The effect of some factors on the helminth parasite infracommunities of *Podarcis* lizards in the Balearic Islands (Western Mediterranean)

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The effect of several abiotic and biotic factors (island area, distance from a potential colonizing source, sex, age and diet of the host) on helminth diversity of the endemic balearic lizards *Podarcis pityusensis* and *Podarcis lilfordi* caught on small islets of the Balearic Islands (Western Mediterranean), has been studied. 564 *P. pityusensis* and 386 *P. lilfordi* hosts were examined for helminths. The variables "size of the island" and "distance to a potential colonizing source", in relation to helminth diversity, do not fit those predicted by the Theory of Island Biogeography. In *P. pityusensis*, older hosts harbour more diverse infracommunities because of the high population densities in small islets. The trend to herbivorism shown by both hosts is a secondary adaptation with no phylogenetic significance.

***Keywords**: lizards, helminth parasites, ecology, Western Mediterranean.*

EFECTE D'ALGUNS FACTORS SOBRE LES INFRACOMUNITATS PARÀSITES DE SARGANTANES DEL GÈNERE *PODARCIS* EN LES ILLES BALEARS (MEDITERRÀNIA OCCIDENTAL). Hom ha analitzat diversos factors abiòtics i biòtics (superficie de les illes o illots, distància a una potencial font de colonització, sexe, edat i tipus d'alimentació del hoste) en relació a la diversitat helmintiana de les sargantanes endèmiques de les illes Balears, *Podarcis pityusensis* i *Podarcis lilfordi*, capturades en illes i illots de l'arxipèlag (Mediterrània occidental). Un total de 564 espècimens de *P. pityusensis* i 386 de *P. lilfordi* foren analitzades helmintològicament. Les variables grandària de l'illa i distància a una potencial font de colonització en relació amb la diversitat helmintiana no s'ajusta a allò que prediu la Teoria de la Biogeografia Insular. En *P. pityusensis*, els hostes mes vells tenen infracomunitats més diverses a causa de les grans densitats de poblacions de sargantanes en illots petits. La tendència cap a l'herbivorisme que tenen tots dos hostes és una adaptació secundària sense significació filogenètica.

***Paraules clau**: sargantanes, helmints paràsits, ecologia, Mediterrània Occidental.*

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Introduction

Lizards of the genus *Podarcis* Wagler, 1830 are a large group of saurians widespread along the Mediterranean Basin, living in continental and insular habitats. All the present species come from one or very few stocks which colonized all the Mediterranean area during the Mesinian period (Alcover, 1988). Different aspects of the biology of these reptiles have been investigated (Pérez-Mellado & Salvador, 1981; Salvador, 1986 a,b; Bruno, 1988 a,b; Lanza,

		Prevelance		Intensity of infection		Abundance
Helminth species	Site of infection	n	(%)	Range	$\bar{x}$	$\bar{x}$
DIGENEA						
Paradistomum mutabile	gall-bladder	129	22.9	1-56	8.1	1.8
Brachylaima sp.(larvae)	intestine	1	0.2	--	--	--
CESTODA						
Oochoristica gallica	intestine	25	4.4	1-264	30.4	1.3
Nematotaenia tarentolae	intestine	19	3.4	1-10	2.6	0.1
Diplopylidium acanthotetra(l)	body cavity	16	2.8	1-35	10.1	0.3
Mesocestoides sp.(larvae)	body cavity	9	1.6	1-56	12.4	0.2
NEMATODA						
Skrjabinodon medinae	cloaca	67	11.9	1-20	4.8	0.6
Spauligodon cabrerae	cloaca	193	34.2	1-222	20.9	7.2
Parapharyngodon bulbosus	cloaca	104	18.4	1-134	17.6	3.2
Parapharyngodon echinatus	cloaca	9	1.6	1-14	4.6	0.1
Parapharyngodon micipsae	cloaca	123	21.8	1-15	4.6	1.0
Strongyloides ophiusensis	intestine	7	1.2	1-37	9.7	0.1
Acuaria sp.(*larvae*)	body cavity	5	0.9	1-8	3.8	0.03
Spirurida gen. sp.(*larvae*)	body cavity	6	1.1	1-6	2.8	0.03
ACANTHOCEPHALA						
Centrorhynchus sp.(*larvae*)	body cavity	4	0.7	1-4	2.5	0.01

Table 1. Infestation parameters of the helminth species parasitizing *P. pityusensis*. Number of sampled hosts = 564; n = number of parasitized hosts.
Taula 1. Paràmetres d'infestació dels paràsits de P. pityusensis. *Nombre d'hostes analitzats = 564; n = nombre d'hostes parasitats.*

1988; Pérez-Mellado, 1989; Brown *et al.* 1992; Delaguerre & Cheylan, 1992; Salvador, 1993; and chapters in Valakos *et al.* 1993). However, parasitological studies are much more scarce and unsystematic. Although several studies concerning reptile parasitological ecology have been made (see Aho, 1990; Roca & Hornero, 1994), the present study is the first one concerning European reptiles connecting several abiotic and biotic factors with their parasite faunas. This paper deals with helminths from two endemic lizards from the Balearic Islands, *Podarcis pityusensis* (Boscá, 1883) and *Podarcis lilfordi* (Günther, 1874) (Reptilia: Lacertidae). *P. pityusensis* occurs in Eivissa and Formentera islands, and in the small islets around them, while *P. lilfordi* can only be found in the small islets surrounding Majorca and Minorca.

		Prevelance		Intensity of infection		Abundance
Helminth species	Site of infection	n	(%)	Range	$\bar{x}$	$\bar{x}$
DIGENEA						
Paradistomum mutabile	gall-bladder	42	10.9	1-26	6.5	0.7
Brachylaima sp.(larvae)	intestine	3	0.8	1-2	1.3	0.01
NEMATODA						
Skrjabinodon medinae	cloaca	96	24.9	1-17	4.1	1.0
Spauligodon cabrerae	cloaca	161	41.7	1-109	12.2	5.1
Parapharyngodon bulbosus	cloaca	14	3.6	1-14	6.5	0.2
Parapharyngodon micipsae	cloaca	25	6.5	1-11	3.8	0.2
Skrjabinelazia hoffmanni	intestine	4	1.0	1-5	2.0	0.02
Abbreviata sp.	intestine	1	0.3	--	--	--
Acuaria sp.(larvae)	body cavity	4	1.0	1-20	6.8	0.1
Spirurida gen. sp.(*larvae*)	body cavity	4	1.0	1-6	2.8	0.02
ACANTHOCEPHALA						
Centrorhynchus sp.(*larvae*)	body cavity	4	1.0	1-5	2.3	0.02

Table 2. Infestation parameters of the helminth species parasitizing *P. lilfordi*. Number of sampled hosts = 386; n = number of parasitized hosts.

Taula 2. Paràmetres d'infestació dels paràsits de P. lilfordi. *Nombre d'hostes analitzats = 386; n = nombre d'hostes parasitats.*

Populations of *P. pityusensis*	$\bar{x}$H	SIZE (km^2)	DISTANCE(m)	$\bar{x}$CONVEG
Eivissa	0.128	541	-	57.5
Vedrà-Vedranell	0.250	0.621	2000	78.0
Murada	0.129	0.013	200	68.8
Calders	0.310	0.028	5	71.7
Illa de S'Hort	0.070	0.005	150	70.0
Tagomago	0.322	0.521	500	63.3
Es Canar	0.275	-	350	--
Sta.Eulàlia-Redona	0.299	0.04	700	70.7
Ses Rates	0.111	0.018	400	60.0
Es Malvins	0.387	0.097	2200	40.8
Ses Illetes Negres	0.173	0.037	1850	50.0
Es Penjats	0.168	0.12	1500	60.8
Sa Torreta	0.066	0.088	75	5.0
S'Espalmador	0.148	2.09	250	48.6
S'Espardell	0.501	0.85	4250	10.0
Illa den Pou	0.031	-	150	--
Formentera	0.571	83	-	50.0
Populations of *P. lilfordi*				
Aire	0.111	0.342	1000	86.5
Rei	0.054	0.042	200	74.0
Colom	0.175	0.402	250	71.3
Addaia	0.083	0.129	600	62.5
Sargantana-Rovells	0.109	0.030	100	61.8
Nitge (Porros)	0.101	0.106	450	33.5

Table 3. Island size, distance from a potential colonizing source, mean values of consumption of vegetable matter by the hosts and $\bar{x}$H of the helminthfauna of *P. pityusensis* and *P. lilfordi.*

Taula 3. Grandària de les illes, distància a una potencial font de colonització, valors mitjans del consum de matèria vegetal pels hostes, i $\bar{x}$H de la fauna paràsita de P. pityusensis *i* P. lilfordi.

Materials and methods

Between 1987 and 1991, several islands and islets of the Balearic Archipelago were visited. In some of them, lizards of both host species were collected by hand. Specimens from museums and private collections were also studied. 564 *P. pityusensis* and 386 *P. lilfordi* were examined; the number of specimens of each host species studied from each island and/or islet, is given in Roca & Hornero (1991a) and Hornero & Roca (1992). Biometric data, sex and age were recorded from all the specimens.

Although Marco (1988) considered three age classes for *Lacerta schreiberi* Bedriaga, 1878 (Reptilia: Lacertidae) (adults, subadults and juveniles), we divided our host sample into two age classes, adults and non-adults (including subadults and juveniles) following Roca *et al.* (1990).

Data on feeding habits were made available to us by Dr. Valentín Pérez-Mellado from the University of Salamanca (Spain).

Helminths were collected, fixed and mounted according to routine techniques (Roca & Hornero, 1994). The parasites were identified at species level and the numbers and location of all individuals of each species were recorded (see Roca & Hornero, 1991a; Hornero & Roca, 1992). Tables 1 and 2, show the total number of parasite species and the infestation parameters, for each host. We follow Margolis *et al.* (1982) and Esch *et al.* (1990) in the use of descriptive ecological terms. All statistical analysis were performed using standard methods (Sokal & Rohlf, 1981).

Pearson's correlation test was used to establish the relationship between "mean helminth diversity" (Brillouin's (H) diversity index) (see Magurran, 1988) and several variables as "island size" (km^2), "distance to a potential colonizing source" (m) and "consumption of vegetable matter" (volum/volum of preys). In the populations of *P. pityusensis* (Table 3) a Kolmogorov-Smirnov test showed that the variable "island size" does not fit a normal distribution. The fitting was made by transformation to ln ($Z= 0.75$; $p>0.05$ in the case of ln size; and $Z= 0.543$; $p> 0.05$ in the case of ln $\bar{x}H$).

Results

a) Island area effects

In *P. pityusensis* (Table 3) no relationship was found between helminth diversity and the size of the islets ($r= 0.3261$; $p> 0.05$). In the populations of *P. lilfordi* (Table 3), no correlation was significant between both variables ($r= 0.7285$; $p> 0.05$).

b) Distance from a potential colonizing source

In *P. lilfordi* (Table 3) the correlation between helminth diversity and the distance to a potential colonizing source (Minorca) was not significant ($r= 0.2209$; $p> 0.05$). For the populations of *P. pityusensis*, the potential colonizing source is Eivissa or Formentera. A positive correlation was found ($r= 0.7293$; $p< 0.05$).

c) Sex and age class of the host

Diversity parameters (Brillouin's index, number of helminth species and number of helminths) (Table 4) have been compared. For *P. pityusensis*, the ANOVAS show significant differences between age classes but not between sexes (Table 5). Age and sex were not interactive. Adult specimens have a greater number of helminths and helminth species than non-adults (Table 4). For *P. lilfordi*, the ANOVAS show significant differences between age classes. The difference is caused by the number of helminth species but not by the total number of helminths (Table 5). Also significant differences between sexes in relation with Brillouin's index were found, but this sex influence in the diversity dissapears if the probability level is set to 0.01.

d) Diet effect

The helminth faunas of *P. pityusensis* and *P. lilfordi* are typical of carnivo-

P. pityusensis	MALES		FEMALES	
	adults	non-adults	adults	non-adults
H	0.29±0.31	0.12±0.20	0.27±0.29	0.19±0.29
Nsphel	1.68±1.08	1.08±0.66	1.39±0.99	0.97±0.92
Ntothel	23.55±39.23	8.08±13.39	18.59±33.32	8.17±15.79
P. lilfordi				
H	0.11±0.21	0.21±0.24	0.06±0.15	0.17±0.23
Nsphel	1.05±0.72	1.04±0.82	0.83±0.64	1.00±0.86
Ntothel	9.47±15.34	8.14±12.32	8.51±13.07	4.77±7.03

Table 4. Diversity parameters of the helminth communities of *P. pityusensis* and *P. lilfordi* related to the sex and the age classes of the hosts. Nsphel = number of helminth species; Ntothel = number of helminths.

Taula 4. Paràmetres de diversitat de les comunitats helmintianes de P. pityusensis *i* P. lilfordi, *en relació al sexe i la classe d'edat dels hostes. Nsphel = nombre d'espècies d'helmints; Ntothel = nombre d'exemplars d'helmints.*

P. pityusensis	SEX	AGE CLASS	AGE x SEX
H	0.011	14.557 *	1.119
Nsphel	0.136	17.133 *	1.504
Ntothel	0.316	28.329 *	2.849
P. lilfordi			
H	4.211 *	10.047 *	0.005
Nsphel	3.680	8.687 *	0.055
Ntothel	0.256	0.883	1.903

Table 5. F values generated by an ANOVA to determine the effect of sex and age classes of the hosts over the mean ranges of the diversity parameters of the helminth communities of *P. pityusensis* and *P. lilfordi*. $p < 0.05$.

Taula 5. Valors de F generats per una anàlisi ANOVA per a determinar l'efecte del sexe i la classe d'edat dels hostes sobre els rangs mitjans dels paràmetres de diversitat de les comunitats helmintianes de P. pityusensis *i* P. lilfordi.

rous reptiles because: (i) they have species with indirect life cycles; (ii) are rich in parasitic groups; and (iii) show typical Pharyngodonidae of carnivorous reptiles and none of the herbivorous reptiles.

Quantitatively, the means of consumption of vegetable matter of the individuals of each population (the consumption was calculated as volume with respect to total volume of preys (Corti & Pérez-Mellado, 1991; Pérez-Mellado, pers. comm.) and the means of the Brillouin's index (Table 3) were analyzed. No correlation was found for *P. pityusensis* ($r = -1.785$; $p > 0.05$) and *P. lilfordi* ($r = 0.6247$; $p > 0.05$). So, the consumption of vegetable matter by endemic Balearic lizards does not affect their helminth diversity.

Discussion

a) Island area effects

In a specific area with a more or less uniform climate (as in our case) there is a relationship between the surface of a sampling area and the number of living species (Darlington, 1957). Mac Arthur & Wilson (1967) observed that the surface has no direct effect on the number of species but it is related with other factors such as habitat variation, which, in turn, may affect species diversity. This situation is much more complicated when considering parasites. Generally larger islands harbour a greater number of parasitic species because a large island size probably implies great diversity of habitats. So, the greater the number of free-living species of potential intermediate or definitive hosts is, the higher the possibility of many parasitic species (Mas-Coma *et al.* 1987). Nevertheless, there are many exceptions to this rule because the presence or absence of a particular host may produce a pronounced deviation of the number of helminth species (Mas-Coma *et al.* 1987). In our case, the islets sampled have no different habitats but all show uniform xeric biotopes. In addition, there is no posibility of several potential hosts in the large or small islands or islets because the only lizards (Lacertidae) in the archipelago are *P. pityusensis* in the Pityusic and *P. lilfordi* in the Gimnesic islets (islets surrounding Minorca). In spite of this, there is no correlation between island size and helminth diversity, as noted also by Kennedy (1978) and Dobson *et al.* (1992), concluding that the local conditions of each island are determinant factors in the composition of parasitic faunas.

b) Distance from a potential colonizing source

The theory of Insular Biogeography predicts a relationship between the number of species living in an island and the distance of that island to a potential colonizing source. This relationship is based on the idea of the equilibrium between immigrant species and species in extinction (Mac Arthur & Wilson, 1967). Kuris & Blaustein (1977) objected the application of this general principle to the parasitic world. Kennedy (1978) and Dobson *et al.* (1992) did not find any correlation between the number of parasitic species from a host and the

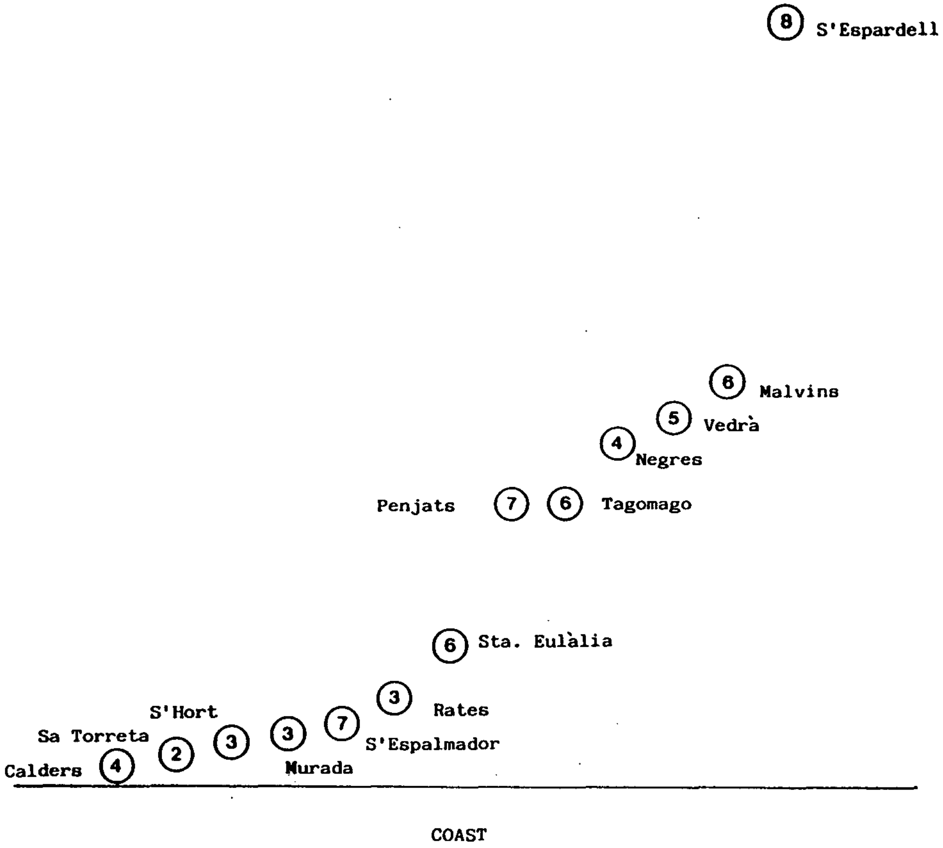

Fig. 1. Diagram showing the proportional distances of islets (circles) where *P. pityusensis* occurs, to the potential colonizing source. The number of helminth species is indicated in the circles.

Fig. 1. Diagrama que mostra les distàncies proporcionals que hi ha entre els illots on es troben les poblacions estudiades de P. pityusensis *i la font potencial de colonització. Dintre dels cercles s'indica el nombre d'espècies d'helmints.*

distance of the island where it lives to the potential colonizing source.

For *P. lilfordi*, our results agree with those of Kennedy (1978) and Dobson *et al.* (1992). The absence of correlation may be due to the short and similar distances separating the islets from the main island (Minorca). The positive correlation between both variables found in the case of *P. pityusensis*, generally shows that there are more helminth species on the islets more distant from the main island (Fig. 1), contrary to the prediction of Mac Arthur & Wilson's theory. So, the low applicability of some concepts of such theory to the parasitic world is confirmed.

c) Sex and age class of the host

For both hosts we can say that the sex has no influence in their helminth diversity. Our results agree with those of Roca *et al* (1990) for other lizards.

Regarding the influence of the age class on helminth diversity of the host, our results on *P. pityusensis* agree with those of Roca *et al.* (1990) for *Lacerta schreiberi*. Adults of *P. pityusensis* are always more parasitized, probably due to: (i) the greater opportunity for infestation of the adults; and (ii) in monoxenous species, the higher number of contacts between lizards implying a larger probability of infection. Considering that the high population densities of lizards in many islets and their small size are factors favouring intraspecific contacts, these are probably more frequent among the adults because of sexual contacts and sexual and/or territorial fights.

P. lilfordi shows an unusual status in respect with other lizards: the non-adult females show a higher number of helminth species.

d) Diet effects

All the plathelminth species (digenea and cestoda) presumably have heteroxenous life cycles, and also the nematodes *S. hoffmanni*, *Abbreviata* sp., *Acuaria* sp. (*larvae*), Spirurida gen. sp. (*larvae*) and the acanthocephalan *Centrorhynchus* sp. (*larvae*)(McAllister & Trauth, 1985; Roca & Hornero, 1991a). The Pharyngodonidae nematodes and also *S. ophiusensis* have direct life cycles (Petter & Quentin, 1976; Roca & Hornero, 1992).

The nematodes Oxyuroidea parasitizing Palearctic lizards belong to the family Pharyngodonidae Travassos, 1919. In this family, two evolutionary lineages, morphologically distinguishable on the basis of the evolution of the caudal end in the male (Petter, 1966; Petter & Quentin, 1976), are recognized. The species included in each of the two evolutionary lineages infect respectively two distinct groups of hosts. One of them includes nematodes parasitizing only carnivorous reptiles (mainly Sauria), being the more representative the genera *Pharyngodon* Diesing, 1861, *Skrjabinodon* Inglis, 1968, *Spauligodon* Skrjabin, Schikhobalova et Lagodovskaja, 1960 and *Parapharyngodon* Chatterji, 1933 (Oxyuroidea: Pharyngodonidae). The other one includes nematodes parasitizing herbivorous iguanas and tortoises (*Testudo* spp.) belonging to the genera *Tachygonetria* Wedl, 1862, *Mehdiella* Seurat, 1918, *Alaeuris* Thapar, 1925, *Thaparia* Ortlepp, 1933, *Ortleppnema* Petter, 1966, *Ozolaimus* Dujardin, 1845, *Travassozolaimus* Vigueras, 1938 and *Mamillomacracis* Dosse, 1939 (Oxyuroidea: Pharyngodonidae). Data from Roca & Hornero (1991b) on Mediterranean Sauria and Testudines agree with the hypothesis of Petter & Quentin (1976), which is why the herbivorous tortoises *Testudo graeca* Linnaeus, 1758 and *Testudo hermanni* Gmelin, 1789 (Reptilia: Testudinidae) show a peculiar group of Pharyngodonidae nematodes (Roca, *et al.*, 1988a,b) while the saurians, all carnivorous, have completely different parasites.

Special attention is paid to insular lizards because many populations of several species show more or less a pronounced trend to herbivorism. This occurs in many islands and islets of the

Mediterranean and particularly in the Balearic Archipelago (Corti & Pérez-Mellado, 1991; Pérez-Mellado, 1989; Pérez-Mellado *et al.*, 1991). Although in the populations of *P. pityusensis* and *P. lilfordi* certain degree of herbivorism has been noted, according to our results, this herbivorism must be considered as a secondary adaptation. Pérez-Mellado (pers. comm.) and Pérez-Mellado *et al.* (1991) also denote the herbivorism of the Balearic lizards as an adaptive response related to the trophic availability and to the evolutionary age of the lizard population on each island.

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References

Aho, J.M. 1990. Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. In: Esch, G., Bush, A. & Aho, J.M. eds. *Parasite communities: patterns and processes*. Chapman & Hall, London, pp.157-195.

Alcover, J.A. 1988. Las faunas preneolíticas de las islas mediterráneas. *Mundo Científico* 80: 504-517.

Brown, R.P., Pérez-Mellado, V., Diego-Rasilla, J., García, J.A., Naranjo, A. & Speakman, J.R. 1992. Individual and population energetics of a lizard on a Mediterranean islet. *Oecologia*, 91: 500-504.

Bruno, S. 1988a. L'erpetofauna delle isole di Cres, Krk et Ada (Jugoslavia-Albania). *Bulletin d'Ecologie*, 19: 265-281.

Bruno, S. 1988b. Considerazioni sull'erpetofauna della Sicilia. *Bulletin d'Ecologie*, 19: 283-303.

Corti, C. & Pérez-Mellado, V. 1991. Feeding ecology of insular populations of *Podarcis* lizards in the North Tyrrenian Sea (Corsica and Tuscan islands) and Balearic islands. A preliminary study. *VI Ordinary General Meeting of the Societas Europaea Herpetologica.* Budapest, Aug. 19-23, 1991. Abstracts of Reports, p. 25.

Darlington, P.J. 1957. *Zoogeography: the geographical distribution of animals.* Wiley, New York.

Delaguerre, M. & Cheylan, M. 1992. *Batraciens et Reptiles de Corse.* L'oikéma, Pamplona. 121 pp.

Dobson, A.P., Pacala, S.W., Roughar-den, J.D., Carper, E.R & Harris, E.A. 1992. The parasites of *Anolis* lizards in the northern Lesser Antilles. I. Patterns of distribution and abundance. *Oecologia*, 91: 110-117.

Esch, G.W., Shostak, A.W., Marcogliese, D.J. & Goater, T.M. 1990. Patterns and processes in helminth parasite communities: an overview. In: Esch, G., Bush, A. & Aho, J. eds. *Parasite communities: patterns and processes*. Chapman & Hall, London, pp. 1-19.

Hornero, M.J. y Roca, V. 1992. Helmintofauna de *Podarcis lilfordi* (Günther, 1874) (Sauria, Lacertidae) de los islotes de Menorca (Islas Baleares, Mediterráneo Occidental). *Misc. Zool.*, 16: 1-6.

Kennedy, C.R. 1978. The parasite fauna of resident char *Salvelinus alpinus* from arctic islands, with special reference to Bear Island. *Journal of Fish Biology*, 13: 457-466.

Kuris, A.M. & Blaustein, A.R. 1977. Ectoparasitic mites on rodents: application of island biogeography theory?. *Science*, 195: 596-598.

Lanza, B. 1988. Hypothèses sur les origines de la faune herpétologique corse. *Bulletin d'Ecologie*, 19: 163-170.

Mac Arthur, R.H. & Wilson, E.O. 1967. *The theory of Island Biogeography*. Princeton University Press. Princeton, 203 pp.

McAllister, C.T. & Trauth, S.C. 1985. Endoparasites of *Crotaphytus collaris collaris* (Sauria: Iguanidae) from Arkansas. *The Southwestern Naturalist*, 30: 363-370.

Magurran, A.E. 1988. *Ecological diversity and its measurement*. Croom Helm. Ltd. London.

Marco, A. 1988. *Autoecología del lagarto verdinegro (Lacerta schreiberi) Bedriaga, 1878 (Sauria: Lacertidae) en el Sistema Central*. Ph. thesis, University of Salamanca.

Margolis, L., Esch, G.W., Holmes, J.C., Kuris, A.M. & Schad, G.A. 1982. The use of ecological terms in Parasitology (report of an ad hoc committee of the American Society of Parasitologists). *Journal of Parasitology*, 68: 131-133.

Mas-Coma, S., Esteban, J.G., Bargues, M.D. & Valero, M.A. 1987. La evolución de una fauna parásita en las islas "continentales": el caso de los helmintos de micromamíferos en las Gimnesias y Pitiusas (archipiélago balear). In: Sans-Coma, V., Gosálbez, J. & Mas-Coma, S. Eds. *Mamíferos y Helmintos. Volumen homenaje al Prof. Dr. Dr. Herman Kahmann en su 81 aniversario*: 203-216. Ketrés, Barcelona.

Pérez-Mellado, V. 1989. Estudio ecológico de la lagartija balear *Podarcis lilfordi* (Günther, 1874) en Menorca. *Revista de Menorca* 80: 455-511.

Pérez-Mellado, V. & Salvador, A. 1981. Actividad y termorregulación estival de *Podarcis pityusensis* (Boscá, 1883) (Sauria: Lacertidae) en Ibiza y Formentera. *Amphibia-Reptilia* 2: 181-186.

Pérez-Mellado, V., Corti, C. & Valakos, E.D. 1991. Spatial herbivorism of the genus *Podarcis* (Sauria: Lacertidae) in the Mediterranean region. *VI International Conference on Mediterranean Climate Ecosystems*. Maleme, Crete, Sept. 23-27, 1991. Abstracts of Reports, p. 61.

Petter, A.J. 1966. Equilibre des espèces dans les populations de Nématodes parasites du colon des tortues terrestres. *Mémoires du Muséum National d'Histoire Naturelle, série A, Zoologie* 39: 1-252.

Petter, A.J. & Quentin, J.C. 1976. Key to genera of the Oxyuroidea. In: Anderson, R.C., Chabaud, A.G. and Willmott, S. eds. *C.I.H. Keys to the Nematode parasites of Vertebrates:* 1-30. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, London.

Roca, V. & Hornero, M.J. 1991a. Helmintofauna de *Podarcis pityusensis* (Boscá, 1883) (Sauria, Lacertidae). *Rev. Esp. Herp.* 5: 77-87.

Roca, V. & Hornero, M.J. 1991b. Diet and helminthfauna in Mediterranean reptiles. *Proceedings of the VI International Conference on Mediterranean Climate Ecosystems:* 205-209.

Roca, V. & Hornero, M.J. 1992. *Strongyloides ophiusensis* sp. n. (Nematoda: Strongyloididae), parasite of an insular lizard, *Podarcis pityusensis* (Sauria: Lacertidae). *Folia Parasitologica,* 39: 369-373.

Roca, V. & Hornero, M.J. 1994. Helminth infracommunities of *Podarcis pityusensis* and *Podarcis lilfordi* (Sauria: Lacertidae) from the Balearic Islands (western Mediterranean basin). *Can. J. Zool.,* 72: 658-664.

Roca, V., Ferragut, M.V. & Hornero, M.J. 1990. Estimaciones ecológicas acerca de la helmintofauna de *Lacerta schreiberi* Bedriaga, 1878 (Sauria: Lacertidae) en el Sistema Central (España). *Revista Española de Herpetología,* 4: 93-100.

Roca, V., Galeano, M. & García-Adell, G. 1988a. Nematodos parásitos de la tortuga mora, *Testudo graeca* Linnaeus, 1758 (Reptilia: Testudinidae) en España. *Revista Ibérica de Parasitología,* 48: 269-274.

Roca, V., Galeano, M., Andreu, A.C. & García-Adell, G. 1988b. *Testudo graeca* Linnaeus, 1758 (Reptilia: Testudinidae) en Doñana: datos helmintofaunísticos y relaciones ecológicas parásito-hospedador. *Revista Española de Herpetología,* 3: 75-82.

Salvador, A. 1986a. *Podarcis lilfordi* (Günther, 1874) Balearen-Eidechse. In: Böhme, W. ed. *Handbuch der Reptilien und Amphibien Europas. Echsen III (Podarcis)*: 83-110. Aula-Verlag, Wiesbaden.

Salvador, A. 1986b. *Podarcis pityusensis* (Boscá, 1883) Pityusen-Eidechse. In: Böhme, W. ed. *Handbuch der Reptilien und Amphibien Europas. Echsen III (Podarcis)*:231-253. Aula-Verlag, Wiesbaden.

Salvador, A. 1993. Els rèptils. In: Alcover, J.A., Ballesteros, E. y Fornós, J.J. eds. *Història Natural de l'arxipèlag de Cabrera*: 427-437. CSIC-Moll, Mallorca.

Sokal, R.R., and Rohlf, F.J. 1981. *Biometry, 2nd ed.* W.H. Freeman and Co.

Valakos, E.D., Böhme, W., Pérez-Mellado, V. & Maragou, P. 1993. *Lacertids of the Mediterranean region. A biological approach.* Hellenic Zoological Society, Athens, Bonn, Alicante, 281 pp.