

# Analysis of Priorities in the Study and Conservation of Vertebrates in the Rio Lerma Basin, State of Mexico, Mexico

Kathleen Ann Babb-Stanley<sup>1</sup>, and Noé Pacheco Coronel<sup>2</sup>

*Laboratory of Vertebrates, Department of Comparative Biology, Science Faculty, National Autonomous of Mexico, UNAM*

**Abstract:** This paper updates and analyzes the information gathered in the field and bibliographically about the diversity of the terrestrial vertebrates, in different types of environments and habitats in the Lerma basin, State of Mexico. With this data we analyzed diverse attributes of each vertebrates: patterns in distribution, richness, endemism, and species at risk, by type of vegetation and habitat, using scores for each attribute, to obtain an index that allows to determine the degree of rarity-vulnerability, and with these and as a direct measure of the status of the faunistic community, an Habitat Conservation Value Index was obtained. 59 percent of the vertebrates of the state, are in the basin; 15.2 percent are very rare and vulnerable, with diverse requirements: *Ambystoma lermaense*, *Pseudoeurycea leper*, *Micrathene whitneyi*, *Ridgwayia pinicola*; *Cratogeomys tylosinus* and *Cryptotis alticola*. The pine-oak forest was the richest in species, endemics and rare species. By sub-basin, is the southern and higher portion that resulted with a very rich wild fauna but has an elevated fragility value. This approach has to do with the generation of biological and ecological knowledge and life history of each vertebrate, especially those endemic, and very rare and vulnerable, in the Lerma, one of the most overpopulated and contaminated hydrological basin of Mexico.

**Key words:** vertebrates, priorities, Lerma basin, rarity, vulnerability

## 1. Introduction

Trends in different attributes like total richness, diversity and rarity over the years of wild fauna species, can be used as indicators of environmental health of the ecosystems, both natural and those transformed for agricultural and livestock activities [1].

Monitoring and evaluating richness of species of terrestrial vertebrates at the scale of watersheds and hydrological sub basins is relevant, as they tend to represent beta diversity. It also allows having the scientific basis for conserving selected areas, habitats and priority species within these watersheds where

there is a wide representation of aquatic and terrestrial ecosystems, all of them with a great variety of environmental services that directly influence the preservation of biodiversity.

Even though the state of Mexico represents only one percent of the national territory, it possesses a high richness of terrestrial vertebrates, of which 5.6% are in some risk category [2]. In general, the knowledge of wildlife in the state has focused on the description and distributional records of vertebrate species; thus, lacking the necessary information for the species and habitat management and conservation [3]. Throughout the entire state, there is a valuable collection of faunal resources, seriously threatened by habitat loss, due to changes in land use, heavy logging and pollution effects. Today we need to know the responses of the fauna species to anthropogenic conditions. One way of doing so it is through using

---

**Corresponding author:** Kathleen Ann Babb-Stanley, Dr.; research areas/interests: Biology, ecology, management and conservation of vertebrates, ornithology. E-mail: kbabbstanley@gmail.com.

key and indicator species and integral biological indices, which allows us to evaluate the requirements of the species and their relevance, necessary knowledge to ensure the survival of the species and the adequate management and conservation of wildlife and their habitats [4]. None of the subprovinces or regions of the Lerma basin has escaped significant damage [5].

A method is applied using scores that includes several general, regional and local criteria, to determine the degree of sensitivity or rarity and vulnerability, of each of the vertebrate species present in the region. With these scores we obtained an index that reflects the conservation value of each vertebrate species by habitat; which allows us to analyze and confront some species priorities and of the different natural ecosystems and those transformed that are present in the Lerma's basin in the state of Mexico. With this is intended to determine the importance of this initial portion of the Lerma Basin for proper management, that will allow to preserve biodiversity, restore aquatic and terrestrial ecosystems and their vertebrate species, and promoting the maintenance of the services that each ecosystem provides.

## **2. Method**

This work comprises the analysis of vertebrate species of the Lerma basin, located in the western portion of the state of México, between 19°15' and 20°05' North latitude and 99°25' and 100°15' west longitude; with a length of 133 km, comprising 35 municipalities. In this area there are a variety of topographic forms and within the state limits is divided into three courses: the first one, El Alto, from Nevado de Toluca, to the entrance of J. A. Alzate dam, at the municipalities of Toluca and Temoaya; the medium part goes from the dam to the limits of the municipalities of San Felipe del Progreso, Jocotitlán and Atlacomulco, and the low course covers El Oro, Temascalcingo and Acambay [6].

Richness, and diversity of vertebrates throughout the basin was obtained by consulting the respective literature and by wildlife monitoring carried out mainly in its southern portion, from 1989 to 2017. Data about species richness by terrestrial vertebrate group, by habitat (lagoons, crop fields, riparian vegetation o riverbank, and oak, oak- pine and fir forests. We examined total richness by vertebrate class was examined, also the number of species at risk, those introduced species and those considered as very rare, and vulnerable. For the quantification of the rarity and vulnerability value, different attributes were used: sensitivity, as well as general and local distribution, and regional (species concentration and habitat selection). Considering the concentration of the species as the number of locations in which the species is registered for the watershed in the state and the habitat selection refers to the number of vegetation types in which the species is registered in these locations. For each attribute we assigned a score from zero to four. The sum of each of these attributes corresponds to the rarity value of the species; in such a way that the maximum expected score was 17 points, being this a very rare and highly sensitive or vulnerable species.

Following the recommendations of Canteburry et al. [7] and Smith & O'Neil [8], once the rarity value by species was determined a Habitat conservation value index of vertebrates by habitat was carried out by scores, as a direct measure of the status or distinction of the faunal community, considering total species richness by group (herpetofauna, birds and mammals), by number of very rare and vulnerable species, by species at risk, endemic and exclusive ones with a maximum Table 1.

## **3. Results**

The terrestrial vertebrates of the Lerma basin in Mexico state represent 59% (466 species) of the total number of species reported for the state. And it is in the initial and most southern portion of the high

course, where 55.6% of these species are recorded (76% amphibians and reptiles, 63.64% mammals and 53% birds), which is considered relevant since this sub-basin represents less than 30% of all the basin area

**Table 1 A) Attributes, and scoring for obtaining the value of rarity and vulnerability and B) For the Habitat conservation value index.**

<b>A: Values of rarity and vulnerability</b>					
Attribute	Criterion	Score	Attribute	Criterion	Score
1. Distribution by region	Wide	0	2. Endemics	Part M. Plateau and Trans Volcanic Belt	3
	Neártic/Neotrop	1		Trans Volcanic Belt	2
	Mexican Plateau	2		End. To Mexico	1
	Trans Volcanic Belt	3		No ennd	0
	Endemic	4		Probably extinct	4
3. No. Municipality State of México	10 or more	1	4. In risk (NOM-ECOL. 059 2010)	In danger	3
	9 to 5	2		Threatened	2
	4 to 1	3		Special protection	1
5. Habitat Selection	1	3		<b>Maximum =17 points= a very rare and very vulnerable species</b>	
	2	2			
	3 or more	1			
<b>B: Habitat Conservation Value Index (HCVI)</b>					
Attribute	(%)	Score	Attribute	(%)	Score
Species total (%)	75%	3	Very rare and vulnerable species	10 to 8%	3
	50-74%	2		7 to 5%	2
	49-10%	1		-5%	1
Endemic Species	20-16%	3		Exclusive species	-10%
	15 a 10%	2	11-19%		2
			20-30%		3
<b>HCVI</b>			<b>12 maximum</b>		

in the state. By habitat it is in the oak-pine forest, where the highest percentage of species is recorded more than 50% of the bird species are found in the riparian area. The axolotl (*Ambystoma lermaense*) and various game bird species are present in the lagoons and these two habitats recorded the highest percentage of exclusive species (50% of the species). And the highest percentage of endemic species concentrates mainly in the elevated portions of oak-pine forest. Analyzing the attributes of rarity vulnerability, results that 15.2% of the species are considered very rare and vulnerable, all with diverse requirements such as: *Ambystoma lermaense*, *Pseudoeurycea leper Micrathene whitneyi*, *Ridgwayia pinicola*, *Cratogeomys tylorhinus* and *Cryptotis alticola*, among

others. It stands out that the species of amphibians and reptiles are those that by habitat had the highest percentage of species in the category of very rare and vulnerable, especially in the lagoon Table 2. The highest values of the Index of conservation value by habitat (IVCH) obtained, was in the pine-oak forest, where in the last years, has change about 3.5%. By sub-basin the most initial and highest and initial, is the richest in species, but with a high fragility value (6 points) and in which more than 50% of its tree cover has been lost.

Some of the very rare and vulnerable species, considered as priorities are: the axolotl (*Ambystoma lermaense*) species umbrella for aquatic animal; the Leprous False Brook salamander or tlaconete

(*Pseudoerycea leperosa*); The endemic and threatened snake (*Crotalus rarus*); the shrews: like *Cryptotis alticola*; mice of the genus *Reithrodontomys* (*R. chrysopsis*, endemic to the Neovolcanic mountains

and *R. microdon* (threatened) and as an umbrella species, the fox (*Urocyon cinereoargenteus*). Birds stand out in aquatic and in riverbanks environments, such as: the

Table 2 Parameters, scoring and percentage (%) by kind of vertebrate and vegetation, Habitat conservation value index and land use change.

Parameter	Fir (Abies spp)	Pine- Oak	Oak	Crop	Fields	Riverbank	Lagoon
	Score (%)	Score (%)	Score (%)	Score (%)	Score (%)	Score (%)	Score %
<b>All species</b>							
Amp+Reptiles	8.33 1	11.11 2	5.56 1	4.86 1	4.86 1	3.09 2	
Mammals	23.81 2	30.95 3	25.40 3	19.05 1	16.67 2	0.00 0	
Birds	28.20 3	43.60 3	32.20 3	27.40 2	42.20 3	4.66 2	
Sum (points)	60.34 6	85.66 8	63.15 7	51.31 5	63.73 6	14.88 4	
Score	2	3	3	1	2	2	
<b>Rare and vulnerable species</b>							
Amp+Reptiles	9.09 2	13.64 3	9.09 1	13.64 2	4.55 1	22.73 3	
Mammals	9.52 2	11.11 2	5.56 3	7.14 1	6.35 2	0.00 0	
Birds	2.57 1	3.86 1	1.54 3	1.03 1	1.29 3	1.80 1	
Sum points	21.19 5	28.60 6	16.19 7	21.81 4	12.18 6	24.53 4	
Score	2	3	3	1	2	3	
<b>Endemic species</b>							
Amp+Reptiles	13.64 2	18.18 3	13.64 2	9.09 1	4.55 1	9.09 2	
Mammals	6.35 1	7.94 1	6.35 1	7.14 1	7.94 1	0.00 0	
Birds	7.20 1	10.54 2	5.91 1	3.34 1	6.17 1	0.51 1	
Sum points	4	6	4	3	3	2	
Score	2	2	2	1	1	1	
<b>Exclusive spp.</b>							
Amp+Reptiles	0.55 1	0.73 1	0.00 0	0.00 0	0.42 1	6.00 1	
Mammals	6.56 2	2.93 1	1.00 1	0.00 0	1.67 1	0.00 0	
Birds	13.11 3	10.99 2	10.95 2	2.98 1	8.37 2	56.72 4	
Sum points	6	4	3	1	4	4	
Score	2	1	1	1	1	1	
<b>SP. In risk</b>							
Amp+Reptiles	27.27 3	36.36 3	22.73 1	22.73 3	22.73 3	45.45 3	
Mammals	5.56 1	7.94 1	5.56 1	5.56 1	6.35 1	2.38 1	
Birds	3.08 1	2.57 1	1.03 1	1.29 1	1.80 1	0.00 0	
Sum points	5	5	3	5	5	4	
Score	2	2	1	2	2	2	
<b>HCVI (Scores sum)</b>	<b>10</b>	<b>11</b>	<b>10</b>	<b>6</b>	<b>8</b>	<b>9</b>	
<b>Land use change (2012) [12]</b>	<b>2%</b>	<b>2%</b>	<b>3.5%</b>	<b>70%</b>	<b>0.20%</b>	<b>1%</b>	

American bittern (*Botaurus lentiginosus*). In the forest, the endemic woodpecker (*Picoides arizonae*), as a forest umbrella species and the owl (*Asio flammeus*); as an umbrella bird species for many endemic birds of

the interior of the forest, the aztec thrush (*Ridgwayia pinicola*) and the endangered chestnut-sided shrike vireo (*Vireolanius melitophrys*).

#### 4. Discussion and Conclusions

Even though in this basin there is a strong process of change in land use for agricultural, urban and industrial purposes; a marked reduction in the area of the lagoons and their riparian vegetation and a strong environmental deterioration along the Lerma River basin, in the state of Mexico [4, 9]; it is a region of high diversity of fauna representing 55% of the vertebrate species reported in the State of Mexico [10]. This richness is related to the presence of an altitudinal gradient in the area, the local topography, as well as the presence of different natural, terrestrial and aquatic environments and those transformed for agriculture and urban developments, which provides a wide range of habitats and microhabitats for diverse species of wildlife, many of which today confronts negative impacts due to climate change and loss of habitat [11], like the riverbanks.

It is on the portions of pine-oak forest where there is the greatest richness of vertebrates, of exclusive, endemic and very rare and vulnerable species, so the index of conservation value per habitat (IVCH) is the highest, thus making it suitable for a significant number of vertebrates, which in the southernmost, high and initial portion of the upper watershed course, from 1989 to 2017, has lost about 55% of its trees and about 80% of wetlands [12]. The percentage of very rare and vulnerable species is high, given both by the area covered by this municipality, in the state, within the physiographic region of the Trans Volcanic Belt and by its loss of vegetation and the impact that in the future will have the climatic change [13]. The rarity-vulnerability index, considering the attributes analyzed, allowed us on one hand to detect those priority species for their management and conservation and in the other, to obtain the index of habitat conservation for the fauna, that allows to identify the priorities in the forest area and the wetlands and surrounding areas; especially if we consider the drastic transformation of land use for various purposes, which throughout this hydrologic

region has been taking since long time ago, particularly in its high course [14].

This approach considering conservation priorities has to do with the global diagnosis of the state and current use of the different terrestrial and aquatic ecosystems of this basin as well as with the generation of ecological knowledge and life history of vertebrates that live there. Especially of those vertebrates that today are endemic and very rare and vulnerable species of the Lerma Basin, one of the most overcrowded and polluted hydrological basins in the State of Mexico. Our review indicates that managers can use this tools and many others ones to address priorities in the conservation of wildlife and their habitats.

#### References

- [1] D. R. Gregory and Arco van Strien, Wild bird indicators: using composite population trends of birds as measures of environmental health, *Ornithol Sci.* 9 (2010) 3-22.
- [2] G. Ceballos and R. List, La diversidad biológica del estado de México. Estudio de Estado. Sría. Del Medio Ambiente, Gobierno del estado de México, México, 2009.
- [3] S. K. Babb and N. Pacheco, Riqueza y estructura poblacional de las aves acuáticas de la laguna de Chiconahuapan, Cuenca Alta del Lerma durante otoño e invierno, in: *Memorias XXI Congreso Nacional de Zoología*, En extensor, Ags, México, 2013, pp. 690-694.
- [4] D. Hartzell, An evaluation of an index of biological integrity for Depressional Wetlands in Central Oklahoma, thesis science in environmental science, Kutztown Univ. Pennsylvania, EUA, 2001.
- [5] Carrera-Hernández Jaime, A tale of Mexico's most exploited — and connected — watersheds: the basin of Mexico and the Lerma-Chapala Basin, *WIREs Water*, 2017, doi: 10.1002/wat2.1247.
- [6] R. Montes-Hernández, A. Romero-Contreras, C. Solís-Morelos, M. G. Rivera-Herrejón and S. Zamorano-Camiro, Las galerías filtrantes del Alto Lerma: usos y manejos sociales, *Sociedad y Territorio, Economía, Sociedad y Territorio XI* (36) (2011) 455-485.
- [7] G. E. Canteburry, T. Martin, D. R. Petit, L. J. Petit and D. Bradford, Bird communities and habitat as ecological indicators of forest condition in regional monitoring, *Conservation Biology* 14 (2000) (29) 554-558.
- [8] N. E. Smith, L. T. Tran and R. V. O'Neil, Regional vulnerability assessment for the Mid-Atlantic Region:

- Evaluation of Integration Methods and assessments results, EPA/600/R-03/082. EUA, 2003, p. 80.
- [9] E. Soto-Galera, E. Díaz-Pardo, E. López-López and John Lyons, Fish as indicators of environmental quality in the Río Lerma Basin, México, *Aquatic Ecosystem Health & Management* 1 (1998) (3-4), 267-276, doi: 10.1080/14634989808656923
- [10] Sría De Medio Ambiente, Situación de la flora y fauna del Estado de México respecto a la NOMN-059 -SEMARNAT-2001, Gobierno Estado de México, México, 2007, p. 2.
- [11] E. Martínez-Meyer, J. E. Sosa-Escalante and F. Álvarez, The study of the biodiversity in Mexico: a route with a course? *Revista Mexicana de Biodiversidad, Supl.* 85 (2014) S1-S9, doi: 10.7550/rmb.43248.
- [12] R. Landgrave and P. Moreno-Casasola, Evaluación cuantitativa de la pérdida de humedales en México, *Investigación ambiental* 4 (2012) (1) 19-35.
- [13] J. R. Mawdsley, T. O' Malley and D. S. Ojima, A review of climate-change adaptation strategies for wildlife management and biodiversity, *Conservation Biology* 23 (5) 1080-1089.
- [14] G. C. Zepeda, N. X. Antonio, H. A. Lot and D. Madrigal, Land use change in Lerma marshes (1973-2008) and its impact on aquatic vegetation, *Investigaciones Geográficas, Boletín del Instituto de Geografía, UNAM*, 2012, No. 78, pp. 48-61.