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The effect of environmental enrichment on *Salvator merianae* (Squamata: Teiidae) under captivity conditions

Efecto del enriquecimiento ambiental en *Salvator merianae* (Squamata: Teiidae) en condiciones de cautiverio

Ana G. Dantur[1*]; Alejandra M. Hurtado[1]; Silvia N. Chamut[2]

[1] Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán. Miguel Lillo 205, (4000) San Miguel de Tucumán, Argentina.
[2] Facultad de Agronomía y Zootecnia, Universidad Nacional de Tucumán. F. Ameghino s/n, (4105) El Manantial, Tucumán, Argentina
[3] Corresponding author. Email: gabydanlo1991@gmail.com

ABSTRACT

Environmental enrichment seeks to improve the quality of care for animals in captivity through the constant generation of new sources of stimuli to simulate a complex and changing environment. *Salvator merianae* is a species of large lizard whose native distribution covers the subtropical and humid zones of southeastern South America. The study was carried out in the Experimental Lizard Hatchery belonging to the Facultad de Agronomía y Zootecnia from Universidad Nacional de Tucumán, UNT for its initials in Spanish. Two pens were used, a control group R1 (Enclosure 1) and an experimental group R2 (Enclosure 2), where data were taken without enrichment (R2 W/O-E) and with enrichment (R2 WE). An ethogram was used to record the different behaviors that were then grouped into eight categories to evaluate how animals spend their time. Behaviors were recorded on video, the applied technique was the focal animal sampling with instantaneous recording, the extracted data were exported into individual spreadsheets. The Landau index was calculated to determine the existence of hierarchies. The data suggest that the modification of the enclosure conditions has the capacity to alter the behavioral profiles. Only a few behavioral categories showed significant differences. No significant differences were found, in the frequency of the behavioral categories, between males and females. There was a decrease in the frequency of reproductive behavior in males in R2. There was a non-linear hierarchy among the individuals. A decrease in the chases was observed among individuals in R2.

Keywords — Behaviour, ethogram, enclosures, welfare, reptiles.

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RESUMEN

El enriquecimiento ambiental busca mejorar la calidad del cuidado de los animales en cautiverio mediante la generación constante de nuevas fuentes de estímulos, para simular un ambiente complejo y cambiante. *Salvator merianae* es una especie de lagarto de gran tamaño cuya distribución nativa abarca las zonas subtropicales y húmedas del sureste de América del Sur. El estudio se realizó en el Criadero Experimental de Lagartos perteneciente a la Facultad de Agronomía y Zootecnia de la UNT. Se utilizaron 2 corrales, un grupo de control R1 (Recinto 1) y uno experimental R2 (Recinto 2) donde se tomaron datos sin enriquecimiento (R2 W/O-E) y luego con enriquecimiento (R2 WE). Se elaboró un etograma para registrar los distintos comportamientos que luego se agruparon en ocho categorías para evaluar cómo los animales emplean su tiempo. Se realizaron filmaciones, a las que se les aplicó la técnica de muestreo animal focal con registro instantáneo y los datos extraídos se volcaron en planillas individuales. Se calculó el índice de Landau para determinar la existencia de alguna jerarquía. Solo "Refugio", "Otros" y "Termorregulación" mostraron diferencias significativas antes y después del enriquecimiento. No hubo diferencias significativas en la frecuencia de las categorías comportamentales entre machos y hembras. Hubo una disminución en la frecuencia del comportamiento reproductivo en machos en el R2. No se registró jerarquía de tipo lineal entre los individuos. Hubo una disminución de las persecuciones entre los individuos en R2.

Palabras clave — Comportamiento, etograma, recintos, bienestar, reptiles.

INTRODUCTION

The term "environmental enrichment" refers to a wide spectrum of practices that involve modifying the environment where animals are housed to provide them with opportunities to perform typical behaviors, with the ultimate goal of increasing the welfare of animals in captivity (Broom, 1991; Shepherdson, 1994, 1998, 2013; Young, 2003; Tarou and Bashaw, 2007; Hosey, 2009). The term animal welfare has different definitions, but we can generalize it by indicating that it is the science that studies the quality of life of animals, being its two main objectives to achieve and evaluate: 1) the maintenance of good physical health conditions, and 2) good mental and emotional health (Newberry, 1995; Young, 2003; Swaisgood, 2007; Watanabe, 2007; Whitham and Wielebnowski, 2013). Although the practice of evaluating animal welfare, and the incorporation of techniques for its improvement, is currently very important in zoos and aquariums (Young, 2003; Hosey, 2009; Sheperdson, 2013; Whitham, 2013) it has its origins in the livestock farming industry. The concept of the Five Freedoms (ie. absence of discomfort) emerged based on a report presented by the Brambell Committee (Brambell, 1965; Farm Animal Welfare Council, 1992), and now are used as the base for legislation and regulations that govern not only arm operations and labs, but also zoological institutions (Young, 2003; Aparicio, Vargas, Prieto, 2005; Hosey, 2009; Córdova Izquierdo et al., 2009; Barber, Lewis, Agoramoorthy and Stevenson, 2010; Kagan and Veasey, 2010).

Because animal welfare is based on good physical and mental health, various methods have been used to evaluate it. However, they can be grouped into two main types: indicators based on the environment and indicators based on the individual; the latter type of indicators provides more direct information on the animal's well-being. (Dawkins, 2006; Manteca, Amat, Salas and Temple, 2016; Benn, McLelland and Whittaker, 2019). This information can be obtained by using physiological parameters (hormone measurements and other substances present in the blood) or behavioral measures (use of time, changes in frequency of behaviors, abnormal behaviors, excessive aggression, and apathy, among others (Broom, 1991; Swaisgood, 2007; Hosey, 2009; Hill and Broom, 2009; Kagan and Veasey, 2010; Manteca et al., 2016).

Measuring animal welfare is a complex task, an analysis of the average time that the animal spends performing different behaviors (activity budget) can be quantitatively measured and compared to wild populations or with other populations in captivity. These comparisons can be used to evaluate welfare and also the effect of enrichment (Young, 2003; Hosey, 2009; Munita, Kagan and Veasey, 2010; Sheperdson, 2013; Tadich and Briceño, 2016; Beaudin Judd, Weladji, Louis Lazure and Paré, 2019; Kamaluddina, Matsudab, Munir Md-Zaina, 2020). Another important measure used is to evaluate the presence and frequency of repetitive abnormal behaviors or stereotypes (rate of abnormal repetitive behaviors -ARB), once present, they are very difficult to eliminate (Mason, Clubb, Latham and Vickery, 2007). Well-being measures also include exploration, play, species-specific behaviors, and behavioral diversity (Hosey, 2009; Shepherdson, 2010, 2013).

Most of the publications on environmental well-being and enrichment are focused on mammals and birds (Shepherson, 1994, 1998; Young, 2003; Hosey, 2009); however, in recent years the number of studies centering on reptiles and amphibians has increased (Warwick, 1990; Hayes, Jennings and Mellen, 1998; Fleming, 2007; Burghardt, 2013; Warwick, Arena, Lindley, Jessop and Steedman, 2013; Eagan, 2018; Benn et al, 2019). Improvements have been recorded in their well-being, play, and even learning (Burghardt, 2013). Enrichment activities have improved welfare of turtles (Burghardt, Ward and Rosscoe, 1996; Therrien, Gaster, Cunningham-Smith and Manire, 2007; Mehrkam and Dorey, 2014) but other taxa have not been well studied (Swaisgood and Shepherdson, 2005; Burghardt, 2013). However, other authors have found no evidence that enrichment affects the behavior of reptiles (Rosier and Langkilde, 2011). These authors warn that more research is required on the effectiveness of the parameters used to evaluate the effects of enrichment, especially when it comes to animals less phylogenetically related to humans.

Commonly known as *Iguana overa*, *Salvator merianae* is one of the largest terrestrial lizards in the American continent, measuring up to 145 cm in length from nose to tail, and weighing up to 8 kg in males, those being larger than females (FWC bioprofile for the Argentine black and white tegu (*Tupinambis merianae*) (Winck and Cechin 2008; Harvey, Ugueto and Gutberlet, 2012; McEachern, Yackel Adams, Klug, Fitzgerald and Reed 2015). Its native distribution covers the subtropical and humid zones of southeastern South America (Jarnevich et al., 2018). It presents a well-marked annual activity pattern alternating a period of activity, which spans from August to April and includes a peak of maximum activity between November and December, with a long period of hibernation in underground burrows (Hall, 1978; Winck and Cechin, 2008; Montaño et al., 2013; McEachern et al., 2015). Its reproductive period extends from September to the end of February and the females exhibit complex parental behaviors (Noriega, Fogliatto, Mignola and Manes, 1996; Manes, Ibañez and Manlla, 2003). Nesting occurs during October and the young are born between January and February.

S. merianae has always been hunted by native populations of Argentina for both subsistence and commercial reasons. Its leather is highly valued and is exported as a raw material for the manufacture of footwear and fine leather goods (Porini, 2006); its meat is also used for consumption (Caldironi and Manes, 2006). In 1988 in Argentina, the "*Tupinambis* Commission" was created to develop a sustainable management plan and later, during the 90s, commercial and experimental hatcheries were created in various parts of the country, to develop and then share techniques for their breeding in captivity as a sustainable alternative to the exploitation of wild populations.

The objective of this study is to evaluate the welfare of *S. merianae* specimens in a hatchery system and determine the influence of environmental enrichment on the variability and types of behaviors in individuals. To do this, we used four behavioral indicators to assess well-being: exploration, species-specific behaviors (thermoregulation, hunting), behavioral diversity, and ARB. A better welfare was assumed if exploration was increased, time spent on species-specific behaviors increased, behavioral diversity increased, or ARB frequency decreased, in the presence of enrichment.

MATERIALS AND METHODS

Subjects of study.— Data were collected from 13 individuals of *S. merianae* belonging to the Lizard Experimental Hatchery in the Developmental Biology Department of the Facultad de Agronomia y Zootecnia from the Universidad Nacional de Tucumán during the 2017, from September to November, this being the most active period.

Workplace.— The hatchery encompasses 800 m^2 made up of 10 pens to separate the different categories of animals by age, 12 nesting enclosures, a *lazaretto*, a food preparation room, a classroom-laboratory, a meeting room, and an incubation room equipped with 3 incubators.

The enclosures are open air, with a dirt floor covered in grass, an underground shelter, two feeders, and one or more water bowls depending on the size of the pen. Animals are fed, *ad libitum* with a diet especially designed for production purposes by Vega, Parry and Manes (2000).

Methodology.— The data were collected from 2 pens, each one housing a reproductive group made up of randomly selected individuals, all weighing over 2 kg.

The studied groups were: a control group R1 (Enclosure 1) comprised of two males and four females and an experimental group R2 (Enclosure 2) formed by two males and five females. In R2, data were taken without enrichment (R2 W/O-E) and later with enrichment (R2 WE), with a 20-minute difference between both measurements.

The enrichment activities were carried out twice a week in September and October, and 3 times a week in November. Applied enrichment consisted of the following: 1) Alimentary: change of the diet incorporating fruit and live prey, change of food presentation; 2) Structural: adding climbing logs, a pool with water and a sandbox; 3) Olfactory: perfumes and grasses with odors and 4) Interactive: balls, dog toys and an elastic band with a piece of food to pursue. Often two or more activities were implemented together on the same day (Figure 1).

Four 20-minute sessions were carried out and recorded per sampling day, with a 10-minute pause between each one and alternating between the two enclosures using a Canon HD Vixia HF R72 57 X camera. Observations were carried out from 9:30 a.m. to 4 p.m. By reviewing the footage using the focal animal technique with instantaneous recording, the behaviors of each individual were recorded on spreadsheets, at 30-second intervals. The 21 defined and identified behaviors were grouped into seven different categories: Physiological needs, Thermoregulation, Aggressive interaction, Exploratory activity, Out of sight, Shelter, Other (Table 1). To determine the presence of hierarchy, sociometric matrices were constructed based on the chase and flight events -defined in the Aggressive Interaction category.

Fig. 1. Examples of different environmental enrichment activities carried out in the R2.

Fig. 1. Ejemplos de diferentes actividades de enriquecimiento ambiental realizadas en el R2.

Data analysis.— To analyze the data, the Mann-Whitney and Wilcoxon tests were applied using the software PAST (PAleontological STatistics) version 3.25.

In the case of the dominance matrices, the dominance coefficient and the Landau index were also calculated.

RESULTS

This study involved 200 hours of observation and a total of 42.87 hours of footage over 28 days. At the end of the video analysis process, the total number of spreadsheets set up was 745, totaling 186.25 tabulated hours with an average of 14.25 hours dedicated to each individual. As a result of these observations and together with contributions taken from the bibliography (Lopez and Abe, 1999), an ethogram was created for the studied species (Table 1).

Table 1. Behaviors and behavioral categories.
Tabla 1. Comportamientos y categorias de comportamiento.

Category	Behavior	Definition
Physiological needs	feed	Consume food
	drink	Consume water from recipient
	defecate	Fecal excretion
Thermoregulation	in the sun	Staying motionless in the sun
	in shadows	Staying motionless in the shadow
Aggressive interaction	bite	An individual holds another tightly with its mouth
	agonistic behavior	An individual turns from side to side arching its body and sometimes opening its mouth
	escape	An animal runs away from another when it is chased
	chase	An animal head straight for another quickly
Male reproductive behavior	biting tale	An animal holds another by the tail
	biting nape	An animal holds another by the back of the head
	mark	The animal walks dragging its hind legs (where the femoral glands are) from side to side against the ground
	scrub	An animal rubs its body with another individual sometimes using one of its legs
	parallel position	One animal is placed side by side in parallel and touching the sides
	mount attempt	An animal tries to get on top of another individual
	copulation	The male tucks his tail under that of the female while he holds her with one of the front legs and copulation occurs
	hook movement	Alternate upward movement of hind legs
	snort	Emission of vocalization externally evidenced by contractions in the neck area
Exploratory activity	explore	The animal moves around the enclosure by moving its head and constantly sticking and sticking its tongue out
	jump	An animal rises from the ground pushed with its legs to try to reach something or climb somewhere
	climb	An animal is attached to some structure and uses its legs to climb on it
	sniff	Quickly inserting and sticking the tongue out in the vicinity of an animal or object
Out of sight	out of sight	The animal is not visible anywhere in the film frame and it is not recorded that it is in the shelter
Shelter	shelter	The animal is inside the shelter
Other	other	Performing behaviors that are not previously defined in the ethogram

Behavior frequency.— From the datasheets, the frequencies of behaviors recorded for each of the different behavioral categories were obtained, discriminating by enclosures and enrichment activity (Figure 2). Differences between sexes were not significant.

The behavioral category "Shelter" was the most frequent in the 2 enclosures (R1 and R2), with or without enrichment. This behavior is more frequent in females in both enclosure and decreases when enrichment is applied (R2) only in males (43% to 29%). On the contrary, "Thermoregulation" activities are more frequent in males than in females, and they decrease with enrichment only in females (25% to 17%). In the "Other" category, the appearance of new behaviors was recorded, and the increase was present in both females and males when environmental enrichment was incorporated (1% to 5%). "Physiological Needs" occupied a small proportion of the total time, increasing with enrichment and without important differences between males and females. "Agonist Interactions" and "Exploratory Activity" were carried out in higher proportions by males in both R1 and R2, increasing with enrichment.

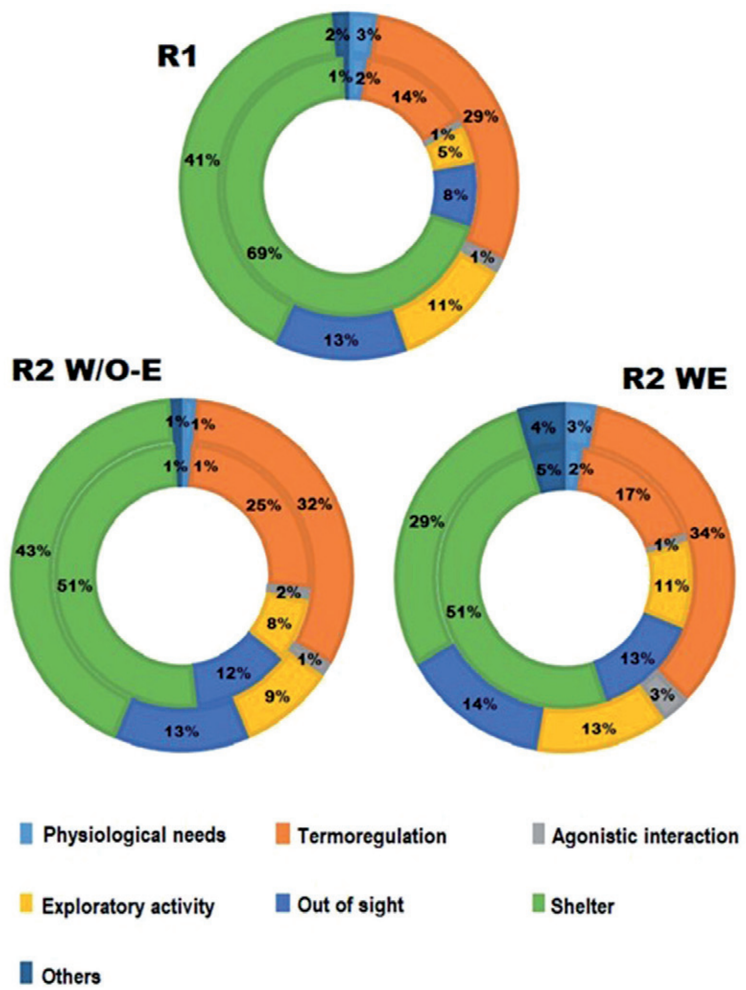

Fig. 2. Comparison of cumulative proportions of behavioral categories in R1 and R2, with and without enrichment (inner circle: females, outer circle: males).

Fig. 2. Comparación de proporciones acumuladas de categorías de comportamiento en R1 y R2, con y sin enriquecimiento (círculo interior: mujeres, círculo exterior: hombres).

Finally, the “Out of Sight” category did not present differences between males and females and only increased slightly with the incorporation of enrichment (Figure 2).

The Mann-Whitmann test comparing the data from R1 and R2 only gave a significant difference for the “Physiological Needs” (U = 485, p = 0.009) and “Shelter” (U = 460, p = 0.001) categories, regardless of sex. To analyze the effect of enrichment, R2W/O-E and R2WE were compared using the Wilcoxon test. A significant difference was found in the categories of “Thermoregulation” (W = 97 p = 0.003), “Shelter” (W = 87.5 p = 0.025) and “Other” (W = 75 p = 0.038).

The frequency of reproductive behaviors was higher in enclosure 1, peaking in October. In the case of R2, much lower values were observed throughout the sampled period, although it followed the same pattern: hitting a minimum in September, reaching its peak also in October and decreasing again in November (Figure 3).

Sociometric matrices and dominance coefficient (CD) by enclosure.— Once the sociometric matrices were constructed (Figure 4), the dominance coefficient was calculated using the formula CD = Gained / (Gained + Lost) * 100 (Lehner, 1998).

The results of the calculations results were:

• R1: F1, F2, F3 = 0; MWP = 25%: F5 = 84.3% and MWM = 90%
• R2W/O-E: F4 and F5 = 0; F2 = 10%; F1 = 33.3%; F3 = 97.3%; MYP = 56.5% and MWM = 57.8%
• R2WE: F1, F2, F5 = 0: F4 = 20%; F3 = 90.9%; MYP = 23.8% and MWM = 100%

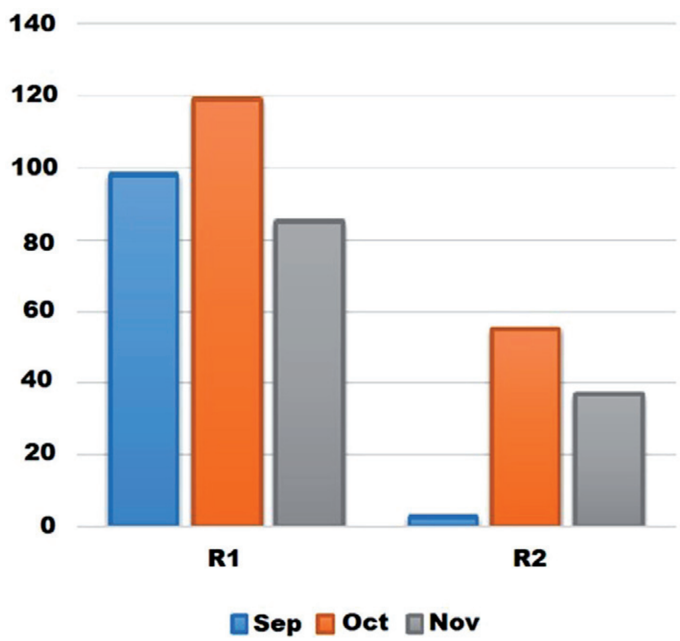

Fig. 3. Comparison in the frequency of Reproductive Behavior in Males between R1 and R2 during the 3 months of the experiment.

Fig. 3. Comparación en la frecuencia del Comportamiento Reproductivo en Machos entre R1 y R2 durante los 3 meses del experimento.

R1

	MWM	F4	MWP	F1	F2	F3	W	L
MWM		5	22	5	5	0	37	4
F4	0		1	3	23	0	27	5
MWP	4			1	3		8	23
F1					0	0	0	9
F2						0	0	31
F3							0	0

R2 WE

	MWM	F3	MYP	F4	F5	F2	F1	W	L
MWM			16	1				17	0
F3				3		7		10	1
MYP					5			5	16
F4		1						1	4
F5								0	5
F2								0	7
F1								0	0

R2 W/O-E

	F3	MWM	MYP	F1	F2	F5	F4	W	L
F3		4	0	4	3	6	19	36	1
MWM	1		10	5	5	0	1	22	16
MYP	0	8		1	1	0	3	13	10
F1	0	3				2		5	10
F2		1						1	9
F5								0	8
F4								0	23

Fig. 4. Tables of sociometric matrices for each enclosure R1 and R2, with (R2 WE) and without enrichment (R2 W/O-E). MWM: male without mark, MWP: male white point, MYP; male yellow point, F: female.

Fig. 4. Cuadros de matrices sociométricas para cada recinto R1 y R2, con (R2 WE) y sin enriquecimiento (R2 W/O-E). MWM: macho sin marca, MWP: macho punto blanco, MYP; punto amarillo macho, F: hembra.

Landau index by enclosure.— By calculating Landau's index, the following values were obtained for each enclosure: R1 = 0.16; R2W/O-E = 0.54 and R2WE = 0.39. None of the enclosures showed a linear hierarchy since all the values were substantially less than one (linear hierarchy).

It is observed that there is a clear dominance of one male over another. MWM dominates MWP in R1, and MWM dominates MYP in R2, with and without enrichment. Furthermore, in this enclosure, the number of interactions between males was similar with and without enrichment (Figure 4). In the case of females, it is similar; one female has a higher dominance coefficient than the others, F5 in R1, and F3 in R2W/O-E and R2WE. The interaction graphs (Figure 5) reflect the recorded chases, in R2 it is observed that in the absence of enrichment there is a complex network of interactions and with the introduction of enrichment, there was a marked decrease in interactions among individuals

DISCUSSION

Reptiles are frequently seen as simple animals from a behavioral point of view; many of the parameters used to measure well-being, such as signs of pain or suffering, are

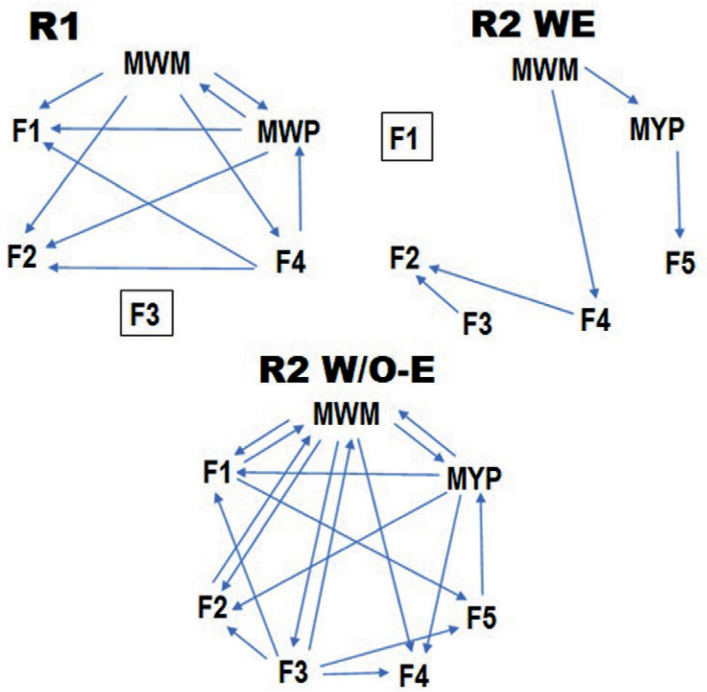

Fig. 5. Representation of the interactions between individuals in each enclosure, R1 and R2, with (R2 WE) and without enrichment (R2 W/O-E) based on the recorded chase and flight events.MWM: male without mark, MWP: male white point, MYP; male yellow point, F: female.

Fig. 5. Representación de las interacciones entre individuos en cada recinto, R1 y R2, con (R2 WE) y sin enriquecimiento (R2 W/O-E) en base a los eventos de persecución y huida registrados. MWM: macho sin marca, MWP: macho punto blanco, MYP; punto amarillo macho, F: hembra.

still difficult to recognize and evaluate in this group (Warwick et al., 2013; Benn et al., 2019). However, reptiles can display abnormal behaviors indicating stress (Warwick, 1990; Warwick et al., 2013). Studies on the application of environmental enrichment and its results in reptiles are less abundant than in mammals and are also quite taxonomically dispersed (Burghardt et al, 1996; Rosier and Langkilde, 2011; Burghardt, 2013; Eagan, 2018; Benn et al., 2019).

During this experiment, much emphasis was placed on structural enrichment, adding several logs, a pool and a sandbox inside the pen; however, the animals seemed to prefer to use the roof of the shelter for basking. The increased interest that the logs aroused was to sniff and scratch the loose bark pieces during the first days, while they only showed interest in the pool on very hot days. On the other hand, the sandbox was useful as a place to hide food, which they actively looked for by digging it out (Figure 1).

A behavioral measure of well-being that increased with enrichment was behavioral diversity represented in the "Other" category of the ethogram (Figure 2). This category includes behaviors such as digging, which was not registered in the initial ethogram (Table 1), but that is part of their behavior under natural conditions (Montaño et al., 2013).

In both enclosures with and without enrichment, the most frequent behaviors were "Shelter" and "Thermoregulation" (Figure 2). The latter is a very important behavior in reptiles and the time they spend thermoregulating is strongly related to active behaviors: foraging, reproduction and feeding (Rocha, Vrcibradic, Kiefer, de Menezes and da Costa Siqueira, 2009). Enrichment produces changes in the thermal behavior of some reptiles (Bashaw, Gibson, Schowe and Kucher, 2016). In this case, a decrease in this activity is observed during enrichment, both when compared with R1, and R2WE. This could indicate that they do not need to spend much time thermoregulating; thus, they can spend more time on another activity. Thermoregulatory studies in reptiles seem to indicate that active lizards carefully thermoregulate when they emerge and are therefore active at body temperatures that lead to maximal locomotor performance. However, they rarely display peak levels of activity, suggesting that they are in a state of "always ready" to act and respond quickly in situations of predator escape, dominance fights, or close-range pursuit (Hertz, Huey and Garland, 1988; Rocha et al, 2009). This implies that they have more energy available than they choose to use, so the decreased time spent in thermoregulation in response to enrichment, would not affect their thermal balance. Appropriate thermoregulation is another indicator of well-being in ectothermic animals (Benn et al, 2019).

In neither of the two enclosures (R1, R2) did the specimens show any abnormal behaviors such as stereotyped movements, tail autotomy, anorexia, or a state of continuous aggression, recognized as behaviors indicating poor well-being (Broom, 1991; Hayes et al., 1998; Warwick et al., 2013; Shepherdson, 2013; Benn et al., 2019), all of which indicate that in general the captivity conditions in the hatchery are good.

Based on the application of enrichment in mammals, an increase in exploratory activity and a decrease in resting time or sedentary lifestyle would be expected (Refuge in this study). In *Salvator*, only a decrease in the time spent in the refuge was observed (Figure 2), unlike what occurs in *Eublepharis macularius*, in which enrichment did not affect this behavior (Bashaw et al., 2016). "Exploratory activity" did not change significantly with enrichment, which could be explained by two possibilities: 1) the quality of the sites in terms of exploration opportunities is very similar; they are large open-air sites with water and shelter available; and, 2) that the changes in exploratory behavior in the enrichment enclosure have been masked in the "Other" category (Figure 2) where behaviors such as digging to find food and scratching logs that imply some types of exploratory behavior were recorded (sniff, sniffing while moving).

The reproductive period of *Salvator* lizards extends from September to the end of February but territoriality and aggression begin first in males (September). In females, aggressiveness appears at the end of October coinciding with the start of egg-laying (Fitzgerald, Chani and Donadio, 1991; Chani, 1995); females also exhibit complex parental behaviors (Noriega et al., 1996; Manes, Ibañez and Manlla, 2003). In the two pens analyzed in this study, a marked decrease in reproductive behavior was observed in enclosure R2 with respect to the control group (Figure 3). There is a possibility that the enrichment activities applied would have distracted the animals, thus reducing the overall proportion of time spent on reproductive behaviors. These circumstances likely affected in some way the interactions between individuals. Figure 3 shows that, despite the smaller number of reproductive behaviors in R2, they followed the same pattern as in R1, peaking in October, which coincides with this species' natural behavior (Fitzgerald et al., 1991).

Landau's index analysis showed that none of the studied groups had a linear hierarchy, although there is evidence of a dominance coefficient. In *Salvator* dominance is size-dependent, with larger individuals behaving more aggressively and displacing smaller ones (Fitzgerald et al., 1991; Chani, 1995; Herrel et al., 2009). Aggression has also been observed to decrease when they are housed in large and familiar spaces (Herrel et al. 2009). The marked decrease in persecutions by introducing enrichment in our enclosures (Figure 5), is of particular interest within an animal farming context. It would contribute to facilitating the coexistence of individuals living in the same enclosure, potentially reducing stress on animals and the need to treat injuries resulting from these aggressive interactions.

There is some controversy as to whether the parameters currently used to evaluate the success of environmental enrichment tasks are suitable for their use in reptiles, amphibians and other organisms phylogenetically further removed from mammals (Rosier and Langkilde, 2011), considering that such parameters were not designed for these animal groups. As environmental enrichment is one of the best tools available to try to improve the level of welfare of animals in captivity, it is very important to rely on empirical evidence that demonstrates the effectiveness of the different techniques for different situations and animal groups.

Also considering the low volume of behavioral data of *S. merianae*, future experiments could be carried out to monitor the behavioral patterns of individuals throughout the entirety of their activity period, to have a better perspective of the full range of behaviors of which this species is capable, information that would also help in designing more appropriate enrichment techniques that produce more apparent results.

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CONFLICT OF INTEREST

There is no conflict of interest

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