FEEDING BEHAVIOUR OF A *Testudo graeca whitei* POPULATION IN MERGUEB NATURE RESERVE, ALGERIA

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Abstract

The diet of a population of the Spur-thighed tortoise (*Testudo graeca whitei*), in the Mergueb Nature Reserve in the Algerian steppe, was studied by direct observation. This tortoise population was fed selectively during the month of April when out of 40 different plant species as potential food, only 11 species were consumed.

***Key words*:** *Testudo graeca whitei*; Threatened species; Mergueb; Feeding preferences; M'Sila.

INTRODUCTION

The spur-thighed tortoise, *Testudo graeca whitei* (*T. g. whitei*), occupies a wide range of environment in North Africa, from arid areas with annual precipitation of about 116 mm to very humid Mediterranean environment where annual precipitation reaches 1092 mm (Anadón *et al.* 2012, Rouag *et al.* 2017). The nomenclature of this subspecies has been recently revisited, being *T. g. whitei* attributed to the subspecies present in the North of Algeria, NE Morocco, and Spain (previously named *T. g. graeca*, Turtle Taxonomy Working Group 2021). The feeding ecology of *T. g. whitei* has been little studied in the Mediterranean sphere (Andreu 1987, Cobo and Andreu 1988), with a few studies done in North Africa (El Mouden *et al.* 2006, Hichami and Znari 2019), while only one study in the northeast of Algeria was noted (Rouag *et al.* 2008).

Information on the composition of natural animal diets, can facilitate understanding the role of a species in the ecosystem (Meek 2010); especially when this species is seriously threatened in its natural habitat, by various factors such as increasing aridity, overgrazing, and also by trade (Znari *et al.* 2005, Moulherat *et al.* 2014). This information also makes it possible to pre-adapt the populations bred in captivity and to enhance survivorship to natural conditions (Willemsen *et al.* 2002, Iftime and Iftime 2012).

Because the long-term conservation of the declining populations of *T. g. whitei* is a particular management concern, we present in this article, data on the food choice of this threatened species that is protected by Algerian regulations.

METERIAL AND METHODS

Study zone

The feeding behavior of *T. g. whitei* was studied in the Mergueb Nature Reserve, located in the high steppe plains in central Algeria, with the northern latitude of 35°35' and East longitude of 03°55', at an average altitude of 620 m, and upon an area of 16,481 ha (Adjabi *et al.* 2019).

This natural site is characterized by several plant species consisting primarily of *Artemisia herba-alba*, *Artemisia campestris*, *Salsola vermiculata*, *Anabasis articulata*, and *Stipa tenacissima* (Kaabeche,

2003, Adjabi *et al.* 2019), and a variety of annual and biennial species. The soils have sandy clay loam and sandy loam structures.The average minimum temperature is 3.5°C in February and the average maximum is 42.2°C in July. The average annual rainfall is between 121 and 181 mm (Adjabi *et al.* 2019).

Research protocol

The natural diet of *Testudo spp.* was studied previously by employing a series of methodologies (Lagarde *et al.* 2003), including analysis of fèces (Cobo and Andreu 1988, El Mouden *et al.* 2006, Díaz-Paniagua and Andreu 2009, Munoz *et al.* 2009, Iftime and Iftime 2012). The method of recording direct feeding observations was selected as it has already been used by several researchers on Testudinidae (Meek 2010, Iftime and Iftime 2012, Jennings and Berry 2015, Attum *et al.* 2021). After the individual tortoises were captured in the Mergueb Reserve, 23 tortoises (12 females, 8 males, and 3 juveniles) were maintained in an open enclosure (the garden of a family house with a surface area of about 168 m^2: 12 m × 14 m), at a distance of 500 m from the Reserve. The study was conducted in April of 2019 when fresh plant species were available in the Reserve and were picked for feeding in the enclosure.

Food availability is estimated by sampling the plant species in the courses of the Reserve, starting with the "Daya", which corresponds to a depression where the runoff water is concentrated, with a relatively deep soil characterized by a silty clay texture, favorable to the establishment and development of annual or biennial species (Kaabeche 2003). Sampling was also carried out in the four courses of perennial species occuring in this reserve: *Artemisia herba-alba, Artemisia campestris, Salsola vermiculata* and *Stipa tenacissima*. The samples were collected along the five transects of 20 m each in the courses, including the "Daya ».

The food availability estimates are carried out, using the Braun-Blanquet and Pavillard (1929) categories (Rouag *et al.* 2008):

- <01 % for species present but rare (score = +); 01-05 % of species cover (score = 1); 05-25 % (score = 2); 25-50 % (score = 3); 50-75 % (score = 4); 75-100 % (score = 5).

The distribution and dissemination of freshly sampled plants, was carried out daily into the enclosure, according to a program of one or two vegetal species every day, after having been mowed from the courses of the Reserve. Observations were recorded on the plants that were preferred and consumed by the tortoises and which plants were not consumed. All the tortoises were released in the Reserve, immediately after the completion of the study.

Statistical analysis

The Simpson Diversity Index (D) was used to define the feeding strategy of the tortoises. The index values ranged from 1 to 0. The value (1) indicated a generalist diet characterized by the consumption of almost any plant that tortoises come across, while the value (0) indicated a very restricted specialized diet (Meek 2010).

$$D = 1 - \frac{\Sigma [n (n-1)]}{N(N-1)}$$

D: Simpson diversity index; n: number of plants consumed of each plant family; N: total number of plant families consumed.

RESULTS AND DISCUSSION

A total of 40 plant species was sampled, according to availability during the study, and considered as potential food plants for *T. g. whitei*, However, only 11 species were consumed (Table 1). The Simpson diversity index (D = 0.33) indicates that a narrow range of plants was consumed by *T. g. whitei* individuals in the Reserve.

The method of direct observation used in the present study was simple and convenient, compared to several other experimental methods, for example, the use of feces as consumption indices, which has high risks of error due to comparable digestibility of different plant species, generating thus difficulties in identifying consumed vegetal species (Rouag *et al.* 2008, Meek 2010, Loss *et al.* 2020).

Table 1. List of plant species sampled from the Mergueb Nature Reserve (Algeria), consumed by the Spur-thighed tortoise, *Testudo graeca whitei***.**

Plant Taxa			Cover	Consumed
Group	**Family**	**Species**		
	Amaranthaceae	*Arthrophytum scoparium*	2	No
		Salsola vermiculata	3	No
	Apiaceae	*Daucus sahariensis*	1	No
		Ferula communis	1	No
		Thapsia garganica	1	No
	Asteraceae	*Anacyclus clavatus*	3	No
		Anvillea radiata	1	No
		Artemisia campestris	4	No
		Artemisia herba-alba	4	No
		Atractylis cancellata	1	No
		Bombycilaena discolor	+	No
		Calendula arvensis	1	No
		Leontodon hispidus	1	No
		Pallenis hierichuntica	1	No
	Boraginaceae	*Arnebia decumbens*	+	No
		Echium pycnanthum	1	No
Dicotyledons		*Noea micrantha*	+	No
	Brassicaceae	*Eruca vesicaria*	4	Yes
		Moricandia arvensis	2	Yes
		Neslia paniculata	1	No
		Rapistrum rugosum	2	Yes
		Vella pseudocytisus	1	Yes
	Caryophyllaceae	*Herniaria fontanesii*	2	No
	Dipsaceceae	*Lomelosia stellata*	+	No
	Fabaceae	*Retama retam*	1	No
		Vicia lutea	1	Yes
		Vicia monantha monantha	1	Yes
	Lamiaceae	*Ajuga iva*	2	Yes
		Marrubium supinum	+	No
	Malvaceae	*Malva parviflora*	1	Yes
	Nitrariaceae	*Peganum harmala*	4	No
	Orobanchacea	*Phelipanche mutelii*	+	Yes
	Papaveraceae	*Glaucium corniculatum*	+	No
	Resedaceae	*Reseda lutea lutea*	2	Yes
	Poaceae	*Andropogon distachyos*	1	No
		Cympobogon schoenanthus	1	No
		Hordeum vulgare	2	Yes
Monocotyledons		*Lygeum spartum*	1	No
		Stipa tenacissima	1	No
		Stipellula parviflora	1	No

The preference was primarily recorded for Brassicaceae: four vegetal species consumed), then Fabaceae: two vegetal species consumed, while the tortoises' preference was less for the Lamiaceae, Malvaceae, Orobanchacea, Resedaceae and Poaceae: one vegetal species consumed from each family (Fig. 1). The vegetal species consumed during spring (April), belonged to seven different plant families, which were all annuals: *Eruca vesicaria, Moricandia arvensis, Rapistrum rugosum, Vella pseudocytisus, Vicia lutea, Vicia monantha monantha, Ajuga iva, Malva parviflora, Phelipanche mutelii, Reseda lutea lutea*, and *Hordeum vulgare.*

Fig. 1. Group of individuals of *T. g. whitei* while eating different plant species sampled in the Mergueb Nature Reserve (Algeria).

Among vegetal species consumed, *Ajuga iva* and *Eruca vesicaria* had the highest availability in the Reserve, while *Phelipanche mutelii* had the lowest availability and it was least common in the sampling locations of the study area. The vegetation cover in the sampled steppe area was dominated by perennial plants, namely *Artemisia campestris* and *Artemisia herba-alba*; however, they weren't consumed by tortoises in the present study.

The results of the present study show that the studied population of *T. g. whitei* during the spring season has a preference for the plant Families that are available in Mergueb Reserve. Brassicaceae

(Crucifers) and Fabaceae (Leguminous), represent staples as was found for *Testudo hermanni hermanni* in Catalonia (Loss *et al.* 2020). Comparatively, similar results in other regions showed a food preference in *Testudo* spp. for leguminous plants (El Mouden *et al.* 2006, Rouag *et al.* 2008, Meek 2010, Iftime and Iftime 2012, Hichami and Znari 2019). Furthermore, comparable observations were made for *Gopherus agassizii* in California, which has a preference for leguminous plants (Jennings and Berry 2015). These selective preferences for one or more plant species would be due to their high nutritional content, and ease of digestion and assimilation (Meek 2010), knowing that plants' high nitrogen content and high nutritional value play an important role in tortoises growth (Jennings and Berry 2015, Hichami and Znari 2019). In the same context, according to Loss *et al.* (2020), this preference could also be linked to the rather soft leaf structure, their high energy content, and the easily assimilated minerals (phosphorus, sodium, calcium).

The food selection oriented towards Brassicaceae can be linked to glucosinolates and other biologically active compounds found in this Family of plants. Recent studies show the beneficial effects of glucosinolates, including regulatory functions of inflammation, stress response, metabolism, and antioxidant activities, as well as direct antimicrobial properties (Favela-Gonzalez *et al.* 2020, Bischoff 2021). Presumably, the nutritional benefits of finding less abundant species with easier energy assimilation (for example: leguminous) outweigh the efforts of foraging and locomotion to locate them (Meek 2010). Many other plant species, that are abundant in the habitat of the present study, such as rangelands perennials plants, were avoided by the population of *T. g. whitei*. Possibly they may be consumed during the summer season when annual plants dry out and are senescent (Attum *et al.* 2021).

In addition to the impacts of the current climatic changes, it remains probable that desertification, plowing, and overgrazing in the Mergueb Reserve could reduce the diversity of plant species. Thus, the tortoise population of *T. g. whitei* would be more vulnerable to a declining availability of preferred food plants. This indicates a need for more research and conservation hard work, with a comparative perspective, to better understand the food and feeding ecology of this turtle species.

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