

Diet and daily activity patterns of the lacertid lizard *Psammodromus algirus* (Sauria: Lacertidae) in a semi-arid Mediterranean region

Idriss Bouam^a, Abdeldjabar Necer^b, Messaoud Saoudi^b, Larbi Tahar-Chaouch^c and Farouk Khelifaoui^a

^aFaculty of Natural and Life Sciences, Department of Ecology and Environment, University of Batna 2, Batna, Algeria; ^bFaculty of Natural and Life Sciences, Department of Biology, University of El Tarf, El Tarf, Algeria; ^cForest Conservation of Batna City, Batna, Algeria

ABSTRACT

The large psammodromus, *Psammodromus algirus*, is one of the most widespread Mediterranean lacertid lizards; unfortunately, its ecology in North Africa remains understudied. In this study, we present detailed data on trophic ecology, daily activity patterns during the breeding season, and the maximum activity period of this lizard in a semi-arid environment at Belezma National Park (Batna, northeast Algeria). Feeding data were collected using stomach flushing, and daily activity patterns were analyzed by surveying standardized transects. Analysis of the contents of 21 stomachs revealed 238 prey items of 74 different taxa classified into five classes, 18 orders, 50 families, and 71 different genera. The diet was highly diverse and primarily consisted of arthropods. Insects were the predominant food comprising 85% of all prey, followed by arachnids (13%). Regarding temporal variation in diet, prey-species richness did not vary noticeably between months; however, the number of individuals within prey categories did. The size of prey consumed varied over a very broad spectrum and followed a logarithmic distribution, but did not vary between months. Concerning daily activity, lizards exhibited a bimodal activity pattern. Overall, compared to littoral and European populations studied in other works, diet differed slightly and daily activity was remarkably reduced in the morning and postponed in the afternoon.

ARTICLE HISTORY

Received 3 March 2016
Accepted 30 May 2016

KEYWORDS

Lacertidae; large psammodromus; diet; daily activity patterns; Belezma National Park; Algeria

Introduction

Early research findings (e.g. Avery 1976) have suggested the existence of interrelationships between climatic conditions, activity patterns, thermoregulation, diet, metabolism, social behavior, and life-history among lacertid lizards. Thus, gathering all this information on a given species is necessary to interpret its ecology.

In the Mediterranean Basin, lacertid lizards colonize a great variety of habitats in which they prey upon arthropods, small invertebrates and even on some vertebrates and plant matter (Carretero 2004). On the contrary, snakes, carnivorous mammals and raptors prey on them (Schleich, Kästle, and Kabisch 1996). As a result of this context, lacertid lizards have an important position in the transfer of matter and energy in food webs within the Mediterranean ecosystems as intermediary between invertebrates and endothermic vertebrates (Valverde 1967). In addition, activity patterns along with food consumption are known to be dependent on one another as two of the major ecological niche dimensions of lacertid lizards (for more details see Avery 1978; Huey and Pianka 1983). Thus, understanding the link between activity patterns and diet is crucial to assess broader issues related

to the dynamics of their use of their ecological niche (Tracy and Christian 1986; Vanhooydonck, Herrel, and Van Damme 2012).

Found in almost the entire Iberian Peninsula, along the Mediterranean coast of France, in the island of Lampedusa and in North Africa from southern Morocco to the northern half of Tunisia, the large psammodromus, *Psammodromus algirus*, is one of the most common Mediterranean lacertids (Schleich, Kästle, and Kabisch 1996; Sindaco 2006; Sillero et al. 2014). The ecology and, more specifically, the diet of this species are relatively well known and European populations have been the subject of several studies over the last decades (e.g. Valverde 1967; Mellado et al. 1975; Di Palma 1984; Carretero and Llorente 1993; Lo Cascio and Corti 2008). On the contrary, studies on diet and activity patterns of the large psammodromus in North Africa are still scarce with only two studies carried out in coastal areas (Arab and Doumandji 2003; Rouag et al. 2007), despite the facts that broadly distributed lacertid populations should show geographic variation in their diet and activity patterns according to climatic conditions (Carretero 2004; Zamora-Camacho et al. 2013). Unfortunately, in the

regions of the Algerian hinterlands where the climate is Mediterranean with Saharan influences, the diet of this species remains unknown.

This study aims mainly to analyze the trophic and daily activity patterns of the large psammodomus. In addition, by providing new data, we test whether daily activity patterns, the composition, diversity, and size of consumed prey differ from those reported in other studies from wetter and colder regions.

Materials and methods

Study area

This study was carried out in Belezma National Park (35°30'N–35°41'N, 05°54'E–06°18'E, average elevation: 1250 m a.s.l.), located in the province of Batna, north-east Algeria. This protected area is ecologically important because of its unique natural features (UNESCO 2015) and its location in an area of great Saharan and Mediterranean influences (Abdessemed 1981). Within the park, this study was conducted near the town of Bouilef (elevation: 1150 m a.s.l.), in a wooded area crossed by a permanent watercourse named Oued Bouilef that is characterized by a semi-arid Mediterranean climate with hot dry summers (32–38 °C) followed by cold wet winters (2–7 °C). The area mainly consists of herbaceous plants, low maquis-type vegetation (primarily *Calycotome spinosa*, *Olea europaea*, *Phillyrea angustifolia*, *Pistacia lentiscus* and *Rosmarinus officinalis*), and trees (mainly *Juniperus oxycedrus*, *Juniperus phoenicea*, *Pinus halpensis* and *Quercus ilex*) (Tahar Chaouch 2012).

Sampling

Surveys were performed during the day in favorable meteorological conditions (warm sunny weather) with a frequency of six surveys per month ($n = 12$ surveys), during May and June 2013. These two months represent the breeding season, as well as the period of maximum activity of the large psammodomus in our study area. This information is based on our personal observation, given that, to our knowledge, there is no available data from Algeria about these periods. In addition, mating and maximum activity periods can vary geographically according to climatic conditions among these lacertid lizards (Zamora-Camacho et al. 2013), thus, using data from studies on European populations might bias our results. Surveys were carried out by walking very slowly in a single direction along standardized transects (i.e. 2000-m-long linear transects, with a 6-m-wide belt, 3 m on each side, laying along a homogeneous vegetation structure). Each transect was explored only once. To avoid statistical problems due to pseudo-replication of data, transects were independent from each other, excluding the possibility of exchanges between individuals taking into account the home-range of this species following Civantos (2000).

In order to analyze the diet patterns of this lizard, a relatively small but representative number of adult specimens (21 specimens: $n_{\text{May}} = 8$, $n_{\text{June}} = 13$) were noosed or caught by hand. The criterion used to identify adults was having a snout-to-vent length (SVL) greater than the minimum size at sexual maturity (55.0 mm) (Carretero 2002). It is noteworthy that a relatively low sample size was due to the dense vegetation constitution of our study area. Vanhooydonck and Van Damme (2003) observed that lacertid lizards run towards patches of dense vegetation, which constitute a safe harbor when approached by human 'predators.' In addition, Martín and López (1995) reported that the large psammodomuses flee to a safe refuge as soon as a predator is detected. Thus, collecting more individuals would have been hard to achieve. Each individual was sexed from its outer secondary sexual characteristics following Carretero (2002) and Díaz, Alonso-Gómez, and Delgado (1994), where orange infralabials occur almost exclusively in adult males, the latter also show more ocelli and a blue area on their body sides compared to adult females, also, femoral pores among males are larger and more numerous. In addition, the SVL of every individual was measured to the nearest 0.1 mm using a digital caliper. We were able to successfully collect the stomach contents of all individuals using stomach flushing (Legler and Sullivan 1979). Pincheira-Donoso (2008) suggested that this method should be the preferred one for analyzing most lacertid lizards diets, as it has the advantage of making soft parts of the food available easily identifiable. We used syringes with the tip covered with rubber to flush the stomach contents of the lizards. The rubber cover reduced injuring the lizards during the procedure. We also used plastic segmented rings to keep the mouth of the lizard open during the process. At the end of the procedure, we released each lizard in the exact place of its capture within a maximum of 24 h. The consumed prey items were examined under a binocular magnifier and classified by taxonomic category (except for Formicidae, which were separated from other Hymenoptera because of their non-flying and aggregated nature) to the lowest possible operational taxonomic units, OTUs (Sneath and Sokal 1962).

To estimate prey size, an eyepiece micrometer was used to measure the size of intact or nearly intact prey. Identifiable anatomical parts were used to estimate the total prey size of incomplete prey using the regression equations for each taxonomic group following Hódar (1997).

Analysis of the daily activity was performed during different days than those in which we performed the sampling for the diet with a frequency of three sampling days per month. We observed lizards using field glasses without approaching individuals because of the species anti-predator behavior (for more details see Martín and López 1995). Hence, determining sex was unfeasible. Overall, 48 adult individuals ($n_{\text{May}} = 28$, $n_{\text{June}} = 20$) were

Table 1. Number of individuals (N), species richness (SR), occurrence frequency (Occ) and occurrence scale (Occ scale) of prey orders found in the large psammomys stomach contents at Belezma National Park (northeast Algeria).

Prey orders	N	SR	PF (%)	Occ (%)	Occ scale
Canalipalpata	1	1	0.42	4.76	HR
Opiliones	5	1	2.1	14.28	RE
Araneae	23	5	9.66	33.33	CM
Acari	2	1	0.84	9.52	RE
Chilopoda	1	1	0.42	4.76	HR
Amphipoda	1	1	0.42	4.76	HR
Isopoda	3	1	1.26	9.52	RE
Odonatoptera	1	1	0.42	4.76	HR
Orthoptera	4	3	1.68	14.28	RE
Dermaptera	4	1	1.68	14.28	RE
Blattoptera	2	1	0.84	9.52	RE
Hemiptera	17	3	7.14	28.57	CM
Coleoptera	63	23	26.46	95.23	CN
Neuroptera	2	2	0.84	9.52	RE
Formicidae	14	7	5.88	38.09	CM
Hymenoptera	40	10	16.8	80.95	CN
Trichoptera	5	1	2.1	9.52	RE
Lepidoptera	9	1	3.78	14.28	RE
Diptera	41	10	17.22	52.38	CN

observed. We considered nine hourly intervals (from 8:00 to 17:00), then we assigned each individual observed to its appropriate daytime interval (for a similar methodology see Rouag et al. (2007)).

Data analysis

The number of individuals n_i was calculated for each prey category, then the prey frequency (PF) was estimated as a fraction of prey category i to the total number of prey-categories individuals (N). Species richness (SR) was assessed as the total number of prey-species identified (Magurran 2004). The mean species richness (S_m) per stomach content was calculated as the average number of prey-species observed in all lizards.

Shannon-Weaver's index ($H' = -\sum p_i \log_2 p_i$, where $p_i = n_i/N$) and evenness index ($E = H'/H_{\max}$, where $H_{\max} = \log_2 SR$) were calculated to assess diet diversity. Frequency of occurrence (Occ) was calculated for each taxonomic order by dividing the number of stomachs in which the order was found by the total number of stomachs examined (Magurran 2004). Each order was assigned to one of four groups based on its occurrence frequency: highly rare prey (HR) (<12.5%); rare prey (RE) (12.5–24%); common prey (CM) (25–49%) and constant prey (CN) ($\geq 50\%$).

No analysis of intersexual dietary differences was performed in this study due to a relatively small sample size (i.e. 6 males and 15 females).

For the daily activity analysis, the mean number and not the total number of lizards observed at each hourly interval was used to minimize the risk of possible statistical errors (Oksanen 2001).

All statistics were computed using the statistical package R-commander {Rcmdr} (Fox 2005).

Results

Diet composition

The analysis of 21 stomach contents revealed 238 prey items belonging to 74 different taxa in five classes, 18 orders, 50 families and 71 different genera (Appendix A), as well as very small plant fragments and a feather of an unidentified chick.

Overall, the diet was almost entirely composed of arthropods, except for an aquatic annelid prey. Insects were the predominant food during the entire study, with 202 individuals representing a prey frequency of 84.84% of all prey, followed by arachnids with 30 individuals (PF = 12.6%); other classes were rarely consumed. Among the insects, three prey categories were persistently consumed: Coleoptera, Diptera and Hymenoptera. Coleoptera ranked first with 63 individuals (PF = 26.46%) and 23 species (particularly the species *Prasocuris phellandrii*), followed by Diptera with 41 individuals (PF = 17.22%) and 10 species, and finally Hymenoptera with 40 individuals (PF = 16.8%) and 10 species (Table 1).

Temporal variation of the diet

On average, the number of prey individuals was 11.33 ± 6.42 per stomach content, with values of 8.33 ± 2.95 and 13.58 ± 7.46 for the months of May and June, respectively. During the two months, the diet was diverse and the representation of prey in stomach contents was uniformly distributed with the same value of evenness ($E = 0.5$) (Table 2).

Chi-square analyzes revealed a significant difference in the number of individuals in prey categories between the two study months ($\chi^2 = 32.36$, $df = 18$, $p = 0.01$). However, the test was not significant for prey-species richness ($\chi^2 = 9.56$, $df = 18$, $p = 0.94$).

Table 2. Temporal variation in the number of individuals (N), prey frequency (PF), species richness (SR), Shannon's diversity index (H') and Shannon's evenness index (E) of the prey-species identified in the stomach contents of the large psammodomus at Belezma National Park (northeast Algeria).

Diet characteristics	May	June	Total
Number of sampled lizards	8	13	21
Number of individuals N	75	163	238
Prey frequency PF (%)	31.51	68.48	100
Mean N per stomach content Nm	8.33 ± 2.95	13.58 ± 7.46	11.33 ± 6.42
Species richness SR	38	61	74
Mean SR per stomach content Sm	5.22 ± 2.43	9.00 ± 3.19	7.38 ± 3.41
Shannon's index H' (bits)	2.66	3.01	3.02
Evenness E	0.5	0.5	0.48

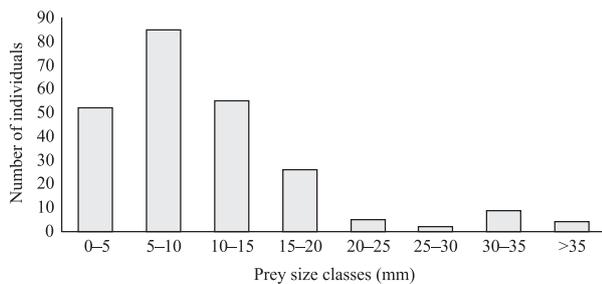


Figure 1. Prey size categories consumed by the large psammodomus at Belezma National Park (northeast Algeria).

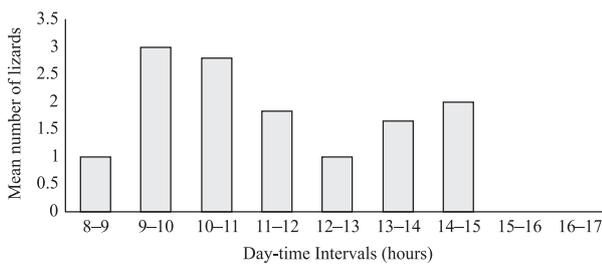


Figure 2. Daily activity patterns of the large psammodomus at Belezma National Park (northeast Algeria).

Prey size

Overall, the size of prey consumed by the large psammodomus varied across a very broad spectrum, ranging from 0.5 to 50.1 mm (mean ± SE = 10.12 ± 3.84 mm) and followed a logarithmic distribution (Figure 1).

The size of commonly consumed prey classes did not vary between the two study months (independent samples *t*-test, $t = -0.24$, $df = 16$, $p = 0.81$). In addition, no significant correlation was detected between SVL and average size of all consumed prey (Pearson correlation, $t = -0.08$, $df = 21$, $p = 0.38$), nor was there correlation between SVL and the largest prey from each stomach ($t = 0.54$, $df = 21$, $p = 0.59$). However, when we limited the analysis to the larger Coleopteran prey (which were the most consumed taxonomic group) from each stomach content, a significant correlation between SVL and prey size was detected ($t = 0.48$, $df = 20$, $p = 0.03$).

Daily activity

Over the entire study, lizards exhibited a similar daily activity pattern ($t = -0.37$, $df = 16$, $p = 0.97$). The pattern

was clearly bimodal with two peaks of activity; the first one occurred in the morning (from 9:00 until 12:00) in which we observed a maximum of specimens (77% of all observed individuals), while the second one was more limited and occurred in the late mid-day (i.e. 13:00–14:00 during May and 14:00–15:00 during June) (Figure 2).

Discussion

This study expands our knowledge of the composition, diversity and size of consumed prey in the diet of the large psammodomuses by analyzing their stomach contents. This technique has helped identify prey such as worms and spiders, neglected in previous studies because of their high digestibility (Pérez-Mellado et al. 2011). In addition, this work has shed light on the patterns of the daily activity of this lizard during its breeding season, as well as the period of maximum activity in an Algerian semi-arid Mediterranean region, where no prior research had been carried out.

The large psammodomus proved to have a very diverse diet like most lacertids (Carretero 2004), and therefore our results are not surprising. Its diet was composed mainly of arthropods with insects as the most abundant prey, followed by arachnids. Insects mostly included Coleoptera, Diptera and Hymenoptera. Our results are consistent with those of Arnold (1987) and Arnold and Ovenden (2002) and confirm that the general diet of mainland lacertids is mainly limited to arthropods (principally insects) and arachnids. However, a more detailed comparison with other studies on the trophic ecology of the large psammodomus showed variation in prey frequencies (Table 3). The latter might be due to two main factors: (i) the availability of food resources (Arnold 1987) and (ii) foraging mode strategy (Schoener 1971; Stephens and Krebs 1986). A comparison of our results with those of Tahar Chaouch (2012) who carried out an ecological diagnosis in the same study area (including the months of May and June) suggests food availability is a reason for the observed diet variation, where Coleoptera, Diptera, Hymenoptera and Lepidoptera were reported to be the most abundant taxonomic groups (>10%). These results correspond to the same prey frequencies consumed by lizards in this study (see Table 1), except for Lepidoptera. The divergence in food composition might also be due to the foraging mode. Arnold (1987) notes

Table 3. Diet composition of other populations of the large psammomorphus for abundant prey categories (>5% of sampled diet) according: (a) Arab and Doumandji (2003); (b) Carretero and Llorente (1993); (c) Di Palma (1984); (d) Rouag et al. (2007); (e) Seva (1984); and (f) Valverde (1967).

Prey type	Algiers (Algeria) (a)	Ebro Delta (Spain) (b)	Lampedusa (Italy) (c)	El Kala (Algeria) (d)	Alicante (Spain) (e)	Almeria (Spain) (f)
Isopoda	–	5.4	–	–	–	–
Araneae	26.2	10.3	10	13.6	8.1	–
Orthoptera	–	–	–	12.5	25.3	7.1
Embioptera	9.1	–	–	–	–	–
Hemiptera	11.2	17.2	8.6	–	24.2	–
Heteroptera	–	9.6	–	–	–	–
Coleoptera	8.6	13.4	16.2	23.8	32.9	52.1
Hymenoptera	10.2	–	–	–	–	–
Formicidae	–	–	20.3	12.5	–	14.8
Lepidoptera	5.3	–	–	–	–	–
Diptera	5.9	27	–	28.4	–	10

that continental populations of lizards tend to use the 'sit and wait' strategy while island populations tend to use active foraging strategies. To determine which factors are the most influential for this species, future studies should include a food availability analysis and quantify the foraging behavior of this species in our study area.

To our knowledge, no studies on the diet of the large psammomorphus have reported the existence of aquatic prey, with the exception of Carretero (1993) where he observed the consumption of an amphipod from the Gammaridae family by an adult male lizard. In the present study, in addition to the presence of an individual from the Gammaridae family, we also found a freshwater annelid worm from the Polychaeta class. Sabo and Power (2002a, 2002b) report that flooding from watercourses can drive out to terrestrial portions a low amount of aquatic prey, which can be consumed by many animals, including lizards. This is presumably the reason for the aquatic prey's presence in the diet.

Plant matter consumption was very low (i.e. only some plant fragments) in our study, which is similar to the results obtained by Carretero and Llorente (1993) and Rouag et al. (2007). However, results from other studies (Di Palma 1984; Seva 1984; Lo Cascio and Corti 2008) demonstrate that this lizard is able to feed on substantial quantities of plant matter. Nonetheless, such shifts in the feeding ecology are most frequent in island ecosystems and usually associated to situations of low arthropod availability (Pérez-Mellado and Corti 1993).

The presence of a feather from an unidentified chick in one lizard stomach may reflect a foraging behavior similar to the one reported by Delaugerre et al. (2012) in Mediterranean islands where lacertid lizards (e.g. *Podarcis gaigeae*, *Podarcis tiliguerta*) feed on remains of prey captured and carried to the nest by the Eleonora falcon. Civantos et al. (2013) observed the same probable commensalism among the skink *Chalcides parallelus* feeding on invertebrates from nests of seagulls.

Temporal variations in the number of prey individuals observed are usually associated with the climate and vegetation structure, which differ from one time to another and naturally influence the availability and abundance of

invertebrates (Wolda 1988). However, no significant variation of the prey-species richness among months was detected. These results are similar to the ones reported by Díaz and Carrascal (1993) where they observed constant prey-species richness even when prey availability fluctuated in time. According to Carretero (2004), among other species of lacertids, such results are not related to optimization strategies of time or energy. However, it suggests the existence of nutritional constraints such as avoidance of toxins that exist in certain prey.

The ranges of prey sizes consumed by the large psammomorphus are typical among medium-sized lacertids (Carretero and Llorente 1993), except for a centipede larger than 50 mm. The logarithmic distribution pattern of prey size among lizards is interpreted as a lack of selection (Pianka 1986). Unlike our results, those of Díaz and Carrascal (1993) which covered two distinct time periods (i.e. the reproductive and the post-breeding seasons) showed that prey size varied in time. Such differences might be related to changing the foraging strategy, which is linked to the phenology of this species (for more details see Díaz, Alonso-Gómez, and Delgado (1994)), or it might be due, simply, to the differences in studied periods. The lack of correlation between prey size and SVL among lizards is typical and occurs only when the biggest prey consumed by an individual is considered (e.g. Carretero 2004; Coleoptera in this study). These correlations depend also on the sample size and the SVL of lizards (Carretero and Llorente 1991). Still, a more detailed analysis of predator-prey size relationships would require quantifying the foraging behavior of lizards in our study area among both sexes and with a larger sample size.

Concerning daily activity patterns, Foà and Bertolucci (2002) note that lacertids reduce their daily activity during the summer months when soil temperatures are above 40 °C around midday and thus their daily activity becomes bimodal. This is a survival strategy to prevent overheating. Bimodal daily activity periods are frequent in summer months and low during the other months when it has no recognizable adaptive significance. Our results were substantially different from those of Pollo

and Pérez-Mellado (1989) and Rouag et al. (2007). The two studies reported a shift from a unimodal activity pattern in spring to a bimodal one in summer. In addition, compared to their results we noticed that large psammomus daily activity in our study area was moderately delayed in the morning and remarkably reduced and postponed in late mid-day. This is one of the most common mechanisms of unfavorable climate avoidance used by lizards, which consist of reducing the activity to daily or even yearly periods of time when climatic conditions are less extreme (e.g. extreme temperatures, limited water supply or other exogenous factor) (Polis 1991; Winne and Keck 2004).

A host of interesting questions remains to be examined in more details by future studies. In particular, the sample size should be increased and seasonal variations included because of potential changes in the preferences of the species and/or availability of prey, as well as variations between age groups or sexes. In addition, the activity of lizards, as ectotherms, is highly related to temperature (see Bennett 1980; Hertz, Huey, and Stevenson 1993), thus, by including data about ambient temperature in future studies, interesting relationships may arise.

Acknowledgments

We express our most sincere thanks to S. Abderrahmani, the director of Belezma National Park for allowing us to carry out the research and providing collecting permits. Guidelines for use of live reptiles in field research were in agreement with current laws and standard rules of Algeria. We appreciate the tremendous assistance of C. Benbouda and A. Bouteghriout in fieldwork. We are grateful to Prof. A. Si Bachir (University of Batna 2, Algeria) for permitting us to use the facilities of the laboratory Laboratoire d'Ecologie et Environnement while conducting this study, and Dr K. Brahmi (University of Tizi-Ouzou, Algeria) for her help in the identification of the large psammomus prey. Two anonymous reviewers helpfully commented on an early version of this manuscript. We also thank Dr N. M. Gordon (University of Evansville, USA) for his help in language editing.

References

- Abdessemed, K. 1981. "Le cèdre de l'Atlas dans les massifs de l'Aurès et du Belezma. Étude phytosociologique et problèmes de conservation et d'aménagement." [The Atlas Cedar in the Massifs of Aures and Belezma. A Phytosociological Study and Conservation Plus Management Issues.] PhD diss., Aix-Marseille University, France.
- Arab, K., and E. Doumandji. 2003. "Étude du régime alimentaire de la Tarente de Mauritanie *Tarentola mauritanica* (Linné, 1758) (Gekkonidae) et le Psammodrome algire *Psammodromus algirus* (Linné, 1758) (Lacertidae) dans un milieu sub-urbain près d'Alger." [Diet of the Common Wall Gecko *Tarentola mauritanica* (Linné, 1758) (Gekkonidae) and the Large *Psammodromus* *Psammodromus Algirus* (Linné, 1758) (Lacertidae) in a Suburban Area Near Algiers.] *Bulletin de la Société Herpétologique de France* 106: 10–16.
- Arnold, E. N. 1987. "Resource Partition among Lacertid Lizards in Southern Europe." *Journal of Zoology* 1: 739–782.
- Arnold, E. N., and D. W. Oviden. 2002. *A Field Guide to the Reptiles and Amphibians of Britain and Europe*. London: Harper-Collins.
- Avery, R. A. 1976. "Thermoregulation, Metabolism and Social Behavior in Lacertidae." In *Morphology and Biology of Reptiles*, edited by A. D. Bellairs and C. B. Cox, 245–259. Linnean Society of London.
- Avery, R. A. 1978. "Activity Patterns, Thermoregulation and Food Consumption in two Sympatric Lizard Species (*Podarcis muralis* and *P. sicula*) from Central Italy." *The Journal of Animal Ecology* 47: 143–158.
- Bennett, A. F. 1980. "The Thermal Dependence of Lizard Behaviour." *Animal Behaviour* 28: 752–762.
- Carretero, M. A. 1993. "Ecología de los lacértidos en arenas costeros del noreste ibérico." [Ecology of Lacertids in Northeastern Iberian Coastal Sandbanks.] PhD diss., University of Barcelona, Spain.
- Carretero, M. A. 2002. "Sources of Colour Pattern Variation in Mediterranean *Psammodromus Algirus*." *Netherlands Journal of Zoology* 52: 43–60.
- Carretero, M. A. 2004. "From Set Menu to a La Carte. Linking Issues in Trophic Ecology of Mediterranean Lacertids." *Italian Journal of Zoology* 71 (Suppl. 2): 121–133.
- Carretero, M. A., and G. A. Llorente. 1991. "Alimentación de *Psammodromus hispanicus* en un arenal costero del noreste ibérico." [Feeding Behavior of *Psammodromus hispanicus* in a Northeastern Iberian Coastal Sandbank.] *Revista Española de Herpetología* 6: 31–44.
- Carretero, M. A., and G. A. Llorente. 1993. "Feeding of Two Sympatric Lacertids in a Sandy Coastal Area (Ebro Delta, Spain)." In *Lacertids of the Mediterranean Region: A Biological Approach*, edited by E. D. Valakos, W. Böhme, V. Pérez-Mellado, and P. Maragou, 155–172. Athens: Hellenic Zoological Society.
- Civantos, E. 2000. "Home-range Ecology, Aggressive Behaviour, and Survival in Juvenile Lizards, *Psammodromus algirus*." *Canadian Journal of Zoology* 78: 1681–1685.
- Civantos, E., J. Ortega, P. López, A. Pérez-Cembranos, V. Pérez-Mellado, and J. Martín. 2013. "Diet Selection by the Threatened Chafarinas' Skink *Chalcides parallelus* in North Africa." *African Journal of Herpetology* 62: 1–12.
- Delaugerre, M., F. Grita, P. Lo Cascio, and R. Ouni. 2012. "Lizards and Eleonora's Falcon (*Falco eleonora* Gené, 1839), a Mediterranean Micro-insular Commensalism." *Biodiversity Journal* 3: 3–12.
- Di Palma, M. G. 1984. "Régime alimentaire de *Psammodromus algirus* (Reptilia, Lacertidae) dans une population insulaire du Canal de Sicile." [Diet of *Psammodromus algirus* (Reptilia, Lacertidae) in an Insular Population of Sicilia Canal.] *Revue d'écologie – la Terre et la Vie* 39: 225–230.
- Díaz, J. A., and L. M. Carrascal. 1993. "Variation in the Effect of Profitability on Prey Size Selection by the Lacertid Lizard *Psammodromus algirus*." *Oecologia* 94: 23–29.
- Díaz, J. A., A. L. Alonso-Gómez, and M. J. Delgado. 1994. "Seasonal Variation of Gonadal Development, Sexual Steroids, and Lipid Reserves in a Population of the Lizard *Psammodromus algirus*." *Journal of Herpetology* 28: 199–205.
- Foà, A., and C. Bertolucci. 2002. "Temperature Cycles induce a Bimodal Activity Pattern in Ruin Lizards: Masking or Clock-controlled Event? A Seasonal Problem." *Journal of Biological Rhythms* 16: 547–584.
- Fox, J. 2005. "Getting Started with the R Commander: A Basic-statistics Graphical User Interface to R." *Journal of Statistical Software* 14: 1–42.
- Hertz, P. E., R. B. Huey, and R. D. Stevenson. 1993. "Evaluating Temperature Regulation by Field-active Ectotherms: The Fallacy of the Inappropriate Question." *The American Naturalist* 142: 796–818.
- Hódar, J. A. 1997. "The Use of Regression Equations for Estimation of Prey Length and Biomass in Diet Studies of Insectivore Vertebrates." *Miscel-lània Zoològica* 20: 1–10.

- Huey, R. B., and E. R. Pianka. 1983. "Temporal Separation of Activity and Interspecific Dietary Overlap (with an Appendix by S. L. Pimm)." In *Lizard Ecology*, edited by R. B. Huey, E. R. Pianka, and T. W. Schoener, 281–296. Cambridge: Harvard University Press.
- Legler, J. M., and L. J. Sullivan. 1979. "The Application of Stomach-flushing to Lizards and Anurans." *Herpetologica* 35: 107–110.
- Lo Cascio, P., and C. Corti. 2008. "Indagini sull'ecologia dei Rettili Sauri della R.N.O. e del S.I.C. 'Isola di Lampedusa'" [Investigations on the Ecology of Saurian Reptiles of R.N.O. and S.I.C. 'Island of Lampedusa']. *Il Naturalista Siciliano*, S. IV 32: 319–354.
- Magurran, A. E. 2004. *Measuring Biological Diversity*. New York: Wiley-Blackwell.
- Martín, J., and P. López. 1995. "Influence of Habitat Structure on the Escape Tactics of the Lizard *Psammotromus algirus*." *Canadian Journal of Zoology* 73: 129–132.
- Mellado, J., F. Amores, F. F. Parreño, and F. Hiraldo. 1975. "The Structure of a Mediterranean Lizard Community." *Doñana Acta Vertebrata* 2: 145–160.
- Oksanen, L. 2001. "Logic of Experiments in Ecology: Is Pseudoreplication a Pseudoissue?" *Oikos* 94: 27–38.
- Pérez-Mellado, V., and C. Corti. 1993. "Dietary Adaptations and Herbivory in Lacertid Lizards of the Genus *Podarcis* from Western Mediterranean Islands." *Bonner Zoologische Beitr.* 44: 193–220.
- Pérez-Mellado, V., A. Pérez-Cembranos, M. Garrido, L. Luiselli, and C. Corti. 2011. "Using Faecal Samples in Lizard Dietary Studies." *Amphibia-Reptilia* 32: 1–7.
- Pianka, E. R. 1986. *Ecology and Natural History of Desert Lizards: Analyses of the Ecological Niche and Community Structure*. Princeton, NJ: Princeton University Press.
- Pincheira-Donoso, D. 2008. "Testing the Accuracy of Faecal-based Analyses in Studies of Trophic Ecology in Lizards." *Copeia* 2008: 322–325.
- Polis, G. A. 1991. "Complex Trophic Interactions in Deserts: An Empirical Critique of Food-Web Theory." *The American Naturalist* 138: 123–155.
- Pollo, C. J., and V. Pérez-Mellado. 1989. "Activity and Thermoregulation in Three Mediterranean Species of Lacertidae." *Herpetological Journal* 1: 343–350.
- Rouag, R., H. Djilali, H. Gueraiche, and L. Luiselli. 2007. "Resource Partitioning Patterns between Two Sympatric Lizard Species from Algeria." *Journal of Arid Environments* 69: 158–168.
- Sabo, J. L., and M. E. Power. 2002a. "Numerical Response of Lizards to Aquatic Insects and Short-term Consequences for Terrestrial Prey." *Ecology* 83: 3023–3036.
- Sabo, J. L., and M. E. Power. 2002b. "River-watershed Exchange: Effects of Riverine Subsidies on Riparian Lizards and their Terrestrial Prey." *Ecology* 83: 1860–1869.
- Schleich, H. H., W. Kästle, and K. Kabisch. 1996. *Amphibians and Reptiles of North Africa*. Koenigstein: Koeltz.
- Schoener, T. W. 1971. "Theory of Feeding Strategies." *Annual Review of Ecology and Systematics* 2: 369–404.
- Seva, E. 1984. "Reparto de recursos en dos especies psammófilas de saurios: *Acanthodactylus erythrurus* y *Psammotromus algirus*. Arenal costero de Alicante." [Resource Partitioning Between Two *Psammophile* Saurian Species: *Acanthodactylus erythrurus* and *Psammotromus algirus*. Coastal Sandbank of Alicante.] *Mediterránea. Serie de Estudios Biológicos* 7: 5–25.
- Sillero, N., J. Campos, A. Bonardi, C. Corti, R. Creemers, P.-A. Crochet, et al. 2014. "Updated Distribution and Biogeography of Amphibians and Reptiles of Europe." *Amphibia-Reptilia* 35: 1–31.
- Sindaco, R. 2006. "*Psammotromus algirus*." In *Atlante degli Anfibi e dei Rettili d'Italia* [Atlas of Italian Amphibians and Reptiles], edited by R. Sindaco, G. Doria, E. Razzetti, and F. Bernini, 407–504. Firenze: Societas Herpetologica Italica.
- Sneath, P., and R. Sokal. 1962. "Numerical Taxonomy." *Nature* 193: 855–860.
- Stephens, D. W., and J. R. Krebs. 1986. *Foraging Theory*. Princeton, NJ: Princeton University Press.
- Tahar Chaouch, L. 2012. "Diagnostic écologique d'une zone humide naturelle (Oued Bouilef, Parc National de Belezma)." [Ecological Diagnosis of a Natural Wetland Area (Oued Bouilef, National Park of Belezma).] Master diss., University of Batna, Algeria.
- Tracy, C. R., and K. A. Christian. 1986. "Ecological Relations among Space, Time, and Thermal Niche Axes." *Ecology* 67: 609–615.
- UNESCO. 2015. *UNESCO Media Services*. Twenty new sites added to UNESCO's World Network of Biosphere Reserves. http://www.unesco.org/new/en/media-services/single-view/news/twenty_new_sites_added_to_unescos_world_network_of_biosphere_reserves#.VzNpB4SLR7M.
- Valverde, J. A. 1967. *Estructura de una comunidad de vertebrados terrestres* [Structure of a Terrestrial Vertebrates Community]. Monografías Estación Biológica de Doñana, no. 1. Madrid.
- Vanhooydonck, B., A. Herrel, and R. Van Damme. 2012. "Interactions between Habitat Use, Behavior and the Trophic Niche of Lacertid Lizards." In *Lizard Ecology*, edited by S. M. Reilly, L. D. McBrayer, and D. B. Miles, 427–449. Cambridge: Cambridge University Press.
- Vanhooydonck, B., and R. Van Damme. 2003. "Relationships between Locomotor Performance, Microhabitat Use and Antipredator Behaviour in Lacertid Lizards." *Functional Ecology* 17: 160–169.
- Winne, C. T., and M. B. Keck. 2004. "Daily Activity Patterns of Whiptail Lizards (Squamata: Teiidae: Aspidoscelis): A Proximate Response to Environmental Conditions or an Endogenous Rhythm?" *Functional Ecology* 18: 314–321.
- Wolda, H. 1988. "Insect Seasonality: Why?" *Annual Review of Ecology and Systematics* 19: 1–18.
- Zamora-Camacho, F. J., S. Reguera, G. Moreno-Rueda, and J. M. Pleguezuelos. 2013. "Patterns of Seasonal Activity in a Mediterranean Lizard along a 2200 m Altitudinal Gradient." *Journal of Thermal Biology* 38: 64–69.

Appendix A. Number of individuals (N), prey frequency (PF), occurrence frequency (Occ) and occurrence scale (Occ scale) of prey items found in the large psammodromus stomach contents at Belezma National Park (northeast Algeria).

Class: Order					
Family	Prey species	N	PF (%)	Occ (%)	Occ scale
Polychaeta	Polychaeta sp.	1	0.42	4.76	HR
Arachnida: Opiliones					
Phalangidae	Phalangidae sp.	5	2.1	14.28	RE
Arachnida: Aranea	Aranea sp.	3	1.26	14.28	RE
Lycosidae	Lycosidae sp.	6	2.52	23.8	RE
Oxyopidae	Oxyopidae sp.	6	2.52	28.57	CM
Salticidae	Salticidae sp.	6	2.52	23.8	RE
Dysderidae	<i>Dysdera</i> sp.	2	0.84	9.52	HR
Arachnida: Acari	Acari sp.	2	0.84	9.52	HR
Myriapoda: Chilopoda	Chilopoda sp.	1	0.42	4.76	HR
Crustacea: Amphipoda					
Gammaridae	Gammaridae sp.	1	0.42	4.76	HR
Crustacea: Isopoda					
Armadillidiidae	<i>Armadillidium</i> sp.	3	1.26	9.52	HR
Insecta: Odonatoptera	<i>Odonatoptera</i> sp.	1	0.42	4.76	HR
Insecta: Orthoptera					
Acrididae	<i>Dociopterus maroccanus</i>	1	0.42	4.76	HR
	Acrididae sp.	2	0.84	9.52	HR
Ensifera	Ensifera sp.	1	0.42	4.76	HR
Insecta: Dermaptera					
Forficulidae	<i>Forficula auricularia</i>	4	1.68	14.28	RE
Insecta: Blattoptera	Blattoptera sp.	2	0.84	9.52	HR
Insecta: Hemiptera					
Aphididae	Aphididae sp.	12	5.04	19.04	RE
Anthocoridae	Anthocoridae sp.	3	1.26	9.52	HR
Cicadellidae	Cicadellidae sp.	2	0.84	4.76	HR
Insecta: Coleoptera	Coleoptera sp.	2	0.84	9.52	HR
Carabidae	<i>Cicindelinae</i> sp.	1	0.42	4.76	HR
	<i>Chaetodera</i> sp.	1	0.42	4.76	HR
	<i>Harpalus</i> sp.	1	0.42	4.76	HR
	Carabidae sp.	2	0.84	9.52	HR
Buprestidae	<i>Julodis</i> sp.	1	0.42	4.76	HR
	Buprestidae sp.	5	2.1	9.52	HR
Scarabaeidae	<i>Hoplia</i> sp.	2	0.84	4.76	HR
	<i>Rhizotrogus</i> sp.	2	0.84	9.52	HR
	Scarabaeidae sp.	1	0.42	4.76	HR
Coccinellidae	<i>Adonia variegata</i>	1	0.42	4.76	HR
	Coccinellidae sp.	1	0.42	4.76	HR
Chrysomelidae	<i>Prasocuri sphellandrii</i>	13	5.46	19.04	RE
	<i>Phyllodecta</i> sp.	3	1.26	4.76	HR
	<i>Clytra</i> sp.	5	2.1	19.04	RE
	<i>Chaetocnema</i> sp.	1	0.42	4.76	HR
	Chrysomelidae sp.	4	1.68	14.28	RE
Curculionidae	<i>Orchestes</i> sp.	1	0.42	4.76	HR
	<i>Otiorhynchus</i> sp.	4	1.68	14.28	RE
Apionidae	<i>Apion</i> sp.	2	0.84	9.52	HR
Oedemeridae	<i>Calopus</i> sp.	3	1.26	9.52	HR
Rutelidae	<i>Anisoplia</i> sp.	3	1.26	4.76	HR
	<i>Phyllopertha</i> sp.	4	1.68	4.76	HR
Insecta: Neuroptera					
Chrysopidae	<i>Chrysoperla</i> sp.	1	0.42	4.76	HR
Myrmeleontidae	Myrmeleontidae sp.	1	0.42	4.76	HR
Insecta: Hymenoptera	Hymenoptera sp.	8	3.36	33.33	CM
Ichneumonidae	Ichneumonidae sp.	4	1.68	14.28	RE
Scoliidae	Scoliidae sp.	7	2.94	23.8	RE
Formicidae	<i>Camponotus</i> sp.	1	0.42	4.76	HR
	<i>Messor</i> sp.	5	2.1	9.52	HR
	<i>Monomorium</i> sp.	1	0.42	4.76	HR
	<i>Pheidole</i> sp.	2	0.84	9.52	HR
	<i>Pheidole pallidula</i>	1	0.42	4.76	HR
	<i>Plagiolepis</i> sp.	1	0.42	4.76	HR
	Formicidae sp.	3	1.26	14.28	RE
Pompilidae	Pompilidae sp.	13	5.46	23.8	RE
Vespidae	<i>Polistes gallicus</i>	1	0.42	4.76	HR
	<i>Vespa</i> sp.	1	0.42	4.76	HR
	Vespidae sp.	2	0.84	9.52	HR
Andrenidae	Andrenidae sp.	1	0.42	4.76	HR
Apidae	<i>Apis mellifera</i>	1	0.42	4.76	HR
	Apidae sp.	2	0.84	9.52	HR
Insecta: Trichoptera	Trichoptera sp.	5	2.1	14.28	RE
Insecta: Lepidoptera	Lepidoptera sp.	9	3.78	14.28	RE
Insecta: Diptera					
Tipulidae	<i>Tipula</i> sp.	5	2.1	9.52	HR
	Tipulidae sp.	7	2.94	23.8	RE
Culicidae	Culicidae sp.	6	2.52	14.28	RE

(Continued)

Appendix A. (Continued)

Class: Order

Family	Prey species	N	PF (%)	Occ (%)	Occ scale
Chironomidae	Chironomidae sp.	5	2.1	14.28	RE
Bibionidae	Bibionidae sp.	7	2.94	4.76	HR
Sciaridae	Sciaridae sp.	4	1.68	14.28	RE
Asilidae	<i>Asilus</i> sp.	3	1.26	9.52	HR
Sarcophagidae	Sarcophagidae sp.	1	0.42	4.76	HR
Muscidae	Muscidae sp.	1	0.42	4.76	HR
Brachycera	Brachycera sp.	2	0.84	9.52	HR