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Thermal ecology of two sympatric saxicolous lizards of the genus *Phymaturus* from the Payunia region (Argentina)

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ABSTRACT

We evaluated the thermal biology of two sympatric saxicolous species of the genus *Phymaturus*, endemic from the Argentine Payunia region. Taking into account that the distributional range of *Phymaturus roigorum* (the largest species) is greater than the range of *P. payuniae*, we evaluated the habitat (type of rocks) used by these species. We recorded body temperature and operative temperatures in different habitats, and we determined the preferred body temperature in the laboratory. We compared the thermal quality of habitats occupied and not occupied by *Phymaturus payuniae*, and the accuracy and effectiveness of thermoregulation between species.

P. roigorum was found on many different kinds of rocks, but *P. payuniae* was found mainly on two types or rocks and not found on dark basalts. No differences were found in habitat thermal quality or in preferred temperatures when comparing among populations or between species. Although both species are thermoregulators, *P. payuniae* demonstrated better accuracy and effectiveness. This is the first study to assess thermal biology in coexisting species of the genus *Phymaturus* and provides the first data on effectiveness of thermoregulation for the genus. The results obtained have importance from a conservation perspective, since both endemic species are vulnerable and no data on habitat or thermal requirements were available up till now.

1. Introduction

Biotic and abiotic components, as well as historical factors, may influence the geographic range of species (MacArthur, 1972; Soberón and Peterson, 2005). Since temperature has a significant impact on the physiology of ectotherms, availability of a microhabitat appropriate for thermoregulation is one of the most important factors that influence activity pattern, habitat selection and spatial distributions (Wilms et al., 2011).

The main costs of thermoregulation are predation risk and the reduction in time for other non thermoregulatory activities such as foraging (Gregory et al., 1999; Huey, 1982; Huey and Slatkin, 1976; Pianka and Pianka, 1970). When thermal availability is outside of the preferred body temperature range, lizards may face two different scenarios: if thermal availability is below the preferred temperature, the cost for thermoregulation may be high, and the habitat could be considered non-optimal for the establishment of the species. However, if thermal availability is above the preferred body temperature, lizards must retreat to cool refuges to avoid overheating (Sinervo et al., 2010), thus increasing the number of hours of restriction and consequently limiting foraging (constraining metabolic functions like growth and reproduction).

The genus *Phymaturus* comprises saxicolous lizards that are distributed in Argentina and Chile. This genus is considered conservative in several of its features, due to the fact that all species are herbivorous and viviparous (Scolaro et al., 2008). Thermal biology and niche requirements were postulated as conservative as well within the genus (Cruz et al., 2009; Debandi et al., 2012). However, species of different size could exhibit different thermal requirements or thermoregulatory behavior. Moreover, species that have different ranges are likely to also have different thermal requirements, and it is expected that those species with wider geographic ranges will show a wider thermal tolerance (Cruz et al., 2005) and/or amplitude in preferred temperatures (difference between maximum and minimum values).

In the Argentine Payunia region, two endemic species of *Phymaturus* coexist: *P. roigorum* (the largest, belonging to the *palluma* group), and *P. payuniae* (belonging to the *patagonicus* group) (Debandi et al., 2012). We observed that the distribution of the smaller *P. payuniae* is included within the distributional range

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of *P. roigorum*, and it has always been found in sympatry (syntopy) with the latter. *Phymaturus roigorum*, instead, was found to be either in allopatry or in sympatry with *P. payuniae*. When coexisting, they share microhabitats for basking and refuge, and show similar patterns of daily activity (Corbalán and Debandi, unpub. data). Basking behavior in these species was recently reported by Corbalán and Debandi (2013). Rock surface temperature has a direct influence on the thermoregulatory behavior, and postural adjustments are similar in both species during cloud covered conditions (Corbalán and Debandi, 2013). Thus, both species exhibit thigmothermic and heliothermic thermoregulation, depending on environmental conditions.

The purpose of this study was to evaluate habitat use and thermal biology of *P. roigorum* and *P. payuniae*. Specifically, the objectives were: (1) to know the distribution of both species in the region and the habitat (type of rocks) used by each one, (2) to determine the preferred body temperature range or set-point range (T_{set}) of both species, and (3) to determine the accuracy of body temperature in the field relative to the set-point range and the effectiveness of thermoregulation.

2. Materials and methods

2.1. Study area

The study was carried out on the Payunia region, an area dominated by a volcanic landscape, in southern Mendoza Province, Argentina (approximately from 35° 40′ to 36° 52′ South latitude, and from 68° 20′ to 69° 40′ West longitude) (Fig. 1). Most of the surveyed areas are situated at La Payunia Reserve, which comprises a total of 259,000 ha. Within the Reserve, lies one of the largest volcanoes in the region, the Payún Matrú, whose summit reaches 3700 m asl. Outside the Reserve, we surveyed the Payún highland plain, and the Palauco and Nevado hills. The climate of the region is arid and cold, influenced by winds from the Pacific Ocean (Candia et al., 1993; Capitanelli, 1972). Winters are rainy and snowy, and summers are dry (Candia et al., 1993). Because of these harsh conditions, lizards remain inactive during cold months.

2.2. Species distribution in the area

Five sampling trips were conducted from February 2007 to November 2011, recording the presence/absence of *Phymaturus* species around the area. All records were georeferenced using a Garmin eTrex Vista HCx GPS. Additionally, notes were taken about the easiness of finding either species at each site as an indirect measure of relative abundance (low/high abundance). Because different types of rocks (and therefore with different mineral composition, color and welding degree) may reflect differences in the thermal quality of the habitat for thermoregulation by the saxicolous lizards, we classified the habitat used by each species based on the type of rocks. For this, we used the available geologic map of the Payún Matrú volcano and its surrounding area (Llambías, 2008).

2.3. Field and laboratory temperatures of lizards

We caught, by noosing, a total of 55 adult individuals of *P. roigorum* and 30 individuals of *P. payuniae* from different rocky promontories of the region (Fig. 1). Most of them (81.18%) were captured within the Payunia Reserve from 4th to 10th November 2011, while the rest were captured outside the Reserve (Payún highland plain, and Nevado and Palauco hills) from 25th to 28th November 2011. In four of these sites both species were syntopic, whereas in another four only *P. roigorum* was present (allopatric

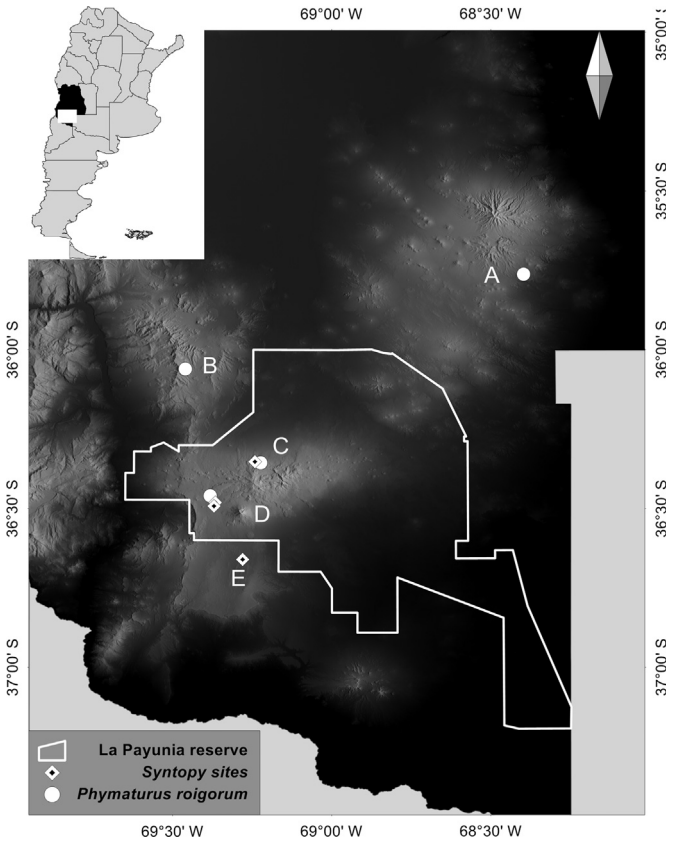

Fig. 1. Sites of capture of *Phymaturus roigorum* and *P. payuniae* in the Payunia region for thermal experiments. Diamonds indicate those sites where both species were present (syntopy), and circles indicate those sites where only *P. roigorum* was present (allopatry). (A) Nevado hills; (B) Palauco hills; (C) Payún Matrú volcano; (D) Payún Liso volcano and (E) Payún highland plain.

sites). Body temperature (T_b) was recorded at the moment of capture using TES TP-K thermocouples connected to a TES 1312A digital thermometer (range: −50 to 1300 °C, resolution: 0.1/1 °C). To minimize the stress in the animals, a laboratory was placed in the scientific station sited near the Reserve in order to perform selected body temperature (T_{sel}) experiments. Each day, captured individuals within the Reserve were transported to the laboratory and kept at ambient temperature 1–3 h before experiments began. Those individuals captured outside the Reserve were transported to Mendoza city and experiments were conducted at the Research Institute (IADIZA) between 1 and 5 days after capture.

Two wooden terrariums of 1 × 1 m with four separated lanes each were used for estimating the T_{sel} (Pough and Gans, 1982) of lizards. At one end of each lane, a 75 W incandescent lamp was placed to generate a temperature gradient (from about 45 °C to 22 °C). A sheet of aluminum paper covered 2/3 of the terrarium above the lamps to keep the end warm and help maintain the gradient. An ultrafine thermocouple was taped to the belly of the lizard and connected to an 8-channel data-logger (Measurement Computing 1.2 kHz Data Acquisition Device). During experiments, each individual (of *P. roigorum* or *P. payuniae*, indistinctly) was placed on a lane for 135 min.

Body temperature was recorded every 60 s, and data for the first 15 min were discarded from the analyses, allowing the animals to recognize the terrarium and to select their preferred temperature.

Once the experiments were finished, all individuals were sexed, weighed (with a Pesola micro-line spring scale, 100 g × 1 g), and snout-vent length and tail length were recorded (with a digital