Unexpected low population levels of *Podarcis carbonelli* in southern Salamanca (Spain)

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RESUMEN: *Podarcis carbonelli* es una especie endémica de la Península Ibérica. Presentamos aquí los resultados de una serie de muestreos que indican una posible reducción de la densidad poblacional de la especie en una de las zonas con mayor abundancia (La Nava de Francia, Salamanca). Muestreos realizados en 1998 en la misma zona mostraron abundancias superiores. La explicación más plausible es que la reducción se deba a fluctuaciones poblacionales, aunque otras hipótesis no pueden ser descartadas.

The Carbonell's wall lizard, *Podarcis carbonelli* Pérez-Mellado, 1981, is endemic to the Iberian Peninsula. Originally described as a subspecies of *Podarcis bocagei* (Seoane, 1884) by Pérez-Mellado (1981), it was elevated to full species rank more than 20 years later by Sá-Sousa & Harris (2002), based on morphological and genetic data. It ranges in the western part of the Iberian Peninsula (Sá-Sousa, 1999, 2000, 2001, 2002, 2004, 2008; Sá-Sousa & Harris, 2002), South to the Duero river, with a fragmented distribution across the Central Mountain Range. Then, it follows the western Atlantic coast of Portugal, splitting into several isolated nuclei southwards. Finally, there is a highly separated range in Doñana, in the south-western Atlantic coast of Spain. It occurs also in Berlenga island as a different subspecies (Vicente, 1985; Sá-Sousa, 2008): *P. carbonelli berlengensis* Vicente, 1985.

Pérez-Mellado (1981) assigned the *terra typica* of *P. carbonelli* in the locality of Laguna de San Marcos, near the village of La Alberca, in the northern slopes of the Central Mountain Range of Salamanca (Spain). This locality is occupied by a well conserved Atlantic forest of oaks (*Quercus pyrenaica*), and belongs to the Natural Park Batuecas-Sierra de Francia. In fact, in the Central Mountain Range, *P. carbonelli* only occurs in oak forests and their succession stages (Pérez-Mellado, 1998). Therefore, this species is distributed in Salamanca province along all the oak forests and succession stages of the northern slopes of the Central Mountain Range West to the valley of the Alagón river (Sillero *et al.*, 2005), which constitutes a Mediterranean inclusion inside the Atlantic region of southern Salamanca. Moreover, although Salamanca province belongs to the basin of the Duero river (which runs along the northern plateau of the Iberian Peninsula), the Alagón river belongs to the Tajo basin (running along the southern plateau). The valley of the Alagón river is too hot for *P. carbonelli*, hampe-

ring its expansion to the east of the Central Mountain Range (Pérez-Mellado, 1981, 1998).

In Salamanca, the density in the *terra typica* is higher than 30 000 ind / km^2 (Pérez-Mellado, 1998). In particular, populations of Laguna de San Marcos and the nearby La Nava de Francia can be considered as abundant. In fact, *P. carbonelli* can be common in suitable habitats. The southern populations are in general very small, but can be locally abundant (Sá-Sousa *et al.*, 2009). In Portugal, it is only considered abundant in the regions of Beira Litoral (150 000 - 160 000 ind / km^2: Pinhal de Cantanhede) and Douro Litoral (Sá-Sousa, 2004). In Berlenga island, Vicente & Barbault (2001) described a population density of 200 000 - 400 000 ind / km^2, depending on the season of the year. In the Doñana National Park, is one of the most frequent lizards of the dunes (Sá-Sousa, 2004).

For all these reasons, the conservation status of *P. carbonelli* in Salamanca has been considered wealthy. In fact, the IUCN conservation status of the species in Spain is Least Concern due to its small distribution range (Sá-Sousa, 2002). It is considered a decrease in its populations, but without major problems for the conservation of the species (Sá-Sousa, 2002). In Portugal, on the other hand, it is classified as Vulnerable (Cabral *et al.*, 2005) due to its small occurrence area and highly fragmented populations, as well as to the continuous decrease of its distribution, habitat quality, number of locations and number of mature individuals. However, its global classification is Endangered due to its extent of occurrence is less than 5000 km^2, its distribution is severely fragmented, and there is continuing decline in its extent of occurrence, in its area of occupancy, in the extent and quality of its habitat, in the number of locations, and in the number of mature individuals (Sá Sousa *et al.*, 2009).

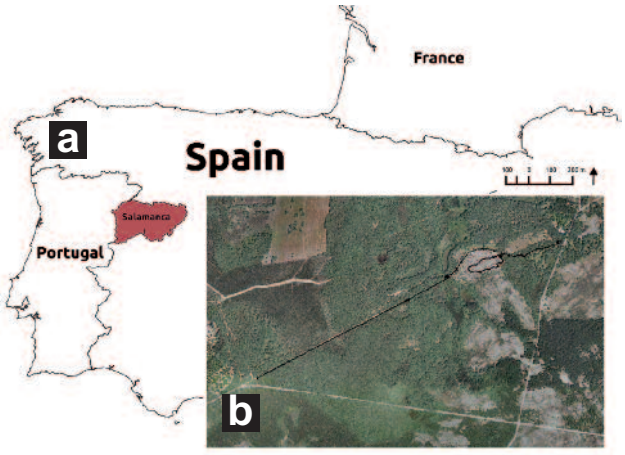

Figure 1: (a) Location of the study area in Salamanca province. (b) Aerial photography (PNOA project: www.pnoa.es) of the study area and track of the surveys.
Figura 1: (a) Localización del area de studio en la provincial de Salamanca. (b) Fotografía aérea (proyecto PNOA: www.pnoa.es) del área de estudio e itinerario de los muestreos.

The population from La Nava de Francia (5 km far away from Laguna de San Marcos) can be considered as one of the most abundant populations in Salamanca (authors, unpublished data). However, during recent surveys related with home range studies, we have found a very important density reduction. It is located in an unpaved pathway along an oak forest from the villages La Nava de Francia to El Casarito (Figure 1). The pathway borders a rocky area where *Podarcis hispanica* tipe 1B is very abundant. The oak forest occupies 90% of the pathway; the remaining 10% corresponds to the rocky area border. The pathway is part of the official tourist trips of the Natural Park of Batuecas-Sierra de Francia, and it is also used by cars, although in reduced numbers.

After finding a very low density of *P. carbonelli* in La Nava de Francia, we decided to survey the pathway several times to confirm this

matter. We included the rocky part in the surveys in order to control if the low density of lizards was common for all the species present in the locality, due to weather conditions. Thus, we performed 19 surveys in six days during the end of May and the beginning of June 2012. Each survey took for more than 2 h (in periods of maximum activity) to 1 h (midday). The total longitude of the survey was 1650 m with a bandwidth of 5 m. We began each survey in one extreme and finish in the other one. Then, we waited 15 min, and began other survey from the final point to the initial one. In order to avoid performing the surveys always in the same direction, we changed the direction after two surveys. The position of each lizard (not only *P. carbonelli*, but also *Psammodromus algirus* and *P. hispanica*) was recorded with a professional GPS (Trimble GeoExporer 2008 HX), with an accuracy around 10 cm after post-processing.

In order to have a comparative reference, we used unpublished data from one of the authors (NS), which performed six surveys in the same area (only the unpaved pathway) in 1998, with a similar longitude and bandwidth. Although the locations where not recorded, we have the exact time of observation. Therefore, we can calculate the number of individuals sighted per survey and per hour. Unfortunately, in those surveys it was only recorded the presence of the two species belonging to the genus *Podarcis*. For this reason, we do not present specific data for *Ps. algirus*. Also, as the rocky area was not included in

Table 1. List of surveys performed in 2012. It is indicated the day and duration (in minutes) of each survey, as well as the total number of individuals (n) observed per survey and total number of records of *P. carbonelli* (PCAR), *P. hispanica* (PH), and *Ps. algirus* (PSA). The four last columns indicates the number of observations per hour, respectively for all the records (ALL / h) and per species (PCAR / h, PH / h, and PSA / h).
Tabla 1. Lista de muestreos realizados en 2012. Se indica el día y la duración (en minutos) de cada muestreo, así como el número total de individuos (n) observado por muestreo y el número total de registros de *P. carbonelli* (PCAR), *P. hispánica* (PH), y *Ps. algirus* (PSA). Las cuatro últimas columnas indican el número de observaciones por hora, respectivamente para todos los registros (ALL / h) y por especie (PCAR / h, PH / h, y PSA / h).

Survey	Day	Duration	n	PCAR	PH	PSA	ALL / h	PCAR / h	PH / h	PSA / h
1	2012-05-27	122	7	0	3	4	3.44	0.00	1.48	1.97
2	2012-05-27	159	5	1	1	3	1.89	0.38	0.38	1.13
3	2012-05-28	102	9	2	0	7	5.29	1.18	0.00	4.12
4	2012-05-29	104	13	1	4	8	7.50	0.58	2.31	4.62
5	2012-05-29	168	26	0	15	11	9.29	0.00	5.36	3.93
6	2012-05-29	118	20	3	5	12	10.17	1.53	2.54	6.10
7	2012-05-29	109	15	3	5	7	8.26	1.65	2.75	3.85
8	2012-05-30	166	22	2	11	9	7.95	0.72	3.98	3.25
9	2012-05-30	134	21	1	8	12	9.40	0.45	3.58	5.37
10	2012-05-30	120	14	5	5	4	7.00	2.50	2.50	2.00
11	2012-05-30	64	1	0	1	0	0.94	0.00	0.94	0.00
12	2012-05-31	126	19	2	4	13	9.05	0.95	1.90	6.19
13	2012-05-31	111	19	2	11	6	10.27	1.08	5.95	3.24
14	2012-05-31	77	8	1	0	7	6.23	0.78	0.00	5.45
15	2012-05-31	136	14	2	7	5	6.18	0.88	3.09	2.21
16	2012-06-01	116	13	1	1	11	6.72	0.52	0.52	5.69
17	2012-06-01	86	8	0	2	6	5.58	0.00	1.40	4.19
18	2012-06-01	71	12	0	4	8	10.14	0.00	3.38	6.76
19	2012-06-01	108	10	1	5	4	5.56	0.56	2.78	2.22

these surveys (1998), all data from the rocky area were excluded from the analysis, except its border with the pathway. We only provided some data for comparative purposes.

In surveys performed this year (2012), we recorded a total number of 256 individuals (680 including the rocky area), corresponding to three species (*P. carbonelli*, *P. hispanica*, and *Ps. algirus*). The number of individuals varied among surveys, from 1 to 26, with a mean of 13.47. The total number of individuals per species was: *P. carbonelli*, 27 (13 males and 13 females, plus one undetermined); *P. hispanica*, 92; and *Ps. algirus*, 137 (Table 1). The high number of observations from the rocky area (424 records) proved that *P. hispanica* was active during the surveys (Table 1). If we consider all species together, we observed 6.89 individuals per hour; considering each species separately (Table 1): *P. carbonelli*, 0.72; *P. hispanica*, 2.36; and *Ps. algirus*, 3.80. The less frequent species was *P. carbonelli*.

In surveys performed in 1998, the total number of observed lizards was 43: *P. carbonelli*, 35 (13 males and 22 females, plus 2 subadults); and *P. hispanica*: 5. Per hour, this number was 5.53 (*P. carbonelli* plus *P. hispanica*) and 4.56 only if *P. carbonelli* is considered (Table 2). In one survey, nine specimens of *P. carbonelli* were observed in one hour (Table 2). Here, the most abundant species was *P. carbonelli*.

Although the surveys were performed in different weather conditions (cloudy in the first days; very hot in the last days), the low density of *P. carbonelli* may not be the result of inactivity: the other two species were active and very abundant. Moreover, this decrease in the population is concordant with previous studies (Sá-Sousa, 2002, 2008; Sá-Sousa *et al.*, 2009) showing a continuous decline in its extent of occurrence, area of occupancy, extent and quality of its habitat, number of locations, and number of mature individuals. We propose several possible causes for this population decrease:

1. Transformation of the habitat, namely of the unpaved pathway and surrender oak forest: apparently, between the two study periods, there have been no changes or disturbances affecting the landscape structure such as logging, fires, new plantings, earthworks, or land development. This was confirmed by Natural Park's protection police.

2. Natural population fluctuations: possible, although more data are necessary. This is

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Tabla 1. Lista de muestreos realizados en 1998. Se indica el número y duración (en minutos) de cada muestreo, así como el número total de individuos (n) observado por muestreo y el número total de registros de *P. carbonelli* (PCAR) y *P. hispanica* (PH). Las tres últimas columnas indican el número de observaciones por hora, respectivamente para todos los registros (ALL / h) y por especie (PCAR / h y PH / h).

Survey	Day	Duration	n	PCAR	PH	ALL / h	PCAR / h	PH / h
1	1998-06-17	95	7	4	3	4.42	2.53	1.89
2	1998-06-21	65	8	7	1	7.38	6.46	0.92
3	1998-06-22	120	6	4	1	3.00	2.00	0.50
4	1998-06-22	60	7	5	0	7.00	5.00	0.00
5	1998-06-24	60	6	6	0	6.00	6.00	0.00
6	1998-06-30	100	9	9	0	5.40	5.40	0.00

supported by the strong dry period that is suffering the Iberian Peninsula during this current year (2012). However, we know that it was raining in the study area during the previous week to our surveys. *P. carbonelli* is highly dependent on humidity (Sillero & Carretero, in press).

3. Scientific collection: improbable, as the species is not currently collected by herpetologists. This was also confirmed by Natural Park's protection police. Moreover, we did not see anyone catching animals during the fieldwork.

4. Human persecution: not probable, because the local human population is quite sensible to the lizards of the area. In fact, they know that the population is usually studied by herpetologists.

In conclusion, we cannot provide a successful explanation of the decrease of the population of *P. carbonelli* in the Natural Park. More surveys outside this place (e.g., Laguna de San Marcos) are necessary, as well as a continuous monitoring in the following years. The current population density can be the result of normal fluctuations, but we consider more prudent to give the advice to the Iberian herpetological community at this moment.

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