Biodivers Conserv (2010) 19:3699–3742
DOI 10.1007/s10531-010-9923-9

ORIGINAL PAPER

A general assessment of the conservation status and decline trends of Mexican amphibians

Patricia Frías-Alvarez · J. Jaime Zúñiga-Vega · Oscar Flores-Villela

Received: 3 August 2009 / Accepted: 21 September 2010 / Published online: 9 October 2010

Abstract We present a review on the conservation status and population trends of the 372 amphibian species currently recognized for Mexico. We based our analyses on the information gathered by the International Union for the Conservation of Nature-the Global Amphibian Assessment (IUCN-GAA) as well as on available literature about imminent or potential threats to these organisms in Mexico. This country has the fifth largest amphibian fauna in the world and almost 58% of the species that inhabit this country are considered as threatened. We highlight the proportion of species per order, family, and genus that are currently under severe risk in Mexico. In addition, we prepared a detailed list of the main factors that are threatening amphibians in this country. Evidence is provided that the six main mechanisms that are globally leading amphibians to extinction (alien species, over-exploitation, land use change, global changes, pollution, and infectious diseases) are indeed currently operating in Mexico. We discuss the relative importance of each of these causes. We also highlight the paucity of quantitative studies that support the current conservation status of Mexican amphibian species.

Keywords Conservation status · IUCN red list · Mexican amphibians · Population trends · Threatened species

P. Frías-Alvarez
Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510 Mexico, DF, Mexico

J. J. Zúñiga-Vega (✉)
Departamento de Ecología y Recursos Naturales, Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510 Mexico, DF, Mexico
e-mail: jzuniga@ciencias.unam.mx

O. Flores-Villela
Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510 Mexico, DF, Mexico

Introduction

Worldwide, many amphibian populations are declining (Laurance 1996; Houlahan et al. 2000; Lips et al. 2005a, b). Reports about the conservation and status of biodiversity indicate that amphibians are threatened and declining at faster rates than birds and mammals (Stuart et al. 2004). Currently 1229 amphibian species are globally reported as endangered and critically endangered, and 39 are considered as extinct in the wild (Stuart et al. 2008; IUCN 2010).

Mexico is considered a mega-diverse country with a complex geologic history, a unique topography, and greatly diverse vegetation types (Flores-Villela and Gerez 1994; Benítez-Díaz and Bellot-Rojas 2003; Ochoa-Ochoa and Flores-Villela 2006). The rich Mexican biodiversity harbors the fifth largest amphibian fauna in the world (Ochoa-Ochoa and Flores-Villela 2006; Stuart et al. 2008; IUCN 2010). Mexico has 372 described amphibian species from which 250 occur only in Mexico (67.2%; Flores-Villela and Canseco-Márquez 2004; Frost 2010). Thus, this country is considered as the number three in amphibian endemic species (Stuart et al. 2008). Nevertheless, the current rate of annual species description is increasing: 11.5 and 27.4% of Mexican anurans and salamanders, respectively, were described between 1992 and 2007 (Flores-Villela and Canseco-Márquez 2004). Therefore, the actual number of Mexican species appears to be greatly underestimated (Frías-Alvarez et al. 2008).

In the past years some studies have documented declines of Mexican amphibians (Parra-Olea et al. 1999; Frías-Alvarez et al. 2008). Recent field surveys indicate that nowadays it is quite difficult to find salamanders and frogs that were collected by hundreds during the 1970s and 1980s (Parra-Olea et al. 1999; Lips et al. 2004). Destruction, fragmentation, and modification of their natural habitats are the best-recognized causes of such declines (Parra-Olea et al. 1999; Rovito et al. 2009). In fact, the highest rates of global habitat loss have occurred in tropical and semi-tropical regions, which correspond to those countries (Mexico included) supporting the richest assemblages of amphibian fauna (Gallant et al. 2007). In addition, diseases (e.g., chytridiomycosis), pollution, increases in UV-B radiation, introduction of exotic species, and over-exploitation have been considered as other important causes for the decline of Mexican amphibians (Frías-Alvarez et al. 2008, 2010; González-Bernal 2008).

These facts highlight the importance of a general picture that summarizes the Mexican amphibian species that are currently experiencing threats and declines. No synthesis of such information is currently available on the scientific literature (Frías-Alvarez et al. 2008). Thus, in this paper we present an evaluation of the current conservation status and trends of the amphibian species that inhabit in Mexico, as well as a summary of the main threats experienced by these organisms in this country. We attempt to create a useful and informative reference for all the future scientific and educational studies focused on the conservation, ecology, and distribution of the Mexican amphibian fauna.

Materials and methods

We consulted the International Union for Conservation of Nature (IUCN)-the Global Amphibian Assessment (GAA) to obtain data on the taxonomy, distribution, habitat, population trends, threats, and conservation status for all Mexican amphibians listed on the data base. We used this red list of threatened species to obtain and summarize

information about Mexican amphibians (IUCN 2010). We followed partially the structure that Stuart et al. (2004) used for a global amphibian assessment but we focus only in Mexico.

The GAA-red list of threatened species has included 16 families, 52 genera, and 364 amphibian species that inhabit in Mexico (227 from the order Anura, 135 from Caudata, and 2 from Gymnophiona). The list lacks a few described species (it includes 364 of 372 currently described species for Mexico; Flores-Villela and Canseco-Márquez 2004; Frost 2010) as well as several others that still await for formal description. We focused our attention on the three main protection categories of the IUCN, which are those pointing out to species under the highest risks of extinction: Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). Henceforth, we use the term "threatened" to indicate that a species is listed in one of these three conservation categories (as per IUCN 2010). In our results, all the percentages of species within particular conservation categories are based on the 364 species included in the GAA data base.

We conducted a comparison of the conservation categories of Mexican amphibians as considered by the Mexican environmental agency with the conservation categories proposed by the IUCN red list. This Mexican official list of species at risk was issued originally in 1994 and updated in 2001 (Norma Oficial Mexicana, NOM-059-ECOL-2001, Secretaría de Medio Ambiente y Recursos Naturales 2002). With this comparison we aimed to evaluate how the Mexican government currently considers the conservation status of the native amphibian fauna. Four conservation categories are defined by this Mexican official list, which according to this document are partially coincident with the IUCN categories. (1) Probably Extinct in the Wild (E). This category coincides with the IUCN Extinct (EX) and Extinct in the Wild (EW) categories. (2) Threatened with Extinction (P), partially coincident with the IUCN CR and EN categories. (3) Threatened (A), partially coincident with the VU category. (4) Under Special Protection (Pr). This category can include the low-risk categories of the red list: Near Threatened (NT), Least Concern (LC), and Data Deficient (DD).

In addition to the information available from the GAA, we conducted an extensive search for literature containing evidence of declining populations of amphibians in Mexico. We surveyed several sources of reliable information: peer-reviewed journals, unpublished academic theses and dissertations, and books. Our aim was to find formal experimental or empirical studies that evaluated the demographic or genetic trends of amphibian populations anywhere throughout Mexico. We also considered reports that compared past and present abundances of amphibians in the wild and those that document imminent threats to focal populations.

Collins and Storfer (2003) proposed that six factors are the main causes of the amphibian declines observed worldwide. These factors are: (1) alien species, (2) overexploitation, (3) land use change, (4) global changes (increased ultraviolet radiation and global warming), (5) chemical pollution, and (6) emerging infectious diseases. The GAA database provides a list of realized and potential threats to each Mexican amphibian according to some literature and to the qualified opinion of its assessors and evaluators. We used such lists, as well as the information that we obtained in our extensive bibliographic search, to generate a table in which we summarize which species are suffering from each of the six main threats proposed by Collins and Storfer (2003). This provided us with a neat summary of the main forces that are driving the observed population declines of amphibians in the Mexican territory.

Results

Mexican amphibians are more threatened than any other vertebrate group as indicated by a larger proportion of amphibian species that are included in one of the three main protection categories of the IUCN red list (57.97%, 211 species), in comparison with Mexican mammals (19.35%), Mexican birds (5.01%) or Mexican reptiles (14.07%; Table 1). In addition, given the high rates of habitat deterioration all throughout Mexico (Challenger 2003), it is not surprising that 21 species (5.77%) are currently listed as Near Threatened (NT; Table 1).

From the 246 amphibian species that according to the GAA data base are endemic to Mexico, a disturbing 69.5% are considered as threatened (171 species). From these, 27 species are categorized as VU, 67 as EN, and 77 as CR.

The families with more threatened species are (percentage of species listed as threatened by the IUCN-GAA; Table 2): Plethodontidae (73.04%), Ambystomatidae (64.71%), Eleutherodactylidae (60.87%), Craugastoridae (59.46%), Hylidae (58.95%), Ranidae (42.30%), Bufonidae (31.25%), and Microhylidae (20%). The single species of the family Salamandridae that occurs in Mexico (*Notophthalmus meridionalis*) is EN. Similarly, one of the two species of the family Caeciliidae (*Dermophis mexicanus*) inhabiting in this country is listed as VU.

Several genera experience severe conservation problems as indicated by their high percentages of threatened species: *Thorius* (95.65%), *Plectrohyla* (87.88%), *Chiropterotriton* (83.33%), *Pseudoeurycea* (77.55%), *Ecnomiohyla* (66.67%), *Ambystoma* (64.71%), *Eleutherodactylus* (60.87%), *Craugastor* (59.46%), and *Exerodonta* (55.56%). All species (100%) in the following genera, which only have a few representatives in Mexico (from 1 to 5 species), are considered as threatened: *Bromeliohyla*, *Charadrahyla*, *Cryptotriton*, *Dendrotriton*, *Duellmanohyla*, *Megastomatohyla*, *Notophthalmus*, *Nyctanolis*, and *Parvimolge*. The genera *Agalychnis*, *Dermophis*, *Hypopachus*, and *Rana* are each represented in Mexico by only two species, for a total of eight species. Of these pairs, one species in each genus is listed as either VU, EN, or CR (Table 2).

The threat to Mexican amphibians is quite alarming in the order Caudata (newts, salamanders, and axolotls), which has 96 species (71.11%) listed as threatened by the IUCN. Eleven of these species are considered as VU (8.15%), 40 as EN (29.63%), and 45 as CR (33.33%). At least 114 members of the order Anura that inhabit Mexico (50.22%) are threatened, with 32 species in the category of VU (14.10%), 39 EN (17.18%), and 43 CR (18.94%). Knowledge about the only two Mexican species of the order Gymnophiona is drastically poor even though one of them is endemic to Mexico (*Dermophis oaxacae*). The latter species is listed as DD whereas the other species, *Dermophis mexicanus*, is considered as VU (Tables 1, 2).

According to the IUCN (2010), the population trends of Mexican amphibians are worrying. A high percentage of species (64.29%, 234 species) are suffering some sort of decrease. In contrast, only 4 (1.10%) Mexican amphibian species are demographically increasing, whereas 72 (19.78%) are apparently stable and 54 (14.84%) lack enough information concerning their population trends. Analyzing these tendencies per taxonomic order we found that 96 (71.11%) species of Mexican caudates, 137 (60.35%) anurans, and 1 caecilian (50%) experience declining demographic tendencies. Only 4 (1.76%) anurans have populations that are currently growing whereas there are no records of caudates or caecilians with positive population trends. Fifty-eight (25.55%) anurans and 14 (10.37%) caudates have apparently stable populations. Unfortunately, no demographic information is available for 28 (12.33%) anurans, 25 caudates (18.52%), and 1 (50%) caecilian.

Table 1 Total number of Mexican amphibians, mammals, birds, and reptiles listed on the IUCN red list

Mexican taxa	Number of species in the IUCN red list	EX	DD	LC	NT	Threatened		
						VU	EN	CR
Amphibians	364	0	38 (10.44)	94 (25.82)	21 (5.77)	44 (12.09)	79 (21.7)	88 (24.18)
Anura	227	0	22 (9.69)	79 (34.8)	12 (5.29)	32 (14.10)	39 (17.18)	43 (18.94)
Caudata	135	0	15 (11.11)	15 (11.11)	9 (6.67)	11 (8.15)	40 (29.63)	45 (33.33)
Gymnophiona	2	0	1 (50)	0	0	1 (50)	0	0
Mammals	527	6 (1.14)	28 (5.31)	368 (69.83)	23 (4.36)	29 (5.50)	43 (8.16)	30 (5.69)
Birds	1078	4 (0.4)	2 (0.2)	977 (90.63)	41 (3.8)	27 (2.5)	17 (1.58)	10 (0.93)
Reptiles	675[a]	0	121 (17.93)	432 (64)	26 (3.85)	46 (6.81)	39 (5.78)	10 (1.48)

Number of species and percentages (within parentheses) of the total species per taxonomic group that appear on each IUCN category are also shown. Red list categories are indicated as follows: Extinct (EX), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). The categories VU, EN, and CR indicate species that are currently threatened in the wild. Amphibian data is also shown separately by order (Anura, Caudata, and Gymnophiona)

[a] One reptile species (*Crocodylus moreletii*) is considered in the red list as Lower Risk/conservation dependent (LR/cd)

Table 2 Number of Mexican amphibian species on each category of the IUCN red list

Order	Family	Genus	Total	EX	DD	LC	NT	VU	EN	CR	TH
Anura	Bufonidae	*Anaxyrus*	11	0	0	8	2	0	1	0	1 (9.1)
Anura	Bufonidae	*Incilius*	20	0	1	10	0	2	6	1	9 (45)
Anura	Bufonidae	*Rhinella*	1	0	0	1	0	0	0	0	0
Anura	Centrolenidae	*Hyalinobatrachium*	1	0	0	1	0	0	0	0	0
Anura	Craugastoridae	*Craugastor*	37	0	6	6	3	7	8	7	22 (59.46)
Anura	Eleutherodactylidae	*Eleutherodactylus*	23	0	5	4	0	7	4	3	14 (60.87)
Anura	Hylidae	*Acris*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Agalychnis*	2	0	0	1	0	0	0	1	1 (50)
Anura	Hylidae	*Anotheca*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Bromeliohyla*	2	0	0	0	0	0	1	1	2 (100)
Anura	Hylidae	*Charadrahyla*	5	0	0	0	0	2	1	2	5 (100)
Anura	Hylidae	*Dendropsophus*	4	0	0	4	0	0	0	0	0
Anura	Hylidae	*Diaglena*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Duellmanohyla*	3	0	0	0	0	1	2	0	3 (100)
Anura	Hylidae	*Ecnomiohyla*	3	0	0	0	1	0	0	2	2 (66.67)
Anura	Hylidae	*Exerodonta*	9	0	2	2	0	4	1	0	5 (55.56)
Anura	Hylidae	*Hyla*	7	0	1	4	1	1	0	0	1 (14.29)
Anura	Hylidae	*Megastomatohyla*	4	0	0	0	0	0	2	2	4 (100)
Anura	Hylidae	*Pachymedusa*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Plectrohyla*	33	0	3	1	0	1	8	20	29 (87.88)
Anura	Hylidae	*Pseudacris*	3	0	0	3	0	0	0	0	0
Anura	Hylidae	*Ptychohyla*	5	0	2	0	1	0	2	0	2 (40)
Anura	Hylidae	*Scinax*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Smilisca*	4	0	0	2	1	0	1	0	1 (25)
Anura	Hylidae	*Tlalocohyla*	4	0	0	3	0	1	0	0	1 (25)

Table 2 continued

Order	Family	Genus	Total	EX	DD	LC	NT	VU	EN	CR	TH
Anura	Hylidae	*Trachycephalus*	1	0	0	1	0	0	0	0	0
Anura	Hylidae	*Triprion*	1	0	0	1	0	0	0	0	0
Anura	Leiuperidae	*Engystomops*	1	0	0	1	0	0	0	0	0
Anura	Leptodactylidae	*Leptodactylus*	2	0	0	2	0	0	0	0	0
Anura	Microhylidae	*Gastrophryne*	3	0	0	3	0	0	0	0	0
Anura	Microhylidae	*Hypopachus*	2	0	0	1	0	1	0	0	1 (50)
Anura	Ranidae	*Lithobates*	24	0	2	11	1	4	2	4	10 (41.67)
Anura	Ranidae	*Rana*	2	0	0	0	1	1	0	0	1 (50)
Anura	Rhinophrynidae	*Rhinophrynus*	1	0	0	1	0	0	0	0	0
Anura	Scaphiopodidae	*Scaphiopus*	1	0	0	1	0	0	0	0	0
Anura	Scaphiopodidae	*Spea*	3	0	0	2	1	0	0	0	0
Caudata	Ambystomatidae	*Ambystoma*	17	0	3	3	0	0	2	9	11 (64.71)
Caudata	Plethodontidae	*Aneides*	1	0	0	1	0	0	0	0	0
Caudata	Plethodontidae	*Batrachoseps*	1	0	0	1	0	0	0	0	0
Caudata	Plethodontidae	*Bolitoglossa*	21	0	3	5	5	2	6	0	8 (38.1)
Caudata	Plethodontidae	*Chiropterotriton*	12	0	1	0	1	1	4	5	10 (83.33)
Caudata	Plethodontidae	*Cryptotriton*	2	0	0	0	0	0	2	0	2 (100)
Caudata	Plethodontidae	*Dendrotriton*	2	0	0	0	0	2	0	0	2 (100)
Caudata	Plethodontidae	*Ensatina*	1	0	0	1	0	0	0	0	0
Caudata	Plethodontidae	*Nyctanolis*	1	0	0	0	0	0	1	0	1 (100)
Caudata	Plethodontidae	*Oedipina*	1	0	0	1	0	0	0	0	0
Caudata	Plethodontidae	*Parvimolge*	1	0	0	0	0	0	0	1	1 (100)
Caudata	Plethodontidae	*Pseudoeurycea*	49	0	7	1	3	5	14	19	38 (77.55)
Caudata	Plethodontidae	*Thorius*	23	0	1	0	0	1	10	11	22 (95.65)
Caudata	Salamandridae	*Notophthalmus*	1	0	0	0	0	0	1	0	1 (100)

Table 2 continued

Order	Family	Genus	Total	EX	DD	LC	NT	VU	EN	CR	TH
Caudata	Sirenidae	*Siren*	2	0	0	2	0	0	0	0	0
Gymnophiona	Caeciliidae	*Dermophis*	2	0	1	0	0	1	0	0	1 (50)
		Total	364	0	38	94	21	44	79	88	211 (57.97)

Data are shown by Order, Family, and Genus. Red list categories are indicated as follows: Extinct (EX), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). The categories VU, EN, and CR indicate species that are currently threatened in the wild. We show the number and percentage (within parentheses) of species of each genus that are listed in the three latter categories (*TH* threatened species)

The GAA-red list misses seven species that recently were described or recognized as present in the Mexican territory. These species are *Ambystoma mavortium*, *A. subsalsum*, *Charadrahyla tecuani*, *Craugastor galacticorhinus*, *C. saltator*, *Lithobates brownorum*, and *Ptychohyla macrotympanum* (Frost 2010). In addition, *Incilius campbelli*, which is listed as NT, was not considered to be present in Mexico by the IUCN (2010). However, this species is currently recognized as occurring in southeastern Mexico (Frost 2010).

In comparison with the 364 taxa listed by the IUCN red list, the Mexican list of species at risk (NOM-059-ECOL-2001, Secretaría de Medio Ambiente y Recursos Naturales 2002) only includes 197 amphibian species (Table 3). However, after the recent taxonomic changes (e.g., Frost et al. 2006) only 194 actual species are listed by the Mexican government. According to the Mexican list, there are no extinct (E) amphibians, 6 species are threatened with extinction (P), 39 are threatened (A), and 149 are under special protection (Pr). From those species missed by the NOM-059-ECOL-2001, 25 are listed by the IUCN as CR, 28 as EN, and 20 as VU (i.e., 73 threatened species). When comparing the 194 species listed by the NOM-059-ECOL-2001 with those listed by the IUCN red list we found that only 59 taxa are in coincident categories. From such 59 species, six are listed as P by the NOM-059-ECOL-2001 and as EN or CR by the IUCN, six are considered as A by the NOM-059-ECOL-2001 and as VU by the IUCN, and 47 are listed as Pr by the NOM-059-ECOL-2001 and as NT, LC or NT by the IUCN red list (Table 3).

We must highlight the fact that 126 amphibian species listed by the Mexican government are in lower-risk conservation categories in comparison with those assigned by the IUCN (Table 3). From such 126 species, 49 and 59 are considered by the red list as EN and CR, respectively, whereas in the NOM-059-ECOL-2001 these are listed as either A (26 taxa) or Pr (82 taxa). The remaining 18 taxa are listed by the IUCN as VU, whereas the NOM-059-ECOL-2001 lists them as Pr. In contrast, only seven amphibian species are included in a higher-risk conservation category according to the Mexican authorities in comparison with their status on the IUCN red list. Such seven amphibians are listed by the IUCN as either NT (four species), LC (two species) or DD (one species), whereas in the NOM-059-ECOL-2001 all them appear as A. Additionally, two species (*Craugastor saltator* and *Lithobates brownorum*) are listed as Pr in the NOM-059-ECOL-2001 and do not appear on the IUCN red list (Table 3).

In Table 3 we also show the factors that are apparently threatening to every single Mexican amphibian species. Notice that the information contained in this table comes from both the GAA assessment and our additional extensive literature survey. The most common threat to Mexican amphibians is land use change. A total of 322 species out of the 372 recognized for Mexico by the IUCN (86.56%) suffer from the consequences of the human activities that modify their natural habitat. Emerging infectious diseases represent the second most conspicuous threat. A total of 87 species (23.39%) have been suggested as actual or at least potential victims of pathogens. Pollution is also impacting a relatively high number of species: 76 Mexican amphibians (20.43%) are threatened by toxic chemicals. The introduction of alien species is currently damaging 41 species (11.02%), whereas global changes and over-exploitation each affects 36 (9.68%) species (Table 3).

Discussion

According to the IUCN-GAA criteria (2010) almost 58% of the Mexican amphibian fauna is threatened. This number is alarming when considering the high degree of endemism in this country that holds the fifth largest amphibian fauna in the world (250 endemic species

Table 3 List of the conservation categories and main threats affecting the 372 Mexican amphibian species

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Anura												
Bufonidae												
Anaxyrus boreas	NT			x		x	x	x	x			
Anaxyrus californicus	EN			x		**x***	x	x	**x**			1
Anaxyrus cognatus	LC					**x***		**x**				2
Anaxyrus compactilis	LC		x			**x***		x				2, 3
Anaxyrus bebilis	LC	Pr									x	
Anaxyrus kelloggi	LC		x								x	
Anaxyrus mexicanus	NT		x		x	x						
Anaxyrus punctatus	LC										x	
Anaxyrus retiformis	LC	Pr			x	x						
Anaxyrus speciosus	LC										x	
Anaxyrus woodhousii	LC			**x**								4
Incilius alvarius	LC			**x**		**x***						1, 4
Incilius bocourti	LC										x	
Incilius campbelli[a]	NT										x	
Incilius canaliferus	LC				x	x		x				
Incilius cavifrons	EN	Pr	x			x						
Incilius coccifer	LC	Pr									x	
Incilius cristatus	CR	Pr	x			**x***		x		**x**		5, 6
Incilius cycladen	VU		x			x		x	x			
Incilius gemmifer	EN	Pr	x			x	x					

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Incilius luetkenii	LC										x	
Incilius macrocristatus	VU					x		x				
Incilius marmoreus	LC		x		**x**							7
Incilius mazatlanensis	LC		x			x						
Incilius nebulifer	LC										x	
Incilius occidentalis	LC		x					x				
Incilius perplexus	EN		x			x						
Incilius pisinnus	DD		x			x		x				
Incilius spiculatus	EN		x			x						
Incilius tacanensis	EN					x		x	x			
Incilius tutelarius	EN					x			x			
Incilius valliceps	LC				**x**			**x**				8, 9, 10
Rhinella marina	LC				**x**							7, 9, 10, 11, 12
Centrolenidae												
Hyalinobatrachium fleischmanni	LC					x		x	x	**x**		13
Craugastoridae												
Craugastor alfredi	VU					x						
Craugastor amniscola	DD					x		x	x			
Craugastor augusti	LC										x	
Craugastor batrachylus	DD	Pr	x								x	

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Craugastor berkenbuschii	NT	Pr	x			**x***			x	**x**		5, 13
Craugastor brocchi	VU					x			x			
Craugastor decoratus	VU	Pr	x			x						
Craugastor galacticorhinus			x								x	
Craugastor glaucus	CR	Pr	x			x						
Craugastor greggi	CR	Pr				x			x	**x**		13
Craugastor guerreroensis[b]	CR	Pr	x			x			x	**x**		13, 14
Craugastor hobartsmithi	EN		x			**x***						15
Craugastor laticeps	NT	Pr				x	x		x	**x**		13
Craugastor lineatus	CR	Pr				x		x	x	**x**		13
Craugastor loki	LC					x	x	x				
Craugastor matudai	VU	Pr				x						
Craugastor megalotympanum	CR	Pr	x			x						
Craugastor mexicanus	LC	Pr	x			x			**x***	**x**		13
Craugastor montanus	EN	Pr	x			x						
Craugastor occidentalis	DD		x			**x**						15
Craugastor omiltemanus	EN	Pr	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Craugastor palenque	DD					x		x	x			
Craugastor pelorus	DD		x			x						
Craugastor polymniae[b]	CR	Pr	x			x			x	**x**		13, 14
Craugastor pozo	CR		x			x						
Craugastor pygmaeus	VU					x						
Craugastor rhodopis	VU		x			x						
Craugastor rugulosus	LC		x			x			x	**x**		13
Craugastor rupinius	LC					x		x	x			
Craugastor saltator		Pr	x								x	
Craugastor silvicola	EN	Pr	x			x						
Craugastor spatulatus	EN	Pr	x			**x***						5
Craugastor stuarti	EN	Pr				x						
Craugastor tarahumaraensis	VU	Pr	x			x						
Craugastor taylori[c]	DD	Pr	x			**x**						16
Craugastor uno[c]	EN	Pr	x			**x***						16
Craugastor vocalis	LC		x			x						
Craugastor vulcani	EN		x			x						
Craugastor yucatanensis	NT	Pr	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Eleutherodactylidae												
Eleutherodactylus angustidigitorum	VU	Pr	x			**x***		**x**				17
Eleutherodactylus cystignathoides	LC										x	
Eleutherodactylus dennisi	EN	Pr	x			x						
Eleutherodactylus dilatus	EN		x			x						
Eleutherodactylus dixoni	CR	Pr	x			x						
Eleutherodactylus grandis	CR	Pr	x			x		x				
Eleutherodactylus guttilatus	LC					x						
Eleutherodactylus interorbitalis	DD	Pr	x			x	x					
Eleutherodactylus leprus	VU					x						
Eleutherodactylus longipes	VU		x			x			x			
Eleutherodactylus maurus	DD	Pr	x			x						
Eleutherodactylus modestus	VU	Pr	x			**x***						15
Eleutherodactylus nitidus	LC		x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Eleutherodactylus nivicolimae	VU	Pr	x			x						
Eleutherodactylus pallidus	DD	Pr	x			x						
Eleutherodactylus pipilans	LC					x						
Eleutherodactylus rubrimaculatus	VU					x						
Eleutherodactylus rufescens	CR	Pr	x			**x***		**x**				17
Eleutherodactylus saxatilis	EN		x			x						
Eleutherodactylus syristes	EN	Pr	x			x						
Eleutherodactylus teretistes	DD	Pr	x			x						
Eleutherodactylus verrucipes	VU	Pr	x			x						
Eleutherodactylus verruculatus	DD	Pr	x								x	
Hylidae												
Acris crepitans	LC			x		x		x				
Agalychnis callidryas	LC					x		x				
Agalychnis moreletii	CR				x	x		x	**x***	**x**		13, 18
Anotheca spinosa	LC					x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Bromeliohyla bromeliacia	EN					x	x	x	x			
Bromeliohyla dendroscarta[b]	CR	Pr	x			x			x	**x**		13, 14
Charadrahyla altipotens[b]	CR	Pr	x			x			x	**x**		13, 14
Charadrahyla chaneque	EN	Pr	x			x						
Charadrahyla nephila	VU		x			x			**x***			13
Charadrahyla taeniopus	VU	A	x		**x***	**x***						5, 10, 19
Charadrahyla tecuani			x								x	
Charadrahyla trux[b]	CR	A	x			x			x	**x**		13, 14
Dendropsophus ebraccatus	LC					x		x				
Dendropsophus microcephalus	LC										x	
Dendropsophus robertmertensi	LC							x				
Dendropsophus sartori	LC	A	x			x		x				
Diaglena spatulata	LC		x			x	x					
Duellmanohyla chamulae	EN	Pr	x			x			x			

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Duellmanohyla ignicolor	EN	Pr	x			x		x	**x***			13
Duellmanohyla schmidtorum	VU	Pr				x			x			
Ecnomiohyla echinata[b]	CR	Pr	x			x			x	**x**		13, 14
Ecnomiohyla miotympanum	NT		x		**x***	x						10, 19
Ecnomiohyla valancifer	CR	Pr	x			x						
Exerodonta abdivita	DD		x			x						
Exerodonta bivocata	DD		x			x						
Exerodonta chimalapa	EN		x			x						
Exerodonta juanitae	VU	A	x			x			x			
Exerodonta melanomma	VU	Pr	x			x			**x***			13, 18
Exerodonta pinorum	VU	Pr	x			x			x			
Exerodonta smaragdina	LC	Pr	x			**x***		**x**				15
Exerodonta sumichrasti	LC		x			x						
Exerodonta xera	VU		x			x						
Hyla arboricola	DD		x			x						
Hyla arenicolor	LC							**x**				2
Hyla euphorbiacea	NT		x			x			**x**			18

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Hyla eximia	LC		x		**x**				**x**			2, 7, 18
Hyla plicata	LC	A	x								x	
Hyla walker	VU					x						
Hyla wrightorum	LC										x	
Megastomatohyla mixe	CR	Pr	x			x						
Megastomatohyla mixomaculata	EN	A	x			**x***						5
Megastomatohyla nubicola	EN	A	x			x						
Megastomatohyla pellita[b]	CR		x			x			x	**x**		13, 14
Pachymedusa dacnicolor	LC		x		**x**	x						7, 12
Plectrohyla acanthodes	CR	Pr				x			x			
Plectrohyla ameibothalame	DD		x			x			x			
Plectrohyla arborescandens	EN	Pr	x			**x***		x	x			5
Plectrohyla avia	CR	Pr				x			x			
Plectrohyla bistincta	LC	Pr	x			**x***		**x**	x			17
Plectrohyla calthula	CR		x			**x***			x			20
Plectrohyla calvicollina[b]	CR		x			x			x	**x**		13, 14

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Plectrohyla celata[b]	CR		x			x			x	**x**		13, 14
Plectrohyla cembra[b]	CR	A	x			x			x	**x**		13, 14
Plectrohyla charadricola	EN	A	x			x			x			
Plectrohyla chryses	CR	Pr	x			x			x			
Plectrohyla crassa	CR	Pr	x			x			x			
Plectrohyla cyanomma[b]	CR	A	x			x			x	**x**		13, 14
Plectrohyla cyclada	EN		x			x			**x***			13
Plectrohyla ephemera[b]	CR		x			x			**x***			14, 21, 22
Plectrohyla guatemalensis	CR					x			x	**x**		13
Plectrohyla hartwegi	CR	Pr				x		x	x	**x**		13
Plectrohyla hazelae[b]	CR	Pr	x			x			x	**x**		13, 14
Plectrohyla ixil	CR					x			**x***			21
Plectrohyla labedactyla[c]	DD		x			**x***						16
Plectrohyla lacertosa	EN	Pr	x			x			x			
Plectrohyla matudai	VU					x		x	**x***			13
Plectrohyla miahuatlanensis	DD		x			x						
Plectrohyla mykter	EN	A	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Plectrohyla pachyderma[c]	CR	Pr	x			**x***			x			16
Plectrohyla pentheter	EN		x			x			x			
Plectrohyla psarosema	CR		x			x						
Plectrohyla pycnochila	CR	A	x			x			x			
Plectrohyla robertsorum	EN	A	x			x			x			
Plectrohyla sabrina	CR	A	x			x			**x***			13
Plectrohyla sagorum	EN					x		x	**x***			13
Plectrohyla siopela[b]	CR		x			x			x	**x**		14
Plectrohyla thorectes[b]	CR	Pr	x			x			x	**x**		13, 14
Pseudacris cadaverina	LC					x		x				
Pseudacris clarkii	LC					x						
Pseudacris regilla	LC			**x**				**x**				4, 23
Ptychohyla acrochorda	DD		x			x			x			
Ptychohyla erythromma	EN	Pr	x			x			**x***			13
Ptychohyla euthysanota	NT	A				x		x	x			

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Ptychohyla leonhardschultzei	EN	Pr	x			x			x	**x**		13
Ptychohyla macrotympanum											x	
Ptychohyla zophodes	DD		x			x			**x***			13
Scinax staufferi	LC										x	
Smilisca baudinii	LC				**x**							7
Smilisca cyanosticta	NT					x			x	**x**		13
Smilisca dentata	EN	A	x			**x***		x				2, 24
Smilisca fodiens	LC					x						
Tlalocohyla godmani	VU	A	x			x						
Tlalocohyla loquax	LC					x						
Tlalocohyla picta	LC					**x**						5
Tlalocohyla smithii	LC		x			**x***						15
Trachycephalus venulosus	LC										x	
Triprion petasatus	LC	Pr									x	
Leiuperidae												
Engystomops pustulosus	LC					x						
Leptodactylidae												
Leptodactylus fragilis	LC					**x**						5

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Leptodactylus melanonotus	LC					**x**		x				15
Microhylidae												
Gastrophryne elegans	LC	Pr				x		x				
Gastrophryne olivacea	LC	Pr					x					
Gastrophryne usta	LC	Pr				**x***						15
Hypopachus barberi	VU					x						
Hypopachus variolosus	LC					**x**						15
Ranidae												
Lithobates berlandieri	LC	Pr			**x**				**x**			1, 9, 10, 21, 25, 26
Lithobates brownorum		Pr		**x**								27, 28, 29
Lithobates catesbeianus	LC										x	
Lithobates chichicuahutla	CR		x			x						
Lithobates chiricahuensis	VU	A		x		x		x	x			
Lithobates dunni	EN	Pr	x		x	x		x				
Lithobates forreri	LC	Pr			**x**			**x**				7, 11, 17, 30, 31, 32
Lithobates johni	EN	P	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Lithobates lemosespinali	DD		x			x						
Lithobates maculatus	LC					x		x				
Lithobates magnaocularis	LC		x		**x**	x						32
Lithobates megapoda	VU	Pr	x		**x**	**x***	x	**x***	**x**			10, 17, 18, 26, 31, 33
Lithobates montezumae	LC	Pr	x	x	**x***	**x***		**x**	**x**			7, 10, 17, 18, 31, 34
Lithobates neovolcanicus	NT	A	x		x	**x***	x	**x**	**x**			2, 17, 18
Lithobates omiltemanus[b]	CR	P	x			**x***			**x**	**x**		13, 14, 35
Lithobates psilonota[c]	DD		x			**x***		**x**				2, 16
Lithobates pueblae[b,c]	CR	P	x			**x***				**x**		14, 16
Lithobates pustulosus	LC	Pr	x								x	
Lithobates sierramadrensis	VU	Pr	x			x			**x***			13
Lithobates spectabilis	LC		x		**x**	x		**x***				12, 18
Lithobates tarahumarae	VU			x		x	x	x	**x***			36, 37

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Lithobates tlaloci[b]	CR	P	x			**x***		**x***		**x**		14, 38, 39, 40
Lithobates vaillanti	LC			**x***	**x**			x				27, 28, 29
Lithobates yavapaiensis	LC	Pr		**x***		**x***	x	x	x			1, 4, 41, 42
Lithobates zweifeli	LC		x			x						
Rana boylii	NT	Pr		x		**x***						1
Rana draytonii	VU			x	x	**x***	x	x	x			1
Rhinophrynidae												
Rhinophrynus dorsalis	LC	Pr									x	
Scaphiopodidae												
Scaphiopus couchii	LC										x	
Spea bombifrons	LC										x	
Spea hammondii	NT			x		x						
Spea multiplicata	LC				**x**	x						7
Caudata												
Ambystomatidae												
Ambystoma altamirani	EN	A	x	x	**x***	**x***		x	**x**			10, 18, 30, 43, 44
Ambystoma amblycephalum	CR	Pr	x	x		**x***		**x***				17
Ambystoma andersoni	CR	Pr	x	x	**x***	**x**		**x***				17

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Ambystoma bombypellum	CR	Pr	x	x		x		x				
Ambystoma dumerilii	CR	Pr	x	x	**x***	**x***		**x***				10, 17, 30, 45
Ambystoma flavipiperatum	DD	Pr	x	x		x		x				
Ambystoma granulosum	CR	Pr	x	x		x		x	**x**			18
Ambystoma leorae	CR	A	x	x	**x**	**x***		x				30, 44
Ambystoma lermaense	CR	Pr	x	x	**x***	**x***		**x***				10, 30, 46, 44
Ambystoma mavortium											x	
Ambystoma mexicanum	CR	Pr	x	**x***	**x***	**x***	**x***	**x***				10, 34, 47, 48
Ambystoma ordinarium	EN	Pr	x	x		**x***		**x***				17
Ambystoma rivulare	DD	A	x	x	**x***	**x***		x	**x**			18, 30, 44
Ambystoma rosaceum	LC	Pr	x	x		x						
Ambystoma silvense	DD		x	x		x						
Ambystoma subsalsum			x								x	
Ambystoma taylori	CR	Pr	x		**x**	x		x				10, 30
Ambystoma tigrinum	LC	Pr		**x***	**x**	**x***	**x**	**x**		**x**		2, 17, 38

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Ambystoma velasci	LC	Pr	x	x	**x**	**x***	x	x	**x**			10, 18, 30, 44
Plethodontidae												
Aneides lugubris	LC	Pr				x						
Batrachoseps major	LC					x						
Bolitoglossa alberchi	LC		x			x						
Bolitoglossa engelhardti	EN	Pr				x						
Bolitoglossa flavimembris	EN	Pr				x						
Bolitoglossa flaviventris	EN					x						
Bolitoglossa franklini	EN	Pr		x		x						
Bolitoglossa hartwegi	NT					x				**x**		49
Bolitoglossa hermosa	NT	Pr	x			x						
Bolitoglossa lincolni	NT					x						
Bolitoglossa macrinii	NT	Pr	x			x						
Bolitoglossa mexicana	LC	Pr				x						
Bolitoglossa mulleri	VU					x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Bolitoglossa oaxacensis	DD		x			x						
Bolitoglossa occidentalis	LC	Pr				x						
Bolitoglossa platydactyla	NT	Pr	x			x						
Bolitoglossa riletti	EN	Pr	x			x	x					
Bolitoglossa rostrata	VU	Pr				x	**x**			**x**		50
Bolitoglossa rufescens	LC	Pr				x						
Bolitoglossa stuarti	DD	Pr				x						
Bolitoglossa veracrucis	EN	Pr	x			x						
Bolitoglossa yucatana	LC	Pr				x						
Bolitoglossa zapoteca	DD		x			x						
Chiropterotriton arboreus	CR	Pr	x			x						
Chiropterotriton chiropterus	CR	Pr	x			x						
Chiropterotriton chondrostega	EN	Pr	x			x						
Chiropterotriton cracens	EN		x				x		x			

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Chiropterotriton dimidiatus	EN	Pr	x		**x**	x	**x**			**x**		34, 49, 50
Chiropterotriton lavae	CR	Pr	x			x		x				
Chiropterotriton magnipes[b]	CR	Pr	x			x				**x**		14
Chiropterotriton mosaueri[b]	DD	Pr	x			x				**x**		14
Chiropterotriton multidentatus	EN	Pr	x		**x**	x	**x***		x	**x**		14, 34, 49, 50
Chiropterotriton orculus	VU		x			x						
Chiropterotriton priscus	NT	Pr	x			x						
Chiropterotriton terrestris	CR		x			x						
Cryptotriton adelos	EN	Pr	x			x						
Cryptotriton alvarezdeltoroi	EN	Pr	x			x						
Dendrotriton megarhinus	VU	Pr	x								x	
Dendrotriton xolocalcae	VU	Pr	x			x						
Ensatina eschscholtzii	LC	Pr				x						
Nyctanolis pernix	EN	Pr				x						
Oedipina elongata	LC	Pr				x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Parvimolge townsendi	CR	A	x			x	**x**			**x**		49, 50
Pseudoeurycea ahuitzotl	CR		x			x						
Pseudoeurycea altamontana	EN	Pr	x			x						
Pseudoeurycea amuzga	DD		x			x						
Pseudoeurycea anitae	CR	A	x			x						
Pseudoeurycea aquatica[b]	CR		x			**x***				**x**		14, 51
Pseudoeurycea aurantia	VU		x			x						
Pseudoeurycea bellii	VU	A	x	x	**x**	**x***	x			**x**		34, 49
Pseudoeurycea boneti	VU		x	x		x						
Pseudoeurycea brunnata	CR	Pr				x						
Pseudoeurycea cephalica	NT	A	x			**x***	**x**					49
Pseudoeurycea cochranae	EN	A	x			x						
Pseudoeurycea conanti	EN	A	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Pseudoeurycea firscheini	EN	Pr	x			x						
Pseudoeurycea gadovii	EN	Pr	x			x						
Pseudoeurycea galeanae	NT	A	x			x						
Pseudoeurycea gigantea	CR		x	x		x		x				
Pseudoeurycea goebeli	CR	A				x						
Pseudoeurycea juarezi	CR	A	x			x				**x**		49
Pseudoeurycea leprosa	VU	A	x			**x***	**x**					49
Pseudoeurycea lineola	EN	Pr	x			x				**x**		49
Pseudoeurycea longicauda	EN	Pr	x			x						
Pseudoeurycea lynchi	CR		x			x		x				
Pseudoeurycea maxima	DD		x			x						
Pseudoeurycea melanomolga	EN	Pr	x			x						
Pseudoeurycea mixcoatl	DD		x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Pseudoeurycea mixteca	LC		x								x	
Pseudoeurycea mystax	EN		x			x						
Pseudoeurycea naucampatepetl[b]	CR	A	x			x				**x**		14
Pseudoeurycea nigra	CR	P	x			x						
Pseudoeurycea nigromaculata[b]	CR	Pr	x			x	**x**			**x**		14, 50
Pseudoeurycea obesa	DD		x			x						
Pseudoeurycea orchileucos	EN		x			x						
Pseudoeurycea orchimelas	EN		x			x						
Pseudoeurycea papenfussi	NT		x			x						
Pseudoeurycea parva[b]	CR	A	x			x				**x**		14
Pseudoeurycea praecellens[b,c]	CR	A	x			**x***				**x**		14, 16, 49
Pseudoeurycea quetzalanensis	DD		x			x						
Pseudoeurycea rex	CR	Pr				x	**x**			**x**		50
Pseudoeurycea robertsi	CR	A	x			x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Pseudoeurycea ruficauda	DD		x			x						
Pseudoeurycea saltator	CR	A	x			x						
Pseudoeurycea scandens	VU	Pr	x			x						
Pseudoeurycea smithi	CR	A	x	x		**x***	**x**			**x**		49, 50
Pseudoeurycea tenchalli	EN		x			x						
Pseudoeurycea teotepec	EN		x			x						
Pseudoeurycea tlahcuiloh	CR		x			x						
Pseudoeurycea tlilicxitl	DD		x								x	
Pseudoeurycea unguidentis	CR	A	x			**x***	**x**		x	**x**		49, 50
Pseudoeurycea werleri	EN	Pr	x			x						
Thorius arboreus	EN		x			x						
Thorius aureus	CR		x	x		x	x					
Thorius boreas	EN		x	x		x	x					
Thorius dubitus	EN	Pr	x			x	**x**			**x**		50
Thorius grandis	EN		x			x						
Thorius infernalis[b,c]	CR		x			**x***				**x**		14, 16

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Thorius insperatus	DD		x			x						
Thorius lunaris	EN		x			x						
Thorius macdougalli	VU	Pr	x			x						
Thorius magnipes[b]	CR		x			x	**x**			**x**		14, 50
Thorius minutissimus	CR	Pr	x			x						
Thorius minydemus[c]	CR		x			**x***		x				16
Thorius munificus	CR		x			x						
Thorius narismagnus[b]	CR		x	x		x				**x**		14
Thorius narisovalis[b]	CR	Pr	x	x		**x***				**x**		14, 49
Thorius omiltemi	EN		x			x						
Thorius papaloae	EN		x			x						
Thorius pennatulus	CR	Pr	x	x		x	**x**			**x**		49, 50
Thorius pulmonaris	EN	Pr	x			**x***				**x**		49
Thorius schmidti	EN		x			x						
Thorius smithi	CR	Pr	x			x						
Thorius spilogaster	CR		x			x						
Thorius troglodytes	EN	Pr	x			x	**x**			**x**		49, 50
Salamandridae												
Notophthalmus meridionalis	EN	P				x		x				
Sirenidae												
Siren intermedia	LC	Pr				x						

Table 3 continued

	IUCN category	Mexican official list	Endemic to Mexico	Alien species	Over-exploitation	Land use change	Global changes	Pollution	Emerging infectious diseases	Lack of recent observations	Lack of information	References
Siren lacertina	LC	Pr				x						
Gymnophiona												
Caeciliidae												
Dermophis mexicanus	VU	Pr				x						
Dermophis oaxacae	DD	Pr	x							**x**		33

Red list categories are indicated as follows: Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). The column Mexican official list indicates the conservation status given by the Mexican government: Threatened with Extinction (P), Threatened (A), and Under Special Protection (Pr). Species in bold type are those for which we found published evidence of actual or potential threats; bold type x indicates the corresponding documented threat. *Asterisks* indicate that both the IUCN-GAA database and published literature document the corresponding threat. *Underlined* species are those not included in the IUCN red list (2010). Lack of recent observations indicates those species that have not been found recently in the wild or whose natural abundances have decreased dramatically during the past years. References in the last column are as follows: 1. Lovich et al. (2009); 2. Vázquez-Díaz and Quintero-Díaz (2005); 3. Santos-Barrera et al. (1994); 4. Grismer (2002); 5. Pineda and Halffter (2004); 6. Canseco-Márquez and Gutiérrez-Mayén (2006); 7. Ruíz-Boites (2008); 8. Camargo-Cruz (1998); 9. Cedeño-Vázquez et al. (2006); 10. Lazcano-Barrero et al. (1986); 11. García and Ceballos (1994); 12. Aguilar et al. (2003); 13. Lips et al. (2004); 14. Baena et al. (2008); 15. Suazo-Ortuño (2002); 16. Ochoa-Ochoa et al. (2009); 17. Alvarado-Díaz (1999); 18. Frías-Alvarez et al. (2008); 19. Cabañas-Hernández (1974); 20. Ustach et al. (2000); 21. Familiar-López (2007); 22. Meik et al. (2005); 23. González-Bernal (2008); 24. Sigala-Rodríguez and Greene (2009); 25. Santos-Barrera (2004); 26. Rudich de la Rosa (1980); 27. Álvarez-Romero et al. (2008); 28. Brooks et al. (2006); 29. León-Règagnon et al. (2005); 30. Casas-Andreu and Aguilar-Miguel (1997a); 31. Casas-Andreu et al. (2001); 32. Chávez et al. (1995); 33. González-Ruiz (2002); 34. Ramírez-Bautista et al. (2009); 35. Flores-Villela and Muñoz-Alonso (1993); 36. Hale (2001); 37. Hale et al. (2005); 38. Méndez-de la Cruz et al. (1992); 39. Hillis and Frost (1985); 40. Casas-Andreu (1989); 41. Rorabaugh et al. (2002); 42. Mellink and Ferreira-Bartrina (2000); 43. Rodríguez-Reyes (2009); 44. Casas-Andreu and Aguilar-Miguel (1997b); 45. Huacuz-Elías (2002); 46. Mendoza-Almeralla (2006); 47. Zambrano et al. (2007); 48. Contreras et al. (2009); 49. Parra-Olea et al. (1999); 50. Rovito et al. (2009); 51. Wake and Campbell (2001)

[a] The IUCN data base does not consider this species as to be present in Mexico; however it actually occurs in southeastern Mexico

[b] Species presumably extinct according to Baena et al. (2008)

[c] Species presumably extinct according to Ochoa-Ochoa et al. (2009)

out of 372 described species in Mexico; Ochoa-Ochoa and Flores-Villela 2006; Frost 2010). According to global data, Mexico is considered as number two within the list of countries with the greatest numbers of threatened species (Stuart et al. 2008). It is important to notice that the number of Mexican amphibian species currently considered as threatened is underestimated because 38 of them (10.44%) are included in the DD category. Moreover, seven Mexican amphibian species are not included in the GAA red list and nothing is known about their conservation status or population trends. Future conservation assessments will thus raise the proportion of amphibian species that in Mexico are experiencing serious threats.

Even though the IUCN does not formally consider any Mexican amphibian as extinct in the wild (i.e., no species listed as EX or EW), a recent assessment of the Mexican biodiversity reports 29 species as extinct (Baena et al. 2008; these species are indicated in Table 3). Most of these 29 amphibian taxa are in the CR category of the IUCN (2010). The only exception is *Chiropterotriton mosaueri* which is listed as DD. The main criteria for considering these amphibians as extinct by Baena et al. (2008) are the deep disturbance of habitat structure along with the lack of recent observations in spite of extensive field work (e.g., *Pseudoeurycea aquatica*; Wake and Campbell 2001). Nevertheless, these authors recognize that these extinctions have been suggested but not yet confirmed. Additionally, Ochoa-Ochoa et al. (2009) state that 9 microendemic taxa represent possible extinctions (also indicated in Table 3). These species are considered as DD, EN, or CR by the IUCN (2010). Baena et al. (2008) and Ochoa-Ochoa et al. (2009) coincide in three species (*Lithobates pueblae*, *Pseudoeurycea praecellens*, and *Thorius infernalis*) which gives a total of 35 presumably extinct amphibians in Mexico. Without a doubt, these species are among those that deserve urgent attention. Biological surveys are needed to determine the existence and viability of their natural populations.

Clearly, the taxonomic pattern on the number and proportion of threatened species is not random. Certain families are experiencing higher rates of declines. For instance, more than 73% of the species in the family Plethodontidae (84 species) are considered as either VU, EN or CR. This fact is greatly significant, given that this family is widespread throughout much of the country and represents a large proportion of the Mexican fauna. Most of the threatened species in the Plethodontidae have very restricted geographic distributions and exhibit very specific micro-habitat requirements. As an example consider the species in the genera *Thorius* and *Chiropterotriton*, which have 95.65 and 83.33% of threatened species, respectively (Parra-Olea et al. 1999; Rovito et al. 2009).

The IUCN-GAA (2010) recognizes that almost 65% of the species in the family Ambystomatidae in Mexico are threatened as well. This family in this country is represented only by the genus *Ambystoma*. Salamanders and axolotls from this genus are of special importance given that 17 out of the 19 species currently recognized for Mexico are endemic with notably restricted geographic distributions (IUCN 2010; Frost 2010). From such 17 endemic ambystomatids, 9 are listed as CR and 2 as EN (Tables 2, 3). Three other members of *Ambystoma* (*A. flavipiperatum*, *A. rivulare*, and *A. silvense*) lack the necessary information to propose accurate conservation categories. Therefore, they have been classified as DD. However, they also exhibit considerably small areas of occurrence, which is an important criterion for including taxa into a high-priority category. This clear risk of extinction experienced by such a large proportion of species in this genus, which is considered as emblematic of the Mexican culture and representative of the Mexican fauna (Armstrong and Malacinski 1989; Huacuz-Elías 2002; Zambrano et al. 2007), is unfortunate and disturbing.

When comparing the IUCN red list with that issued by the Mexican environmental agency (NOM-059-ECOL-2001, Secretaría de Medio Ambiente y Recursos Naturales 2002), we realized that the latter misses an important large number of species: 170 taxa from which 73 are threatened according to the IUCN. Also disturbing are the 126 amphibian species that are included into lower-risk conservation categories by the Mexican authorities in comparison with those assigned by the IUCN, as well as the low level of coincidence between the two lists (only 59 species are in coincident categories). These facts reflect two main issues. First, in Mexico the conservation status of amphibians is considered to be way better than their actual situation. Second, the official knowledge about the amphibian fauna in this country is markedly out of date. This is noticeable because in 1994 the number of species in Mexico recognized as threatened by the IUCN was strikingly low in comparison with the Mexican official list (Flores-Villela and Gerez 1994). Obviously, this is not the case anymore. The consequence is clear cut: within Mexico several threatened amphibians can be officially ignored, traded, and exploited.

Among the six factors that Collins and Storfer (2003) proposed as the main causes of amphibian declines, land use change is by far the most important affecting Mexican species (322 affected species; Table 3). Agriculture, aquaculture, cattle breeding, logging, wood harvesting, and urban development are the most common activities in Mexico that promote habitat destruction and fragmentation (Merino-Pérez 2003). This has seriously impacted the diversity and abundance of amphibian populations. In several well-studied neotropical regions in Mexico, where habitat destruction has been evident, nowadays it is difficult to find a single amphibian, even though 30–35 years ago many plethodontid salamanders were encountered by hundreds (Parra-Olea et al. 1999; Lips et al. 2004; Rovito et al. 2009). The xeric habitats in northern Mexico have also suffered from intense land use change, negatively affecting amphibian populations. For example, human development in the Baja California region is depleting freshwater and associated native habitats, critically threatening species such as *Anaxyrus californicus* and *Rana draytonii* (Lovich et al. 2009). Similarly, increasing urbanization in the dry plains of Aguascalientes has reduced drastically the distribution range of *Smilisca dentata*, a micro-endemic species considered as EN (Vázquez-Díaz and Quintero-Díaz 2005; Sigala-Rodríguez and Greene 2009). In fact, Ochoa-Ochoa et al. (2009) demonstrated that all amphibians endemic to Mexico have suffered the effects of habitat loss and 36 of such species have lost more than 50% of their original area of distribution.

Emerging infectious diseases represent the second most important threat to Mexican amphibians. It has long been recognized that new diseases caused by infectious agents such as bacteria, viruses, and fungi can cause the decline and extinction of amphibian populations (Collins and Storfer 2003). One of the major pathogens presently known as responsible for several cases of decline of amphibians in the wild and in captivity is the fungus *Batrachochytrium dendrobatidis* (*Bd*; Berger et al. 1998). Research on the presence and effects of this disease (chytridiomycosis) in Mexico is only starting. Nevertheless, a few studies have documented the presence of *Bd* in Mexican amphibian species, either by indirect evidence such as the loss of keratinized mouthparts in tadpoles (Lips et al. 2004) or by direct examination of specimens (both adults and larvae) using real-time PCR assays (Frías-Alvarez et al. 2008). Several species (almost all endemic to Mexico) have been found positive with *Bd* (e.g., *Agalychnis moreletii*, *Ambystoma altamirani*, *A. granulosum*, *A. mexicanum*, *A. rivulare*, *A. velasci*, *Craugastor saltator*, *Hyla euphorbiacea*, *H. eximia*, *Exerodonta melanomma*, *Lithobates megapoda*, *L. montezumae*, *L. neovolcanicus*, *L. spectabilis*, *Pachymedusa dacnicolor*, and *Ptychohyla erythromma*; Lips et al. 2004; Frías-Alvarez et al. 2008). Many other species might present this fungus but not enough

surveys have been conducted. This disease might have played an important role in the declines of Mexican amphibians in high-altitude zones, where habitats remain relatively pristine (Lips et al. 2004). However, future studies are urgently needed to confirm this hypothesis.

Chemical pollution is another important factor causing negative population trends in Mexican amphibians. Excessive use of fertilizers, pesticides and other synthetic organic compounds has generated high levels of water contamination. Moreover, the water bodies adjacent to urban settlements usually receive elevated amounts of wastewater (CONAGUA 2007). Metals as aluminum, zinc, plumb, mercury, arsenic, and silver have strong impacts on amphibians such as slow growth and developmental and behavioral alterations (Blaustein and Kiesecker 1997). Sosa et al. (2002) reported severe corporal malformations in an unidentified species of *Hyla* inhabiting near a mine in the state of Guanajuato. These malformations are apparently associated with the abundance of tailings (a mineral mix containing calcium, magnesium, iron, potassium and toxic metals such as copper, zinc, plumb, and silver) in the zone. Several endemic species of threatened neotenic axolotls in the genus *Ambystoma* inhabit freshwater systems in central Mexico, which is currently the region with the highest human population density and with the highest levels of water pollution (Ezcurra et al. 2006). Various species in the genera *Incilius* and *Lithobates* are also suffering from the pollution of the water bodies where they inhabit (Table 3).

A total of 41 Mexican amphibians are experiencing the negative effects of alien species. Clearly, most ambystomatid salamanders and some native members of the genus *Lithobates* are currently threatened by exotic species (Table 3). All these species have in common a strong dependency of water bodies and all throughout Mexico many species of farmed fish have been introduced to such freshwater systems (Arredondo-Figueroa 1983; Courtenay 1997). These exotic fishes prey upon eggs, tadpoles and juveniles and are rough competitors for native amphibians (Canonico et al. 2005).

Alien amphibians also represent a serious threat for native species (Kraus 2009). Some members of the genus *Lithobates*, when introduced to places outside their original range of distribution, exert strong pressures on the native fauna. These species can be voracious predators, rough competitors, and disease vectors (Lever 2003; León-Règagnon et al. 2005; Brooks et al. 2006; Álvarez-Romero et al. 2008). *Lithobates catesbeianus*, the American bullfrog, has been introduced to southern and western Mexico (Domínguez-Torres and Mellink 2003; Lever 2003; Cisneros-Heredia 2004; Kraus 2009) and currently represents a serious risk for local populations of amphibians (Casas-Andreu et al. 2001). This species, which is commonly farmed for human consumption, is an aggressive and generalist predator that displaces other native amphibians (Casas-Andreu et al. 2001; Álvarez-Romero et al. 2008). For example, the introduction of *L. catesbeianus* to the lower Colorado River has been associated with the local extirpation of *L. yavapaiensis* (Mellink and Ferreira-Bartrina 2000). Moreover, bullfrogs appear to transmit parasites to local amphibians. The trematod, *Haematoloechus floedae*, originally described from the lungs of *L. catesbeianus*, has been recently detected in *L. brownorum* and *L. vaillanti*, in the Yucatán peninsula (León-Règagnon et al. 2005; Brooks et al. 2006).

Two other aggressive ranids have expanded their range of distribution to northwestern Mexico. *Lithobates berlandieri* (introduced to northwestern Sonora, northern Baja California, and the Colorado River; Rorabaugh et al. 2002) and *L. forreri* (introduced to the Baja California peninsula; Grismer 2002; Álvarez-Romero et al. 2008) have invaded riverine and agricultural habitats. These species might likely contribute to the regional decline and extirpation of native ranid frogs such as *L. yavapaiensis* (Mellink and Ferreira-Bartrina 2000; Rorabaugh et al. 2002). Another anuran species native to Africa, *Xenopus*

laevis, has also been introduced to the northern portion of the Baja California peninsula (Domínguez-Torres and Mellink 2003; Lever 2003; Kraus 2009). Its effects on native amphibian fauna are not completely clear, but it has been suggested that this alien frog can be a strong competitor and an important predator of larvae of native amphibians (Álvarez-Romero et al. 2008).

Global warming and increased ultraviolet radiation is apparently affecting 36 amphibian species in Mexico. Unfortunately, studies attempting to formally test the effects of these factors on their population trends are remarkably scarce. However, the existing evidence highlights the feasible consequences of these global changes. Parra-Olea et al. (2005) used the Genetic Algorithm for Rule-set Prediction (GARP) and projected the potential distribution of two endemic plethodontid species (*Pseudoeurycea leprosa* and *P. cephalica*) under scenarios of global climate change. They suggested that the effects of climate change may drastically reduce their geographic distribution and therefore, decrease the persistence probabilities of *P. leprosa* and *P. cephalica*. These effects could be more drastic for *P. leprosa* which may lose almost 75% of its distributional area approximately by the year 2050. This scenario of habitat reduction caused by present and future increases in the global temperature (Thomas et al. 2004) must also apply for many other vertebrate species in Mexico, as has just been shown for Mexican lizards (Huey et al. 2010; Sinervo et al. 2010).

Several studies have documented the adverse effects of ultraviolet radiation (particularly of the B portion of the spectrum: UV-B) in amphibians (Blaustein et al. 1995; Lizana and Pedraza 1998; Broomhall et al. 2000; Häkkinen et al. 2001). These negative effects can be lethal (mortality) or sub-lethal (e.g., malformations and lowered rates of growth) and can affect different developmental stages (embryos, tadpoles, juveniles, and adults; Blaustein et al. 2001). The embryo stage is probably the most vulnerable to UV-B radiation (Langhelle et al. 1999). Frías-Alvarez et al. (2010) conducted controlled experiments with the Mexican axolotl, *Ambystoma mexicanum*, which is an endemic and critically endangered species that nowadays can only be found in two reduced water bodies immersed within Mexico City (Zambrano et al. 2007; Contreras et al. 2009). They found that the environmental UV-B radiation of Mexico City negatively affects hatching success, time to hatch, size of hatchlings, and significantly induces several types of malformations. This in turn would drastically affect the persistence probability of the remaining population of this emblematic species for the Mexican culture (Zambrano et al. 2007). Experimental or empirical evidence of the adverse effects of increased ultraviolet radiation on other Mexican amphibians is currently lacking.

In Mexico, several species of amphibians such as *Ambystoma dumerilii*, *A. mexicanum*, *Charadrahyla taeniopus*, *Ecnomiohyla miotympanum*, *Incilius marmoreus*, *I. valliceps*, *Lithobates berlandieri*, *L. megapoda*, *L. montezumae*, and *Rhinella marina* are used for food, as folk ornaments, or in traditional medicine (Cabañas-Hernández 1974; Lazcano-Barrero et al. 1986; Huacuz-Elías 2002; Ruíz-Boites 2008; Ramírez-Bautista et al. 2009). Other species experience relatively high levels of pet trade such as *A. taylori*, *Chiropterotriton dimidiatus*, *C. multidentatus*, *Hyla eximia*, *Pachymedusa dacnicolor*, *Pseudoeurycea bellii*, and *Smilisca baudini* (Lazcano-Barrero et al. 1986; Aguilar et al. 2003; Vázquez-Díaz and Quintero-Díaz 2005; Ruíz-Boites 2008; Ramírez-Bautista et al. 2009). The lack of federal regulations or monitoring programs for these activities is resulting in the over-exploitation of these organisms (36 species are under this threat), which in turn is drastically reducing their natural populations. A clear example is the 53% demographic decrease documented for *A. dumerilii* (Huacuz-Elías 2001, 2002). However, recent efforts have had success in reproducing *A. dumerilii* in captivity for commercial and research

purposes (Pérez-Saldaña et al. 2006), which in the long term would help to minimize the over-exploitation of its natural population.

One of the main findings of our extensive literature search was the unfortunate scarcity of formal demographic or genetic studies that quantitatively address the population trends of Mexican amphibians. Even though the concern and scientific interest in the conservation status of amphibians occurred approximately at the same time in Mexico (Lazcano-Barrero et al. 1986; Casas-Andreu 1989; Flores-Villela and Gerez 1994; Santos-Barrera et al. 1994) as in other countries (Barinaga 1990; Wake 1991), few studies have been conducted in Mexico since then. For only 138 species (37.1%) we could find some documented evidence of actual or potential threats (Table 3). Furthermore, only two studies formally examined the population dynamics of threatened native amphibians (*Ambystoma mexicanum* and *A. altamirani*; Zambrano et al. 2007; Rodríguez-Reyes 2009), whereas not even a single work evaluated the conservation genetics of their studied species. Thus, the great majority of the conservation status rankings are based mostly on appreciative comparisons of species abundances in the past and in recent years, on reports of apparent reductions of distributional ranges and on the presence of imminent threats such as the detection of the chytrid fungus in some localities. Therefore, we strongly encourage future quantitative (either demographic, genetic or both) work on these organisms in Mexico in order to provide the basis for strongly-supported conservation categories.

Concluding remarks

The general picture that we presented here on the conservation status and decline trends of Mexican amphibians appears to be disturbing. Rather than pretending to be pessimistic about the future, we aimed to motivate, with this information, development of future studies on these organisms in Mexico. Even though this country represents the fifth largest amphibian fauna in the world (Ochoa-Ochoa and Flores-Villela 2006; Stuart et al. 2008; IUCN 2010), only few scientists, academic institutions, and funding agencies are currently working and investing resources on this vertebrate group. In fact, many Mexican species lack the necessary information to propose more accurate conservation categories. Our summary may also be used as a basis to guide future studies because it points out to the taxa that suffer from unfortunate lack of information as well as to those that are under the highest risk and which in consequence need urgent attention. The first step towards the conservation of amphibians in Mexico is to acquire deep knowledge of their basic biology, distribution, taxonomy, demography, and population genetics.

Acknowledgments We are grateful to J. Bagley and two anonymous reviewers who made helpful comments to the manuscript. G. Parra-Olea, A. Muñoz-Alonso, and L. Canseco-Márquez provided valuable information. OFV acknowledges the support of J. Campbell and the University of Texas at Arlington as well as that provided by UNAM authorities. Most of the data summarized here was taken from the Global Amphibian Assessment—the International Union for Conservation of Nature. We recognize the great efforts that this institution makes to preserve and understand the world's biodiversity.

References

Aguilar R, Dorado O, Arias DM, Alcaraz H, Castro R (2003) Anfibios y reptiles de la Sierra de Huautla, Estado de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Universidad Autónoma del Estado de Morelos, Fondo Mexicano para la Conservación de la Naturaleza, Centro de Educación Ambiental e Investigación Sierra de Huautla, México

Alvarado-Díaz J (1999) Amphibians in Michoacan Mexico. Froglog 31:1

Álvarez-Romero JG, Medellín RA, Oliveras de Ita A, Gómez de Silva H, Sánchez O (2008) Animales exóticos en México: una amenaza para la biodiversidad. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Universidad Nacional Autónoma de México, Secretaria de Medio Ambiente y Recursos Naturales, Distrito Federal, México

Armstrong JB, Malacinski GM (1989) Developmental biology of the axolotl. Oxford University Press, New York

Arredondo-Figueroa JL (1983) Especies animales acuáticas de importancia nutricional introducidas en México. Biotica 8:175–199

Baena ML, Halffter G, Lira-Noriega A, Soberón J (2008) Extinción de especies. In: Soberón J, Halffter G, Llorente-Bousquets J (eds) Capital natural de México. Vol 1. Conocimiento actual de la biodiversidad. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Distrito Federal, México

Barinaga M (1990) Where have all the froggies gone? Science 247:1033–1034. doi:10.1126/science.247.4946.1033

Benítez-Díaz H, Bellot-Rojas M (2003) Biodiversidad: uso, amenazas y conservación. In: Sánchez O, Vega E, Peters E, Monroy-Vilchis O (eds) Conservación de sistemas templados de montaña en México, Instituto Nacional de Ecología-Secretaria de Medio Ambiente y Recursos Naturales (INE-SEMARNAT), pp 93–106

Berger L, Speare R, Daszak P, Green DE, Cunningham AA, Goggin CL, Slocombe R, Ragan MA, Hyatt AD, McDonald KR, Hines HB, Lips KR, Marantelli G, Parkes H (1998) Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proc Natl Acad Sci USA 95:9031–9036

Blaustein AR, Kiesecker JM (1997) The significance of ultraviolet-B radiation to amphibian population declines. Rev Toxicol 1:147–165

Blaustein AR, Edmond B, Kiesecker JM (1995) Ambient ultraviolet radiation causes mortality in salamander eggs. Ecol Appl 5:740–743. doi:10.2307/1941981

Blaustein AR, Belden LK, Hatch AC, Kats LB, Hoffman PD, Hays JB, Marco A, Chivers DP, Kiesecker JM (2001) Ultraviolet radiation and amphibians. In: Cockell CS, Blaustein AR (eds) Ecosystems, evolution, and ultraviolet radiation. Springer, New York, pp 63–79

Brooks DR, McLennan DA, León-Règagnon V, Hoberg E (2006) Phylogeny, ecological fitting and lung flukes: helping solve the problem of emerging infectious diseases. Rev Mex Biodivers 77:225–233

Broomhall SD, Osborne WS, Cunningham RB (2000) Comparative effects of ambient ultraviolet-B radiation on two sympatric species of Australian frogs. Conserv Biol 14:420–427

Cabañas-Hernández, D (1974) Etnozoología mexicana, biología y aprovechamiento de los "calates" H*yla miotympanum* Cope, e *Hyla taeniopus* Günther, en el municipio de Atzalan, Veracruz. Thesis, Escuela de Biología, Universidad Veracruzana, Jalapa, Veracruz

Camargo-Cruz E (1998) Determinación de metales pesados en el anfibio *Bufo valliceps* en la zona agrícola de Meztitlan Hidalgo. Bol Soc Herpetol Mex 8:21–23

Canonico GC, Arthington A, McCrary JK, Thieme ML (2005) The effects of the introduced tilapias on native biodiversity. Aquat Conserv Mar Freshw Ecosyst 15:463–483

Canseco-Márquez L, Gutiérrez-Mayén MAG (2006) Herpetofauna del municipio de Cuetzalan del Progreso, Puebla. In: Ramírez-Bautista A, Canseco-Márquez L, Mendoza-Quijano F (eds) Inventarios herpetofaunísticos de México: Avances en el conocimiento de su biodiversidad. Publicaciones de la Sociedad Herpetológica Mexicana No. 3, Distrito Federal, México

Casas-Andreu G (1989) Los anfibios y reptiles y su estado de conservación en el Estado de México. In: Gio AR, Hernández I, Sainz E (eds) Ecología Urbana. Sociedad Mexicana de Historia Natural, México

Casas-Andreu G, Aguilar-Miguel X (1997a) El Estado de México y la declinación mundial de anfibios. Siyan Can, Rev de la Fac Ciencias, UAEMéx Nueva Epoca 2:3–6

Casas-Andreu G, Aguilar-Miguel X (1997b) La polémica sobre la declinación mundial de poblaciones de anfibios. Ciencia Ergo Sum 4:97–102

Casas-Andreu G, Aguilar-Miguel X, Cruz-Aviña R (2001) La introducción y el cultivo de la rana toro (*Rana catesbeiana*). ¿Un atentado a la biodiversidad de México? Ciencia Ergo Sum 8:62–67

Cedeño-Vázquez JR, Calderón-Mandujano RR, Pozo C (2006) Anfibios de la región de Calakmul Campeche, México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, El Colegio de la Frontera Sur, Comisión Nacional de Áreas Naturales Protegidas, Programa de Naciones Unidas para el Desarrollo, Sociedad Herpetológica Mexicana, Sociedad Herpetológica Mexicana, México

Challenger A (2003) Conceptos generales de los ecosistemas templados de montaña de México y su estado de conservación In: Sánchez O, Vega E, Peters E, Monroy-Vilchis O (eds) Conservación de sistemas templados de montaña en México, Instituto Nacional de Ecología-Secretaria de Medio Ambiente y Recursos Naturales (INE-SEMARNAT), pp 17–44

Chávez EA, Valdez-Ornelas VA, Salgado-Barragán J (1995) La explotación y disponibilidad de rana en el noroeste de México. Ciencia Ergo Sum 2–3:361–366
Cisneros-Heredia DF (2004) Geographic distribution. *Rana catesbeiana*. Herpetol Review 35:406
Collins JP, Storfer A (2003) Global amphibian declines: sorting the hypotheses. Divers Distrib 9:89–98. doi: 10.1046/j.1472-4642.2003.00012.x
CONAGUA (Comisión Nacional del Agua) (2007) Estadísticas del agua en México. Comisión Nacional del Agua, México, Distrito Federal, México
Contreras V, Martínez-Meyer E, Valiente E, Zambrano L (2009) Recent decline and potential distribution in the last remnant area of the microendemic Mexican axolotl (*Ambystoma mexicanum*). Biol Conserv 142:2881–2885. doi:10.1016/j.biocon.2009.07.008
Courtenay WR (1997) Tilapias as non-indigenous species in the Americas: environmental, regulatory and legal issues. In: Costa-Pierce BA, Rakocy JE (eds) Tilapia aquaculture in the Americas, vol 1. World Aquaculture Society, Baton Rouge
Domínguez-Torres J, Mellink E (2003) Invasive aquatic animals and possible effects on native frogs and toads in mediterranean Baja California. Bull South Calif Acad Sci 102:89–95
Ezcurra E, Mazari-Hiriart M, Pisanty I, Aguilar AG (eds) (2006) La cuenca de México: aspectos ambientales críticos y sustentabilidad. Fondo de Cultura Económica, México
Familiar-López M (2007) La variación de la temperatura diaria y su relación con los brotes de quitridiomicosis en anfibios de las montañas de Guerrero y Oaxaca, México. Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México
Flores-Villela O, Canseco-Márquez L (2004) Nuevas especies y cambios taxonómicos para la herpetofauna de México. Acta Zool Mex 20:115–144
Flores-Villela O, Gerez P (1994) Biodiversidad y conservación en México: vertebrados, vegetación y uso del suelo, 2nd edn. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad and Universidad Nacional Autónoma de México, Distrito Federal, México
Flores-Villela O, Muñoz-Alonso A (1993) Anfibios y reptiles. In: Luna-Vega I, Llorente-Bousquets J (eds) Historia natural del parque ecológico estatal Omiltemi, Chilpancingo, Guerrero, México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad and Universidad Nacional Autónoma de México, Distrito Federal, México
Frías-Alvarez P, Vredenburg VT, Familiar-López M, Longcore JE, González-Bernal E, Santos-Barrera G, Zambrano L, Parra-Olea G (2008) Chytridiomycosis survey in wild and captive Mexican amphibians. Ecohealth 5:18–26. doi:10.1007/s10393-008-0155-3
Frías-Alvarez P, Zúñiga-Vega JJ, Parra-Olea G (2010) UV-B radiation severely affects embryo development in the Mexican axolotl. Anim Biol 60:299–318
Frost DR (2010) Amphibian species of the world: an online reference. Version 5.4. American Museum of Natural History, New York. http://research.amnh.org/vz/herpetology/amphibia/. Cited 13 April 2010
Frost DR, Grant T, Faivovic J, Bain RH, Haas A, Haddad CFB, De Sá RO, Channing A, Wilkinson M, Donnellan SC, Raxworthy CJ, Campbell JA, Blotto BL, Moler P, Drewes RC, Nussbaum RA, Lynch JD, Green DM, Wheeler WC (2006) The amphibian tree of life. Bull Am Mus Nat Hist 297:1–370
Gallant AL, Klaver RW, Casper GS, Lannoo MJ (2007) Global rates of habitat loss and implications for amphibian conservation. Copeia 2007:967–979
García A, Ceballos G (1994) Guía de campo de los reptiles y anfibios de la costa de Jalisco México, Fundación Ecológica de Cuixmala A.C. Instituto de Biología, Universidad Nacional Autónoma de México, México
González-Bernal EL (2008) Estado de conservación de *Pseudacris hypochondriaca* en la Península de Baja California, México. Thesis, Instituto de Biologia, Universidad Nacional Autónoma de México
González-Ruiz A (2002) Los anfibios mexicanos y el desprecio que conduce a su extinción. Especies 11:3–7
Grismer LL (2002) Amphibians and reptiles of Baja California. University of California Press, Berkeley
Häkkinen J, Pasanen S, Kukkonen JVK (2001) The effects of solar UV-B radiation on embryonic mortality and development in three boreal anurans (*Rana temporaria*, *Rana arvalis* y *Bufo bufo*). Chemosphere 44:441–443. doi:10.1016/S0045-6535(00)00295-2
Hale SF (2001) The status of the Tarahumara frog in Sonora, Mexico. A re-survey of selected localities and report on additional population. Fish and Wildlife Service, Phoenix. USDA Forest Service proceedings RMRS-P-36
Hale SF, Rosen PC, Jarchow JL, Bradley GA (2005) Effects of the chytrid fungus on the Tarahumara Frog (*Rana tarahumarae*) in Arizona and Sonora, Mexico. USDA Forest Service proceedings RMRS-P-36
Hillis DM, Frost JS (1985) Three new species of leopard frogs (*Rana pipens* complex) from the Mexican plateau. Occasional Papers of the Museum of Natural History, The University of Kansas Lawrence, Kansas 117:1–14

Houlahan JE, Findlay CS, Schmidt BR, Meyer AH, Kuzmin SL (2000) Quantitative evidence for global amphibian population declines. Nature 404:752–755. doi:10.1038/35008052

Huacuz-Elías DC (2001) Estado de Conservación del Genero *Ambystoma* en Michoacán, México. Universidad Michoacana de San Nicolás de Hidalgo, Universidad Nacional Autónoma de México, Secretaria de Medio Ambiente y Recursos Naturales, Morelia, Michoacán, México

Huacuz-Elías DC (2002) Programa de Conservación y Manejo de *Ambystoma dumerili*. El achoque del lago de Pátzcuaro. Universidad Michoacana de San Nicolás de Hidalgo, Fondo Mexicano para la Conservación de la Naturaleza, A.C. Secretaria de Medio Ambiente y Recursos Naturales, Morelia, Michoacán, México

Huey RB, Losos JB, Moritz C (2010) Are lizards toast? Science 328:832–833

International Union for Conservation of Nature IUCN (2010) IUCN red list of threatened species. Version 2010.1. www.iucnredlist.org. Cited 16 Apr 2010

Kraus F (2009) Alien reptiles and amphibians a scientific compendium and analysis. Springer, USA

Langhelle A, Lindell MJ, Nyström P (1999) Effects of ultraviolet radiation on amphibian embryonic and larval development. J Herpetol 33:449–456

Laurance WF (1996) Catastrophic declines of Australian rainforest frogs: is unusual weather responsible? Biol Conserv 77:203–212. doi:10.1016/0006-3207(95)00142-5

Lazcano-Barrero MA, Flores-Villela OA, Benabib-Nisenbaum M, Hernández-Gómez JA, Chávez-Peón MP, Cabrera-Aldave A (1986) Estudio y Conservación de los Anfibios y Reptiles de México: Una Propuesta. Cuadernos de Divulgación INIREB no 25, Xalapa, Veracruz, México

León-Règagnon V, Guillén-Hernández S, Arizmendi-Espinosa MA (2005) Intraspecific variation of *Haematoloechus floedae* Harwood, 1932 (Digenea: Plagiorchiidae), from *Rana* spp. in North and Central America. J Parasitol 91:915–921

Lever C (2003) Naturalized reptiles and amphibians of the world. Oxford University Press, New York

Lips KR, Mendelson JR III, Muñoz-Alonso A, Canseco-Márquez L, Mulcahy DG (2004) Amphibian population declines in montane southern Mexico: resurveys of historical localities. Biol Conserv 119:555–564. doi:10.1016/j.biocon.2004.01.017

Lips KR, Burrowes PA, Mendelson JR III et al (2005a) Amphibian declines in Latin America: widespread population declines, extinctions, and impacts. Biotropica 37:163–165. doi:10.1111/j.1744-7429.2005.00023.x

Lips KR, Burrowes PA, Mendelson JR III et al (2005b) Amphibian population declines in Latin America: a synthesis. Biotropica 37:222–226. doi:10.1111/j.1744-7429.2005.00029.x

Lizana M, Pedraza EM (1998) The effects of UV-B radiation on toad mortality in mountainous areas of central Spain. Conserv Biol 12:703–707. doi:10.1111/j.1523-1739.1998.97187.x

Lovich RE, Grismer LL, Danemann G (2009) Conservation status of the herpetofauna of Baja California, México and associated islands in the Sea of Cortez and Pacific Ocean. Herpetol Conserv Biol 4:358–378

Meik JM, Canseco-Márquez L, Smith EN, Campbell JA (2005) A new species of *Hyla* (Anura:Hylidae) from Cerro de Las Flores, Oaxaca, Mexico. Zootaxa 1046:17–27

Mellink E, Ferreira-Bartrina V (2000) On the wildlife of wetlands of the Mexican portion of the Rio Colorado delta. Bull South Calif Acad Sci 99:115–127

Méndez-de la Cruz FR, Camarillo JL, Villagrán-Santa Cruz M, Aguilar-Cortez R (1992) Observaciones sobre el status de los anfibios y reptiles de la sierra de Guadalupe (Distrito Federal-Estado de México). Anales Inst Biol Univ Nac Autón Mex Ser Zool 63:249–256

Mendoza-Almeralla C (2006). Malformaciones en *Ambystoma lermaense* (Amphibia: Ambystomatidae). Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México

Merino-Pérez L (2003) Procesos de uso y gestión de los recursos naturales comunes. In: Sánchez O, Vega E, Peters E, Monroy-Vilchis O (eds) Conservación de sistemas templados de montaña en México. Instituto Nacional de Ecología-Secretaria de Medio Ambiente y Recursos Naturales (INE-SEMARNAT), Distrito Federal, México

Ochoa-Ochoa LM, Flores-Villela O (2006) Áreas de Diversidad y Endemismo de la Herpetofauna Mexicana. Universidad Nacional Autónoma de México-Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México

Ochoa-Ochoa L, Urbina-Cardona JN, Vázquez LB, Flores-Villela O, Bezaury-Creel J (2009) The effects of governmental protected areas and social initiatives for land protection on the conservation of Mexican amphibians. PLoS One 4:e6878. doi:10.1371/journal.pone.0006878

Parra-Olea G, García-París M, Wake D (1999) Status of some populations of Mexican salamanders (Amphibia: Plethodontidae). Rev Biol Trop 47:217–223

Parra-Olea G, Martínez-Meyer E, Pérez-Ponce de León G (2005) Forecasting climate change effects of salamanders distributions in the Highlands of Central Mexico. Biotropica 37:202–208. doi:10.1111/j.1744-7429.2005.00027.x

Pérez-Saldaña MC, Gutiérrez-Acosta M, Morales FO, Pérez-Saldaña J (2006) Experiencias de cultivo de achoque (*Ambystoma dumerilii*) en cautiverio. Monasterio de Dominicas de Orden Predicadores María Inmaculada de la Salud AR, Pátzcuaro

Pineda E, Halffter G (2004) Species diversity and habitat fragmentation: frogs in a tropical montane landscape in Mexico. Biol Conserv 117:499–508. doi:10.1016/j.biocon.2003.08.009

Ramírez-Bautista A, Hernández-Salinas U, García-Vázquez UO, Leyte-Manrique A, Canseco-Márquez L (2009) Herpetofauna del Valle de México: diversidad y conservación. Universidad Autónoma del Estado de Hidalgo and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Pachuca

Rodríguez-Reyes FR (2009) Dinámica poblacional del ajolote *Ambystoma altamirani* en el río Magdalena, D. F. Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México

Rorabaugh JC, Sredi MJ, Miera V, Drost CA (2002) Continued invasion by an introduced frog (*Rana berlandieri*): southwestern Arizona, southeastern California, and Río Colorado, México. Southwest Nat 47:12–20

Rovito SM, Parra-Olea G, Vásquez-Almazán CR, Papenfuss TJ, Wake DB (2009) Dramatic declines in neotropical salamander populations are an important part of the global amphibians crisis. Proc Natl Acad Sci USA 106:3231–3236. doi:10.1073/pnas.0813051106

Rudich de la Rosa JJP (1980) Sinopsis biológica y de explotación sobre las principales especies del género *Rana* en México. Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México, México

Ruíz-Boites M (2008) Uso y comercialización de anfibios y reptiles de cuatro mercados del Distrito Federal. Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México

Santos-Barrera G (2004) Las enfermedades infecciosas y su papel en la declinación mundial de las poblaciones de anfibios. Biodiversitas 56:1–6

Santos-Barrera G, Flores-Villela O, Mendoza-Quijano F (1994) La declinación de las poblaciones de anfibios en el mundo ¿Qué está sucediendo en México? Rev Soc Mex Hist Nat 45:125–132

Secretaría de Medio Ambiente y Recursos Naturales (2002) Norma Oficial Mexicana. (NOM-059-SEMARNAT-2001). Protección ambiental. Especies nativas de México de flora y fauna silvestres. Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio. Lista de especies en riesgo. Diario Oficial de la Federación, Instituto Nacional de Ecología, México

Sigala-Rodríguez JJ, Greene HW (2009) Landscape change and conservation priorities: Mexican herpetofaunal perspectives at local and regional scales. Rev Mex Biodivers 80:231–240

Sinervo B, Méndez-de la Cruz F, Miles DB, Heulin B, Bastiaans E, Villagrán-Santa Cruz M, Lara-Resendiz R, Martínez-Méndez N, Calderón-Espinosa ML, Meza-Lázaro RN, Gadsden H, Avila LJ, Morando M, De la Riva IJ, Sepulveda PV, Rocha CFD, Ibargüengoytía N, Puntriano CA, Massot M, Lepetz V, Oksanen TA, Chapple DG, Bauer AM, Branch WR, Clobert J, Sites JW Jr (2010) Erosion of lizard diversity by climate change and altered thermal niches. Science 328:894–899

Sosa L, Parra M, Canales V, Ornelas D, Cano C, Obregón A, Ramos R (2002) Poblaciones de ranas en humedales formados artificialmente sobre presas de jales mineros en Guanajuato. In: Paper presented at the 7th Reunión Nacional de Herpetología, Universidad de Guanajuato, México, 25–28 November 2002

Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischman DL, Waller RW (2004) Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786. doi:10.1126/science.1103538

Stuart SN, Hoffmann M, Chanson JS, Cox NA, Berridge RJ, Ramani P, Young BE (eds) (2008) Threatened amphibians of the world. Lynx Edicions, Barcelona

Suazo-Ortuño I (2002) Effects of habitat disturbance on a frog community in a Mexican tropical dry forest. Froglog 49:2

Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, Ferreira de Siqueira M, Grainger A, Hannah L, Hughes L, Hutley B, van Jaarsveld AS, Midgley GF, Miles L, Ortega-Huerta MA, Peterson AT, Phillips OL, Williams SE (2004) Extinction risk from climate change. Nature 427:145–148. doi:10.1038/nature02121

Ustach PC, Mendelson JR III, McDiarmid RW, Campbell JA (2000) A new species of *Hyla* (Anura:Hylidae) from the Sierra Mixes, Oaxaca, Mexico, with comments on ontogenetic variation in the tadpoles. Herpetologica 56:239–250

Vázquez-Díaz J, Quintero-Díaz GE (2005) Anfibios y Reptiles de Aguascalientes. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Centro de Investigaciones y Estudios Multidisciplinarios de Aguascalientes A.C., México

Wake DB (1991) Declining amphibian populations. Science 253:860. doi:10.1126/science.253.5022.860

Wake DB, Campbell JA (2001) An aquatic plethodontid salamander from Oaxaca, México. Herpetologica 57:509–514

Zambrano L, Vega E, Herrera LG, Prado E, Reynoso VH (2007) A population matrix model and population viability analysis to predict the fate of endangered species in highly managed water systems. Anim Conserv 10:297–303. doi:10.1111/j.1469-1795.2007.00105.x