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Activity patterns of the spur-thighed tortoise, *Testudo graeca* (Reptilia: Testudines: Testudinidae) in northeastern Algeria

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Abstract
We study the activity patterns of a population of the spur-thighed tortoises *Testudo graeca* occurring in an enclosed area of 30 ha in the National Park of El Kala (northeastern Algeria) with the aim of exploring the variation in daily and seasonal activity of males, females and juveniles from March, 2004 to March, 2005. Our results show that the species displays a unimodal daily activity pattern during spring, with the highest activity during the mornings (81.55 % of active tortoise are seen between 10:00 h and 14:00 h).In summer the daily activity pattern of tortoises is lower and shows a bimodal distribution (22.22 % of active tortoises are seen early in morning between 09:00 h and 10:00 h and 41.67 % are seen later between 16:00h and 18:00 h). No differences were found between the daily activity of males and females. The monitoring of the activity during 7 months revealed that tortoises are most active in March with 2.44 tortoises/hour of search. Later, the activity decreases with 0.97 tortoises/hour of search in June. It becomes very low from July to September (from 0.25 to 0.15 tortoises/hour of search). The annual activity pattern does not vary according to age and sex.

Keywords: Algeria, daily activity patterns, annual activity patterns, maquis vegetation, *Testudo graeca*, tortoise

1. Introduction
The spur-thighed tortoise (*Testudo graeca*) occupies a very wide range of environmental conditions in North Africa, ranging from arid (116 mm of annual rainfall) to very humid Mediterranean (1092 mm) environments [1]. The species has been widely studied in terms of ecology, demography, geographic variation and Phylogeography [2-10]. Reptiles are conditioned by environmental factors, especially temperature that influences their metabolism and activity [3]. The habitats provide access to optimum temperatures [11], but they are limited by the degree of openness of vegetation [12]. For reptiles, open environments are ideal grounds to the extent that they provide spaces necessary for thermoregulation and diet, and bushy vegetation that can be used to escape predators [13]. Activity patterns of *Testudo graeca* have never been studied in northern Africa; none was carried for dune maquis vegetation. The aim of this work is to study the seasonal and annual activity patterns in dune maquis vegetation in north-eastern Algeria.

2. Materials and methods
2.1 Study area: This study was carried out in the National Park of El Kala, in north-eastern Algeria, situated between 36° 49′ 01″ north and 8° 24′ 47″ east. The national park comprises a total of 78 400 ha [14]. The climate is Mediterranean [14]; with moderate rainfall, strongly concentrated during the winter months (total annual rainfall is around 630 mm). The study site is characterized by Mediterranean maquis vegetation growing on sandy soils; the main vegetation cover is due to the Mediterranean dwarf palm *Chamaerops humilis*, but the site is also strongly cultivated (mainly cereals, peanuts, etc.) (Fig. 1). The mean height of the bushy layer is 32.4 cm, and the mean bushy vegetation coverage is 19.4%; the mean height of the grassy layer is 2.3 cm, and the average grassy vegetation coverage is 70% [15].

2.2 Research protocol: The study was carried out over a period of one year between March 2004 and March 2005. The surface of the study site was approximately 30 ha. The tortoises were searched for by random walks throughout the study area. Once captured, they were marked individually by carapace scale notching [16] and then set free unharmed to the site of

capture. Sex was determined by examining the plastron concavity and the tail length (which is much longer in the males than in the females). Age determination of each captured tortoise was considered in this work to separate adult individuals from juveniles. It was done by growth annuli counts on the shell, considering that one growth annulus being added each year [17-18].

In order to analyze the daily activity patterns of the tortoises, line transects of 1000 m in length were walked very slowly at different daytime intervals, and all the tortoise specimens encountered were recorded and assigned to their appropriate daytime interval. A total of ten intervals of one hour (from 08:00 h to 18:00 h) were considered for the analyses. Surveys were conducted only during sunny days, thus avoiding rainy or windy days which can bias the data. A total of 150 man-hours of research were spent in carrying out this study. The seasonal activity pattern was estimated as the average number of tortoises found by hour of search in each month; it provides information on the variation in the activity of the species by sex and age in relation to seasonal variations.

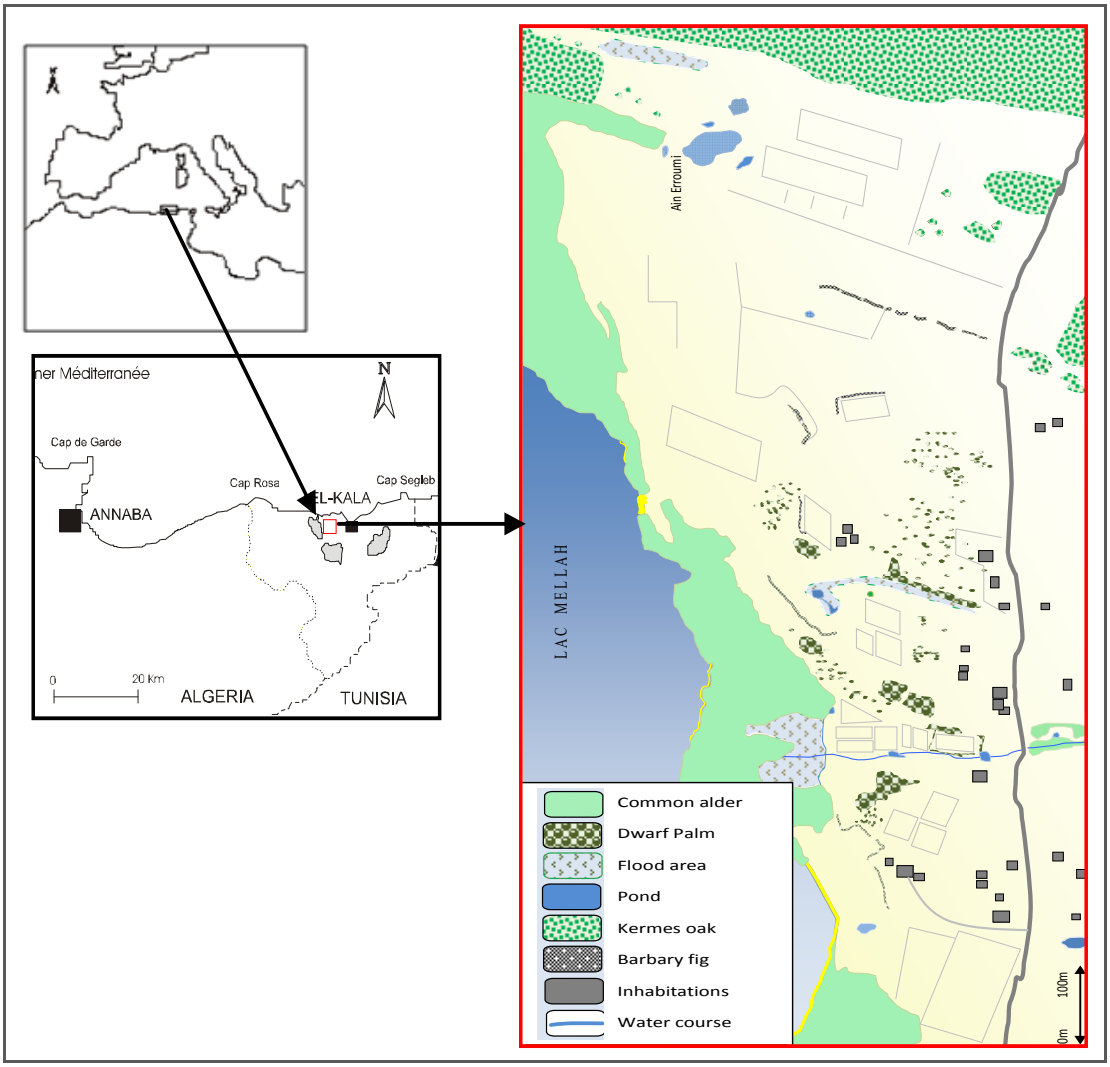

Fig 1: Location of the study sites in the National Park of El Kala

2.3: Statistical analysis. The procedures used to assess the daily activity patterns and the type of statistical design used (i.e. non-parametric Mann–Whitney U-test, calculated by comparing the daily means of animals observed at each daily interval and not the total number of specimens observed at each daily interval) minimized the risk of eventual statistical biases [19]. To test for annual activity differences among the three groups (male, female and juvenile), we used contingency table ($\chi 2$) tests on the number of active tortoises in the different months. All statistics were computed by SPSS (version 11.0) PC package, with all tests being two-tailed and alpha-value set at 0.05.

3. Results

During springtime 92.26 % of tortoises were actives between 09:00 h and 14:00 h, when the daily activity patterns were clearly unimodal with a peak of activity at 12:13 h. During the summer, the activity was lower and showed a bimodal distribution pattern (highest peak at 09:10 h; second peak at 16:17 h) (Fig. 2). The mean number of tortoises observed per daytime interval differ significantly between seasons ($U = 68$; $P<0.05$).

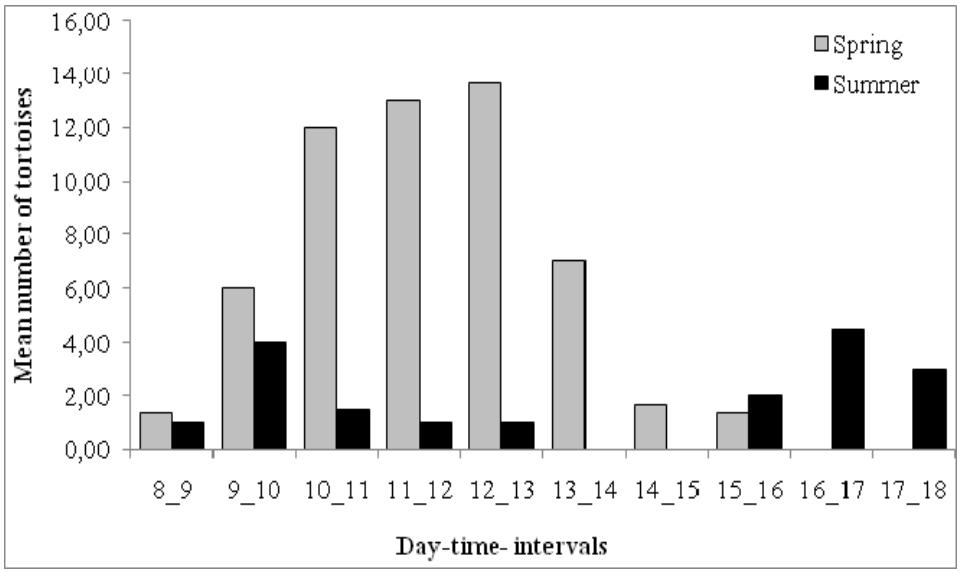

Fig 2: Daily activity patterns of *Testudo graeca* at the study area, expressed as the mean number of individuals seen at each daytime interval.

The tortoises were active over 7 months corresponding to the active season for this period. No tortoises were observed from October 2004 to February 2005 because of an exceptionally rainy autumn and winter for this season. Individuals were already active from March, mainly males. Males were active for a larger percentage of the time, and they were active both earlier (March) and later in the year (September). The activity then declines in May and June. In July, it was practically nonexistent (Fig. 3). These differences were usually attributed to males searching for mates [20-21]. Juveniles have a different activity pattern from adults. They show high activity in spring immediately after leaving hibernation. The main activity during this period is foraging particularly in March and April [9]. Between May and July, their activity decreases considerably and they was completely inactive from August. This situation is related to the increase of the temperature at the study site. The annual activity did not varied significantly according to age and sex. The application of the chi-square test ($\chi 2$) did not show any difference in the monthly activity between males and females ($\chi 2 = 1.009$; $P = 0.135 > 0.05$). No difference in monthly activity between males and juveniles ($\chi 2 = 0.011$; $P = 0.916 > 0.05$); and between females and juveniles ($\chi 2 = 0.815$; $P = 0.367 > 0.05$).

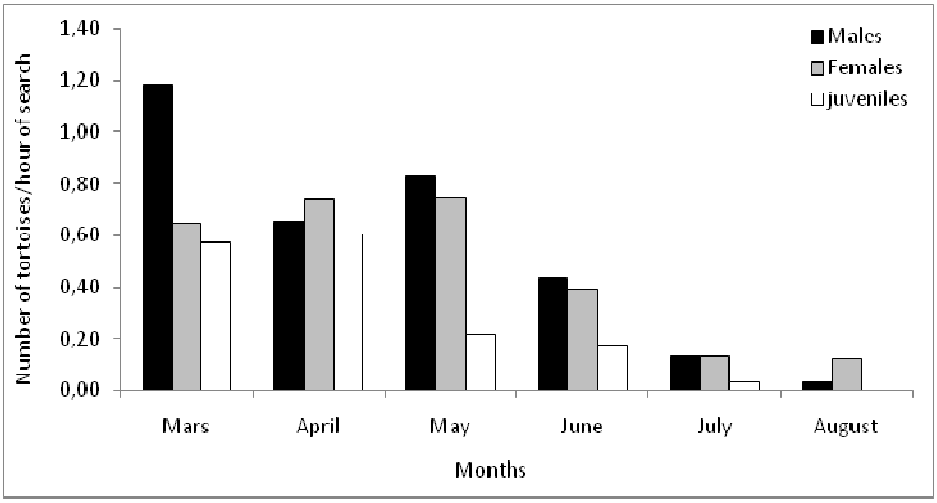

Fig 3: Seasonal activity patterns of *Testudo graeca* expressed as the number of tortoises by hour of search at each month by ages and sex at the study area.

4. Discussion

About the daily activity patterns, our results are consistent with the available data for *T. graeca* in Spain [22] and *Testudo hermanni* [23] where these species display a clearly unimodal daily activity during spring and bimodal during summer. This daily activity rhythm is otherwise highly variable also between seasons, because of the oscillations of the critical values of air temperature. In the cooler regions activity often remains unimodal during the summer [24-25-20], but on hot days, it may stop about noon or become bimodal [26]. No significant differences were found between the numbers of males and females active monthly. Our data are conforming to the available data for *T. graeca* in Murcia [27] and in Doñana [28]. Tortoises dig deep inside dense tufts of *Chamaerops humilis* and bury it completely or partially. This behavior allows them to avoid high temperatures sinking into a relatively cool substrate. These observations are similar to those carried out by Díaz-Paniagua *et al*. [28-3] in populations of *T. graeca* in the Doñana National Park where the highest activity of *T. graeca* took place between March and April. In any case, the activity

of the tortoises is mainly dependent on the maximum temperature. The variation in climatic conditions at the region affects directly the behavior and the mobility of the tortoises [29].

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