effect of the small Indian mongoose (*Urva auropunctatus*), island quality and habitat on the distribution of native and endemic birds on small islands within Fiji. *PLoS One* 2013; **8**(1): e53842.

[25] Vellend M, Lajoie G, Bourret A, Múrria C, Kembel SW, Garant D. Drawing ecological inferences from coincident patterns of population- and community-level biodiversity. *Mol Ecol* 2014; **23**(12): 2890-901.

[26] Ishida K, Murata K, Nishiumi I, Takahashi Y, Takashi M. Endemic Amami Jay, invasive Small Indian Mongoose, and other alien organisms: a new century investigation of island aliens towards improved ecosystem management. *J Ornithol* 2015; **156**(1): 209-16.

[27] Voss RS, Jansa SA. Snake-venom resistance as a mammalian trophic adaptation: lessons from didelphid marsupials. *Biol Rev Camb Philos Soc* 2012; **87**(4): 822-37.

[28] Miller S, Zieger U, Ganser C, Satterlee SA, Bankovich B, Amadi V, et al. Influence of land use and climate on *Salmonella* carrier status in the small Indian mongoose (*Herpestes auropunctatus*) in Grenada, West Indies. *J Wildl Dis* 2015; **51**(1): 60-8.

[29] Mani RS, Moorkoth AP, Balasubramanian P, Devi KL, Madhusudana SN. Rabies following mongoose bite. *Indian J Med Microbiol* 2016; **34**(2): 256-7.