The effect of habitat degradation, season and gender on morphological parameters of lesser jerboas (*Jaculus jaculus* L.) in Kuwait

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Al–Mutairi, M., Mata, F. & Bhuller, R., 2012. The effect of habitat degradation, season and gender on morphological parameters of lesser jerboas (*Jaculus jaculus* L.) in Kuwait. *Animal Biodiversity and Conservation*, 35.1: 119–124.

Abstract
*The effect of habitat degradation, season and gender on morphological parameters of lesser jerboas (*Jaculus jaculus *L.) in Kuwait.*— Arid environments suffer anthropogenic interference causing habitat degradation. This degradation can influence animal populations. We randomly captured a total of 198 lesser jerboas *Jaculus jaculus* in three seasons (autumn, spring and summer) in two relatively close areas (intact and degraded). All animals were sexed, and weight, body and tail length, and thigh thickness were taken. We found significant differences in weight ($p < 0.001$), which was lower in summer ($p < 0.05$) when fewer food resources were available. Thigh thickness was greater in the intact habitat ($p < 0.01$), explained by the greater amount of food resources and also by the higher numbers of predators in this area, prompting escape behaviour. Females in the intact area were heavier and had longer bodies and tails. This was related to greater availability of time for mothers to search for food in this area.

Key words: Habitat, Degradation, Kuwait, Lesser jerboa, *Jaculus jaculus* L.

Resumen
*El efecto de la degradación del hábitat, la estación del año y el sexo en algunos parámetros morfológicos del jerbo egipcio (*Jaculus jaculus *L.) en Kuwait*.— En los climas áridos las interferencias antropógenas causan la degradación del hábitat, que puede afectar a las poblaciones animales. Se capturaron 198 jerbos egipcios al azar en tres estaciones del año (otoño, primavera y verano) y en áreas intactas y degradadas cercanas. Los individuos capturados se sexaron y se les registró el peso, la longitud del cuerpo, la longitud de la cola y el grosor del muslo. Se encontraron diferencias significativas en el peso ($p < 0,001$), que fue inferior en verano ($p < 0,05$), cuando hay menos recursos alimentarios. El grosor del muslo fue mayor en el hábitat intacto ($p < 0,01$), lo que se atribuye a una mayor disponibilidad de alimento y también a una mayor presencia de depredadores en la zona, que provocaba conductas de huida. Las hembras fueron más pesadas y tuvieron mayor longitud del cuerpo y de la cola en las zonas intactas, como consecuencia de una mayor disponibilidad de tiempo para buscar alimento por parte de las madres en esta zona.

Palabras clave: Hábitat, Degradación, Kuwait, Jerbo egipcio, *Jaculus jaculus* L.

(Received: 26 IV 12; Conditional acceptance: 31 V 12; Final acceptance: 15 VI 12)

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ISSN: 1578–665X

Introduction

Desert mammal species have developed complex combinations of behavioral and physiological adaptations to ameliorate the impact of extreme temperatures and limited free water. These adaptations typically consist of being nocturnal, semi–fossorial, and having the ability to extract all their water from their food (Whitford, 2002).

Human activities have modified natural habitats in many ways. The most dramatic changes involve widespread degradation of entire areas, such as shift from forest to agricultural use or urbanization. However, a more pervasive influence is the construction of linear open areas —truck paths and roads — through previously continuous habitat. These open areas may provide ecological situations that differ profoundly from those of the surrounding habitat and cause habitat fragmentation and deterioration of food resources for desert mammals.

Limited food resources would result in smaller body size. Small desert mammals are often limited in their food choices in that they are forced to select more digestible, energy–rich diets such as those based on seeds, as compared to large animals (Demment & Van Soest, 1985). Heavier individuals have higher overwinter survival rates for the two genders: males and females. This is primarily because larger body size should increase energy conservation and probability of survival (Schorr et al., 2009). Larger individuals typically have more fat reserves and maybe less dependent upon food availability (French, 1988). Larger rodents use their fat storage while fasting at a slower rate than smaller individuals and as a result, they can spend longer times at higher body temperatures during hibernation, enabling enables them to survive (Geiser, 2004).

Several ecological and biological changes have been attributed to climate change. Visser (2010), referring to small mammals, stated that climate change is affecting the seasonal timing of reproduction and hibernation, as well as body size and species´´ distribution ranges. Brown et al. (1993) assumed that each animal taxon has an optimal body weight; if reached for mammals smaller than 100 g, their foraging range will decrease and their energy will be diverted to reproduction which increases the population. In addition, population growth is related to the carrying capacity of the ecosystem. With fixed resources, the carrying capacity of any ecosystem should decrease with increasing body size. Therefore, if the resources are limited, body size would be reduced to maintain the population (Savage et al., 2004).

The United Nations Environmental Program (UNEP) defined desertification as land degradation in arid, semi–arid and dry–sub humid areas caused by adverse human impact. The causes of desertification are a combination of several factors that include: scarcity and decrease of mean rainfall as a result of global changes, overgrazing, the increase of human population that inhabits the dry lands, industrial misuse, land exploitation, domestic use of fragile vegetation especially for fuel, and many more factors that vary from one region into another (Thomas, 1993). In Kuwait, nearly all plants and animals outside protected areas are lost. The country has lost most of its valuable and vulnerable plants in the second half of the last century due to urbanization, human impact and climate change, factors that also reduced wildlife. Unfortunately, plant and animal communities are disappearing quickly from other areas with open access. Habitat loss and land deterioration are not the only factors contributing to the diminished wildlife populations in Kuwait. Other factors include unjustified hunting and intentional destruction of their shelters. Mammals are the animals that suffer most from these natural and anthropogenic factors.

The aim of this study was to analyse differences in morphological parameters of lesser jerboa (*Jaculus jaculus* L.) populations living in intact habitat with abundant food resources, and populations living in degraded habitats with scarce food resources. The effect of season and gender on the morphological parameters of lesser jerboas was also analysed.

Material and methods

The data were collected in autumn 2010, spring 2011 and summer 2011 in the semi–arid lands of the State of Kuwait. Two study sites were designated for the study purposes: intact and degraded habitat. The intact study area was the Kabd Research Station, which is located 35 km southwest of Kuwait City. Ground elevation in this area ranges between 70 and 130 m above sea–level (Misak et al., 2002). Dense vegetation covers the area and is dominated by the *Arfaj* shrubs (*Rhanterium epapposum* Oliv.) and other plants. It covers an area of 40 km^2. The area is fenced and protected, and human disturbance is minimal because free access is prohibited. This allows free foraging behavior for the lesser jerboas governed only by natural predation risk.

The degraded study area is an unprotected area with free access and many camps for sheep and camel herders. The area has poor vegetation cover of the same type found in protected areas, but found in scattered patches only. It is located almost 45 km to the west of Kuwait city. It is separated from the intact study area by almost 10 km and has a ground elevation ranging between 100 and 140 m.

Jerboas were captured over 24 nights for the three seasons (eight nights per season) for each of the sites, totaling 48 nights. The aim was to capture four jerboas per night to sample around 100 in each area. To achieve these figures, the capture effort almost doubled in the degraded areas where around five hours on average were spent per night, in contrast with around three hours on average in the protected areas. Animals were captured using a slowly–driven vehicle with powerful spotlights immediately after sunset when the animals start foraging for food. The lesser jerboas were blinded by the powerful light and they stopped moving provided no sounds were produced. To capture jerboas, a soft net with a long handle was used (a similar approach was followed by Happold, 1967).

Body weight, body length, tail length and thigh thickness of captured jerboas were measured. All jerboas were released at the point of capture immediately after

Table 1. Lesser jerboa mean weights (g), with 95% confidence intervals, in different seasons. The letters in superscript indicate a significant difference ($p < 0.05$).

Tabla 1. Pesos medios (g) de jerbo egipcio con intervalos de confianza del 95%, en diferentes estaciones del año. Las letras en forma de exponente indican una diferencia significativa ($p < 0,05$).

Season	Weight (g)
Autumn 2010	$60.09^{a} \pm 1.98$
Spring 2011	$61.55^{a} \pm 1.67$
Summer 2011	$55.94^{b} \pm 2.00$

taking the measurements that took only a few minutes. Juveniles, pregnant and lactating females were discarded from the study. The captures took place more than 100 m apart on each night and more than 500 m on different nights, providing a low probability of recapturing the same individual. Observations of gender and body weight measurements were done in the autumn. Body length, tail length and thigh thickness were additionally measured in the spring and summer.

An ANOVA followed by the Fisher's least significant differences post–hoc test was used to analyse differences in the body weights of jerboas in three different seasons (autumn 2010, spring 2010 and summer 2011). T–tests for independent samples were also used to analyse differences between gender and between habitats in the variable weight, and body length, tail length and thigh thickness (data from autumn 2010 only). Gender was used as the dependent variable in a logistic regression via generalized linear models, where the independent variables used were categorical habitat (intact and degraded), and covariates were all the measurements (data from autumn 2010 only). A backwards stepwise procedure for selection of significant variables and covariates was implemented, and those found significant ($p < 0.05$) were left in the model. The statistical package used was the SPSS© Statistics 19.

Results

A total of 198 lesser jerboas were caught for this study. In autumn 2010, n = 29 lesser jerboas were caught from the intact habitat and n = 26 from the deteriorated habitat. In spring 2011, n = 39 lesser jerboas were caught in the intact study site while n = 35 were captured in the deteriorated site, and in summer 2011, the captures were n = 36 and n = 33, in the intact and deteriorated habitats, respectively.

With regards to season, a significant difference ($p < 0.05$) was found in body weight between summer 2011 and the other seasons (autumn 2010, spring 2011), as summarised in table 1. With regards to gender, significant differences were found between male and female jerboas for body weight ($p < 0.001$), body length ($p < 0.001$) and tail length ($p < 0.001$). No significant differences ($p > 0.05$) were found for thigh thickness (as summarised in table 2).

With regards to habitat, significant differences were found between intact and degraded habitats for body weight ($p < 0.001$) and thigh thickness ($p < 0.01$), and no significant differences ($p > 0.05$) were found for body length and tail length, as summarised in table 3.

Table 2. Means with 95% confidence interval for the parameters body weight (g), body length (cm), tail length (cm) and thigh thickness (cm) in male and female lesser jerboas: ^{a} $p < 0.001$; ^{b} $p > 0.05$.

Tabla 2. Medias con intervalos de confianza del 95% para los parámetros peso (g), longitud del cuerpo (cm), longitud de la cola (cm) y grosor del muslo en los machos y las hembras de jerbo egipcio: ^{a} $p < 0,001$; ^{b} $p > 0,05$.

	Gender	
	Male	Female
Weight^{a}	55.52 ± 1.87	63.49 ± 1.71
Body^{a}	28.80 ± 0.60	30.61 ± 0.54
Tail^{a}	17.94 ± 0.43	19.10 ± 0.39
Thigh^{b}	9.45 ± 0.48	9.91 ± 0.44

Table 3. Means with 95% confidence interval for the parameters body weight (g), body length (cm), tail length (cm) and thigh thickness (cm) in lesser jerboas in the intact and degraded habitat: ^{a} $p < 0.001$); ^{b} $p < 0.01$; ^{c} $p > 0.05$.

Tabla 3. Medias con intervalo de confianza del 95% para los parámetros peso (g), longitud del cuerpo (cm), longitud de la cola (cm) y grosor del muslo en el jerbo egipcio, en hábitat intacto y degradado: ^{a} $p < 0,001$; ^{b} $p < 0,01$; ^{c} $p > 0,05$.

	Habitat	
	Intact	Degraded
Weight^{a}	63.58 ± 1.74	55.43 ± 1.83
Body^{c}	29.96 ± 0.56	29.44 ± 0.59
Tail^{c}	18.72 ± 0.40	18.32 ± 0.42
Thigh^{b}	10.27 ± 0.45	9.08 ± 0.47

Table 4. Logistic regression parameters to model gender in lesser jerboas, as a function of the factor habitat (intact or degraded) and the covariate weight (g).

Tabla 4. Parámetros de la regresión logística para la modelar el sexo de los jerbos egipcios en función del factor hábitat (intacto vs. degradado) y de la covariable peso (g).

	Variables in the equation							
	β	SE (β)	*p* value	95% CI (β)		OR (e^{β})	95% CI OR (e^{β})	
Intercept	–27.49	–7.45	< 0.001	–42.09	–12.89	$1.16 \cdot 10^{-12}$	$5.28 \cdot 10^{-19}$	$2.53 \cdot 10^{-6}$
Habitat								
Intact	–4.27	1.43	< 0.01	–7.07	–1.47	0.014	0.001	0.230
Degraded	0							
Weight	0.50	0.14	< 0.001	0.24	0.77	1.652	1.269	2.153

The body weights and thigh thickness of jerboas were found to be greater in the intact habitat.

In the logistic regression, the factor 'habitat' ($p < 0.01$) and the covariate 'body weight' ($p < 0.001$) were found to be significant to model gender. Table 4 shows the full description of the model parameters and the 95% confidence intervals for the respective values are also stated, together with the odd ratios. The graphs in figure 1 show the probability of being females in dependency of the variable and covariate considered in the model.

Discussion

The study shows that lesser jerboas in the intact, protected area with thicker vegetation cover have significantly greater body weight than those in the degraded habitat. The change of morphological measurements of mammals in different habitats is well documented in several studies (*e.g.* Heaney, 1978; Jennings et al., 2010). The abundance of biodiversity and food resources, with minimal disturbances, favours morphological changes towards increased body size in mammals. The extremely disrupted habitats in the State of Kuwait have been well documented (*e.g.* Omar, 2000; Omar et al., 2001; Misak et al., 2002). The effect of disrupted habitat on wildlife has also been monitored, mostly on the abundance of animals in different habitats rather than on morphological parameters (*e.g.* Al–Sdirawi, 1985; Taha et al., 2000; Delima et al., 2002; Zaman et al., 2005).

This pioneer study in Kuwait focused on determining the effects of habitat degradation on the morphology of lesser jerboas. The magnitude of damage on habitats in both study areas was fully described by Misak et al. (2002) and Omar et al. (2001). Within the enclosed intact habitat, *Rhanterium epapposum* shrubs and associated plant communities thrive, and they have a good ground cover compared to the surrounding non–protected and degraded areas. There is a direct relationship between the range of available and accessible food, and the body mass of animals, particularly mammals (Schoener, 1968; Harestad & Bunnell, 1979; Peters & Wassenberg, 1983). An increased body mass usually means an increase in the availability of large food quantities (positive correlation).

Another reason for differences in body weight between intact habitat and degraded habitat populations can be the dispersion and abundance of seeds in desert soils, which comprise the main source of energy in desert rodents' diets (Brown et al., 1994; Baker & Patterson, 2010). Seeds beneath shrubs are concentrated in densities that 5 to 10 times greater than those in open areas between shrubs (Nelson & Chew, 1977; Thompson, 1980). Therefore, when annual plants reach the end of their cycle, there are plenty of seeds available for consumption by desert rodents.

Body mass shows a highly significant positive correlation with the amount of annual rainfall (Abramsky et al., 1985). It may seem that the differences in body mass and other morphological parameters are related to possible differences in rainfall rates in the two areas, but the two study areas were located close to each other; they are separated by only 10 km and have similar elevation, averaging 100 m in the protected and 120 m in the degraded areas. The possibility of weight differences being attributed to rainfall differences can thus be ruled out.

Other body dimensions, such as body length and tail length, showed no difference in this study when comparing the degraded habitat to the intact habitat. The difference was seen in the thickness of the thigh (hind limb), with greater thigh thickness in jerboas in the intact habitat. This could be explained by the fact that lesser jerboas use bipedal hopping as an escape mechanism from predators. They can jump up to 2 m high and jump while running in different directions. The increased thickness of the muscle tissues in the hind limb improves the animal´s jump performance (Alexander et al., 1981; Perry et al.,

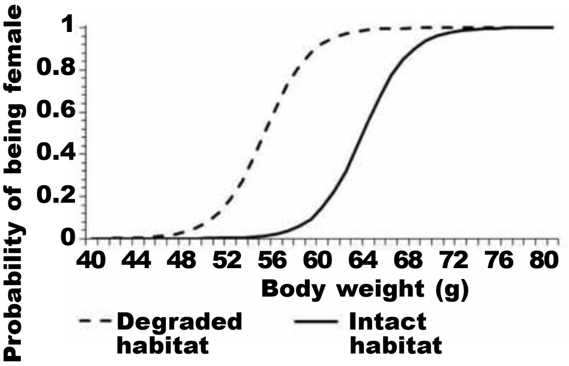

Fig. 1. Logistic regression modelling the weight (g) dynamics of lesser jerboa in dependency of its gender and habitat

Fig. 1. Regresión logística modelando la dinámica del peso (g) del jerbo egipcio en función del sexo y tipo de hábitat.

1988; Taraborrelli et al., 2003; James et al., 2007). Intact areas contain a higher number of predators (Zaman et al., 2005) than the degraded habitats. Therefore, lesser jerboas in the protected areas might be under a higher predation risk than animals living in unprotected, degraded habitats.

Sexual dimorphism in body size has been well defined as the difference in mean body size of males and females. This occurs in rodents and other animals (Ralls, 1976, 1977) and is traditionally explained by sexual selection acting on males (Lammers et al., 2001). Ralls (1976) explained that larger body sizes in females was the result of selection, favouring smaller males in mating systems where male reproductive success is related to encounter rate with females and where smaller males may be favoured when food is limited (a trade–off between foraging and mate acquisition favouring smaller males with regards to mate acquisition). Dimorphism in monogamous species is less pronounced than in species with more promiscuous habits (Dewsbury et al., 1980). Sachser et al. (1999) determined that the rodent *Galea musteloide* has a promiscuous mating system in smaller males, as reproduction is decided by sperm competition rather than male–male contest, which appears to result in greater offspring survival. The lesser jerboa is a solitary species; males and females meet during the mating season and the female is left alone to breed and nurse the offspring. Some studies (Krasnov et al., 2005), nevertheless, suggest that sexual differences in body size are related to foraging behaviour and the home range of each sex. Therefore, the more active the foraging animal, the larger it is. This indicates that female lesser jerboas have a wider home range and forage for food more frequently than males. This is a reasonable interpretation of the results, since females have to carry and nurse the offspring. Female lesser jerboas have to store as much fat as possible to feed their young. Body length and tail length are related to the animal's body size. Many others species of desert rodents are social; the males are subject to sexual selection, and they also play a role in nurturing the young.

The results also revealed that weight of the lesser jerboa changes with the seasons. Greater body weights were seen in spring and autumn than in summer. This could be because of the availability of feed resources, which depends on the annual rain cycles. The annual rain cycle in Kuwait is concentrated in autumn and winter, with year accumulations lower than 100 mm (Zaman, 1997). The annual plants flourish with the onset of rainfall in arid lands in the autumn and complete their life cycles in the spring. Seeds of annual plants germinate and produce seeds in a very short life span. Annual plants form most of the vegetation cover in Kuwait (Zaman, 1997; Brown, 2002), and the protein levels of annual grasses decrease immediately after blooming, with seed formation. Lesser jerboas can also extract moisture from these annual plants that are abundant in the autumn and spring. Consequently, body condition is better in autumn and spring in preparation for the winter hibernation and summer shortage.

The findings in this study clearly show that a degraded habitat has a negative effect on the body weight and dimensions of lesser jerboas. Lower body weight may decrease the winter survival rate and negatively impact on the lesser jerboa population size and distribution in the degraded habitat.

References

Abramsky, Z., Brand, S. & Rosenzweig, M., 1985. Geographical ecology of gerbilline rodents in sand dune habitats of Israel. *Journal of Biogeography*, 12: 363–372.

Alexander, R., Jayes, A., Maloiy, G. & Wathuta, E., 1981. Allometry of the leg muscles of mammals. *Journal of Zoology*, 194: 539–552.

Al–Sidrawi, F., 1985. *Conservation and protection of the wildlife in Kuwait (phase I): review and assessment of information on desert fauna. Final Report*. Kuwait Inst. for Scientific Research, Kuwait.

Baker, M. & Patterson, B., 2010. Patterns in the local assembly of Egyptian rodent faunas: Areography and species combinations. *Mammalian Biology,* 75: 510–522.

Brown, G., 2002. Species richness, diversity and biomass production of desert annuals in an ungrazed Rhanterium epapposum community over three growth seasons in Kuwait. *Plant Ecology*, 165: 53–68.

Brown, J., Kotler, B. & Mitchell, W., 1994. The foraging theory, patch use and the structure of a Negev desert granivore community. *Ecology,* 75: 2286–2300.

Brown, J., Marquet, P. & Taper, M., 1993. Evolution of body size: consequences of an energetic definition of fitness. *American Naturalist*, 142: 573–584.

Delima, E., Peacock, J. & Khalil, E., 2002. *Bibliographic list of the wildlife fauna of Kuwait.Technical Report.* Kuwait Inst. for Scientific Research, Kuwait.

Demment, M. & Van Soest, P., 1985. A nutritional explanation for body–size patterns of ruminant and nonruminant herbivores. *American Naturalist*, 125: 641–672
Dewsbury, D., Baumgardner, D., Evans, R. & Webster, D., 1980. Sexual dimorphism for body mass in 13 taxa of Muroid rodents under laboratory conditions. *Journal of Mammalogy*, 61: 146–149.
French, A., 1988. The patterns of hibernation. *American Scientist*, 76: 569–575.
Geiser, F., 2004. Metabolic rate and body temperature reduction during hibernation and daily torpor. *Annual Review of Physiology*, 66: 239–274.
Happold, D., 1967. Biology of the jerboa, *Jaculus jaculus butleri* (*Rodentia, Dipodidae*), in the Sudan. *Journal of Zoology*, 151: 257–275.
Harestad, A. & Bunnell, F., 1979. Home range and body weight a re–evaluation. *Ecology*, 60: 389–402.
Heaney, L., 1978. Island area and body size of insular mammals: evidence from the tri–colored squirrel (*Callosciurus prevosti*) of Southeast Asia. *Evolution*, 32: 29–44.
Isaac, J., 2005. Potential causes and life–history consequences of sexual size dimorphism in mammals. *Mammal Review*, 35: 101–115.
James, R. & Navas, C. & Herrel, A., 2007. How important are skeletal muscle mechanics in setting limits on jumping performance? *The Journal of Experimental Biology*, 210: 923–933.
Jennings, A., Zubaid, A. & Veron, G., 2010. Range behavior, activity, habitat use, and morphology of the Malay civet (*Viverra tangolunga*) on peninunsular Malaysia and comparison with studies on Borneo and Sulawesi. *Mammalian Biology*, 75: 437–446.
Krasnov, B., Morand, S., Hawlena, H., Khokhlova, I. & Shenbrot, G., 2005. Sex–biased parasitism, seasonality and sexual size dimorphism in desert rodents. *Oecologia*, 146: 209–217.
Lammers, A., Dziech, H. & German, R., 2001. Ontogeny of sexual dimorphism in *Chinchilla lanigera* (Rodentia: Chinchillidae). *Journal of Mammalogy*, 82: 179–189.
Misak, R., Al–Awadhi, J., Omar, S. & Shahid, S., 2002. Soil degradation in Kabd area, southwestern Kuwait City. *Land degradation & development*, 13: 403–415.
Nelson, J. & Chew, R., 1977. Factors affecting seed reserves in the soil of a Mojave Desert ecosystem, Rock Valley, Nye County, Nevada. *American Midland Naturalist*, 97: 300–320.
Omar, S., 2000. *Vegetation of Kuwait: a comprehensive illustration guide to the flora and ecology of the desert of Kuwait*. Kuwait Inst. for Scientific Research, Kuwait.
Omar, S., Misak, R., King, P., Shahid, A., Abo–Rizq, H., Grealish, G. & Roy, W., 2001. Mapping the vegetation of Kuwait through reconnaissance soil survey. *Journal of Arid Environments*, 48: 341–355.
Perry, A., Blickhan, R., Biewener, A., Heglund, N. & Taylor, C., 1988. Preferred speeds in terrestrial vertebrates: are they equivalent? *Journal of Experimental Biology*, 137: 207–219.
Peters, R. & Wassenberg, K., 1983. The effect of body size on animal abundance. *Oecologia (Berl.)* 60: 89–96.
Ralls, K., 1976. Mammals in which females are larger than males. *Quarterly Review of Biology*, 51: 245–276.
– 1977. Sexual dimorphism in mammals: avian models and unanswered questions. *American Naturalist*, 111: 917–938.
Sachser, N., Schwarz–Weig, E., Keil, A. & Epplen, J., 1999. Behavioural strategies, testis size, and reproductive success in two caviomorph rodents with different mating systems. *Behaviour*, 136: 1203–1217.
Savage, V., Gillooly, J., Brown, J., West, G. & Charnov, E., 2004. Effects of body size and temperature on population growth. *American Naturalist*, 163: 429–441.
Schoener, T., 1968. Sizes of feeding territories among birds. *Ecology*, 49: 123–141.
Schorr, R., Lukacsb, P. & Florant, G., 2009. Body mass and winter severity as predictors of overwinter survival in Preble's Meadow jumping mouse. *Journal of Mammalogy,* 90: 17–24.
Taha, F., White, P., Cowan, P., Delima, E., Al–Hadad, A., Al–Ragam, O. & Al–Mutawa, S., 2000. *Collection and holding of living desert fauna specimens for the scientific center. Final Report, 5909*. Kuwait Inst. for Scientific Research, Kuwait.
Taraborelli, P., Corbalán, V. & Giannoni, S., 2003. Locomotion and Escape Modes in Rodents of the Monte Desert (Argentina). *Ethology,* 109: 475–485.
Thomas, D., 1993. Sandstorm in a teacup? Understanding Desertification. *The Geographical Journal*, 159: 318–311.
Thompson, S., 1980. *Microhabitat use, foraging behavior, energetics and community structure of heteromyid rodents. Dissertation*. Univ. of California, Irvine, California, USA.
Visser, M., 2010. Climate change: Fatter marmots on the rise. *Nature* 466: 445–447.
Whitford, W., 2002. *Ecology of desert systems*. Elsevier Science, London.
Zaman, S., 1997. Effects of rainfall and grazing on vegetation yield and cover of two arid rangelands in Kuwait. *Environmental Conservation*, 24: 344–350.
Zaman, S., Peacock, J., Al–Mutairi, M., Delima, E., Al–Othman, A., Loughland, R., Tawfiq, H., Siddiqui, K., Al–Dossery, S. & Dashti, J., 2005. *Wildlife and vegetation survey (Terrestrial Cluster 3) Addendum 2. Final Report, 7885*. Kuwait Ins. for Scientific Research, Kuwait.