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The food of *Podarcis milensis* and *Podarcis erhardii* in the insular ecosystems of the Aegean

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Introduction

Small lacertid lizards of the genus *Podarcis* are generally insectivorous lizards that feed mainly on arthropods (ARNOLD, 1987), although plant food may also be eaten especially by populations on small Mediterranean islands with impoverished faunas (PÉREZ-MELLADO & CORTI 1993). They are believed to be opportunistic predators, with lack of obvious dietary specializations, which impels the idea that differences in diet composition reflect in a large extent differences in the trophic availability or in body size constraints (e.g. AVERY 1966, ARNOLD 1987). On the other hand, there has been shown to exist a high selective behaviour towards food (e.g. PÉREZ-MELLADO 1982).

The insular ecosystems of the Mediterranean basin are characterized by strong seasonal climatic fluctuations which lead to variations in food resources (FUENTES 1984). The dominant prey groups vary from island to island, and depend on the natural characteristics of every one of them. The diet of certain island populations has also been observed to change according to the season (PÉREZ-MELLADO & CORTI 1993, VALAKOS 1986, CHONDROPOULOS et al. 1993).

Studies made on the diet composition of Lacertidae from western Mediterranean islands, show adaptations related to the trophic availability such as herbivory, high consumption of clumped prey and myrmicophagy (OUBOTER 1981, SADEK 1981, SORCI 1990, PÉREZ-MELLADO & CORTI 1993, DÍAZ 1995). On the other hand, data on the trophic ecology of the insular ecosystems of the eastern Mediterranean are relatively few. *Podarcis erhardii* on the big islands of the Aegean feeds on Coleoptera, ants and insect larvae with seasonal dietary shifts (VALAKOS 1986, 1987, 1990). The diet of *Podarcis taurica* from the Ionian islands shows the same pattern (CHONDROPOULOS et al. 1993), while for *Podarcis milensis*, endemic species of the Aegean, data are insufficient.

Podarcis erhardii, the cicladian wall lizard, is differentiated and predominant in most of the insular ecosystems of the north, central and south Aegean with the exception of the Southwest Cyclades, that is Milos, Kimolos and their surrounding islets, where it is replaced by *Podarcis milensis* (fig.1, tab. 1).

In the present study, the first data on the feeding ecology of *Podarcis milensis* from the mainly volcanic Milos group islands, are presented. Besides, data on the diet of *Podarcis*

Fig. 1. Map of the examined islands. Abbreviations as in table 1.

erhardii from Naxos isl. and small islets of the south Aegean, are given. The two species are never found sympatric. The differences in their feeding ecology are discussed.

	Milos	Antimilos	Ananes	Velopoula	Falconera	
Abbr.	M	Am	An	V	F	
Area (km^2)	150.6	8.2	0.1	1.86	1.29	
Species	*P. milensis*	*P. milensis*	*P. milensis*	*P. milensis*	*P. milensis*	
N	12	12	8	7	3	
Volcanic	+	+	+	+	+	
	Naxos	**Pori**	**Anydros**	**Antileousa**	**Pergousa**	**Pachia**
Abbr.	N	Po	Ad	Al	Pr	Pa
Area (km^2)	428.1	1.0	1.13	2.0	1.2	1.0
Species	*P. erhardii*	*P. erhardii*	*P. erhardii*	*P. erhardii*	*P. erhardii*	*P. erhardii*
N	59	5	11	7	8	9
Volcanic	–	–	–	–	+	+

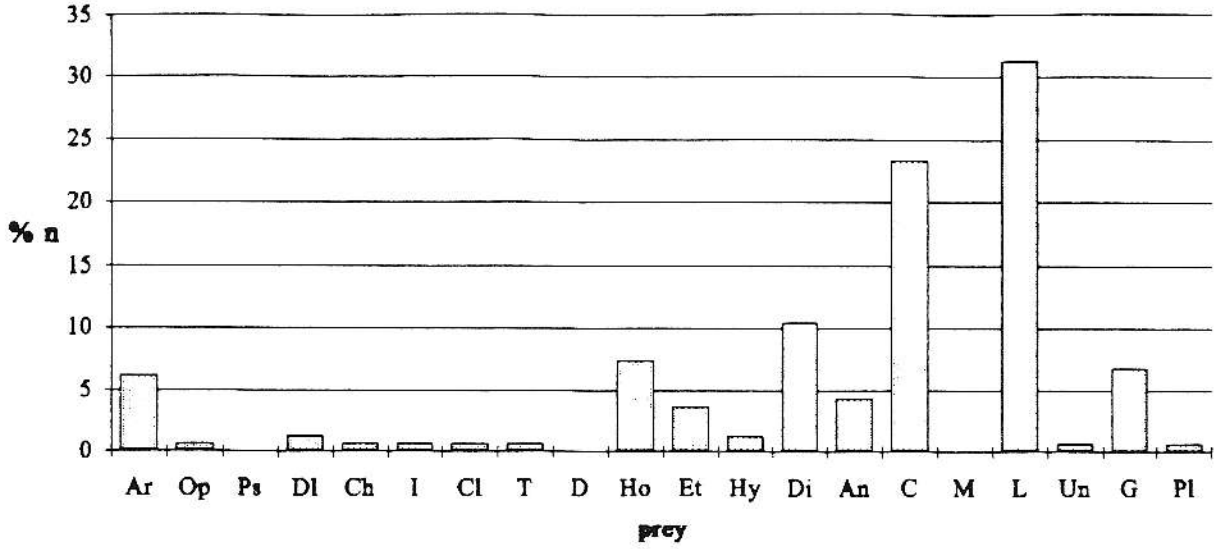
Tab. 1. The examined islands. Abbr. = Abbreviations, N = Sample size.

Study methods

We studied 6 insular populations of *Podarcis erhardii* and 5 populations of *Podarcis milensis*. The main characteristics of the examined islands are the rocky terrain and the vegetation which is mainly phryganic (e.g. *Thymus* sp., *Genista* sp., *Sarcopoterium spinosum*). In table 1 the distribution of the species and the sample size of every island are shown. A total of 138 animals was examined, from which only 9 were captured. The specimens from Naxos island (59), belong to the Herpetological collection of the Section of Animal & Human Physiology of the University of Athens. All the other samples of *Podarcis erhardii* and *Podarcis milensis* from the rest of the islands, with the exception of Milos, were from specimens deposited at the Herpetological collection of the Natural History Museum of the University of Creta (import number: 200 – 208). Only *Podarcis milensis* specimens from Milos island (9) were collected, that are going to be used in the PH.D. Thesis of the second author concerning the ecology of this species. In this way, these are the first results of a study that has just started in Milos island. The threatened situation of *Podarcis* populations discourages the capture of many specimens, while the faeces analysis was not preferred since *Podarcis milensis* is in sympatry with *Cyrtopodium kotschyi*. All animals were checked to be collected in spring season when both their activity and the arthropods' one are at their peak (KARAMAOUNA 1987).

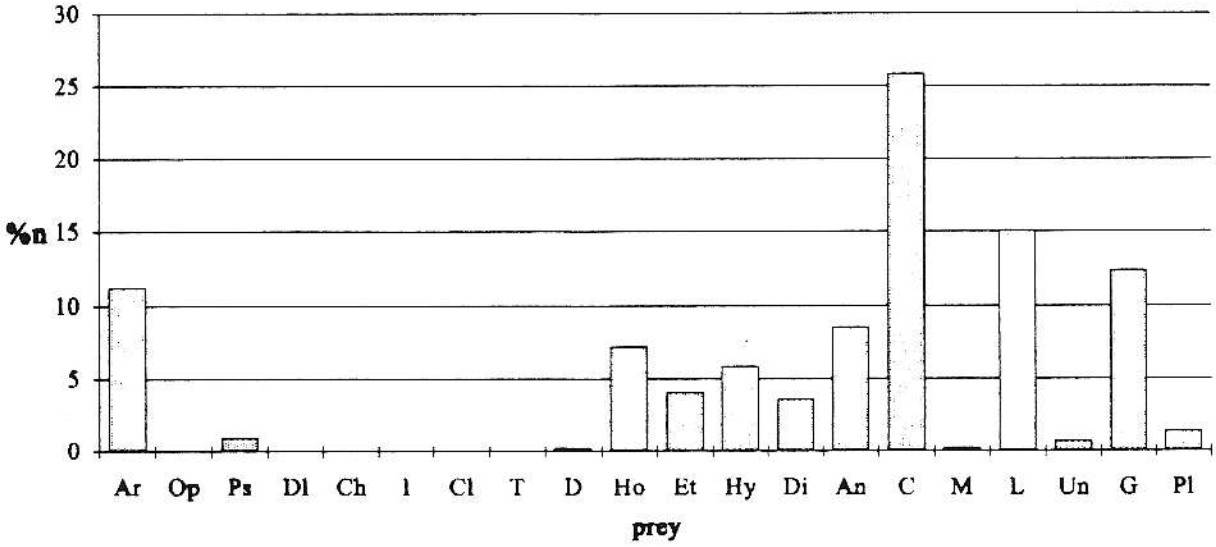
For each animal we removed the entire digestive track and examined it for the presence of prey remnants. Prey items were grouped to taxonomic categories, generally ordinal level. Coleopteran and Lepidopteran larvae were grouped in one category as "insect larvae".

Podarcis milensis



n=163

Podarcis erhardii



n=445

Fig. 2. Proportion of prey in the examined stomachs (% n) of the two species. n = Number of prey items.

Ar: Araneae, Op: Opiliones, Ps: Pseudoscorpionida, Dl: Diplopoda, Ch: Chilopoda, I: Isopoda, Cl: Collembola, T: Thysanoura, D: Dermaptera, Ho: Homoptera, Et: Heteroptera, Hy: Hymenoptera, Di: Diptera, An: Ants, C: Coleoptera, M: Mantidae, L: Insect larvae, Un: Arthropoda undet., G: Gastropoda, Pl: Plant material.

In order to avoid biasses in the evaluation of the diet, stomach contents were summarized in two ways: 1) proportion of the total number of prey items in the stomach (% n), 2) proportion of lizards eating a prey taxon (F). Trophic niche breadth was calculated according to LEVIN's index (1968). The food similarity between the examined populations was calculated using PIANKA's formula (1973).

Results

The diet of the two species (pooled data of all populations) is given in figure 2. There is a significant difference in the proportion of prey items consumed ($x^2 = 62.752$, df = 19, $p < 0.05$). Due to the small sample size of each island, our data refer to the species-specific differences and not to island differences.

Podarcis milensis feeds mainly on insect larvae, Coleoptera, Diptera, Homoptera, Gastropoda and Araneae. All the other prey groups participate in the diet with a small proportion (< 4 %). In the majority of cases the similarity values are higher than 0.65 (tab. 3). By frequency of occurrence the most important groups are the same.

Podarcis erhardii feeds mainly (according to n % or F) on Coleoptera, insect larvae, Gastropoda, Araneae, Homoptera, Hymenoptera and ants. These groups seem to dominate in all the examined populations (tab. 2). The similarity values are higher than 0.6 (tab. 3).

In all islands the proportion of Gastropoda is significant. In the volcanic islands there is no significant difference in the proportion of snails between the two species (Fisher exact test with correcting for continuity Z = 0.866, p = 0.19).

The niche breadth in all the examined islands ranges from 3.448 to 6.545 according to %n and from 4,5 to 7.622 according to F (tab. 2). The two values are related significantly (Spearman test $r_s = 0.627$ $P<0.05$).

Discussion

Just in the case with other *Podarcis* of the Mediterranean, *Podarcis milensis* feeds mainly on arthropods. The diet of *Podarcis milensis* is composed of the most common terrestrial arthropods found during the spring in the insular ecosystem of the Aegean (KARAMAOUNA 1987, MAGIORIS 1991). *Podarcis milensis* seems to be a widely foraging predator because there were several invertebrates in its prey which are not either active on the surface or remain hidden when the lizard's foraging takes place (Insect larvae, snails etc.) (VITT 1991) and also used many different types of prey (HUEY & PIANKA 1981).

Podarcis erhardii showed also a terrestrial diet, with Coleoptera and larvae being the most dominant groups. These results are not different from those given previous studies (VALAKOS 1986, 1987, 1990).

Though the two species feed with the same taxa, the proportions are different. *Podarcis milensis* preys on insect larvae, followed by Coleoptera and Diptera while *Podarcis erhardii* feeds on Coleoptera, insect larvae and Gastropoda. These groups participate with a high proportion in the invertabrate's fauna of the insular ecosystem of the Aegean. The lack of

Prey type	*Antimilos*		*Falkonera*		*Ananes*		*Velopoula*		*Milos*		Antileousa		Pergousa		Pachia		Pori		Anydros		Naxos	
	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F	% n	% F
Araneae	6.17	41.7			16.7	37.5	4.16	14.3	3.57	12.5	9.1	28.6	3.03	12.5			19	60	9.52	63.6	13.7	61
Opiliones	1.23	8.33																	1.19	9.09	1.17	5
Pseudoscorpions																						
Diplopoda			16.7	33.3																		
Chilopoda							4.16	14.3														
Isopoda					5.55	12.5																
Collembola	1.23	8.33																				
Thysanura									3.57	12.5												
Dermaptera											4.5	14.3										
Homoptera	9.87	41.7	8.33	33.3	11.1	25					9.1	28.6			6.66	11.1					11	39
Heteroptera	1.23	8.33	8.33	33.3					14.3	37.5	4.5	14.3			3.33	11.1	4.76	20	7.14	27.3	3.53	19
Hymenoptera							8.33	28.6					12.1	25			4.76	20	8.33	36.4	5.49	24
Diptera	8.64	41.7	8.33	33.3	11.1	25	25	28.6	3.57	12.5					6.66	22.2			8.33	54.5	3.53	17
Formicidae	2.46	16.7	8.33	33.3					14.3	25			18.2	37.5					4.76	27.3	11	27
Coleoptera	16	66.7	16.7	33.3	27.8	62.5	29.1	57.1	35.7	87.5	31.8	57.1	21.2	75	33.3	66.7	33.3	80	14.3	72.7	32.2	78
Mantidae																					0.39	2
Insect larvae	45.7	91.7	25	66.7	5.55	12.5	20.8	42.9	17.9	62.5	13.6	42.9	12.1	50	40	55.6	4.76	20	3.33	81.8	7.45	39
Unidentified	1.23	8.33											3.03	12.5	3.33	11.1			1.19	9.09		
Gastropoda	3.7	25	8.33	33.3	22.2	50	8.33	14.3	3.57	12.5	22.7	28.6	15.2	37.5	6.66	22.2	28.6	60	11.9	63.6	10.6	35
Plant material									3.57	12.5	4.5	14.3	15.2	37.5			4.76	20				
No. of prey items	81		12		18		24		28		22		33		30		21		84		255	
No. of liz. examin	12		3		8		7		8		7		8		9		5		11		59	
Bn	3.78		6.54		5.4		4.8		4.84		5.15		6.44		3.49		4.2		5.67		5.92	
BF	6.67		7.36		5.4		5.44		5.16		6.4		6.22		4.5		5.16		7.62		7.46	

Tab. 2. Diet of *P. milensis* (the examined islands in italics) and *P. erhardii*. Bn = niche width according to % n, Bf = niche width according to % F.

detailed studies on the trophic availability of many islands does not permit us to explain these differences.

The food choice in both species seems to be related to many factors that characterize the insular ecosystems of the Aegean. The high proportion of insect larvae in their diet could be connected to their high content in water (LEGAKIS pers.com.), since the spring rainfall in the area is less than 100 mm (MYLONAS 1982). In the volcanic islands the choice of gastropods seems to be related to the low calcium availability. In these islands the diversity of gastropods is very low (MYLONAS unp. data). The malacophagy seems to be common in the Aegean insular ecosystems. PÉREZ-MELLADO & CORTI (1993) found that *Podarcis* species in West Mediterranean islands do not usually eat snails, attributing this result to the high cost of handling and crushing their shells. The fact that in our results most of the snails were crushed and small sized could be related to the abundance of small sized snails in the malacofauna of the Aegean (MYLONAS 1982, RIEDEL 1992).

The choice of clumped prey like Homoptera, Curculionidae and ants is supposed to be a good strategy in arid environments because the searching costs are low due to their clumped distribution (POLLO & PÉREZ-MELLADO 1988, 1991). Especially in the big is-

	Antimilos	*Falkonera*	*Ananes*	*Velopoula*	*Milos*	Antileousa	Pergousa	Pachia	Pori	Anydros	Naxos
Antimilos	–										
Falkonera	0.824	–									
Ananes	0.514	0.578	–								
Velopoula	0.736	0.720	0.742	–							
Milos	0.664	0.754	0.649	0.746	–						
Antileousa	0.626	0.682	0.905	0.716	0.786	–					
Pergousa	0.515	0.607	0.616	0.618	0.755	0.738	–				
Pachia	0.932	0.836	0.627	0.830	0.822	0.777	0.618	–			
Pori	0.407	0.499	0.907	0.641	0.690	0.926	0.721	0.577	–		
Anydros	0.910	0.816	0.608	0.797	0.724	0.702	0.670	0.877	0.600	–	
Naxos	0.570	0.655	0.882	0.732	0.850	0.887	0.767	0.704	0.855	0.648	–

Tab. 3. Similarity values between the examined populations (islands in italics as in table 2).

lands of our sample this strategy is more usefull since it minimises the predation risk. It is known that in Milos and Naxos islands distribute some snake species e.g. *Vipera lebetina schweizeri* and *Vipera ammodytes* which feed on *Podarcis* (ADAMOPOULOU et al. in prep., VALAKOS 1990).

PÉREZ-MELLADO & CORTI (1993) found that in Balearic islands many *Podarcis* populations feed on plant matter and they related that with paleogeographical and paleoclimatological reasons. In our results the percentage of plant matter in the stomachs is very low.

Both species appear to be euryphagus being in agreement with the opinion that in islands with poor trophic resources we expect a more generalised diet (STEPHENS & KREBS 1986). The density of arthropods in the insular ecosystems of the Aegean is one of the lowest in the Mediterranean type ecosystems (see MAGIORIS 1991).

However, more detailed studies of the available trophic resources and the study of museum specimens are necessary in order to form a clear picture.

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