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Notes on the diet of *Testudo hermanni boettgeri* and *T. graeca ibera* in south-western Bulgaria with first cases of geophagy and myrmecophagy from the country

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Abstract. Data on the diet of *Testudo hermanni* and *T. graeca* have been published in Bulgaria for more than a century. Yet, few studies have provided more details on the feeding habits of the two species. Here, we present information about their diet in south-western Bulgaria where they coexist. The results showed that *T. graeca* fed exclusively on plants, whereas *T. hermanni* was more opportunistic and supplemented its diet with other food sources, including ants and soil particles.

Key words: *feeding habits, dietary overlap, Testudinidae*

Introduction

Although data on *T. hermanni* Gmelin, 1789 and *T. graeca* Linnaeus, 1758 in Bulgaria have been published for over a century (Hristovitsch 1892), most studies have focused on their distribution. The first more detailed study on the diet of tortoises was conducted at the end of the 20th century (Lazarkevich-Stancheva 1997).

To the best of our knowledge, there is no published data on direct observations of myrmecophagy and geophagy by *Testudo* spp. in Bulgaria. The aim of this study was to supplement the knowledge of the diet of *T. hermanni* and *T. graeca* in the country.

Materials and Methods

The observations on the diet of both species were carried out in Kresna Gorge and some adjacent areas in south-western Bulgaria. The two species coexist in this part of the country, with *T. hermanni* being more abundant than *T. graeca* (see Results). Observations took place from 2020 to 2023 during the active season of the tortoises. The diets of the two species were investigated through direct observation. When possible, photographs were taken during the feeding to properly identify the food consumed. No identification of the plants was possible in about 50% of the cases when feeding was noted.

Results

One thousand and thirty-four individuals of *T. hermanni* and 309 individuals of *T. graeca* were observed in the wild. A total of 65 different cases of food consumption were

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registered. Forty-eight of them or 73.84% were of *T. hermanni*, and the other 17 or 26.15% of *T. graeca*. Herbaceous plants predominated in the diet of both species. In fact, they constituted 76% of the diet of the Hermann's Tortoise and 100% of the diet of the Spur-thighed Tortoise.

Plants from eight families were consumed by *T. hermanni*: Araceae, Fabaceae, Asteraceae, Polygonaceae, Plantaginaceae, Rhamnaceae, Scrophulariaceae, and Rosaceae. The species was mainly observed to feed on *Arum maculatum* and *Trifolium* sp., including *Trifolium campestre*. It also consumed *Crepis sancta*, *Rumex acetosella*, *Plantago lanceolata*, leaves of *Paliurus spina-christi*, *Medicago* sp., *Veronica* sp., and *Potentilla* sp. In addition, the species occasionally fed on fallen fruits – mulberries, wild pears, and figs, as well as dog feces (Fig. 1). *Testudo graeca* fed on plants belonging to four families: Asteraceae, Crassulaceae, Rosaceae, and Fabaceae. The species was noted to feed on *Cichorium intybus*, *Sedum rubens*, *S. album*, *Potentilla* sp., *Taraxacum* sp., and *Medicago* sp.

Fig. 1. Individuals of *T. hermanni* feeding on figs (A), mulberries (B), and dog feces (C).

Intriguingly, we also noted an adult male *T. hermanni* that was feeding on ants belonging to the species *Liometopum microcephalum* (Panzer, 1798); det. by Ivaylo Georgiev. The tortoise was standing at the basis of a large tree of the species *Populus nigra* (Linnaeus, 1753) and preying on the ants that were moving up and down on the trunk of the tree.

Almost immediately after this observation, we witnessed geophagy – an adult female *T. hermanni* was feeding on soil particles. The individual consumed particles from alluvial sand soil, which is a part of the high flood-plain Holocene terrace in the area. The soil that lies right above the terrace belongs to the type of shallow-leached cinnamonic forest soil (Marinova 1991).

Discussion

Our observations on the feeding habits of *T. hermanni* and *T. graeca* confirm the fact that herbaceous plants predominate in their diet (Lazarkevich-Stancheva 1997; Bertolero *et al.* 2011; Stojanov *et al.* 2011; Iftime & Iftime 2012). The Hermann's Tortoise can feed on many plant species belonging to over 45 families (Bertolero *et al.* 2011). However, the species usually has a distinct preference for a few of them such as Fabaceae, Asteraceae, and Rosaceae (Lazarkevich-Stancheva 1997; Meek 2010; Bertolero *et al.* 2011). In our observations, *T. hermanni* also often consumed species of these families, especially Fabaceae. Species of the genus *Trifolium* and *Medicago* were preferred by the individuals. Additionally, the Hermann's Tortoise consumed plants of the family Araceae such as *Arum maculatum*, which contains alkaloids (Meek 1985). It seems that the species deliberately searches for plants containing alkaloids (Bertolero *et al.* 2011) as they possibly neutralize some intestinal parasites (Longepierre & Grenot 1999).

The exclusively vegetarian diet of *T. graeca* in our study is in agreement with the results of Lazarkevich-Stancheva (1997), who found that *T. graeca* fed only on plants. Similarly, Iftime & Iftime (2012) mentioned that 96.5% of the diet of *T. graeca* in their study was formed of plants. However, the species normally supplement its diet with various sources of food, including animal matter (Beshkov & Nanev 2002; Stojanov *et al.* 2011).

Similar to *T. hermanni*, *T. graeca* feeds predominantly on plant species of several families, with Fabaceae and Asteraceae being favored (Lazarkevich-Stancheva 1997; Mouden *et al.* 2006; Rouag *et al.* 2008; Iftime & Iftime 2012). This is in agreement with our findings as the species often selected plant species of the family Fabaceae and Asteraceae. Thus, the diet of both species overlapped to some extent. That was also observed in other coexisting populations in the area (Lazarkevich-Stancheva 1997). This could be expected since the two species have similar biological and ecological requirements and equal access to the same resources.

Unlike *T. graeca*, *T. hermanni* was occasionally observed to consume fallen fruits. Other authors have also noted the same (e.g. Beshkov & Nanev 2002; Stojanov *et al.* 2011). Further, we recorded several cases of consumption of dog feces by *T. hermanni*. This appears normal as feces may be a source of moisture, hair, and fragments of bones and are thus consumed when available (Bertolero *et al.* 2011). The species was also found to feed on carrion in the study area, which was described in our previous paper (Mitrevichin *et al.* 2022).

What is more, we witnessed a case in which an adult Hermann's Tortoise was predating on ants of the species *L. microcephalum*. To our knowledge, this is the first case of direct observation of the consumption of ants by a tortoise in the country. Many Bulgarian authors have mentioned that *T. hermanni* may intentionally or unintentionally ingest invertebrates (Lazarkevich-Stancheva 1997; Beshkov & Nanev 2002; Stojanov *et al.* 2011; Tzankov *et al.* 2014). Gagno *et al.* (2012) analyzed the content of the alimentary canal of 30 Hermann's tortoises and found animal remains in 73% of the cases. Most of the remains belonged to invertebrates, in particular to ants, which were the most abundant group. Gagno *et al.* (2012) suggested that due to the high quantity of the remains, the species had intentionally consumed more invertebrates. Our observation confirms this suggestion and indicates that *T. hermanni* can supplement its diet with invertebrates, which are a vital source of protein, lipids, and amino acids (Gagno *et al.* 2012).

It seems that *T. hermanni* may opportunistically feed on what is available within its habitat. This is further supported by the geophagy that we observed. As far as we know, this is the first direct observation of deliberate geophagy by a tortoise in the country. Other authors have also documented deliberate geophagy in the species (Sokol 1971; Gagno & Alotto 2010; Đorđević & Golubović 2013). The function of the particles ingested may vary. For example, bigger particles can help in the mechanical breakdown of food. In addition, the ingested particles might play a role in the expelling of intestinal parasites (Gagno & Alotto 2010).

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