

Consequences of Volcanic Ash Deposition on the Locomotor Performance of the *Phymaturus spectabilis* Lizard from Patagonia, Argentina



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ABSTRACT

The locomotor performance of lizards depends on their morphological and physiological adaptations to the habitat. However, when the habitat changes dramatically, for example, by a volcanic eruption, the performance of lizards may be affected. We registered the vegetation cover, the surface covered by ash, the presence of crevices suitable for *Phymaturus* and the rocks slopes to analyze the effects of ash accumulation produced by the eruption of Puyehue-Cordon Caulle volcanic complex on microhabitat use and availability of the *Phymaturus spectabilis* lizard. In addition, we studied the effect of ashes and slope on the locomotor performance of *P. spectabilis* by registering the maximum speed in sprint runs and long runs under four different treatments (cork and on the level, ashes and on the level, cork and slope, and ashes and slope). *P. spectabilis* selected microhabitats unvegetated, with crevices and steep slopes. Regarding locomotor performance, the speed of lizards was negatively affected by the presence of ash only in sprint runs on the level and in long runs with slope. The slope had a negative impact on the speed in all the treatments. These results show that the presence of volcanic ashes in the substrate might have affected the locomotor performance of the lizards, especially in long runs, and hence, the interaction of individuals with the environment, that is, escaping from predators and social behavior. *J. Exp. Zool.* 9999A: 1–9, 2013. © 2013 Wiley Periodicals, Inc.

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Catastrophic events like floods, fires, storms, volcanic eruptions, and earthquakes have demonstrated how rapidly environments can turn inhospitable for organisms (Hoffmann and Parsons, '97). In particular, volcanic activity has direct and notorious effects on the biota, such as the immediate and massive loss or transformation of the habitat (Arendt et al., '99). However, the indirect effects of volcanic eruptions over the native species are more complex and less evident. In a semi-desert area like Patagonia, ash particles from a volcanic eruption can cause intense and prolonged damage to the environment as the dry conditions and lack of vegetation prevent the rapid settlement and fixation of the ashes (Inbar et al., '95).

In June 4, 2011, the volcanic complex Puyehue-Cordón Caulle (2236-m asl, 40°02'24" S; 70°14'26" W) erupted and deposited

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approximately 65 tons of volcanic materials per hectare affecting more than 3,300 hectares in Río Negro province, Argentina (Cremona et al., 2011; Gaitán et al., 2011). It has been demonstrated that volcanic ashes of the Puyehue-Cordón Caulle had a negative impact on the insect community and pollination (Buteler et al., 2011; Huerta, 2012; Fernández-Arhex et al., 2013; Martínez et al., 2013), vegetation (Grosfeld and Puntieri, 2011; Ghermandi and Gonzalez, 2012), and forage availability (Siffredi et al., 2011).

In the case of lizards, a change in the habitat characteristics, like the type of substrate, the vegetation cover (VC), and the availability of shelters could alter their interactions with the environment (Goodman et al., 2008). Particularly, the fitness of individuals can be affected if an environmental disturbance restrains locomotor performance, and therefore the possibility to escape from predators, disperse, reproduce, and capture preys (Greenwald, '74; Bennett, '80, '90; Christian and Tracy, '81; Jayne and Bennett, '90). The negative effect of an environmental disturbance like an ash fall in locomotor performance would be potentiated in lizards living in complex habitats composed of surfaces of varying inclines since inclines per se have negative mechanical consequences for locomotion (Irschick and Jayne, '99).

Phymaturus is a genus of lizards of the Liolaemidae family characterized by the consistent preference for rocky microhabitats, stout, and flattened generalized body shapes, mainly a herbivorous diet, and a viviparous reproductive mode (Boretto and Ibagüengoytia, 2009; Scolaro and Pincheira-Donoso, 2010; Debandi et al., 2011). This genus, composed by 40 species, is distributed in Andean and Patagonian steppe habitats of Argentina and Chile (Scolaro et al., 2012; Lobo et al., 2013; Morando et al., 2013), and its members exhibit a common pattern characterized by prolonged female reproductive cycles, late sexual maturity, small clutch sizes, and probably parental care (Boretto et al., 2012). The aim of this study is to investigate the effects of ash fall from Puyehue-Cordon Caulle on the locomotor performance, and also the selection of microhabitat of the *Phymaturus spectabilis* lizard considering the impact of ashes in the landscape. We hypothesized that the ashes have negatively affected *P. spectabilis*' locomotion since they have widely covered the lizards' rocky substrate with a sandy volcanic material. In addition, the availability of microhabitats suitable for the species might have

been affected too, resulting in a differential use of microhabitats by *P. spectabilis* selecting places without ashes.

MATERIALS AND METHODS

Studied Species and Environment

P. spectabilis is a medium-sized lizard (Table 1) with robust, elongated, and flattened body that belongs to the *patagonicus* phylogenetic group (Etheridge, '95; Lobo and Quinteros, 2005). This species is restricted to volcanic rocky plateaus close to Ingeniero Jacobacci, in the southwestern area of Río Negro Province, Patagonia Argentina (Lobo and Quinteros, 2005; Scolaro et al., 2008). The fieldwork was carried out 25-km south of Ingeniero Jacobacci (41°26' S and 69°45' W, 983 to 1064-m asl). The study area is located in the arid district of the Monte Austral, a steppe showing open ground, with gravel and effusive rocks between 900- and 1100-m asl (Scolaro et al., 2008). The dominant landscape is characterized by barren steppe and dissected rolling plains interspersed with rocky outcrops and vegetation of shrub-steppe grassy appearance (Cabrera, '71; Godagnone and Bran, 2009). The dominant vegetation consists of cushion bushes and sparse large clumps of shrubs. The study site, located approximately 230-km southeast of the volcanic complex Puyehue-Cordón Caulle, was affected by the ash fall during the 10 months that the volcano continued releasing ashes due to the predominant winds from the west that dispersed volcanic ash into this territory (Gaitán et al., 2011).

Use and Availability of Microhabitat

In order to evaluate microhabitat availability, 40 control plots (1 m²) were sampled every 10 m on parallel line transects ($n = 5$; 80-m length), separated by 10 m and distributed uniformly all over the study site. In total we obtained five transects, each one with eight plots. In addition, in order to estimate the use of the microhabitat by the lizards, a capture site plot of 1 m² around the place where each lizard was first detected was considered. In each plot, both control and capture site plots, four qualitative variables were classified: (1) VC according to three categories: bare substrate; herbaceous coverage; shrubby coverage; (2) the surface covered by ash (AC) according to three categories: 0–20% (small surface covered by ashes); 20–40% (prevalent, medium coverage);

Table 1. Snout-vent length (SVL, mm) and body mass (g) of *Phymaturus spectabilis*.

	<i>n</i>	SVL (mm)		Body mass (g)	
		Mean \pm SE	Range	Mean \pm SE	Range
Adult males	17	85.90 \pm 0.89	81.35–91.68	22.20 \pm 0.72	17.50–27.00
Adult females	18	88.99 \pm 0.70	84.84–93.38	23.83 \pm 0.82	19.50–30.00
Juveniles	30	70.15 \pm 1.48	51.94–83.09	13.11 \pm 0.71	7.00–22.00
Means \pm SE, and ranges are indicated.					

40–100% (high coverage); (3) the presence or absence of crevices suitable for *Phymaturus* (CR); and (4) the slope of the terrain (SL) into three categories: 0–15° (gentle slopes as those commonly found at the base of the plateau); 15–45° (medium slopes prevalent in the mid section of the plateau); 45–90° (high slopes characteristic of the top of the plateau where boulders are common). The orientation of the slope was not considered because the whole rocky outcrop faced north. The number of categories of VC, AC, and SL were determined according to Garshelis (2000). The number established was big enough to avoid overlapping important categories, but it was not large enough to lessen the power of statistical discernment of the method used.

Lizard Captures and Locomotor Performance Trials

During February 2012, 65 individuals of *P. spectabilis* were captured by hand or noose and each microsite of capture was geo-referenced (GPS Garmin Map 60C Sx). Lizards were brought to the laboratory in order to perform locomotor performance trials and they were individually kept in cloth bags to avoid stress. Lizards were not fed during the experiments. The runs were performed within 48 hr of capture and between 10:00 and 20:00 hr, when lizards showed activity in their natural environment. The experiments were performed at ambient temperatures (Table 2) which were within the interquartile range of field active temperatures of this species (17.05–35.50°C, mean \pm SE = 29.52 \pm 0.58°C; unpublished data). Before the run, the body temperature of each lizard was taken with a catheter probe TES TP-K01 (1.62-mm diameter) introduced ca. 1 cm inside the cloacae connected to a TES 1303 thermometer (TES Electrical Electronic Corp., Taipei, Taiwan, \pm 0.03°C). Running trials were performed on a racetrack 0.075-m wide (which allowed lizards of all sizes to move freely along the track) and 1.05-m long, leading to a shelter. Photocells, positioned at 0.15-m intervals along the track, signaled passing lizards to a microcomputer that calculated speed over each 0.15-m section. Lizards ran two types of runs: (1) the sprint run (SR), the first 0.15-m run by each lizard, represented the fright reaction frequently observed in the field, and (2) the long run (LR), was

the run between the first and the last photoreceptor (1.05 m), which indicated the locomotor capability of the lizard to perform activities such as foraging, territorial defense, and courtship. For sprint runs, only those nonstop runs were considered. In long runs, if lizards attempted to stop, we stimulated them by touching them gently on their tail taking care not to interfere with the running speed. Moreover, lizards ran three consecutive times and only the maximum run speed (V_{\max}) of the three repetitions was considered for the analyses, regardless whether they stopped or not during the run. Between these three trials lizards were not rested but they were always rested at least 4 hr between the different treatments.

Experimental Design

Each specimen ran under four different conditions in a random sequence in order to determine the effects of volcanic ashes and slope on speed. The lizards were divided into eight groups, and the conditions sequence for each group was randomly chosen between the 24 possible options. The treatments were: cork floor racetrack and on the level (A– S–), ashes on the race track and on the level (A+ S–), cork floor racetrack and positive slope of 10° (A– S+), and ashes on the race track and positive slope of 10° (A+ S+). In order to simulate the accumulation of volcanic ash in the field we covered the floor of the racetrack with a fine layer (0.5 cm) of volcanic ashes taken from the lizards' environment. We used a 10° slope because this was the highest angle of repose of the volcanic ash.

Body Mass and Size, Sex and Sexual Maturity

In laboratory, after all experiments were performed, we registered the body mass of each lizard using a 100-g Pesola spring scale (\pm 0.5 g), and the snout vent length (SVL) using a digital caliper (\pm 0.02 mm). Sex was determined by the presence of pre-cloacal pores in males. Juvenile and adults were determined according to the minimum adult sizes (80-mm for males and 83-mm for females; Boretto, personal communication). After all the experiments were conducted, the lizards were released in good health conditions at their exact capture site.

Table 2. Maximum run speeds (V_{\max}) and body temperatures of *P. spectabilis* for sprint runs (SR) and long runs (LR) under the four treatments.

Treatment	Body temperature (°C), mean \pm SE (range)	Sprint runs (m/sec)		Long runs (m/sec)	
		Mean \pm SE	Range	Mean \pm SE	Range
On the level					
Cork	22.27 \pm 0.14 (19.4–24.2)	1.04 \pm 0.06	0.12–3.12	0.86 \pm 0.03	0.20–1.45
Ashes	22.27 \pm 0.17 (19.9–25.5)	0.92 \pm 0.04	0.23–2.11	0.82 \pm 0.03	0.24–1.18
Slope					
Cork	21.82 \pm 0.08 (20.6–24.1)	0.84 \pm 0.04	0.15–1.72	0.72 \pm 0.03	0.22–1.57
Ashes	22.37 \pm 0.10 (19.4–24.2)	0.83 \pm 0.03	0.22–1.41	0.72 \pm 0.02	0.28–1.06
The mean \pm SE, and ranges are indicated.					

Statistical Analysis

In order to compare the use and availability of microhabitat, a chi-square test was used, while to analyze the selection of microhabitat simultaneous confidence intervals were calculated (Marcum and Loftsgaarden, '80). The effect of ashes and slope on speed was determined using speed as the residuals obtained from the regression of V_{\max} against the body temperature. Residuals were used to avoid thermal dependence on speed, considering that the regressions of body temperature against the V_{\max} resulted in significant slopes ($P < 0.05$). The dependence between body mass and speed, and body mass and the difference between speed on the level and speed with slope were analyzed by simple regressions. The main effects and interactions of the locomotor performance treatments were analyzed using a two-way repeated measures ANOVA (Two-Way RMANOVA) which is used when all members of a random sample are measured under a number of different conditions. In a Two-Way RMANOVA as the sample is exposed to each condition in turn, the measurement of the dependent variable is repeated. The slope and ashes were used as intra-group factors. The simple effects of each level of factors were analyzed using all pairwise multiple comparison procedures (Bonferroni adjustment).

The statistical software programs Sigma Stat 3.5[®] and SPSS 15.0[®] were used for statistical analysis. The assumptions of normality and homogeneity of variance for parametric procedures were checked using Kolmogorov-Smirnov and Levene's tests, respectively. All the assumptions were fulfilled.

RESULTS

Selection of Microhabitat

P. spectabilis is located in basaltic plateaus with a high percentage of volcanic surface rocks. During sampling conducted in early February 2012 it was noted that the persistence of the volcanic ash is variable between different areas of the rocky outcrop, with zones still covered with a thick layer of ashes (2–5 cm; Fig. 1) and other zones with no ashes at all.

P. spectabilis used the three types of ash coverage (0–20%, 20–40%, 40–100%) proportionally to their availability ($\chi^2_{2,101} = 5.62$, $P = 0.060$; Fig. 2). Considering VC and crevices, *P. spectabilis* selected positively bare substrates ($\chi^2_{2,101} = 6.33$, $P = 0.042$) and microhabitats with presence of rocky crevices ($\chi^2_{1,101} = 26.86$, $P < 0.001$; Fig. 2). There were differences between the use and availability of the terrain slopes ($\chi^2_{2,101} = 32.49$, $P < 0.001$; Fig. 2). Terrains with high slopes (45–90°) were selected positively while plain terrains (0–15°) were selected negatively.

Effect of Body Mass on Speed

Body masses of the individuals, discriminated by sex and juveniles and adults, are summarized in Table 1. The effect of slope on speed uphill (speed on the level – speed with slope) was not related to body mass considering the treatments with and without ashes, both in sprint runs and long runs (linear regressions: SR without



Figure 1. Ash accumulation in *Phymaturus spectabilis* habitat eight months after the eruption of Puyehue-Cordon Caulle volcanic complex. Photo by Nora Ibargüengoytia.

ashes: $r = 0.000$, $F_{1,60} = 0.001$, $P = 0.998$; SR with ashes: $r = 0.015$, $F_{1,60} = 0.900$, $P = 0.347$; LR without ashes: $r = 0.013$, $F_{1,60} = 0.780$, $P = 0.381$; LR with ashes: $r = 0.002$, $F_{1,60} = 0.156$, $P = 0.694$). The speed was not related to the body mass on the level in the treatments with or without ashes, in both sprint and long runs (SR without ashes: $r = 0.020$, $F_{1,60} = 1.206$, $P = 0.277$; SR with ashes: $r = 0.001$, $F_{1,60} = 0.013$, $P = 0.908$; LR without ashes: $r = 0.031$, $F_{1,60} = 1.891$, $P = 0.174$; LR with ashes: $r = 0.008$, $F_{1,60} = 0.476$, $P = 0.493$). Hence, juveniles and adults were analyzed together.

Effects of Ashes and Slope in Sprint Runs

The lizards' speed was affected by ashes in sprint runs (Table 3). Specifically, lizards on the level ran faster over cork than over ashes, however, in the treatments with slope the speed was not affected by the presence of ashes (Table 3).

Lizards ran faster in sprint runs on the level than with slope in both cases, over cork and over ashes (Table 3).

Effects of Ashes and Slope in Long Runs

In long runs, the ashes affected the speed only in the treatment with slope; although the lizards ran faster over cork than over ashes, those that ran on the level were not affected by ashes (Table 3).

The slope affected negatively lizards' speed in long runs in both treatments, over cork and over ashes (Table 3).

DISCUSSION

Rocky outcrops habitats are complex and composed of inclined surfaces that often consist of large areas with minimal VC, which increases lizards' predation risk by visual predators, imposing

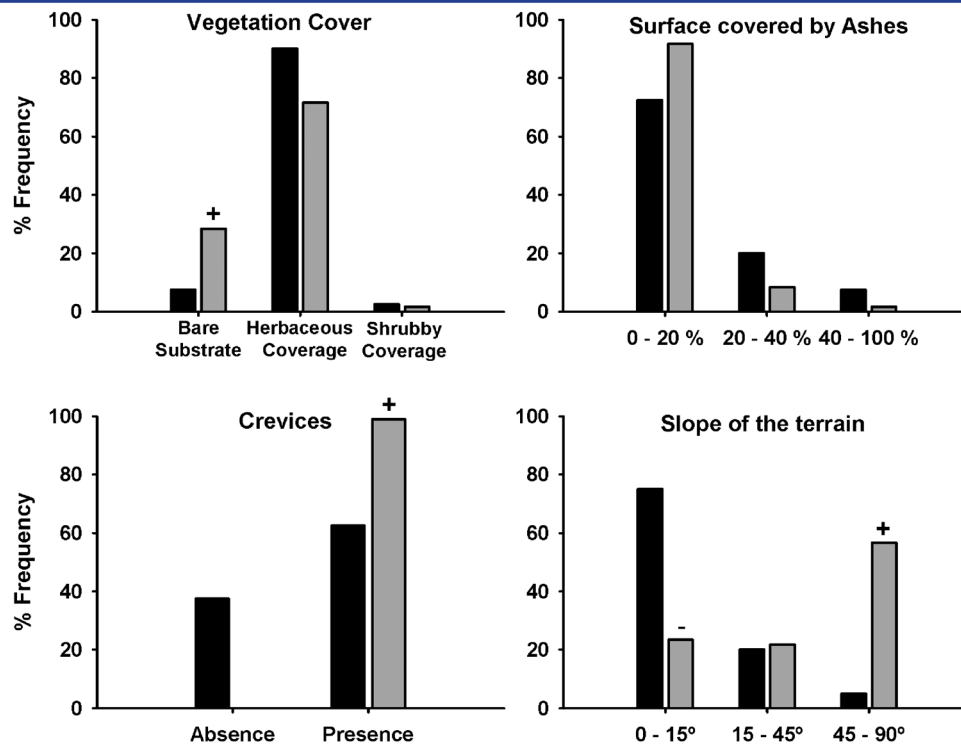


Figure 2. Bar charts of the frequency percentage of use (gray bars) and availability (black bars) of four microhabitat variables. The plus sign (+) indicates the categories of each variable selected positively and the minus sign (–) indicates the categories of each variable selected negatively.

greater demands on the locomotor performance of species to cover such areas quickly (Goodman et al., 2008). The present study showed that *P. spectabilis* lizards selected microhabitats characterized by high slope (45–90°) and abundance of crevices, and that even a low slope (10°) affected negatively their speed, both in sprint and long runs, especially with the presence of ashes.

Lizards are expected to balance their microhabitat choice among different resources such as, food abundance and its distribution (Simon, '75; Waldschmidt, '83; Hews, '93), places with suitable conditions for thermoregulation (Castilla and Bauwens, '91; Díaz et al., '96; Grover, '96), and availability of refuges (Stamps, '83; Clark and Gillingham, '90; Pough et al., '98). The

Table 3. Main effects and simple effects of slope and ashes on the speed of sprint runs (SR) and long runs (LR) of *P. spectabilis* ($n = 65$).

Main effects				Simple effects		
Factor	Type of run	$F_{1, 63}$	P	Treatment	Difference between mean speeds	P
Slope	SR	9.725	0.003*	Cork	0.165	0.009*
				Ashes	0.087	0.049*
	LR	39.973	0.001*	Cork	0.099	0.001*
				Ashes	0.121	0.001*
Ashes	SR	6.799	0.011*	On the level	0.155	0.027*
				Slope	0.078	0.064
	LR	7.950	0.006*	On the level	0.038	0.088
				Slope	0.060	0.022*

Statistic parameters and P values are indicated.

Significant results ($P < 0.05$) are indicated with an asterisk (*).

abundance of crevices might influence the presence of *P. spectabilis* especially considering that they might serve as isothermal refuges to hibernate (Ibargüengoytia et al., 2008) and they favor their antipredatory behavior. These lizards shelter in narrow rock crevices inflating their bodies (*sensu* Cooper et al., 2000) as the chuckwalla *Sauromalus* do to avoid predation (Smith, '46; Lappin et al., 2006). In the same way, the preference of *Phymaturus* for high slopes may provide safe basking sites of difficult access for snakes like *Philodryas patagoniensis*, *Philodryas trilineata*, and *Rhinocerocephalus ammodontoides*, and mammals like the minor ferret (*Galictis cuja*, personal observation) and gray fox (*Lycalopex griseus*) which are common potential predators (Bonino, 2005; Scolaro et al., 2008).

The presence of slopes in the terrain has a great impact in reptiles' locomotion and its effect is more severe for larger individuals (Huey and Hertz, '82; Muegel and Claussen, '94; Claussen et al., 2004). The work against gravity in running uphill is proportional to the slope and body mass, and steep slopes should slow larger individuals more severely than small ones (Hill, '50; Maynard Smith, '68). In this study, the effect of slope in the speed was not related to the body mass, probably because the range of sizes in this species is not great enough to detect the effect of the body mass in the speed. Another possible explanation would be that the slope used in this study was not great enough to detect the effect of body mass in the speed uphill.

When the substrate was volcanic ash, *P. spectabilis* lizards attained slower speeds in long runs with slope, which suggests that the accumulation of ashes over the rocks has probably affected locomotion when lizards performed long runs uphill, and hence foraging and social activities such as territory defense or courtship (Scolaro et al., 2008). Although we cannot confirm that the decrease in the locomotor performance is caused by a biomechanical effect or by a higher frequency of stops in the runs, the frequency of stops might depend more of the individual behavior than of the treatment since we have observed frequently that in the same treatment some individuals tend to stop and others simply ran non-stop the three consecutive trials.

In the sprint runs, important for fright reaction (Goodman et al., 2008), ashes affect lizards' speed on the level probably because the initial impulse of the run is more difficult in the ashes because the claws are adapted to rocky substrates (Tulli et al., 2009). This result contrasts with that obtained by Tulli et al. (2012), who found that saxicolous *Liolaemus*, including seven species of *Phymaturus*, showed better locomotor performance over sandy substrates than over cork. However, they included *Liolaemus* species in their analyses which could mask the actual effect of the type of substrate on the locomotor performance of *Phymaturus* lizards.

Locomotor performance in lizards influences fitness, given its role in escaping from predators or foraging (Bennett and Huey, '90; Garland and Carter, '94; Bauwens et al., '95; Irschick and Garland, 2001; Van Damme and Vanhooydonck, 2001),

therefore, negative effects over movement can potentially influence growth rates, survival, and reproduction (Arnold, '83; Garland and Losos, '94; Irschick and Garland, 2001). The accumulation of volcanic ashes in the habitat seems to have affected negatively the reproductive biology of *P. spectabilis*, since skipping in the reproduction of females has been reported during the season post-eruption (Boretto, personal communication). Probably, the negative effects of ash fall on the recruitment of annual plant species (Ghermandi and Gonzalez, 2012) had a negative effect over the food availability of these lizards that feed mainly on plants (Espinoza et al., 2004). In addition, ashes had a negative impact on bees and pollination (Huerta, 2012; Martínez et al., 2013) which might have produced a decrease in the floration, and insects' abundance due to the insecticide effect of volcanic ash (Buteler et al., 2011; Fernández-Arhex et al., 2013). The combined effect of a reduction of food availability and the *P. spectabilis* preference for unvegetated microhabitats would force lizards to travel longer distances, over a substrate predominantly covered by ash, to feed on flowers and fruits. Moreover, since the effect of ashes on the habitat has been of a spatial magnitude much greater than the modest home ranges that these lizards present (Araya-Díaz, 2007), they might not have been able to obtain enough food, within their home ranges, to attain an optimal nutritional condition to reproduce during the activity season that followed the eruption. In relation to this, it has been demonstrated that pregnant females captured before the eruption exhibited higher body mass relative to SVL than those captured the second year post-eruption and that newborns born in captivity before the eruption presented higher body mass relative to SVL than those born the second year post-eruption (Boretto, personal communication).

The volcanic eruption of Puyehue-Cordon Caulle has also affected *P. spectabilis*' competitors and predators, which could probably compensate the negative effects over this species. Considering other co-existing lizard species, it can be presumed that the effect of ash fall over locomotion might have been weaker than that registered for *P. spectabilis*, probably because coexisting species like those of the genus *Liolaemus* are more generalist in their habitat requirements and their morphology allows them to perform well in a variety of substrates (Tulli et al., 2012). However, as most of the sympatric lizards' species of *P. spectabilis* are strictly insectivorous, they might have suffered a more significant decrease in their nutritional condition than *P. spectabilis*, considering the significant reduction in insects' abundance registered after the ash fall (Buteler et al., 2011; Fernández-Arhex et al., 2013). Regarding mammal competitors and predators, it has been demonstrated that ashes caused gastrointestinal disorders and death by inanition (due to the reduction in forage availability) in livestock like cattle, horses, sheep, and goats (Robles, 2011). An increase in the mortality of other terrestrial species such as foxes, pichis, and hare has also been reported, however, most studies remained unpublished. In contrast, raptors and scavenger

birds, which are among the main predators of *P. spectabilis*, have resulted favored by the increase in the mortality of livestock and other animals due to the ash fall (Barbar, personal communication) and probably their abundance has increased, imposing a higher predation pressure over *Phymaturus*, which enhance the negative effects of ash fall in these lizards.

Environmental changes are not a recent phenomenon, as they have occurred throughout the geological time. Organisms have always been exposed to fluctuations of temperature, humidity, and in the composition of the atmosphere (Hoffmann and Parsons, '97). The few studies which estimated the effects of volcanic eruptions over animal populations like arthropods (Marske et al., 2007) and birds (Dalsgaard et al., 2007) showed that disturbance is usually limited in intensity and duration, and populations showed rapid recovery in the subsequent years. Since their origin at the uplift of the Andes (~22 m.a., Gregory-Wodzicki, 2002; Fontanella et al., 2012; Morando et al., 2013) *Phymaturus* lizards of North Patagonia have probably been exposed to volcanic ashes of the Puyehue-Cordon Caulle complex (Singer et al., 2007) which might have produced localized extinctions followed by immigration from unaffected areas (Díaz-Gómez, 2009). However, these vulnerable lizards are currently being threatened by other extrinsic factors such as sheep farming, habitat fragmentation, extractive activities, global warming, and desertification. In particular, desertification would be the environmental change most comparable to a volcanic ash fall, since it has similar effects as the loss of vegetation and modification of the substrate (Glantz and Orlovsky, '83). The combination of all these factors and the restricted distributional range of *Phymaturus* species could probably lead to the extinction of some populations after the volcanic event of Puyehue-Cordon Caulle. Our results shed light on one of the effects of volcanic ashes on lizards' biology, but further physiological and ecological studies are essential in order to get full knowledge of the impact of this phenomenon over *Phymaturus* populations.

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