

## **Spanish Sand Racer – *Psammodromus hispanicus* Fitzinger, 1826**

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Publication date: 17-09-2012



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## Common Names and Synonyms

Catalan, Sargantana Timonera; English, Spanish Sand Racer or Spanish *Psammmodromus*; French, *Psammmodrome hispanique* or *Psammmodrome d'Espagne*; German, Spanischer Sandläufer; Portuguese, Lagartixa-do-mato ibérica; Spanish, Lagartija cenicienta - Lagartija de prado ibérica. No known synonyms.

## History of Nomenclature

Fitzinger (1826) first mentioned a new species collected in Spain, which he named *Psammmodromus hispanicus*. He classified the new species as belonging to a new genus; *Psammmodromus*. Mertens (1925a, 1925b, 1926) split *Psammmodromus hispanicus* into two subspecies; *Psammmodromus hispanicus hispanicus* Fitzinger, 1826 and *Psammmodromus hispanicus edwardsianus* (Dugès, 1829), and in 2010, Fitze and coworkers elevated the subspecies to the species level (Fitze et al., 2010; San José García et al., 2010) based on molecular, phenotypic, and ecological analyses (Fitze et al., 2011, 2012).

## Type locality

Fitzinger (1826) reported that the new species was found in Spain, but did not specify the location. In 1928, Mertens and Müller (1928) assigned terra typica restricta to Southern Spain, again without specifying the location. In 2010 a neotype was assigned, given that the holotype was lost (Fitze et al., 2010, 2012). The type locality is in central Spain in Perales de Tajuña, Madrid (Fitze et al., 2012). Based on the original description by Fitzinger (i.e. species from Spain) the neotype location was assigned to a location in Spain representative of the typical genetic patterns of the species (Fitze et al., 2012).

## Origin and Evolution

*Psammmodromus hispanicus* belongs to the genus *Psammmodromus*, the sister taxa of *Gallotia*. Both taxa form the subfamily Gallotiinae (Harris et al., 1998), which belongs to the family Lacertidae (Harris et al., 1998).

The *Psammmodromus* genus consists of six species: *P. algirus* (Linnaeus, 1758), the oldest species with an estimated split at  $25 \pm 0.27$  Mya (Carranza et al., 2006); *P. blanci* (Lataste, 1880), with an estimated split at  $20 \pm 0.2$  Mya (Carranza et al., 2006); *P. microdactylus* (Boettger, 1881), whose phylogenetic relationship is unknown; *P. occidentalis* (Fitze et al., 2012) with an estimated split at 8.3 Mya (range: 2.9 – 14.7); and *P. edwardsianus* (Dugès, 1829) and *P. hispanicus* (Fitzinger 1826), whose split is estimated at 4.8 Mya (1.5 – 8.7) (Fitze et al., 2011). The split between *P. edwardsianus* (Dugès, 1829) and *P. hispanicus* (Fitzinger 1826) dates back to the Miocene/Pliocene boundary and thus coincides with the Messinian salinity crisis and the opening of the Gibraltar Strait. The phylogenetic relationships, spatial distribution of molecular diversity, and current ecological niche suggest that *P. hispanicus* has diversified its ecological niche, which in turn may have led to its speciation (Fitze et al., 2011, 2012). None of the *P. hispanicus* populations studied to date include *P. occidentalis* or *P. edwardsianus*, suggesting that the barriers that gave rise to speciation continue to prevent population mixing and range expansion.

## Identification

*Psammmodromus hispanicus* can be easily distinguished from *Psammmodromus edwardsianus* by the absence of a supralabial scale below the subocular scale. Compared with *Psammmodromus edwardsianus* and *Psammmodromus occidentalis*, *Psammmodromus hispanicus* exhibits fewer ocelli, femoral pores, and throat scales, and has a rounder snout (Fitze et al., 2011). Moreover, *Psammmodromus hispanicus* has greater snout-to-vent length (SVL), higher body mass, more

ventral scale rows, more collar scales, a larger head ratio (head width/head length), more extended nuptial coloration, and a smaller SVL ratio (SVL/total length) as compared with *Psammodromus edwardsianus* (Fitze et al., 2011).

### Description of the adult

*Psammodromus hispanicus* is a Lacertid of small body size. Compared to other species (*P. algerus*, *P. blanci*, *P. microdactylus*) its skull is relatively elevated (Salvador, 1981) and it has no pterygoid teeth (Pérez-Mellado, 1998). Its dorsal coloration ranges from greyish to grey-brown and it exhibits four dorsal longitudinal lines ranging from cream to grey colour (Gosá and Bergerandi, 1994). The belly is predominantly white. Nuptial coloration is conspicuous yellow-green (Fitze, P. S., personal observations).

No supralabial scale exists below the subocular scale. *Psammodromus hispanicus* has 4 superciliar scales, 4 supraocular scales,  $17.9 \pm 0.2$  (mean  $\pm$  SE; range: 15 – 23) gular scales,  $1.3 \pm 0.2$  (0 – 3) collar scales,  $25.8 \pm 0.3$  (20 – 30) ventral scale rows,  $9.9 \pm 0.1$  (8 – 12) femoral pores, and  $0.7 \pm 0.1$  (0 – 3) ocelli (Fitze et al., 2011, 2012). The adult has an SVL of  $49.81 \pm 0.43$  mm (42 – 57 mm) and a body mass of  $1.877 \pm 0.004$  g (1.375 – 2.892 g) (Fitze et al., 2011; Salvador, 1981). An adult SVL of  $50 \pm 1$  mm (50 – 52 mm) with a body mass of  $3.1 \pm 0.5$  g (2.8 – 4 g) was observed close to El Espinar (Segovia) (López and Martín, 2009).

### Description of the juvenile

The juvenile exhibits the same colour pattern as the adult, albeit of reduced intensity, greater homogeneity and more cryptic coloration.

### Sexual dimorphism

Males exhibit  $10 \pm 1$  SE (range: 9 – 11) femoral pores, which produce visible secretions. Females have 9 – 11 femoral pores, which are smaller than the male pores and produce no visible secretions (López and Martín, 2009).

### Femoral pore secretions

Male femoral pore secretions consist mainly of carboxylic acids and steroids. As compared with other species, these secretions contain relatively few compounds, suggesting that they primarily mediate short-distance interactions (López and Martín, 2009). Femoral pore secretions mainly consist of 6 steroids (72.6 % of TIC; total ion current) and 7 carboxylic acids ranging from n-C<sub>9</sub> to n-C<sub>18</sub> (23.5 %). Other components include 6 alcohols between C<sub>16</sub> and C<sub>29</sub> (3.8 %), and squalene (0.1 %). Major compounds are present in all individuals and relative proportions exhibit inter-individual variability. The 2 most abundant components are cholesterol (31.5 % of TIC) and campesterol (25.6 %), followed by dodecanoic acid (10.2 %) and stigmast-7-en-3-ol (9.6 %) (López and Martín, 2009).

### Karyotype

The karyotype of *Psammodromus sp.* (belonging to *Psammodromus hispanicus*) has been described without specifying the origin of the individuals studied. As a consequence, it is not known whether the description indeed refers to *Psammodromus hispanicus*. The karyotype of *Psammodromus sp.* consists of  $2n = 38$  chromosomes, 2 of which are microchromosomes (Matthey, 1939), 2 metacentric and the remaining 34 acrocentric (Calera González and Cano Pérez, 1979).

## Geographic variation

Genetic diversity is higher in Southern versus Northern populations. Northward range expansion has been proposed for Northern populations, but not for the more diverse Southern populations (Fitze et al., 2011). These range expansions may have resulted from post-glacial expansions from Southern refuges (Fitze et al., 2011). Mertens (1925b) mentioned individuals that may correspond to intermediate forms between *P. hispanicus* and *P. edwardsianus*, which were also mentioned by Boulenger (1921). These individuals originated from an area that may be a contact zone between the two species, suggesting the existence of hybrids. However, these early observations should be interpreted with care as no evidence supporting the existence of hybrids has been reported to date (Fitze et al., 2011, 2012).

## Habitat

*P. hispanicus* is found at altitudes ranging from 660 – 1350 m above sea level (asl) (Fitze et al., 2011, 2012). Besides these studies, little information is available regarding its altitudinal range, which may be more expansive than than reported.

The habitat of *P. hispanicus* is characterized by harsh winters and climatic conditions (Santos and Tellería, 1989), *i.e.*, low winter temperatures and low precipitation seasonality (Fitze et al., 2011).

In general, *P. hispanicus* selects an open microhabitat with patches of uncovered soil and loose vegetation consisting of dense herbs and shrubs, that are densest from 0 to 10 cm above the ground. It avoids dense vegetation, high vegetation, and wooded areas (Carrascal et al., 1989).

*P. hispanicus* prefers habitats that are dominated by human activity, such as degraded habitats and those close to cereal plantations (Santos and Tellería, 1989). In Segovia, *P. hispanicus* has been observed in uncultivated land and wasteland (48.6 %), cultivated areas (41.4 %), bush land of 0.25 – 0.5 m in height (5.2 %), grassland (4.1 %), and stony areas (0.6 %) (Santos and Tellería, 1989).

In Navarra, *P. hispanicus* has been observed in cultivated dry land and wasteland (4.2 % of citations), Mediterranean shrub (25 % of citations) and semi-arid steppes (70.8 % of citations) (Gosá and Bergerandi, 1994). Mediterranean shrub is the preferred habitat, within which it selects open areas containing *Artemisia herba-alba*, *Stipa iberica*, *Brachypodium retusum*, different *Thymus* species, and esparto fields growing on argillaceous rather than sandy substrate (Gosá and Bergerandi, 1994). These habitats are characterized (at least in Navarra) by low annual precipitation (< 500 mm) (Gosá and Bergerandi, 1994).

## Abundance

Very little information exists regarding the abundance of *P. hispanicus*. The only study that may correspond to *P. hispanicus* estimated its density at 2 individuals/ha using transect methodology (Cano Corcuera, 1984), which normally underestimates actual densities. The populations sampled by Fitze and coworkers (2011) revealed much higher densities, reaching 10 – 40 adult individuals/hectare in El Espinar, Segóvia (Fitze, P. S., personal observations), although this study sampled high-density populations, which may not be representative of the average population density, which were restricted to very small areas ( $\leq 1$  ha).

## Conservation status

The conservation status of *P. hispanicus* is classified as of least concern (LC) according to the IUCN Global Categories (2009), given its wide distribution and large populations, which presumably are not declining fast enough to qualify for listing in a more threatened category (Pleguezuelos et al., 2012). It should be noted that in the distribution of *P. hispanicus* has been significantly overestimated, and thus the first criteria (wide distribution) for determining the conservation status is invalid.

IUCN Category for Spain (2002): of Least Concern (LC) (Carretero et al., 2002).

### Threats

*P. hispanicus* may be locally threatened by the loss of scrubland (Pleguezuelos et al., 2012). Direct threats include intensive agriculture, fires, urbanization of suitable habitat, and the transformation of habitat into agricultural land (Gosá and Bergerandi, 1994). In addition, ecological succession leads to dense bush land, which is unattractive to *P. hispanicus*.

### Conservation measures

Conservation measures include the prevention of habitat destruction and the protection of small bushes and Mediterranean scrub (Carretero et al., 2002). It is very important to maintain open areas of uncovered soil, *i.e.*, to prevent natural ecological succession.

### Geographic distribution

*P. hispanicus* inhabits the central Spanish Peninsula, and has been recorded from Pamplona in the North, to Albacete in the South, and Segovia in the West (Fitze et al., 2011, 2012). Sightings have been recorded in Andosilla (Navarra), El Espinar (Segovia), Perales de Tajuña (Madrid), Ermita del Cristo Villajos (Ciudad Real) and Riópar (Albacete) (Fitze et al., 2012). The exact species limits have not yet been described.

The climatic variables that best describe the distribution of *P. hispanicus* are the average temperature of the driest trimester and the annual temperature range (Fitze et al., 2011).

### Trophic ecology

To date, no detailed study of the diet of *P. hispanicus* has been conducted, though its diet may resemble that of *P. occidentalis* and/or *P. edwardsianus*.

### Reproduction

In May, females gestate 1 – 4 eggs (mean  $\pm$  SE:  $2.65 \pm 0.18$  eggs) (Fitze, P. S., personal observations). In Navarra, females lay clutches of 3 – 4 eggs in May (Gosá and Bergerandi, 1994). The eggs are deposited in cavities excavated by the female or at the base of bushes (Gosá and Bergerandi, 1994). In May, a positive correlation between female snout-to-vent length and clutch size is observed ( $F_{1,36} = 12.49$ ;  $P < 0.01$ ), and clutch sizes is independent of female body condition ( $F_{1,35} < 0.01$ ;  $P = 0.93$ ) (Fitze, P. S., personal observations).

### Population structure and population dynamics

To date no data on population structure or population dynamics have been published. Between emergence from hibernation and hatching of the juveniles in August, populations comprise the adult age class, while during the period between hatching and hibernation, two age classes are observed (juveniles and adults). The number of adults decreases from the reproduction stage onwards until the juveniles reach adult body size. In autumn, the juvenile age class predominates (Fitze, P. S., personal observations).

*P. hispanicus* occupies a narrow ecological niche within the ecological succession (see Habitat section). As a consequence, strong and frequent interannual population fluctuations are observed, and temporally stable populations only exist in climax communities, which are rare (*i.e.*, climax communities corresponding to the habitat characteristics of *P. hispanicus*), or in habitats that are temporally maintained by humans (*e.g.*, habitats with annual sheep and goat grazing) (Fitze, P. S., personal observations).

### **Interactions between species**

*P. hispanicus* sometimes lives in the presence of other lizards such as *Psammodromus algirus*, *Acanthodactylus erythrurus*, and *Podarcis hispanica*. However, there is little habitat overlap with other lizard species and even less overlap at the microhabitat level (Carrascal et al., 1989; Santos and Tellería, 1989; Fitze, P. S., personal observations). No information is available regarding behavioural interactions among species.

### **Antipredator strategies**

In the presence of possible risks *P. hispanicus* flees, accelerating explosively, and hides at the base of thick bushes. Upon reaching cover it stops abruptly, and remains motionless, as movements are easily detected. It relies on its cryptic coloration and dorsal colour pattern to aid concealment. Once the predator begins to move, attempting to locate the Sand Racer from the side or from above, it can no longer detect fine movement in the bush, at which point *P. hispanicus* begins to slowly creep to the edge of the bush. Upon reaching the edge of the bush it accelerates explosively once again to reach the cover of the next bush. This escape behaviour is usually undetected by the predator (and by humans) and the Sand Racer remains in the next bush or repeats the process to escape again. This escape behaviour can occur in all possible directions, and may involve returning to a bush in which it has previously hidden. It is extremely rare for *P. hispanicus* to hide in holes. However, it frequently walks around stones, suggesting that it hides in a hole, and simply passes through the gap between stone and vegetation in order to exit via a route that is not visible to the predator (Fitze, P. S., personal observations).

### **Predators**

Predators likely include those described for *P. edwardsianus* and *P. occidentalis*.

### **Parasites**

No specific information exists. Potential parasites include those described for *P. edwardsianus*.

### **Activity**

Winter is spent in hibernation. Activity begins (in Navarra) in April and lasts until October. Activity up to December is rare (Gosá and Bergerandi, 1994). Activity increases after bad weather (Fitze, P. S., personal observations).

### **Thermal biology**

No specific information exists. Thermal biology of *P. hispanicus* may be similar to that described for *P. edwardsianus* and *P. occidentalis*.

### **Home range**

No specific information exists regarding the home range of *P. hispanicus*, although it likely resembles that described for *P. edwardsianus*.

## Behaviour

*P. hispanicus* emits high-pitched squeaks when manipulated (von Bedriaga, 1879; Mertens, 1946; Fitze, P. S., personal observations). These noises are produced in the presence of predators and during reproduction (von Bedriaga, 1879). The frequency of the emitted sound is 1.5 – 16 kHz and the duration 700 – 900 ms, as determined by phonogram (Böhme et al., 1985), although it is unclear whether these recordings were of *P. hispanicus*, *P. edwardsianus* or *P. occidentalis*.

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