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Food habits and daily activity patterns of the North African ocellated lizard *Timon pater* from northeastern Algeria

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Abstract
The large-sized lizard *Timon pater* (Lacertidae) has been recently recognised as a distinct species from the European ocellated lizard (*Timon lepidus*), and is endemic to Morocco, Algeria and Tunisia. The ecology of this lizard is entirely unknown, and in this study detailed data on the diet composition and on the daily activity patterns, in spring and summer, are presented. The field study was carried out at the Parc National d'El Kala, northeastern Algeria. Food data were recovered by faecal pellet analysis, and daily activity patterns by standardised surveys along 1000-m-long line transects. In total, 164 *T. pater* pellets were collected and analysed, and 428 prey items were identified. The mean volume of the pellets collected in July and August was significantly less than that of the pellets collected in all the other months. The diet of Algerian *T. pater* was dominated by three prey categories (Coleoptera, Gastropoda, and Formicidae); Coleoptera and Formicidae were the most important prey types through the whole study period, whereas other prey types were important only in some periods (i.e. Gastropoda in August and Orthoptera in September). The diet composition did not change noticeably between spring and summer, and the same was true for the daily activity patterns. Overall, *T. pater* appeared remarkably similar to the European *T. lepidus* populations as far as dietary habits and daily activity patterns are concerned.

Keywords: *Algeria, daily activity, diet, ecology, lizard,* Timon pater

Introduction

The great majority of the lacertids is characterised by small body size and insectivorous habits (e.g. Arnold 1987; Corti and Lo Cascio 2002), with some shifts towards omnivory and herbivory on islands (Pérez Mellado and Corti 1993). However, there are a few species of the genera *Gallotia*, endemic to the Canary islands, and *Timon*, with a Mediterranean distribution, which are characterised by a gigantic size, and that, because of this peculiar morphological characteristic, may have a more variable diet than their smaller counterparts (Corti and Lo Cascio 2002). In addition, these very large lizards are seriously declining over much of their range: *Timon lepidus* is threatened in Italy, France, and part of the Iberian peninsula (Corti and

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Lo Cascio 2002), and *Timon pater* is clearly declining in Algeria and Tunisia, although it is not as seriously threatened as its European counterpart. Thus, an increasing knowledge of them—especially of their ecological traits—is very important to the preservation of these taxa from further rarefaction.

All the large-sized *Timon* species of the Mediterranean basin were for a long time considered a single species, the European ocellated lizard *Lacerta lepida* (Daudin, 1802; now *Timon lepidus*), with a wide distribution in North Africa as well as in the Iberian peninsula, southern France, and northwestern Italy (Corti and Lo Cascio 2002), but the North African forms have been elevated to the rank of full species (named *Timon pater* (Lataste, 1880)) after careful morphological, karyological, and genetical analyses during recent years and subsequently assigned to the genus *Timon* (e.g. Bischoff 1982; Mateo 1990; Odierna et al. 1990). It is now therefore evident that *T. pater* is a distinct species, distributed exclusively in North Africa, where it is endemic to Morocco, Algeria and Tunisia. However, while for the European *T. lepidus* there has been some ecological research, particularly in Portugal (Allen 1977; Vicente et al. 1995), Spain (e.g. Castilla and Bauwens 1989, 1992; Castilla et al. 1991; Hernandez et al. 1991; Hodar et al. 1996; Galan 2000), and Italy (Salvidio et al. 2006), the ecology of *T. pater* still remains completely unstudied.

In this article we report a field study of the diet and daily activity patterns of *T. pater* from a study area in northeastern Algeria, focusing our attention on the seasonal variations in these aspects as well as on comparisons with populations of the closely related *T. lepidus* from southern Europe.

Materials and methods

Study area

This study was carried out in the "Parc National d'El Kala", in northeastern Algeria. This protected territory is ecologically very important because it includes some water bodies which are intensively used by birds and other animals as they are among the few wet areas situated inside the overall dry environments of northern Algeria. The study area is a part of the northeastern Algerian Tull, and is situated between 36°43′N and 36°57′N latitude, and between 07°43′E and 08°37′E longitude. Overall, the national park has a surface of 78,400 ha, and is characterised by an alternation of lakes, marshes, and hilly territories (up to 600 m elevation), covered with relatively dense vegetation (De Belair 1990). The climate is arid with Mediterranean influences (Seltzer 1946; Toubal 1986). Rainfall is moderate, and strongly concentrated during the winter months (Figure 1): total annual rainfall is about 630 mm, and the mean monthly rainfall is about 52 mm. The field study was conducted at the "Réserve biologique de Brabtia", which is characterised by a forested valley, with grassy vegetation (Graminaceae, asphodels, and dwarf palms *Chamaerops humilis*) having an average cover of 7%, bushy vegetation of "maquis" type with an average cover of 73% and up to 2.5 m height (main plants being *Phillyrea augustifolia*, *Pistacia lentiscus*, *Mirtus communis*, *Rubus ulmifolius*, *Calycotome villosa*, *Erica arborea*, *Erica scoparia*, and *Smilax aspera*), and trees (*Quercus suber*) with an average height of 7.7 m and an average cover of 57%. The valley is crossed by a stream ("Oued Bouaroug") with abundant bank vegetation, mainly ferns (Boukherouf 2005).

Protocol

The field study was carried out between 1 June and 28 September 2004, and from 1 to 30 April 2005. Each month, four research days were conducted, i.e. a total of 16 research days

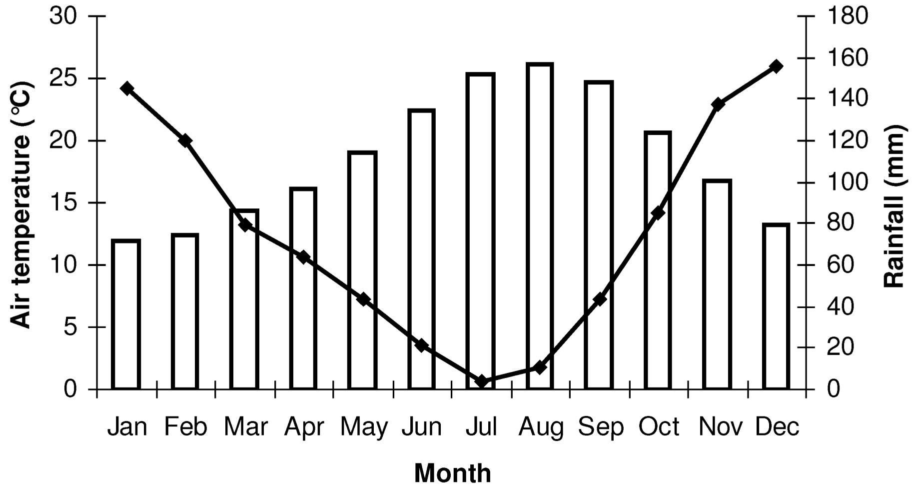

Figure 1. Mean monthly temperature (°C, bars) and rainfall (mm, line) at the study area in north-eastern Algeria.

were spent in the field during the whole study. Each day, research was conducted approximately from 07:00 to 17:00 h, i.e. a total of approximately 160 man-hours of research were spent in carrying out this study.

Food data were recovered by faecal pellet analysis after having verified that stomach flushing was difficult to apply with this species given its body vigour and the relative stress caused by capture. Obviously no animal was killed given the rarity and low population abundance of these lizards. Pellets were collected from the soil. Their shape and size allowed 100% exact determination of the species producing them, as the faeces of the other small-sized sympatric lacertids are very different and easily identified (R. Rouag et al., unpublished). This method allowed collection of a relatively large number of pellets, but did not allow identification of the sex of the defecating lizard. Given the rarity of the study species, it is likely that some pellets were produced by the same individual lizards. However, given the rarity and the threatened status of this large-sized lizard in Algeria, it was impossible to apply any better method for collecting diet data for *T. pater*. Each pellet was dried and weighed, and then intact length and width were measured. To calculate the pellet volume, each pellet was approximated to a cylinder, and then its volume was calculated. After these measurements were taken, the pellets were dissected and analysed. Prey items were identified to the lowest taxon possible (generally to order level, except for the Formicidae which were separated from the other Hymenoptera species because of their obvious differences in ethological, ecological, and morphological characteristics).

The diet was analysed according to several descriptors:

1. prey type richness (PR, in the following text) which is the number of prey types recorded in the pellet;
2. index of presence (% IP) which is the frequency (per cent abundance) of each prey type in the total number of pellets examined;
3. number of prey items (*N*) and the abundance of each prey type in relation to the total number of prey items (% *N*);

4. Shannon–Weaver diversity index (H') to calculate a measure of the prey species diversity for each lizard pellet:

$$H' = -\sum_{i=1}^{i=n} P_i \log P_i \text{ where } P_i = n_i/N.$$

In this formula, P_i is the relative percentage contribution of each prey type to the total diet; n_i is the number of items of the prey category i, and N is the total number of prey items found in the diet.

The application of the above-mentioned formulae to dietary studies is discussed in Barbault (1981). For % IP, the interseasonal (spring versus summer) variation was analysed by Chi-square test.

Food niche overlap (O_{jk}) between seasons was quantified using Pianka's (1986) symmetric equation with values ranging from 0 (no overlap) to 1 (total overlap). For species 1 and 2, with resource utilisations p_{1i} and p_{2i}, Pianka's overlap index of species 1 on species 2 (O_{12}) is calculated as:

$$O_{12} = O_{21} = \frac{\sum_{i=1}^{n} p_{2i} p_{1i}}{\sqrt{\sum_{i=1}^{n} (p_{2i}^2)(p_{1i}^2)}}$$

In order to analyse the activity patterns of the study species, line transects of 1000 m in length were walked very slowly at different daytime intervals (it took approximately 2 h to walk an entire transect on each occasion), and all the lizard specimens encountered were recorded and assigned to their appropriate daytime interval. A total of five, 2 h-long intervals (from 07:00 to 17:00 h) were considered for the analyses. The transects were laid in homogeneous habitats for their entire length, i.e. there was no portion of them which was heterogeneous in habitat structure. Surveys were conducted only during sunny days, thus avoiding rainy or windy days which can bias the data. In order to avoid statistical problems due to data pseudoreplication (Hurlbert 1984), (1) only independent transects with no possibility of individual interchanges were surveyed, and (2) each transect was surveyed by walking very slowly in one direction once each research day (for a similar methodology see Rugiero and Luiselli 2006). These procedures and the type of statistical design used (i.e. ANOVA comparisons among daytime intervals on the means of the number of specimens observed each day rather than on the total number of specimens observed) minimised the risk of eventual statistical biases (Oksanen 2001).

All statistics were computed by SPSS (version 10.0) PC package, with all tests being two-tailed and α set at 5%.

Results

Diet

A total of 164 (139 whole and 25 broken) independent *T. pater* pellets were collected and analysed; these gave a total of 428 identified prey items. The majority of the pellets were found in June and July (Figure 2A). There were statistically significant differences (one-way

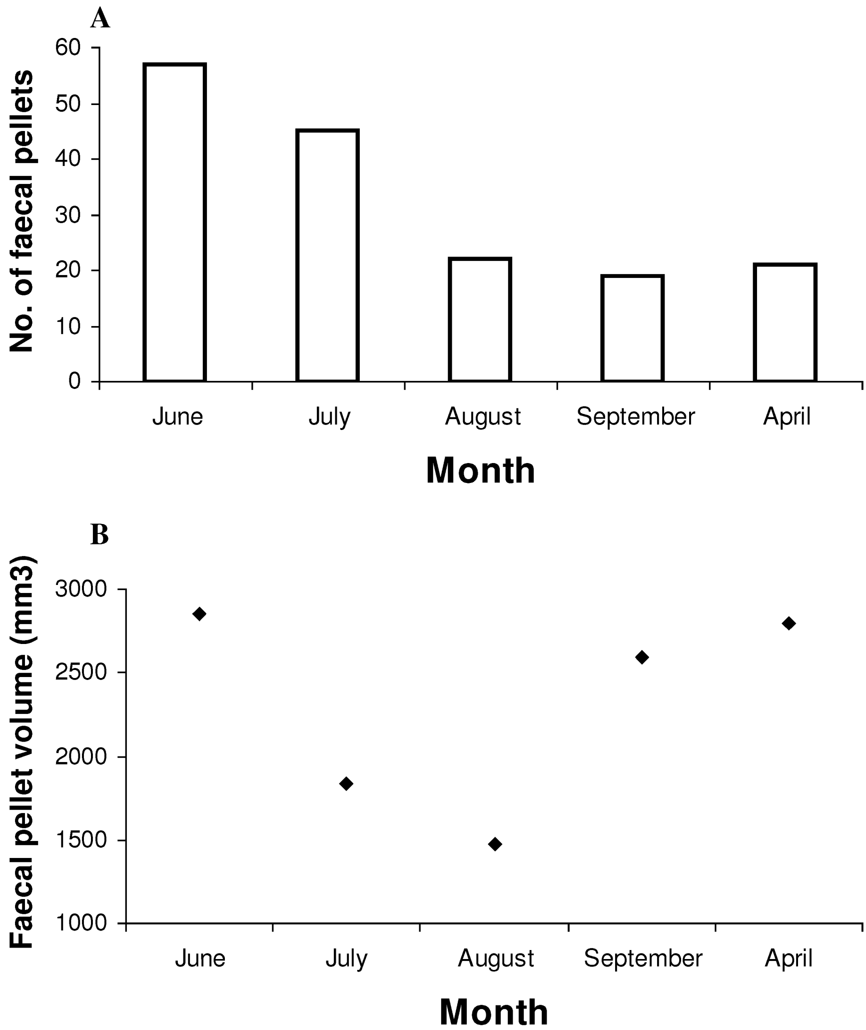

Figure 2. Monthly variation in the number of faecal pellets collected (A) (total sample, $n=164$) and in the mean volume of each pellet (B) (total sample, $n=139$) of *Timon pater* at the study area.

ANOVA, $P<0.0001$) in the mean volume of the pellets collected in the various months, and Tukey HSD post-hoc test revealed that the volume of the pellets collected in July and August was significantly less than that of the pellets collected in all the other months (Figure 2B).

The diet of *T. pater* consisted essentially of arthropods (mainly insects, i.e. Coleoptera, Orthopera, and Formicidae), but molluscs (Gastropoda) were also regularly eaten (Table I). Plant remains were also frequently identified from the lizard pellets. During April, the lizards consumed a higher variety of arthropod types than in the other months (PR=7 versus 5.5; Table I).

In terms of number of prey items, the diet of Algerian *T. pater* was dominated by three prey categories (Coleoptera, Gastropoda, and Formicidae; these being pooled accounted for 88.5% of the total *N*), whereas all the other prey types were scarce (Table II). In terms

Table I. Monthly variation of the prey type richness (PR) in the pellets of *Timon pater*.

Month	Coleoptera	Orthoptera	Formicidae	Hymenoptera	Odonata	Dermaptera	Hemiptera	Diptera	Gastropoda	PR
June 2004	+	+	+	+	−	−	−	−	+	5
July 2004	+	+	+	+	−	−	−	+	+	6
August 2004	+	+	+	−	−	−	+	+	+	6
September 2004	+	+	+	−	−	+	−	−	+	5
April 2005	+	+	+	−	+	−	+	+	+	7

Table II. Total number of prey items (*N*, and their relative percentage frequency of occurrence, % *N*) in the faecal pellets of *Timon pater*.

Prey type	*N*	% *N*
Gastropoda	52	12.1
Coleoptera	223	52.1
Orthoptera	24	5.7
Hymenoptera	10	2.3
Formicidae	104	24.3
Odonata	1	0.2
Diptera	4	0.9
Dermaptera	3	0.7
Hemiptera	7	1.7
Total	428	100.0

of IP, Coleoptera and Formicidae were the most important prey types through the whole study period, whereas other prey types were important only in some periods (i.e. Gastropoda in August, and Orthoptera in September) (Table III).

Seasonal comparisons of the diet data (Table IV) indicated that, in terms of % *N*, the summer and spring diets were very similar (O_{jk}=0.954), but in terms of % IP there were significant interseasonal differences (χ^2, $P<0.01$) with the statistical differences being higher abundances in summer of Orthoptera and Gastropoda, and in spring of Formicidae, Hemiptera, and Diptera. The interseasonal variations for the parameters E and H' (summer versus spring: E=0.16 versus 0.15; H'=0.52 versus 0.47) were low, and revealed that the diet diversity of this species was constantly low, being based essentially on ants and beetles (see above).

Daily activity patterns

During both spring and summer, the lizards exhibited similar daily activity patterns (one-way ANOVA: $P>0.3$), with intense activity during the early morning hours (07:00–09:00 h), and a second, less high peak, around midday (i.e. 11:00–13:00 h in spring and 13:00–15:00 h in summer) (Figure 3).

Discussion

This study is the only detailed research conducted on the food and daily activity patterns of the North African ocellated lizard, thus it could not be compared directly with other studies on conspecifics. However, comparisons can be made with the datasets available for the closely related, large-sized European ocellated lizard (e.g. Castilla et al. 1991; Hernandez et al. 1991; Salvidio et al. 2006).

In terms of the food eaten by *T. pater*, our study showed that this species has (1) a primarily arthropod diet, and (2) a relatively low diversity diet, with a few prey types (i.e. Coleoptera, Formicidae, and Gastropoda) accounting for the great majority of the prey items through both spring and summer months. This latter point is not consistent with the expectation of a very diversified diet for a large-sized lizard which can even forage on small vertebrates (Corti and Lo Cascio 2002), but mirrors the datasets from European *T. lepidus* populations. Indeed, vertebrate items appeared to be extremely rare in all the *T. lepidus* populations studied to date (see Castilla et al. 1991; Hernandez et al. 1991; Vicente et al.

Table III. Monthly variation in the index of presence (% IP) of each prey type in the total number of pellets ($n=164$) of *Timon pater* examined during this study.

	% IP								
	Coleoptera	Orthoptera	Formicidae	Gastropoda	Hymenoptera	Hemiptera	Odonata	Dermaptera	Diptera
June 2004	95	3	35	14	43	0	0	0	0
July 2004	100	11	29	22	4	0	0	4	6
August 2004	100	36	90	40	0	4	0	0	4
September 2004	100	94	52	26	0	0	0	5	0
April 2005	100	4	100	14	0	28	4	0	14
Mean	99.0	29.6	61.2	23.2	9.4	6.4	0.8	1.8	4.8

Table IV. Seasonal variation in the descriptors (% *N* and % IP) of the diet of *Timon pater* from the study area.

	Coleoptera	Orthoptera	Formicidae	Hymenoptera	Gastropoda	Diptera	Hemiptera	Dermaptera	Odonata
% *N*									
Summer 2004	52	7	20	3	16	1	0	1	0
Spring 2005	56	1	30	0	3	3	6	0	1
% IP									
Summer 2004	99	36	52	32	5	1	0	3	4
Spring 2005	100	4	99	14	0	28	4	0	14

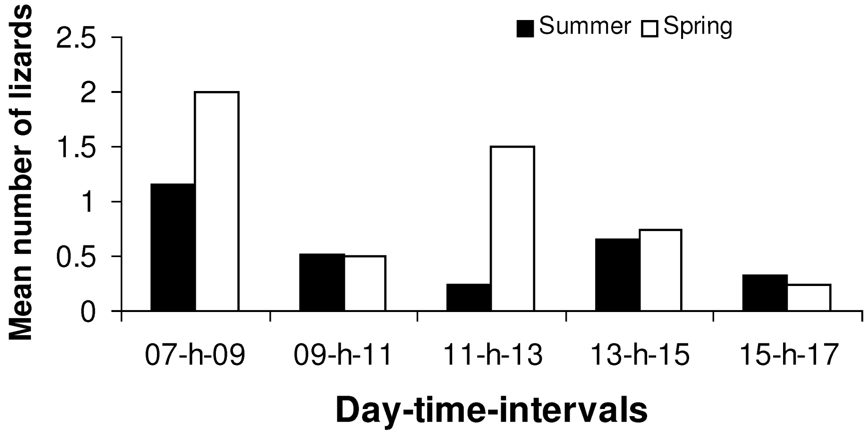

Figure 3. Daily activity patterns of *Timon pater* at the study area, expressed as the mean number of individuals seen at each daytime interval along several independent 1000-m-long transects.

1995; Hodar et al. 1996; Salvidio et al. 2006), which, in agreement with *T. pater*, were also almost exclusively arthropod-eaters. We did not observe instances of oophagia or necrophagia, which were however reported for Spanish *T. lepidus* (Pleguezuelos et al. 1999), but the finding of vegetable matter also mirrors data available for *T. lepidus* (e.g. Castilla et al. 1991; Hernandez et al. 1991; Salvidio et al. 2006). The predominance of Coleoptera in the diet (which was clearly seen in our population of *T. pater* during both spring and summer) was also confirmed by all studies on *T. lepidus*, including Valverde (1967; 85.2% of the prey items), Escarré and Vericad (1981; 47.6%), Castilla et al. (1991; 74%), Hernandez et al. (1991; 41.7%), and Salvidio et al. (2006; 34.9%). Thus, although there were obviously some minor differences in the trophic spectrum of the various populations of *Timon* studied to date, and although these differences are likely attributable to the relative dietary generalism of lacertid lizards (e.g. Avery 1966, 1971; Arnold 1987; Vicente et al. 1995; etc.), there is a clear constant trend for *Timon* species to prey essentially upon coleopterans. We suggest that this feeding preference may be related to the strong mouth vigour and chewing strength of these large-sized lizards, that can easily consume also relatively large, hard-bodied, beetle species. It is also likely that the frequency of availability of beetles in these lizards' natural habitats may be related to the frequency of consumption of these animals by *Timon*, but we do not have data on the relative availability of these prey in the natural habitats of the various *Timon* populations (apart from Vicente et al. 1995; Hodar et al. 1996) to confirm this hypothesis.

The main difference between Algerian *T. pater* and European *T. lepidus* was the difference in mean number of prey items recorded per pellet: this was much less in the former (2.6 prey items per pellet) than in the latter species (from 12.6 in Hodar et al. 1996 to 23.1 in Hernandez et al. 1991). The difference in prey items per pellet may be derived by (1) differences in predator size (the Algerian species is a little bit smaller than its European counterpart), (2) differences in prey size, i.e. the Algerian species may prey on disproportionately larger arthropods than the European *T. lepidus*. This latter pattern may in turn depend on the relative differences among geographic regions in terms of availability of the various prey size categories in the field, but this hypothesis needs further investigation.

Concerning the daily activity patterns of *T. pater*, our data are consistent with the available data for *T. lepidus* (e.g. see Franco et al. 1980; Hodar et al. 1996; Corti and Lo

Cascio 2002), although the respective habitats and climatic conditions were likely quite different. However, it is somewhat noteworthy that *T. pater* did not exhibit remarkable interseasonal differences in diel activity patterns, whereas other sympatric lizard species did (Rouag et al. in press). It is likely that the relatively high vegetation cover of the study area may have helped the lizards to be active according to constant patterns despite the monthly oscillations in the air temperature and in rainfall (see Figure 1).

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