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SEASONAL VARIATIONS OF THE DIET OF *LAUDAKIA STELLIO* (AGAMIDAE) FROM NISYROS ISLAND, DODECANESE (GREECE)

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Laudakia stellio is a large-sized agamid lizard with a scattered distribution in mainland and island Greece, north-western Africa, and south-western Asia (Arnold, Burton & Ovenden, 1978). In the Dodecanese archipelago the species is widespread, but it is not found on the smaller islands (Chondropoulos, 1986; Foufopoulos, 1997). The first record for Nisyros island, our study site, dates back to Zavattari (1929).

The data available on the ecology and natural history of *L. stellio* are very few, possibly because of its extremely elusive habits. Apparently, *L. stellio* shares some important natural history features with some of its African relatives of the genus *Agama* (e.g. *A. agama*, cf. Harris, 1964; Yeboah, 1982; Anibaldi, Luiselli & Angelici, 1998), including bright male dorsal coloration which can be changed rapidly, brightest colours in dominant specimens, and peculiar displays (exaggerated posturing, head bobs, etc) (Arnold *et al.*, 1978; Xyda, 1986). Almost nothing is documented on the diet of *L. stellio*, whereas detailed data are available for the common rainbow lizard *A. agama* of Africa (Chapman & Chapman, 1964; Harris, 1964; Cloudsley-Thompson, 1981; Anibaldi *et al.*, 1998). Some information is available from Cyprus (Cecconi, 1908) and Antiparos (Cyclades; Cattaneo, 1984), and a general review is found in Beutler (1981).

In this note we present detailed data on the composition of the diet of a population of *L. stellio* from the Dodecanese, based on food remains in faecal pellets. We focus our attention on seasonal variations in diet composition.

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The fieldwork was conducted by one of us (PLC), during spring (April and May) and summer (August) 1999 on Nisyros island, Dodecanese, Greece (36° 35' N, 27° 10' E). Nisyros is a medium-sized island (41.2 km^2, maximum elevation 698 m a.s.l.) belonging to the active volcanic arc of the southern Aegean. The origin of the island can be dated back to 150 000 years ago, when there was very strong eruptive activity in the region (Vougioukalakis, 1998). The soil consists mainly of tephritic-pumiceous material coming from the last eruptions. The vegetation of Nisyros consists of high Mediterranean evergreen maquis comprising the following species: *Quercus macrolepsis, Quercus coccifera, Pistacia terebinthus* and *Olea europaea sylvestris*. The total human population of the island is approximately 1000 and is mainly concentrated on Mandraki village, where *L. stellio* is known as "Kurkutavlos". In the study area, *L. stellio* is sympatric with the lacertid *Ophisops elegans*, and possibly with the snake *Coluber gemonensis* (Boettger, 1888; Ghigi, 1929). Potential predators of *L. stellio* could be raptors, feral cats and rats. *Ophisops elegans* is undoubtedly the only other lizard of Nisyros island (Boettger, 1888; Ghigi, 1929; Lo Cascio, unpublished data).

Sampling was carried out on four occasions during the spring and two occasions during the summer. Faeces were collected on the surface of dry, stony walls that represent the typical habitat of *L. stellio* in the study area. The collected faeces could undoubtedly be attributed to the study species on account of their typical size and shape. Indeed, the size of the collected faeces was too large for the smaller species *Ophisops elegans*. Moreover, *Laudakia stellio* and *Ophisops elegans* exhibited a clear habitat separation, with the former species inhabiting only stony walls, whereas the latter is an exclusively ground-dwelling species (P. Lo Cascio, unpubl. data). The transects of walls where the faeces were collected were 100 m to 200 m long, and the local density of *L. stellio* specimens averaged one specimen every 5-10 m of linear transect (P. Lo Cascio, unpubl. data). The lizard population size within the walked transects was estimated to consist of 100 to 400 individuals (P. Lo Cascio, unpubl. data). Along these transects, however, sightings of faecal pellets were scarce, mainly because in parts of the transect it was impossible to search for them due to the thick spiny bush coverage. Faeces were examined in the laboratory under a dissecting microscope. Faecal analysis has proved to be a reliable technique for evaluating diet composition of large lizards (Angelici, Luiselli & Rugiero, 1997; Anibaldi *et al.*, 1998). Remains were identified to the lowest taxon possible. Size of prey items (precision ± 1 mm) was evaluated by comparisons with reference collections of Nisyros arthropods and seeds stored in the Zoological Museum "La Specola" (Florence, Italy) and in the private collection of one author (P. Lo Cascio). For practical reasons, every food remnant was assigned to one of the following seven size categories:

(1) 0-3 mm, (2) 3.1-6 mm, (3) 6.1-9 mm, (4) 9.1-12 mm, (5) 12.1-15 mm, (6) 15.1-18 mm, (7) >18.1 mm in length. Statistical analyses were computed using SPSS for Windows PC package, with alpha set at 5% and all tests being two-tailed.

In total 81 faecal pellets were obtained from the soil, 54 during spring and 27 during summer. Given that we did not capture *L. stellio* specimens, and given the highly sedentary habits of agamid lizards inhabiting walls (e.g. see Anibaldi *et al.*, 1998), it remains possible that several pellets were produced by single specimens. These faeces consisted of 857 identifiable food remains during spring (mean = 15.9 identifiable food items per pellet), and 127 identifiable food remains during summer (mean = 4.7 identifiable food items per pellet). The mean number of prey per pellet was significantly different between spring and summer (one-way ANOVA: F=43.132, df=1,78, P<0.00001). However, the spring faeces were not larger than the summer ones, which were often drier and more fragmented due to faster desiccation. In addition, small stones and remains of leaves (presumed to be secondarily ingested by lizards) were found in a few faeces, but are not included in this analysis. The dietary data are summarized in Table 1. The diet composition shifted considerably from spring to summer (χ^2 test, 2 x 19 contingency table, P<0.000001). During spring, it consisted mainly of arthropods, though gastropods, seeds and fruits were occasionally consumed. If we consider only arthropod remains, there was a considerable excess of Coleoptera (particularly Rutelidae) and Hymenoptera (mainly Formicidae) over all other taxonomic groups (χ^2 test, df=6, P<0.000001). During summer, arthropods (mainly insects) were also frequently eaten, but plants and seeds assumed a much higher significance. In particular, the fruits of *Pistacia terebinthus* were frequently consumed (Table 1). In this regard, it is noteworthy that *L. stellio* specimens were observed while searching actively for these fruits on the ground, whereas they were never observed climbing on *Pistacia* trees. This is consistent with Beutler's (1981) report that *L. stellio* is not arboreal in the Aegean islands. With regard to *Pistacia* fruits, it should be mentioned that they are mainly constituted by the seed, while the edible part is limited to a thin external layer where the available energy content is concentrated.

TABLE 1. Dietary composition by numbers of items (N), and by numbers of pellets containing that prey type (n), in samples of *Laudakia stellio* faecal pellets from Nisyros island, Dodecanese (Greece).

	Spring		Summer	
Prey Type	*N*	*n*	*N*	*n*
(1) PLANTS AND SEEDS				
Plant remains	1	1	-	-
Compositae seeds	37	16	-	-
Pistacia terebinthus fruits	-	-	40	21
Undetermined seeds	12	2	-	-
(2) ANIMALS				
Gastropoda (Pulmonata)	4	4	1	1
Acarina	1	1	-	-
Araneae	7	7	4	4
Heteroptera undet.	20	17	7	5
Odontoscelis sp.	1	1	-	-
Dermaptera	-	-	7	7
Orthoptera (Acridoidea)	2	2	2	2
Coleoptera undet.	10	10	22	5
Tenebrionidae	12	11	4	4
Chrysomelidae	2	2	-	-
Nitidulidae	4	4	-	-
Curculionidae	22	17	7	5
Lixus sp.	2	1	-	-
Carabidae	6	5	-	-
Scarabaeidae	1	1	-	-
Cetoniidae	2	2	-	-
Oxythyrea cinctella	3	3	-	-
Rutelidae	31	10	-	-
Anisoplia sp.	7	4	-	-
Blitopertha lineolata	465	44	1	1
Buprestidae	-	-	1	1
Lepidoptera	1	1	-	-
Hymenoptera (Chrysididae)	2	2	2	2
Apoidea	39	18	3	1
Formicidae	163	29	26	11

Size was determined in nearly 95% of the total sample of consumed items during spring, and 62.2% of consumed items during summer. During spring, there was a unimodal size distribution peaking at 9-12 mm (Fig. 1). This modal size corresponded with the size of Rutelidae beetles, which accounted for over 80% of consumed items in this size category. During summer, the modal size of the arthropods eaten was slightly smaller (Fig. 1), but the seed component was much higher than in spring.

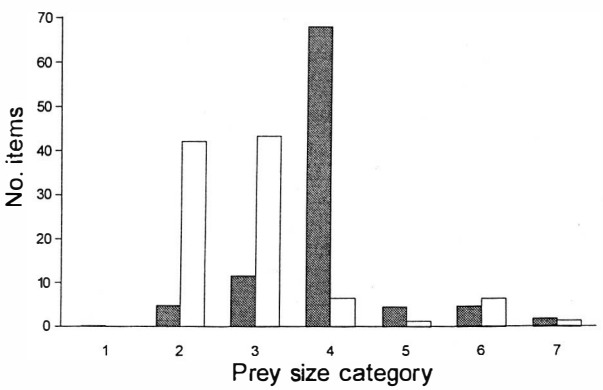

FIG. 1. Prey size distributions inferred from faecal pellets of *Laudakia stellio* from Nisyros island, Dodecanese (Greece). Total N is 813 during spring and 79 during summer. Shaded columns indicate spring, and unshaded columns indicate summer. Symbols for prey size categories: 1, 0-3 mm; 2, 3.1-6 mm; 3, 6.1-9 mm; 4, 9.1-12 mm; 5, 12.1-15 mm; 6, 15.1-18 mm; 7, >18 mm

In general, our data show that there is a very pronounced seasonal dietary shift in the studied population of *L. stellio.* During the spring, these lizards are typical arthropod-eating agamids. In this period, they exhibited a foraging tactic that may be described as "slow searching scan behaviour", which is quite similar to a typical sit-and-wait strategy. It is noteworthy that Rutelidae, as well as other flower-visiting Scarabeoidea beetles that are the commonest prey items in spring, are readily available in the environment in that season. In fact, they exhibit a peculiar phenology that is limited exclusively to the early spring months (April to May). During summer, *L. stellio* forages upon arthropods of similar size, but actively searches for larger fruits and seeds. In this regard, it should be noted that the plant *Pistacia terebinthus* has the fruit phase in summer, and is therefore not available to lizards during spring. Thus, it is concluded that the lizards exhibited a mixed foraging strategy in summer, with an active searching component. The modal size of animal prey was slightly greater in *L. stellio* during spring than during summer, but this may reflect differences in prey size availability in the various study sites and during the survey periods (cf. Vicente, Araujo & Barbault, 1995). The fact that Agamidae species may feed upon both animal and plant material is not, in itself, a new finding, as it has already been mentioned for African species (Harris, 1964).

Cecconi (1908) reported a diet based on arthropods (mainly insects) for a few dissected specimens of this species, and Beutler (1981) also reported generically the presence of beetles and orthopterans in the diet. These studies provide data quite similar to those recorded by us in spring. Conversely, Cattaneo (1984) found that invertebrates (mainly small beetles) are not the only dietary components of *L. stellio,* as flowers of Compositae plants (mainly *Chrysanthemum coronarium*) are also consumed. It is noteworthy that the evolution of herbivory is positively correlated with insularity in the primarily insectivorous lizards of the family Lacertidae (Pérez-Mellado & Corti, 1993; Van Damme, 1999), and our data on *L. stellio* suggests that the same may be true for Old World Agamidae as well.

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