Conspecific eggs and hatchlings in the diet of the insular lizard, *Podarcis hispanica atrata*

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The incidence of cannibalism in the lizard *Podarcis hispanica atrata* in the Columbretes islands (Castelló de la Plana, Spain) under natural and captive conditions is described. Adult male lizards can ingest one hatchling in approximately four minutes. Hatchling digestability appeared to be very high.
Keywords: *Mediterranean islands, lizard, endemism, cannibalism, diet.*

ALIMENTACIÓ CONSPECÍFICA D'OUS I JUVENILS EN LA SARGANTANA INSULAR *Podarcis hispanica atrata*. Es descriu la incidència del canibalisme en la sargantana *Podarcis hispanica atrata* de les illes Columbrets (Castelló de la Plana, Espanya) sota condicions naturals i de cautiveri. Els mascles de les sargantanes adultes poden ingerir un jove en quatre minuts aproximadament. La digestibilitat del jove és aparentment elevada.
Paraules clau: *illes mediterrànies, sargantana, endemisme, canibalisme, dieta.*

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Introduction

For many species, cannibalism can strongly affect population dynamics and mortality rates (Polis 1981; Dong & Polis 1992). Individuals become vulnerable to cannibalism during particular life history stages. Eggs, embryos, neonates and nestlings are often defenceless and frequently cannibalized (Polis, 1981; 1984; Elgar & Crespy, 1992). Considering that cannibalism appears to be of ecological and evolutionary significance for many species (Hausfater & Hrdy, 1984; Huntingford & Turner, 1987), a very important and

basic task is to describe in what species, how and when this phenomenon occurs.

Cannibalistic interactions are common in nature, but they are rarely witnessed in comparison to other interspecific feeding interactions (Dong & Polis, 1992; Elgar & Crespi, 1992). It is therefore expected that the number of known cannibalistic species will increase as more research is completed (Polis & Myers 1985).

Although infanticide has been much studied in vertebrates (Fox, 1975), the relevance of cannibalism in reptile populations is poorly known (Polis & Myers, 1985; Elgar & Crespi, 1992). In reptiles, most existing reports of infanticide are anecdotical, correspond to captive individuals (but see Jenssen *et al.*, 1989; Castilla & Van Damme, in press), and offer no information on the Mediterranean lizard species (see review in Polis & Myers, 1985).

In this study, I report the occurrence of prevalent cannibalism on eggs and juveniles in a population of *Podarcis hispanica atrata* under natural and semicaptive conditions, and I present data on juvenile digestion by adult lizards.

Material and methods

Podarcis h. atrata is an endangered subspecies endemic to the Columbretes islands (Mediterranean sea, 39º 54' N, 0º 41' E, Castellón, Spain), whose world range is restricted to 20 ha (Castilla & Bauwens, 1991a,b). This is the only non-avian vertebrate present in the archipelago. It is a small heliothermic lizard with clear sexual dimorphism in body mass, snout-vent length (SVL) and head size (Castilla & Bauwens, 1991b). Lizards spend most time on the ground in semi-open habitats. Bushes, burrows, rocks, bricks and rock crevices serve as nocturnal retreats and diurnal refugia from predators. Adults typically capture food by foraging widely, but then occasionally sit and wait for prey. Some females lay at least three clutches from the end of April to mid July. Hatchlings emerge between the end of June and September with a mean SVL and body mass of 28.1 mm and 0.51 g (Castilla & Bauwens, in press).

Field observations. Observations in the field were conducted by myself and the guardians of the Natural Reserve, in the biggest (13 ha) island 'Columbrete Grande' from May to October 1991-1994.

Experiment in terraria. In October 1994 I quantified the reaction of adults to living juveniles under semi-natural captive conditions. Adult lizards (7 males and 7 females) with a mean snout-vent length (SVL) between 60.8-71.4 mm, and a mean body mass between 3.8-8.4 g, and juveniles (n=14, SVL: 29.9-36.3 mm; Mass: 0.5-1.1 g) were captured using a baited noose (Castilla *et al.*, 1994). Fourteen terraria (100x20x50 cm) were placed outdoors at the study site, with one adult and one juvenile randomly placed in each. Lizards were provided with cover (rocks, wood and vegetation), sunny and shady spots and plenty of water and food (meal-worms and fruit). Containment to a terrarium undoubtedly

a

b

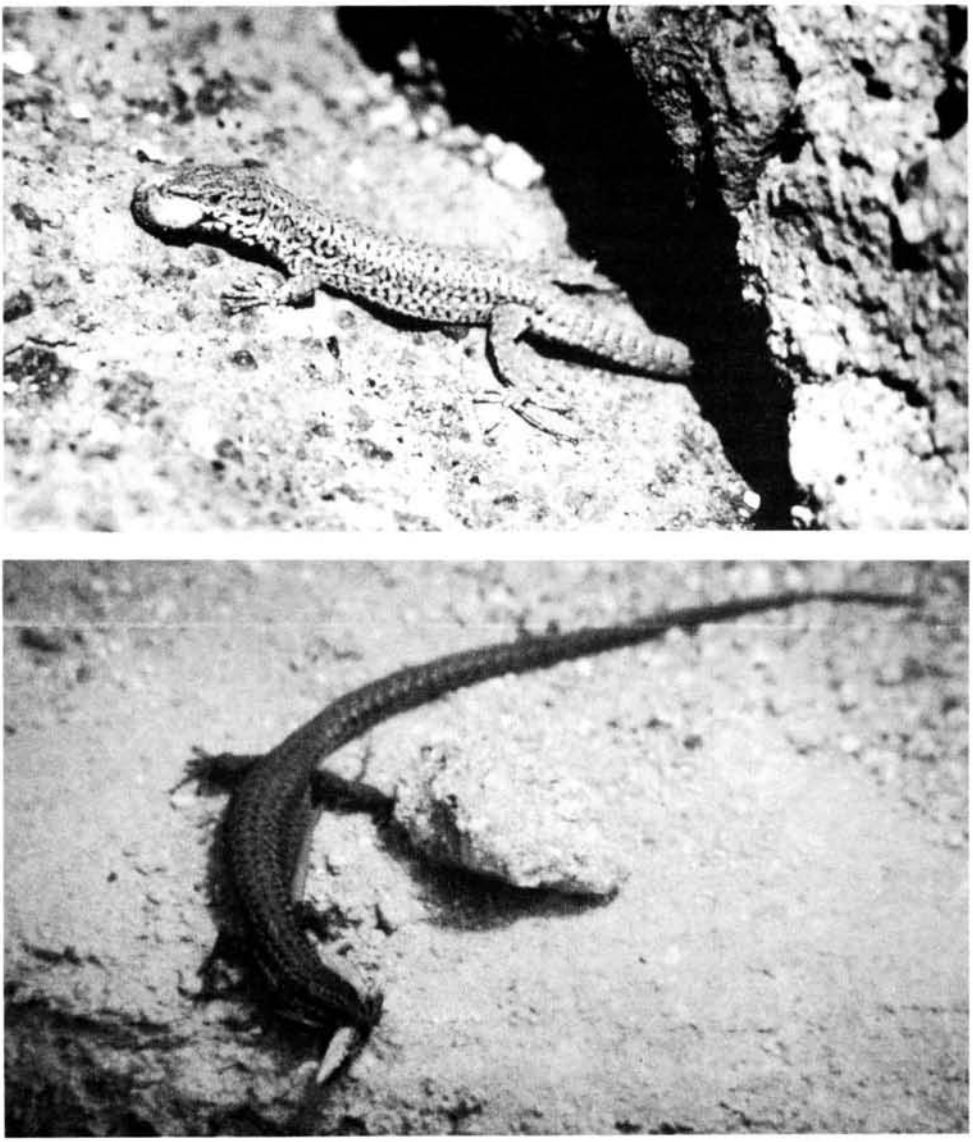

Fig. 1. Predation by adult male (a) and female (b) *P. hispanica atrata* on conspecific eggs (a) and hatchlings (b) under natural conditions in the island Columbrete Grande.
Fig. 1. Predació per mascle adult (a) i femella (b) P. hispanica atrata *sobre ous (a) i juvenils (b) de la seva espècie en condicions naturals a l'illa Gran.*
Foto a: Antonio Sánchez; foto b: Valentín Tena.

produces unnatural stress. Nevertheless, I consider conspecific predation by captive lizards to be strong evidence of a cannibalistic tendency. First, individuals of this species tolerate terrarium conditions well enough to perform normal activities (e.g. copulation, laying, foraging). In addition, captive adults had ample alternative food. Finally, juveniles could avoid predation by seeking refuge under available cover. To confirm the presence of adult and juvenile, all terraria were inspected three times a day for seven consecutive days (1-7 October 1994). Lizards were subsequently released at their point of capture.

Juvenile digestion. To assess the degree of digestion of conspecific prey, four adult lizards that had ingested juveniles in natural or semi-captive conditions were captured, maintained in terraria and provided with abundant food and water. Faecal material was examined using a hand lens. Lizards were kept in terraria during four to five days until faecal material was consistently free of any vertebrate remains. During the digestion period, weather was erratic and cold.

Results

Field observations. Adult males and females were observed eating eggs of conspecific (n=29), capturing and swallowing hatchlings (n=20) and aggressively chasing juveniles (n=16). Most of these observations occurred under strictly natural conditions in areas with high and low density of adult lizards (Fig. 1, Table 1).

On separate occasions, I saw adult males and females carrying eggs in their mouths. Lizards were observed eating and fighting over eggs. The fresh appearance of the eggs suggested that they were recently taken from their natural nests. In addition to that, 10 eggs were taken from artificial nests that were placed in the study site (Castilla & Swallow, 1995). Three of those eggs were taken by lizards from the same nest and position on successive days. During hunting activity, adults stalk juveniles from a distance and then chase them. They bite them

year	month	egg	month	juvenile
1991	V	2 *	VII	1
	VI	3		
1992	V	2	VII	1
	VI	8	VIII	2
1993	VI	3	VII	2 *
	VI	9 +	VII	3
	VII	1 +	VIII	2
1994			IX	1
			X	6
			X	2 *

Table 1. Number of observations on infanticide on eggs and juvenile *Podarcis h. atrata* in the island Columbrete Grande during different months (in romans) and years. All events refer to natural conditions unless it is indicated: in outdoor terraria (*), in artificial nests (+).
Taula 1. Nombre d'observacions d'infanticidi sobre ous i juvenils de Podarcis h. atrata *a l'illa Columbret Gran durant diferents mesos (en xifres romanes) i anys. Totes les situacions fan referència a condicions naturals, les excepcions estan indicades: en terrari a l'aire lliure (*), en nius artificials (+).*

Male	Pellet number	Juvenile remnants
A	1	0
	2	1 forehand
	3	0
	4	2 forefingers
	5	0
B	1	1 femur
		1 tail
	2	0
	3	1 forehand
	4	0
C	1	1 femur
	2	0
	3	0
D	1	0
	2	3 forefingers
	3	2 head scales
	4	0

Table 2. Juvenile remnants (type and number) found in the faecal pellets numbered by order of elimination in four cannibalistic adult males (A-D).
Taula 2. Restes de juvenils (tipus i nombre) trobades en excrements de marès adults (A-D) numerats per ordre d'eliminació en quatre casos de canibalisme.

in the back and then they pin them down with their legs and tail. Juveniles were always consumed head-first. Only in one case the adult male crushed the head of the juvenile first, and started eating the juvenile from the tail to the head. The entire predatory event (handling time), from capture to complete ingestion of the juveniles in adult males lasted 3.10 to 5.02 minutes (X=3.6, SE=0.14, n=7).

Cannibalism in captivity. Two males (SVL=67.0 and 69.8 mm; Mass=7 and 8.4 g respectively) consumed juveniles (SVL=33.5 and 35.2 mm; Mass=0.8 and 1.1 g respectively) despite the abundance of other food items. Cannibalism took place on the fourth and sixth days of confinementin the terraria. Juveniles in terraria were unusually very wary, spending most of the time hidden under rocks or vegetation. None of the females consumed juveniles under captive conditions.

Juvenile digestion. Digestability of conspecific juveniles appeared to be very high, at least when additional food (invertebrates) was consumed. Faecal pellets of *Podarcis h. atrata* containing remains of conspecific juveniles are usually similar to pellets lacking them. Juvenile remnants were eliminated over several pellets defecated by adults within four days. Only insignificant parts of ingested juveniles were eliminated. I found only a few and small remains in adult faecal pellets (femurs, forefingers, forehand, head scales, and a 9 mm piece of tail (Table 2).

Discussion

No Mediterranean lizards have yet been reported to be consistently cannibalistic under natural conditions. Nevertheless, occasional observations in the field, the presence of conspecifics in stomach contents and observations in terraria have been documented (see references in Table 3).

Species	Source
Podarcis hispanica atrata	present study
Podarcis lilfordi	Salvador, 1986; Pérez-Mellado, 1989
Podarcis bocagei	Bowker, pers. comm.
Podarcis muralis	refs. in Polis & Myers, 1985
Psammodromus algirus	Carretero, 1993
Lacerta vivipara	Bauwens, pers. comm.
Lacerta agilis	Paraskiv, 1956
Acanthodactylus erythrurus	Busack & Jaksic, 1982
Lacerta lepida	Castilla *et al.*, 1991
Lacerta viridis	Szcerbak & Szcerbak, 1980
Leiocephalus schreibersi	Jenssen *et al.*, 1989
Eumeces laticeps	Cooper & Vitt, 1985
Sceloporus (8 species)	refs. in Polis & Myers, 1985
Uta stanburiana	refs. in Polis & Myers, 1985
Crotaphytus (2 species)	refs. in Polis & Myers, 1985
Anolis lineatopus	refs. in Polis & Myers, 1985
Caiman crocodilus	refs. in Polis & Myers, 1985
Moloch horridus	refs. in Polis & Myers, 1985
Varanus gouldii	Pianka, 1994
Gallotia galloti	Matuschka & Bannert, 1987
Agama agama	refs. in Polis & Myers, 1985
Crocodylus niloticus	refs. in Polis & Myers, 1985
Hemidactylus flaviviridis	refs. in Polis & Myers, 1985

Table 3. Some lizards and other saurian species for which cannibalism has been described. *Taula 3. Algunes altres espècies de sargantanes i de saures sobre els que s'han descrit fenòmens de canibalisme.*

Podarcis h. atrata has repeatedly been observed preying on conspecific eggs and juveniles under natural conditions. These observations are supported by the results of an experiment conducted in situ, where 59% of 22 males and 17% of 12 females tried to attack conspecific juveniles (Castilla & Van Damme, unp). These results collectively suggest the importance of cannibalism to the population dynamics of this lizard in Columbrete Grande.

Even if cannibalistic interactions are common in *Podarcis h. atrata*, analyses of stomach contents an faecal pellets indicate that the diet of this species consists largely of arthropods (Castilla *et al.*, 1987). Prior to this study, no vertebrate remains have been found in their stomachs or faeces. These observations may result from the nearly complete digestion of ingested juveniles. In addition, juvenile remnants were eliminated over several pellets defecated

within four days. Hence, detection of newly-born juveniles in faeces must be nearly impossible, and quantification of overall cannibalism in this population via faecal analysis would be very difficult. A more reliable approach for determining the frequency of cannibalism in this population must be the frequent examination of stomach contents in a large number of individuals.

The few available observations indicate that adult lizards seems to be efficient in finding and excavating eggs and hunting juveniles. Interestingly, the few observations also indicate that adults do not attack the tails of juveniles, but instead bite the body, thus increasing the likelihood of prey capture. Juveniles are generally consumed head-first, a behavior that may facilitate prey manipulation as has been reported for salamanders (Reilly et al., 1992). In fact, the entire predation process is brief in comparison to the time needed to ingest lower energetic items like tenebrionids (*Blaps gigas*) and other hard chitinous beetles (pers. obs., time visually estimated). During the predatory events (n=7), the tail of the juvenile was never shed. Because lizards shed their tail as an antipredator mechanism (Arnold, 1988), adult hunting behaviour could perhaps indicate learning (see Cooper & Vitt, 1985).

The extent of cannibalism in the population of this endangered lizard *Podarcis h. atrata* is still unknown. More research is needed to understand the foraging decisions of conspecific predators, the antipredator mechanisms of this vulnerable prey, and the overall causes and rate of evolution of cannibalism in lizards.

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