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Agalychnis lemur (SMF 89959), Cerro Negro, PNSF, Veraguas [Reference this issue: 6(2): 9–30 (e46)]. *Photo by Arcadio Carrizo.*

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Amphibian & Reptile Conservation 6(2):2-4.

Short Communication

New records of the Dice snake, *Natrix tessellata*, in the Suez Canal zone and Sinai

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***Abstract.*—Ten years of herpetological surveys in the Suez Canal zone revealed that *Natrix tessellata* was most common in fresh water irrigation canals. It is recorded herein for the first time in Port Said and Suez provinces and discovered in Sinai.**

Key words. Dice snake, *Natrix tessellata*, Suez Canal, Sinai, new records

Citation: Ibrahim AA. 2012. New records of the Diced snake, *Natrix tessellata*, in the Suez Canal zone and Sinai. *Amphibian & Reptile Conservation* 6(2):2-4(e42).

The Dice snake (*Natrix tessellata*; Figs. 1 and 2) was long known from the northern part of the Nile Delta (Anderson 1898; Flower 1933; Marx 1968; Saleh 1997), and its distribution extended in the lower extremes of the River Nile as far as Al Wasta in Bani Suef province (Baha El Din 2011). However, no record of *N. tessellata* was known from Sinai, and its distribution in the Suez Canal zone was lacking.

The Dice snake (*Natrix tessellata*) was first reported from the Suez Canal zone by Werner (1983) referring to an individual collected by Tortonese in 1948 from Qassasin, 35 km west of the Suez Canal in the Ismailia province, and two other individuals, one found eight km south of Ismailia and the other, west of Bitter Lakes. Recently, *N. tessellata* was reported from several different localities in the Suez Canal area (all in the Ismailia region). Stein and Helmy (1994) reported the snake from Ismailia gardens; they also recorded an individual from Bahr Al Baqar, a town in Sharqiya province, not Port Said province as they claimed (the town is located 35 km west of the Suez Canal). Two snakes were collected by the author from Ferdan (10 km N. Ismailia), and Ain Ghossain (15 km S. Ismailia) and deposited in the Muséum National d'Historire Naturelle, Paris (MNHN 2000.5147 and 2000.5148). Baha El Din (2011) reported this species 48 km south of Port Said and associated it with Port Said; however, a locality at the stated distance actually is in Ismailia province. A ten-year herpetological survey in the Suez Canal region by the author revealed that *N. tessellata* is wide-spread in fresh water irrigation canals, which constitute a huge irrigation web along the Suez Canal west bank, from Port Said to Suez (Table 1 and Fig. 3), thus documenting its first record from both Port Said and Suez provinces. At Al-Ganayen of Suez, it approaches the Red Sea within five km. The Dice snake is well-known to Suez Canal farmers as a non-venomous snake; however, many people still continue to kill them unnecessarily.

The Dice snake was transported to the east bank of the Suez Canal through the fresh water canal connecting west to east (Sinai) at Déversoir. At Meet Abul Koum Al-Jadidah, a road-killed snake was first observed in 2008 documenting its first occurrence in Sinai. This species is now widely distributed in fresh water canals irrigating newly cultivated lands east of Bitter Lakes in Sinai.

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Acknowledgments.—I thank Dr. Mohammad Hereher for drawing the location map, and Craig Hassapakis for editing the early draft of this manuscript. Many thanks are due to the reviewers, John Simmons and Dr. Konrad Mebert for their valuable comments and suggestions.

Literature cited

Anderson J. 1898. *Zoology of Egypt. Volume 1. Reptilia and Batrachia.* Quaritch, London. 370 p.

Baha El Din S. 2011. Distribution and recent range extension of *Natrix tessellata* in Egypt. *Mertensiella* 18:385-387.

Flower SS. 1933. Notes on the recent reptiles and amphibians of Egypt, with a list of the species recorded from that kingdom. *Proceedings of the Zoological Society of London* 103(3):735-851.

Figure 1. *Natrix tessellata*, Ismailia city, 7 August 2007. *Photo: Adel A. Ibrahim.*

Figure 2. *Natrix tessellata,* Déversoir, 24 May 2008. *Photo: Adel A. Ibrahim.*

Marx H. 1968. *Checklist of the Reptiles and Amphibians of Egypt*. U.S. Naval Medical Research Unit No. 3, Cairo. 51 p.

Saleh MA. 1997. *Amphibians and Reptiles of Egypt*. Publication of National Biodiversity Unit (Egypt) No. 6. 234 p.

Stein K, Helmy I. 1994. Some new distribution records for the snakes of Egypt (Squamata: Serpentes). *Bulletin of the Maryland Herpetological Society* 3:15-26

Werner YL. 1983. Lizards and snakes from eastern lower Egypt in the Hebrew University of Jerusalem and Tel Aviv University, with range extensions. *Herpetological Review* 14(1):29-31.

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Table 1. Locations of *Natrix tessellata* in the Suez Canal zone and Sinai.

	Location	Date	Coordinates
1	8 km S. Port Said	25.5.2009	31° 10' 54" N, 32° 18' 12" E
2	Abu Khalifa Ezbet Attawwab	31.7.2002	30° 46' 30" N, 32° 15' 41" E
3	Km 17, N.W. Ismailia	13.5.2009	30° 44' 00" N, 32° 13' 42" E
4	Qaryat Assama'ana	9.5.2005	30° 43' 23" N, 32° 15' 34" E
5	Ferdan	11.5.2000	30° 39' 42" N, 32° '19' 49"E
6	Km 8, N.W. Ismailia	25.5.2009	30° 39' 41" N, 32° 15' 31" E
7	Km 6, N.W. Ismailia	24.6.2008	30° 38' 35" N, 32° 15' 07" E
8	4 km N.W. Ismailia	23.7.2004	30° 37' 43" N, 32° 14' 30" E
9	Ismailia City	7.8.2007	30° 35' 19" N, 32° 16' 56" E
10	Al-Manayef	5.3.2006	30° 33' 13" N, 32° 11' 54" E
11	Ain Ghosain	16.7.1999	30° 30' 45" N, 32° 18' 13" E
12	Meet Abul Koum Al-Jadidah, S.	25.5.2008	30° 25' 28" N, 32° 24' 47" E
13	Al-Aqqadah	1.6.2001	30° 26' 01" N, 32° 20' 13" E
14	Déversoir	24.5.2008	30° 25' 33" N, 32° 20' 49" E
15	Jeneeva	8.5. 2002	30° 12' 23" N, 32° 25' 43" E
16	Al-Ganayen, Suez	31.5.2001	29° 59' 53" N, 32° 33' 07" E

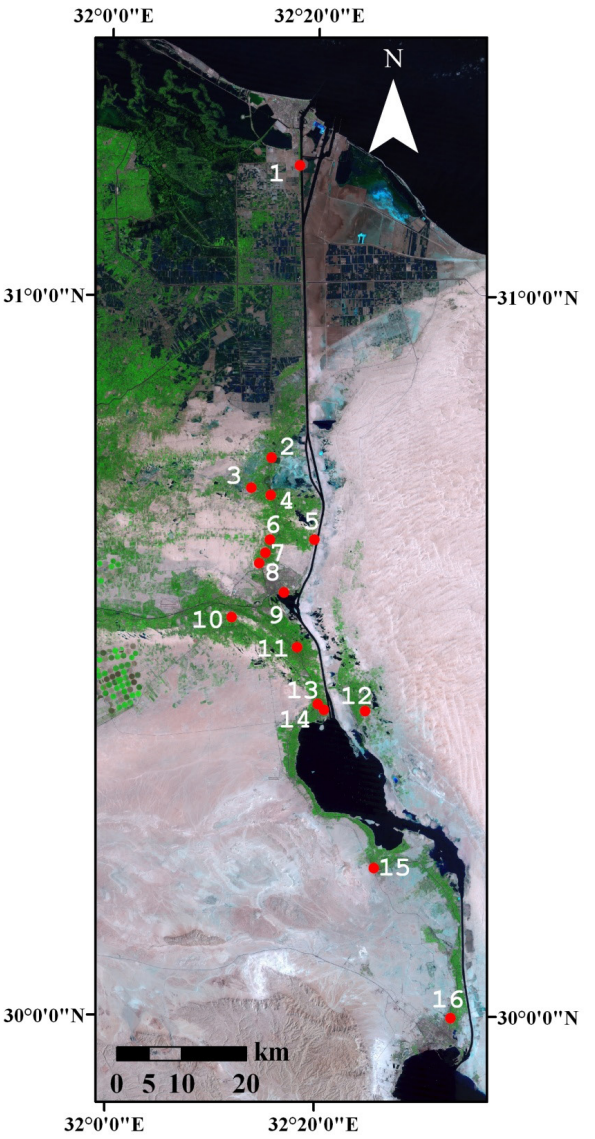

Figure 3. Distribution of *N. tessellata* in the Suez Canal zone and Sinai.

ADEL IBRAHIM is associate professor of zoology (herpetologist), was previously head of the Department of Environmental Sciences, Suez Canal University, Suez, Egypt, and is currently a visiting professor at Ha'il University, Saudia Arabia. Adel has published 33 scientific papers (all in the field of herpetology), and currently two chapters in *Amphibians of Egypt and Amphibians of Libya* (In press). Adel has researched the herpetofauna of Sinai since 1987 and the Suez Canal zone for more than 10 years. Adel is an avid photographer having contributed about 40 photos of reptile species to the Reptile Database: http://www.reptile-database.org/. He is member of the International Herpetological Committee Advisory Board 2005-2012 (elected at the 5th World Congress of Herpetology, South Africa).

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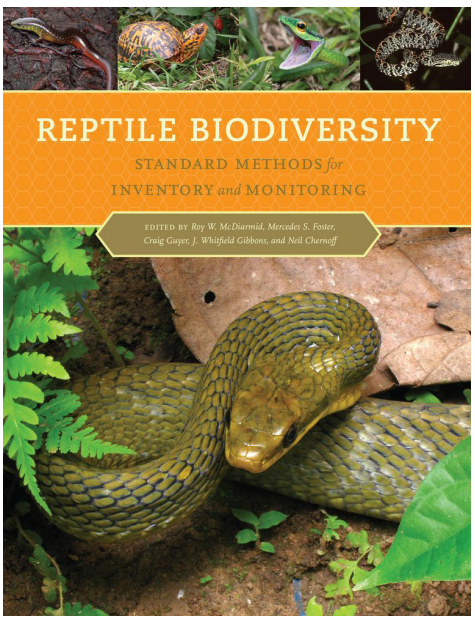
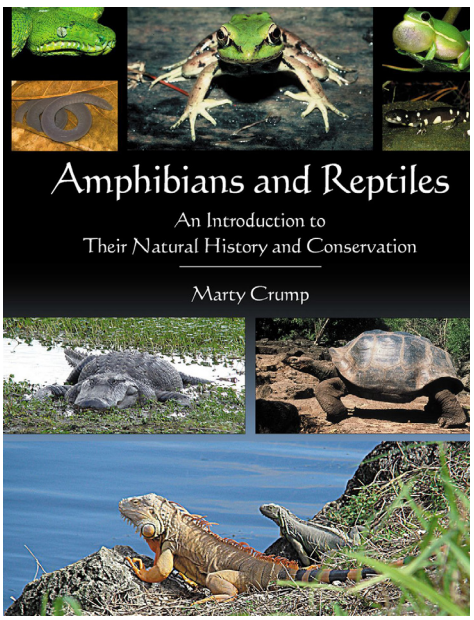




Reptile Biodiversity: Standard Methods for Inventory and Monitoring

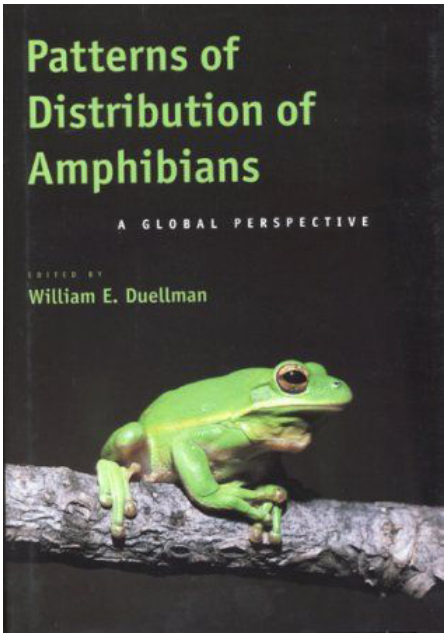
Editors, Roy W. McDiarmid, Mercedes S. Foster, Craig Guyer, J. Whitfield Gibbons, and Neil Chernoff. University of California Press, Berkeley, California. First edition, January 12, 2012.

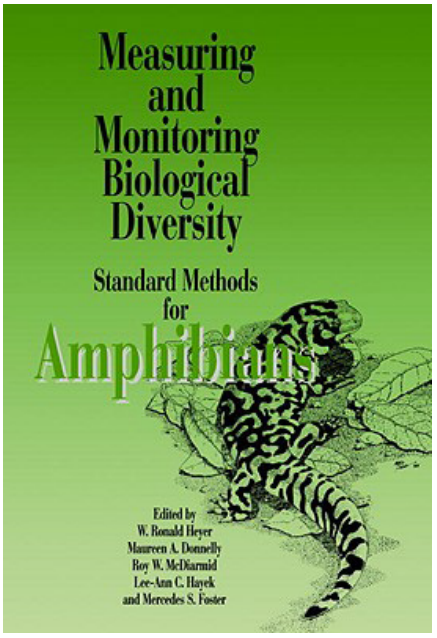
Product dimensions: 11.1 × 8.4 × 1.1 inches. xii + 412 pages. Hardcover: US$67.00. ISBN:-13: 978-0-520-26671-1.

Amphibians and Reptiles: An Introduction to Their Natural History and Conservation

By Marty Crump. The McDonald & Woodward Publishing Company, Granville, Ohio. September 20, 2011.

Product dimensions: 8.9 × 6.9 × 0.7 inches. Children 5th to 8th grade and older. ix + 249 pages. Paperback: US$29.95. ISBN-13: 978-1-935778-20-2.





Patterns of Distribution of Amphibians: a Global Perspective

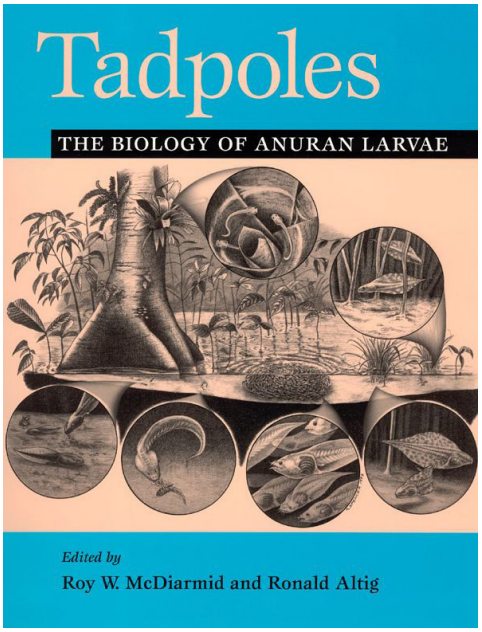
Editor, William Duellman. The John Hopkins University Press, Baltimore, Maryland. First edition, July 20, 1999.

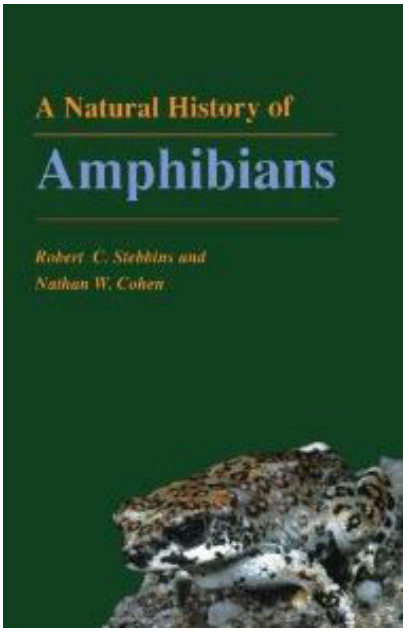
Product dimensions: 10.3 × 7.4 × 1.5 inches. 648 pages. Hardcover: US$90.00. ISBN-13: 978-0-8018-6115-4.

Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians (Biological Diversity Handbook)

Editor, W. Ronald Heyer. Smithsonian Books, Washington, D.C. First edition, February 17, 1994.

Product dimensions: 6.9 × 0.8 × 1.0 inches. 364 pages. Paperback: US$23.87. ISBN-13: 978-1-56098-284-5.





Tadpoles: The Biology of Anuran Larvae

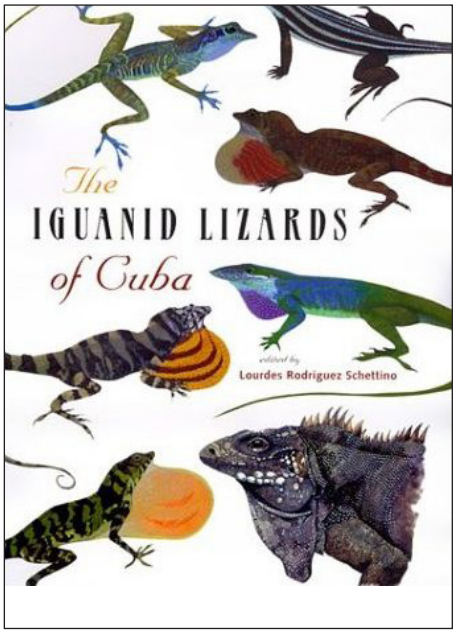
Editors, Roy W. McDiarmid and Ronald Altig. University of Chicago Press, Chicago, Illinois. First edition, October 1, 2000.

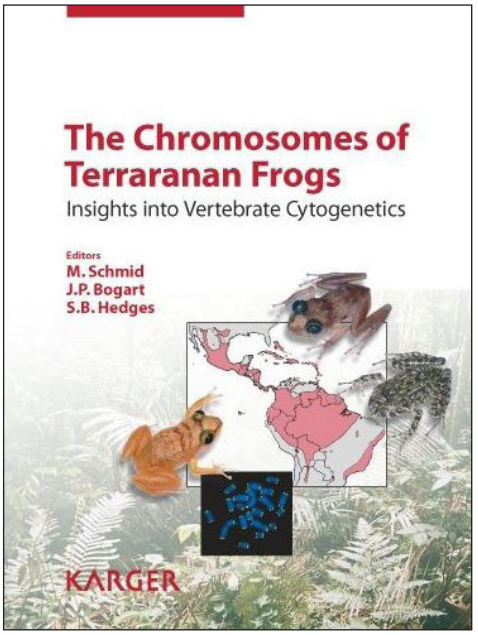
Product dimensions: 10.9 × 8.4 × 1.0 inches. Hardcover: US$90.00; Paperback: US$47.50 ISBN-13: 978-0-226-55763-2.

A Natural History of Amphibians

By Robert C. Stebbins and Nathan W. Cohen. Princeton University Press, Princeton, New Jersey. January 6, 1997.

Product dimensions: 9.1 × 6.0 × 0.8 inches. 332 pages. Paperback: US$31.95. ISBN-13: 978-0-691-10251-1.





The Iguanid Lizards of Cuba

By Lourdes Rodriguez Schettino. University Press of Florida, Gainesville, Florida. First edition, December 31, 1999.

Product dimensions: 9.5 × 6.4 × 1.5 inches. 448 pages. Hardcover: US$85.00. ISBN-13: 978-0-8130-1647-4.

The Chromosomes of Terraranan Frogs: Insights into Vertebrate Cytogenetics

Editors, M. Schmid, Würzbur, J.P. Bogar, and S.B. Hedge. S. Karger AG, Basel, Switzerland. First edition, October 25, 2010.

Product dimensions: 11.1 × 8.6 × 1.2 inches. 568 pages. Hardcover: US$797.00. ISBN-13: 978-3-8055-9607-7.

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Agalychnis lemur (SMF 89959), Cerro Negro, PNSF, Veraguas. *Photo by AC.*

Amphibian & Reptile Conservation 6(2):9-30.

Field notes on findings of threatened amphibian species in the central mountain range of western Panama

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***Abstract.*—During field work along a transect in the Cordillera Central of western Panama between 2008 and 2010, we detected several populations of amphibian species which are considered as "Endangered" or "Critically Endangered" by the IUCN. Some of these species had suffered from serious population declines, probably due to chytridiomycosis, but all are generally threatened by habitat loss. We detected 53% of the Endangered and 56% of the Critically Endangered amphibian species that have previously been reported from within the investigated area. We report on findings of species that have not been found in Panama for many years, and provide locality data of newly discovered populations. There is a need to create a new protected area in the Cerro Colorado area of the Serranía de Tabasará, where we found 15% of the Endangered and Critically Endangered amphibian species known to Panama.**

***Resumen.*—Durante trabajo de campo en un transecto a lo largo de la Cordillera Central en el oeste de Panamá entre 2008 y 2010, encontramos varias poblaciones de anfibios que son considerados "En Peligro" o "En Peligro Crítico" por la UICN. Algunas de estas especies habían sufrido serias disminuciones de sus poblaciones, probablemente causadas por la quitridiomicosis, pero todas se encuentran amenazadas por pérdida de hábitat. Detectamos el 53% de las especies En Peligro y el 56% de las especies En Peligro Crítico que se habían reportado previamente en el área de estudio. Reportamos hallazgos de especies que no se habían avistado en Panamá por muchos años, así como localidades de poblaciones descubiertas por primera vez. Se requiere crear una nueva área de protección en los alrededores del Cerro Colorado en la Serranía de Tabasará, donde se han encontrado 15% de los anfibios En Peligro y En Peligro Crítico de todo Panamá.**

Key words. Anura, *Batrachochytrium dentrobatidis* (*Bd*), decline, Panama, Serranía de Tabasará, Serranía de Talamanca, Urodela

Citation: Hertz A, Lotzkat S, Carrizo A, Ponce M, Köhler G, Streit B. 2012. Field notes on findings of threatened amphibian species in the central range of western Panama. *Amphibian & Reptile Conservation* 6(2):9-30(e46).

Introduction

Amphibian populations are declining or disappearing around the globe at an alarming rate, and are the most threatened vertebrate class on earth (Daszak et al. 1999; Stuart et al. 2004; Gascon et al. 2007). The most obvious threat to tropical amphibians and to biodiversity in general, comes from anthropogenic activities such as deforestation, habitat modification, and contamination. In addition, from the late 1980s on, even amphibian populations in pristine, undisturbed habitats have begun to decline enigmatically. These enigmatic declines have been especially severe at upland sites of Australia (Campbell 1999) and the Neotropics (Young et al. 2001, 2004; Lips et al. 2006). In particular, lower central America has suffered from multiple amphibian population declines that were well documented (e.g., Crump et al. 1992; Young et al. 2001; Lips 1999; Lips et al. 2006; Ryan et al. 2008).

After several experts have conducted research regarding the causes, these enigmatic amphibian die-offs and population declines could be clearly associated with, an emerging infectious disease (EID) (Daszak et al. 2000) caused by the fungus *Batrachochytrium dendrobatidis* (*Bd*) soon known as chytridiomycosis (Berger et al. 1998; Daszak et al. 1999; Ryan et al. 2008). The mortality rate of infected individuals can be as high as 100% in some populations (Lips et al. 2003b), but not all species have been affected equally. Due to the physiology of *Bd*, which grows best at temperatures between 17-28 °C (Piotrowski et al. 2004), populations in tropical moun-

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tainous habitats are more likely to be affected than those in tropical lowlands (Longcore et al. 1999; Andre et al. 2008). Montane riparian or lentic amphibian species are at highest risk to *Bd* infection and population decline (Lips et al. 2003b; Kriger and Hero 2007). Furthermore, degree of disease susceptibility of species depends on their particular immunologic defence in terms of quantity and quality of antimicrobial skin peptide mixtures (Woodhams et al. 2006).

Chytridiomycosis first appeared in western Panama between 1993 and 1994 and spread in a wave-like manner south-eastward, crossing the Panama Canal in 2007 (Lips et al. 2008; Woodhams et al. 2008). The disease has caused population declines and loss of amphibian diversity wherever it has been detected (Crawford et al. 2010a). Since *Bd*'s arrival, many formerly abundant species have disappeared or become rare. Only recently, reports on rediscoveries or newly discovered populations of amphibian species, which were thought to be lost, have been reported (Puschendorf et al. 2005; Lotzkat et al. 2007; Rodríguez-Contreras et al. 2008; Kolby and McCranie 2009; Abarca et al. 2010; McCranie et al. 2010), but none from Panama.

Our objective is to report on amphibian species found in the central mountain range of western Panama facing a high (IUCN category: Endangered, EN) to extremely high (IUCN category: Critically Endangered, CR) risk of extinction in the wild. Most species mentioned in this paper are highly susceptible to *Bd* infection and have suffered dramatic population declines in Costa Rica and Panama, although their distribution areas comprise well-protected areas like national parks and protected forests (IUCN 2011). Others have always been rare and are only known from a few specimens. Almost all of these species have not been reported for many years and most of them are the only persisting populations known. We also inspected some of the collected voucher specimens for chytrid infection by either histological examination of skin scrapings or PCR testing of skin swabbings. Moreover, we provide information on localities and contexts of our findings and add brief ecological field notes on every species.

Material and methods

Between 2008 and 2010, we collected amphibian species along a transect which covered the continental divide mainly above 1000 m a.s.l., from the Costa Rican-Panamanian border to about 81 degrees of western longitude. Only two findings were made prior to this project (see *Isthmohyla angustilineata* and *Oedipina grandis* accounts) in 2006. An overview of the investigated area, with all localities sampled, is shown in Fig. 1 below.

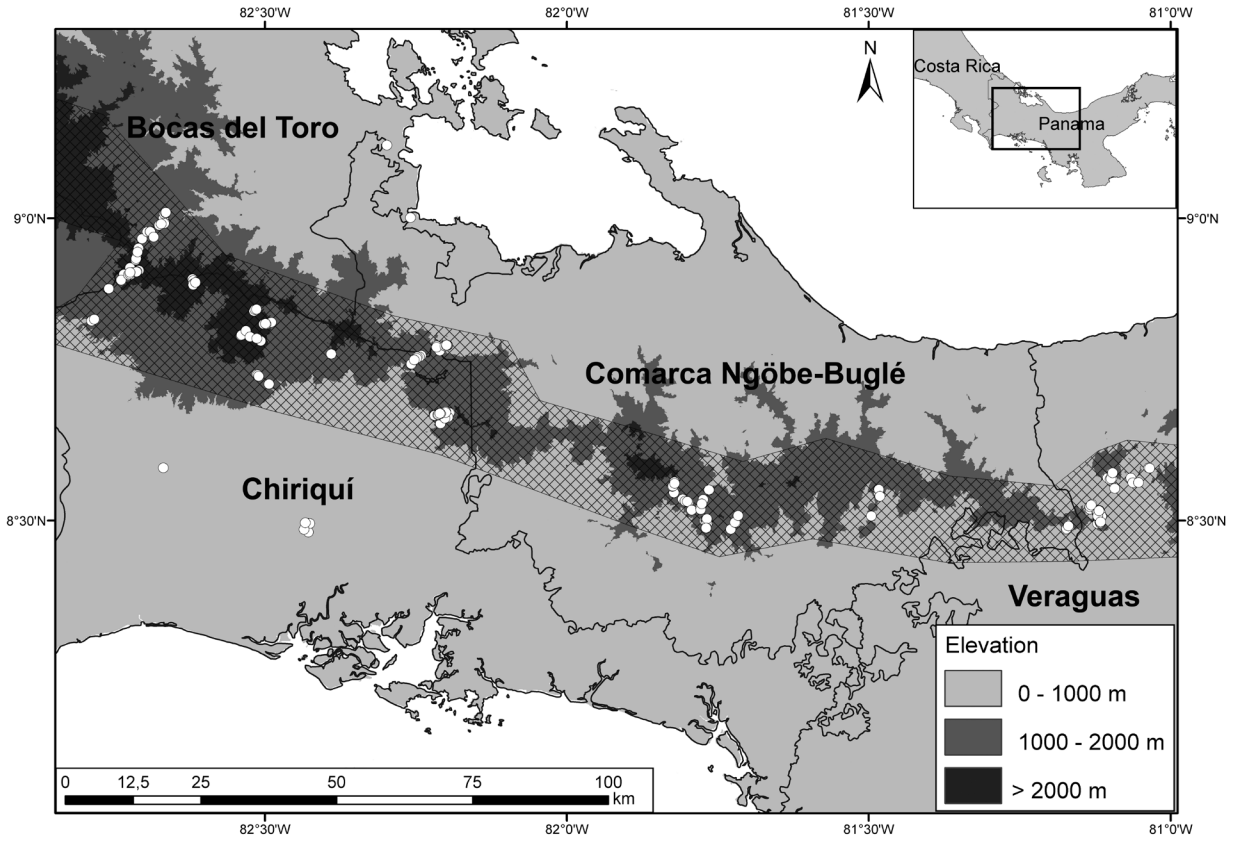

Figure 1. Sampled localities in the central mountain range of western Panama (Cross hatched area = transect, white dots = collecting sites).

We collected all specimens (adults and larvae) during opportunistic searches mostly at night. We obtained coordinates and altitude of the study sites using a Garmin GPS Map 60 CSx GPS receiver or alternatively a Garmin Etrex Summit, both with integrated barometric altimeters. For preservation and preparation of voucher specimens we follow the recommendations of Köhler (2001). We assigned tadpoles to Gosner stages (Gosner 1960) prior to identification. We identified specimens to the species level using the dichotomous keys of Köhler (2011), Savage (2002), and Duellman (2001), and if necessary original species descriptions. We deposited voucher specimens (listed in Appendix I) in the collection of the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Germany (SMF), those labelled with AH field numbers will be included into the Museo Herpetológico de Chiriquí (MHCH), the herpetological collection of the Universidad Autónoma de Chiriquí, Davíd, Panama.

We created all maps using ArcGIS 10, and calculated mean distances of populations to the next Protected Area with the "Near" tool in the "Proximity" folder. We obtained map layers from the map server of the Smithsonian Tropical Research Institute (STRI) (URL: http://mapserver.stri.si.edu/geonetwork/srv/en/main.home). All maps and coordinates are in the geographic coordinate system and WGS 1984 datum. We rounded coordinates to the second decimal place; elevations are rounded to the next tenth.

Some of the detected specimens have been tested for infection with *Batrachochytrium dentrobatidis*. Therefore, we gently rubbed a cotton swap over the ventral surfaces of the pelvic patch and inner thighs following the sampling guidelines of Hyatt et al. (2007). Testing for *Bd* was performed by real-time Taqman PCR assay following the protocol of Boyle et al. (2004). Because this technique was not available to us prior to 2010, we did not take PCR samples from all specimens. Further, we examined 10 specimens collected before 2010 by histological examination of stained skin scrapings, for detection of *Bd* thalli and sporangia. We took skin scrapings from the ventral surface of the inner left thigh of preserved animals and stained them with 0.01% solution of Congo Red dye dissolved in PBS buffer (pH 7.4) and stained for 20 minutes (Briggs and Burgin 2003, 2004). Stained scrapings were examined with bright-field microscopy using a Bresser Biolam optical microscope.

Since the most recently published list of amphibian species known to occur in Panama (Jaramillo et al. 2010), ongoing investigation has led to some changes and additions to this list. To get an updated list (Appendix II) of the amphibian species that are currently known to be native in Panama we updated and revised the list of Jaramillo et al. (2010). First we included all species that have been added to the Panamanian herpetofauna after 2010. These are (with references in parentheses): *Agalychnis annae* (Hertz et al. 2011), *Craugastor evanesco* (Ryan et al. 2010b), *Incilius karenlipsae* (Mendelson and Mulcahy 2010), *Pristimantis adnus* (Crawford et al. 2010b) and *P. educatoris* (Ryan et al. 2010a). Moreover, we included *Bolitoglossa pygmea* and *B. robinsoni* (Bolaños and Wake 2009) not found in Jaramillo et al. (2010). Because of taxonomic changes we exchanged *Rhinella granulosa* for *R. centralis* (Narvaes and Rodriguez 2009), and excluded *Agalychnis lithodryas* that we treat as a synonym of *A. spurelli* (Ortega-Andrade 2008). We follow Köhler 2011 and list *Lithobates taylori* in place of *L. pipiens* complex. Although *Hyalinobatrachium vireovittatum* might be a synonym of *H. talamancae* (Kubicki 2007; Hertz et al. 2011) we decided to list both species until further investigation has been conducted. The same decision was taken for *Relictivomer pearsei* that might be a synonym of *Elachistocleis ovalis*, and both taxa are listed as present in Panama. Further, we excluded the three introduced species *Eleutherodactylus antillensis*, *E. johnstonei*, and *E. planirostris* (Crawford et al. 2011).

In the following text we use the abbreviation PA for "Protected Areas" and abbreviations for Panamanian PAs (in parentheses) reflect their original names in Spanish: Parque Internacional La Amistad (PILA); Parque Nacional Volcán Barú (PNVB); Reserva Forestal La Fortuna (RFLF); Bosque Protector Palo Seco (BPPS); Parque Nacional Santa Fé (PNSF). Abbreviations of IUCN categories follow IUCN (2011).

Results

We now count 206 native species of amphibians known to occur in Panama. Of these, 23 species (11%) are considered Endangered (EN) and 22 (11%) Critically Endangered (CR) as defined by the IUCN (Fig. 2).

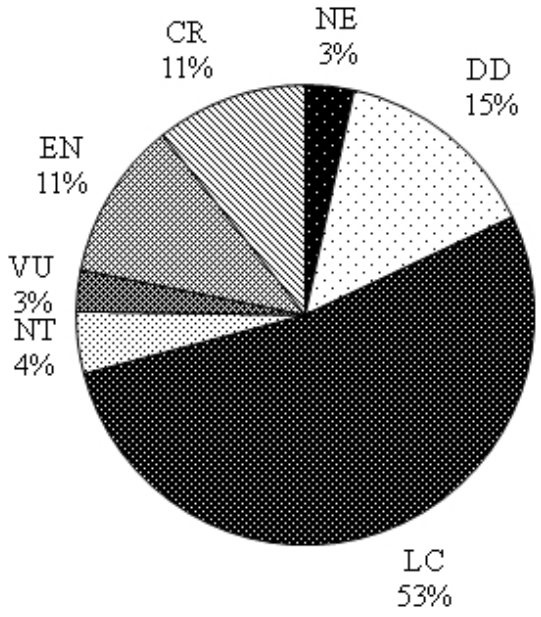

Figure 2. Percentage of Panamanian amphibian species in each IUCN category.

In total 33 (73%) of those 45 species, in detail 17 (74%) of the 23 species in the EN and 16 (73%) of the 22 species in the CR category, are known to occur within the investigated area (Appendix II). During this study we found 18 (55%) of these 33 species, on which we report below. We further present the positive results of analysis of skin swabbings and histological examination for presence of *Bd* illustrated in an overview map (Fig. 3).

Individual species accounts of species categorized as Endangered (EN)

We found a total of nine EN species within the investigated areas representing 4% of all amphibian species known to occur in Panama. Furthermore, 39% of the Panamanian species in the EN category, and 53% of the EN species that are known to occur within the transect. We made all but three findings within the boundaries of PAs, except one at Santa Clara (*Ptychohyla legleri*), and two in the Cerro Colorado region (*Agalychnis annae* and *Pristimantis museosus*). The former two species could not be reported from any of Panama's PAs (Appendix II).

Agalychnis annae (Duellman 1963): This species, formerly considered as a Costa Rican endemic, has been only recently recorded from Panama (Hertz et al. 2011). Between 1980 and 1990, *Agalychnis annae* disappeared from all PAs in Costa Rica and was subsequently listed as EN. In Costa Rica, it is only found near heavily polluted streams in the metropolitan region of San José. Pounds et al. (2008) hypothesized that the frog and its tadpoles may be less susceptible to water pollution than the chytrid fungus, so it survives only at disturbed and polluted sites. We found a single female during daytime surveys inactive on a leaf by the side of a dirt road. The area is inhabited and fit for agricultural use, though streams in the area did not appear to be heavily polluted. Admittedly, we did not conduct chemical analysis. We furthermore cannot tell whether a reproductive population exists. Thus, further monitoring is strongly needed.

Ecnomiohyla fimbrimembra (Taylor 1948): This species is associated with primary humid montane forest. It is an obligatory canopy dweller that lives and reproduces principally in tree crowns. *Ecnomiohyla fimbrimembra* is very rarely observed and collected, and there are no dependable data on its population status (Savage 2002). However, it is presumed to have a decreasing population trend, because it is strongly associated with mature primary forests, which are endangered by human activities. The first and formerly only specimen from Panama was an adult male collected in 1982 at Cerro Horqueta, PILA, Chiriquí (Ibáñez et al. 1991).

We collected an adult male during a rainy night on the north-eastern slopes of Volcán Barú. This expands the known distribution of *E. fimbrimembra* in Panama to a second PA, the PNVB, and represents the second male specimen in a scientific collection (Savage 2002; Mendelson et al. 2008).

Ptychohyla legleri (Taylor 1958): This species is considered moderately common in appropriate habitats (Solís et al. 2008). We found only a single froglet near a small creek at Santa Clara in extreme western Panama, where the first Panamanian specimens were collected in 1966 (Duellman 2001). Despite intensive search efforts we carried out at different times of the year at this site, it remained the only encountered specimen. Even though it was found on an organic farm, the surroundings are dominated by intensive coffee plantations nowadays. As a stream breeder it faces a potential risk of chytrid infection, but there are no reports on population declines of this species due to chytridiomycosis yet. Santos-Barrera et al. (2008) recorded *P. legleri* from the San Vito region in Costa Rica, near Santa Clara, but found no evidence for *Bd* in that area. However, former studies have proved the presence of *Bd* at this site (Lips et al. 2003a; Picco and Collins 2007). In addition, we collected a male glass frog (*Cochranella granulosa*) at the same creek in Santa Clara, which tested positive for *Bd* by PCR.

Pristimantis museosus (Ibáñez, Jaramillo, and Arosemena 1994): This species can be characterised as uncommon. We found it on the Caribbean slopes along the central mountain range wherever pristine forest was present. Ibáñez et al. (1994) collected the type material at pristine premontane wet forest and lower montane rainforest life zones (Holdridge 1967). Likewise, we never found it in degraded habitats and therefore suspect it of being very sensitive to deforestation.

Bolitoglossa magnifica Hanken, Wake, and Savage 2005: The type material of this species was collected on the lower slopes of Volcán Barú, Chiriqui, Panamá in 1975. This species was first assigned to *B. nigrescens* until the revision of the *B. nigrescens* complex by Hanken et al. (2005). It has not been collected or observed since. It is listed as EN because of its small known distribution range and a general loss of habitat. In fact, inadequate data allow only a restrained assessment of this species. We collected four individuals during the day only a few kilometres away from the species' type locality at PNVB while ascending from the town of Boquete to the peak by car. In a relatively short period of time (approximately 15 min), we found all four individuals under a pile of wood by the side of the road. Further research is needed, but it seems to be common at certain sites.

Bolitoglossa compacta Wake, Brame, and Duellman 1973: This is a rather uncommon species (Savage 2002) with a small distribution between the Costa Rican-Panamanian border and Volcán Barú. The type material was collected on the northern slope of Cerro Pando between 1920 and 1970 m a.s.l. in undisturbed cloud forest (Wake et al. 1973). It was first recorded from Costa Rica by Lips (1993), who did not give much information on its habitat, but described the vegetation at this site as lower montane

rainforest in a later work (Lips 1998). Although little is known about the species' environmental demands, it is assumed to inhabit relatively undisturbed lower montane rainforest, and therefore is threatened by habitat loss due to logging.

We found a single specimen on the south-eastern slope of Volcán Barú, within the boundaries of PNVB, under a rotten trunk by the side of the road.

Bolitoglossa marmorea (Tanner and Brame 1961): This species has almost the same distribution as *Bolitoglossa compacta*, but inhabits slightly higher elevations. Specimens collected during this study were, just as the type material, found in montane rainforest at the edge of the timberline and pluvial paramo above timberline. The ability to live in open habitats is probably the reason why it persists also in degraded habitats. There is a need for further studies as these are the first records of the species in more than ten years (IUCN 2010).

Still it seems to be a common species at the peak of Volcán Barú. In only one morning, we collected five specimens by turning a couple of rocks near the summit of the volcano.

Bolitoglossa minutula Wake, Brame, and Duellman 1973: This seems to be still a quite common species where unspoiled forest exists. Nevertheless, its known distribution area is small and it is assumed to be threatened by deforestation. We collected at least nine specimens of *B. minutula* at PILA and PNVB. Especially near the continental divide on both southern and northern slopes of Cerro Pando (PILA), it appears to be the most common salamander.

Oedipina grandis Brame and Duellman 1970: This elongate, fossorial salamander was easily found in the early 1990s, but then decreased in abundance for unknown reasons (Lips 1998). We detected a single, adult female in January 2006 at night in Jurutungo on the edge of PILA. The specimen was crawling between recently cut *Heliconia* leaves, on a small trail leading to a water intake point of a small stream. It remained the only individual taken during this study.

Individual species accounts of species categorized as Critically Endangered (CR)

We found a total of nine CR species within the investigated area. That is 4% of all Panamanian amphibian species, 41% of all Panamanian amphibian species in the CR category, and 56% of all Panamanian CR amphibians that are known to occur within the transect. We made most of the records within the boundaries of PAs, except three species (*Isthmohyla debilis*, *I. graceae*, and *I. tica*) from

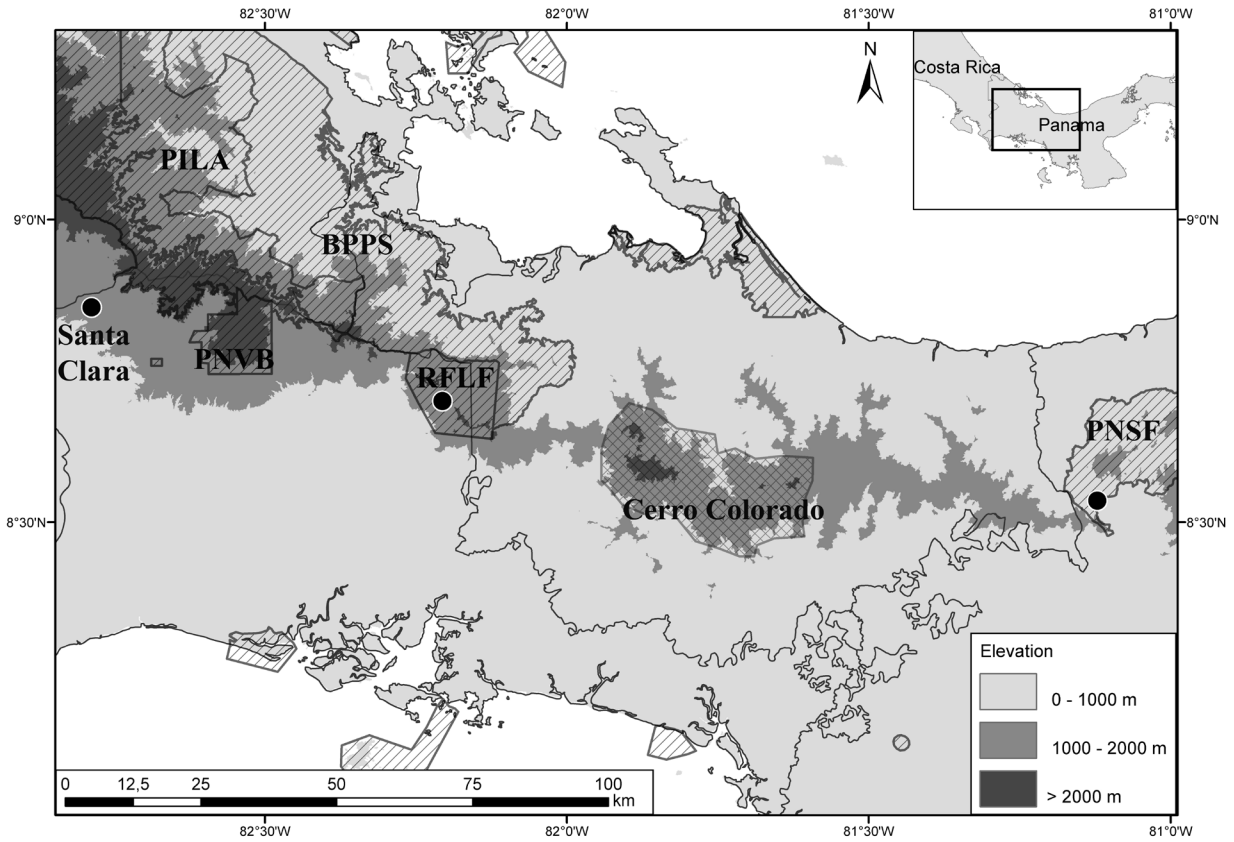

Figure 3. Map of localities referred to in Table 1. (hatched areas = PAs; cross hatched area = Cerro Colorado region, with Cerro Saguí massive in the western and Cerro Santiago in the eastern portion; black dots indicate positive *Bd* results).

the Cerro Colorado region. We could not find the former two in any of Panamas PAs, while the latter one was also present in PILA (Appendix II).

Atelopus varius (Lichtenstein and von Martens 1856): This eye-catching harlequin toad once was a common species in Costa Rica and Panama, but has suffered dramatic population declines throughout its range (Crump et al. 1992; Pounds and Crump 1994; Lips 1998, 1999; Lips et al. 2003b; La Marca et al. 2005). Although there have been sporadic sightings of this species, it is believed to be still in serious decline. We observed four individuals, all at Cerro Negro (PNSF), Veraguas. All adults were found sleeping on low riparian vegetation and a single tadpole (Gosner stage: 36) was found in a mountain stream. None of the collected individuals appeared to be sick. We conducted histological examination of skin scrapings from two adults, which yielded no evidence for *Bd*. These specimens are probably part of a small population that still persists at Cerro Negro.

Agalychnis lemur (Boulenger 1882): This used to be a quite common species in Costa Rica and Panama, but has become rare in recent years, probably due to chytridiomycosis. It is suspected that *A. lemur* is more resistant to *Bd* than is other species (Woodhams et al. 2006). There is no doubt that deforestation is a major threat to this species as well. We collected a single specimen at Cerro Negro (PNSF), Veraguas. The frog was found in a small creek where it was sitting on a rock. Although we visited Cerro Negro between 2008 and 2009 seven times at different seasons of the year, this remained the only detected specimen.

Duellmanohyla uranochroa (Cope 1875): This species was once common in the RFLF, but has become rare after severe declines (Lips 1999; Pounds et al. 2008). We collected the first four tadpoles (Gosner stages: 26-29) from a small creek on the south-western slope of Cerro Pata de Macho (RFLF) in 2008, where several more tadpoles were present in slow-moving water puddles along the creek. In the following years, tadpoles have been observed in this creek during several times of the year. In 2009, we found two adults: one from vegetation near the collection site of the tadpoles, and a second at BPPS, Comarca Ngöbe-Buglé, only a few km from the former adult. This individual was also arranged in riparian vegetation, about three m above the ground. The latter one appeared meagre and feeble and we found it to be parasitized by a large nematode that moved under its skin. Both adults tested negative for the presence of *Bd*. All of the collected tadpoles showed mouthpart deformations ranging from slight folding of the oral disc to complete loss of keratine in denticles and beak. A skin scraping we took from a tadpole's oral disc tested positive for *Bd* by histological examination. *D. uranochroa* is currently known from Monteverde and Tuis de Turrialba, Costa Rica (IUCN 2010). Our records represent the only recent findings of this species in Panama.

Hyloscirtus colymba (Dunn 1931): This species has undergone drastic population declines in western and central Panama (Lips 1999; Lips et al. 2006; Crawford et al. 2010a). We made the first record in 2008, collecting four tadpoles from a fast-moving stream near Alto de Piedra, Veraguas. A few weeks later, we found a single adult male, and in 2009 we encountered an adult female. Then, in 2010 we collected four adult specimens, two males and two females, in both forest and streams, and some more tadpoles. One male was calling from riparian vegetation, and we heard several additional males calling along the stream. Although field work has been carried out in Alto de Piedra between 1998 and 2004, e.g., by Brem and Lips (2008), this population was only recently discovered in the course of this project (Hertz et al. 2011). One of the individuals we collected in 2010 at first sight appeared to be sick tested positive for *Bd* by PCR. This confirms that *Bd* is still present within the habitat. All other collected specimens were also tested, but appeared to be healthy and we did not find any evidence for a *Bd* infection.

Isthmohyla angustilineata (Taylor 1952): This has always been an uncommon species (Savage 2002). There are only sparse data available on geographic distribution and population status. The most recent record comes from Costa Rica at Braulio Carillo National Park near Volcán Barva (Nishida 2006). At Monteverde it has declined drastically but is still found sporadically, whereas there are no recent records from Cerro Chompipe and Tapantí (IUCN 2010). In Panama there is little information on its distribution and population status. The species was first reported from Panama by Arosemena and Ibáñez (1991), who collected three specimens in 1990 at Cerro Horqueta, PILA, the only published record for Panama until now. In 2006, we collected an adult female at almost the same locality; the frog was sitting in a shrub in an inundated pasture. The current population status at this site is unknown.

Isthmohyla debilis (Taylor 1952): This small frog is an uncommon species collected at a few locations (Savage 2002). In 1996 and 1997, the populations of this species collapsed at RFLF (Lips 1999). In Panama, *I. debilis* was last detected in 1998 from neighboring BPPS (Hofer and Bersier 2001; IUCN 2010). In Costa Rica it had equally declined, and there are no recent findings in this country. We collected two calling males at La Nevera on the western slopes of Cerro Santiago, Comarca Ngöbe-Buglé, in 2008. The frogs were only traceable by following their cricket-like calls, as they sat in very dense vegetation overhanging a stream. In 2009, we collected another male near Llano Tugrí on the eastern slopes of Cerro Santiago, Comarca Ngöbe-Buglé. This one was not hidden in vegetation nor was it calling, but sat exposed on a rock in a mountain stream. In the same year, we collected two more male specimens, one of which was found calling in bushes at the margin of a mountain

stream at La Nevera; the other one sat in the same bush, moving towards its calling conspecific. Only two days later we found an additional calling male, but for conservation reasons refrained from collecting it. The frog cowered well-concealed between the leaves of a fallen tree overhanging a mountain stream. Our findings represent the only recent records of this species within its native range. Accordingly, there are no known lingering populations within the boundaries of any PA. These records also extend the known geographic distribution of the species about 30 to 40 km to the east from its nearest collecting site at Río Chiriquí, RFLF, Chiriquí (Myers and Duellman 1982).

Isthmohyla graceae (Myers and Duellman 1982): Since there were drastic declines of the species reported from RFLF, Chiriqui (Lips 1999) this Panamanian endemic has disappeared from all well-known sites. Despite many search efforts, it is uncertain if any of these populations now survive (IUCN 2010). Although the Cerro Colorado area is the type locality of this species, previous search efforts concentrated mainly on PAs. In 2010, at the south-eastern slopes of Cerro Sagui, Comarca Ngöbe-Buglé, close to the species' type locality, we detected various calling males and tadpoles at a marshy headwater of Río Cricamola between pasture and forest. We collected four adult males and one tadpole as representative samples. All four collected adults were tested for *Bd* using swab samples for PCR; three with negative and one with a uncertain result(s). Like in the previous species, this represents the only known population that so far persists, and there are no recent records from any PA.

Isthmohyla rivularis (Taylor 1952): This species once was very common (Savage 2002), but declined throughout its range in the 1990s. In Panama, the last records date back to 1996 (IUCN 2010). In 2007, it was rediscovered at Monteverde, Costa Rica (Andrew Gray, pers. comm. 2011), where it was last seen in 1989. We collected a total of six adult males and one adult female around Cerro Pando, PILA, Chiriquí and Bocas del Toro. Six specimens were obtained from the Pacific slopes and one from the Caribbean slopes. The first individual was detected in 2008 by coincidence at night near a small mountain stream. In one of the ensuing nights, after heavy rain falls, we located three more males by the side of an unpaved road by following their calls. Calling site was very dense vegetation, intermingled with leaf litter that was overhanging a small creek. The calling males were sitting near ground level, well-hidden between plant material. In the same night, we heard more males calling from different creeks in the surrounding area. In 2009, we collected another calling male from the bank of a mountain creek, where it was perched on a leaf near a small cascade. In the same night, and only about 100 m away from the latter specimen, we detected a female on a broad-leaved plant in a waterless anabranch. In November 2009, we found another individual, when crossing over the continental divide to the Caribbean slopes of Cerro Pando. It was sitting in a bush, about 1.5 m above ground level, near a fast-moving mountain creek. The abundance of this species in the surroundings of Cerro Pando indicates that there is a surviving population. None of the collected specimens appeared to be sick. Histological examination of skin scrapings did not provide any evidence of a chytrid infection.

Isthmohyla tica (Starrett 1966): This stream-breeder has also been a common species in Costa Rica and Panama (Savage 2002), until it dramatically declined at all known sites. In Panama, it had been collected at multiple sites between PILA and RFLF in the 1980s and 90s (Tejera and Dupuy 2003). These populations collapsed in 1997 and there were no recent sightings in Costa Rica or Panama. In July 2010, we collected a male specimen at Río Changena, northern slope of Cerro Pando, PILA, Bocas del Toro. The cricket-like call drew our attention to the frog that was sitting well-hidden about three m above the water line in a bush. We heard another male from the opposite side of the river, but could not find it. Later in the same month, we found a specimen at the upper reaches of Río Hacha, Comarca Ngöbe Buglé. This individual was not calling, but sitting about 3.5 m above the water in a small tree.

Discussion

The Panamanian Central Cordillera is an area where *Bd* driven amphibian declines have been especially severe (Young et al. 2001) and where declines were exceptionally well documented (Lips 1998, 1999; Lips et al. 2006). At all of these sites certain species, mainly hylids, bufonids, and stream-associated craugastorids, have not been found since these documented decline events. While in neighboring Costa Rica recent surveys have led to several rediscoveries of lost species (García-Rodruíguez et al. 2012), upland sites in western Panama were not frequently visited by herpetologists. The majority of present amphibian research in Panama is carried out east of El Copé following the *Bd* wave and little attention has been paid to post decline sites. Accordingly, to date the present paper is the only information on relict populations of rare amphibians, and shall serve as a basis for future studies. There is a paucity of data for many species in general, as indicated by the high number of species listed as Data Deficient by the IUCN. In Panama, there are 34 species (more than 16% of all Panamanian amphibians; Fig. 2) for which more information is required to assess their population status and conservation trend.

The absence of chytrid at a certain site could explain why a population persists. We took chytrid samples from several specimens and various localities. Though, the sample size presented here is not large enough to prove the absence of *Bd* at an investigated site, and we cannot identify refuge areas free of *Bd*; this will require further investigation. However, our presence data together

Table 1. Visited areas, protection status, and percentage of all EN/CR species found.

Name of area	Land cover (ha)	Protection status	Number of EN species found	Number of CR species found	Percentage of EN/CR species in transect
PILA	207,000 (Panama only)	Transboundary Protected Area; UNESCO World Heritage Site	3	3	18%
BPPS	167,410	Conservation Forest	1	1	7%
PNSF	72,636	National Park	1	3	12%
RFLF	19,500	Forest Reserve	0	1	3%
PNVB	14,322	National Park	5	0	15%
Cerro Colorado Area	at least 14,000	unprotected	2	3	15%
Santa Clara	N.A.	unprotected	1	0	3%

with other studies (e.g., Kilburn et al. 2011) show that at a large-scale this pathogen is still present at sites in Panama where chytridiomycosis once emerged (Fig 3). Further research on chytridiomycosis in wild amphibian populations should focus on populations at post-decline sites.

Altitudinal distribution of a species may also be a reason for a species to persist. There is evidence that populations of species that inhabit a vast altitudinal range may at least persist at lower altitudes where mean temperature is higher (Berger et al. 2004), or could even actively keep *Bd* infections low by exploration to warm microclimate (Daskin et al. 2011). The same is imaginable with species having wide horizontal distributions, with populations persisting in climatic refuges, e.g., drier and warmer regions (Puschendorf et al. 2005). Unfortunately, lowland forests are facing a higher deforestation risk due to a better accessibility and higher agricultural value. For example, nowadays there are almost no remainders of pristine pacific lowland forest in western Panama.

Notwithstanding, habitat loss by means of modification, fragmentation, and destruction is still the biggest threat to amphibians and wildlife in general (Gardner et al. 2007; Young et al. 1999, 2004). About 44% of Panama's land mass is still covered by forests. Compared to other Central American countries, Panama showed a relatively low deforestation rate of -1.2% in the period between 1990 and 2000 (total Central America -1.6%), and an even lower -0.4% between 2000 and 2010 (total Central America -1.2%; data taken from FAO 2011). But deforestation rates in Panama are not equally distributed, and some forests are under higher anthropogenic pressure than others. By far the highest deforestation rate among Panamanian provinces is found in the Comarca Ngöbe-Buglé (-21.8%, 1992-2000) followed by the central-eastern provinces of Darién (-13.9%), and Panamá (-12.2%) (ANAM 2009). A great portion of the Cordillera Central, almost the whole part known as Serranía de Tabasará, is located within the limits of the Comarca Ngöbe-Buglé. In addition, the Cordillera Central is home to 73% of the EN and CR amphibian species in Panama. Consequently, there is a general need for more well-protected areas in this mountain range. During this study, we identified the Cerro Colorado region as one of the most important unprotected areas for amphibian conservation in Panama. The minimum convex polygon drawn around our collection points would comprise around 14,000 ha and could include at least 15% of Panamas EN and CR amphibian species (Table 1). Two Critically Endangered species, *Isthmohyla debilis* on the slopes of Cerro Santiago and *I. graceae* on the slopes of Cerro Saguí, both of which had not been detected since the late 1990s, do occur here. These are the only known populations of those two species that now persist. Additionally, it is the only place in Panama where the Endangered *Agalychnis annae* is known, and beside La Amistad, the only additional place across its whole distribution area where the Critically Endangered *I. tica* can still be found. As presumed by the restricted time we spent in field, these findings are better understood as only a limited sample of an estimated apparent higher species diversity, including certainly many undescribed species, signifying important diversity of other non-herpetological organisms possibly as well. Unfortunately, Cerro Colorado is under increased anthropogenic pressure, especially through international mining companies that wish to establish a copper mine at this site. At present time, the current Panamanian government is attempting to ease the solicitation process for foreign countries to get concessions (Nakoneczny and Whysner 2010). From all that we know, mining at Cerro Colorado will cause severe environmental damage and reduce Panamanian amphibian fauna once more. Thus, we strongly recommend to Panamanian authorities, both the government of Panama and traditional authorities of Ngöbe-Buglé, to assign the Cerro Colorado area, including Cerro Santiago, Cerro Saguí, and the whole mountain ridge in between, an area of approximately 65,400 ha (Fig. 3), as PA in order to preserve this highly diverse area for future generations.

Unfortunately, even PAs are not always successful in their ability to control deforestation. This is especially severe in PILA and BPPS, where deforestation of mature forest was high, despite the protection status (Oestreicher et al. 2009). Currently, the discussion on new roads

through remote areas of different PAs, including PILA, PNVB, and BPPS, has come up again. The Panamanian government expects an increase of tourism and trade to be triggered by these projects. However, costs to build and maintain roads in tropical mountainous forests are usually high, making it doubtful that economic aims will be achieved (Reid and Hanily 2003). Beside other effects these roads will exacerbate deforestation by facilitating the access to formerly well-protected sites (Young 1994; Chomitz and Gray 1996; Nelson and Hellerstein 1997). It is further questionable if new roads in PAs rather annoy tourists, who are predominantly looking for pure nature, than stimulating them to make a visit, in particular if there is no forest left to see when driving through a park. There is a general need for comprehensive management plans, better demarcation of PAs, and year-round personnel to stop ongoing deforestation in areas that are supposed to be protected.

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Literature cited

Abarca J, Chaves G, García-Rodríguez A, Vargas R. 2010. Reconsidering extinction: Rediscovery of *Incilius holdridgei* (Anura: Bufonidae) in Costa Rica after 25 years. *Herpetological Review* 41(2):150-152.

ANAM (Autoridad Nacional del Ambiente). 2009. Informe GEO Panamá. 2009. Informe del estado del ambiente. Panama City, Panama. 155 p.

Andre SE, Parker J, Briggs CJ. 2008. Effect of temperature on host response to *Batrachochytrium dendrobatidis* infection in the mountain yellow-legged frog (*Rana muscosa*). *Journal of Wildlife Diseases* 44(3):716-720.

Arosemena FA, Ibáñez R. 1991. Geographic Distribution: *Isthmohyla angustinileata*. *Herpetological Review* 22(4):133.

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. *Proceedings of the National Academy of Sciences* 95(15):9031-9036.

Berger L, Speare R, Hines HB, Marantelli G, Hyatt AD, McDonald KR, Skerratt LF, Olsen V, Clarke JM, Gillespie G, Mahony M, Sheppard N, Williams C, Tyler M. 2004. Effect of season and temperature on mortality in amphibians due to chytridiomycosis. *Australian Veterinary Journal* 82(7):31-36.

Boyle DG, Boyle DB, Olsen V, Morgan JAT, Hyatt AD. 2004. Rapid quantitative detection of chytridiomycosis (*Batrachochytrium dendrobatidis*) in amphibian samples using real-time Taqman PCR assay. *Diseases of Aquatic Organisms* 60:141-148.

Brem FMR, Lips KR. 2008. *Batrachochytrium dendrobatidis* infection patterns among Panamanian amphibian species, habitats and elevations during epizootic and enzootic stages. *Diseases of Aquatic Organisms* 81(3):189-202.

Briggs C, Burgin S. 2003. A rapid technique to detect chytrid infection in adult frogs. *Herpetological Review* 34(2):124-126.

Briggs C, Burgin S. 2004. Congo Red, an effective stain for revealing the chytrid fungus, *Batrachochytrium dentrobatidis*, in epidermal skin scrapings from frogs. *Mycologist* 18(3):98-103.

Campbell A. 1999. *Declines and Disappearances of Australian Frog*s. Environment Australia, Canberra, Australia. 236 p.

Chomitz KM, Gray DA. 1996. Roads, land use, and deforestation: A spatial model applied to Belize. *The World Bank Economic Review* 10(3):487-512.

Crawford AJ, Lips KR, Bermingham E. 2010a. Epidemic disease decimates amphibian abundance, species diversity, and evolutionary history in the highlands of central Panama. *Proceedings of the National Academy of Science* 107(31):13777-13782.

Crawford AJ, Ryan MJ, Jaramillo CA. 2010b. A new species of *Pristimantis* (Anura: Strabomantidae) from the Pacific coast of the Darien Province, Panama, with a molecular analysis of its phylogenetic position. *Herpetologica* 66(2):192-206.

Crawford AJ, Alonso R, Jaramillo CA, Sucre S, Ibáñez R. 2011. DNA barcoding identifies a third invasive species of *Eleutherodactylus* (Anura: Eleutherodactylidae) in Panama City, Panama. *Zootaxa* 2890:65-

67.

Crump ML, Hensley FR, Clark KL. 1992. Apparent decline of the golden toad: Underground or extinct? *Copeia* 1992(2):413-420.

Daskin JH, Alford RA, Puschendorf R. 2011. Short-term exposure to warm microhabitats could explain amphibian persistence with *Batrachochytrium dendrobatidis*. *PLoS ONE* 6(10):e26215. doi:10.1371/journal.pone.0026215.

Daszak P, Berger L, Cunningham AA, Hyatt AD, Green DE, Speare R. 1999. Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases* 5(6):735-748.

Daszak P, Cunningham AA, Hyatt V. 2000. Emerging infectious diseases of wildlife-threats to biodiversity and human health. *Science* 287(5452):443-449.

Duellman WE. 2001. *The Hylid Frogs of Middle America*. Society for the Study of Amphibians and Reptiles, Ithaca, New York, USA. 1170 p.

FAO (Food and Agriculture Organizations of the United Nations). 2011. *State of the World's Forests 2011*. Rome, Italy. 179 p.

García-Rodríguez A, Chaves G, Benavides-Varela C, Puschendorf R. 2012. Where are the survivors? Tracking relictual populations of endangered frogs in Costa Rica. *Diversity and Distributions* 18(2):204-212.

Gardner TA, Barlow J, Peres CA. 2007. Paradox, presumption and pitfalls in conservation biology: The role of habitat change for amphibians and reptiles. *Biological Conservation* 138(1-2):166-179.

Gascon C, Collins JP, Moore RD, Church DR, McKay JE, Mendelson III JR. (Editors). 2007. *Amphibian Conservation Action Plan*. IUCN/SSC Amphibian Specialist Group, Gland, Switzerland and Cambridge, UK. 68 p.

Gosner KL. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16(3):183-190.

Hanken J, Wake DB, Savage JM. 2005. A solution to the large black salamander problem (genus *Bolitoglossa*) in Costa Rica and Panamá. *Copeia* 2005(2):227-245.

Hertz A, Lotzkat S, Stadler L, Hamad N, Carrizo A, Köhler G. 2011. Noteworthy records of amphibians from western Panama. *Herpetological Review* 42(2):245-250.

Hofer U, Bersier L-F. 2001. Herpetofaunal diversity and abundance in tropical upland forests of Cameroon and Panama. *Biotropica* 33(1):142-152.

Holdridge LR. 1967. *Life Zone Ecology*. Tropical Science Center, San José, Costa Rica. 140 p.

Hyatt AD, Boyle DG, Olsen V, Boyle DB, Berger L, Obendorf D, Dalton A, Kriger K, Hero M, Hines H, Phillott R, Campbell R, Marantelli G, Gleason F, Colling A. 2007. Diagnostic assays and sampling protocols for the detection of *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 73(3):175-192.

Ibáñez R, Jaramillo CA, Solís FA, Jaramillo FE. 1991. Geographic Distribution: *Ecnomiohyla fimbrimembra*. *Herpetological Review* 22(4):133-134.

Ibáñez R, Jaramillo CA, Arosemena FA. 1994. A new species of *Eleutherodactylus* (Anura: Leptodactylidae) from Panamá. *Amphibia-Reptilia* 15(4):337-341.

IUCN. 2010. IUCN Red List of Threatened Species. Version 2010.4. [Online]. Available: http://www.iucnredlist.org [Accessed: 27 April 2011].

Jaramillo CA, Wilson LD, Ibáñez R, Jaramillo F. 2010. The herpetofauna of Panama: Distribution and conservation status In: *Conservation of Mesoamerican Amphibians and Reptiles*. Editors, Wilson LD, Townsend JH, Johnson JD. Eagle Mountain Publishing Company, Eagle Mountain, Utah, USA. 812 p. 604-673.

Kilburn VL, Ibáñez R, Sanjur, O, Bermingham E, Suraci JP, Green DM. 2011. Ubiquity of the pathogenic chytrid fungus, *Batrachochytrium dentrobatidis*, in anuran communities in Panamá. *EcoHealth* 8(1):1-12.

Köhler G. 2001. *Anfibios y Reptiles de Nicaragua*. Herpeton, Offenbach, Germany. 208 p.

Köhler G. 2011. *Amphibians of Central America*. Herpeton, Offenbach, Germany. 279 p.

Kolby JE, McCranie JR. 2009. Discovery of a surviving population of the montane streamside frog *Craugastor milesi* (Schmidt). *Herpetological Review* 40(4):444.

Kubicki B. 2007. *Ranas de Vidrio de Costa Rica/Glass frogs of Costa Rica*. InBio, Santo Domingo de Heredia, Costa Rica. 304 p.

Kriger KM, Hero JM. 2007. The chytrid fungus *Batrachochytrium dendrobatidis* is non-randomly distributed across amphibian breeding habitats. *Diversity and Distributions* 13(6):781-788.

La Marca E, Lips KR, Lötters S, Puschendorf R, Ibáñez R, Rueda-Almonacid JV, Schulte R, Marty C, Castro F, Manzanilla-Puppo J, García-Pérez JE, Bolaños F, Chaves G, Pounds JA, Toral E, Young BE. 2005. Catastrophic population declines and extinctions in neotropical Harlequin frogs (Bufonidae: *Atelopus*). *Biotropica* 37(2):190-201.

Lips KR. 1993. Geographic Distribution: *Bolitoglossa compacta*. *Herpetological Review* 24(3):107.

Lips KR. 1998. Decline of a tropical montane amphibian fauna. *Conservation Biology* 12(1):106-117.

Lips KR. 1999. Mass mortality and population declines of anurans at an upland site in western Panama. *Conservation Biology* 13(1):117-125.

Lips KR, Green DE, Papendick R. 2003a. Chytridiomycosis in wild frogs from southern Costa Rica. *Journal of Herpetology* 37(1):215-218.

Lips KR, Reeve JD, Witters LR. 2003b. Ecological traits predicting amphibian population declines in Central America. *Conservation Biology* 17(4):1078-1088.

Lips KR, Brem F, Brenes R, Reeve JD, Alford RA, Voyles J, Carey C, Livo L, Pessier AP, Collins JP. 2006. Emerging infectious disease and the loss of

biodiversity in a neotropical amphibian community. *Proceedings of the National Academy of Science* 103(9):3165-3170.

Lips KR, Diffendorfer J, Mendelson III JR, Sears MW. 2008. Riding the wave: Reconciling the roles of disease and climate change in amphibian declines. *PLOS Biology* 6(3):441-454.

Longcore JE, Pessier AP, Nichols DK. 1999: *Batrachochytrium dentrobatidis* gen. et sp. nov., a chytrid pathogenic to amphibians. *Mycologia* 91(2):219-227.

Lotzkat S, Hertz A, Valera-Leal J. 2007. Amphibia, Anura, Hylidae, *Hylomantis medinai*: Distribution extension by discovery of a third population. *Checklist* 3(3):200-203.

McCranie JR, Valdés Orellana L, Himes JG. 2010. Rediscovery of two Honduran endemic streamside frogs, *Craugastor emleni* (Dunn) and *Craugastor stadelmani* (Schmidt). *Froglog* 94:12-15.

Mendelson III JR, Savage JM, Griffith E, Ross H, Kubicki B, Gagliardo R. 2008. Spectacular new gliding species of *Ecnomiohyla* (Anura: Hylidae) from central Panama. *Journal of Herpetology* 42(4):750-759.

Mendelson III JR, Mulcahy DG. 2010. A new species of toad (Bufonidae: *Incilius*) from central Panama. *Zootaxa* 2396:61-68.

Myers CW, Duellman WE. 1982. A new species of *Hyla* from Cerro Colorado, and other tree frog records and geographical notes from western Panama. *American Museum Novitates* 2752:1-32.

Narvaes P, Rodrigues MT. 2009. Taxonomic revision of *Rhinella granulosa* species group (Amphibia, Anura, Bufonidae), with a description of a new species. *Papéis Avulsos de Zoologia* (São Paulo) 40(1):1-73.

Nelson GC, Hellerstein D. 1997. Do roads cause deforestation? Using satellite images in econometric analysis of land use. *American Journal of Agricultural Economics* 79(1):80-88.

Nakoneczny L, Whysner K. 2010. *In the "Heart" of the Comarca: Understanding the Environmental and Social Impacts of Mining the Cerro Colorado Deposit*. ENVR451 Final Report. Prepared for Centro de Incidencia Ambiental, the Smithsonian Institute, McGill University and the communities of the Ngöbe-Buglé Comarca. [Online]. Available: http://www.mcgill.ca/files/pfss/Understandingtheenvironmentalandsocialimpact.doc. [Accessed: 10 July 2011].

Nishida K. 2006. Encounter with *Hyla angustilineata* Taylor, 1952 (Anura: Hylidae) in cloud forest of Costa Rica. *Brenesia* 66:79-81.

Oestreicher JS, Benessaiah K, Ruiz-Jaen MC, Sloan S, Turner K, Pelletier J, Guay B, Clark KE, Roche DG, Meiners M, Potvin C. 2009. Avoiding deforestation in Panamanian PAs: An analysis of protection effectiveness and implications for reducing emissions from deforestation and forest degradation. *Global Environmental Change* 19:279-291.

Ortega-Andrade HM. 2008. *Agalychnis spurrelli* Boulenger (Anura, Hylidae): Variación, distribución y sinomia. *Papéis Avulsos de Zoologia* (São Paulo) 48(13):103-117.

Piotrowski JS, Annis SL, Longcore JE. 2004. Physiology of *Batrachochytrium dendrobatidis*, a chytrid pathogen of amphibians. *Mycologia* 96(1):9-15.

Pounds JA, Crump ML. 1994. Amphibian declines and climate disturbance: The case of the golden toad and the harlequin frog. *Conservation Biology* 8(1):72-85.

Pounds JA, Bolaños F, Chaves G. 2008. *Agalychnis annae* In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. [Online]. Available: www.iucnredlist.org [Accessed: 20 April 2011].

Puschendorf R, Chaves G, Crawford AJ, Brooks DR. 2005. *Eleutherodactylus ranoides* (NCN): Dry forest population, refuge from decline? *Herpetological Review* 36(1):53.

Reid J, Hanily G. 2003. *Análisis Económico de tres Inversiones Viales a Través del Parque Nacional Volcán Barú y Áreas Aledañas en Panamá Occidental*. The Nature Conservancy, Panama City, Panama. 39 p.

Rodríguez-Contreras A, Señaris JC, Lampo M, Rivero R. 2008. Rediscovery of *Atelopus cruciger* (Anura: Bufonidae): Current status in the Cordillera de La Costa, Venezuela. *Oryx* 42:301-304.

Ryan MJ, Lips KR, Eichholz MW. 2008. Decline and extirpation of an endangered Panamanian stream frog population (*Craugastor punctariolus*) due to an outbreak of chytridiomycosis. *Biological Conservation* 141(6):1636-1647.

Ryan, M.J., Lips, K.R., Giermakowski, J.T. 2010a. New species of *Pristimantis* (Anura: Terrarana: Strabomantidae) from lower Central America. *Journal of Herpetology* 44:193-200.

Ryan MJ, Savage JM, Lips KR, Giermakowski JT. 2010b. A new species of the *Craugastor rugulosus* series (Anura: Craugastoridae) from west-central Panama. *Copeia* 2010(3):405-409.

Savage JM. 2002. *The Amphibians and Reptiles of Costa Rica. A Herpetofauna Between Two Continents, Between Two Seas.* University of Chicago Press, Chicago, Illinois, U.S.A., and London, United Kingdom. 954 p.

Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischman DL, Waller RW. 2004. Status trends of amphibian declines and extinctions worldwide. *Science* 306(5702):1783-1786.

Tejera VH, Dupuy OA. 2003. *Anfibios del Museo de Vertebrados de la Universidad de Panamá*. Catálogo. Universidad de Panamá, Panama City, Panama. 188 p.

Wake DB, Brame Jr AH, Duellman WE. 1973. New species of salamanders, genus *Bolitoglossa*, from Panama. *Contributions in Science, Natural History Museum of Los Angeles County* 248:1-19.

Woodhams DC, Voyles J, Lips KR, Carey C, Rollins-Smith LA. 2006. Predicted disease susceptibility in a Panamanian amphibian assemblage based on

skin peptide defenses. *Journal of Wildlife Diseases* 42(2):207-218.

Woodhams DC, Kilburn VL, Reinert LK, Voyles J, Medina D, Ibáñez R, Hyatt AD, Boyle DG, Pask JD, Green DM, Rollins-Smith LA. 2008. Chytridiomycosis and amphibian population declines continue to spread eastward in Panama. *EcoHealth* 5(3):268-274.

Young BE, Sedaghatkish G, Roca E, Fuenmayor QD. 1999. *El Estatus de la Conservación de la Herpetofauna de Panama*. Resumen del Primer Taller Internacional Sobre la Herpetofauna de Panama. The Nature Conservancy y Asociación para la Conservación de la Naturaleza, Panama City, Panama. 40 p.

Young BE, Lips KR, Reaser JK, Ibáñez R, Salas AW, Cedeño JR, Coloma LA, Ron S, La Marca E, Meyer JR, Muñoz A, Bolaños F, Chaves G, Romo D. 2001. Population declines and priorities for amphibian conservation in Latin America. *Conservation Biology* 15(5):1213-1223.

Young BE, Stuart SN, Chanson JS, Cox NA, Boucher TM. 2004. *Disappearing Jewels: The Status of New World Amphibians*. Nature Serve, Arlington, Virginia, USA. 60 p.

Young KR. 1994. Roads and environmental degradation of tropical montane forests. *Conservation Biology* 8(4):972-976.

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Appendix I

Voucher specimens

Anura: ***Agalychnis annae*:** Comarca Ngöbe-Buglé: Cerro Colorado, N8.53, W81.81, 1600 m a.s.l.: SMF 89791; ***Agalychnis lemur***: Veraguas: PNSF, Cerro Negro, N8.57, W81.10, 690 m a.s.l.: SMF 89959; ***Atelopus varius***: Veraguas: PNSF, Cerro Negro, N8.57, W81.10, 730-1090 m a.s.l.: SMF 89822-3, 89917, AH 218; ***Duellmanohyla uranochroa***: Chiriquí: RFLF, western slopes of Cerro Pata de Macho, N8.67, W82.20. 1420 m a.s.l.: SMF 89824, 89826, AH 195; Comarca Ngöbe-Buglé: BPPS, continental divide, street to Petroterminal, N8.79, W82.21, 1060-1080 m a.s.l.: SMF 89825, 89827; ***Ecnomiohyla fimbrimembra***: Chiriquí: Boquete, Bajo Mono, north-eastern slopes of Volcán Barú, N8.83, W82.50, 1820 m a.s.l.: SMF 89857; ***Hyloscirtus colymba***: Veraguas: Alto de Piedra, N8.51, W81.12, 880-940 m a.s.l.: SMF 89794, 89828-32, AH 059, AH 547; ***Isthmohyla angustilineata***: Chiriqí: PILA, Cerro Horqueta, N8.85, W82.42, 1800 m a.s.l.: MHCH 483; ***Isthmohyla debilis***: Comarca Ngöbe-Buglé: La Nevera, western slopes of Cerro Santiago, N8.50, W81.77, 1540-1650 m a.s.l.: SMF 89833, 89835, AH 166, AH 347; Llano Tugrí, eastern slopes of Cerro Santiago, N8.50, W81.72, 1570 m a.s.l.: SMF 89834; ***Isthmohyla graceae***: Comarca Ngöbe-Buglé: Cerro Saguí, Finca Alto Cedro, N8.56, W81.82, 1710 m a.s.l.: SMF 8936-8, AH 477, AH 478; ***Isthmohyla rivularis***: Chiriquí: PILA, Jurutungo, southern slopes of Cerro Pando, N8.91, W82.72, 1870-2070 m a.s.l.: SMF 89839-43, AH 138, AH 139; northern slopes of Cerro Pando near continental divide, N8.93; W82.71, 2290 m a.s.l.: SMF 89843; ***Isthmohyla tica***: Bocas del Toro: PILA, Río Changena, northern slopes of Cerro Pando, N8.98, W82.69, 1620 m a.s.l.: SMF 89845; Comarca Ngöbe-Buglé: Caribbean slopes of Cordillera de Tabasará, valley of Río Hacha, N8.52, W81.79, 1220 m a.s.l.: SMF 89846; ***Pristimantis museosus***: Bocas del Toro: PILA, Río Changena, northern slopes of Cerro Pando, N8.98, W82.69, 1650 m a.s.l.: SMF 89859; Private Reserve Willi Mazu, N8.79, W82.20, 690 m a.s.l.: SMF 89860; Comarca Ngöbe-Buglé: La Nevera, western slopes of Cerro Santiago, N8.50, W81.77, 1590 m a.s.l.: SMF 89858; Veraguas: Alto de Piedra, N8.51, W81.12, 940-1000 m a.s.l.: SMF 89861-2, AH 555; PNSF, Cerro Negro, N8.57, W81.10, 770 m a.s.l.: SMF 89864; ***Ptychohyla legleri***: Chiriquí: Santa Clara, N8.83, W82.78, 1200 m a.s.l.: SMF 89863.

Caudata: ***Bolitoglossa compacta***: Chiriquí: PNVB, Volcán Barú, road from Boquete to summit, N8.80, W82.52, 3000 m a.s.l.: SMF 89849; ***Bolitoglossa magnifica***: Chiriquí: PNVB, Volcán Barú, road from Boquete to summit, N8.80, W82.51, 2350 m a.s.l.: SMF 89847-8, AH 323, AH 325; ***Bolitoglossa marmorea***: Chiriquí: PNVB, Volcán Barú, summit region of volcano, N8.81, W82.54, 3340-3400 m a.s.l.: SMF 89850-2, AH 328, AH 329; ***Bolitoglossa minutula***: Chiriquí: PILA, Jurutungo, southern slopes of Cerro Pando, N8.91, W81.72, 1960-2030 m a.s.l.: SMF 89854, AH 141; northern slopes of Cerro Pando near continental divide, N8.93, W82.71, 2320 m a.s.l.: SMF 89855, AH 277; PNVB, Sendero Los Quezales, northern slope of volcano, N8.85, W82.51, 2130 m a.s.l.; SMF89856; PNVB, Volcán Barú, road from Boquete to summit, Camp Mamecillos, N8.80, W82.51, 2600 m a.s.l.: SMF 89853; ***Oedipina grandis***: Chiriquí: PILA, Jurutungo, southern slopes of Cerro Pando, N8.54, W82.43, 2060 m a.s.l.: SMF 85076.

APPENDIX II

List of amphibians known to occur in Panama

Amphibian species reported for Panama	IUCN Category	EN/CR known from transect	EN/CR detected during this study	Distance of detected population to nearest PA (km)	Name of nearest PA
Order Anura					
Family Aromobatidae					
Allobates talamancae	LC				
Family Bufonidae					
Atelopus certus	EN				
A. chiriquiensis	CR	X			
A. glyphus	CR				
A. limosus	EN				
A. varius	CR	X	X	0	PNSF
A. zeteki	CR				
Crepidophryne epiotica	LC				
Incilius aucoinae	LC				
I. coniferus	LC				
I. fastidiosus	LC				
I. karenlipsae	NE				
I. melanochlorus	LC				
I. peripatetes	CR	X			
I. signifer	LC				
Rhaebo haematiticus	LC				
Rhinella acrolopha	DD				
R. alata	DD				
R. centralis	NE				
R. marina	LC				
Family Centrolenidae					
Cochranella euknemos	LC				
C. granulosa	LC				
Espadarana prosoblepon	LC				
Hyalinobatrachium aureoguttatum	NT				
H. chirripoi	LC				
H. colymbiphyllum	LC				
H. fleischmanni	LC				
H. talamancae	LC				
H. valerioi	LC				
H. vireovittatum	DD				
Sachatamia albomaculata	LC				
S. ilex	LC				
Teratohyla pulverata	LC				
T. spinosa	LC				
Family Craugastoridae					
Craugastor azueroensis	EN				
C. bransfordii	LC				
C. catalinae	CR	X			
C. crassidigitus	LC				

Amphibian species reported for Panama	IUCN Category	EN/CR known from transect	EN/CR detected during this study	Distance of detected population to nearest PA (km)	Name of nearest PA
C. emcelae	CR	X			
C. evanesco	NE				
C. fitzingeri	LC				
C. gollmeri	LC				
C. gulosus	EN	X			
C. jota	DD				
C. longirostris	LC				
C. megacephalus	LC				
C. melanostictus	LC				
C. monnichorum	DD				
C. noblei	LC				
C. obesus	EN	X			
C. opimus	LC				
C. podiciferus	NT				
C. polyptychus	LC				
C. punctariolus	EN	X			
C. raniformis	LC				
C. ranoides	CR	X			
C. rhyacobatrachus	EN	X			
C. rugosus	LC				
C. stejnegerianus	LC				
C. tabasarae	CR				
C. talamancae	LC				
C. taurus	CR				
Family Dentrobatidae					
Ameerega maculata	DD				
Colostethus latinasus	DD				
C. panamansis	LC				
C. pratti	LC				
Dendrobates auratus	LC				
Hyloxalus chocoensis	DD				
Oophaga arborea	EN	X			
O. granulifera	VU				
O. pumilio	LC				
O. speciosa	EN	X			
O. vicentei	DD				
Phyllobates lugubris	LC				
Ranitomeya claudiae	DD				
R. fulgurita	LC				
R. minuta	LC				
Silverstoneia flotator	LC				
S. nubicola	NT				
Family Eleutherodactylidae					
Diasporus diastema	LC				
D. hylaeformis	LC				
D. quidditus	LC				
D. vocator	LC				

Amphibian species reported for Panama	IUCN Category	EN/CR known from transect	EN/CR detected during this study	Distance of detected population to nearest PA (km)	Name of nearest PA
Family Hemiphractidae					
Gastrotheca cornuta	EN	X			
G. nicefori	LC				
Hemiphractus fasciatus	NT				
Family Hylidae					
Agalychnis annae	EN	X	X	30	BPPS
A. callidryas	LC				
A. lemur	CR	X	X	0	PNSF
A. spurelli	LC				
Anotheca spinosa	LC				
Cruziohyla calcarifer	LC				
Dendropsophus ebraccatus	LC				
D. microcephalus	LC				
D. phlebodes	LC				
D. subocularis	LC				
Duellmanohyla lythrodes	EN	X			
D. uranochroa	CR	X	X	0	BPPS; RFLF
Ecnomiohyla fimbrimembra	EN	X	X	0	PNVB
E. miliaria	VU				
E. rabborum	CR				
E. thysanota	DD				
Hyloscirtus colymba	CR	X	X	0	PNSF
H. palmeri	LC				
Hypsiboas boans	LC				
H. crepitans	LC				
H. pugnax	LC				
H. rosenbergi	LC				
H. rufitelus	LC				
Isthmohyla angustilineata	CR	X	X	0	PILA
I. calypsa	CR	X			
I. debilis	CR	X	X	36	BPPS
I. graceae	CR	X	X	27	BPPS
I. infucata	DD				
I. lancasteri	LC				
I. picadoi	NT				
I. pseudopuma	LC				
I. rivularis	CR	X	X	0	PILA
I. tica	CR	X	X	0	PILA
I. zeteki	NT				
Phyllomedusa venusta	LC				
Ptychohyla legleri	EN	X	X	7	PILA
Scinax altae	LC				
S. boulengeri	LC				
S. elaeochrous	LC				
S. rostratus	LC				
S. ruber	LC				
Smilisca phaeota	LC				

Amphibian species reported for Panama	IUCN Category	EN/CR known from transect	EN/CR detected during this study	Distance of detected population to nearest PA (km)	Name of nearest PA
S. sila	LC				
S. sordida	LC				
Trachycephalus venulosus	LC				
Family Leiuperidae					
Engystomops pustulosus	LC				
Pleurodema brachyops	LC				
Family Leptodactylidae					
Leptodactylus bolivianus	LC				
L. fragilis	LC				
L. fuscus	LC				
L. melanonotus	LC				
L. poecilochylus	LC				
L. savagei	LC				
Family Microhylidae					
Chiasmocleis panamensis	LC				
Elachistocleis ovalis	LC				
Nelsonophryne aterrima	LC				
Relictivomer pearsei	LC				
Family Pipidae					
Pipa myersi	EN				
Family Ranidae					
Litobathes taylori	LC				
L. vaillanti	LC				
L. vibicarius	CR	X			
L. warszewitschii	LC				
Family Strabomantidae					
Pristimantis achatinus	DD				
P. adnus	NE				
P. altae	NT				
P. caryophyllaceus	NT				
P. cerasinus	LC				
P. cruentus	LC				
P. educatoris	NE				
P. gaigei	LC				
P. moro	LC				
P. museosus	EN	X	X	0	PILA; BPPS; PNSF
P. pardalis	NT				
P. pirrensis	DD				
P. ridens	LC				
P. taeniatus	LC				
Strabomantis bufoniformis	LC				
S. laticorpus	DD				
Order Caudata					
Family Plethodontidae					
Bolitoglossa anthracina	DD				
B. biseriata	LC				

Amphibian species reported for Panama	IUCN Category	EN/CR known from transect	EN/CR detected during this study	Distance of detected population to nearest PA (km)	Name of nearest PA
B. bramei	DD				
B. colonnea	LC				
B. compacta	EN	X	X	0	PNVB
B. copia	DD				
B. cuna	DD				
B. gomezi	DD				
B. lignicolor	VU				
B. magnifica	EN	X	X	0	PNVB
B. marmorea	EN	X	X	0	PNVB
B. medemi	VU				
B. minutula	EN	X	X	0	PILA; PNVB
B. phalarosoma	DD				
B. pygmaea	DD				
B. robinsoni	DD				
B. robusta	LC				
B. schizodactyla	LC				
B. sombra	VU				
B. taylori	DD				
Oedipina alfaroi	VU				
O. alleni	LC				
O. collaris	DD				
O. complex	LC				
O. cyclocauda	LC				
O. fortunensis	NE				
O. gracilis	EN				
O. grandis	EN	X	X	0	PILA
O. maritima	CR				
O. pacificensis	LC				
O. parvipes	LC				
Order Gymnophiona					
Family Caeciliidae					
Caecilia isthmica	DD				
C. leucocephala	LC				
C. nigricans	LC				
C. volcani	DD				
Dermophis glandulosus	DD				
D. gracilior	DD				
D. parviceps	LC				
Gymnophis multiplicata	NE				
Oscaecilia elongata	DD				
O. ochrocephala	LC				
Total 206		**33**	**18**		

APPENDIX III

Representative species

Agalychnis annae (SMF 89791), Cerro Colorado, Comarca Ngöbe-Buglé. *Photo by SL.*

Agalychnis lemur (SMF 89959), Cerro Negro, PNSF, Veraguas. *Photo by AC.*

Atelopus varius (AH 218), Cerro Negro, PNSF, Veraguas. *Photo by AH.*

Bolitoglossa compacta (SMF 89849), Volcán Barú, PNVB, Chiriquí. *Photo by AH.*

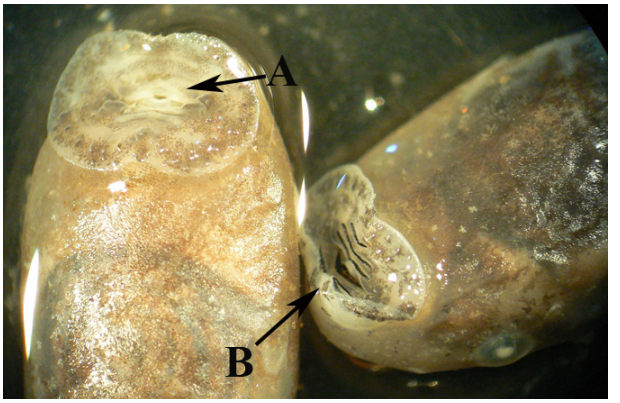
Bolitoglossa magnifica (AH323), Volcán Barú, PNVB, Chiriquí. *Photo by AH.*

Bolitoglossa marmorea (SMF 89850), summit of Volcán Barú, PNVB, Chiriquí. *Photo by AH.*

Bolitoglossa minutula (SMF 89855), valley of Jurutungo, southern slope of Cerro Pando, PILA, Chiriquí. *Photo by AH.*

Duellmanohyla uranochroa (SMF 89824), western slope of Cerro Pata de Macho, RFLF, Chiriquí. *Photo by AH.*

Back view of *Duellmanohyla uranochroa* (SMF 89825) with large nematode under the skin, BPPS, Comarca Ngöbe-Buglé. *Photo by AH.*



Tadpoles of Duellmanohyla uranochroa (AH 195) showing complete loss of keratinized mouthparts (A) and deformation of oral disk (B), western slope of Cerro Pata de Macho, RFLF, Chiriquí. *Photo by AH through dissecting microscope.*

Ecnomiohyla fimbrimembra (SMF 89857), Bajo Mono, eastern slope of Volcán Barú, PNVB, Chiriquí. *Photo by AH.*

Hyloscirtus colymba (AH 547), Alto de Piedra, PNSF, Veraguas. *Photo by AH.*

Hyloscirtus colymba (SMF 89831) infected with chydridiomycosis, note reddish coloration through vascular dilatation, Alto de Piedra, PNSF, Veraguas. *Photo by AH.*

Isthmohyla angustilineata (MHCH 483), El pianista, PILA, Bocas del Toro. *Photo by MP.*

Isthmohyla debilis (AH 347), La Nevera, Comarca Ngöbe-Buglé. *Photo by AH.*

Isthmohyla graceae (SMF 89837), Cerro Saguí, Comarca Ngöbe-Buglé. *Photo by AH.*

Isthmohyla rivularis (SMF 89843), northern slope of Cerro Pando, PILA, Bocas del Toro. *Photo by AH.*

Isthmohyla tica (SMF 89846), Río Hacha, Comarca Ngöbe-Buglé. *Photo by AH.*

Oedipina grandis (SMF 85076), valley of Jurutungo, southern slope of Cerro Pando, PILA, Chiriquí. *Photo by GK.*

Pristimantis museosus (SMF89859), Río Changena, northern slopes of Cerro Pando, PILA Bocas del Toro. *Photo by AH.*

Ptychohyla legleri froglet (SMF 89863), Santa Clara, Chiriquí. *Photo by AH.*

View of the Cerro Colorado area looking westward along the continental divide, from La Nevera. Note road from San Felix and cone-shaped peak of Cerro Saguí in the background (cp. Fig. 1 in Myers and Duellman 1982). *Photo by SL.*

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Amphibian & Reptile Conservation **6(2):31-34.**

Habitat associations and conservation of *Eremias acutirostris* (Boulenger, 1887) in the Sistan region, Zabol, Iran

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***Abstract.*—During a field survey in the Sistan region of Iran in October 2011, habitat of *Eremias acutirostris* was surveyed and four specimens of the species were collected. We report a locality situated along the road from Zabol to Doost Mohammad, near the town of Bonjar. The fragile habitat, consist of immobile sand dunes, is situated in proximity to an industrial zone, placing this remnant population under threat of pollution and other anthropogenic edge effects. We call the Zabol Environmental Protection Agency to act and insure the species' future in Iran.**

Key words. *Eremias acutirostris*, Zabol, sand dune, Doost Mohammad, conservation

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Introduction

Eremias is a widespread Lacertid genus that is distributed from China to eastern Europe and southward to the Iranian plateau (Anderson 1999; Rastegar-Pouyani et al. 2007). The genus comprises approximately 15 species in Iran. *Eremias acutirostris* (Fig. 1) occurs in Iran, Afghanistan, and Pakistan, and listed as "Least Concern" by the IUCN (Anderson 1999, Rastegar-Pouyani et al. 2008). As a specialist species, *E. acutirostris* requires a suitable habitat, perhaps critical for its survival.

Within the distribution range of the species, its occurrence in Iran is limited to a small area (Zabol region) (Fig. 2). This particular habitat, characterized by vegetated sand dunes, is consumedly degraded by the high human population density in the area; main threats are overgrazing and industrial activities. In this study, we examined the species' habitat preferences and provide suggestions about its conservation, in association to these environmental problems.

Materials and methods

During a three day field survey in the Sistan region of Iran in October 2011, we observed 12 specimens of *E. acutirostris* in the field; four were collected and deposited in the Hakim Sabzevari Zoological Museum (SUHC 1084, 1085, 1086, and 1087). The locality was in an arid area of the Hamoon basin, approximately 20 km W of Bonjar on the road between Zabol and Doost Mohammad (N 31° 05' 15.6'', E 061° 37' 32.8'', elevation 440 m). The habitat consisted of immobile sand dunes with large shrubs (*Tamarix* sp. and *Haloxylon* sp.) (Fig. 3). The snake *Echis carinatus* and the gecko *Bunopus tuberculatus* were also observed and collected in the same habitat.

Results and discussion

Reptiles inhabit a diverse array of habitats, but are known to be sensitive to habitat destruction and degradation (Goode et al. 1995). Lizards in the genus *Eremias* inhabit xeric habitats in Iran, which are threatened mainly by grazing and industrial development. Human activity in the study area is evident and an industrial park has recently been constructed along the road between the villages. The construction of the industrial township, with all its accompanying structures, inevitably destroyed some of the fragile habitat. Drought conditions resulting in loss of vegetation have deteriorated the habitat, as shrubs are viable resources for food (via insect attraction) and shelter (refuge from predators) for the lizards. We presume that these recent modifications are negatively affecting the species' population within the area and may possibly lead to extinction of this lizard in Iran, if not restricted and protected.

Conservation of *E. acutirostris* and other rare species that may occur in the studied habitat are significantly depended on the decision making of the Department of Environment of the region, and the establishment of protected area(s). We hope that publication of our findings will improve the conservation of this rare species, with its restricted distribution in Iran.

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Literature cited

Anderson SC. 1999. *The Lizards of Iran*. Society for the Study of Amphibians and Reptiles, Ithaca, New York, USA. 137 text-figs., distribution maps [unnumbered], 25 col. pls., 442 p.

Goode MJ, Howland JM, Sredl MJ. 1995. *Effects of microhabitat destruction on reptile abundance in Sonoran Desert rock outcrops*. Nongame and Endangered Wildlife Program Heritage Report. Arizona Game and Fish Department, Phoenix, Arizona, USA. 25 p.

Rastegar-Pouyani N, Johari M, Rastegar-Pouyani E. 2007. *Field Guide to the Reptiles of Iran* (Volume 1: Lizards). Razi University Press, Kermanshah, IRAN. 298 p.

Rastegar-Pouyani N, Kami HG, Rajabizadeh M, Shafiei S, Anderson SC. 2008. Annotated checklist of amphibians and reptiles of Iran. *Iranian Journal of Animal Biosystematics* 4(1):43-66.

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Figure 1. Adult male *Eremias acutirostris* from the Zabol region, Iran.

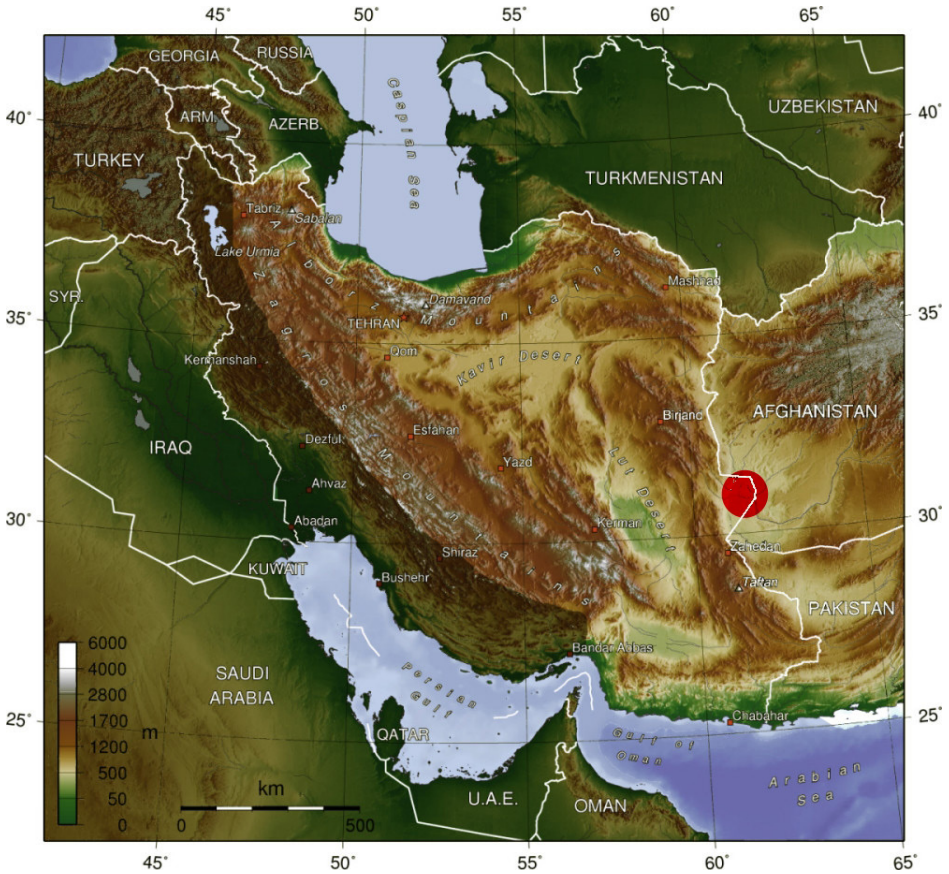

Figure 2. Map of Iran and the location of limited population (A) of *Eremias acutirostris* in east of Iran.

Figure 3. Habitat of *Eremias acutirostris* along the road from Bonjar to Doost Mohammad, Sistan region, Iran.

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***Amphibian & Reptile Conservation* 6(2): 35–39.**

New country record and range extension of *Eremias suphani* Başoğlu & Hellmich, 1968 from Iran

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***Abstract.*—Iran is located in an area that is bordered by several mountains and contains herpetofaunal constituents from adjacent countries such as Pakistan, Iraq, Afghanistan, and Turkey. We surveyed several border provinces of Iran to more completely understand the Iranian herpetofauna. During one survey in the northwestern part of Iran we found a species of the genus *Eremias* that can be added to Iran's herpetofauna. Previously, the distribution of *Eremias suphani* was limited to the Van Lake in Turkey (type locality). We compared Iranian samples with *E. suphani* from Turkey using a molecular marker (Cytochrome *b*) and confirmed that this species is also present in Iran. The new record of this species is located on the road from Firoragh to Chaldoran in the west of the province of Azarbaijan, Iran.**

Key words. *Eremias suphani*, Iran, Turkey, new record, molecular marker

Citation: Rastegar-Pouyani E, Avci A, Kumlutaş Y, Ilgaz C, Hosseinian Yousefkhani SS. 2013. New country record and range extension of *Eremias suphani* Başoğlu & Hellmich, 1968 from Iran. *Amphibian & Reptile Conservation* 6(2): 35–39 (e73).

Introduction

The herpetofauna of Iran remains poorly documented and in some isolated areas completely unknown (Anderson 1999). Historically, the Iranian herpetofauna has been studied by several foreign herpetologists (Mertens 1957; Anderson 1966, 1999; Leviton et al. 1992; Tuck 1971, 1974) who visited Iran, as well as by Iranian herpetologists (Latifi 1991; Balouch and Kami 1995; Kami and Vakilipoure 1996a, 1996b; Firouz 2000; Rastegar-Pouyani et al. 2007). Nonetheless, herein we report the presence of a previously undocumented species from the country. According to the recent published data, 15 species of the genus *Eremias* exist in Iran (Hosseinian Yousefkhani et al. 2013), to which we add another.

Eremias suphani (Suphan Racerunner) was considered to be confined to Turkey, where it was described from Van Lake (Başoğlu and Hellmich 1968), with some additional populations of this species having been recorded from western Turkey (Bischof and Böhme 1980). The species is morphologically similar to *Eremias strauchi*, its putative sister species, but there are differences in scalation (Bischof and Böhme 1980).

Adults of *Eremias suphani* can be distinguished from *E. strauchi* by the presence of a double or single row of gular scales separating the scales of the third pair of chin shields (third pair of chin shields in contact in *E. strauchi*), the presence of enlarged gular scales bordering the third pair of chin shields (no enlarged gulars in *E. suphani*), and the presence of a ventrolateral row of well-defined, large, round, white spots, that may be fused to form a longitudinal band (diffuse small longitudinal spots or a diffuse thin line in *E. strauchi*).

The distribution of these two sister species meet in the Dogubayazit Depression in NE Turkey (Bischof and Böhme 1980). In Iran, *E. suphani* is found on compacted, loamy soil at the Iran-Turkey border. In Turkey, *E. suphani* also lives on pebbly/sand substrates with sparse vegetation (Franzen and Hecks 1999; Baran et al. 2012). Amphibian and reptile species that have a sympatric distribution with *E. suphani* include: *Bufotes variabilis*, *Pelophylax ridibundus*, *Rana macrocnemis*, *Testudo graeca*, *Trapelus lessonae*, *Ophisops elegans*, and *Lacerta media*. *Eremias suphani* is listed as Least Concern because, although its extent of occurrence is less than 20,000 km^2, it is common with large population sizes, no major threats, and it is unlikely to be declining fast enough to qualify for listing in a more threatened category (Kaska et al. 2013).

Herein we report a new Iranian country record for *E. suphani*, confirmed using a molecular marker (Cytochrome *b*).

Materials and Methods

The Iranian samples were collected during field trips to the northwest of the country in June 2005 on the road

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Figure 1. Habitat of *Eremias suphani* in NW Iran on the road from Firoragh to Chaldoran in Ali Sheykh village (Photo by Eskandar Rastegar-Pouyani, 2005).

from Firoragh to Chaldoran, at the village of Alishekh (Fig. 1) (E 44° 34′ 78.4″, N 38° 49′ 22.1″, elevation: 1934 m). Four specimens were collected (SUHC 310-313) (Fig. 2) and deposited in the Sabzevar University Herpetological Collection (SUHC), Iran. The sites of the new records near the border of Iran-Turkey are provided in Figure 3. Turkish specimens were collected from three different localities in 2010 and 2012 (Aydınlar Village, Adilcevaz, Bitlis—between Tatvan and Bitlis km 4, Bitlis—Hoşap, Güzelsu, Van). They were deposited in the Biology Laboratories of Dokuz Eylül University, İzmir, Turkey.

DNA was obtained from tissue samples (muscle or liver) that were preserved in 96% ethanol (Rastegar-Pouyani et al. 2010). DNA was extracted using a high salt method (Kabir et al. 2006). Fragments of Cytochrome *b* were amplified (PCR) using the primers Mtanew (5′-CTC CCA GCC CCA TCC AAC ATC TCA GGA TGA TGA AAC-3′) and Mtfsh (5′-TAG TTG GCC AAT GAT GAT GAA TGG GTG TTC TAC TGG-3′). Sequences from three specimens of *E. strauchi* and five specimens of *E. suphani* from Turkey where compared with the Iranian samples using MEGA 5.0 software (Table 1). The sequences have been deposited in the GeneBank with accession numbers from KF797802 to KF797813.

Results

Genetic distance (Table 2) indicates that the Iranian samples are very close to *Eremias suphani* of Turkey with only about 2% of genetic distance. Distances between *Eremias strauchi* population and both *Eremias suphani* and *Eremias* sp. samples from Iran, are 16%. *Eremias* sp. samples from Iran now confirmed as *Eremias suphani*.

In addition to previous studies on the Iranian herpetofauna, our initial research in the NW corner of Iran revealed the presence of *Eremias suphani* in Iran. We focused our search in NW Iran to the border of Turkey for other localities, but in the other locations *Eremias strauchi* has been recorded.

Table 1. Examined samples in this study along with their locality and coordinates.

Code	Species name	N	E	Elevation	Locality
Str-1	*Eremias strauchi*	39° 51′ 57.1″	42° 29′ 03.3″	864 m	Between Aralık and Gündoğdu, Iğdır
Str-2	*Eremias strauchi*	39° 51′ 57.1″	42° 29′ 03.3″	864 m	Between Aralık and Gündoğdu, Iğdır
Str-3	*Eremias strauchi*	39° 51′ 57.1″	42° 29′ 03.3″	864 m	Between Aralık and Gündoğdu, Iğdır
SÜ2-A	*Eremias suphani*	38° 18′ 18.2″	43° 48′ 46.4″	1,997 m	Hoşap, Güzelsu, Van
SÜ2-B	*Eremias suphani*	38° 18′ 18.2″	43° 48′ 46.4″	1,997 m	Hoşap, Güzelsu, Van
SÜ2-C	*Eremias suphani*	38° 18′ 18.2″	43° 48′ 46.4″	1,997 m	Hoşap, Güzelsu, Van
SÜ1-B	*Eremias suphani*	38° 53′ 55.2″	42° 55′ 38.8″	2,000 m	Aydınlar village, Adilcevaz, Bitlis
SÜ1-C	*Eremias suphani*	38° 53′ 55.2″	42° 55′ 38.8″	2,000 m	Aydınlar village, Adilcevaz, Bitlis
SUHC 724	*Eremias* sp.	38° 49′ 22.1″	44° 34′ 78.4″	1,934 m	on the road from Firoragh to Chaldoran
SUHC 725	*Eremias* sp.	38° 49′ 22.1″	44° 34′ 78.4″	1,934 m	on the road from Firoragh to Chaldoran
SUHC 726	*Eremias* sp.	38° 49′ 22.1″	44° 34′ 78.4″	1,934 m	on the road from Firoragh to Chaldoran

Figure 2. General view of *Eremias suphani* from Iran. The color pattern of this species is different from *Eremias strauchi strauchi* (Photo by EskandarRastegar-Pouyani, 2005).

Discussion

Specimens of *Eremias* collected from Ahlat, Bitlis, in eastern Turkey were considered to be *Eremias velox* ssp. by Başoğlu and Hellmich (1959). In 1968, these authors examined specimens from Ahlat, Süphan Dağı, Mukus, and Van and described a new subspecies, *Eremias velox suphani*. Peters (1964) considered *E. velox strauchi* to be a full species (*E. strauchi*), whereas specimens collected from Doğubayazıt, Iğdır, and Kağızman were considered as *E. velox* by Clark and Clark (1973). Başoğlu and Baran (1977) stated that *E. suphani* and *E. strauchi* are subspecies of *E. velox* whereas Bischoff (1978) suggested that *E. suphani* is a subspecies of *E. strauchi*. Finally, *E. velox suphani* was regarded as a distinct species by Bishoff and Böhme (1980).

Eremias suphani is considered to be endemic to eastern Turkey, where it is known from the vicinity of Lake Van (Mulder 1995; Franzen and Heckes 1999; Baran et al. 2012).

According to the previous studies on the Iranian herpetofauna (Leviton et al. 1992; Anderson 1999; Rastegar-Pouyani et al. 2007, 2008), *E. suphani* has not been recorded from Iran. During field trips to northwest Iran in 2005, four specimens from a population belonging to the genus *Eremias* were collected that were not compatible with diagnostic key of the Iranian species of *Eremias*, but were comparable to *E. strauchi*. Considering these observations we assumed that these specimens represented a new species of *Eremias*, and decided to compare the specimens with individuals of other species of the genus that were described and previously recorded from the region, specifically *Eremias strauchi* and *Eremias suphani*. Genetic analysis revealed that the Iranian samples clustered (with 2% distance) with *E. suphani* and not with *E. strauchi* (16% distance). This new country record demonstrates how the border regions of Iran have not been carefully investigated, and that additional effort must be made to document reptile diversity in these areas.

These results strongly suggest that the Iranian samples are conspecific with *Eremias suphani*. Consequently, we conclude that *Eremias suphani* is recorded for the first time in Iran near the border with Turkey on the road from Firoragh to Chaldoran in Ali Sheykh village.

Acknowledgments.—We thank Hamzeh Oraei and Azar Khosravani for their efforts in providing the molecular data and Dr. Jim Bogart for his generous help in improving the English of an earlier version of this manuscript.

Table 2. Estimates of evolutionary divergence (p–distance) over sequence pairs between samples of *Eremias* in this study.

	Eremias suphani Turkey	*Eremias* sp. Iran Firoragh	*Eremias strauchi strauchi*
Eremias suphani Turkey	—	0.022	0.193
Eremias sp. Iran Firoragh	0.022	—	0.166
Eremias strauchi strauchi	0.193	0.166	—

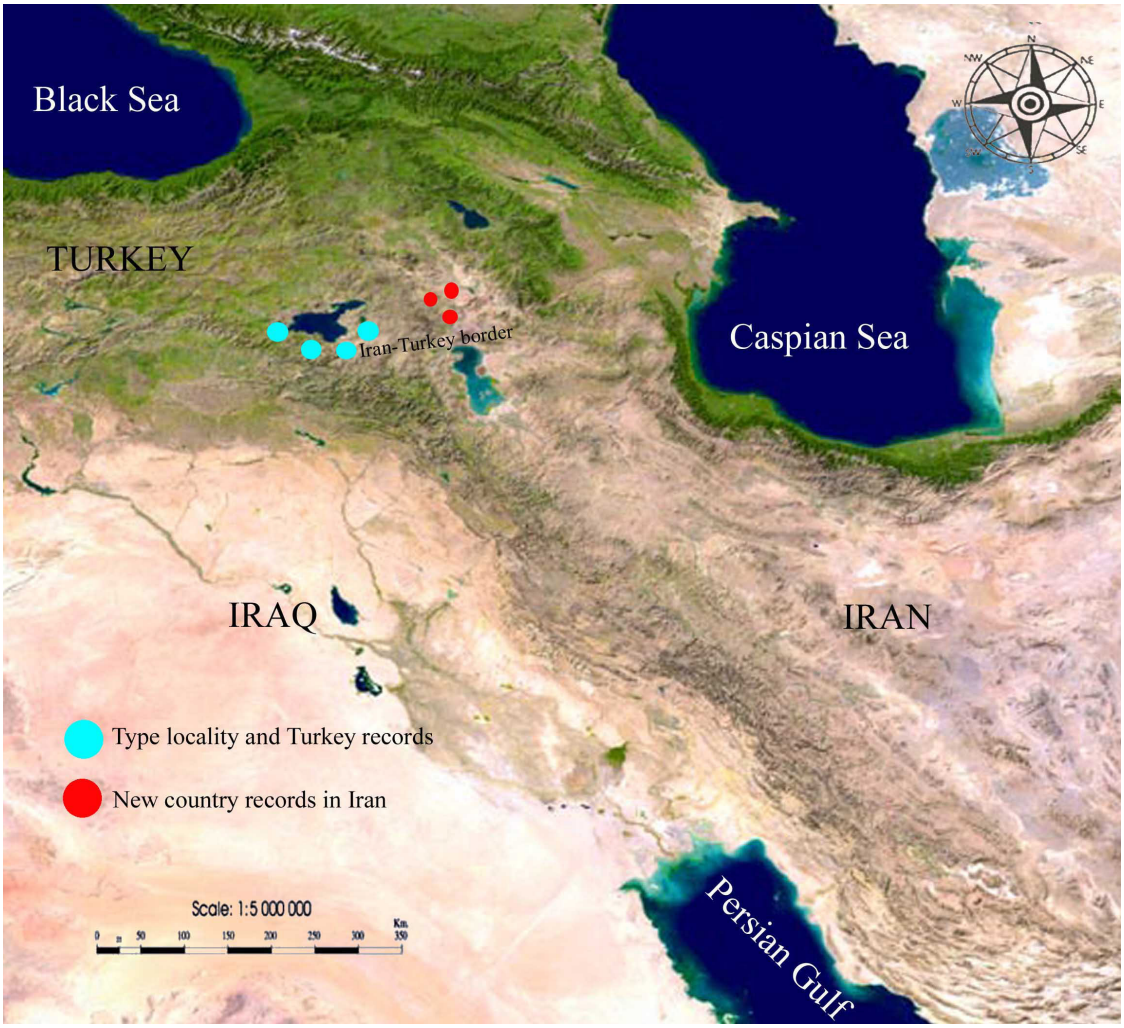

Figure 3. Iran-Turkey map and localities of new records in Iran and the type locality of *Eremias suphani* around the Van Lake in Turkey. Red circles relate to new country records in Iran and the blue circles are type localities of the Turkish samples.

Literature Cited

Anderson SC. 1966. The turtles, lizards, and amphisbaenians of Iran. Ph.D. thesis. Stanford University, Stanford, California, USA. 660 p.

Anderson SC. 1999. *The Lizards of Iran*. Society for the Study of Amphibians and Reptiles, Ithaca, New York, USA. 442 p.

Baloutch M, Kami HG. 1995. *Amphibians of Iran*. Tehran University Publication, Tehran, Iran.177 p.

Başoğlu M, Hellmich W. 1959. Auf herpetologischer Forschungsfahrt in Ost-Anatolien. *Aquarien und Terrarienzeitschrift* (Stuttgart) 12: 118–121.

Başoğlu M, Hellmich W. 1968. Eine neue *Eremias*-Form aus Ost-Anatolien (Reptilia, Lacertidae). *Ege Üniversity Fen Fakültesi İlmi Raporlar Serisi* (Izmir) 67: 1–9.

Başoğlu M, Baran İ. 1977. *Türkiye Sürüngenleri. Kısım* 1. Kaplumbağa ve Kertenkeler. Ege Üniversity Fen Fakültesi Kitaplar Series No. 76: 1–272. Bornova.

Baran İ, Ilgaz Ç, Avcı A, Kumlutaş Y, Olgun K. 2012. *Türkiye Amfibi ve Sürüngenleri*. TÜBİTAK, Ankara. 204 p. (ISBN: 978-975-403-703-6).

Bischoff W. 1978. Beiträge zur Kenntnis der Echsen des Kaukasus. *Salamandra* 14: 178–202.

Bischoff W, Böhme W. 1980. Der systematische Status der türkischen Wüstenrenner des Subgenus *Eremias* (Sauria: Lacertidae). *Zoologische Beiträge N.F.* (Berlin) 26(2): 297–306.

Clark RJ, Clark ED. 1973. Report on a collection of amphibians and reptiles from Turkey. *Occasional Papers of the California Academy of Sciences* 104: 1–62.

Kaska Y, Kumlutaş Y, Kaya U, Avci A, Üzüm N, Yeniyurt C, Akarsu F. 2009. *Eremias suphani*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. Available: www.iucnredlist.org [Accessed: 04 October 2013].

Hosseinian Yousefkhani SS, Hamzeh O, Khosravani A, Rastegar-Pouyani E. 2013. Habitat associations and

conservation of *Eremias acutirostris* (Boulenger, 1887) in the Sistan region, Zabol, Iran. *Amphibian & Reptile Conservation* 6(2): 31–34(e60).

Firouz E. 2000. *A Guide to the Fauna of Iran*. Tehran University Press, Tehran, Iran. 491 p. (In Persian).

Franzen M, Heckes H. 1999. *Eremias suphani* Basoglu & Hellmich, 1968 und *Eremias strauchi* Kessler, 1878 in der östlichen Türkei: Diagnostische Merkmale, Verbreitung und Lebensräume (Sauria: Lacertidae). *Salamandra* 35(4): 255–266.

Kabir S, Shahriar M, Hamidul Kabir AN, Uddin MG. 2006. High salt SDS-based method for the direct extraction of genomic DNA from three different gram-negative organisms. *The CDR Journal* 1(2): 57–64.

Kami HG, Vakilipoure A. 1996a. Geographic distribution: *Bufo bufo*. *Herpetological Review* 27: 148.

Kami HG, Vakilipoure A. 1996b. Geographic distribution: *Rana camerani*. *Herpetological Review* 27: 150.

Latifi M. 1991. *The Snakes of Iran*. Society for the study of Amphibians and Reptiles, Ithaca, New York, USA. 159 p.

Leviton AE, Anderson SC, Adler K, Minton SA. 1992. *Handbook to Middle East Amphibians and Reptiles*. Society for the study of Amphibians and Reptiles, Ithaca, New York, USA. 252 p. + 33 plates.

Mertens RFW. 1957. Weitere unterlagen zur herpetofauna von Iran 1956. *Jahreshefte desVereins fur vaterlandische Naturkunde in Wurtemberg* 112: 118–128.

Mulder J. 1995. Herpetological observations in Turkey. *Deinsea* 2: 51–66.

Peters G. 1964. Sekundäre Geschlechtsmerkmale, Wachstum und Fortpflanzung bei einigen transkaukasischen *Eremias*-Formen (Reptilia, Lacertidae). *Senckenbergiana Biologica* (Frankfurt) 45: 445–467.

Rastegar-Pouyani N, Rastegar-Pouyani E, Jawhari M. 2007. *Field Guide to the Reptiles of Iran* (Volume 1: Lizards). Razi University Press, Kermanshah, Iran. (In Persian).

Rastegar-Pouyani N, Kami HG, Rajabizadeh M, Shafiei S, Anderson SC. 2008. Annotated checklist of amphibians and reptiles of Iran. *Iranian Journal of Animal Biosystematics* 4: 43–66.

Rastegar-Pouyani E, Rastegar-Pouyani R, Kazemi Noureini S, Joger U, Wink M. 2010. Molecular phylogeny of the *Eremias persica* complex of the Iranian plateau (Reptilia: Lacertidae), based on mtDNA sequences. *Zoological Journal of the Linnean Society* 158: 641–660.

Tuck RG. 1971. Amphibians and reptiles from Iran in the United State National Museum Collection. *Bulletin of the Maryland Herpetological Society* 7: 48–36.

Tuck RG. 1974. Some amphibians and reptiles from Iran. *Bulletin of the Maryland Herpetological Society* 10: 59–65.

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Appendix I. List of the material examined in this study and their accession numbers.

Species name	Country	Accession Number
Eremias suphani	Turkey	KF797802
Eremias suphani	Turkey	KF797803
Eremias suphani	Turkey	KF797804
Eremias suphani	Turkey	KF797805
Eremias suphani	Iran	KF797806
Eremias suphani	Iran	KF797807
Eremias suphani	Iran	KF797808
Eremias suphani	Iran	KF797809
Eremias strauchi strauchi	Iran	KF797810
Eremias strauchi strauchi	Iran	KF797811
Eremias strauchi strauchi	Iran	KF797812
Eremias strauchi strauchi	Iran	KF797813

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