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PROTECTED NATURAL AREAS AND THE CONSERVATION OF AMPHIBIANS IN A HIGHLY TRANSFORMED MOUNTAINOUS REGION IN MEXICO

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***Abstract*.—Protected natural areas (PNAs) help protect biological diversity in the face of different threats. The efficacy of each PNA at protecting and maintaining varies as a function of the current characteristics of each reserve, the environment in which it is located, and the taxonomic group to be protected. In this study we evaluated the role of three PNAs (two state-run, and one private) in the conservation of the amphibians in the mountains of central Veracruz, Mexico, a region of high species diversity and turnover. During field work carried out from July to December 2012, we recorded 1262 amphibians belonging to 15 species (10 salamanders and five frogs), with 53% in a high risk conservation category. We found significant differences among the three PNAs in species richness, abundance, assemblage structure, and species composition. This is the first report of the presence of the endangered salamanders *Pseudoeurycea gigantea*, *Thorius munificus*, and *Chiropterotriton lavae* in a PNA. Each of the three reserves differs in its contribution to amphibian conservation in central Veracruz and, collectively, the three reserves function in a complementary manner to conserve the regional amphibian fauna, including endangered species, some of which are in imminent danger of extinction.**

Key Words.—complementarity; endangered species; frogs; salamanders; species diversity; Veracruz

INTRODUCTION

The protection of natural areas is one of the most widespread strategies to protect biodiversity, threatened by human activities (Margules and Pressey 2000). The term Protected Natural Area (PNA) was defined at the IVth World Congress on National Parks and Protected Areas (Caracas, Venezuela, 1992) as "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (cited in Rodrigues et al. 2003). The efficacy of each PNA at protecting and maintaining biodiversity may vary as a function of the local characteristics of the reserve including reserve size, shape, and management strategy, land use history, and the environment in which it is located.

In Mexico, PNAs are currently managed by different levels of government. These include federal PNAs including Ramsar sites (wetlands of international importance), state and municipal PNAs, and more recently PNAs run as community or private initiatives (Ochoa-Ochoa et al. 2009). Evaluating the role and conservation success of PNAs has focused mainly on the federal reserve system (Figueroa and Sánchez-Cordero 2008; Urbina-Cardona and Flores-Villela 2010), with little evaluation of regional or local, and state, municipal, community, and private natural areas. Together, these areas represent approximately 80% of the PNAs in Mexico (Bezaury-Creel et al. 2007; CONANP, Comisión Nacional de Áreas Naturales Protegidas. 2014. Áreas Protegidas Decretadas. Available from http://www.conanp.gob.mx [Accessed 1 October 2014]). The role of non-federally protected areas could be of great importance for the conservation of biodiversity, especially in regions where the degree of species turnover (beta diversity) is high and the federal protected areas are insufficient to protect all of the species (Halffter 2007). Thus, it is necessary to assess the role of these PNAs to protect the biodiversity, especially in regions where the original habitat has been or is being transformed dramatically.

The mountainous region in central Veracruz, Mexico is known for its high degree of biodiversity, specifically that of amphibians. Central Veracruz is home to 72 amphibian species, representing 19% of the approximately 380 species recorded for all of Mexico. Of the 72 amphibian species of the region (see Wake et al. 1992; Parra-Olea et al. 2001; Pineda and Halffter 2004; Meza-Parral and Pineda 2015), 27 are endemic to Mexico and limited to this region (Frost D.R. 2014. Amphibian Species of the World: an Online Reference. Version 6.0. Available from http://research.amnh.org/ herpetology/amphibia/ index.html. [Accessed 1 October

2014]). Although the region is characterized by its high amphibian beta diversity (Pineda and Halffter 2004; Meza-Parral and Pineda 2015), 39 species (54% of the regional pool) are assigned to an IUCN high endangerment risk category (IUCN. 2014. The IUCN Red List of Threatened Species. Version 2014-2. Available from http://www.iucnredlist.org [Accessed 15 October 2014]), and 34 species (47 % of the regional pool) are at risk of extinction according to the Mexican government (SEMARNAT 2010). Because of the dire conservation status of so many species, the region is of high amphibian conservation priority (Ricketts et al. 2005; Alliance for Zero Extinction. 2010. Available from http://www.zeroextinction.org [Accessed 20 February 2012]; EDGE, Evolutionarily Distinct & Globally Endangered. 2014. Focal Species. Available from http://www.edgeofexistence.org/amphibians/top_100.php [Accessed 10 July 2014]). Conservation of amphibians in this region is complicated because much of the original forests of this region have been converted to agriculture land and urban areas (Arriaga et al. 2000), federally run PNAs are scarce, and those that do exist are generally located above 3,000 m a.s.l. (CONANP, Comisión Nacional de Áreas Naturales Protegidas. 2014. *op*. *cit*.) where there are few amphibian species. In this study, we examined the role of three protected natural areas (two state-run and one private) in the conservation of amphibians in the mountainous central region of the state of Veracruz, Mexico, a region with high species diversity and turnover and a high degree of forest transformation. Specifically, we evaluated species richness, abundance, assemblage structure, species composition, and the conservation status of the species that inhabit these reserves.

MATERIALS AND METHODS

Study site.—The study region is located in central-eastern Veracruz, Mexico, within an elevation band from roughly 1,950 to 3,300 m a.s.l. (Fig. 1). Pine and mixed pine-oak were the original forest covers of the region. After decades of deforestation, the region is now dominated by a matrix of cattle pastures, agricultural crops (e.g., potato, corn, tree plantations), open pit mines, and human settlements (Castillo-Campos et al. 2011). Two of the study PNAs (San Juan del Monte Reserve and the Pancho Poza Ecological Reserve) are regulated by the state of Veracruz, and the third (Ocelotl Ecological Park) is regulated by a private owner. The distances separating the three PNAs are relatively small, ranging from approximately 12 to 23 km straight-line distance (Fig. 1), and all three PNAs encompass 1,135 ha.

San Juan del Monte Reserve (SJM).—This reserve is located in the municipality of Las Vigas de Ramírez, Veracruz (19°39'00" and 19°35'00"N, and 97°05'00" and 97°07'30"W) and was established by decree in 1980 as a Green Area Reserved for Ecological Education (Área Verde Reservada para la Educación Ecológica). The SJM PNA covers an area of 609 ha at an elevational gradient of 2,327–2,600 m a.s.l. The climate is cool, with a mean annual temperature (± SD) of 11.7 ± 1.4° C; the mean annual precipitation is 1,170 mm (calculations made with data from 1981 to 2010; CONAGUA, Comisión Nacional del Agua-Servicio Meteorológico Nacional. 2012. Normales Climatológicas por Estación, Estadística Descriptiva. Available from http://smn.cna.gob.mx [Accessed 10 December 2014]). Approximately 90% of the reserve is covered with mixed pine-oak forests of different ages, and 10% of the area is covered with small pastures. Agricultural land, pastures, and residential areas surround the protected area of the PNA. Furthermore, a highway runs through part of it. The SJM is used primarily for ecological education, and access to the reserve is limited to students from educational institutions. The only study previously conducted in SJM was a preliminary inventory compiled by Bello-Sánchez (2008), who also analyzed some of the ecological attributes of the herpetofauna of the reserve.

Pancho Poza Ecological Reserve (PPR).—This reserve is located in the municipality of Altotonga, Veracruz (19°43'33" and 19°46'66"N, 97°14'57" and 97°15'71"W) and was established by decree in 1992 as the Ecological Reserve of the Pancho Poza River. The PPR covers an area of 57 ha at an elevational gradient of 1,984–2,095 m a.s.l. The climate is temperate semi-dry and temperate subhumid with year-round rains. Mean annual temperature (± SD) is 14.3 ± 1.1° C, and mean annual precipitation is 1,495 mm (calculations made with data from 1981 to 2010; CONAGUA, Comisión Nacional del Agua-Servicio Meteorológico Nacional. 2012. *op*. c*it*.). Approximately 60% of the reserve is covered by pine-oak forest with differing degrees of disturbance. The remaining 40% of the reserve is covered with pastures, orchards, and residential areas (SEDEMA 2001). Tours of the reserve are given by local people and because of its proximity to an urban area and used by many people as a right-of-way, the land is crossed by footpaths. Agricultural fields, highways, and an urban zone surround this protected area. Previous studies conducted in this PNA include an inventory of the herpetofauna by Lambert-Izquierdo (2000) and a management plan with lists of potential species by SEDEMA (2001).

Ocelotl Ecological Park (OEP).—This park is located in the municipality of Perote, Veracruz (19°32'09.6" and 19°31'11.9" N, 97°10'33.6" and 97°11'16.8" W). The

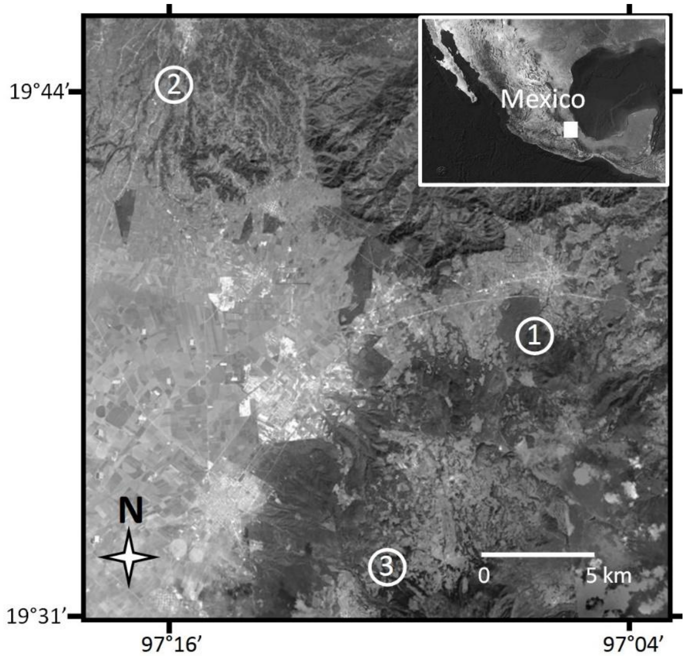

FIGURE 1. Location of the three protected natural areas (white circles) in the mountainous region of central Veracruz, Mexico. Numbers denote study sites: 1 = San Juan del Monte Reserve; 2 = Pancho Poza Ecological Reserve; and 3 = Ocelotl Ecological Park. (Map by Eduardo Pineda).

OEP covers 469 ha with and elevational gradient of 3,005–3,338 m a.s.l. and lies within the Cofre de Perote National Park. The climate is cool with a mean annual temperature (± SD) of 9.5 ± 1.2° C, and mean annual precipitation of 620 mm (calculations made with data from 1981 to 2010; CONAGUA, Comisión Nacional del Agua-Servicio Meteorológico Nacional. 2012. *op*. *cit*.). Approximately 40% of the reserve is covered with pine and fir forest, and 60% of the reserve is a matrix of transformed areas including potato and corn crops and pastures. Agricultural fields and roads surround the OEP, which is a tourist attraction offering various recreational activities. The only study conducted in this PNA was on the distribution and population parameters of the salamander *Pseudoeurycea melanomolga* (Yacotú-Barojas 2012).

Recording amphibians in the field.—We conducted field work between July and December 2012, throughout the entire warm-wet season and into the beginning of the cold-wet season. We sampled each PNA three consecutive days per month for a total of 18 sampling days per site. We conducted two time-constrained surveys (3 h each survey) each sampling day, with one survey conducted during the day and one at night. We focused our surveys on microenvironments we assumed to be used by amphibians, and we used both visual and auditory detection methods (Rödel and Ernst 2004). Sampling effort was 54 person-hours per visit (three people × three hours × six surveys), 324 person-hours per reserve, and 972 person-hours over the course of the entire study. During each survey we identified each animal to species and recorded the total number of amphibians observed for a relative estimate of abundance. The first individual we captured for each species was collected as a voucher specimen, preserved in 70% alcohol, and deposited in the Amphibian and Reptile collection of the Instituto de Ecología A.C. (CARIE). We released all other amphibians at the point of capture after being identified. We identified salamanders belonging to the genus *Chiropterotriton* based on their geographic distribution and morphology following the species designations proposed by Darda (1994).

Data analysis.—We calculated species richness and total number of species detected for each PNA and for the three PNAs combined. To determine the completeness of the inventory for each PNA and the three PNAs combined, we calculated species accumulation curves using three nonparametric estimators: Mao Tau (and its 95% confidence interval), Chao 1, and Bootstrap, using EstimateS version 9.1.0. (Colwell, R.K. 2013. EstimateS: statistical estimation of species richness and shared species from samples. Available from viceroy.eeb.uconn.edu/estimates [Accessed 15 August 2014]). We tallied the number of individuals recorded for a species at each reserve to determine the abundance of each species. Furthermore, we tallied the number of individuals of a species at all three reserves to determine the overall abundance of the species. To evaluate species assemblage structure of each PNA, we used rank-abundance or Whittaker curves (Magurran 2004) and Solow's (1993) test with 10,000 randomizations to determine if these differed. In this test, Shannon's Index was used because our objective was to compare assemblage evenness (Magurran 2004). The analyses were run in the software Species Diversity and Richness III version 3.0.2. (Pisces Conservation Inc. Lymington, Hampshire, UK). To evaluate dissimilarity in species composition among the PNAs, we analyzed the data using the method proposed by Carvalho et al. (2012), in which diversity total beta (β_{cc}) is divided into two components corresponding to two different biological phenomena: species replacement (β_{-3}), i.e., the replacement of species at one site by different species at another site, and the difference in species richness between pairs of sites (β_{rich}), i.e., the loss or gain of species between the two sites. Using this approach it is possible to distinguish among the causes of beta diversity and estimate its relative contribution to any differences detected in species composition among the PNAs.

We calculated total beta diversity using the following equation, divided into two terms:

$$\beta_{CC} = \frac{b + c}{a + b + c}$$

with species replacement as

$$\beta_{-3} = 2 \times \frac{\min(b, c)}{a + b + c}$$

and we calculated the difference in species richness between pairs of sites as

$$\beta_{rich} = \frac{|b - c|}{a + b + c}$$

where *a* is the number of species common to both sites, *b* is the number of species exclusive to the first site, *c* is the number of species exclusive to the second site, and min (*b*, *c*) is the minimum number of exclusive species. The values obtained from these analyses range from zero (when all species occur at both sites), to 1 (when no species is shared between sites). For the conservation status of each species and its risk category, we used the IUCN Red List of Threatened Species (IUCN, International Union for Conservation of Nature. 2014. Red List of Threatened Species. Available from http://www.iucn.org [Accessed 1 October 2014]) along with the legislated Mexican Official Standard NOM-059-SEMARNAT-2010 (SEMARNAT 2010).

RESULTS

Species richness of each reserve and cumulative species richness.—Within all three PNAs, we detected 15 species (10 salamanders and five frogs), belonging to five families and seven genera. The salamander family Plethodontidae had the most species with nine, followed by two frog families (Craugastoridae and Ranidae), each with two species, and the families Ambystomatidae and Hylidae, each with one species (Table 1). Of the three PNAs, species richness was highest in PPR, with nine species (four salamanders and five frogs), followed by SJM with seven species (all salamanders) and OEP, with four species (all salamanders; Table 1). No one species was detected in all three of the PNAs and nine species were recorded in only one PNA. The estimators indicate that inventory completeness was 79% to 100%. In PPR it was 98 to 100%, in SJM 79 to 90%, in OEP it was 100%, and for all three it was > 97% (Fig. 2; Table 2).

Abundance and assemblage structure.—We observed 1,262 individual amphibians within all three PNAs: 44% in SJM, 37% in OEP, and 19% in PPR. The most abundant species was the salamander *Pseudoeurycea leprosa*, with 828 individuals, representing 66% of the total abundance of the three PNAs. In contrast, the salamander *Thorius munificus* was the only species for which a single individual was recorded. For the remaining species, abundance was three to 86 animals (Table 1).

The species assemblage structure of the three reserves differed significantly: for SJM vs. PPR $\delta = 0.86$ ($P < 0.001$), for SJM vs. OEP $\delta = 0.36$ ($P < 0.001$), and for PPR vs. OEP $\delta = 1.23$, $P < 0.001$). The PPR species assemblage was the assemblage with higher evenness, with the smaller difference between the most abundant species (*Craugastor mexicanus*, 86 individuals) and least abundant species (*Chiropterotriton lavae*, two individuals), and with relative abundance more similar among the other species (Fig. 3). In SJM and OEP, one species (*Pseudoeurycea leprosa*) was markedly dominant and had similar abundance at each site (421 and 407 individuals, respectively). However, for SJM, two species had only one individual, though this did not occur in OEP, in addition to which the values for moderately abundant species were more similar (Fig. 3). The hierarchical position of some species changed notably among PNAs. Examples of this include the salamander *P. melanomolga*, which was rare in SJM, but was the second most abundant in OEP, and the salamander *C. lavae*, which was rare in PPR but moderately abundant in SJM. Results from the assemblage structure considering all three studied PNAs

TABLE 1. Abundance and conservation status of amphibian species from three protected natural areas in a mountainous region of Veracruz, Mexico. Sites are SJM = San Juan del Monte Reserve, PPR = Pancho Poza Ecological Reserve; and OEP = Ocelotl Ecological Park. Risk categories according to the Mexican Ministry of the Environment (NOM-059): A = Endangered, Pr = Subject to Special Protection, P = In Danger of Extinction; and the International Union for Conservation of Nature (IUCN) LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, and CR = Critically Endangered.

		Protected Natural Area				Conservation Status	
Code	Species	SJM	PPR	OEP	Total	NOM-059	IUCN
	Ambystomatidae						
A	*Ambystoma velasci*	5			5	Pr	LC
	Craugastoridae						
B	*Craugastor decoratus*		3		3	Pr	VU
C	*Craugastor mexicanus*		86		86		LC
	Hylidae						
D	*Ecnomiohyla miotympanum*		18		18		NT
	Plethodontidae						
E	*Chiropterotriton lavae*	28	2		30	Pr	CR
F	*Chiropterotriton* aff. *chiropterus*		27		27		
G	*Chiropterotriton* sp. D			4	4		
H	*Chiropterotriton* sp. H	33		15	48		
I	*Pseudoeurycea cephalica*	71	6		77	A	NT
J	*Pseudoeurycea gigantea*		10		10		CR
K	*Pseudoeurycea leprosa*	421		407	828	A	VU
L	*Pseudoeurycea melanomolga*	1		42	43	Pr	EN
M	*Thorius munificus*	1			1		CR
	Ranidae						
N	*Lithobates johni*		24		24	P	EN
O	*Lithobates spectabilis*		58		58		LC
	Individuals number	560	234	468	1262		
	Species number	7	9	4	15		

show an assemblage with the highest evenness, composed of a larger number of species with intermediate abundances (Fig. 3).

Differences in species composition.—Differences in species composition among the three PNAs were very high, with total dissimilarity values (β_{cc}) > 0.6 (60% dissimilarity) and as high as 1.0 (100%: completely different). Dissimilarity in species composition between PPR and SJM, and between PPR and OEP, can largely be explained by species replacement given that replacement values (β_{-3}) were 71 and 62%, respectively. In contrast, between SJM and OEP differences in composition were mainly the result of differences in species richness, with a value of 37% (Fig. 4).

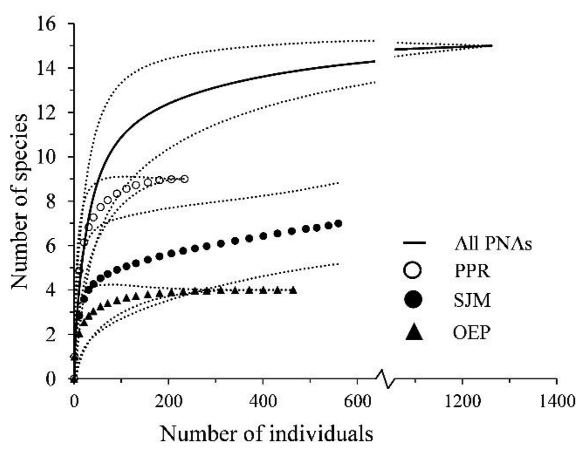

FIGURE 2. Species accumulation curves for each of three protected natural areas in the mountainous region of central Veracruz, Mexico and for all three together. Dashed lines are the upper and lower 95% confidence intervals. Sites are PPR = Pancho Poza Ecological Reserve, SJM = San Juan del Monte Reserve, and OEP = Ocelotl Ecological Park.

Threatened species on the reserves.—Nine of the 15 species we recorded across all three PNAs (seven salamanders and two anurans) belong to at least one IUCN risk category (Fig. 5) or Mexico's NOM-059-SEMARNAT-2010 list (SEMARNAT, 2010; Table 1). Six of these nine endangered species are in high risk categories (Fig. 5). Of those on the Red List, two are listed as Vulnerable (VU), two are Endangered (EN), and three are Critically Endangered (CR). Of those on the NOM-059-SEMARNAT-2010 list, two are listed as Endangered (*Amenazada*, A), four are Subject to Special Protection (Sujeta a Protección Especial, Pr) and one is In Danger of Extinction (En Peligro de Extinción, P; Table 1). Each PNA has endangered species, ranging from two species in OEP to four species in the other two reserves. Similarly, the abundance of endangered species varies by PNA (Fig. 3).

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TABLE 2. Observed and estimated amphibian richness for the three protected natural areas and all three in the mountains of the state of Veracruz, Mexico. Sites are SJM = San Juan del Monte Reserve, PPR = Pancho Poza Ecological Reserve; and OEP = Ocelotl Ecological Park. The value suggested by the Mao Tau estimator (asterisk) includes the upper 95% confidence interval.

Protected area	Number of species observed	Number of species estimated			Completeness
		Mao Tau*	Chao 1	Bootstrap	
SJM	7	8.8	8.0	7.6	79–90%
PPR	9	9.0	9.0	9.2	98–100%
OEP	4	4.0	4.0	4.0	100%
All PNAs	15	15.0	15.0	15.4	97–100%

DISCUSSION

Variation in species richness, abundance, composition, and assemblage structure indicates that the three PNAs differ in their contribution to conserving or maintaining the amphibians of the region. Furthermore, the three reserves function in a complementary manner, each conserving part of the regional amphibian diversity, including endangered species, some of which are in imminent danger of extinction. Inventory completeness is satisfactory given that the values were > 79% for each PNA and > 95% for all three PNAs. Thus, comparisons between the reserves are valid. Apparently, very few of the species with a distribution within the region were not recorded in our study; those not recorded include the frog *Lithobates spectabilis*¸ previously recorded in SJM (Bello-Sánchez 2008) and *P. leprosa* in PPR (Lambert-Izquierdo 2000).

The high species richness of the PPR lies in the integration of an amphibian fauna consisting of frogs and salamanders in almost equal proportions. This eveness of frogs and salamanders might be explained by the low elevation (2,000 m a.s.l.) of PPR where frog diversity is greater (Naniwadekar and Vasudevan 2007). At the higher elevation SJM and OEP sites, 2,500 and 3,100 m a.s.l., respectively, frog diversity is lower and the amphibian fauna is dominated by salamanders. However, the high abundance detected in SJM and EPO is associated with the abundance of one species, *P. leprosa*. The other species recorded in both reserves were less abundant. *Pseudoeurycea leprosa* is a salamander species that is usually abundant in high mountains in central Mexico (García-Vázquez et al. 2006).

Variation in reserve assemblage structure that occurs in spite of the short distances among the three reserves supports the hypothesis that each reserve has specific environmental characteristics and offers different resources to the amphibian fauna of the region. The reserve at the lowest elevation (PPR) also receives the most rain each year (1,495 mm) and is the warmest of the three reserves (mean annual temperature is 14.3° C).

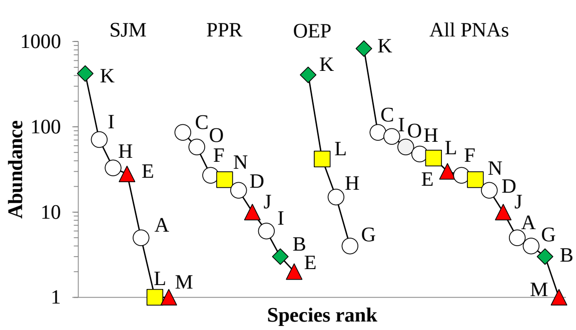

FIGURE 3. Rank-abundance plot for the amphibian assemblages of three protected natural areas in the mountainous region of central Veracruz, Mexico. Sites are SJM = San Juan del Monte Reserve, PPR = Pancho Poza Ecological Reserve; and OEP = Ocelotl Ecological Park. IUCN high risk categories are: Vulnerable, green diamond; Endangered, yellow square; Critically Endangered, red triangle. Sampling effort was 324 person-hours per reserve and 972 person-hours over the course of the entire study (All PNAs). Species codes (capital letters) are defined in Table 1.

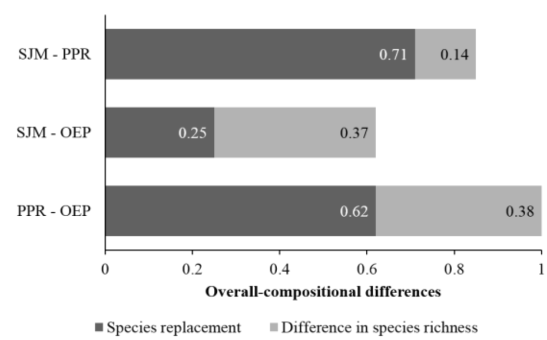

FIGURE 4. Total dissimilarity between pairs of reserves, the proportion resulting from species replacement, and the difference in species richness in the comparison of species composition among three protected natural areas in the mountainous region of central Veracruz, Mexico. Sites are SJM = San Juan del Monte Reserve, PPR = Pancho Poza Ecological Reserve, and OEP = Ocelotl Ecological Park.

FIGURE 5. Threatened species of amphibians according to the IUCN or Official Mexican Standard NOM 059 that were recorded in one or more of the three protected natural areas studied. A) *Ambystoma velasci*, B) *Craugastor decoratus*, E) *Chiropterotriton lavae*, I) *Pseudoeurycea cephalica*, J) *Pseudoeurycea gigantea*, K) *Pseudoeurycea leprosa*, L) *Pseudoeurycea melanomolga*, M) *Thorius munificus*, and N) *Lithobates johni*. The white bar in each image measures approximately 2 cm. (Photographed by Jose L. Aguilar-López).

The OEP, located higher up on the western face of the Cofre de Perote mountain (on the inland side) and only 23 km from PPR, receives less than half the annual precipitation of the PPR (620 mm) and is 5° C colder on average (CONAGUA, Comisión Nacional del Agua-Servicio Meteorológico Nacional. 2012. *op. cit.*). These environmental differences and those associated with vegetation could explain the differences observed in the amphibian assemblages, as has been addressed by several studies on elevational amphibian species diversity (see Fauth et al. 1989; Kozak and Wiens 2010; McCain and Sanders 2010). Similarly, the variation in the hierarchical position of certain species in each PNA is noteworthy, such as the case of *P. leprosa*, the dominant species in SJM and OEP that was not recorded in PPR, and that of *P. melanomolga*, the second most abundant species in OEP (42 individuals), which was rare in SJM (one individual). These differences show that each reserve plays a different role for each species, including several of the endangered species, such as the two mentioned above.

No species was shared among all three reserves and 10 of the 15 species are exclusive to one reserve. This high degree of dissimilarity in species composition agrees with previous studies for the mountainous region of central Veracruz, but at lower elevations dominated by cloud forest (Pineda and Halffter 2004; Meza-Parral and Pineda 2015), which were conducted at the same spatial scale with study sites close to each other, similar to this study. This pattern could be linked to the limited distribution of the species, to the variation in elevation of the region, and to differences in the degree of conservation of the vegetation or canopy cover.

These reserves are important to the conservation of the amphibians of this region not only because of their species richness, which in some cases is rather low, but also because they are home to populations of endangered or threatened species. If the species we identified as *Chiropterotriton aff. chiropterus* is actually *Chiropterotriton chiropterus* (genetic analysis would be required to confirm this identity of the specimen), then another endangered species could be added to the list of species in high risk categories that inhabit the study PNAs. Each PNA has two to four species at risk of extinction, and each of these species are considered microendemics because each has a total geographic range < 100 km^2 (Ochoa-Ochoa et al. 2011). In our study we report for the first time two salamanders, *Pseudoeurycea gigantea* (PPR) and *Thorius munificus* (SJM), within a PNA. Both species are considered Critically Endangered according to the IUCN Red List (IUCN, International Union for Conservation of Nature.

2014. *op*. *cit*.). We confirm that the frog *Lithobates johni* observed in PPR, previously recorded by Bello-Sánchez et al. (2014) and listed as Critically Endangered on several lists (e.g., IUCN, EDGE or SEMARNAT, the Mexican Ministry of the Environment), is moderately abundant in the reserve likely owing to suitable habitats such as clear water rivers in forested areas. Although we recorded only four species in OEP, this reserve could be playing an important role in the conservation of *P. melanomolga*, as reported by Yacotú-Barojas (2012), given that in our study it was the second most abundant species on the reserve. This suggests that this reserve offers suitable conditions for survival and reproduction of this endangered species.

Although all three reserves occur in protected areas, there remain constant pressures and threats that could compromise their integrity and the future trends of the amphibians they protect. The three PNAs are surrounded by anthropogenic pressure with signs of disturbance in their interiors. For example, PPR is adjacent to an urban area, and there is illegal logging within its boundaries. We recommend that the impact of tourism on the reserve be evaluated given that the presence of many tourists could have a notable impact on some of the microhabitats used by amphibians, including fallen trees, ponds or bromeliads. At SJM, the forest is fragmented and it is necessary to evaluate how forest fragmentation in this area is affecting the amphibian populations that inhabit the reserve. In the OEP, the forest is being transformed, though to a lesser degree. Therefore, it is essential to protect these areas efficiently to conserve the amphibian populations that live in them. Finally, the results of this study emphasize the need to explore other aspects of the relationship of each species with its current surroundings to get a more complete picture of the conservation status of the amphibians in this region. It would be useful to extend survey time to learn about the population dynamics in each area, broaden the study area to include other reserves in the region, carry out complementary studies such as population genetics analysis, and explore the impact of the chytrid fungus, which has been detected in species in this region (Cheng et al. 2011; Van Rooij et al. 2011; Murrieta-Galindo et al. 2014).

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