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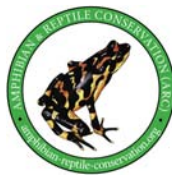
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*Oxyrhopus petolarius*, Yotoco, Reserva forestal, 2012, Fdo Castro.



## Conservation status of the herpetofauna, protected areas, and current problems in Valle del Cauca, Colombia

<sup>1</sup>Alejandro Valencia-Zuleta, Andrés Felipe Jaramillo-Martínez, Andrea Echeverry-Bocanegra, Ronald Viáfara-Vega, Oscar Hernández-Córdoba, Victoria E. Cardona-Botero, Jaime Gutiérrez-Zúñiga, and Fernando Castro-Herrera

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**Abstract.**—In this study, we present an analysis of the conservation status of amphibian and reptile species by associating the natural protected areas and municipalities with the distribution of richness in Valle del Cauca. We establish the percentage of species of amphibians and reptiles in each of the IUCN (International Union for Conservation of Nature) threat categories and assign local conservation categories to all species, construct distribution maps for the records of species in relation to their threat status, and analyze the endemic and total number of species in each of the protected areas. We found that nearly 50% of the species in the Valle del Cauca are under some degree of risk or threat, that the largest percentage are in the Vulnerable (VU) category, whereas 37% of the fauna is not threatened (Least Concern [LC] and Near Threatened [NT]), and 13% is categorized as Data Deficient (DD). Although the distribution of species is scattered throughout the territory, patterns are maintained within the various regions, with areas of greater richness found in the Pacific region and the cordilleras; the municipalities with the largest number of species under some level of threat are Buenaventura, Darién, El Cairo, Dagua, Cali, La Cumbre, and Yotoco. The types of protected areas with the largest number of species are the Reservas Forestales Protectoras Nacionales (RFPN) 37%, followed by the Parques Nacionales Naturales (PNN) 18%, the Reservas Forestales Protectoras Regionales (RFPR) 10%, and the Parques Naturales Regionales (PNR) 7.5%; 17% (~ 57 spp.) of the species in the Valle del Cauca have not been recorded in any of the protected areas, and more than 65% of these are under some type of threat. We consider this study a starting point for evaluating conservation priorities for the herpetofauna of Valle del Cauca.

**Key words.** Amphibians, reptiles, distribution, IUCN, population declines, threats

**Resumen.**—En este trabajo presentamos un análisis del estado de conservación de las especies de anfibios y reptiles relacionando las áreas naturales protegidas y los municipios con la distribución de riqueza en Valle del Cauca. Establecemos los porcentajes de especies de anfibios y reptiles en cada categoría de amenaza establecida por UICN (Unión Internacional para la Conservación de la Naturaleza) y asignamos categorías de conservación local a todas las especies, se realizó mapas de distribución de los registros de las especies en relación a los estados de amenaza, y analizamos el número de especies totales y endémicas en cada área protegida. Encontramos que cerca del 50% de las especies en el Valle del Cauca presentan algún grado de riesgo o amenaza, que la mayor proporción se encuentra en la categoría vulnerable (VU), mientras que el 37% de la herpetofauna no se encuentra en riesgo (preocupación menor [LC] y casi amenazado [NT]) y el 13% está categorizada en datos deficientes (DD). Aunque la distribución es diferencial a lo largo del territorio, se conservan patrones a lo largo de las regiones, con sitios de mayor riqueza en la región pacífica y las cordilleras; y los municipios con mayor número de especies con algún grado de amenaza son Buenaventura, Darién, El Cairo, Dagua, Cali, La Cumbre y Yotoco. Los tipos de áreas protegidas con mayor número de especies son las Reservas Forestales Protectoras Nacionales (RFPN) 37%, seguidas por los Parques Nacionales Naturales (PNN) 18%, Reservas Forestales Protectoras Regionales (RFPR) 10%, y los Parques Naturales Regionales (PNR) 7.5%; el 17% (~

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**57 spp.) de las especies del Valle del Cauca no se han registrado en ningún tipo de área protegida y más del 65% de ellas presenta algún tipo de amenaza. Consideramos este trabajo un punto de partida para evaluar prioridades en la conservación de la herpetofauna vallecaucana.**

**Palabras claves.** Anfibios, reptiles, distribución, UICN, declive poblacional, amenazas

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## Introduction

Many populations of amphibians and reptiles are in decline (Mendelson et al. 2006; Böhm et al. 2013), primarily as a result of habitat loss, climate change, introduced species, diseases, and illegal trafficking (Young et al. 2001; Stuart et al. 2004; Mendelson et al. 2006; Wake 2007; Rovito et al. 2009; Böhm et al. 2013). Estimates indicate that 15–36% of the world's species of reptiles are threatened (Böhm et al. 2013), and according to Stuart et al. (2004) 22.5% of the species evaluated by IUCN lacked sufficient information to evaluate their status. Although the IUCN standardized the use of categories that can be applied to any taxon and has attempted to catalogue the majority of species (IUCN 2012), many species still have not been evaluated or lack the necessary information for conducting an assessment; in the case of reptiles, 59% of the species have not been assessed.

In Colombia, in addition to the above mentioned factors that threaten populations of amphibians and reptiles (Rueda 1999; Ruiz and Rueda-A 2008; Velásquez et al. 2008; Isaacs and Urbina 2011; Urbina 2011; Urbina et al. 2011; Vargas and Amezcua 2013), the social problem associated with the planting and eradication of illicit crops threatens the fauna because of the destruction of primary forests and the use of pesticides such as Glifosato (Arroyo and Lynch 2009; Brain and Solomon 2009). A mining crisis also has developed in the country, where mining permits are granted to people for economic purposes while the long-term impact on the environment caused by these activities is ignored (Mancera and Alvarés 2006; UPME 2007; Hernández et al. 2013).

In response to these problems, early in the 1930s “áreas naturales protegidas” (= natural protected areas) were designated in the country, which led to the formation of “zonas forestales protectoras” (= protected forest areas) in the department (dpto= a territorial division in Colombia that has autonomy in the administration of regional issues, planning, and the promotion of economic and social development within its territory under the terms established by the Constitution) of Valle del Cauca (decree 1393/40). Regulations for determining the exact management categories that competent authorities at dif-

ferent levels can assign to protected areas, however, still have not been implemented in the country (Vásquez and Serrano 2009). Currently, 197 reserves of all types exist in the Valle del Cauca; three natural national parks are the most important because of their large size and location in areas of high herpetofaunal diversity, in the dpto and in the country—the “Cordillera Occidental” (= the Western Cordillera) and the “Región Pacífica” (= Pacific Region) (Cardona et al. 2013); environmental problems, however, are present in these areas, as their biological patrimony has not been fully elucidated (Patiño 2010).

Valle del Cauca is one of the dptos with the greatest amount of herpetofaunal species richness (333 species), which represents 24% of the amphibian and 25% of the reptile species recorded from the country (Cardona et al. 2013). We are unaware, however, of the number of threatened species in the dptos, or plans for their conservation. In a red book of amphibians, Castro-H and Bolívar-G (2010) included 68 species under some type of threat, and along with an action plan for the conservation of amphibians in Valle de Cauca provided by Corredor et al. (2010); these publications are considered pioneer efforts in conservation; in general, research programs usually are developed separately and independently.

The objective of this paper is to present an analysis of the conservation status of the species of amphibians and reptiles by associating the natural protected areas and municipalities with the distribution of richness in Valle del Cauca, as a starting point for evaluating conservation priorities for the herpetofauna of this region.

## Materials and Methods

### Study area

Valle del Cauca is a dpto in southwestern Colombia that consists of 42 municipalities (Fig. 1) with a total surface area of 22,142 km<sup>2</sup>; it contains a diversity of landscapes, including very humid tropical forests, premontane pluvial forests in warm transition, dry and very dry tropical forests, and lowland montane to pluvial montane forests that range in elevation from sea level to 4,000 m. This

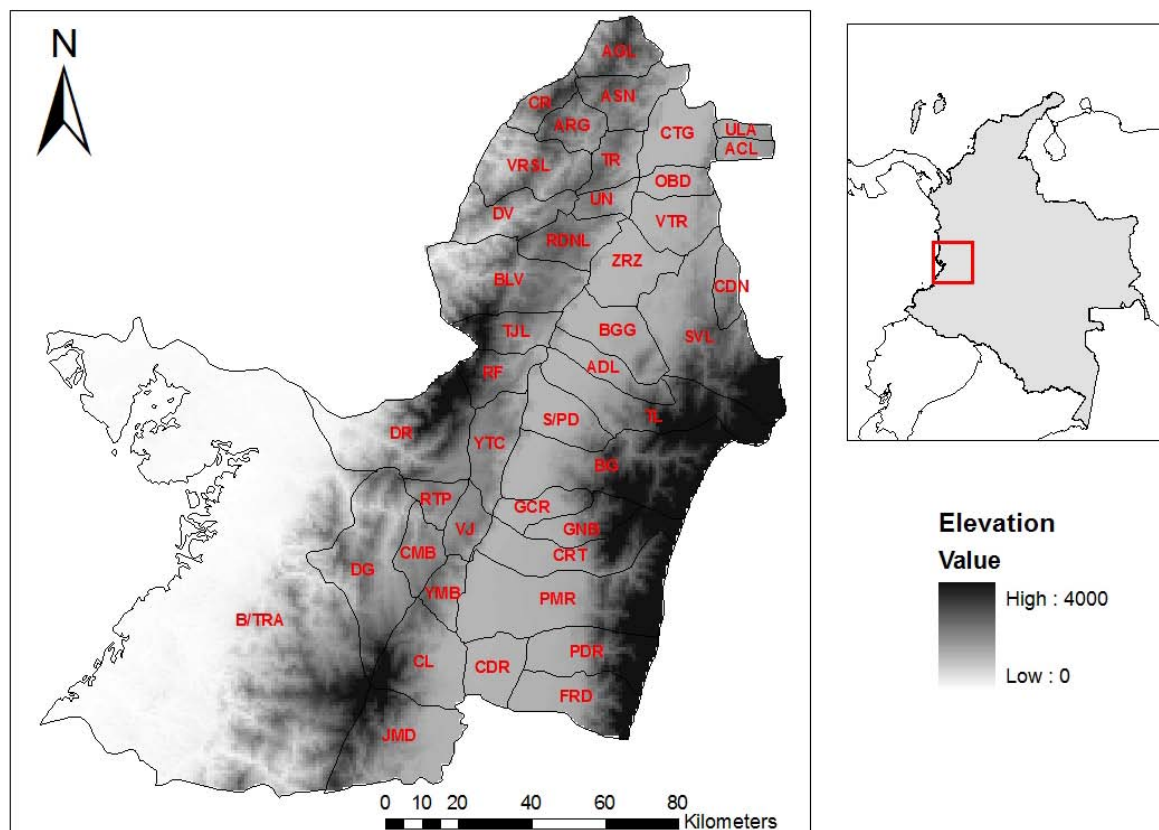
dpto has allocated 233,889 ha for parks and natural reserves, which because of their ecological importance and abundance of natural resources have been established in various strategic ecosystems and protected areas (Gómez et al. 2007).

### Sources of information

In updating their list on the herpetofauna of Valle del Cauca, Cardona et al. (2013) considered the following:

- Geographic data: Obtained from bibliographic sources, field notes, and biological collections of amphibians and reptiles at the Universidad del Valle (UV-C), and online databases from the Instituto de Ciencias Naturales (ICN), and the National Museum of Natural History at the Smithsonian Institution (USNM).
- Threat category (species recorded from the dpto were catalogued using the following criteria): trafficking in species, deaths caused by vehicular traffic or by humans, distribution within the dpto (eco-regions, localities, life zones), occurrence in disturbed habitats, frequency of observation, number of citations in publications, and the presence of species in protected

areas. All these criteria were scored from 0 to 4, where 0 means no risk in the particular criteria, 3 high risk, and 4 is unknown (see supplemental material at [amphibian-reptile-conservation.org](http://amphibian-reptile-conservation.org) for the definition of the score in each criteria). Based on the data obtained for each species, it calculated the weighted average for the different natural groups (amphibians, lizards, and snakes), and assigned a percentage in the final score to each criteria according to the natural group, because the same criteria does not affect each natural group in the same way (see supplemental material for the percentage assigned in each criteria). With the weighted average of each species, these were assigned to some of the categories proposed by the IUCN, as follows: LC 0–1.4, NT 1.5–2.0, VU 2.1–2.6, EN 2.7–3.0, CR 3.1–3.3, DD 3.4–4.0. Each category was justified according to the appendix of the IUCN (2012), especially considering the threats to each species. Additionally, the threat status for each species reported from the dpto was examined by searching through the IUCN Red List of Threatened Species (<http://www.iucnredlist.org/>), the red books of amphibians and reptiles in Colombia (Castaño-M 2002; Rueda-A et al. 2004), and the red book of amphibians from Valle del Cauca (Castro-H and Bolívar-G 2010).



**Fig. 1.** Political map of Valle del Cauca (Colombia). North: El Águila (AGL), El Cairo (CR), Ansermanuevo (ASN), Argelia (ARG), Cartago (CTG), Ulloa (ULA), Alcalá (ACL), Toro (TR), Versalles (VRSL), Obando (OBD), La Unión (UN), El Dovio (DV), Roldanillo (RDNL), La Victoria (VTR), Zarzal (ZRZ), Bolívar (BLV); East: Sevilla (SVL), Caicedonia (CDN); Middle: Bugalagrande (BGG), Trujillo (TJL), Andalucía (ADL), Rio Frio (RF), Tuluá (TL), San Pedro (S/PD), Yotoco (YTC), Darién (DR), Buga (BG), Guacarí (GCR), Ginebra (GNB), Vijes (VJ), Restrepo (RTP), Cumbre (CMB), El Cerrito (CRT); South: Palmira (PMR), Yumbo (YMB), Cali (CL), Candelaria (CDR), Pradera (PDR), Florida (FRD), Jamundí (JMD); West: Buenaventura (B/tura), Dagua (DG).

- Protected areas: Each species was recorded according to geographic location and the use of bibliographic resources on protected areas within the dpto, considering the important areas with a wide extension and with the ability to hold a great diversity of herpetofauna. The definition of protected areas were defined based on the Decree-Law 622 of 1977 and 2372 of 2010 of the National Government (in parentheses the areas that were chosen in this work):
  - Parques Nacionales Naturales (PNN) is an area of great extent permitted ecological autoregulation and whose ecosystems in general have not been substantially altered by human exploitation or occupation, where plant and animal species, geomorphological resorts, historical or cultural events have scientific, educational, aesthetic and recreational value and their perpetuation is subjected to an appropriate management regime (Farallones de Cali, Las Hermosas, Uramba-Bahía Málaga, Tatamá).
  - Santuario de Flora y Fauna (SFF) is dedicated to preserving wildlife species or plant communities to preserve genetic resources of native flora and fauna (Decreto 622 de 1977), (Isla Malpelo).
  - Parque Natural Regional (PNR) is a regional geographic area where landscapes and strategic ecosystems, maintain their structure, composition and function. The natural and cultural values are associated with human disposition for preservation, restoration, knowledge, and enjoyment (La Sierpe and Páramo del Duende).
  - Reservas Forestales Protectoras (RFP) is a geographical area where forest ecosystems maintain their function, although their structure and composition have been modified and associated natural values are accessible to the human population to who allocated their preservation, sustainable use, restoration, knowledge, and enjoyment. In this type of protected area are the forests, national (RFPN) (Amalme, Anchicayá, San Cipriano and Escalerete rivers, Bosque de Yotoco, Dagua, Cali, Tuluá, Sonso-Guabas, Cerro Dapa-Carisucio) and regional (RFPR) (Bitaco and Frayle-Desbaratado) protection.
  - Reserva Natural (RN) is an area in which undisturbed conditions exist or have undergone minimal human disturbance of flora, fauna, and soil, and it is intended for conservation, research, and study of its natural wealth (Laguna de Sonso).
- Distrito de Manejo Integrado (DMI) is a geographical space where landscapes and ecosystems retain their composition and function, although their structure have been modified and whose natural and cultural associated values are set to reach the human population who allocated their sustainable use, preservation, restoration, knowledge, and enjoyment (La Plata and Enclave Subxerofítico Atuncela).
- Municipalities: Each species was recorded based on its documented geographic location within the municipalities of the dpto.

## Analysis of the Data

The species distribution model for each threat category was performed using all the records collected from the different museums and georeferenced using Google Earth 7.1.2.2014; these models were constructed in MaxEnt Version 3.3.3a. The software generated models using the theory of maximum entropy only when presence data were available (Phillips et al. 2006). For this work, we used the 19 climate layers of the WorldClim project ([www.worldclim.org](http://www.worldclim.org), spatial resolution of 30 arc second or  $\sim 1 \text{ km}^2$ ). To evaluate the predictive ability of the models generated, the Area Under the Curve (AUC) score was taken into account. The AUC is a ranked approach for assessing model fit, which determines the probability that a presence location will be ranked higher than a random background location (Phillips et al. 2006). The prediction models generated by MAXENT were mapped in ArcGIS 10.1 (ESRI 2013), with only the detection probabilities above 0.5 taken into account.

The percentages of amphibian and reptile species for each threat status was determined, and through histograms indicate the endemic number of species and total number of species in each of the protected areas.

## Results

### Status of threats to the herpetofauna

Approximately 51% of the species in the dpto showed some degree of risk or threat. The majority of amphibians (60%) are in one of the threat categories, with the Vulnerable (VU) containing the most species (59), followed by the Critically Endangered (CR) and Endangered (EN), each with 29, and 27 in the Near Threatened (NT) (Fig. 2A) categories. Conversely, more than one-third of the reptile species show some degree of risk, with those in the NT and VU containing the largest number of species (38 in each), followed by the EN (14), and a few (six) in the CR (Fig. 2B) categories. Of the remaining herpetofaunal species in the dpto, 17% show no risk (LC), and 14% are Data Deficient (DD; see supplemental material).

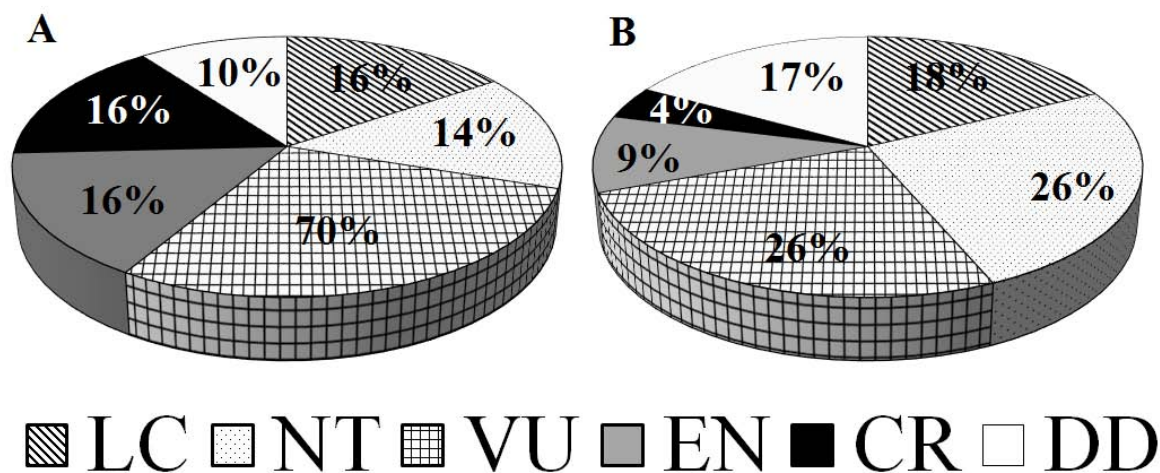


Fig. 2. Threat status of the percentage of herpetofaunal species in Valle de Cauca: (A) = Amphibians, (B) = Reptiles.

Eighty percent of the amphibian families contain species under some level of threat, with 40% of the species in the family Craugastoridae in one of the threat categories. In general, the NT species are represented mostly in the families Craugastoridae, Centrolenidae, Hylidae, Dendrobatidae, and Leptodactylidae. In addition, more than one-half of the VU species are in the family Craugastoridae; in particular, the VU and EN species follow the same pattern and include the families Craugastoridae, Centrolenidae, Dendrobatidae, and Hylidae. Significantly, 70% of the CR species are grouped in the Craugastoridae, Bufonidae, and Centrolenidae, families with the greatest risk of losing species, along with representatives of the family Hemiphractidae, which are restricted to the EN and CR. As with the amphibians, most families of reptiles (84%) contain species under some level of threat. In particular, most of the threatened species are in the families Colubridae, Dactyloidae, Dipsadidae, and Gymnophthalmidae, with most in the NT and VU categories. Over 30% of the NT species are in the family Colubridae, followed by the Dipsadidae and Dactyloidae, whereas the VU species are mostly in the Dactyloidae and Dipsadidae. The majority of EN species are in the families Colubridae, Dipsadidae, and Gymnophthalmidae. Furthermore, the CR species are represented by one species in each family, except for the Dactyloidae.

The modeling of the maps present an AUC of 0.754–0.83, indicating a better performance than the random models (Manel et al. 2001). Herpetofaunal richness is scattered throughout Valle del Cauca, but the areas (see Cardona-B. et al. [2013] to define ecoregions in the Valle del Cauca) with the greatest amount of richness are the Pacific region and the Cordilleras (Fig. 3A). The NT species show a wide distribution along the western Cordillera (specifically in the northern and central area), and cover a large area along the Interandean Valley and the Pacific (Fig. 3B). The VU species are found along the foothills and northern and central portions of the western Cordillera, but are less represented in the central Cor-

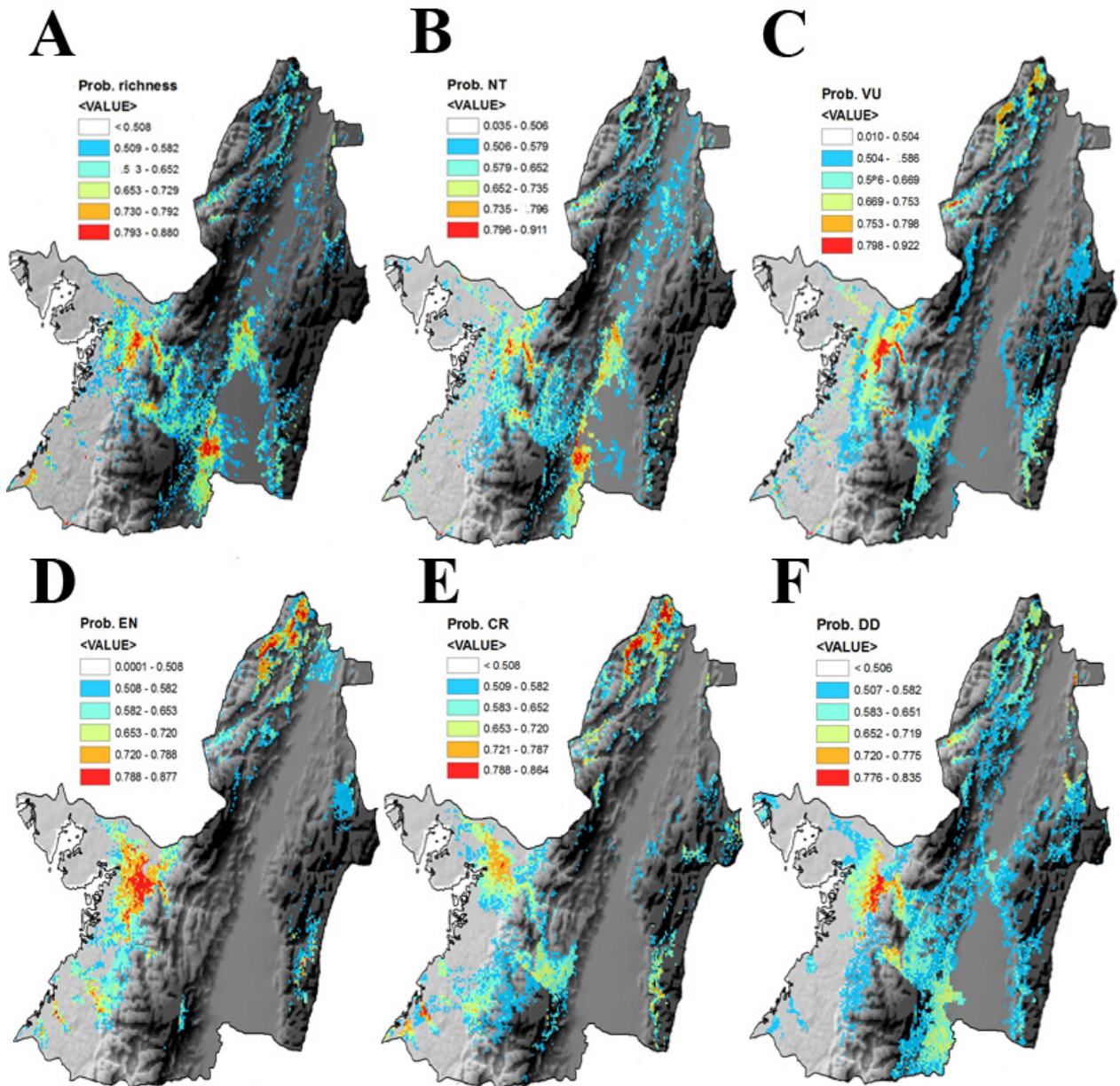
dillera and in the Interandean Valley (Fig. 3C). The EN species are found in two important areas, the Pacific region and the western Cordillera in the northern part of the dpto; in the central Cordillera, a few representatives are found in the high elevation areas of Sevilla, Tuluá, and Buga, to the north, and Palmira, Pradera, and Florida, to the south (Fig. 3D). The distribution of the CR species is important, based on the presence of *Atelopus* in the central and western Cordilleras and groups of *Pristimantis* in highland areas of the western and central Cordilleras; in addition, the centrolenids and dendrobatids are found in the western Cordillera and the Pacific region (Fig. 3E). Significantly, the DD species are distributed all along the dpto, but show similar patterns to species in the threat categories (Fig. 3F).

In particular, 90% of the municipalities in Valle del Cauca contain one species in at least one of the threat categories, whereas 62% of the municipalities contain more than two species. The municipalities of Buenaventura (82 species), Darién (61), El Cairo (51), Dagua (45), Cali (42), La Cumbre (19), and Yotoco (11) contain the greatest number of species under some level of threat (Fig. 4). A similar pattern was found in these municipalities, where the majority of species fall into the VU category, followed by the EN, and last by the CR, with the only exceptions in the municipalities of Cali and La Cumbre. The municipalities of Buenaventura (six amphibians, five reptiles), El Cairo (10, zero), and Darién (eight, one) contain the largest number of CR species.

### The herpetofauna and protected areas

Protected areas in Valle del Cauca with the greatest number of species are the RFNP (228 species), followed by the PNN (120), RFPR (60), PNR (45), DMI (34), and RN (21), and the area with the least number is the SSF (three species of reptiles). The majority of the species in the RFNP and the PNN are in the VU, and in the remaining areas most of the species are in LC, except for the





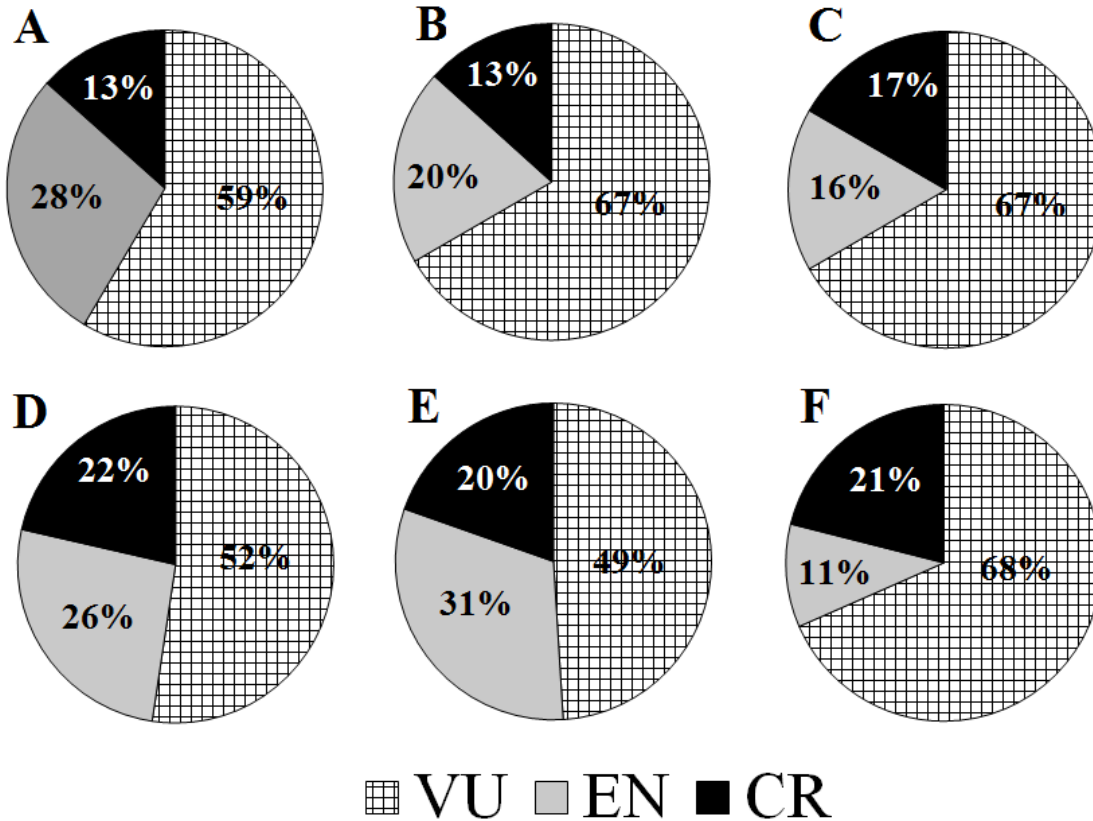
**Fig. 3.** Distribution maps for the richness of herpetofauna in the most documented areas in Valle del Cauca. (A) richness, (B) NT species, (C) VU species, (D) EN species, (E) CR species, and (F) DD species.

SFF (Fig. 5). The areas that protect the largest number of species in a threat category are the RFPN (162 species), the PNN (84), the RFPR (37), and the PNR (25), and the areas that protect the least numbers are the DMI, RN, and SFF (13, four, and three, respectively). Throughout the dpto, 17% (~ 57 spp.) of the species are not found in a protected area, and more than 65% of those fall into one of the threat categories (NT = four, VU = 10, EN = seven, and CR = 15). In addition, information is not available for 31% of these species (DD). The protected area with the largest number of species is the RFN de Anchicayá (183 species), followed by the PNN Farallones de Cali (90), the RFPN of the rivers San Cipriano and Escalerete (84), and the RFPR de Bitaco (49).

### Endemic species

Nineteen endemic species are found in the dpto, which represents only 6% of the species diversity. Amphibians represent the largest number of species (13), with 75% in one of the threat categories: CR (six species), EN (three), and VU (two); the remaining 15% are categorized as DD. With regard to the threat categories for reptiles, three species are in the CR, and the other three are DD because they lacked sufficient information for an assessment (Fig. 6). The endemic species are distributed in four types of protected areas, the PNN and the RFPN, which contain a high number of species, and it is worth noting that the PNR el Páramo del Duende and the SFF Isla

Conservation status of the herpetofauna in Colombia



**Fig. 4.** Municipalities in Valle del Cauca with the greatest number of species in the threat categories: (A) Buenaventura, (B) Dagua, (C) Cali, (D) Darién, (E) El Cairo, and (F) La Cumbre.

de Malpelo are the types of areas with the greatest number of endemic species. Only four species (*Pristimantis diaphonus*, *Anomaloglossus atopoglossus*, *Nymphargus armatus*, and *Geophis betaniensis*) are not found in any of these areas.

**Discussion**

**Conservation status of amphibians and reptiles**

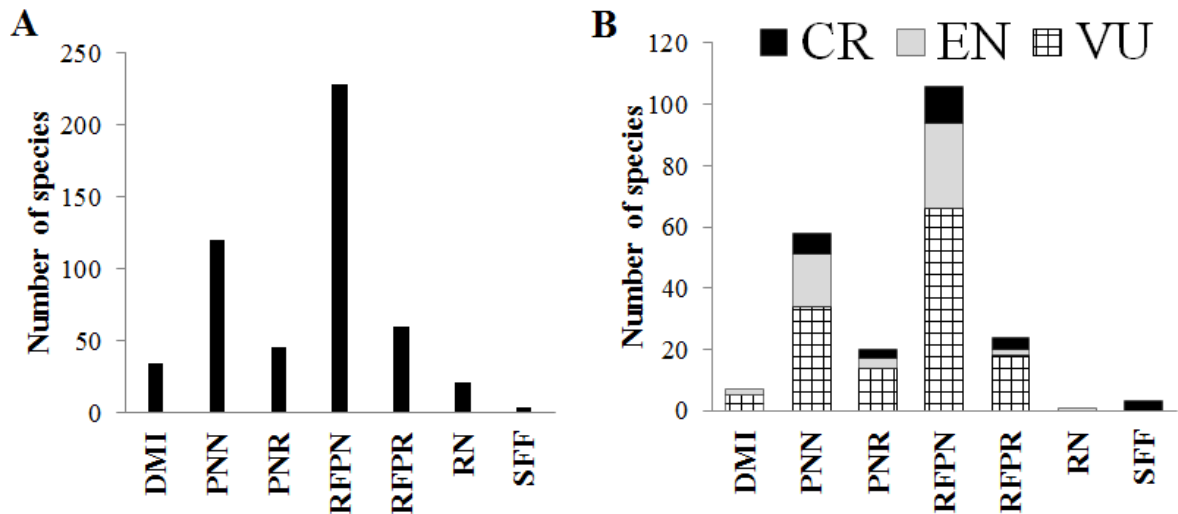
The need to recognize the status of a species in a specific area should be considered baseline information for developing studies and management plans for its conservation. The IUCN categorizations are generally applied globally for each taxon to determine the status of a species at the local or regional levels, and are considered advanced studies (Castro-H. and Bolívar-G. 2010); information on certain species (e.g., population status, natural history) is necessary to elicit an approximate categorization. Records for the DD species (13% of the species in this study) are not well represented in herpetological collections (some are only known from their original descriptions), and thus it is not possible to determine their status.

The dpto contains a high proportion of amphibian species (60%) in one of the threat categories, which represents nearly one-half of the total herpetofauna of the dpto, and the majority of these species show a moderate risk of extinction or population decline over the medium term (VU). In comparison with the results of Castro-H

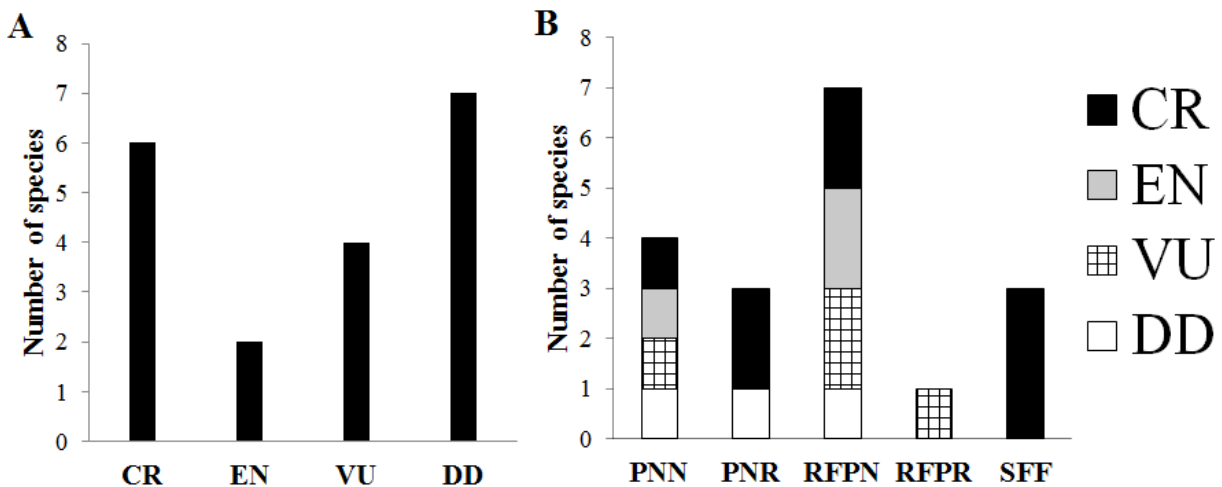
and Bolivar-G (2010), we show a significant increase in the number of species in the CR (11), EN (10), VU (12), and NT (one) categories, indicating that the risk of disappearance has increased in certain species, which is troublesome.

The lack of a threat status among the reptiles results from insufficient basic ecological information and the actual distribution of their populations (Urbina-Cardona 2008), for which an evaluation of the threat status has focused on specific species or groups (e.g., the red book of reptiles in Colombia), and thus has become a problem for planning conservation strategies. For this reason, the status of populations of reptile species in a given area has been proposed as a mechanism to change attitudes and generate interest in preserving these organisms (Dodd 2001), the protection and restoration of large areas these organism inhabit (Roe et al. 2004; França and Araújo 2006), species-specific information, field studies, demographics, natural history, and possible threats (Cagle 2008; Elfes et al. 2013). Significantly, this study is a local proposal that easily addresses the status of reptile species in Valle del Cauca, so that more effective strategies can be accomplished. This study is the first to assess many species of reptiles, and in spite of their low density threats might make them vulnerable and affect their abundance in the dpto; in many cases, characteristics of their natural history allow them to avoid these conditions.

The conservation of snakes remains subjective, because the current status of many species remains un-



**Fig. 5.** The herpetofauna of Valle del Cauca according to (A) the type of protected area, and (B) species with some degree of threat in each type of protected area.



**Fig. 6.** Endemic species listed according to (A) threat category, and (B) by protected areas in Valle del Cauca.

known. According to Lynch (2012), these animals are some of the most threatened because their deaths are provoked by people living in rural areas, vehicles traveling on highways, the loss of habitat, climate change, and illegal trafficking. Vargas et al. (2011) showed that even in a protected area such as the RFPN Bosque de Yotoco (Valle del Cauca), some snakes are vulnerable to the effects of roads on account of the prolonged amount of time that deaths by vehicles have been caused, considering the low density of populations and small size of the reserve.

### Threatened species in the municipalities and protected areas

Because of their considerable size and strategic location in high diversity life zones, municipalities such as Buenaventura, El Cairo, and Dagua contain a large number of threatened species of both groups (Cardona et al. 2013); however, these areas are the focal point of

anthropogenic pressures, and thus certain species have been affected. Moreover, municipalities such as El Águila, Ulloa, El Dovio, Versalles, Ansermanuevo, Florida, Pradera, Palmira, El Cerrito, Buga, Tuluá, and Sevilla, among others, lack adequate sampling and are under-represented in collections, and the few data available from these municipalities correspond to widely distributed generalist species, such as colubrid and dipsadid snakes that because of their high dispersal abilities can easily adapt to anthropogenic environments, and thus are categorized as LC (Adams 1994). Conservation efforts, therefore, should be focused in habitats influenced by the western versant of the central Cordillera, important areas for species in the different threat categories.

The distribution of the threat categories in the dpto reflects the pressures on the categorized species; for example, a large number of CR species are in the genus *Atelopus* and most of these are distributed in the two Cordilleras, and like their congener species possibly have been seriously affected by chytridiomycosis (Bonaccorso



*Hypsiboas picturatus*, Buenaventura, San Cipriano, 2003, Fdo Castro.

and Guayasamin 2003; Sanchez et al. 2008; Coloma et al. 2010). In addition, the fragmentation and loss of habitat due to human activities have affected certain sensitive species (like the centrolenids and dendrobatids) principally distributed in the Andean Cordilleras (Hutter et al. 2013) and in the Pacific region (Castro-H and Bolívar 2010). Besides these pressures, several species have experienced a population decline as a result of illegal trafficking and collection for scientific studies (Castro-H and Bolívar-G 2010; Corredor et al. 2010).

Additionally, in evaluating natural groups the “Sistemas Municipales de Áreas Protegidas” (Municipal System of Protected Areas; SIMAP) and the “Sistemas Nacionales de Áreas Protegidas” (National System of Protected areas; SINAP) have centered in municipalities such as Buenaventura, Cali, Dagua, La Cumbre, El Cairo, Darién, and Yotoco in an effort to better understand the conservation status of species in these areas, and to promote the monitoring of populations of these organisms. Furthermore, a network of community reserves is present in the municipality of El Cairo, in the Serranía de los Paraguas (which were not included in our analysis), and we suggest studying and monitoring the natural populations of many threatened and endemic species in this area in order to promote their conservation.

A greater number of species are found in RFPN than in the PNN because of three factors: (1) an extensive area of the RFPN (ca. 154,091 ha) lies in Valle del Cauca, (CVC 2012); although is not larger than that of the PNN,

compared to other types of areas it represents a substantial part of the territory; (2) several reserves in the dpto are located in areas of great richness, such as the RFPN of Anchicayá, and of the San Cipriano and Escalere rivers in the Pacific Region (Cardona et al. 2013); and (3) extensive research projects have been conducted in several of these areas, for which many bibliographic references are available and a large number of specimens are present in collections, such as in the RFPN del Bosque de Yotoco, in which the research group from the Laboratorio de Herpetología de la Universidad del Valle has been conducting inventories from 1978 until the present and recorded a large list of species, of which some are no longer being reported from the area (Castro et al. 2007).

In spite that one of the most effective methods for preserving natural spaces is the use of specific forms of protection and legal regulation that limit or prohibit the development of productive or extractive activities (Vásquez and Serrano 2009), state policies are necessary to guarantee the conservation of important ecological areas (Castro-H and Bolívar-G. 2010) by means of the environmental authority granted to autonomous corporations. In Valle del Cauca, several CR species undergoing population pressures were found in the PNN and the RFPN, such as *Oophaga lehmani*, in which the principal causes for decline in protected areas are the loss of habitat and illegal trafficking (Avila 2007), a clear example of not applying the articles of the *Código de Recursos Naturales Renovables y Protección del Medio Ambiente*



*Bolitoglossa medemi*, Buenaventura, Bendiciones, 2011.



*Oophaga histrionica*, Buenaventura, Anchicaya, 2000.



*Strobomantis ruizi*, Trujillo, Andinapolis, 2010.



*Agalychnis spurelli*, Buenaventura, san Cipriano, 2003.



*Andinobates bombetes*, Darien, Lago Calima, 2005.



*Diasporus gularis*, Buenaventura, Bazan, 2010.



*Gastrotheca antomia*, Dagua, Alto Queremal, 1993, Extinct.



*Pristimantis achatinus*, Buenaventura, Bazan, 2010.

(Code of Renewable Natural Resources and Environmental Protection; CRN). A similar situation exists with other species of amphibians and reptiles that are under great pressure in protected areas of Valle del Cauca, such as the ones mentioned previously and including mining, death caused by humans, and pesticide contamination from the fumigation of illicit crops, which illustrates a lack of control in these protected areas. In addition, the current laws in these areas and the reasons for proposing them are not clear, such as for preservation, conservation, and ecotourism, and in some areas they could supersede their carrying capacity.

Castro-H and Bolívar-G (2010) indicated that within the great variety of habitats found in the dpto those with specific characteristics became inclusive centers of speciation, and that these unique areas are of great importance because they contain endemic species. The endemic species in these areas could easily disappear on account of an environmental threat, because of their specialized requirements and limited distribution. The size of their distributional range is indispensable for their conservation, and these species should be included in at least one state protected area where conditions are stable, so there is less potential for risks and their populations can continue to develop (Rueda-A. et al. 2004). These requirements are necessary for their preservation, but it is worth noting that four endemic species (*Nymphargus armatus* and *Anomaloglossus atopoglossus* [CR], *Pristimantis diaphonus* [EN]; and the snake *Geophis betaniensis* [DD]) are not found in any of protected areas designated by the government and/or autonomous regional corporations (CAR = Institutions that are responsible for implementing the policies, plans, programs, and projects on environment and renewable natural resources. Also, they give a full and application to current legal provisions, under the regulations, standards, and guidelines issued by the ministry of environment), which makes them even more susceptible to threats.

### Global categorization vs local situations

Many species of continental turtles and crocodilians are sacrificed for consumption of their meat and eggs, and commercialization of their skins. In addition, pet commercialization, global warming, and developmental activities such as hydroelectric plants also have had a negative impact on their populations (Rueda-A. et al. 2007; Páez et al. 2012). For these reasons, these charismatic species are used to promote studies (biological and economic) and the categorization of these organisms (Castaño-M. 2002; Páez et al. 2012). Various local pressures, however, lead to an analysis of the situation or threat status of these species; for example, *Kinosternon leucostomum* (NT in this study) is a broadly-distributed species for which we have wide information on its ecology and reproductive biology (Giraldo et al. 2012), but it has been affected by habitat deterioration and is con-

sidered the most trafficked pet trade vertebrate species in southwestern Colombia (Galvis-R. and Corredor-L. 2005), which threatens the natural populations.

Although the loss of biological diversity in Colombia has been studied for several years, and plans for the management of threatened species that include a prioritized list of amphibians (Castro-H and Bolívar 2010) have been implemented at the regional and national levels, additional actions and research are still required. Some species in Valle del Cauca that appear in the IUCN category of LC, such as *Gastrotheca argenteovirens* (Ramírez-P. et al. 2004) and *Anolis fraseri* (Castañeda et al. 2011), are at risk and others listed as VU, such as *Centrolene geckoiideum* (Bolívar et al. 2004) and *Gastrotheca antomia* (Castro and Lynch 2004), have not been reported from the dpto in recent years, which suggests a subjectivity in analyzing the threat category in these species, especially on a regional basis. Also, the fossorial habits and difficulty in locating organisms such as caecilians must be considered, and thus their threat status is difficult to determine. According to the IUCN, most species of caecilians are categorized as LC and two species (*Caecilia guntheri* and *Osaecilia polizona*) as DD; however, on a local scale and considering the lack of information for these organisms, not enough data is available to establish a category in the dpto, as reflected in the family Caeciliidae. Similarly, other species might appear stable, but with additional data and the implementation of management plans their threat status might be updated so that protected areas will be able to comply with their function and agreements, in addition to the implementation of management plans for the short, medium, and long terms that are in place but have not been assumed by the environmental authority (CAR del Valle del Cauca, CVC), where all the stakeholders are included.

### Conclusions

One-half of the herpetofauna of Valle del Cauca is under some degree of threat, which is important for the conservation of this fauna, mainly in two areas in the western Pacific region (municipality of Buenaventura) and north on western Cordillera (municipality of Cairo). These hotspots are locations where extensive sampling of the herpetofauna has been conducted, and where species under some degree of threat occur differentially along the dpto.

Additional information on the distribution of amphibians and reptiles, the current status of populations, and the natural history of species in Valle del Cauca are necessary to develop an initiative for a conservation program with specific short-term objectives, so that decisions can help mitigate negative effects in the populations. Furthermore, the protected areas and municipalities in the dpto must develop monitoring plans in their areas that contain detailed information on the presence or absence



*Hypsiboas rubracila*, Buenaventura, Bazan, 2014.



*Pristimantis juanchoi*, La Cumbre, Chicoral, 2010.



*Centrolene gekkoideum*, La Cumbre, Chicoral, 1988, Extinct.



*Anolis lyra*, Buenaventura, Bazan, 2010.



*Kinosternon Leucostomum*, Buenaventura, Zaragoza, 2013.



*Thecadactylus rapicaudus*, Buenaventura, Zaragoza, 2009.



*Basiliscus galeritus*, Buenaventura, Zaragoza, 2013.



*Diploglossus monotropis*, Buenaventura, Bahia Malaga, 2013.

of species, so that along with other organizations they can negotiate the protection and conservation of ecosystems essential for the herpetofauna. In particular, we ask the CAR to ensure compliance with the development of these initiatives.

The conservation of endemic species of amphibians and reptiles should be clear and we must recognize that this requires special management, but the current regulations are not clear enough to define the measures that actually will allow the implementation of specific conservation plans for these species; in many places, the type of area will not allow the sustainability of these species, which are an emblem for the dpto.

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## Conservation status of the herpetofauna in Colombia



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- Small changes in vegetation structure changes in amphibian create great ensembles in the Colombian Pacific rainforest. *Tropical Conservation Science* 6(6): 749–769 (2013). Available: [http://tropicalconservationscience.mongabay.com/content/v6/TCS-2013-Vol6%286%29\\_749-769\\_Cortes-et-al.pdf](http://tropicalconservationscience.mongabay.com/content/v6/TCS-2013-Vol6%286%29_749-769_Cortes-et-al.pdf) [Accessed: 30 November 2014].
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*Animal photo credits: Fernando Castro-Herrera.*



## Supplemental Material

# Conservation status of the herpetofauna, protected areas, and current problems in Valle del Cauca, Colombia

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**Table 1.** Taxonomic list of amphibians and reptile of the department of Valle del Cauca (Cardona-B. et al. 2014). Actualization of threat categories based on: IUCN (red list), Red Book of Amphibians (Rueda et al. ) and Reptile (Castaño-M. et al 2002) of Colombia, Red Book of Amphibians of Valle del Cauca (Castro-H. and Bolívar-G 2010), and current categorization of the amphibians and reptile for Valle del Cauca. Also is denoted the municipalities and protected areas where the species is distributed; and a (†) is noted in the category when a species is endemic for the department.

TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the department	Municipality	Protected area
<b>CLASS AMPHIBIA</b>						
<b>ORDEN ANURA</b>						
<b>FAMILIA AROMOBATIDAE</b>						
<i>Allobates talamancae</i> (Cope, 1875)	LC			NT	Bu, Dar	RFPN Anchicaya
<i>Anomaloglossus atopoglossus</i> (Grant, Humphrey & Myers, 1997)	DD		CR	CR, B1ab(iii)(†)	Cai	
<i>Anomaloglossus lacrimosus</i> (Myers, 1991)	DD		VU	EN, B1a	Bu	RFPN Anchicaya, PNR La sierpe
<b>FAMILIA BUFONIDAE</b>						
<i>Atelopus cf. famelicus</i> (Rivero and Morales, 1995) ( <i>sensu lato</i> )	CR		CR	CR, B1ab(iii)	Bu, Cal, Yo	RFPN Anchicaya, RFPN de Cali
<i>Atelopus chocoensis</i> (Lötters, 1992)	CR		CR	CR, B2ab(iii)	Cai	
<i>Atelopus eusebianus</i> (Rivero and Granados, 1993)	CR	EN		CR, B2ab(iii)	Fl	
<i>Atelopus cf. ebenoides</i> (Rivero, 1963)	CR	CR		CR, B1ab(iii)	Ce	

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TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Atelopus pictiventris</i> (Kattan, 1986)	CR		CR	CR, B2ab(iii)(†)	Cal	PNN Farallones de Cali, RFPN de Cali
<i>Atelopus spurrelli</i> (Boulenger, 1914)	VU		VU	EN, A1a	Bu, Dar	RFPN Anchicaya, DMI La Plata, PNR La sierpe
<i>Incilius coniferus</i> (Cope, 1862)	LC			CR, B2ab(iii)	Dar	
<i>Rhaebo andi-nophrynooides</i> (Mueses-Cisneros, 2009)	NE			DD	Bu	PNN Farallones de Cali
<i>Rhaebo blombergi</i> (Myers and Funkhouser, 1951)	NT		NT	CR, B1ab(iii)	Bu, Dar	PNN Farallones de Cali, RFPN Anchicaya
<i>Rhaebo haematiticus</i> (Cope, 1862)	LC			LC	Bu, Da, Dar	RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete, PNN Farallones de Cali
<i>Rhaebo hypomelas</i> (Boulenger, 1913)	NT			VU, A1ace	Bu, Da, Dar	RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete, PNN Farallones de Cali
<i>Rhinella cf. margaritifera</i> (Laurenti, 1768)	LC			LC	Bu, Dar	RFPN Anchicaya, PNR La sierpe, RFPN de los rios San Cipriano y Escalerete, DMI La Plata
<i>Rhinella paraguas</i> (Bolívar and Grant, 2014)	EN	VU		EN, B2ab(iii)	Cai	
<i>Rhinella marina</i> (Linnaeus, 1758)	LC			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fi, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPR Bitaco, RFN Cerro Dapa-Carisucio, PNN Tatama, RFPN Anchicaya, RFPN de Tuluá, RFPN de los rios San Cipriano y Escalerete, PNN Farallones de Cali, RFPN de Cali, RNR Laguna de sonso o Cienaga de chircal, RFPN del Bosque de Yotoco,
<b>FAMILIA CENTROLENIDAE</b>						
<i>Centrolene ballux</i> (Duellman & Burrows, 1989)	CR			CR, B2ab(iii)	Da	PNN Farallones de Cali
<i>Centrolene buckleyi</i> (Boulenger, 1882)	VU		VU	VU, B2ab(iii)	Cal, Cai, Tu, Tr	PNN Farallones de Cali, PNR Paramo El Duende
<i>Centrolene geckoi-deum</i> (Jiménez de la Espada, 1872)	VU		VU	CR, A1ace	Cal, Cai, Da, Cu	PNN Farallones de Cali, RFPN Anchicaya, RFPR Bitaco
<i>Centrolene heloderma</i> (Duellman, 1981)	CR		CR	EN, B2ab(iii)	Cal, Cai	PNN Farallones de Cali
<i>Centrolene peristictum</i> (Lynch & Duellman, 1973)	VU		VU	EN, B2ab(iii)	Cal, Cai, Da	PNN Farallones de Cali, RFPN Anchicaya

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TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Centrolene robledoii</i> (Ruiz-Carranza & Lynch, 1995)	VU			EN, B2ab(iii)	Cai, Da, Ri	RFPN Anchicaya
<i>Centrolene savagei</i> (Ruiz-Carranza & Lynch, 1991)	VU			NT	Bo, Cal, Da, Cu, Yo	PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPN Bosque de Yotoco, RFPR Bitaco
<i>Cochranella balionota</i> (Duellman, 1981)	VU			CR, B2ab(iii)	Da	
<i>Cochranella megista</i> (Rivero, 1985)	NT			CR, B2ab(iii)	Cai	
<i>Espadarana callistomma</i> (Guayasamin & Trueb, 2007)	DD			NT	Bu	RFPN de los rios San Cipriano y Escalerete
<i>Espadarana prosoblepon</i> (Boettger, 1892)	LC			NT	Bu, Dar	RFPN de los rios San Cipriano y Escalerete, RFPN Anchicaya
<i>Hyalinobatrachium aureoguttatum</i> (Barrera & Ruiz-Carranza, 1989)	NT			VU, A3ace	Bu, Da, Dar	RFPN Anchicaya
<i>Hyalinobatrachium colymbiphylum</i> (Taylor, 1949)	LC			CR, B1ab(iii)	Bu	RFPN Anchicaya
<i>Hyalinobatrachium fleischmanni</i> (Böettger, 1893)	LC			VU, A3ace	Bu	RFPN Anchicaya
<i>Hyalinobatrachium valerioi</i> (Dunn, 1931)	LC			VU, A3ace	Bu	RFPN Anchicaya
<i>Nymphargus armatus</i> (Lynch & Ruiz-Carranza, 1996)	VU		VU	CR, B2ab(iii)(†)	Cai	
<i>Nymphargus grandisonae</i> (Cochran & Goin, 1970)	LC			VU, B1ab(iii)	Cai, Da	RFPN Anchicaya
<i>Nymphargus griffithsi</i> (Goin, 1961)	VU		VU	VU, A2ace	Cal, Cai, Da	PNN Farallones de Cali, RFPN Anchicaya
<i>Nymphargus ignotus</i> (Lynch, 1990)	NT		NT	NT	Cal, Cai, Da, Cu	PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPR Bitaco
<i>Nymphargus prasinus</i> (Duellman, 1981)	VU		VU	CR, B2ab(iii)	Da	
<i>Nymphargus ruizi</i> (Lynch, 1993)	VU		VU	VU, A2ace	Bug, Cal, Cai, Da, Pa	PNN Farallones de Cali, PNN Las hermosas, RFPN Anchicaya, RFPN de Amaime
<i>Rulyrana orejuela</i> (Duellman & Burrowes, 1989)	DD			EN, B1ab(iii)	Da	RFPN Anchicaya
<i>Sachatamia albomaculata</i> (Taylor, 1949)	LC			EN, B2ab(iii)	Bu	RFPN Anchicaya
<i>Sachatamia ilex</i> (Savage, 1967)	LC			NT	Bu, Da, Dar	RFPN Anchicaya, DMI La Plata

TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Teratohyla pulverata</i> (Peters, 1873)	LC			VU, B2ab(iii)	Bu, Da	RFPN de los rios San Cipriano y Escalere-te, RFPN Anchicaya
<i>Teratohyla spinosa</i> (Taylor, 1949)	LC			NT	Bu, Da	RFPN de los rios San Cipriano y Escalere-te, RFPN Anchicaya
<b>FAMILIA CRAUGASTORIDAE</b>						
<i>Craugastor fitzingeri</i> (Schmidt, 1857)	LC			LC	Bu, Dar	PNR La sierpe, RFPN Anchicaya
<i>Craugastor longirostris</i> (Boulenger, 1898)	LC			LC	Bu, Dar	PNR La sierpe, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalere-te
<i>Craugastor opimus</i> (Savage & Myers, 2002)	LC			CR, B2ab(iii)	Bu, Dar	PNR La sierpe
<i>Craugastor raniformis</i> (Boulenger, 1896)	LC			LC	Bu, Da, Dar	RFPN Anchicaya, DMI Enclave subxe-rofitico de Atuncela, PNR La sierpe, RFPN de los rios San Cipriano y Escalere-te
<i>Hypodactylus babax</i> (Lynch, 1989)	LC			EN, B2ab(iii)	Da, Cai	RFPN Anchicaya
<i>Hypodactylus mantipus</i> (Boulenger, 1908)	LC			NT	Cal, Cu, Da, Dar, Tr, Yo, Yu	PNN Farallones de Cali, RFPN de Cali, RFPR Bitaco, RFPN Anchicaya, RFPN del Bosque de Yotoco; RFPN Cerro Dapa - Carisucio
<i>Pristimantis acatallelus</i> (Lynch & Ruiz-Carranza, 1983)	LC			VU, B2ab(iii)	Cal, Cai	PNN Farallones de Cali
<i>Pristimantis achatinus</i> (Boulenger, 1898)	LC			LC	Bu, Da, Dar	RFPN Anchicaya, DMI La Plata.
<i>Pristimantis alalocophus</i> (Roa-Trujillo & Ruiz-Carranza, 1991)	NT		NT	VU, B2ab(iii)	Bug, Fl, Pa, Tu	RFN Amaime, PNN Las hermosas, RFPR Frayle-Desbaratado
<i>Pristimantis albericoi</i> (Lynch & Ruiz-Carranza, 1996)	CR			CR, B2ab(iii)	Cai	
<i>Pristimantis angustilineatus</i> (Lynch, 1998)	EN		EN	VU, B2ab(iii)	Cai, Tr	
<i>Pristimantis aurantiguttatus</i> (Ruiz-Carranza, Lynch & Ardila-Robayo, 1997)	DD			DD	Cai	
<i>Pristimantis boulengeri</i> (Lynch, 1981)	LC			VU, B2ab(iii)	Bug, Fl, Pa	RFPR Frayle-Desbaratado, PNN Las hermosas
<i>Pristimantis brevifrons</i> (Lynch, 1981)	LC			LC	Cal, Cai, Cu, Da, Fl, Tr, Yo	RFPR Bitaco, RFR Frayle-Desbaratado, PNN Farallones de Cali, RFPN del Bosque de Yotoco, RFPN Cerro Dapa - Carisucio, RFPN de Cali, RFPN Anchicaya



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TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Pristimantis buckleyi</i> (Boulenger 1882)	LC			NT	Cal, Cai, Ce, Fl, Pa, Tu	RFN Amaime, PNN Farallones de Cali, RFPR Frayle-Desbaratado,
<i>Pristimantis calcaratus</i> (Boulenger, 1908)	EN		EN	NT	Cal, Cai, Cu, Da, Yo	RFPN de Cali, PNN Farallones de Cali, RFPR Bitaco, RFPN del Bosque de Yotoco
<i>Pristimantis calcarulatus</i> (Lynch, 1976)	VU			VU, B2ab(iii)	Cal, Cum	PNN Farallones de Cali, RFPR Bitaco
<i>Pristimantis capitonis</i> (Lynch, 1998)	EN		VU	VU, B2ab(iii)	Cal, Cai, Da, Tr	PNN Farallones de Cali, RFPN Anchicaya
<i>Pristimantis caprifer</i> (Lynch, 1977)	LC			VU, B2ab(iii)	Bu, Da, Dar	RFPN Anchicaya
<i>Pristimantis chalceus</i> (Peters, 1873)	LC			NT	Bu, Da, Dar	RFPN Anchicaya
<i>Pristimantis chrysops</i> (Lynch & Ruiz-Carranza, 1996)	EN		EN	EN, B2ab(iii)	Cal, Cai, Da, Yo	RFPN Anchicaya, RFPN de Cali, RFPN del Bosque de Yotoco
<i>Pristimantis deinops</i> (Lynch, 1996)	EN		EN	EN, B2ab(iii)(†)	Cal, Cai, Da, Yo	RFPN Anchicaya, RFPN de Cali, RFPN del Bosque de Yotoco
<i>Pristimantis diaphonus</i> (Lynch, 1986)	VU		VU	EN, B2ab(iii)(†)	Da, Re	
<i>Pristimantis duende</i> (Lynch, 2001)	DD			CR, B2ab(iii)(†)	Tr	PNR Páramo el Duende
<i>Pristimantis erythropleura</i> (Boulenger, 1896)	LC			LC	Cal, Cai, Cu, Da, Dar, Tr, Yo	RFPR Bitaco, RFPN de Cali, RFPN Anchicaya, PNN Farallones de Cali, RFPN del Bosque de Yotoco
<i>Pristimantis gaigeae</i> (Dunn, 1931)	LC			NT	Bu	RFPN Anchicaya, DMI La Plata, RFPN de los rios San Cipriano y Escalerete
<i>Pristimantis gracilis</i> (Lynch, 1986)	VU		VU	CR, B2ab(iii)	Cal, Cai, Cu	PNN Farallones de Cali, RFPR Bitaco
<i>Pristimantis hybotragus</i> (Lynch, 1992)	VU		VU	VU, B2ab(iii)(†)	Bu, Dar	PNR La sierpe, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete
<i>Pristimantis juanchoi</i> (Lynch, 1996)	VU		NT	NT	Cal, Cai, Cu, Da, Dar, Yo	RFPR Bitaco, RFPN Anchicaya, RFPN de Cali, RFPN del Bosque de Yotoco.
<i>Pristimantis kelephas</i> (Lynch, 1998)	VU		VU	CR, B2ab(iii)	Cai	
<i>Pristimantis labiosus</i> (Lynch, Ruiz-Carranza & Ardila-Robayo, 1994)	LC			NT	Bu, Dar	RFPN de los rios San Cipriano y Escalerete, PNN Farallones de Cali
<i>Pristimantis latidiscus</i> (Boulenger, 1898)	LC			LC	Bu, Dar	RFPN de los rios San Cipriano y Escalerete, RFPN Anchicaya, DMI La Plata
<i>Pristimantis molybri-gnus</i> (Lynch, 1986)	NT		NT	VU, B2ab(iii)	Cal, Da, Dar, Yo	RFPN Anchicaya, RFPN de Cali, RFPN del Bosque de Yotoco

TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Pristimantis moro</i> (Savage, 1965)	LC			VU, B2ab(iii)	Bu	RFPN Anchicaya, PNR La sierpe
<i>Pristimantis myops</i> (Lynch, 1998)	DD			VU, B2ab(iii)	Cal, Cai, Da	PNN Farallones de Cali
<i>Pristimantis obmutescens</i> (Lynch, 1980)	LC			VU, B2ab(iii)	Fl, Gi, Tu	RFPR Frayle-Desbaratado, RFPN de sonso-guabas
<i>Pristimantis orpacobates</i> (Lynch, Ruiz-Carranza & Ardila-Robayo, 1994)	VU		VU	VU, B1ab(iii)	Cal, Cu, Dar, Yo	RFPR Bitaco, RFPN de Cali, RFPN del Bosque de Yotoco
<i>Pristimantis palmeri</i> (Boulenger, 1912)	LC			LC	Cal, Cai, Cu, Da, Dar, Yo, Yu	PNN Farallones de Cali, RFPR Bitaco, RFPN de Cali, RFPN del Bosque de Yotoco, RFPN Cerro Dapa - Carisucio
<i>Pristimantis peraticus</i> (Lynch, 1980)	LC			VU, B1ab(iii)	Ce, Fl, Pa	RFPN Amaime, RFPR Frayle-Desbaratado
<i>Pristimantis permixtus</i> (Lynch, Ruiz-Carranza & Ardila-Robayo, 1994)	LC			NT	Ce, Cu, Fl, Pa	RFPR Bitaco, RFPR Frayle-Desbaratado
<i>Pristimantis phalarus</i> (Lynch, 1998)	VU		VU	VU, B1ab(iii)	Cai	
<i>Pristimantis piceus</i> (Lynch, Ruiz-Carranza & Ardila-Robayo, 1996)	LC			VU, B1ab(iii)	Ce, Fl, Pa	RFPN Amaime, RFPR Frayle-Desbaratado
<i>Pristimantis platytilus</i> (Lynch, 1996)	VU		VU	VU, B1ab(iii)	Cal, Da	RFPN de Cali, RFPN Anchicaya, RFPR Bitaco
<i>Pristimantis ptochus</i> (Lynch, 1998)	DD			DD	Cal, Cai	PNN Farallones de Cali
<i>Pristimantis quantus</i> (Lynch, 1998)	VU		VU	VU, B1ab(iii)	Cai	
<i>Pristimantis quicato</i> (Ospina-Sarria, Mendez-Narvaez, Burbano-Yandi & Bolivar-Garcia, 2011)	-			DD (†)	Pa	PNN Las hermosas
<i>Pristimantis racemus</i> (Lynch, 1980)	LC			VU, B1ab(iii)	Ce, Gi, Pa, Tu	RFPN de sonso-guabas
<i>Pristimantis restrepoi</i> (Lynch, 1996)	LC			VU, B1ab(iii)	Cai	
<i>Pristimantis ridens</i> (Cope, 1866)	LC			NT	Bu, Dar	PNR La sierpe, RFPN Anchicaya
<i>Pristimantis roseus</i> (Boulenger, 1918)	NT		NT	VU, B2ab(iii)	Bu, Da, Dar	PNR La sierpe, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalereite
<i>Pristimantis sanguineus</i> (Lynch, 1998)	NT			DD	Bu	
<i>Pristimantis silverstonei</i> (Lynch & Ruiz-Carranza, 1996)	NT		NT	VU, B2ab(iii)	Cai, Da	PNN Farallones de Cali, PNR Paramo del Duende

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TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Pristimantis simoteriscus</i> (Lynch, Ruiz-Carranza & Ardila-Robayo 1996)	EN		EN	EN, B2ab(iii)	Gi, Tu	RFPN de sonsoguas
<i>Pristimantis supernatis</i> (Lynch, 1979)	VU		VU	VU, B2ab(iii)	Ce, Gi, Pa, Tu	RFPN de sonsoguas
<i>Pristimantis taeniatus</i> (Boulenger, 1912)	LC			VU, B2ab(iii)	Bu	DMI La Plata
<i>Pristimantis thectopterus</i> (Lynch, 1975)	LC			VU, A1ace	Cal, Cu, Da, Dar, Fl, Pa, Tr	RFPN de Cali, RFPR Bitaco, RFPN Anchicaya
<i>Pristimantis uranobates</i> (Lynch, 1991)	LC			EN, B2ab(iii)	Ce, Pa	RFPN de Amaime
<i>Pristimantis viridicans</i> (Lynch 1977)	EN		VU	CR, A1ace	Cal, Cu	PNN Farallones de Cali, RFPR Bitaco
<i>Pristimantis w-nigrum</i> (Böettger, 1892)	LC		LC	NT	Cal, Cu, Tr, Yo	PNN Farallones de Cali, RFPR Bitaco, RFPN de Cali, RFPN del Bosque de Yotoco
<i>Pristimantis xeniolum</i> (Lynch, 2001)	DD			DD (†)	Tr	PNR Páramo el Duende
<i>Pristimantis xylochobates</i> (Lynch & Ruiz-Carranza, 1996)	VU		VU	EN, A1ace	Cal, Cai	PNN Farallones de Cali
<i>Strabomantis anatypes</i> (Lynch and Myers, 1983)	VU		VU	CR, A1ace	Da	RFPN Anchicaya
<i>Strabomantis anomalous</i> (Boulenger, 1898)	LC			LC	Bu, Da, Dar	RFPN Anchicaya
<i>Strabomantis bufoniformis</i> (Boulenger, 1896)	LC			VU, A1ace	Bu, Dar	PNN Farallones de Cali, RFPN Anchicaya
<i>Strabomantis cerastes</i> (Lynch, 1975)	LC			VU, A1ace	Cal, Cai, Da, Yo	RFPN de Cali, RFPN del Bosque de Yotoco
<i>Strabomantis cheiropethus</i> (Lynch, 1990)	VU		VU	VU, A1ace	Bu, Cai, Da	PNN Farallones de Cali.
<i>Strabomantis ruizi</i> (Lynch, 1981)	EN	EN	EN	VU, A1ace (†)	Cal, Cu, Da, Tr, Yo	RFPR Bitaco, PNN Farallones de Cali, RFPN del Bosque de Yotoco
<i>Strabomantis zygodactylus</i> (Lynch and Myers, 1983)	LC			NT	Bu, Dar	RFPN de los rios San Cipriano y Escalerete RFPN Anchicaya
<b>FAMILIA DENDROBATIDAE</b>						
<i>Andinobates bombetes</i> (Myers & Daly, 1980)	EN	VU	EN	VU, B1ab(iii)	Cal, Cai, Cu, Da, Dar, To, Yo	RFPN Anchicaya, RFPN de Cali, RFPN Bosque de Yotoco, RFPR Bitaco, DMI Enclave subxerofítico de Atuncela
<i>Andinobates fulguritus</i> (Silverstone, 1975)	LC		NT	VU, B1ab(iii)	Bu	RFPN de los rios San Cipriano y Escalerete, RFPN Anchicaya, PNR La Sierpe
<i>Andinobates minutus</i> (Shreve, 1935)	LC			LC	Bu, Dar	PNN Uramba-Bahia Malaga, RFPN de los rios San Cipriano y Escalerete, RFPN Anchicaya, PNR La Sierpe, DMI La plata

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<i>Andinobates viridis</i> (Myers & Daly, 1976)	VU	EN	VU	EN, A1acde (†)	Bu	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya
<i>Colostethus agilis</i> (Lynch & Ruiz-Carranza, 1985)	NT		NT	EN, B2ab(iii)	Cal, Cai, Da	PNN Farallones de Cali, RFPN Anchicaya
<i>Colostethus brachistriatus</i> (Rivero & Serna, 1986)	DD			VU, A1ace	Fl, Pa, Tu	PNN Las Hermosas, RFPR Frayle-Desbaratado
<i>Colostethus fraterdanieli</i> (Silverstone, 1971)	NT			NT	Bug, Cal, Cu, Da, Fl, Ri, Tu, Yo	PNN Farallones de Cali, RFPN Anchicaya, RFPN Bosque de Yotoco, RFN de Tulua, RN Laguna de Sonso
<i>Epipedobates bou-lengeri</i> (Barbour, 1909)	LC			LC	Bu	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya, DMI La plata
<i>Hyloxalus abditaurantius</i> (Silverstone, 1975)	LC			VU, B2ab(iii)	Cal, Cai, Da, Dar	PNN Farallones de Cali, RFPN Anchicaya
<i>Hyloxalus chochoensis</i> (Boulenger, 1912)	DD			EN, B2ab(iii)	Da, Dar	RFPN Anchicaya
<i>Hyloxalus fascianigrus</i> (Grant & Castro-Herrera, 1998)	NT		NT	VU, B2ab(iii)	Cal, Cu, Da, Dar, Yo	RFPN Anchicaya, RFPN Bosque de Yotoco, RFPN de Cali, PNR Páramo El Duende, RFPR Bitaco, RFPR Frayle-Desbaratado
<i>Hyloxalus lehmanni</i> (Silverstone, 1971)	NT		NT	VU, A1ace	Bug, Cal, Cai, Cu, Tu	PNN Farallones de Cali, RFPN Anchicaya, RFPR Bitaco, RFN de Amaime
<i>Oophaga histrionica</i> (Berthold, 1845)	LC		VU	VU, A1acde (†)	Bu, Da, Dar	RFPN Anchicaya, RFPN Dagua
<i>Oophaga lehmanni</i> (Myers & Daly, 1976)	CR	CR	CR	CR, A2acde	Bu, Da	RFPN Anchicaya
<i>Phyllobates bicolor</i> (Duméril & Bibron, 1841)	NT		NT	EN, A1acde	Bu, Cai	
<i>Phyllobates cf. aurotaenia</i> (Boulenger, 1913)	NT		NT	EN, A2acde	Bu	RFPN Anchicaya
<i>Phyllobates terribilis</i> (Myers, Daly & Malkin, 1978)	EN	CR		CR, B1ab(iii)	Bu	
<i>Silverstoneia nubicola</i> (Dunn, 1924)	NT		NT	NT	Bu, Dar	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya
<b>FAMILIA ELEUTHERODACTYLIDAE</b>						
<i>Diasporus tinker</i> (Lynch, 2001)	LC			LC	Bu, Dar	PNR La sierpe, DMI La Plata, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalere-re

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<i>Diasporus gularis</i> (Boulenger, 1898)	LC			LC	Bu, Da, Dar	DMI La Plata, RFPN Anchicaya, RFPN Uramba Bahía Malaga, RFPN de los ríos San Cipriano y Escalerete
<i>Diasporus quidditus</i> (Lynch, 2001)	LC			DD	Bu, Dar	
<i>Eleutherodactylus johnstonei</i> (Barbour, 1914)	LC			LC	Cal, Ja, Yu	
<b>FAMILIA HEMIPHRACTIDAE</b>						
<i>Gastrotheca angustifrons</i> (Boulenger, 1898)	VU			CR, A1ace	Dar	
<i>Gastrotheca antomia</i> (Ruiz-Carranza, Ardila-Robayo, Lynch & Restrepo, 1997)	VU		VU	CR, A1ace	Cal, Cai, Cu, Da	RFPN de Cali, RFPN Anchicaya, RFPN Bitaco
<i>Gastrotheca argenteovirens</i> (Böettger, 1892)	LC			EN, A1ace	Ce, Pa, Tu	PNN Las hermosas, RFN de Amaime
<i>Gastrotheca cornuta</i> (Boulenger, 1898)	EN		VU	EN, A1ace	Bu	RFPN Anchicaya, RFPN de los ríos San Cipriano y Escalerete
<i>Gastrotheca dendronastes</i> (Duellman, 1983)	VU		VU	CR, A1ace	Cal, Cai, Da, Dar, Yo	RFPN Anchicaya, PNN Farallones de Cali, RFPN del Bosque de Yotoco
<i>Hemiphractus fasciatus</i> (Peters, 1862)	NT		EN	EN, B2ab(iii)	Bu, Dar	
<b>FAMILIA HYLIDAE</b>						
<i>Agalychnis psilopygion</i> (Cannatella, 1980)	DD			EN, B2ab(iii)	Bu, Dar	RFPN Anchicaya
<i>Agalychnis spurrelli</i> (Boulenger, 1913)	LC			NT	Bu, Dar	PNN Farallones de Cali, RFPN Anchicaya
<i>Cruziohyla calcarifer</i> (Boulenger, 1902)	LC			VU, A2acde	Bu, Dar	RFPN Anchicaya
<i>Dendropsophus columbianus</i> (Böettger, 1892)	LC			LC	Al, An, Ans, Ar, Bo, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vj, Yo, Yu, Za	RFPN Cerro Dapa - Carisucio, PNN Tatama, PNN Farallones de Cali, PNN Las Hermosas, RFPN Bitaco, RFPN de Amaime, RFPN de Cali
<i>Dendropsophus ebraccatus</i> (Cope, 1874)	LC			VU, B2ab(iii)	Bu	RFPN de los ríos San Cipriano y Escalerete
<i>Dendropsophus microcephalus</i> (Boulenger, 1898)	LC			EN, B2ab(iii)	Bu	RFPN de los ríos San Cipriano y Escalerete
<i>Hyloscirtus alytolylax</i> (Duellman, 1972)	NT		NT	EN, B2ab(iii)	Cal, Cai, Cu, Da	RFPN BITACO, RFPN Anchicaya, RFPN de Cali

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<i>Hyloscirtus larinopygion</i> (Duellman, 1973)	NT		NT	VU, A1ace	Cal, Cai, Ce, Cu, Da, Fl, Ri	RFPR Bitaco, PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPN de Amaime
<i>Hyloscirtus palmeri</i> (Boulenger 1908)	LC			NT	Bu, Da, Dar	PNN Farallones de Cali, RFPN Anchicaya
<i>Hyloscirtus simmonsii</i> (Duellman, 1989)	EN		EN	CR, B1ab(iii)	Dar	
<i>Hypsiboas boans</i> (Linnaeus, 1758)	LC			NT	Bu, Da, Dar	DMI La Plata, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete
<i>Hypsiboas pellucens</i> (Werner, 1901)	LC			VU, B2ab(iii)	Bu	RFPN Anchicaya
<i>Hypsiboas picturatus</i> (Boulenger, 1899)	LC			LC	Bu, Dar	PNR La sierpe, DMI La Plata, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete
<i>Hypsiboas pugnax</i> (Schmidt, 1857)	LC			LC	Bu, Car, Ja, Rol	RFPN Anchicaya
<i>Hypsiboas rosenbergi</i> (Boulenger, 1898)	LC			LC	Bu, Dar	RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete
<i>Hypsiboas rubracylus</i> (Cochran & Goin, 1970)	LC			VU, B1ab(iii)	Bu	PNR La sierpe, RFPN Anchicaya
<i>Scinax elaeochroa</i> (Cope, 1875)	LC			VU, B2ab(iii)	Bu	RFPN de los rios San Cipriano y Escalerete
<i>Scinax ruber</i> (Laurenti, 1768) (sensu lato)	LC			LC	Bu, Ja	RFPN Anchicaya
<i>Scinax sugillatus</i> (Duellman, 1973)	LC			EN, B2ab(iii)	Bu	RFPN Anchicaya
<i>Smilisca phaeota</i> (Cope, 1862)	LC			LC	Bu, Dar	PNR La sierpe, PNN Farallones de Cali, DMI La Plata, RFPN Anchicaya, RFPN de los rios San Cipriano y Escalerete
<b>FAMILIA LEPTODACTYLIDAE</b>						
<i>Leptodactylus colombiensis</i> (Heyer, 1994)	LC			LC	An, Ans, Bo, Bug, Bul, Cal, Can, Ce, Fl, Gu, Ja, Ob, Pa, Un, Ri, Ro, Sp, To, Tr, Tu, Vi, Vij, Yo, Yu, Za	RNR Laguna de Sonso
<i>Leptodactylus fragilis</i> (Brocchi, 1877)	LC			LC	An, Bug, Cal, Ja, Yu	RNR Laguna de Sonso
<i>Leptodactylus melanotus</i> (Hallowell, 1861)	LC			LC	Bu	RFPN Anchicaya, PNR La Sierpe
<i>Leptodactylus rhodomerus</i> (Heyer, 2005)	LC			LC	Bu, Dar	RFPN de los rios Escalerete y San Cipriano, RFPN Anchicaya, DMI La Plata

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<i>Leptodactylus ventrimaculatus</i> (Boulenger, 1902)	LC			NT	Bu, Dar	
<i>Leptodactylus wagneri</i> (Peters, 1862)	LC			NT	Bu	
<b>FAMILIA MICROHYLIDAE</b>						
<i>Nelsonophryne aterrima</i> (Günther, 1900)	LC			EN, B2ab(iii)	Dar	
<b>FAMILIA RANIDAE</b>						
<i>Lithobates catesbeiana</i> (Shaw, 1802)	LC			LC	Bug, Gi, Pa, Ri, Ro, Tu, Yo	RN Laguna de Sonso
<i>Lithobates vaillanti</i> (Brocchi, 1877)	LC			LC	Bu	RFPN de los rios Escalereite y San Cipriano, RFPN Anchicaya
<b>ORDEN CAUDATA</b>						
<b>FAMILIA PLETHODONTIDAE</b>						
<i>Bolitoglossa biseriata</i> (Tanner, 1962)	LC			NT	Bu, Da	RFPN de los rios Escalereite y San Cipriano, RFPN Anchicaya
<i>Bolitoglossa walkeri</i> (Brame & Wake, 1972)	NT		NT	VU, B2ab(iii)	Cal, Cai, Cu	RFPN de Cali, RFPR Bitaco
<i>Bolitoglossa hiemalis</i> (Lynch, 2001)	DD		DD	CR, B2ab(iii)(†)	Tr	PNR Páramo El Duende
<i>Bolitoglossa valleculea</i> (Brame & Wake, 1963)	VU			EN, B2ab(iii)	Cai	RFPN Anchicaya
<i>Bolitoglossa silverstonei</i> (Brame & Wake, 1972)	LC			DD	Bu	
<i>Oedipina parvipes</i> (Peters, 1879)	LC			DD	Bu	RFPN Anchicaya
<b>ORDEN GYMNOPIHONA</b>						
<b>FAMILIA CAECILIIDAE</b>						
<i>Caecilia guntheri</i> (Dunn, 1942)	DD			DD	Cai	
<i>Caecilia leucocephala</i> (Taylor, 1968)	LC			DD	Bu	RFPN Anchicaya
<i>Caecilia nigricans</i> (Boulenger, 1902)	LC			DD	Bu	RFPN de los rios San Cipriano y Escalereite
<i>Caecilia occidentalis</i> (Taylor, 1968)	DD			DD	Cal, Da	PNN Farallones de Cali
<i>Caecilia orientalis</i> (Taylor, 1968)	LC			DD	Se	
<i>Caecilia perdita</i> (Taylor, 1968)	LC			DD	Bu	RFPN Anchicaya, RFPR Bitaco
<i>Caecilia subdermalis</i> (Taylor, 1968)	LC			DD	Cu, Da, Ja	
<i>Caecilia subnigricans</i> (Dunn, 1942)	LC			DD	Re	RFPN de los rios San Cipriano y Escalereite
<i>Caecilia cf. tentaculata</i> (Linnaeus, 1749)	LC			DD	Bu, Re	
<i>Oscacaecilia polyzona</i> (Fisher, 1880)	DD			DD	Bu	PNR La sierpe

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<b>FAMILIA RHINATREMATIDAE</b>						
<i>Epicrionops bicolor</i> (Boulenger, 1883)	LC			NT	Bo, Cu, Da	RFPR Bitaco, PNN Farrallones de Cali
<b>FAMILIA TYPHLONECTIDAE</b>						
<i>Typhlonectes natans</i> (Fisher, 1880)	LC			NT	An, Ans, Bo, Bug, Bul, Cal, Can, Car, Fl, Gu, Ja, Un, Vi, Ob, Ri, Ro, Sp, To, Tr, Tu, Vij, Yo, Yu, Za	
<b>CLASS REPTILIA</b>						
<b>ORDEN CROCODYLIA</b>						
<b>FAMILIA ALLIGATORIDAE</b>						
<i>Caiman crocodilus</i> (Linnaeus, 1758)	LC	LC		LC	Bu, Bug	RN Laguna de sonso
<b>FAMILIA CROCODYLIDAE</b>						
<i>Crocodylus acutus</i> (Cuvier, 1807)	VU	CR		VU, A1acd	Bu	
<b>ORDEN SQUAMATA</b>						
<b>SUBORDEN AMPHISBAENIA</b>						
<b>FAMILIA AMPHISBAENIDAE</b>						
<i>Amphisbaena fuliginosa</i> (Linnaeus, 1758)	NE			NT	Bu	RFPN Anchicaya
<b>SUBORDEN SAURIA</b>						
<b>INFRAORDEN IGUANIA</b>						
<b>FAMILIA CORYTOPHANIDAE</b>						
<i>Basiliscus basiliscus</i> (Linnaeus, 1768)	NE			NT	Bu, Bug, Ja, Pa, Yu	RFPN Anchicaya, RNR Laguna de Sonso
<i>Basiliscus galeritus</i> (Duméril, 1851)	NE			NT	Bu, Da	PNN Uramba-Bahía Malaga, RFPN Anchicaya
<b>FAMILIA DACTYLOIDAE</b>						
<i>Anolis agassizi</i> (Stejneger, 1900)	NE			CR, B2ab(iii)(†)	Bu	SFF Isla Malpelo
<i>Anolis anchicayae</i> (Poe, Velasco, Miyata & Williams, 2009)	NE			VU, B2ab(iii)	Bu, Dar	RFPN de los rios San Cipriano y Escalere, RFPN Anchicaya
<i>Anolis antonii</i> (Boulenger, 1908)	NE			LC	Cal, Cai, Cu, Ce, Da, Yo	PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPN Bosque de Yotoco, RFPR Bitaco
<i>Anolis auratus</i> (Daudin, 1802)	NE			LC	Bu, Bug, Cal, Ce, Ja, Pa, Yu	PNN Farallones de Cali
<i>Anolis biporcatus</i> (Wiegmann, 1834)	NE			VU, B2ab(iii)	Bu	
<i>Anolis calimae</i> (Ayala, Harris & Williams, 1983)	NE			VU, B2ab(iii)	Cal, Da, Vi	PNN Farallones de Cali
<i>Anolis chloris</i> (Boulenger, 1898)	NE			VU, B2ab(iii)	Bu	RFPN Anchicaya



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<i>Anolis chocorum</i> (Williams & Duellman, 1967)	NE			VU, A2ac	Bu	RFPN de los rios San Cipriano y Escalere-te, RFPN Anchicaya
<i>Anolis eulaemus</i> (Boulenger, 1908)	LC			VU, A2ac	Cal, Cu, Vi	PNN Farallones de Cali, RFPR Bitaco
<i>Anolis fraseri</i> (Günther, 1859)	LC			VU, B2ab(iii)	Cal, Da, Yo	PNN Farallones de Cali, RFPN Anchicaya, RFPN Bosque de Yotoco
<i>Anolis gracilipes</i> (Boulenger, 1898)	NE			EN, B2ab(iii)	Bu	RFPN Anchicaya
<i>Anolis granuliceps</i> (Boulenger, 1898)	LC			VU, B2ab(iii)	Bu, Da	RFPN Anchicaya
<i>Anolis heterodermus</i> (Duméril, 1851)	NE			VU, B2ab(iii)	Cal, Cai, Cu, Da	RFPN Anchicaya, RFPR Bitaco
<i>Anolis latifrons</i> (Berthold, 1846)	NE			NT	Bu	
<i>Anolis lyra</i> (Poe, Velasco, Miyata & Williams, 2009)	NE			VU, B2ab(iii)	Bu, Dar	
<i>Anolis macrolepis</i> (Boulenger, 1911)	NE			NT	Bu	RFPN Anchicaya
<i>Anolis maculiventris</i> (Boulenger, 1898)	NE			NT	Bu	RFPN Anchicaya
<i>Anolis mirus</i> (Williams, 1963)	NE			CR, B1ab(iii)	Bu	RFPN de los rios San Cipriano y Escalere-te, RFPN Anchicaya
<i>Anolis notopholis</i> (Boulenger, 1896)	NE			NT	Bu, Da, Dar	RFPN Anchicaya
<i>Anolis propinquus</i> (Williams, 1984)	NE			CR, B1ab(iii)	Da, Dar	RFPN Anchicaya
<i>Anolis rivalis</i> (Williams, 1984)	NE			DD	Bu	
<i>Anolis ventrimaculatus</i> (Boulenger, 1911)	NT			LC	Cal, Cai, Cu, Da	PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPR Bitaco
<b>FAMILIA HOPLOCERCIDAE</b>						
<i>Enyalioides heterolepis</i> (Bocourt, 1874)	NE			NT	Bu, Da	RFPN Anchicaya
<i>Enyalioides oshaughnessyi</i> (Boulenger, 1881)	NE			DD	Bu	
<b>FAMILIA IGUANIDAE</b>						
<i>Iguana iguana</i> (Linnaeus, 1758)	NE			LC	Bu, Bug, Cal, Can, Ce, Cu, Da, Gu, Ja, Pa, Sp, Vi, Vj, Yu	RFPN de los rios Escalere-te y San Cipriano, RN Laguna de Sonso
<b>FAMILIA POLYCHROTIDAE</b>						
<i>Polychrus guttuosus</i> (Berthold, 1846)	NE			EN, A2ac	Bu, Dar	RFPN de los rios San Cipriano y Escalere-te

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<b>INFRAORDEN GEKKOTA</b>						
<b>FAMILIA GEKKONIDAE</b>						
<i>Hemidactylus brookii</i> (Gray, 1845)	NE			LC	An, Bu, Bul, Cal, Can, Gu, Ja, Ob, Pa, Yu	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya
<i>Hemidactylus frenatus</i> (Schlegel, 1836)	LC			LC	An	
<i>Lepidodactylus lugubris</i> (Duméril & Bibron, 1836)	NE			LC	Bu, Cal, Yu	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya
<b>FAMILIA PHYLLODACTYLIDAE</b>						
<i>Phyllodactylus transversalis</i> (Huey, 1935)	NE			CR, B2ab(iii)(†)	Bu	SFF Isla Malpelo
<i>Thecadactylus rapicauda</i> (Houttuyn, 1782)	NE			LC	Bu, Dar	RFPN de los rios San Cipriano y Escalere-re
<b>FAMILIA SPHAERODACTYLIDAE</b>						
<i>Gonatodes albogularis</i> (Duméril & Bibron, 1836)	NE			LC	Bu, Bug, Cal, Cu, Ja, Pa, To, Tu, Vi, Vj, Yo, Yu, Za	RN Laguna de Sonso
<i>Lepidoblepharis duolepis</i> (Ayala & Castro, 1983)	NE			NT	Cal, Tr, Yo	RFPN Bosque de Yotoco, RFPN de Cali
<i>Lepidoblepharis intermedius</i> (Boulenger, 1914)	NE			VU, B2ab(iii)	Bu	RFPN Anchicaya
<i>Lepidoblepharis microlepis</i> (Noble, 1923)	NE			VU, B2ab(iii)	Bu	
<i>Lepidoblepharis peraccae</i> (Boulenger, 1908)	NE			VU, B2ab(iii)	Bu	RFPN Anchicaya
<b>INFRAORDEN SCINCOMORPHA</b>						
<b>FAMILIA GYMNOPHTHALMIDAE</b>						
<i>Alopoglossus festae</i> (Peracca, 1904)	NE			EN, B2ab(iii)	Bu, Dar	RFPN de los rios San Cipriano y Escalere-re
<i>Alopoglossus lehmanni</i> (Ayala & Harris, 1984)	NE			EN, B2ab(iii)	Bu, Dar	
<i>Anadia vittata</i> (Boulenger, 1913)	NE			VU, B2ab(iii)	Bu	PNN Farallones de Cali, RFPN Anchicaya
<i>Cercosaura argulus</i> (Peters, 1863)	LC			NT	Cal, Da, Fl, Pa, Yo	PNN Farallones de Cali, PNN Las hermosas, RFPN Anchicaya, RFPN Bosque de Yotoco, RFPR Frayle-Desbaratado
<i>Cercosaura vertebralis</i> (O'Shaughnessy, 1879)	NE			LC	Cal, Cai, Cu, Da, To, Tr	PNN Farallones de Cali, RFPN Anchicaya, RFPN de Cali, RFPR Bitaco
<i>Echinosaura horrida</i> (Boulenger, 1890)	NE			NT	Bu	RFPN de los rios San Cipriano y Escalere-re, RFPN Anchicaya

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<i>Echinosaura orcesi</i> (Fritts, Almendáriz & Samec, 2002)	NE			VU, B2ab(iii)	Bu	RFPN Anchicaya
<i>Gymnophthalmus speciosus</i> (Hallowell, 1861)	NE			DD	Bug, Ja, Ro, Yu	
<i>Leposoma southi</i> (Ruthven & Gaige, 1924)	NE			NT	Bu	RFPN de los rios San Cipriano y Escalere, RFPN Anchicaya
<i>Ptychoglossus stenolepis</i> (Boulenger, 1908)	LC			NT	Cai, Da, Tr, Yo	RFPN Anchicaya
<i>Ptychoglossus vallenensis</i> (Harris, 1994)	NE			DD	Cal	RFPN de Cali
<i>Riama columbiana</i> (Andersson, 1914)	NE			VU, A2acd	Cal, Cai, Tu	PNN Farallones de Cali, RFPN de Tulua
<i>Riama laevis</i> (Boulenger, 1908)	NE			EN, A2acd	Cai, Cu	RFPN Bitaco
<i>Riama striata</i> (Peters, 1863)	NE			DD	Cal	PNN Farallones de Cali
<b>FAMILIA TEIIDAE</b>						
<i>Ameiva ameiva</i> (Linnaeus, 1758)	NE			VU, B2ab(iii)	Cal, Ja, Pa	
<i>Cnemidophorus lemniscatus</i> (Linnaeus, 1758)	NE			LC	Bug, Cal, Ja, Pa, Vij, Yo, Yu	RN Laguna de Sonso
<i>Holcosus anomalus</i> (Echternacht, 1977)	NE			NT	Bu, Da, Dar	RFPN de los rios San Cipriano y Escalere, RFPN Anchicaya
<b>FAMILIA SCINCIDAE</b>						
<i>Mabuya</i> sp. ( <i>sensu lato</i> )	NE			VU, B2ab(iii)	Bu, Cal	PNN Farallones de Cali, RFPN de Cali
<b>INFRAORDEN DIPLOGLOSSA</b>						
<b>FAMILIA ANGUIDAE</b>						
<i>Diploglossus millepunctatus</i> (O'Shaughnessy, 1874)	NE			CR, B1ab(iii)(†)	Bu	SFF Isla Malpelo
<i>Diploglossus monotropis</i> (Kuhl, 1820)	NE			VU, B2ab(iii)	Bu, Dar	RFPN Anchicaya
<b>SUBORDEN SERPENTES</b>						
<b>FAMILIA BOIDAE</b>						
<i>Boa constrictor</i> (Linnaeus, 1758)	NE			VU, A2acd	Bu	RFPN Anchicaya
<i>Corallus annulatus</i> (Cope, 1876)	NE			EN, B1ab(iii)	Bu	
<b>FAMILIA COLUBRIDAE</b>						
<i>Chironius carinatus</i> (Linnaeus, 1758)	NE			NT	Bu, Cal	PNN Farallones de Cali, RFPN de Cali
<i>Chironius grandisquamis</i> (Peters, 1868)	NE			NT	Bu	RFPN Anchicaya, PNR La Sierpe, RFPN de los rios Escalere y San Cipriano

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<i>Chironius monticola</i> (Roze, 1952)	NE			NT	Ar, Bo, Cal, Cai, Cu, Da, Do, Tr, Ve, Yo	RFPN del Bosque de Yotoco, PNN Farallones de Cali, RFPN de Cali
<i>Dendrophidion bivittatus</i> (Duméril, Bibron & Duméril, 1854)	NE			NT	Bu, Bug, Cal, Cu, Da, Yo	PNN Farallones de Cali, RFPN de Cali, RFPN del Bosque de Yotoco, RFPN Anchicaya
<i>Dendrophidion clarkii</i> (Dunn, 1933)	NE			EN, B2ab(iii)	Bu, Dar	PNN Farallones de Cali, RFPN de los rios Escalerete y San Cipriano
<i>Dendrophidion percarinatus</i> (Cope, 1893)	NE			EN, B1ab(iii)	Ar, Bu, Cai, Dar, Do, Ve	RFPN de los rios Escalerete y San Cipriano
<i>Dendrophidion prolixum</i> (Cadle, 2012)	NE			DD	Bu	RFPN Anchicaya
<i>Drymarchon melanurus</i> (Bibron & Duméril 1854)	NE			NT	An, Bu, Cal, Can, Ce, Yo	RFPN Anchicaya, RFPN del Bosque de Yotoco
<i>Drymobius rhombifer</i> (Günther, 1860)	NE			EN, B1ab(iii)	Bu	RFPN Anchicaya; RFPN de los rios Escalerete y San Cipriano
<i>Lampropeltis triangulum</i> (Lacépède, 1789)	NE			LC	Bu, Cal, Cai, Da, Ja, Pa, Tu, Vij, Yu	RFPN de los rios Escalerete y San Cipriano, RFPN Anchicaya, RFPN de Cali, PNN Farallones de Cali, RFPN Bitaco, RFPN Cerro Dapa - Carisucio
<i>Leptophis ahaetulla</i> (Linnaeus, 1758)	NE			NT	Bu, Bul, Cal, Pa, Yo	RFPN del Bosque de Yotoco
<i>Leptophis depressirostris</i> (Cope, 1861)	NE			NT	Bu	RFPN de los rios Escalerete y San Cipriano, RFPN Anchicaya
<i>Mastigodryas boddaerti</i> (Senzen, 1796)	NE			LC	Bu, Cal	RFPN Anchicaya, PNN Farallones de Cali, RFPN de los rios Escalerete y San Cipriano, DMI La Plata, PNN Uramba Bahía Malaga, PNR La sierpe, RFPN de Cali
<i>Mastigodryas danieli</i> (Amaral, 1935)	NE			NT	Cal, Cu, Pa	RFPN de Cali, PNN Farallones de Cali, PNN Las hermosas
<i>Mastigodryas pleei</i> (Duméril, Bibron & Duméril, 1854)	NE			NT	Bug, Cal, Cu, Da, Gu, Ja, Pa, Re, Ro, Se, Tu, Vi, Vij, Yo, Yu	PNN Farallones de Cali
<i>Mastigodryas pulchriiceps</i> (Cope, 1868)	NE			NT	Bu, Cal	RFPN Anchicaya, RFPN de Cali, RFPN de los rios Escalerete y San Cipriano

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<i>Oxybelis aeneus</i> (Wagler, 1824)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN Anchicaya, PNN Farallones de Cali, PNN Las hermosas, RFPN de los rios Escalerete y San Cipriano, DMI La Plata, PNN Uramba Bahia Malaga, PNR La sierpe, RN Laguna de sonso, RFPN de Cali, RFPN Dagua, DMI Enclave subxerofitico de Atuncela, PNR Paramo el Duende, PNN Tatama, RFPN Amaime, RFPR Bitaco, RFPN Cerro Dapa - Carisucio
<i>Oxybelis brevirostris</i> (Cope, 1861)	NE			LC	Bu, Da	DMI La Plata, RFPN Anchicaya, PNN Farallones de Cali
<i>Pliocercus euryzonus</i> Cope, 1862	LC			VU, B2ab(iii)	Bu, Da, Dar	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, PNN Farallones de Cali
<i>Pseustes poecilonotus</i> (Günther, 1858)	LC			VU, B2ab(iii)	Bu	RFPN Anchicaya, PNN Farallones de Cali
<i>Pseustes shropshirei</i> (Barbour & Amaral, 1924)	NE			VU, B2ab(iii)	Bu	RFPN Anchicaya, PNR La sierpe
<i>Rhinobothryum bovallii</i> (Anderson, 1916)	NE			EN, B1ab(iii)	Bu	RFPN Anchicaya, PNR La sierpe
<i>Spilotes pullatus</i> (Linnaeus, 1758)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, RFPN de Cali, RFPN del Bosque de Yotoco, RFPN Dagua, RFPN de Amaime, RFPN de sonso-guabas, RFPR Bitaco, RFPN Cerro Dapa - Carisucio, RN Laguna de sonso, PNR La sierpe, DMI La Plata, DMI Enclave subxerofitico de Atuncela, PNR Paramo el Duende, PNN Tatama, PNN Farallones de Cali, PNN las hermosas, PNN Uramba-Bahia Malaga
<i>Stenorrina degenhardtii</i> (Berthold, 1845)	NE			NT	Bu, Dar	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, DMI La Plata

TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Tantilla melanocephala</i> (Linnaeus, 1758) ( <i>sensu lato</i> )	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN del Bosque de Yotoco, RFPN de Cali, RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, RFPR Bitaco, RFPN Cerro Dapa - Carisucio, RFPN Dagua, RFPN de Amaime, DMI Enclave subxerofitico de Atuncela, RN Laguna de sonso, PNN Tatama, PNN Farallones de Cali
<b>FAMILIA DIPSADIDAE</b>						
<i>Atractus boulengerii</i> (Peracca, 1896)	NE			DD (†)	Bu	RFPN Anchicaya
<i>Atractus clarki</i> (Dunn & Bailey, 1939)	NE			DD	Re	
<i>Atractus lehmanni</i> (Boettger, 1898)	NE			DD	Cal, Cu, Da, Se	RFPN Anchicaya, RFPR Bitaco
<i>Atractus melas</i> (Boulenger, 1908)	NE			DD	Bu, Cal, Da	PNN Farallones de Cali, RFPN de Cali
<i>Atractus multicinctus</i> (Jan, 1865)	NE			VU, B2ab(iii)	Bu, Cal, Cu, Da	RFPN de Cali, RFPN Anchicaya
<i>Atractus obesus</i> (Marx, 1960)	NE			DD	Cal, Ce, Fl	PNN Farallones de Cali, PNN las hermosas, RFPR Frayle-Desbaratado
<i>Clelia clelia</i> (Daudin, 1803)	NE			LC	Bu, Cal, Ce, Cu, Da, Yo, Yu	RFPN Anchicaya, RFPN de Cali, RFPN del Bosque de Yotoco, PNN las hermosas
<i>Clelia equatoriana</i> (Amaral, 1924)	NE			EN, B2ab(iii)	Ans, Ar, Bo, Cai, Do, Un, Pr, To, Ve	PNN Las hermosas
<i>Diaphorolepis wagneri</i> (Jan, 1863)	NE			VU, B2ab(iii)	Bu, Cal, Cai, Cu, Da	PNN Farallones de Cali
<i>Dipsas sanctiioannis</i> (Boulenger, 1911)	DD			LC	Bu, Cal, Cu, Da, Yo	RFPN de los rios Escalerete y San Cipriano, PNN Farallones de Cali, RFPN de Cali, RFPN del Bosque de Yotoco
<i>Dipsas temporalis</i> (Werner, 1909)	NE			DD	Bu	RFPN Anchicaya
<i>Erythrolamprus bizonus</i> (Jan, 1863)	LC			LC	Bu, Bug, Cal, Car, Cu, Da, Dar, Fl, Ja, Pa, Un, Yu	RFPN Anchicaya, PNN Farallones de Cali, PNN las hermosas, RFPN de Cali, RFPR Bitaco, RFPN Cerro Dapa - Carisucio, RFPN Dagua
<i>Erythrolamprus epinephelus</i> (Cope, 1862)	NE			NT	Bo, Bu, Bug, Cal, Cai, Da, Tr	RFPN de Cali, RFPN Anchicaya, PNN Farallones de Cali

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<i>Erythrolamprus mimus</i> (Cope, 1868)	NE			VU, B2ab(iii)	Bu, Da	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, PNN Farallones de Cali
<i>Geophis betaniensis</i> (Restrepo & Wright, 1987)	NE			DD (†)	Bo, Da, Ri	
<i>Geophis nigroalbus</i> (Boulenger, 1908)	NE			DD	Bo,Cu, Tr	
<i>Imantodes cenchoa</i> (Linnaeus, 1758)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN de los rios Escalerete y San Cipriano, RFPN Anchicaya, PNN Farallones de Cali, DMI La Plata, PNN Uramba Bahia Malaga, PNR La sierpe, RN Laguna de sonso, RFPN de Cali, RFPN Dagua, DMI Enclave subxerofitico de Atuncela, PNR Paramo el Duende, RFPN de Amaime, PNN Tatama, RFPN del Bosque de Yotoco, RFPR Bitaco, RFPN Cerro Dapa - Carisucio
<i>Imantodes inornatus</i> (Boulenger, 1896)	NE			DD	Bu	
<i>Imantodes chocoensis</i> (Torres-Carvajal, Yáñez-Muñoz, Quirola, Smith & Almendáriz, 2012)	LC			DD	Bu	RFPN de los rios Escalerete y San Cipriano
<i>Leptodeira annulata</i> (Linnaeus, 1758)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN Anchicaya, PNN Farallones de Cali, RFPN de los rios Escalerete y San Cipriano, DMI La Plata, PNN Uramba Bahia Malaga, PNR La sierpe, RN Laguna de sonso, RFPN de Cali, RFPN Dagua, DMI Enclave subxerofitico de Atuncela, PNN Tatama, RFPN del Bosque de Yotoco, RFPR Bitaco; RFPN Cerro Dapa - Carisucio, RFPN de Amaime
<i>Leptodeira septentrionalis</i> (Kennicott, 1859)	NE			NT	Bu	
<i>Ninia atrata</i> (Hallowell, 1845)	NE			EN, B2ab(iii)	Bu	RFPN Anchicaya
<i>Nothopsis rugosus</i> (Cope, 1871)	NE			EN, B1ab(iii)	Bu	RFPN Anchicaya; RFPN de los rios Escalerete y San Cipriano

TAXON	IUCN	Red book of Colombia	Red Book of Valle del Cauca	Categorization for the departament	Municipality	Protected area
<i>Oxyrhopus petolarius</i> (Linnaeus, 1758)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN Anchicaya, PNN Farallones de Cali, RFPN de los rios Escalerete y San Cipriano, DMI La Plata, PNN Uramba Bahia Malaga, PNR La sierpe, RN Laguna de sonso, RFPN de Cali, RFPN Dagua, DMI Enclave subxerofitico de Atuncela, PNN Tatama, RFPN del Bosque de Yotoco, RFPR Bitaco, RFN Cerro Dapa - Carisucio
<i>Saphenophis boursieri</i> (Jan, 1867)	NE			VU, B2ab(iii)	Cai	
<i>Saphenophis sneiderni</i> Myers, 1973	NE			VU, B2ab(iii)	Cai	
<i>Saphenophis tristatus</i> (Rendahl & Vestergren, 1941)	NE			VU, B2ab(iii)	Cal, Pa	PNN Farallones de Cali, PNN Las hermosas
<i>Sibon nebulata</i> (Linnaeus, 1758)	NE			LC	Al, An, Ans, Ar, Bo, Bu, Bug, Bul, Ca, Cal, Can, Car, Da, Dar, Do, Cai, Ce, Ag, Fl, Gi, Gu, Ja, Cu, Vi, Un, Ob, Pa, Pr, Re, Ri, Ro, Sp, Se, To, Tr, Tu, Ul, Ve, Vij, Yo, Yu, Za	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, RFPN del Bosque de Yotoco, RFPN de Cali, RFPR Bitaco, RFPN Cerro Dapa - Carisucio, PNR La sierpe, RN Laguna de sonso, RFPN Dagua, DMI La Plata, DMI Enclave subxerofitico de Atuncela, PNN Tatama, PNN Farallones de Cali, PNN Uramba - BahiaMalaga
<i>Siphlophis compressus</i> (Daudin, 1803)	LC			NT	Bu, Dar	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano
<i>Synophis plectovertebralis</i> (Sheil & Grant, 2001)	NE			DD (†)	Da	RFPN Anchicaya
<i>Tretanorhinus taeniatatus</i> (Boulenger, 1903)	NE			DD	Bu	RFPN Anchicaya
<i>Urotheca decipiens</i> (Gunter 1893)	NE			NT	Cal, Cu, Da, Yo, Yu	PNN Farallones de Cali, RFPR Bitaco, RFPN Cerro Dapa - Carisucio, RFPN del Bosque de Yotoco
<i>Urotheca fulviceps</i> (Cope, 1886)	NE			DD	Da	RFPN Anchicaya
<i>Urotheca lateristriga</i> (Berthold, 1859)	NE			NT	Bo, Bu, Cal, Da, Cu	RFPN de Cali, RFPN Anchicaya, RFPR Bitaco
<i>Xenodon rabdocephalus</i> (Wied, 1824)	NE			VU, B2ab(iii)	Bu	DMI La Plata, RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano



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<b>FAMILIA ELAPIDAE</b>						
<i>Micrurus ancoralis</i> (Jan, 1872)	NE			NT	Bu	DMI La Plata, RFPN Anchicaya, RFPN de los rios Escalere y San Cipriano
<i>Micrurus clarki</i> (Schmidt, 1936)	NE			DD	Da	RFPN Anchicaya
<i>Micrurus dumerilii</i> (Jan, 1858)	NE			NT	Bu, Da	RFPN Anchicaya, RFPN de los rios Escalere y San Cipriano, RFPN de Cali; PNR La sierpe, PNN Farallones de Cali
<i>Micrurus mipartitus</i> (Duméril, Bibron & Duméril, 1854)	NE			LC	Bo, Bug, Bu, Cal, Cai, Cu, Da, Dar, Fl, Gu, Ja, Pa, Pr, Ri, Tu, Yo	RFPN del Bosque de Yotoco, RFPN Anchicaya, RFPN de los rios Escalere y San Cipriano, RFPN de Cali, RFPR Bitaco, PNR La sierpe, RN Laguna de sonso, PNN Farallones de Cali, PNN Las hermosas
<i>Micrurus multifasciatus</i> (Jan, 1858)	NE			DD	Dar	
<i>Micrurus multiscutatus</i> (Rendahl & Vestergren, 1940)	DD			DD	Bu, Dar	
<b>FAMILIA LEPTOTYPHLOPIDAE</b>						
<i>Trilepida joshuai</i> (Dunn, 1944)	LC			DD	Bo, Cal, Cai, Da	RFPN de Cali, PNN Farallones de Cali
<i>Trilepida macrolepis</i> (Peters, 1857)	NE			DD	Cal, Dar	RFPN de Cali
<b>FAMILIA TROPIDOPHIIDAE</b>						
<i>Trachyboa boulengeri</i> (Peracca, 1910)	NE			NT	Bu	RFPN de los rios Escalere y San Cipriano, DMI La Plata
<b>FAMILIA VIPERIDAE</b>						
<i>Bothriechis schlegelii</i> (Berthold, 1846)	NE			NT	Bu, Cal, Cai, Cu, Da, Dar, Fl, Pa, Se, Tr, Yo	RFPN Anchicaya, RFPN del Bosque de Yotoco, RFPR Bitaco, PNN Las hermosas
<i>Bothrocophias myersi</i> (Gutberlet & Campbell, 2001)	LC			VU, A2ac	Bu, Dar	RFPN Anchicaya, PNR La sierpe
<i>Bothrops asper</i> (Garman, 1884)	NE			LC	Bu, Cal, Da, Dar, Pa, Yo	RFPN Anchicaya, RFPN de los rios Escalere y San Cipriano, RFPN del Bosque de Yotoco, DMI Enclave subxerofítico de Atuncela, DMI La Plata, RFPN Dagua, RFPN de Cali, PNR La sierpe, PNN Farallones de Cali, PNN Uramba-Bahia Malaga

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<i>Bothrops punctatus</i> (Garcia, 1896)	NE			VU, A2ac	Bu	RFPN de los rios Escalerete y San Cipriano, PNR La sierpe
<i>Bothrops rhombeatus</i> (Garcia, 1896)	NE			VU, B2ab(iii)	Cal, Pa	RFPN de Cali
<i>Lachesis acrochorda</i> (Garcia 1896)	NE			VU, A2ac	Bu	RFPN Anchicaya
<i>Porthidium nasutum</i> (Bocourt, 1868)	LC			VU, A2ac	Bu	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano
<b>ORDEN TESTUDINATA</b>						
<b>SUBORDEN CRYPTODIRA</b>						
<b>FAMILIA CHELYDRIDAE</b>						
<i>Chelydra acutirostris</i> (Peters, 1862)	NE	DD		NT	An, Bu, Bug, Cal, Car, Pa, Yo, Za	RFPN de los rios Escalerete y San Cipriano, RN Laguna de sonso
<b>FAMILIA EMYDIDAE</b>						
<i>Trachemys scripta</i> (Thunberg in Schoepff, 1792)	NE			LC	Bug, Cal	RN Laguna de sonso
<b>FAMILIA GEOEMYDIDAE</b>						
<i>Rhinoclemmys annulata</i> (Gray, 1860)	NT	DD		VU, A2acd	Bu	RFPN de los rios Escalerete y San Cipriano, PNR La sierpe
<i>Rhinoclemmys melanosterna</i> (Gray, 1861)	NE	NT		VU, A2acd	Bu	RFPN Anchicaya, PNR La sierpe
<i>Rhinoclemmys nasuta</i> (Boulenger, 1902)	NT	DD		NT	Bu	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, PNR La sierpe
<b>FAMILIA KINOSTERNIDAE</b>						
<i>Cryptochelys dunni</i> (Schmidt, 1947)	VU	VU		VU, B2ab(iii)	Bu	PNR La sierpe
<i>Cryptochelys leucostomum</i> (Duméril, Bibron & Duméril, 1851)	NE			NT	Bu	RFPN Anchicaya, RFPN de los rios Escalerete y San Cipriano, PNR La sierpe

Considering that recently some taxonomic problems have been resolved, we provide to some species or groups of species, the taxonomic category of *Sensu lato* or cf., understanding that these species could eventually change and give new information for the department.

Table 2. Criteria

Criteria	Score				Percentage			
	0	1	2	3	4	Amphibians	Snakes	Lizards
<b>1 Illegal trade</b>	No illegal trade	Low trade	median trade	High trade	Unknown	10	5	5
<b>2 Distribution</b>	more than 20 localities	11–20 localities	6–10 localities	2–5 localities	Restricted to only the descriptions	25	20	25
<b>3 Ecorregions</b>	4 ecorregions	3 ecorregions	2 ecorregions	1 ecorregion	Restricted to only the descriptions	5	5	5
<b>4 Ecological life zones</b>	9 ecological life zones	8–6 ecological life zones	5–3 ecological life zones	2–1 ecological life zones	Restricted to only the descriptions	5	5	5
<b>6 Adaptability to perturbed habitats</b>	Extremely adaptable (found in urban areas)	Adaptable (found in suburban areas or habitats completely modified in pastures, grasslands)	Just adaptable (found in natural habitats with some degree of intervention)	Not adaptable (habitats are strictly with little or no degree of perturbed)	Unknown	10	15	15
<b>7 Rarity</b>	Introduced	Abundant	Common	Frequent	Rare	20	20	20
<b>8 Publications</b>	More than 10 publications	8–10 publications	4–7 publications	2–3 publications	0–1 publications	10	10	10
<b>9 Mortality in roads and hunting</b>	Never found dead	<10% of the species found dead	10–20%	>20%	Unknown	Not applicable	10	Not applicable
<b>10 Present in Protected Areas</b>	More than three protected areas	3 protected areas	1 protected area	2 protected areas	None	15	10	15



*Pristimantis achatinus*



*Pristimantis palmeri*



*Anolis maculiventris*



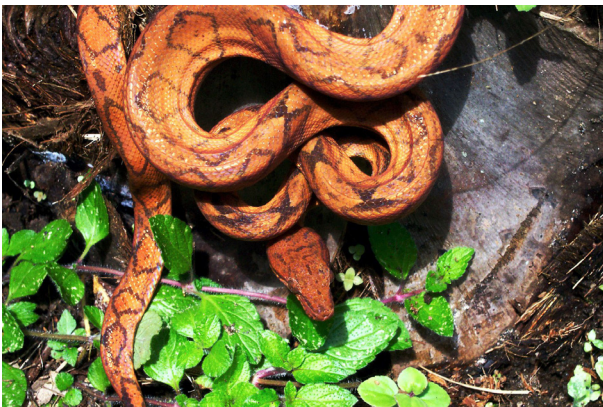
*Anolis chocorum*



*Bothrops asper*



*Clelia clelia*



*Corallus annulata*



*Dendrophidion bivittatus*



Comparative dorsal view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: male, female (holotype), male, all alive, from Sumatra Utara Province, Sumatra. Right: adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. Photos: N. Maury.



# On *Trimeresurus sumatranus* (Raffles, 1822), with the designation of a neotype and the description of a new species of pitviper from Sumatra (Squamata: Viperidae: Crotalinae)

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**Abstract.**—Variation in morphological characters were investigated among 126 specimens from at least 67 populations covering the whole range of the large pitviper currently known as *Trimeresurus sumatranus* (Raffles, 1822). The results showed that two distinct taxa are involved. Herein *Trimeresurus sumatranus* is redefined. In order to fix the status of this species, a neotype is selected and described. Its type locality is restricted to the vicinity of Bengkulu, Bengkulu Province, Sumatra. The second taxon represents a distinct, previously unnamed species, which is described. The new species differs from *Trimeresurus sumatranus* by a lower number of ventrals in males (162–179 against 178–185) and females (164–171 vs. 175–191); a distinctly longer tail in males (value of the ratio tail length/total length: 0.201–0.210 vs. 0.150–0.168), the color of the tail (see the description), the color of the eyes: green in the new species, vs. dark grey in *T. sumatranus*, the color of the ventrals, which are green with a pale posterior suture in the new species and pale with dark posterior suture in *T. sumatranus*. The new species lives in higher elevations than *T. sumatranus* and seems to be endemic to the higher mountain ranges of western Sumatra.

**Key words.** Sumatra, West Malaysia, Borneo, *Trimeresurus gunaleni* spec. nov., *Trimeresurus malcolmi*, *Trimeresurus sumatranus*

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## Introduction

The genus *Trimeresurus* Lacépède, 1804 is currently composed of 46 species, of which 12 were described since the year 2000 (David et al. 2011). This genus and most of its species have complex systematic and nomenclatural histories. For example, the generic nomen *Parias* Gray, 1849 was regarded as a valid subgenus only recently (David et al. 2011). This extensive series of confusions arose from the fact that many species of this genus are arboreal; green snakes that are superficially similar in color and scalation. This factor is exemplified by the case of *Trimeresurus sumatranus* (Raffles, 1822) and its relatives. *Trimeresurus sumatranus* (Raffles, 1822) was one of the first species of this genus of Asian pitvipers to have been described (as *Coluber sumatranus*), a point that is quite surprising as it is a rather uncommon species with a limited distribution in the Sunda Islands. Sir Thomas Stamford Raffles (1781–1826), best known as the founder of Singapore, made a long stay in Bencoolen, now Bengkulu, a city of south-western Sumatra, between March 1818 and August 1824, although this stay was in-

terrupted several times for trips to Nias and, especially Singapore. He held the position of Governor-General of Bencoolen from 1818 to 1822. An account on the activities of Sir T. Raffles in Sumatra can be found in Raffles (1835). Sir Raffles was definitely not a scholarly naturalist but had a strong interest in local plants and animals which he described himself (Raffles 1821, 1822).

*Trimeresurus sumatranus* has been extensively confused in the literature with *Trimeresurus hageni* (Van Lidth de Jeude, 1886), a related but distinct species that inhabits lower elevations in Sumatra, Borneo, and the Malay Peninsula. Both species share similar scalation, and juvenile specimens of both species are uniformly green in color. However, although the adults are very different in coloration, the similarities in scalation led Boulenger, the leading herpetologist of his time, to synonymize these two species (Boulenger 1896). A reason for this misinterpretation was the fact that at that time, the British Museum of Natural History, the place where Boulenger was working, had only a single specimen of the species *T. sumatranus* which unfortunately was a juvenile and thus shared the green color with *T. hageni*.

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Boulenger's appraisal was followed by subsequent workers, until the works of van Lidth de Jeude (1922) and especially Brongersma (1933). This latter author was the first to show that *T. sumatranus* and *T. hageni* were valid, distinct species, and he provided new characters separating both species from one another.

Furthermore, it is worth noting that Schlegel (1826) described the taxon *Cophias wagleri* (nec *Cophias wagleri* Boie, 1827) as a replacement name for *Coluber sumatranus* (Raffles, 1822). We refer to Savage et al. (2012) for a discussion on the early confusion between these species. Nevertheless, other authors such as Schlegel (1837), Gray (1842: 48; 1849: 10), Cantor (1847: 1042, Pl. 40: Fig. 9), Günther (1858: 266), Peters (1862: 671) and later as Ouwens (1916: Pl. 15: Fig. 22 and 22a) also confused in part or totally *Coluber sumatranus* with *Cophias wagleri* Boie, 1827, a totally different species now known as *Tropidolaemus wagleri*.

Loveridge (1938: 45) described *Trimeresurus sumatranus malcolmi* (Type locality: "Sungii River, near Bunduntuan, Mount Kinabalu, British Nord Borneo," a river in the vicinity of Bundu Tuhan, on the southern slopes of Mt. Kinabalu, state of Sabah, Borneo, Federation of Malaysia). This subspecies was regarded as valid by all subsequent authors for some populations of northern Borneo whereas other populations of this island were referred to the nominative subspecies (David and Ineich 1999; McDiarmid et al. 1999; Malkmus et al. 2002). Subsequently, *Trimeresurus sumatranus malcolmi* was raised to full species status by Stuebing and Inger (1998). As a consequence, *Trimeresurus sumatranus* was subsequently considered monotypic.

More recently, two revisions of the systematics of these two species were published by Sanders et al. (2002, 2004). Results of the first publication, which was based on scalation characters, pattern and coloration, can be summarized as follows: (1) *T. sumatranus* and *T. hageni* are clearly separate as shown by canonical multivariate analysis; (2) *T. sumatranus* inhabits South Thailand, Borneo, and central western Sumatra, whereas *T. hageni* is living in North and South Sumatra, Thailand, Malaysia, Singapore, Nias, and Siberut; (3) the authors showed clear differences between populations of *T. sumatranus* inhabiting the central part of western Sumatra and that one living on Borneo; and (4) morphological differences, especially in males, were pointed out between populations of the islands of Nias and Siberut on the one hand, and all other populations on the other hand. In these islands, specimens referable to *Trimeresurus hageni* show some characters of the pattern typical to *T. sumatranus*, such as black dorsal crossbars and the presence of dark edges on head scales. This partial similarity has led to erroneous records of *T. sumatranus* from these islands.

In contrast, Sanders et al. (2004) included molecular analyses and considered all species of the subgenus *Parias* Gray, 1849 as defined by Malhotra and Thorpe (2004) (as a genus). For the species treated here, the

results of Sanders et al. (2004) can be summarized as follows: (1) *T. hageni* has an expanded distribution compared with Sanders et al. (2002), i.e. populations of southern Thailand, West Malaysia, and the islands of Bangka, Siberut, Nias, and all islands of the Mentawai Archipelago are referred to this species; (2) little morphological variation was found between populations of *T. hageni*, in contrast to results presented by Sanders et al. (2002); (3) without justification, populations of South Thailand and West Malaysia were no longer referred to *T. sumatranus* but to *T. hageni*; as a consequence, the range of *T. sumatranus* was restricted to a narrow area covering mid elevations between 650 and 800 m—the central and southern parts of the Barisan Range, western Sumatra, and a wide range throughout Borneo mainly below 300 m; (4) populations of Sumatra and Borneo are separated by a genetic distance of 3.3%; (5) differences in ecology were pointed out between the Bornean and Sumatran populations; and (6) ecological adaptation has led to a convergence in the pattern between *T. hageni* and *T. sumatranus* in Sumatra. Sanders et al. (2004) considered that this convergence made useless some characters which used to be considered diagnostic; for example the separation of the fourth and fifth supralabial with the suboculars (see Brongersma 1933). Sanders et al. (2004) provided quite a different definition of *T. sumatranus* compared with Brongersma (1933). However, it must be emphasized that only two populations of *T. hageni* and two populations of *T. sumatranus*, both from Bengkulu Province for this latter species, were compared in molecular analyses.

In the frame of a revision of the subgenus *Parias* in the Sunda Islands, namely of populations referred in the literature to *T. sumatranus*, *T. hageni*, and *T. malcolmi*, we examined specimens referred to as *Trimeresurus sumatranus* originating from throughout the range of this taxon, including material not investigated previously. Our data suggest that the combination of several characters, both of pattern and scalation, allow a clear distinction between *T. sumatranus* and *T. hageni*. Definitions of these two species will be presented in a subsequent paper. In the first step of this revision, presented here, we put emphasis on the morphology of the various populations referred to as *T. sumatranus auctorum*. Our data also show that two distinct forms of *T. sumatranus auctorum* can be defined in Sumatra, both deserving to be recognized as full species.

## Material and Methods

The present paper is based on 126 preserved specimens examined by us from 67 localities covering the whole range of *T. sumatranus auctorum* and *T. hageni*, and several live specimens of both species. Preserved examined specimens of the two forms of *T. sumatranus* are listed under their respective account; specimens of *T. hageni* are listed in Appendix I.

**Selection of morphological characters**

We retained standard morphological characters used in the genus *Trimeresurus* by Brongersma (1933), Pope and Pope (1933), and Regenass and Kramer (1981), along with other morphometric characters adapted from Vogel et al. (2004). We made a pre-selection of characters with a limited number of specimens. Characters not suitable, due to variability or uniformity were deleted and a set of 30 characters was retained (Table 1).

Measurements, except body and tail lengths, were taken with a slide-calliper to the nearest 0.1 millimeter (mm); all measures on body were taken to the nearest mm. In order to minimize inter-observer error, all measurements considered here were made by Gernot Vogel (GV). Ventral scales were counted according to Dowling (1951). The first subcaudal was defined as the first scale posterior to the vent that touched the opposite scale. The terminal scute is excluded from the number of sub-

caudals. The numbers of dorsal scale rows are given at one head length behind the head, at midbody (i.e., at the level of the ventral plate corresponding to half of the total number of ventrals), and at one head length anterior to the vent respectively. Values for symmetric head characters are given in left/right order. The real coloration of body and eyes were observed only on living animals or freshly preserved specimens.

Morphometric, meristic, and coloration characters retained for this study are listed in Table 1. Altogether, 30 variables were considered, either standing on their own or derived from the raw characters listed above. Not all variables listed in this table proved to be useful to separate at least one taxon of the *Trimeresurus sumatranus* group from the others, but all were investigated and used in combinations of characters and/or were used in univariate analyses.

**Table 1.** List of morphological characters and variables used in this study and their abbreviations.

Number	Abbreviation	Character
<i>Morphometry</i>		
1	SVL	Snout-vent length
2	TaL	Tail length
3	TL	Total length
4	TaL/TL	Ratio tail length/Total length
<i>Scalation</i>		
5		Dorsal scale rows
6	Do	Dorsal scale rows at midbody
7		Dorsal scale rows at midbody
8	Ven	Ventral plates
9	Sc	Subcaudal plates
10	Cep	Cephalic scales (scales on a line between the middle of supraoculars)
11	InN	Internasal scale(s)
12	InN sep	Internasal scales touching each other
13		Keeling of the occipital scales
14		Supralabial scales
15		Number of scales between third supralabial and subocular
16		Number of scales between fourth supralabial and subocular
17		Number of scales between fifth supralabial and subocular
18	CtotSL	Total number of supralabials touching subocular
19	IL	Infralabials
<i>Pattern</i>		
20		Presence of black margins on dorsal scales of the head
21		Upper labials being lighter than other parts of the head
22		Ventrals with dark margins
23		Subcaudals with dark margins
24		Presence of bands on the body
25		Presence of dorsolateral light spots on the body
26		Coloration and presence of a ventrolateral stripe
27		Coloration and presence of a temporal streak
28		Color of eyes
29		Posterior part of the tail reddish
30		Pattern of the tail



The analyses of external morphological data were based on comparisons of statistical values (mean value and standard deviation). A test of Mann-Whitney (*U* test; see Siegel 1956) was applied as necessary. Calculations were run online on the website: <http://elegans.som.vcu.edu/~leon/stats/utest.html> (last accessed on 14 July 2014). Abbreviations are: *n*: number of specimens;  $\bar{x}$ : mean value; *s*: standard deviation; *P*: probability of occurrence of a value as extreme as or more extreme than the observed value; *U*: the statistic in the Mann-Whitney test.

The color of the eyes is shown here to be a taxonomic character. However, it is problematic as it cannot be observed in preserved specimens. According to our observations, the eye color in adult animals is stable for each species and sex (Vogel et al. 2004). In the species treated here, there was no sexual dimorphism in eye coloration. The color of the tail is diagnostic and we recognize two patterns: “uniform reddish-brown with dark margins,” or “mottled,” for specimens with a mixture of brown and green colors on the tail.

#### Museum abbreviations

BMNH: The Natural History Museum, London, UK; CAS: California Academy of Sciences, San Francisco, USA; FMNH: Field Museum of Natural History, Chicago, USA; IRSNB: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; MNHN: Muséum National d’Histoire Naturelle, Paris, France; NHMB: Naturhistorisches Museum, Basel, Switzerland; NHMW: Naturhistorisches Museum Wien, Austria; MZB: Museum Zoologicum Bogoriense, Bogor à Cibinong, Java, Indonesia; OMNH: Osaka Museum of Natural History, Osaka, Japan; PSGV: Gernot Vogel’s private collection, Heidelberg, Germany; RMNH: Nationaal Natuurhistorisch Museum (Naturalis), Leiden, Netherlands; SMF: Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt-am-Main, Germany; ZFMK: Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany; ZMB: Zoologisches Museum für Naturkunde der Humboldt-Universität zu Berlin, Berlin, Germany; ZMH: Zoologisches Institut und Museum, Universität Hamburg, Hamburg, Germany; ZRC: Zoological Reference Collection, National University of Singapore, Singapore; ZSM: Zoologische Staatssammlung, München, Germany.

#### Other abbreviations

*Measures and ratios*: ED: vertical diameter of the eye. HL: Head length, SVL: Snout-vent length, TaL: Tail length, TL: Total length, TaL/TL: Ratio tail length/total length.

*Meristic characters*: DSR: Formula of dorsal scale rows, IL: Infralabials, SC: Subcaudals, SL: supralabials, VEN: Ventrals.

## Results

In our sample of 53 specimens referred to *Trimeresurus sumatranus*, as currently defined, we noticed that nine specimens from western Sumatra differed in several morphological characters from other populations. *Trimeresurus sumatranus* (Raffles, 1822) was briefly described (as *Coluber sumatranus*) without any designation of a name-bearing type. Therefore, we first redefine this species and note intraspecific variation of the characters examined. We then designate a neotype for this species in agreement with Art. 75.3.1 to 75.3.7 of the *International Code of Zoological Nomenclature* (I.C.Z.N. 1999; merely designated below as the *Code*).

### *Trimeresurus sumatranus* (Raffles, 1822)

Fig. 1–7

#### *Coluber sumatranus* Raffles, 1822: 334.

*Type locality*. By virtue of neotype designation: “SW Sumatra” (original type locality: implicitly “Sumatra;” restricted to vicinity of Bengkulu city, Bengkulu Province, Sumatra *vide* Wallach et al. [2014: 527]; see also the discussion given below).

*Neotype*. ZFMK 76340, adult female; deposited by Andreas Gumprecht (holotype not traced according to McDiarmid et al. 1999: 345, considered to be lost).

*Trigonocephalus formosus* Müller and Schlegel, 1842 (in 1842–1845): Pl. 7 [dated 1842]; text [dated 1845]: 52 and 55.

*Type locality*. “*Aan de westkust van het eiland Sumatra, in de omstreken van het dorp Limomanis, eenige uren beoosten Padang...*,” i.e.: on the west coast of Sumatra Island, in the vicinity of Limomanis, a few hours east of Padang, now near Limau Manis, Province of Sumatera Barat, Sumatra, Indonesia.

*Holotype*. RMNH 1583, adult male; deposited by S. Müller, 1835.

*Status*. Junior subjective synonym of *Coluber sumatranus* Raffles, 1822. Synonymized by Lidth de Jude (1886: 51).

#### Material Examined (*n* = 44)

##### Indonesia

*Sumatra*. Bengkulu Province. MZB 1035, Gunung Gedang; MZB 2180, “Muara Aman, North Bengkulu;” MZB 3718, ZMB 66177–8; ZMB 76340, ZMB 70490, “Bengkulu;” ZMH R06936, Lebong-Tandai (3°01’S–101°5’E). Jambi Province. MZB 457, “Jambi.” Lampung Province. MZB 2166, Rimba; MZB 2219, “Propinsi Lampung.” Sumatera Barat Province. OMNH R2135–6,

Kambot, Ulu Gadut, Mt. Gadut, ca. 800 m; MZB 2443, MZB 2445, Anai River. No locality. ZFMK 76340 (neotype), South-western Sumatra.

**Borneo (Kalimantan).** Kalimantan Barat Province. MZB 1052, Sungai Mentawit Balik; ZSM 283/1977-1-2, Landak River; MZB 2138a-b, Tangung Lokang, Kapuas Hulu Regency. Kalimantan Tengah Province. MZB 2647, Maruwai. Kalimantan Timur Province. MZB 1340, Mapa Kelai River. Unidentified locality. MZB 2424, Sungai Auge.

## Federation of Malaysia

**Borneo (East Malaysia).** State of Sabah. FMNH 239949-52, FMNH 239957-8, Tenom District; FMNH 239959, Sipitang District. State of Sarawak. BMNH 91.8.29.33, Mt. Dulit, Miri District, Miri Division; BMNH 1978.1879, Gunung Mulu National Park, Miri District, Miri Division; FMNH 138687-8, FMNH 138690, FMNH 148829, Kapit District, Kapit Division; FMNH 158671, Bintulu, Bintulu Division.

**West Malaysia.** State of Johore. BMNH 1971.1532, Pantii Forest Reserve, South Johore. State of Pahang. ZRC 2.2929, Kuala Tahan; ZMB 69982, “Pahang.” State of Trengganu. BMNH 1974.5001-3, Gunong Lawit.

## Thailand

Yala Province. BMNH 1936.9.12.3, “Betong, Pattani.”

### *Taxonomic and nomenclatural comments*

There is no doubt about the distinct specific status of *T. sumatranus* and *T. hageni*. Our material shows that, in contrast to the conclusions of Sanders et al. (2004), *Trimeresurus sumatranus* is a rather wide-ranging species. We examined several specimens from West Malaysia and one from extreme southern Thailand, and they are morphologically identical with specimens originating from most populations of Sumatra and Borneo. There is no reason for assigning them to any other species of the subgenus *Parias*, and definitely not to *T. hageni*.

Furthermore, *T. sumatranus auctorum* is here shown to be composed of two species in Sumatra. Some populations of Sumatera Barat Province, in the northern part of the range of the species, are here referred to a new species that is described below. We examined the holotype of *T. formosus* Müller and Schlegel (1842: Fig. 2). We confirm that this specimen is definitely referred to *Trimeresurus sumatranus* and not to the new species described below that inhabits the same region. *Trimeresurus sumatranus*, as here redefined, is monotypic.

Raffles (1822) described this species on the basis of a single specimen. As he was posted in “Bencoolen,” and according to S. Raffles (1835: 102-104), his widow, T. Raffles was interested in local “wonders in natural

history.” Furthermore, T. Raffles announced in a letter dated on 14 March 1820 that he planned to ship home, (England) the whole of his zoological collection “in a few days.” This collection was shipped before 29 March. So, by all evidence, the holotype of *Coluber sumatranus* originated from Bengkulu or its vicinity. On the basis of these historical considerations, Wallach et al. (2014) restricted the type locality of *Coluber sumatranus* to this city on the south-western coast of Sumatra. Considering that the description of the new species was published in 1822, we may ascertain that the holotype was included in this shipment and originated from the vicinity of Bengkulu. However, the fate of the specimen is unknown and, by all evidence, it should be considered lost. As a consequence, we here designate a neotype for *Coluber sumatranus* (Raffles, 1822).

## Designation and Description of the Neotype of *Coluber sumatranus* Raffles, 1822

The designation is made on the following basis and in agreement with the following articles of the *Code*: (1) the neotype is designated in order to fix the status of *Coluber sumatranus* (Raffles, 1822) according to its current definition in the literature, especially in regards to populations described below as a new species and of other species of the subgenus *Parias* (Art. 75.3.1 of the *Code*); (2) diagnostic characters of *Coluber sumatranus* for which we designate this neotype, are given below (Art. 75.3.2); (3) the neotype is designated in details below (Art. 75.3.3); (4) a holotype has never been mentioned in the literature, for example by Boulenger (1896). It could not be traced in the collections of the Natural History Museum (London), in contrast to Cox et al.’s (2012) statement, or of the Zoological Reference Collection of the National University of Singapore. For these reasons, we consider the holotype to be lost (Art. 75.3.4); (5) we select a specimen, the morphology of which i.e., scalation, pattern, and coloration, that agrees with characters provided in the original description (Art. 75.3.5); (6) as shown above, the holotype most probably originated from Bengkulu Province. We select a neotype from an area of Sumatra that encompasses Bengkulu Province (Art. 75.3.6). For these reasons, and in agreement with Art. 75.3.7 of the *Code*, we here designate as the neotype of *Coluber sumatranus* as the following specimen:

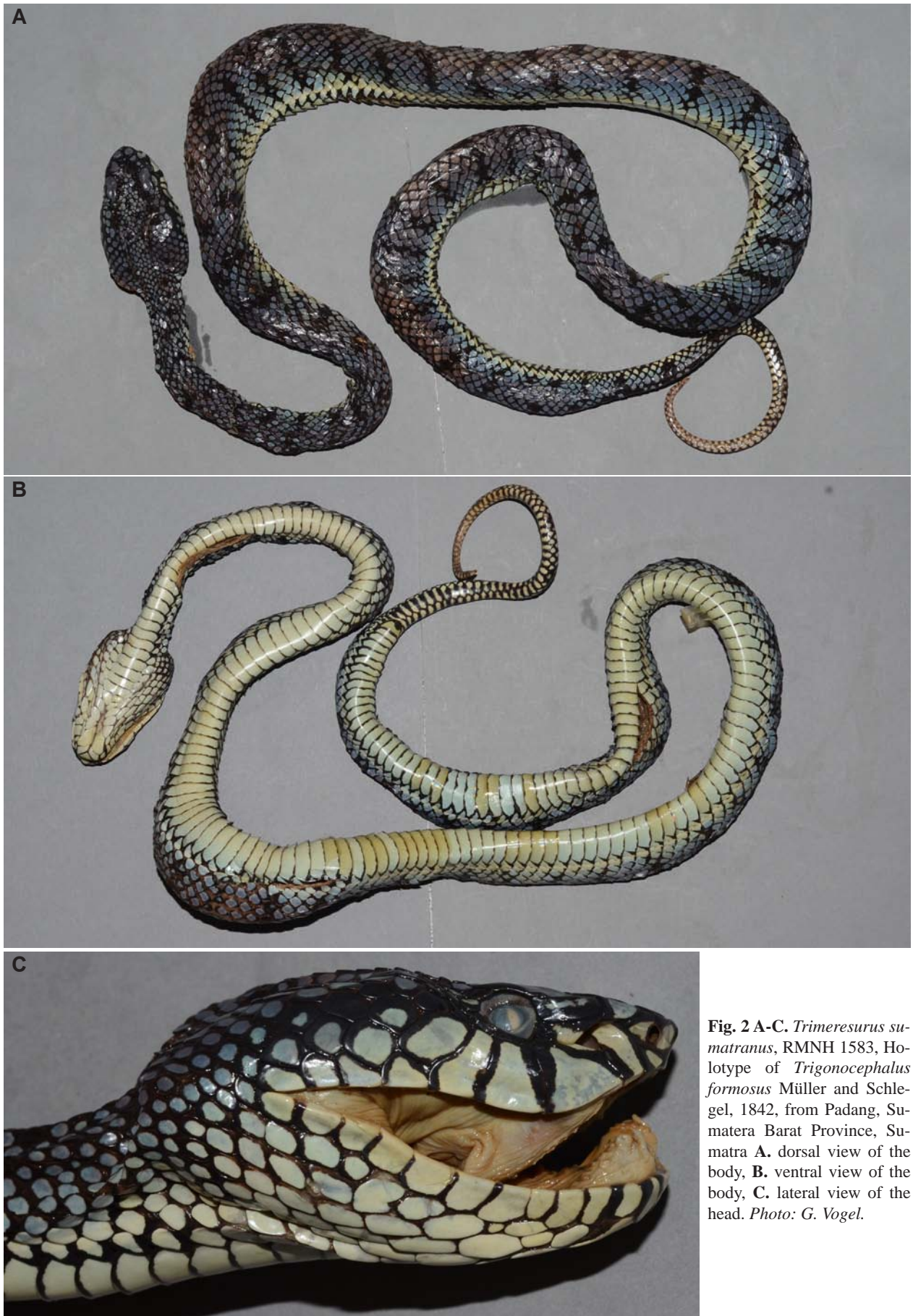
ZFMK 76340, an adult female, from “Southwestern Sumatra” (Fig. 1)

### *Morphology and measurements*

Body elongate, compressed; head elongate, relatively narrow seen from above, massive seen from the side, distinctly triangular, wide at its base, clearly distinct from the neck, flattened but thick, 1.8 times as long as wide; snout quite long, round when seen from above, strongly obliquely truncated when seen from the side, with a mod-



**Fig. 1 A-C.** *Trimeresurus sumatranus*, ZFMK 76340, neotype of *Coluber sumatranus* Raffles, 1822, southwest Sumatra, Bengkulu Province, Sumatra. **A.** dorsal view of the body, **B.** ventral view of the body, **C.** lateral view of the head. *Photo: G. Vogel.*



**Fig. 2 A-C.** *Trimeresurus sumatranus*, RMNH 1583, Holotype of *Trigonocephalus formosus* Müller and Schlegel, 1842, from Padang, Sumatera Barat Province, Sumatera **A.** dorsal view of the body, **B.** ventral view of the body, **C.** lateral view of the head. *Photo: G. Vogel.*



**Fig. 3A.** MZB.Ophi.5452 live holotype of *Trimeresurus gunaleni* spec. nov. from Mt. Sibayak, ca. 1,800 m a.s.l., west of Brastagi, Sumatera Utara Province, Sumatra, adult female. Photo: G. Vogel.



**Fig. 3B.** MZB.Ophi.5452 live holotype of *Trimeresurus gunaleni* spec. nov. from Mt. Sibayak, ca. 1,800 m a.s.l., west of Brastagi, Sumatera Utara Province, Sumatra, adult female. Photo: G. Vogel.



**Fig. 4A.** Live male of *Trimeresurus gunaleni* spec. nov. from Mt. Singkut, 1,600 m a.s.l., Sumatra Utara Province, Sumatra. Photo: G. Vogel.



**Fig. 4B.** Live male of *Trimeresurus gunaleni* spec. nov. from Mt. Singkut, 1,600 m a.s.l., Sumatra Utara Province, Sumatra. Photo: G. Vogel.

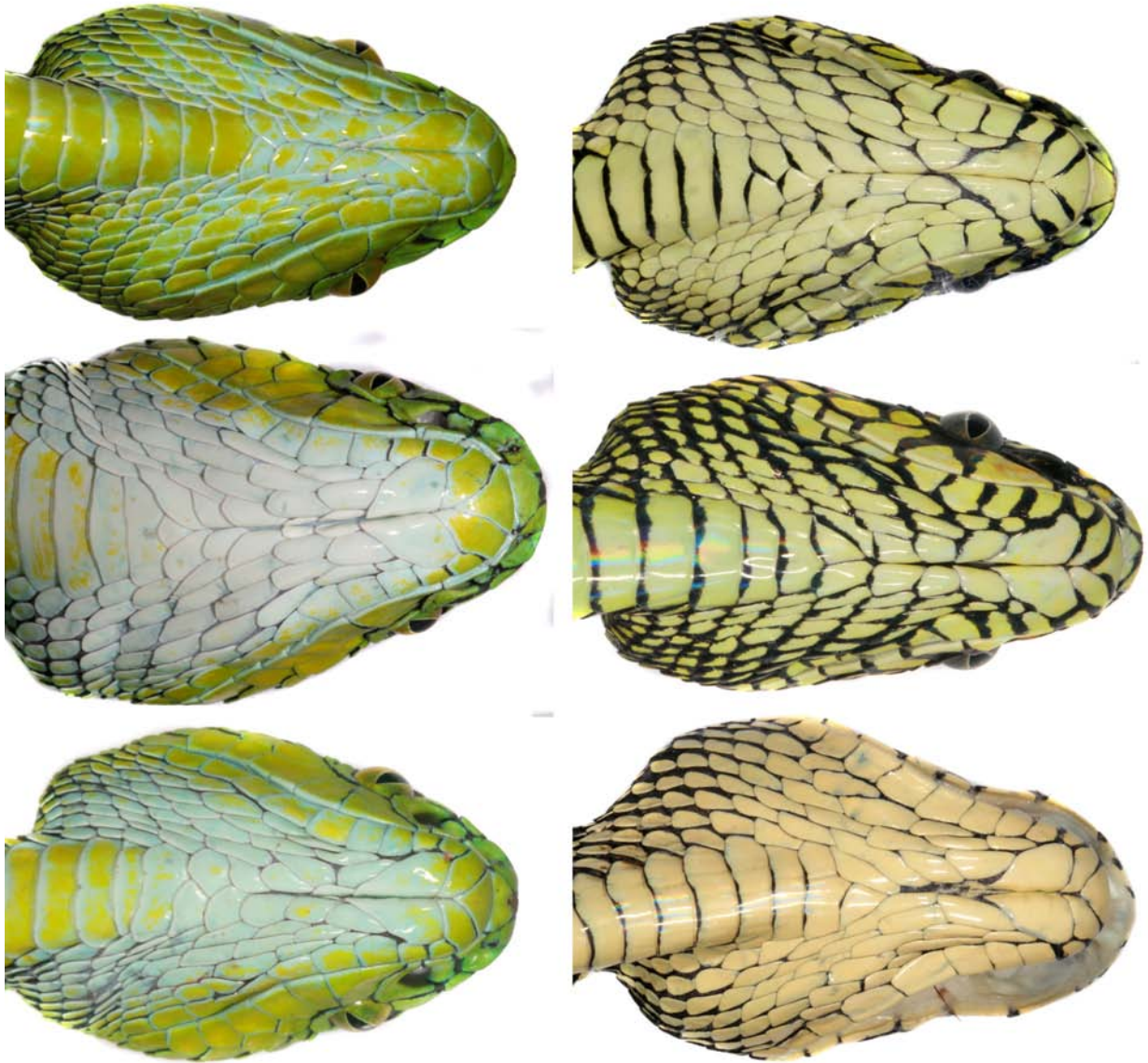


**Fig. 5.** Comparative dorsal view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*



**Fig. 6.** Comparative lateral view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. Photos: N. Maury.





**Fig. 7.** Comparative ventral view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*

erate *canthus rostralis*, totalling 28% of head length and 1.9 times as long as diameter of eye; a large, oval nostril piercing in the middle of nasal scale; nostril-loreal pit distance about 0.4 times the distance between the nostril and the eye; eye average, amounting for 0.6 times the distance between the lower margin of eye and upper lip border; tail, tapering and prehensile. SVL 895 mm, TaL 155 mm, TL 1,050 mm; ratio TaL / TL 0.148.

#### *Body scalation*

DSR: 21–21–15 scales, rhomboid, very weakly keeled with the exception of scales of first dorsal scale row which is smooth and not enlarged; 186 ventrals (+ two pre-ventrals); 61 subcaudals, all paired; anal entire.

#### *Head scalation*

Rostral barely visible from above, triangular, about as high as broad; nasals subrectangular, large, elongate, entirely divided by a furrow; two subrectangular, laterally elongate internasals, about 1.8 times wider than long, separated each from the other by one small scale; each internasal followed on each side by one very large scale on the snout, much larger than internasals, broader than long, separated each from the other by two longitudinal series of small scales; 2/2 canthal scales bordering the *canthus rostralis* between internasal and corresponding supraocular, i.e., the very large scale behind internasal followed by a small scale smaller than adjacent snout scales between the largest canthal scale and the supraoculars respectively; on each side, one elongate loreal scale between nasal and the upper preocular; 2/2 preoculars above the loreal pit, the upper one visible from above, both scales elongate and in contact with loreal; lower preocular forming the lower margin of loreal pit; 1/1 thin, elongated, crescent-like subocular; 2/2 small postoculars; 1/1 large supraocular, broad, 2.2 times as long as wide, about 1.3 times as wide as internasal, not indented by upper head scales; scales on upper snout surface much enlarged, smooth, juxtaposed, subrectangular, with four scales on a line between the scale separating the internasals and a line connecting the anterior margins of eyes; six cephalic scales on a line between supraoculars, smooth, flat, and juxtaposed; occipital scales flat, smooth; temporal scales in two or three rows, smooth, lower ones much enlarged; 9/9 SL, first SL triangular, rather short, completely separated from the nasal; second SL tall, bordering entirely the loreal pit and anteriorly in contact with nasal; third SL longest and highest, about 1.1 times longer than high, in contact on both sides with subocular; fourth SL barely shorter than third SL, in contact with the subocular; fifth SL barely shorter than fourth one, also in contact with the subocular; 10/11 infralabials, those of the first pair not longitudinally in contact, shortly separated by the apex of the mental scale, first–second IL in contact with anterior chin shields; four

rows of smooth gular scales; throat shields irregularly arranged.

#### *Coloration and pattern*

The body is olive-green on third–eleventh DSR, slightly paler on the bottom of the sides; most dorsal scales distinctly edged with black producing a reticulate pattern; 46 irregular black crossbars on each side of the body, either symmetrical, forming black rings or more or less set off from each other on each side across vertebral line; scales of the first DSR and lower half of those of the second DSR pale greenish-yellow with black edges, producing a pale, diffuse ventrolateral stripe extending from the area just behind the neck up to vent; scales of the first DSR with a broad, irregular black edge on their anterior lower part. The tail is olive-green on its anterior half, with scales strongly edged with black, producing a strongly reticulate pattern, and two or three more or less distinct black crossbars anteriorly, becoming progressively rusty red, strongly reticulate with black.

The head is olive-green above and on the temporal region, with cephalic, occipital, and temporal scales strongly edged with black; on each side, another long streak extends from internasals to the posterior part of the head along the inner edge of supraoculars; two oblique black streaks on the occiput forming an inverted V, its apex pointing forward; supraoculars olive green, broadly edged with black; some other cephalic and occipital scales entirely black, so as to produce black blotches and streaks between supraoculars; upper snout surface heavily marked with pure black, producing broad edges around olive-green prefrontals and internasals; scale behind and between internasals black; black vertical and horizontal streaks on the rostral; supralabials yellowish-green, distinctly paler than upper head surface, strongly edged with black, with a broader streak at the limit between third–fourth supralabials; preoculars olive-green strongly edged with black; a black postocular streak extending from the eye to the area above the corner of the mouth on lower postocular and the upper rows of temporals. Chin and throat pale greenish-yellow; an irregular dark grey spot on each infralabials of the first pair; all infralabials edged with black on their posterior margin; gular scales below the corner of the mouth also narrowly edged with black.

The venter is pale greenish-yellow; each ventral narrowly edged with black, especially on their central part, sometimes on the whole of their posterior margin; tips of ventrals narrowly edged with black on each side, producing an irregular, zigzag-like black ventral stripe below the pale ventrolateral stripe. The tail is yellowish-green or greyish-yellow below on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation, turning more or less abruptly to rusty red, strongly reticulated with black.

## Diagnosis

A large species of pitviper of the genus *Trimeresurus*, characterized by the combination of (1) body elongate, head long and massive in adults; (2) body deep green or dark green with conspicuous, black crossbars on the sides in adults, with a broad, pale ventrolateral stripe, and without sexual dimorphism in coloration; (3) 21 (exceptionally 23) DSR at midbody; (4) first supralabial distinct from nasal scale; (5) large internasals, most usually separated by one scale, only exceptionally in contact; (6) three supralabials, third, fourth, fifth SL in contact with subocular, or fifth exceptionally separated by one scale; (7) supraoculars broad, separated by 3–7 (usually 5–6) scales; (8) tail average, with a ratio TaL/TL between 0.150 and 0.168 in males and 0.128 and 0.160 in females; (9) 175–191 VEN; (10) 54–68 SC (males: 66–71; females: 54–68); (11) eye dark grey in life, rather bronze, brown, dark greyish-brown or golden-brown in preservative; (12) supralabials and cephalic scales strongly and broadly edged with black; (13) a black postocular streak; (14) venter is yellowish-green or pale green, with each ventral narrowly edged with black posteriorly; and (15) tail green as the body on its anterior half, becoming more or less abruptly salmon, pinkish-red, or rusty-red on its posterior half, strongly and broadly reticulate with black.

Characters separating *Trimeresurus sumatranus* from the new species and *T. malcolmi* are discussed below and summarized in Table 2.

## Description and Variation of *T. sumatranus* (Fig. 5–9)

According to Brongersma (1933), Sanders et al. (2002), Gumprecht et al. (2003), Das (2010), and our material, this large species reaches a maximum total length of 1,355 mm. Gumprecht et al. (2003) mentioned a total length of 1,400 mm. Males are seemingly shorter, the longest male seen by us being only 878 mm long. Adults reach usually a maximum total length of 90–110 cm.

The body is robust but elongate in both males and in females, or slightly thinner in males. In adults, the snout is 24.0–28.0% as long as head or 1.8–2.6 times as long as diameter of eye. Eye average, amounting for 0.6–1.0 times the distance eye–lower edge of the lip in both sexes. Ratio TaL/TL: 0.128–0.168, with a weak sexual dimorphism: males: 0.150–0.168; females: 0.128–0.160.

### Hemipenis

After Gumprecht et al. (2004: 304: Fig. IV), hemipenes are long and slender, deeply forked, extending up to twenty-second subcaudal, forked opposite ninth subcaudal, smooth at its base and after the forking point, for about a third of the organ, then strongly papillose and spinose, with longitudinal folds.

### Body scalation

DSR: 21–25 one head length posterior to the head; 21 (exceptionally 23) at midbody; 15 (exceptionally 13 or 17) scales one head length before vent, weakly or dis-

**Table 2.** Main characters to distinguish between the species of the *Trimeresurus sumatranus* complex, source specimens from Appendix I, if not noted different.

Characters	<i>Trimeresurus gunaleni</i> spec. nov.	<i>Trimeresurus sumatranus</i> Sumatra	<i>Trimeresurus sumatranus</i> Borneo	<i>Trimeresurus sumatranus</i> Peninsular Malaysia	<i>Trimeresurus malcolmi</i> <sup>1</sup>
N males/females	5/4	2/13	3/19	2/5	3/4
Middorsal scale rows	21	21	21	21	19
Ventrals males	162–179	179–182	182–185	178–183	169–173
Ventrals females	164–174	175–186	176–191	180–186	168–174
Subcaudals males	71–72	66–70	66–71	69–70	64–81
Subcaudals females	58–66	57–68	54–64	61–66	61–64
Total length	1170	1152	1350	1220	1330
Relative tail length males	0.201–0.210	0.160–0.166	0.154–0.168	0.150–0.161	0.160–0.179 <sup>4</sup>
Relative tail length females	0.144–0.180	0.130–0.159	0.128–0.150	0.134–0.160	0.158 <sup>5</sup>
White lateral line <sup>3</sup>	Thin	Broad	Broad <sup>2</sup>	Broad	Absent
Ventrals with dark margins	No	Yes	Yes	Yes	Yes
Subcaudals with dark margins	No	Yes	Yes	Yes	Yes
Tail reddish	No	Yes	Yes	Yes	Yes
Eye in life	Green	Dark grey	Dark grey	Dark grey	Dark grey

<sup>1</sup>From Stuebing and Inger (1998).

<sup>2</sup>In two specimens there is no real ventrolateral stripe visible, but the outer row of dorsals is pale.

<sup>3</sup>Sometimes there is a faint black line below the white lateral line.

<sup>4</sup>Holotype and one paratype only according to Loveridge (1938).

<sup>5</sup>One paratype only according to Loveridge (1938).

tinctly keeled, smooth on first DSR; VEN: 175–191 (plus 1–2 preventrals); SC: 54–68, all paired, with a sexual dimorphism (males: 66–71; females: 54–68); anal entire.

In our sample of 44 specimens, we have not examined any specimen with 23 DSR at midbody but this value has been recorded in the literature by Brongersma (1933) from a specimen from Borneo. In our material, two specimens had 13 scale rows before vent and only one had 17 rows before vent.

### Head scalation

Rostral barely visible from above, triangular, wider than high; nasals subrectangular, divided; one large, subrectangular or nearly square internasal on each side; internasals usually separated by one scale or in contact (in 11/44 examined specimens); two (rarely three) canthal scales bordering the *canthus rostralis*, one larger than the large adjacent snout scales and one (or two) of similar size; two (exceptionally one) postoculars on each side; one very large and wide supraocular on each side, about 1.8–2.2 times as long as wide, 1.0–1.3 times as wide as internasal, not indented by adjacent cephalic scales; 4–7 much enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth and juxtaposed; 3–7 (usually 5–6) cephalic scales on a line between supraoculars, large, smooth, flat, and juxtaposed; occipital scales larger than cephalic scales, smooth; temporal scales smooth, large, subequal, in two rows anteriorly, three rows posteriorly; 8–11 (usually 9–10) supralabials; first SL always separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, always in contact with nasal; third SL longest and highest, 1.1–1.4 times as long as high, always in contact with subocular; fourth SL as long as high, as high or barely shorter than third SL, always in contact with subocular; fifth SL usually in contact with subocular, exceptionally separated by one scale (on one side in 3/44 specimens); 9–15 (usually 10–12) IL; scales of the first pair longitudinally in contact or barely separated by the apex of the long mental scale; first two or three pairs of infralabials in contact with anterior chin shields; 5–9 rows of smooth gular scales; throat shields irregularly arranged.

### Coloration and pattern

In live adult specimens, the dorsum is yellowish-green, grass green, deep emerald green, or olive green (deep green, bluish-green, or dark brown in preservative); many scales of the body narrowly edged with black; usually a series of about 45–50 irregular, black crossbars one or two dorsal scales in length, reaching downwards to the third or second dorsal scale rows on each side of the body. These crossbands are either symmetrical, forming black rings, or offset from each other on each side of the vertebral line. Each crossbar includes one or two entirely black scales, the other dorsal scales are strongly edged in

black. The interstitial skin between the large dorsal scale is also black, making an overall distinctly barred and reticulate pattern. A more or less conspicuous, cream, greenish-yellow, or pale yellow ventrolateral stripe on the first and lower half to whole of the second dorsal scale rows, extends from the base of the neck to the vent. This pale stripe is bordered below by a narrow dark stripe created by the black edge of the outer tips of the ventral scales. The background color of the tail is as green as the body on its anterior half, with scales distinctly edged with black, producing a strongly reticulate pattern. There are 2–5 irregular black crossbars on each side of the tail which, becomes more or less abruptly greenish-orange, salmon, pinkish-red, or rusty-red on its posterior half.

The upper head surface and temporal regions are as green as the body, the sides of the head and temporals are slightly paler and usually more yellowish-green or paler green. The rostral is green with black vertical and horizontal streaks. Scales of the upper snout surface are also green, broadly edged with black, and may be entirely black with the exception of a large, round green blotch on each internasal and each scale behind the internasal. Supraoculars green, broadly edged with black; many scales of the cephalic and occipital regions black, producing a pattern of black blotches or streaks. On each side of the head, a long streak usually extends from internasals to the posterior part of the head along the inner edge of supraoculars; two oblique black streaks on the occiput forming an inverted V; its apex pointing forward. Supralabials greenish-yellow, pale green, yellowish-green, or bluish-green, paler than the upper head surface, strongly edged with black, black edges at the limits between third–fourth and fourth–fifth supralabials broader and more conspicuous; preoculars and postoculars green and black or entirely black; a black postocular streak extends from the eye to the corner of the mouth on the postoculars or lower postocular and the upper rows of temporals, more or less broadly blotched with the green background color. The chin and throat are white, cream, pale greenish-yellow, or yellowish-green, uniform or with scattered dark grey dots. The infralabials are white, pale bright yellowish-green, or pale green, with or without a few dark grey spots, edged with black on their posterior margin; gular scales below the corner of the mouth narrowly edged with black. In life, the eye is rather dark, bronze, brown, dark greyish-brown, or golden-brown.

The venter is yellowish-green, pale greenish-yellow, or pale green; each ventral is narrowly edged with black posteriorly, the edge usually broader on their central part tips of ventrals narrowly edged with dark grey or black, producing an irregular, zigzag-like dark ventral stripe below the pale ventrolateral stripe. The under surface of the tail is green or greenish-yellow on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation, becoming more or less abruptly greenish-orange, salmon or pinkish-red, strongly reticulated with black.



**Fig. 8.** Live female of *Trimeresurus sumatranus* from vicinity of Padang Panjang, Sumatera Barat Province, Sumatra. Photo: G. Vogel.

Juveniles show a rather different pattern. The dorsum is usually bright or grass-green, with only faint and narrow black spots or edges of dorsal scales producing faint, diffuse crossbars. The head is speckled with black dots but without dark lines and streaks on the edges of scales; no black edges on the suture of supralabials but with scattered black spots. The orange, salmon color or rusty red color of the tail is brighter than in adults.

### Distribution (Fig. 8)

#### Indonesia

**Sumatra.** Known from the provinces of Sumatera Barat, Jambi, Bengkulu, and Lampung, in Barisan Range.

**Borneo (Kalimantan).** Seemingly throughout the island.

#### Federation of Malaysia

**Borneo.** Known from the States of Sabah and Sarawak.

**West Malaysia.** Definitely recorded from the States of Perak (Sukumaran 2002 as *Tropidolaemus wagleri*, pers. comm.), Johore, Pahang, and Trengganu.

#### Thailand

Recorded only from Yala Province.

In contrast to Sanders et al. (2004), we confirm the occurrence of *T. sumatranus* in extreme southern Thailand and West Malaysia. Examined specimens present the combination of all scalation and pattern characters, both of the head and body, in full agreement with the definition of this species. They all differ from *Trimeresurus hageni* and we could not find any reason for not referring them to *T. sumatranus*. The range of *T. sumatranus* in Sumatra is wider than indicated in Sanders et al. (2004) but the records from the Indonesian islands of Bangka, Belitung, Nias, Simeulue, and the Mentawai Archipelago (see, for example, Brongersma 1933; Dring et al. 1990), are now referred to the *T. hageni* group.

### Natural History

This beautiful species inhabits regions typically covered with equatorial rainforests, lowland tropical wet forests, and tropical wet submontane forests, from sea level up to about 1,000 m. The species shows a predilection for lowlands in Borneo but, seemingly, only for hilly areas at elevations between 650 and about 900 m in Sumatra (Ryabov et al. 2002; Gumprecht et al. 2003; Sanders et al. 2004). This pitviper is found in tropical forests, along clearings, in bamboo thickets, mangroves, swamps, plantations, and cultivated fields such as coffee and tea estates. However, in Sumatra, all specimens recorded by Ryabov et al. (2002) and Gumprecht et al. (2003) in Bengkulu Province (Sumatra) were found in forest, none in cultivated areas or near villages.



**Fig. 9.** Live female of *Trimeresurus sumatranus* from Bengkulu Province, Sumatra. *Photo: G. Vogel.*



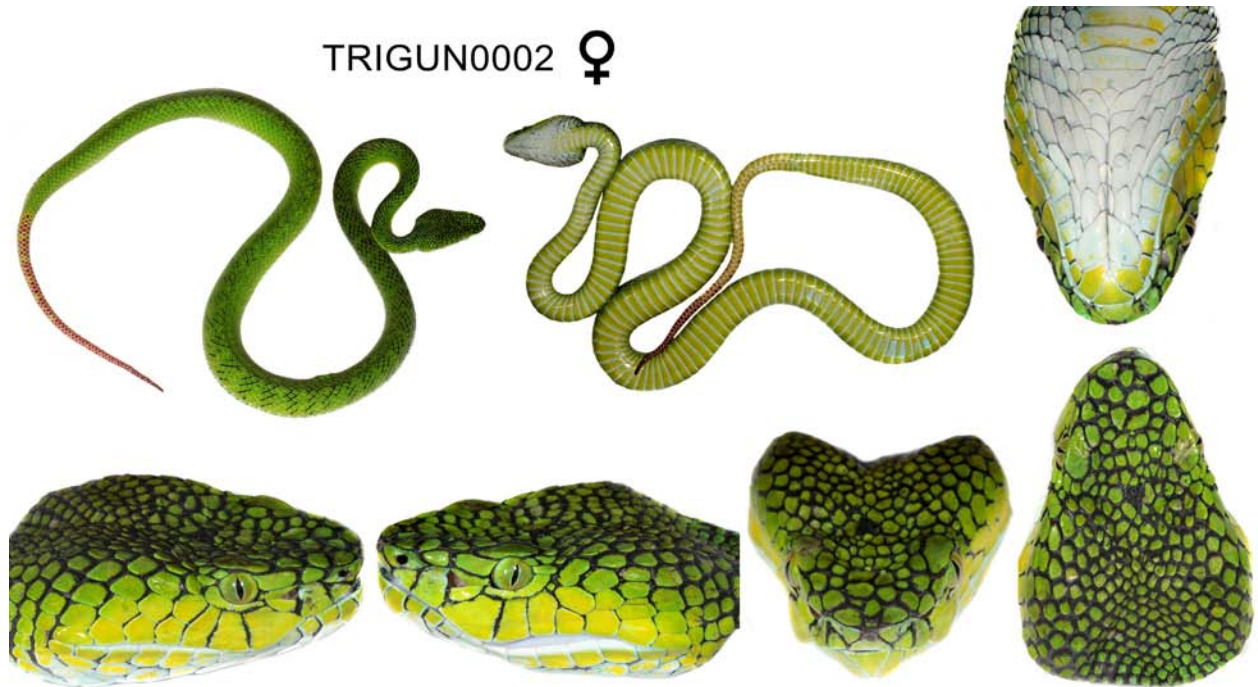
**Fig. 10.** Live female of *Trimeresurus malcolmi* from Mount Kinabalu, Sabah, Borneo. *Photo: M. Dehling.*



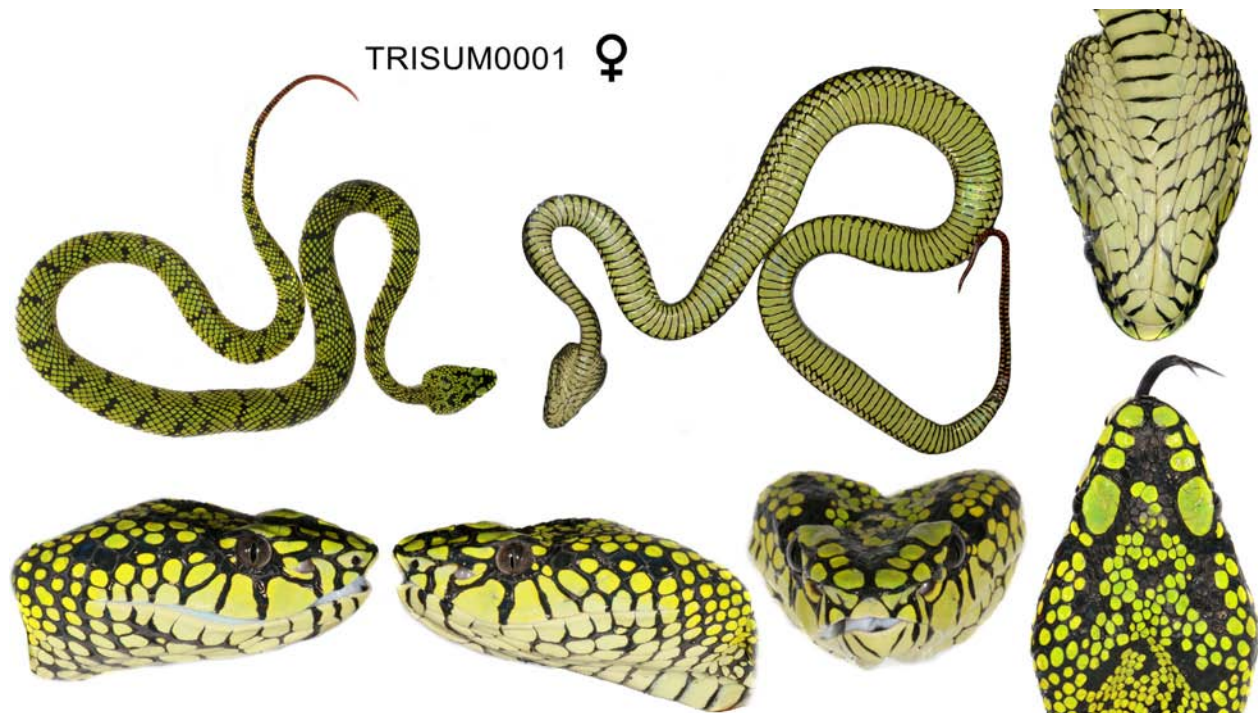
**Fig. 11.** Live female of *Trimeresurus malcolmi* from Mount Kinabalu, Sabah, Borneo. Photo: M. Dehling.



**Fig. 12.** Live male of *Trimeresurus toba* from vicinity of Padang Panjang, Sumatera Barat Province, Sumatra, a species sympatric with *T. gunaleni* spec. nov. Photo: G. Vogel.



**Fig. 13.** MZB.Ophi.5452 holotype of *Trimeresurus gunaleni* spec. nov., adult female. Photo: N. Maury.



**Fig. 14.** Live female of *Trimeresurus sumatranus* from Bengkulu Province, Sumatra. Photo: N. Maury.



*Trimeresurus sumatranus* often occurs along the banks of rivers, ponds, and other watered areas. This diurnal and nocturnal species is chiefly arboreal but lives in the lower vegetation such as in thick bushes, shrubs, and the tangled lower tree foliage up to 2.5 m above the ground, where it proves to be a skilled climber. Ryabov et al. (2002) found specimens basking in early morning. *Trimeresurus sumatranus* feeds on small mammals, frogs, lizards, and frogs. It is oviparous, but little is known on its breeding habits. Ryabov et al. (2002) mentioned a clutch of 17 eggs that were guarded by the female; we refer to Ryabov et al. (2002) and Gumprecht et al. (2003) for additional data on the biology of this species.

In our sample of specimens identified in collections as *Trimeresurus sumatranus*, we identified a total of six specimens that present noteworthy morphological differences with the species as defined above. We also noted the same differences in three specimens that were kept alive. As these differences with *T. sumatranus* are constant, we consider these specimens to be referable to a distinct species that we here describe as:

### ***Trimeresurus gunaleni* spec. nov.**

#### **Fig. 3–7, 13**

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*Trimeresurus sumatranus* (nec *Coluber sumatranus* Rafles, 1822): Sanders et al. (2002: 107, part.; 2004: 722, part.).

#### **Holotype**

MZB.Ophi.5452, adult female, from Mt. Sibayak, ca. 1,500–2,200 m a.s.l., west of Brastagi (Berastagi), Karo Regency (Kabupaten Karo), Sumatera Utara Province, Sumatra, Indonesia. Collected by the team of Danny Gunaleni, Hidekazu Miyake, Cho Sangyeon, and Moon Suk Cha.

#### **Paratypes (six specimens)**

NHMW 28159:1 (male), ZMB 29642 (male), NHMW 23909:4, NHMW 28159:2 (females), “Padang, Sumatra;” NHMB 2599 (male), “Solok, Sumatra;” SMF 52844 (female), “Padang Mountains, Sumatra, 1,700 m,” all from Sumatera Barat Province, Sumatra.

#### **Non-type material (two live male specimens)**

Mt. Singkut, 1,600 m a.s.l., Karo Regency, Sumatera Utara Province, Sumatra.

#### **Diagnosis**

A large species of pitviper of the genus *Trimeresurus*, characterized by the combination of (1) body elongate, head long and massive in adults; (2) an overall green

coloration with interstitial skin forming irregular, hollow, black dorsal crossbands, with a thin, pale ventrolateral line; (3) 21 DSR at midbody; (4) first supralabial totally separated from nasal scale; (5) large internasals, most usually separated by one scale, only exceptionally in contact; (6) three supralabials, third, fourth, fifth SL in contact with subocular; (7) supraoculars large but elongate, separated by 5–7 cephalic scales; (8) tail long, with a ratio TaL/TL between 0.201 and 0.210 in males and 0.144 and 0.180 in females; (9) 162–179 VEN; (10) 58–72 SC (males: 71–72; females: 58–66); (11) eye yellowish-green in life and preservative; (12) cephalic scales strongly and broadly edged with black but not forming streaks; (13) no black postocular streak; (14) venter greenish-yellow or pale green, uniform, with posterior margin of ventrals paler green; and (15) tail greyish-red, rusty brown or reddish-brown, mottled with green crossbars anteriorly.

Main characters separating *T. gunaleni* spec. nov. from other taxa of the complex of *T. sumatranus* are summarized in Table 2. *Trimeresurus gunaleni* spec. nov. mainly differs from *T. sumatranus* by (1) a lower number of ventrals in males (162–179,  $\bar{x}$  = 168.4 vs. 178–185,  $\bar{x}$  = 181.5;  $U = 33.5$ ,  $P < 0.005$ ) and females (164–171,  $\bar{x}$  = 169.5 vs. 175–191,  $\bar{x}$  = 183.3); (2) a higher value of the ratio TaL/TL in males (0.201–0.210,  $\bar{x}$  = 0.206 vs. 0.150–0.168,  $\bar{x}$  = 0.161); (3) the color of the tail with hues of red throughout mottled with green crossbars anteriorly vs. green as the body on its anterior half, becoming more or less abruptly red (see above description) posteriorly, strongly reticulate with black; (4) the color of the eyes: green or yellowish-green in *T. gunaleni* spec. nov. vs. dark brown, dark grey, or bronze in *T. sumatranus*; (5) the color of the ventral scales, which are green with a paler posterior margin in *T. gunaleni* spec. nov. vs. pale green with a dark grey or black posterior margin in *T. sumatranus*.

*Trimeresurus gunaleni* spec. nov. differs from *T. malcolmi* by (1) the number of dorsal scales around midbody (21 vs. 19); (2) a higher value of TaL/TL in males (0.201–0.210,  $\bar{x}$  = 0.206 vs. 0.160–0.179,  $\bar{x}$  = 0.162,  $s = 0.009$ ); (3) the presence of a white lateral stripe in *T. gunaleni* spec. nov., missing in *T. malcolmi*; (4) the color of the tail: greyish-red, rusty brown or reddish-brown, mottled with green crossbars anteriorly in *T. gunaleni* vs. greenish-orange, salmon or pinkish-red, strongly reticulated with black in *T. malcolmi*; below, the tail is yellowish green anteriorly, turning to brown posteriorly in *T. gunaleni* spec. nov. vs. green or greenish-yellow on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation; (5) the color of the eyes: yellowish-green in *T. gunaleni* spec. nov. vs. dark grey in *T. malcolmi*.

*Trimeresurus gunaleni* spec. nov. differs from *T. hageni* by (1) a lower number of ventrals in males (162–179,  $\bar{x}$  = 168.4 against 177–189,  $\bar{x}$  = 181.8;  $U = 139.5$ ,  $P < 0.001$ ) and females (164–171,  $\bar{x}$  = 169.5 vs. 176–196,  $\bar{x}$  =

186.7); (2) by the internasals being separate (in eight out of nine specimens) against being most usually in contact in *T. hageni* (in 66 out of 73 specimens;  $U = 545.5$ ,  $P < 0.001$ ); (3) by the number of supralabials, usually being nine (in 14 out of 18 cases, only exceptionally 8 or 10,  $\bar{x} = 9.11$ ) in *T. gunaleni* spec. nov. vs. usually 10 or 11 (in 123 of 148 occurrences, exceptionally 9, 12, or 13,  $\bar{x} = 10.54$ ;  $U = 637.0$ ,  $P < 0.001$ ) in *T. hageni*; (4) by the total number of supralabials (on both sides) touching the subocular, six (in one case in seven,  $\bar{x} = 6.1$ ) vs. usually being 2–4 (in 56 out of 74 cases, exceptionally 0, 1, 5, 6,  $\bar{x} = 2.9$ ;  $U = 632.0$ ,  $P < 0.001$ ) in *T. hageni*; (5) by the number of infralabials, usually 11 (in 11 out of 16 occurrences, only exceptionally 10 or 12,  $\bar{x} = 10.93$ ) vs. usually 12–14 (in 120 of 148 cases, exceptionally 11, 15, or 16,  $\bar{x} = 13.08$ ;  $U = 710.0$ ,  $P < 0.001$ ) in *T. hageni*; (6) the lack of a pale temporal streak in *T. gunaleni* spec. nov., usually present in *T. hageni*, especially in males (in 27 of 29 males of *T. hageni*); and (7) the missing of dorsolateral white dots in *T. gunaleni* spec. nov., are usually present in *T. hageni* especially in males (in 27 of 29 males of *T. hageni*).

### Etymology

The specific nomen is dedicated to Mr. Danny Gunalen, who was the first to find the species alive and who greatly supported the work resulting in the description of this new species. Suggested common names: English: Gunalen's Pitviper. Bahasa Indonesia: Ular Hijau Gunung. Karo: Nipe Ratah. Padang (Minang): Ular Ijo Babiso. French: Trimérésure de Gunalen. German: Gunalen's Grubenotter.

### Description of the holotype (Fig. 3, 5–7, 13)

Body elongate, compressed; head elongate, distinctly triangular, wide at its base, clearly distinct from the neck, flattened anteriorly, thick posteriorly, 1.6 times as long as wide; snout long, round when seen from above, strongly obliquely truncated when seen from the side, with a moderate *canthus rostralis*, totaling 32.0 % of head length, and 2.7 times as long as diameter of eye; a large oval nostril piercing in the middle of nasal scale; nostril-loreal pit distance about 0.5 times the distance between the nostril and the eye; eye average, totaling 0.65 times the distance between the lower margin of eye and upper lip border; tail rather long, tapering, and prehensile.

SVL 995 mm, TaL 195 mm, TL 1,170 mm; largest head width 35.0 mm; ratio TaL / TL 0.167.

### Body scalation

DSR: 21–21–13 scales, rhomboid, distinctly keeled with the exception of scales of first DSR which are smooth; 171 VEN (+ two preventrals); 60 SC, all paired; anal entire.

### Head scalation

Rostral barely visible from above, triangular, much broader than high; nasals pentagonal, partly divided by a shallow furrow; on each side, one large, subtriangular internasal, the rounded apex pointing outwards; internasals separated by one small scale; 2/2 canthal scales bordering the *canthus rostralis*, not larger than the large adjacent snout scales on each side, one elongate loreal scale between nasal and the upper preocular; 2/2 preoculars above the loreal pit, the upper one visible from above, both scales elongated and in contact with loreal; lower preocular forming the lower margin of loreal pit; 1/1 thin, elongated, crescent-like subocular; 2/2 small postoculars, followed by 2/3 small scales between postoculars and first temporals; 1/1 large, subtriangular, elongate supraocular on each side, 1.8 times as long as wide, 1.1 times as wide as internasal, not indented by adjacent cephalic scales; three much enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth and juxtaposed; seven cephalic scales on a line between supraoculars, smaller than upper snout scales, smooth, flat, and juxtaposed; occipital scales not larger than cephalic scales, smooth; temporal scales smooth, large, subequal, arranged in two rows anteriorly, three rows posteriorly; 9/9 supralabials, third–fifth SL in contact with subocular; first SL entirely separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, in contact with nasal; third SL longest and highest, 1.4/1.5 times longer than high; fourth SL tall and relatively narrow, 1.1/1.2 times higher than long, as high as third SL; fifth SL relatively narrow; 12/12 IL; scales of the first pair longitudinally in contact; first three pairs of infralabials in contact with anterior chin shields; six rows of smooth gular scales; throat shields irregularly arranged.

### Coloration and pattern

The body is uniformly deep green (bright emerald green in life), with some scales narrowly edged with black, more strongly on the fore part of the body; a faint, diffuse pattern of black, hollow crossbars resulting from irregular areas of interstitial skin around dorsal scales, more conspicuously visible on the fore part of the body, producing about 25 crossbars, three or four DSR long and separated by one or two scales around which the skin is grey, reaching downwards the first or second DSR; from about midbody, the black skin is progressively restricted to the eighth or ninth DSR, producing irregular dorsal bars, disappearing entirely before the vent; a narrow ventrolateral stripe, pale blue in life, white in preservative, extends from the neck to the vent on the upper edge of scales of the first DSR, and lower edge of scales of the second DSR; posterior edge of scales of the first DSR also pale blue. The tail is greyish-red throughout, with scales narrowly edged with pale grey and with five pale green incomplete rings anteriorly.

The head is deep green above (bright emerald green in life) and on the temporal region, with scales of the snout, preoculars, supraoculars, cephalic, occipital, and lower temporal scales narrowly edged with black and surrounded with black interstitial skin, producing a conspicuous pattern of a “mixed” black background with bright green spots; no cephalic or occipital streaks; supraoculars narrowly edged with black; top of rostral black; anterior supralabials greenish-yellow, distinctly paler than upper head surface, others supralabials bright yellow in life; first–third SL narrowly edged with black posteriorly; no postocular streak; upper temporals green as the upper head surface. Chin and throat pale bluish-grey (cream in preservative); mental and first three infralabials greenish-yellow; other infralabials more or less marbled with greenish-yellow; posterior gular scales dotted with green.

The venter is uniformly yellowish-green, with the posterior edge of each ventral pale bluish-grey, distinctly paler than the background color of the venter. The tail is greenish-yellow on the first two subcaudals then greyish-red throughout as the upper surface of tail, with scales narrowly edged with pale grey.

**Description of the paratypes**

A summary of morphological and meristic data of the paratypes is given in Table 3. None of the paratype significantly differs from the description given for the holotype.

**Description and variation**

The maximal confirmed total length known is 1,170 mm (SVL 995 mm, TaL 195 mm; holotype). The second largest female has a length of 1,154 mm (SVL 972 mm, TaL 182 mm; NHMW 28159:2, from Padang). The largest known male is 927 mm long (SVL 732 mm, TaL 195 mm; NHMW 28159:1, from Padang). In our sample of nine specimens, there is a noteworthy difference of size between males and females (see below, sexual dimorphism).

The body is robust but elongate in both males and in females. In adults, the snout is 28.0–32.8 % as long as head or 2.3–2.8 times as long as diameter of eye. Eye average, amounting for 0.7–0.9 times the distance eye–lower edge of the lip in both sexes. Ratio TaL/TL: 0.144–0.210, with a sexual dimorphism (see below).

**Hemipenis**

Unknown.

**Body scalation**

DSR: 21–22 one head length posterior to the head, 21 at midbody, 13–15 scales one head length before vent, distinctly keeled, smooth on first DSR; VEN: 162–179 (plus preventrals), without sexual dimorphism; SC: 58–72, all paired, with a sexual dimorphism (see below); anal entire.

In our sample of nine specimens, only one specimen has 22 DSR on the neck, all others have 21 rows. Furthermore, all males have 13 rows before the vent but two females have 15 rows.

**Head scalation**

As described for the holotype, with the following variation for major characters: internasals separated by one small scale in 8/9 specimens, in contact only in specimen ZMB 29642; only two canthal scales on each side in all specimens, not larger than adjacent snout scales or slightly smaller, bordering the *canthus rostralis* between the internasal and corresponding supraocular; two small postoculars, in contact with first temporals or followed by 2–3 small scales between postoculars and first temporals; one large, elongate, subtriangular supraocular on each side, 1.6–2.1 times as long as wide, 1.0–1.3 times as wide as internasal, not indented by adjacent cephalic scales; 3–4 enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth, and juxtaposed; 5–7 cephalic scales (5: 1/9 specimens; 6: 5/9; 7: 3/9) on a line between supraoculars, smaller than upper snout scales, smooth, flat, and juxtaposed; occipital scales not enlarged and smooth; temporal scales smooth, large, subequal, in two or three rows; 8–10 supralabials (8: 2/18 occurrences; 9: 12/18; 10: 4/18); third, fourth, fifth SL in contact with subocular in all specimens; first SL always separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, always in contact with nasal; third SL longest and highest, 1.2–1.5 times as long as high; fourth SL higher than long; fifth SL tall and narrow; 10–12 IL (10 or 11 in most specimens); scales of the first pair longitudinally in contact; first three

**Table 3.** Morphological characters of the paratypes of *Trimeresurus gunaleni* spec. nov. M: male, F: female, for other abbreviations see Table 1.

Collection number	Sex	SVL (mm)	TaL (mm)	TaL/ TL	VEN	SC	SL	SL touching sublabial	Cep	IL	Do
NHMW 28159:1	M	732	195	0.210	162	71	9/9	6	6	11/10	21
NHMB 2599	M	651	inc.	inc.	175	inc.	9/9	6	6	11/11	21
ZMB 29642	M	638	165	0.205	179	inc.	9/9	6	6	11/11	21
NHMW 23909:4	F	309	52	0.144	174	58	10/10	7	6	11/11	21
NHMW 28159:2	F	972	182	0.158	169	58	9/10	6	6	11/11	21
SMF 52844	F	400	88	0.180	164	66	9/9	6	7	?*/ ?*	21

inc.: Tail incomplete or partly destroyed.

\*Destroyed.

pairs of infralabials in contact with anterior chin shields; 5–8 rows of smooth gular scales; throat shields irregularly arranged.

#### *Coloration and pattern*

The body is bluish-green or deep green (bright green or emerald green in life) with most of the dorsal scales narrowly edged with black, usually more strongly on the anterior part of the body; a faint, diffuse pattern of dark, hollow crossbars created by irregular areas of black interstitial skin surrounding three or four rows of dorsal scales, most conspicuous and extensive on the fore part of the body, separated by one or two scales around which the skin is grey; these dark crossbands reach downwards the first or second DSR on the anterior part of the body, progressively restricted to the upper DSR posteriorly, producing irregular dorsal bars and disappearing entirely before the vent; a narrow ventrolateral, stripe, white, cream, or pale yellow in preservative (cream or pale blue in life), extends from the neck to the vent on the upper half of scales of the first DSR and sometimes on lower edge of scales of the second DSR; posterior edge of scales of the first DSR also white or cream (cream or pale

blue in life). The tail is greyish-red or rusty-red throughout, with scales narrowly edged with cream to pale grey, and mottled with incomplete cream, pale grey or pale greenish-grey rings (pale greyish-green in life), present on the anterior half of the tail or throughout.

The head is deep green above and on the temporal region; scales of the snout, preoculars, supraoculars, cephalic, occipital and lower temporal scales narrowly edged with black and entirely surrounded with interstitial black skin, producing a conspicuous pattern made of a black background “mixed” with bright green spots; no cephalic, occipital, or postocular streaks; supraoculars narrowly edged with black; top of rostral usually black; anterior supralabials green or yellowish-green, distinctly paler than upper head surface, others supralabials yellow, greenish-yellow or green; first–third SL usually narrowly edged with black on their posterior edge; upper temporals green as the upper head surface. Chin and throat cream (pale bluish-grey in life); mental and first three infralabials greenish-yellow or pale yellowish-green; other infralabials more or less marbled with greenish-yellow; posterior gular scales sometimes dotted with greyish-green or green spots.



**Fig. 15.** Habitat of *Trimeresurus gunaleni* spec. nov. Photo: D. Gunalen.

The venter is uniformly bluish-green or yellowish-green in preservative (yellow, greenish-yellow, or green in life), with the posterior edge of each ventral pale bluish-grey or greyish-green, distinctly paler than the background color of the venter. The tail is greenish-yellow or green anteriorly on a distance varying from the first subcaudals to the middle of the tail then greyish-red or rusty-red throughout as the upper surface of tail, with scales narrowly edged with pale grey and with cream, pale grey or pale greenish-grey blotches (pale greyish-green in life) corresponding to the rings of the upper surface.

### Sexual dimorphism

Males and females differ in the relative length of the tail, in total length, and in the number of subcaudals:

- (1) Strong difference in the ratio TaL/TL:  
males: 0.201–0.210 ( $\bar{x}$ =0.206); females: 0.144–0.180 ( $\bar{x}$ =0.162).
- (2) Total length:  
Largest male: 927 mm vs. largest female 1,170 mm.
- (3) Differences in the number of subcaudals:  
71–72 ( $\bar{x}$ =71.5) in two males vs. 58–66 ( $\bar{x}$ =60.5) in four females.

There is no difference in the numbers of ventral scales or in other scalation characters, nor in pattern or in eye color.

### Distribution

#### Indonesia

**Sumatra.** Endemic; *Trimeresurus gunaleni* spec. nov. is known only from two provinces: Sumatera Barat (Solok and Padang Mountains) and Sumatera Utara (Mt. Sibayak, Mt. Sinabung and Mt. Singkut near Berastagi).

This species can be expected in higher elevations all over the mountainous areas of Sumatra.

### Natural History

*Trimeresurus gunaleni* spec. nov. inhabits regions typically covered with tropical moist montane forests, from 1,500 m to as high as at least 2,000 m, perhaps as much as 2,200 m, where it has been observed by local insect collectors (Figs. 15 and 16). There is no record of populations lower than 1,500 m. On Mount Sibayak, Danny Gunalen collected specimens of *Trimeresurus hageni* at elevation of 500 m, and *Tropidolaemus wagleri* at 200 m. *Trimeresurus gunaleni* is clearly isolated as a high montane dweller.

The female holotype of *T. gunaleni* spec. nov. was collected during the daytime in dense humid montane forest scattered with tiny springs. The snake was resting on the ground under tree roots. In another instance, a male was seen perched at night on a tree branch at about two m above the ground. None of the specimens were found

near open water, the biotopes are dense humid montane forests.

Based on regurgitated prey items and direct observations in the wild, the diet includes rodents, amphibians, and lizards (*Gonocephalus lacunosus* Manthey and Denzer, 1991; E. Manik, pers. comm.). In captivity, *T. gunaleni* spec. nov. feeds on mice, birds, and lizards (D. Gunalen, pers. comm). Reproductive habits are still unknown.

### Discussion

The differences in pholidosis and coloration, together with the fact that *T. gunaleni* spec. nov. and *T. sumatranus* are living in close proximity, leaves no doubt that *T. gunaleni* spec. nov. deserves full species status. Although *T. sumatranus* and *T. gunaleni* spec. nov. have been recorded from the same mountain ranges in Sumatera Barat Province, it is not yet known whether these two species are living in sympatry or syntopy. However *T. sumatranus* seems to live at lower elevations than *T. gunaleni* spec. nov. Too little is known about the exact ranges of both species in western Sumatra to ascertain if there is a zone of true sympatry.

The recognition of *T. gunaleni* brings the number of species in the subgenus *Parias* on Sumatra to three. Sumatra is inhabited by *T. sumatranus*, *T. hageni*, and *T. gunaleni* spec. nov., whereas Borneo is the home of *T. sumatranus* and *T. malcolmi*. This latter species is obvi-



**Fig. 16.** Habitat of *Trimeresurus gunaleni* spec. nov. Photo: D. Gunalen.

ously the highland equivalent of *T. gunaleni* spec. nov. In the Malay Peninsula, only *T. sumatranus* is known, although this species is rarely collected there. The relationship between the Malayan population and the other two populations of *T. sumatranus* are not known. In former reviews of this complex (Sanders et al. 2004), the existence of *T. sumatranus* in Peninsular Malaysia was denied, despite the fact that there are five specimens available in the collections of the Natural History Museum of London. Re-examination of these specimens and new specimens leave no doubt about the occurrence of *T. sumatranus* in West Malaysia and extreme southern Thailand. So far no highland population corresponding to *T. gunaleni* spec. nov. or *T. malcolmi* have been found in Peninsular Malaysia.

A rather similar scheme of relationships between zoogeographical entities of the Sunda Shelf can also be defined in other pitvipers. In the subgenus *Popeia* of the genus *Trimeresurus*, i.e., the complex of *Trimeresurus popeiorum* Smith, 1937 (see Vogel et al. 2004), the species *T. barati* Regenass and Kramer, 1981 is known from western and south-western Sumatra whereas *T. toba* David, Petri, Vogel and Doria, 2009, inhabits mountains of central northern Sumatra. In Peninsular Malaysia, *T. fucatus* Vogel, David, and Pauwels, 2004 is widespread but *T. nebularis* Vogel, David, and Pauwels, 2004 is currently considered endemic to the Cameron Highlands. However, only *T. sabahi* Regenass and Kramer, 1981 is known in Borneo. As in the subgenus *Parias*, there is no species of the subgenus *Popeia* known from Java. The situation is slightly different for the subgenus *Craspedocephalus*, i.e., the complex of *Trimeresurus puniceus* (see David et al. 2006). Here we do have *T. puniceus* (Boie, 1827) widely distributed in Java and in southern Sumatra, but also a distinct species, *T. andalasensis* David, Vogel, Vijayakumar, and Vogel, 2006 in northern Sumatra. Another species, *T. wiroti* Trutnau, 1981 is known from Peninsular Malaysia and southern Thailand, whereas *T. borneensis* Peters, 1872 is widespread in Borneo.

*Trimeresurus hageni* and *T. purpureomaculatus* are both distributed on Sumatra and Peninsular Malaysia (David and Vogel 1996) but not in Borneo. The systematics of both species is not resolved and there might be more taxa hidden under these names. The distribution of *T. purpureomaculatus* is restricted to mangrove areas. Lastly, *Trimeresurus albolabris* lives in the south of Sumatra (David and Vogel 2000) and on Java (Creer et al. 2003) but is unknown from West Malaysia and Borneo.

These species or complexes of pitvipers show the close zoogeographic relationships of the islands of Borneo and Sumatra with Peninsular Malaysia. Furthermore, it can also be seen that Sumatra is split into a northern and a southern region, with the larger northern region closely connected to Western Malaysia and Borneo, and the smaller southern region connected with Java. The limit between these two regions seems to be located between Padang and Bengkulu. Previously, these species

complexes were regarded as widely distributed species, obscuring the zoogeographical relations of these regions. We are not confident that the taxonomy of the genus *Trimeresurus* is fully resolved and previously mentioned taxa might still prove to be endemic for one of the regions.

The finding of such a large and venomous pitviper as *T. gunaleni* spec. nov. in a group that was supposed to be well known is quite surprising. It is hard to understand that it was overlooked for such a long time despite the fact that the three specimens in the collection of Vienna have been available for a long time (collected 1899) and were already examined by other groups of herpetologists. The mountainous areas of Sumatra are still very incompletely known and further research in these areas is highly desirable.

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## Appendix I. Additional specimens examined

***Trimeresurus hageni* (n=73). INDONESIA. Sumatra.** BMNH 89.12.26.20, District of Deli; BMNH 93.6.5.11, East coast of Sumatra; MNHN 1880.0042, Sumatra; MZB 446, Pulau Batu, west Sumatra; MZB 1740, Padang Bukit Sebelah; MZB 1892a, b, Ketambe Aceh Tenggara; MZB 1898, Aceh Barat; MZB 2886, a, b Kembang Manis, Bengkulu; MZB 3716, Kubu Peraka Primer; NHMB 5108, Pelambang, South Sumatra; NHMB 9423, Sumatra; NHMW 23909:1–2, Medan; NHMW 23909:3, Deli; NHMW 28150:1–3; Padang; NHMW 28150:4, Pagay; NHMW 28155:3, Medan; RMNH 5587A, Deli; RMNH RENA 819 (lectotype), Deli; ZFMK 32508, Sumatra; ZMB 15884, Sukuranda, Oberer Langkat, O-Sumatra; ZMB 29642, Padang; ZMB 32193a, b, Sumatra; ZMB 62699, Aceh; ZMB 66176, Bengkulu province; ZMH R06937, Serdang; ZSM 109/1927, Goenoeng Rintels, S. Deli; ZSM 202–1979a, Lau Rakit, near Deli; ZSM 202–1979b, Gunoeng Rinteh. **Banka.** RMNH 4697, Banka; ZSM 365/1907 (4), ZSM 365/1908 (1–3) Simpang, Banka. **SINGAPORE.** BMNH 80.9.10.6, Singapore. **MALAYSIA. West Malaysia.** BMNH 1936.9.12.5, “Kualla Taku, Malay Penin;” BMNH 1936.9.91, Perak; BMNH 1967.2290–1, Gunung Benom; CAS 16831, Silensing, Pahang; MNHN 1899.0269, Peninsular Malaysia; MNHN 1974.0044, Kuala Lumpur; NHMW 28158:1–2, Kedah; PSGV 393, Kuala Lumpur; S 0117 “West Malaysia;” SMF 64464–5, Perak; ZFMK 16680, Yombak; ZFMK 68522, north of Kuala Lumpur; ZMB 70235, frim, Selangor; ZRC 2.2928, Tasik Bera, Pahang; ZRC 2.2930, Tembeling, Pahang; ZRC 2.2932, Bukit Lagong Forest, Selangor; ZRC 2.2933–4, Ulu Langat, Selangor; ZRC 2.2935, Cameron Highlands, Pahang; ZRC 2.2943, Negeri Sembilan, Gunung Angsi; ZRC 2.5362, Bellum, Perak; ZRC 2.5397, Kepong, Frim, Selangor. **THAILAND.** BM 1936.9.12.4, Betong, Yala; BM 1988.858–62, Trang; IRSNB 3059 Betong. no locality; ZFMK 18835, no locality; ZFMK 21497, Sunda Islands.





**Gernot Vogel** was born in Heidelberg, Germany and received a Ph.D. in Chemistry. Dr. Vogel is now working as a chemist at an international company, doing research and registration of plant protection products in Hirschberg, close to Heidelberg. Beginning as a reptile keeper, Dr. Vogel developed a great interest in the snake fauna of the Oriental region. He has concentrated his work on southwestern China, Indonesia, and tropical India. Dr. Vogel has revised large snake genera with a wide distribution, and this has been achieved through international collaborations with, for example, the institutes of Chengdu and Kunming in China, with Lipi and KPH Salvator in Indonesia, and with various Indian groups including ARRS and ANET. His research is based on specimen collections all over the world and on field research in the regions cited above. Dr. Vogel has authored or co-authored the following books: *The Snakes of Sumatra*; *The Snakes of Sulawesi*; *Amphibians and Reptiles of Mount Kinabalu*; and parts I to III in the Terralog Series on the venomous snakes of the world.



**Patrick David** (born in 1959 near Paris, France), received a Ph.D. in polymers chemistry at the University of Paris-Orsay. Dr. David developed an early interest in herpetology as a reptile keeper and then turned to the systematics of Asian reptiles. He is, or has been a member of several international herpetological societies. Dr. David has been involved for nearly 25 years, mostly with Gernot Vogel, in systematic research on several groups of Asian reptiles, especially the *Trimeresurus*-complex and the genera *Oligodon*, *Amphiesma*, *Xenochrophis*, and *Cyrtodactylus*. His geographic areas of interest include India, Thailand, China, Vietnam, and especially Laos and Sumatra (Indonesia). Dr. David has also addressed problems of nomenclature affecting various taxa of snakes and lizards. As of July 2014, Dr. David is the author or co-author of 121 publications, including five monographs or books. He has co-authored the description of a total of 31 new species of amphibians and reptiles. Along with Gernot Vogel, Dr. David is preparing a monograph on Asian pitvipers and the snake fauna of Sumatra.



**Irvan Sidik** was born in Bandung, West Java Province, Indonesia. Irvan obtained a Masters of Science degree in the field of phylogenetics at the Institute Technology of Bandung. Since 1992 Irvan has worked as a staff researcher in the laboratory of herpetology at the Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI) in the Cibinong Science Center. Beginning as an auxiliary field survey researcher, and then as a local CITES officer, Irvan became interested and developed a great interest in the snakes of the region of Sundaland. Irvan has continued with more scholarly work on the mountainous areas of the western part of Indonesia. Irvan's research is based on museum collections of specimens and field research in Indonesia's regions mentioned above. Irvan has been involved in several international research collaborations, and is currently working with the University of Texas at Arlington, USA on research of amphibians and reptiles in the mountains of Java and Sumatra. Irvan has published on the herpetofauna of Kalimantan and his first book was about snakes that are traded in Indonesia (CITES appendices I, II, and III) written in Indonesian. Currently, Irvan is studying the phylogeography of the reed snake genera *Calamaria* for his Ph.D. at the University of Brawijaya, Malang.

In accordance with the *International Code of Zoological Nomenclature* new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in *ZooBank* (Polaszek 2005a, b), the official online registration system for the ICZN. The *ZooBank* publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/". The LSID for this publication is: urn:lsid:zoobank.org:pub:27336534-BAFC-40BE-84F7-43E0334596CD.

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## Short Communication

# Field surveys in Western Panama indicate populations of *Atelopus varius* frogs are persisting in regions where *Batrachochytrium dendrobatidis* is now enzootic

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The stunning Harlequin frogs of the genus *Atelopus*, once common, are now among the most imperiled of all amphibian species (La Marca et al. 2005; Zippel et al. 2006). Of 88 described *Atelopus* species in Central and South America, 65 (74%) are Critically Endangered (La Marca et al. 2005). The most pressing threat to these frogs is chytridiomycosis, a fungal disease caused by *Batrachochytrium dendrobatidis* (hereafter “*Bd*”) and associated with die-offs of amphibians around the world (Berger et al. 1998; Longcore et al. 1999; Kilpatrick et al. 2010). In Western Panama, an epidemic wave spreading from west to east caused mass mortality events, resulting in catastrophic losses in amphibian diversity (Lips et al. 2006; Brem and Lips 2008; Woodhams et al. 2008; Kilburn et al. 2010), including declines in three *Atelopus* species: *A. varius*, *A. zeteki*, and *A. chiriquiensis*.

Relatively few studies have been conducted on the amphibian communities of Western Panama following chytridiomycosis outbreaks. Those few investigations that have focused on understanding community composition where *Bd* is now enzootic report differential survival among host species (e.g., Brem and Lips 2008), with some species putatively driven to local extinction (Gagliardo et al. 2008). In particular, *Atelopus* species were considered to be highly vulnerable to disease-induced extinction for multiple reasons. First, *A. varius* was used as an “indicator species” to monitor declines

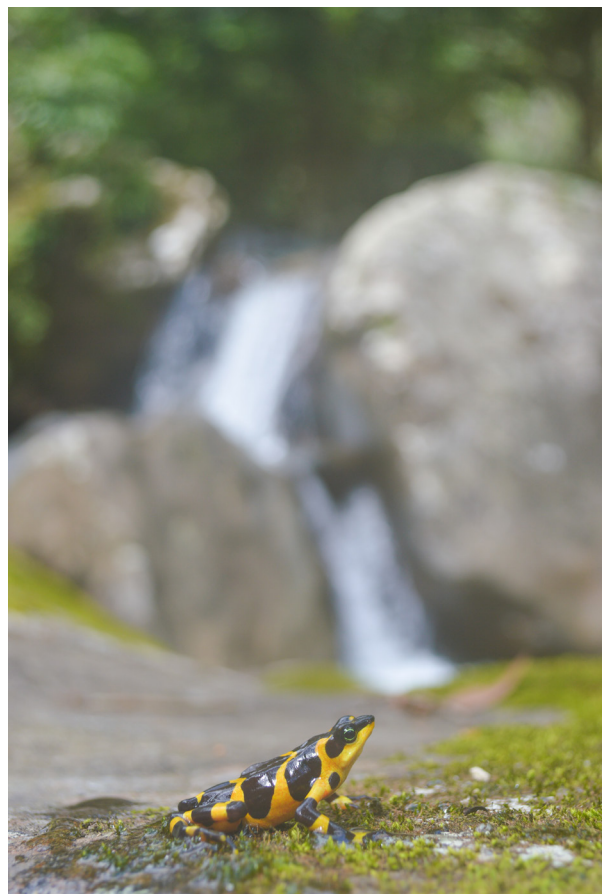
and thus helped to document *Bd* invasion and characterize *Bd*-related amphibian losses (Brem and Lips 2008). Second, *A. zeteki* has been repeatedly tested in controlled laboratory infection experiments and found to be highly susceptible to lethal chytridiomycosis (Bustamente et al. 2010; DiRenzo et al. 2014; Ellison et al. 2014). Third, recent immunogenetics research suggests that *A. zeteki* adaptive immune responses are suppressed by *Bd* (Ellison et al. 2014). Thus, *Atelopus* species have become important focal species in the study of chytridiomycosis dynamics and have also provided motivation for progressive conservation action (Gagliardo et al. 2008).

In October 2012, we revisited study sites that were surveyed for *Atelopus* from 2001 to 2004 (Richards and Knowles 2007) and we established new study sites in hopes of discovering extant populations of Critically Endangered *Atelopus* species. Using a measuring tape, a 200 m transect was developed and marked with flagging tape every 10 m. For our surveys, 2–3 observers walked these transects slowly, searching for amphibians according to established visual encounter survey protocols (e.g., Lips 1999). We captured all post-metamorphic amphibians we encountered using a fresh pair of gloves or inverted plastic bag to minimize transmission or infection and followed strict field hygiene protocols (Phillot et al. 2010). We noted the time and location of capture, identified the species, sex and age class, and measured

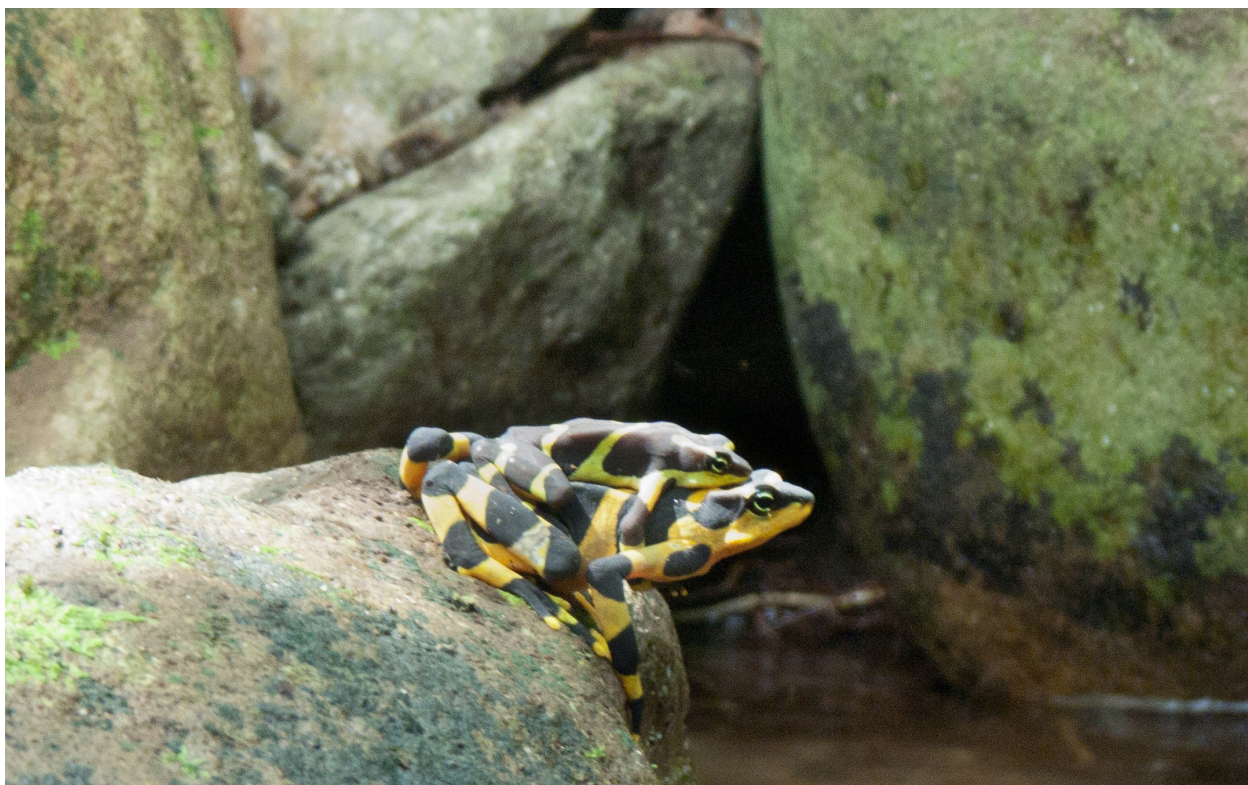
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snout-to-vent length and body mass. We also collected skin swab samples for all amphibians using standardized swabbing techniques (Hyatt et al. 2007). We preserved the skin swab samples (by freezing at  $-20\text{ }^{\circ}\text{C}$ ) to test for *Bd* infection using quantitative polymerase chain reaction (qPCR; Boyle et al. 2005; Hyatt et al. 2007). For the qPCR assay, we analyzed all samples in triplicate with an internal positive control (Hyatt et al. 2007) and used a dilution set of plasmid standards (obtained from Pisces Molecular, Boulder, Colorado) to quantify pathogen load. We converted plasmid copy numbers to zoospore copy numbers using the line of best fit ( $r^2 > 0.999$ ) from a linear regression of  $\log(\text{plasmids})$  vs.  $\log(\text{zoospores})$  ( $t_4 = 210.6$ ,  $P < 0.0001$ ) that we obtained by running the plasmid standard set alongside a series of standards containing known quantities of zoospores (obtained from Alex Hyatt, Australian Animal Health Laboratory). If one of three replicate wells turned up positive, we checked Cycle Threshold (Ct) value to determine whether non-amplification in two of three wells could have been caused by a low-level infection (near the detection threshold) and verified that the qPCR was not inhibited (IPC amplified normally). In cases of inhibition or Ct values far from the detection threshold, we re-ran and considered them positive if *Bd* was detected in any of the three re-run wells.

We surveyed 16 field sites from 2012 to 2013, 10 of which were sites where *Atelopus* species were found in 2004 (Richards and Knowles 2007), prior to the chytridiomycosis epidemic. The remaining six sites were chosen based on other biologists' sightings of *Atelopus*



**Figure 1.** A female Harlequin frog, *Atelopus varius*. This species, classified as Critically Endangered by IUCN, has been found in small numbers in the mountains of Western Panama.



**Figure 2.** A pair of *Atelopus varius* in amplexus, found in the mountains of Western Panama.

## *Atelopus varius* populations persisting after chytridiomycosis

**Table 1.** Summary of infection prevalence of *Batrachochytrium dendrobatidis* from amphibians found at three sites where *Atelopus varius* still persist.

Site (Elevation)	Species	Prevalence	N	Lower 95%	Upper 95%
Highland 1 (735 m)	<i>Atelopus varius</i>	0%	0/1	0	0.975
	<i>Colostethus flotator</i>	0%	0/1	0	0.975
	<i>Craugastor bransfordii</i>	0%	0/1	0	0.975
	<i>Craugastor crassidigitus</i>	0%	0/1	0	0.975
	<i>Craugastor fitzingeri</i>	0%	0/1	0	0.975
	<i>Lithobates warszewitschii</i>	60%	3/5	0.147	0.947
	<i>Pristimantis cerasinus</i>	100%	1/1	0.025	1
	<i>Pristimantis cruentus</i>	0%	0/2	0	0.842
	<i>Pristimantis museosus</i>	0%	0/1	0	0.975
	<i>Pristimantis ridens</i>	0%	0/1	0	0.975
	<i>Sachatamia albomaculata</i>	25%	2/8	0.0715	0.591
	<i>Terahyla spinosa</i>	0%	0/1	0	0.975
	Glass frog metamorph	0%	0/1	0	0.975
Highland 2 (521 m)	<i>Atelopus varius</i>	0%	0/6	0	0.459
	<i>Colostethus flotator</i>	0%	0/7	0	0.41
	<i>Colostethus panamensis</i>	25%	1/4	0.073	0.524
	<i>Pristimantis ridens</i>	0/1	0/1	0	0.975
	<i>Rhaebo haemitticus</i>	42%	1/5	0.057	0.437
	<i>Silverstoneia flotator</i>	33%	1/3	0.008	0.906
	<i>Smilisca</i> spp.	100%	3/3	0.292	1
Lowland 1 (0 m)	<i>Atelopus varius</i>	0%	0/1	0	0.975
	<i>Craugastor bransfordii</i>	0%	0/2	0	0.842
	<i>Craugastor crassidigitus</i>	0%	0/1	0	0.975
	<i>Craugastor longirostris</i>	0%	0/1	0	0.975
	<i>Craugastor fitzingeri</i>	0%	0/2	0	0.842
	<i>Dendrobates auratus</i>	0%	0/3	0	0.708
	<i>Dendrobates minnutus</i>	0%	0/1	0	0.975
	<i>Diasperous</i> spp.	0%	0/3	0	0.708
	<i>Pristimantis caryophyllaceus</i>	0%	0/1	0	0.975
	<i>Rhinella alata</i>	0%	0/10	0	0.308
	<i>Silverstoneia flotator</i>	0%	0/1	0	0.975

(e.g., Hertz et al. 2012) or predicted habitat suitability in species distribution models. We found persisting populations of *A. varius* at three of 16 (18.7%) field sites (Fig. 1, Table 1). At one site, we found one juvenile *A. varius*, five adult males, and two adult females, including one pair in amplexus (Fig. 2). We found individual adult males at each of the other two respective sites (Table 1). We have intentionally only provided general site information, rather than precise site coordinates, due to the risk of illegal animal collections.

We confirmed that *Bd* is present in two of these three populations based on detection of *Bd* on skin swabs from other species (e.g., *Lithobates warszewitschii* and *Sachatamia albomaculata*), but none of the *Atelopus* samples were *Bd* positive on these transects (Table 1). These sites vary in elevation from 45 to 750 m and all three are in areas where fungal epidemics were associated with mas-

sive amphibian declines from 2004 to 2006 (Lips et al. 2006; Brem and Lips 2008; Kilburn et al. 2010). We did not detect *A. zeteki* or *A. chiriquiensis* at any of our study sites. Although survey efforts for these species are still underway, the absence of these species is concerning because we know that they previously had restricted ranges (Zippel et al. 2006) and at least *A. zeteki* is known to be highly susceptible to chytridiomycosis in laboratory infection experiments (Bustamente et al. 2010; DiRenzo et al. 2014; Ellison et al. 2014).

We found that *A. varius* is persisting in multiple sites following a chytridiomycosis outbreak in western Panama. Furthermore, our positive qPCR results suggest that these populations have survived despite the presence of *Bd*. Prior to this study, Hertz et al. (2012) was the only study to document sightings of *A. varius* in the wild in Panama since 2006. Those observations were made in

2009 at a site in Santa Fe National Park. These populations may be persisting for a wide range of biotic (e.g., changes in host behavioral, innate or acquired immune responses, anti-*Bd* microbial communities) or abiotic (e.g., environmental/thermal conditions) reasons. However, because there have been few coordinated efforts to locate new populations, resurvey historical localities, or test for *Bd* infections, the question of how these populations have persisted—and whether any other *Atelopus* populations have survived—remains to be unraveled. We believe that the lack of post-decline survey effort has not been so much an oversight, but likely a consequence of the enormity of the challenge of monitoring these species while simultaneously establishing conservation programs to abate the threat of chytridiomycosis to entire amphibian communities.

Post-decline surveys are critical for conservation of *Atelopus* species, as well as for other neotropical amphibians. Documenting rediscovered species is critically important for informing conservation and management initiatives (Minteer et al. 2014) and, in this case, could be accomplished with photographs, rather than collecting the individuals. Moreover, understanding the variables that permit some populations to persist while others die out will be critical to conservation, especially since several species are being bred in captivity (e.g., *A. varius* and *A. zeteki*) with the expectation of one day returning them to the wild (Gagliardo et al. 2008; Zippel et al. 2011). Our discovery of extant populations of *A. varius* in *Bd*-enzootic areas underscores the importance of continued monitoring for species presumed to be “extinct in the wild,” even after long periods without any sightings.

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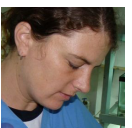
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# Confirmation of introduced Louisiana pinesnakes, *Pituophis ruthveni*, in Florida based on molecular analyses

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**Abstract.**—As more wide-range phylogenetic studies are available, the opportunity arises to compare DNA from these data sets to suspected introduced individuals in order to confirm species identification and determine their geographic origins. Two recently collected *Pituophis* specimens in Miami-Dade County, Florida, were examined using molecular analyses. Maximum likelihood and Bayesian inference methods place our specimens within the *P. catenifer sayi* / *P. ruthveni* clade. Additional morphological evidence support their identification as the Louisiana pinesnake, *Pituophis ruthveni* Stull 1929, a species indigenous to a small area in western Louisiana and eastern Texas and candidate for listing by the U.S. Fish and Wildlife Service. Although *P. ruthveni* is viewed as a distinct species from *P. catenifer sayi* based on allopatry and differences in color pattern, no molecular evidence was found supporting the recognition of *P. ruthveni* as a separate species. However, adding other mtDNA and nuclear DNA genes might provide needed data for distinguishing between these two named taxa.

**Key words.** DNA, exotics, ND4, mitochondrial, mtDNA, nonnative, phylogenetics, Squamata, species

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## Introduction

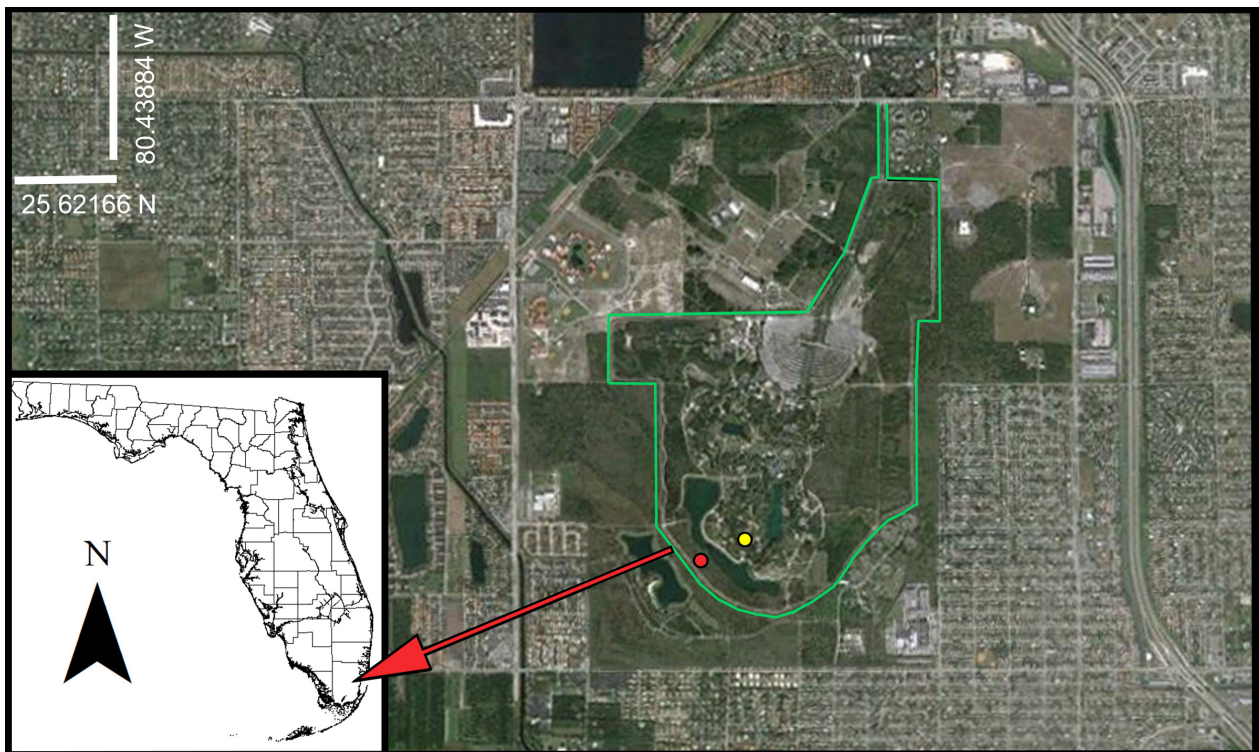
Introduced species (e.g., stages 2–5 after Colautti and MacIsaac 2004) are those transferred from their native range into a new nonindigenous area. Over the past century it has become increasingly clear how disruptive human-caused biological introductions have been to the planet. While not all introduced species cause obvious harm, some introduced species can eventually become economic threats and lead to serious conservation problems (Simberloff et al. 1997). As of 2005, it was estimated that the cost of environmental damages, losses, and control due to introduced species exceeded \$120 billion per year in the United States alone (Pimentel et al. 2005). Prior to 2011, the state of Florida had 137 documented introduced reptile and amphibian taxa (56 being established), which ranks highest in the world (Krysko et al. 2011a, 2012). Invasion pathways in Florida include (few-

est to highest numbers) biological control, zoos, cargo/plant shipments, and the pet trade.

Pinesnakes, bullsnakes, and gophersnakes (*Pituophis* Holbrook 1842) are large (up to 254 cm total length) constrictors native to North America, characterized by disproportionately small heads, four prefrontal scales, and a large rostral plate that extends upwards between the internasals (Conant and Collins 1991). Based primarily on molecular data using Parsimony and Maximum Likelihood analyses with 893 base pairs (bp) of the nicotinamide adenine dinucleotide dehydrogenase subunit 4 (ND4) region (Rodriguez-Robles and De Jesus-Escobar 2000), the *P. melanoleucus* species complex contains three currently recognized species; *P. melanoleucus* (sensu stricto; Pinesnakes; with three subspecies *P. m. lodingi*, *P. m. melanoleucus*, *P. m. mugitus*), *P. catenifer* (gophersnakes and bullsnakes; with six subspecies *P. c. affinis*, *P. c. annectens*, *P. c. catenifer*, *P. c. deserti-*

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**Figure 1.** Map of Zoo Miami bounded in green. Note that major roadways, residential areas, and undeveloped protected lands surround zoo property. Dots represent locations of *Pituophis* found on zoo property; yellow = UF-Herpetology 157954 (gravid female) and red = UF-Herpetology 163092 (adult male).

*cola*, *P. c. pumilis*, *P. c. sayi*), and *P. ruthveni* (Louisiana pinesnake). *Pituophis melanoleucus* (Daudin 1803) occurs in the eastern United States from southern New Jersey south to extreme southern peninsular Florida (i.e., Miami-Dade County; Krysko et al. 2011b) and west to Kentucky and southeastern Louisiana (Rodríguez-Robles and De Jesus-Escobar 2000). This species lacks a dark line from the eye to the angle of the jaw, has a dorsal pattern either absent (uniform black), obscure, or whitish to brownish with 23–30 distinct dark dorsal body blotches that are clearly separated from each other both anteriorly and posteriorly along the body and tail (Knight 1986; Powell et al. 1998; Reichling 1995; Thomas et al. 1976). *Pituophis catenifer* occurs from the Pacific Ocean east to Wisconsin, Illinois, and Texas, and from Canada south to Mexico (Rodríguez-Robles and De Jesus-Escobar 2000; Powell et al. 1998). This species typically has a dark line from the eye to the angle of the jaw, and a yellow or cream-colored dorsal pattern with 41–79 distinct dark dorsal blotches that are clearly separated from each other both anteriorly and posteriorly along the body and tail (Knight 1986; Powell et al. 1998; Reichling 1995; Thomas et al. 1976). *Pituophis ruthveni* occurs in allopatric populations in western-central Louisiana to eastern Texas (Ealy et al. 2004; Powell et al. 1998). This species sometimes lacks a dark line from the eye to the angle of the jaw, and has a pale brown dorsal pattern with 28–38 dark dorsal blotches; near the head the blotches obscure the ground coloration, whereas near the tail they are distinctly separated from each other (Knight 1986; Pow-

ell et al. 1998; Reichling 1995; Stull 1929; Thomas et al. 1976). Although *P. ruthveni* is nested within a clade containing only *P. c. sayi*, it is recognized as a separate species because it occurs in allopatric populations and is somewhat diagnosable using color pattern characters (Collins 1991; Knight 1986; Reichling 1995; Rodríguez-Robles and De Jesus-Escobar 2000; Thomas et al. 1976). *Pituophis ruthveni* is also a candidate for listing as an imperiled species by the U.S. Fish and Wildlife Service (2013).

The last known *Pituophis melanoleucus* from extreme southern peninsular Florida (UF-Herpetology 45970) was collected in 1980 in a disturbed pineland (with *Casuarina* and *Schinus*) in Cutler Ridge, Miami-Dade County, and because of ongoing dense urbanization this species is believed to be extirpated along the Atlantic Coast Ridge (Krysko et al. 2011b). In 2010, two *Pituophis* were collected on the Atlantic Coast Ridge at Zoo Miami, Miami-Dade County; one was found in an undeveloped area and another near public access. Based on color pattern alone, these snakes were suspected to be introduced *P. ruthveni* and reported to represent the first known vouchers for this species in Florida (Krysko et al. 2011a). Many documented introductions categorize species based on sometimes vague superficial morphology, such as color patterns, which may or may not be arbitrary human constructs. However, as more wide-range phylogenetic studies are conducted and published, the opportunity arises for other researchers to compare DNA from known data sets to suspected introduced individuals in



**Figure 2.** Well-developed *Pituophis* embryo (UF-Herpetology 164295) oviposited from wild collected gravid female (UF-Herpetology 157954) in Miami, Miami-Dade County, Florida.

order to confirm species identification as well as determine their geographic origins. In this paper, we conduct molecular analyses of *Pituophis* in a coalescent framework to confirm species identity and phylogenetic placement of our two specimens, followed by more detailed examination of morphology and color pattern.

## Material and Methods

### Site description and specimen acquisition

Zoo Miami is situated at 12400 SW 152<sup>th</sup> Street, Miami, Miami-Dade County, Florida, USA (Fig. 1; 25.611926°N, 80.398042°W, Datum WGS84, elev. 2 m). The property consists of ca. 300 ha, 106 ha of which are undeveloped managed lands, predominantly of pine rockland habitat. Zoo Miami property is surrounded by a mixture of natural areas, disturbed areas, and a county park, followed by dense urbanization.

On 16 May 2010 at 1645 h, an adult *Pituophis* (gravid female, 1,302 mm SVL, 1,486 mm TL; UF-Herpetology 157954; see Fig. 86 in Krysko et al. 2011) was collected in a service area behind a large animal exhibit (25.60395°N, 80.4006°W). This snake was observed by zoo staff the previous day along an adjacent public walkway, but was not captured. This snake was retained in captivity and oviposited three eggs on 22 June 2010. The eggs were viewed with a light on 28 June 2010; all three eggs contained a dark blood spot, but only one egg had an obvious network of veins developing. The first two eggs failed to develop and were discarded on 06 July 2010. The third egg had an unpleasant odor and was frozen on 14 September 2010; it was dissected on 20 Sep-

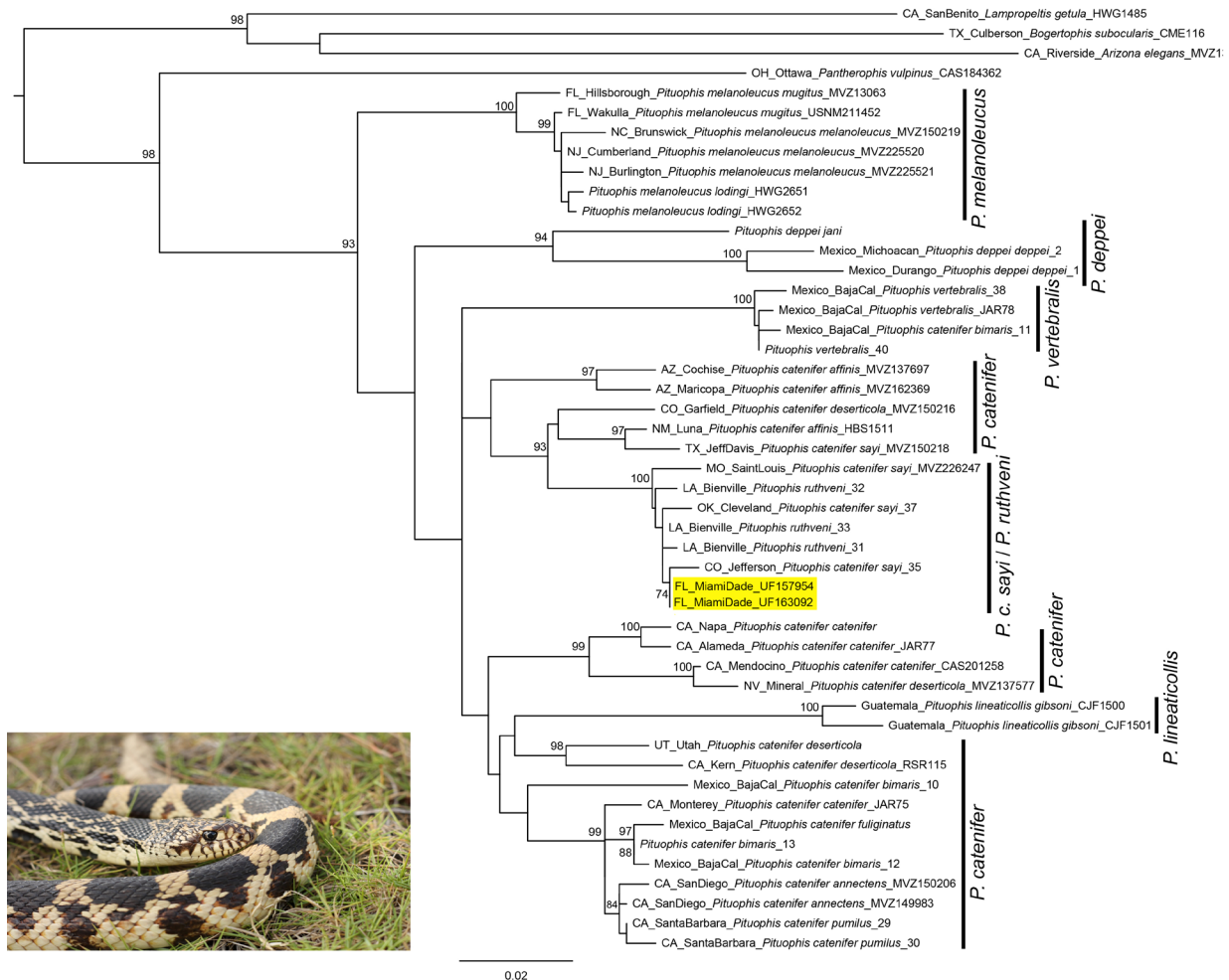
tember 2010 and revealed a well-developed embryo (UF-Herpetology 164295; Fig. 2).

On 25 December 2010 at 1215 h, another adult (male, 1,425 mm SVL, 1,635 mm TL) *Pituophis* (UF-Herpetology 163092) was collected in an undeveloped area (25.60304°N, 80.40295°W), across a large man-made lake and 0.26 km southwest of the first snake.

The well-developed embryo, shed skins from the two adults, and digital images were deposited in the Division of Herpetology, Florida Museum of Natural History, University of Florida. The female (UF-Herpetology 157954) is currently housed at the Memphis Zoo, and the male (UF-Herpetology 163092) is housed at Zoo Miami.

### Laboratory techniques

DNA isolations were obtained using QIAquick PCR Purification Kit and DNeasy Blood and Tissue Kit (Qiagen Sciences, LLC). Using total cellular DNA as a template and Polymerase Chain Reaction (PCR) methodology (Saiki et al. 1988), mitochondrial DNA (mtDNA) was amplified and sequenced for the ND4 region following Rodriguez-Robles and De Jesus-Escobar (2000). The ND4 region includes a section of the 3' end of the ND4 gene, and two subsequent transfer ribonucleic acids (tRNA<sup>His</sup>, tRNA<sup>Ser</sup>), which were sequenced using the primers ND4 and Leu (Arevalo et al. 1994). PCR was conducted in 25 µl reactions: 9.5 µl H<sub>2</sub>O, 12.5 µl GoTaq<sup>®</sup> Master Mix (Promega Corp, Madison, Wisconsin, USA), 1.0 µl each primer (10 µM), and 1.0 µl DNA template. PCR parameters included initial denaturing at 94 °C for three min, followed by 35 cycles of amplification: de-



**Figure 3.** Maximum Likelihood phylogeny for *Pituophis* (Squamata: Colubridae) snakes, including the two known *P. ruthveni* (highlighted in yellow, UF-Herpetology 157954 and 163092) collected in Miami, Miami-Dade County, Florida. Note that values ( $\geq 50\%$ ) above nodes represent bootstrap support. *Inset photograph of UF-Herpetology 157954 by Dustin C. Smith.*

naturing at 94 °C for one min, annealing at 52 °C for one min, and extension at 72 °C for one min, followed by a final extension at 72 °C for seven min. Three  $\mu$ l of each PCR product were electrophoresed on a 1% agarose gel, visualized with GelRed™ staining (Biotium Inc., Hayward, California, USA), and compared with a DNA standard. Sequence files from the automated sequencer (Genomics Division, Interdisciplinary Center for Biotechnology Research, University of Florida) were assembled and edited as necessary with Geneious software (ver. 6.1, created by Biomatters. Available from <http://www.geneious.com>).

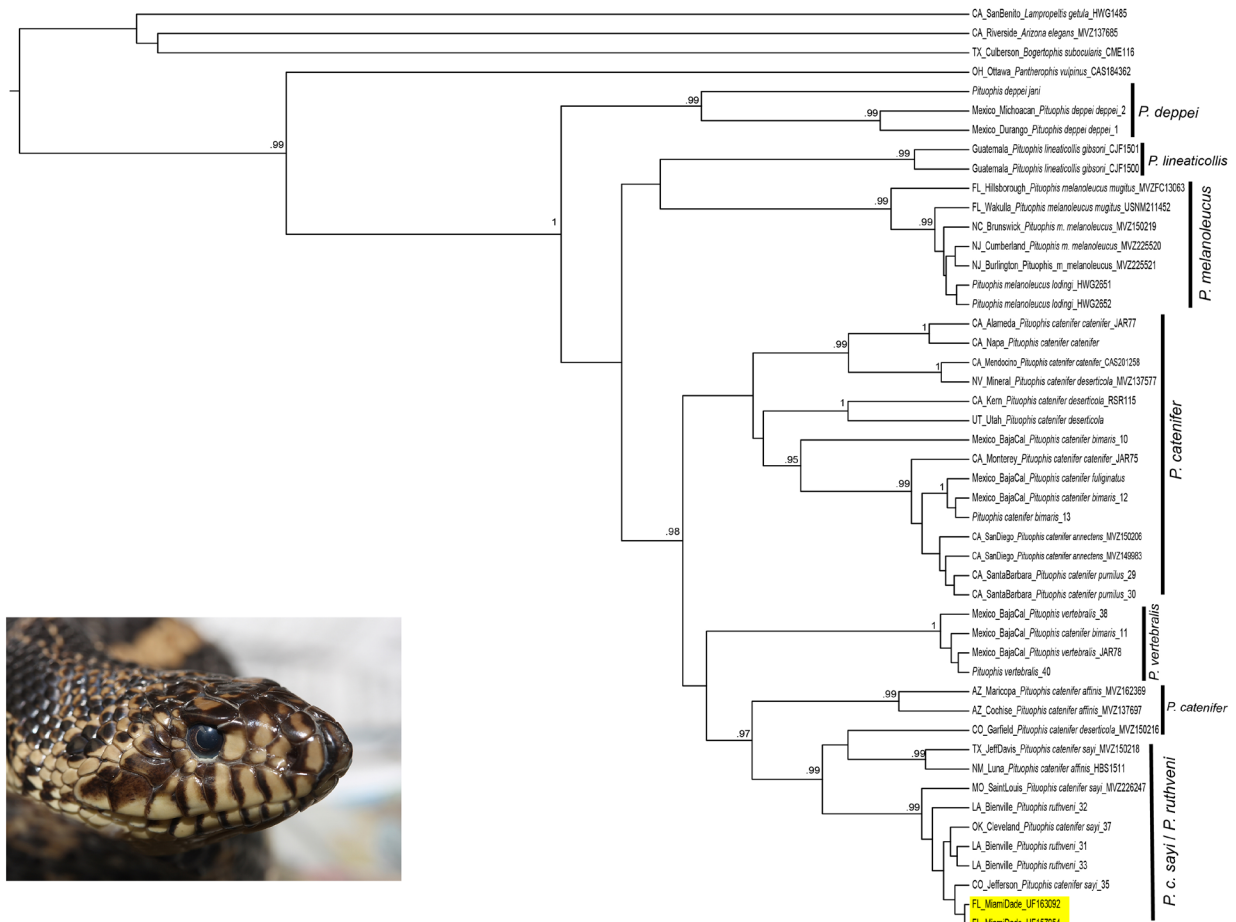
**Phylogenetic analyses.**—DNA sequence data were downloaded from GenBank for 46 snakes, including 42 *Pituophis*, and one of each *Lampropeltis getula*, *Pantherophis vulpinus*, *Bogertophis subocularis*, and *Arizona elegans* incorporating the original data set from Rodriguez-Robles and De Jesus-Escobar (2000) and current taxonomy after Pyron and Burbrink (2009). GenBank Accession numbers for our two *Pituophis* specimens

(UF-Herpetology 157954 and 163092) are KJ938643 and KJ938644, respectively.

A total of 48 specimens with 875 base pairs (bp) of sequence data were analyzed. Relationships among mtDNA haplotypes were estimated using both Maximum Likelihood (ML) and Bayesian Inference (BI) methods. ML was conducted with the General Time Reversible model with gamma distributed rate heterogeneity (GTR +  $\Gamma$ ) and 1,000 nonparametric bootstrap replicates (Felsenstein 2004) to assess node support using RAxML-HPC BlackBox (Stamatakis 2006; Stamatakis et al. 2008) from the CIPRES Science Gateway (Miller et al. 2010).

BI was conducted using BEAST (ver. 1.8; Drummond and Rambaut 2007) from the UF-HPC Galaxy instance (<http://hpc.ufl.edu>; Blankenberg et al. 2010; Giardine et al. 2005; Goecks et al. 2010). The Bayesian Information Criterion in jModelTest (ver. 2.1.4; Darriba et al. 2012; Guindon and Gascuel 2003) determined the best-fit nucleotide substitution model to be Hasegawa, Kishino, and Yano with a proportion of invariant sites and gamma distributed rate heterogeneity (HKY + I +  $\Gamma$ ). A relaxed

## Verification of introduced *Pituophis ruthveni* in Florida



**Figure 4.** Bayesian Inference phylogeny for *Pituophis* (Squamata: Colubridae) snakes, including the two known *P. ruthveni* (high-lighted in yellow, UF-Herpetology 157954 and 163092) collected in Miami, Miami-Dade County, Florida. Note that values ( $\geq 95\%$ ) above nodes represent posterior probabilities. *Inset photograph of UF-Herpetology 163092 by Dustin C. Smith.*

phylogenetics method was used without relying on a potentially arbitrary molecular clock (Zuckermandl and Pauling 1965) that might incorporate uncertainty in the tree estimation process (Drummond et al. 2006). An uncorrelated lognormal relaxed clock with coalescent constant population size (Kingman 1982), estimated base frequencies, randomly generated starting tree, and normal distribution for the ucl.d.mean parameter priors were used. Two independent runs were performed consisting of three heated and one cold Markov Chain Monte Carlo (MCMC) estimated for 40 million generations, with every 1,000th sample being retained. Both MCMC runs were analyzed independently (to confirm chains were converging and not sampling local optima) using Tracer (ver. 1.6) for ESS values  $>200$ , as well as for a split standard deviation less than 0.005 for  $-\ln L$  tree values among chains that indicate parameter stationarity was achieved. Trees sampled prior to stationarity were discarded as burn-in, which occurred prior to five million generations. Trees from both independent MCMC runs were combined and burn-in was removed using LogCombiner (ver. 1.8), the best statistically supported tree (i.e., Maximum clade credibility tree) with mean heights was obtained using TreeAnnotator (ver. 1.8), and a phylogenetic hy-

pothesis with posterior probabilities was created using FigTree (ver. 1.4).

The most credible inferences of phylogenetic relationships were confined to nodes where nonparametric bootstrap values  $\geq 70\%$  and posterior probability (Pp) was  $\geq 95\%$  (Hillis and Bull 1993; Felsenstein 2004).

### Morphology and color pattern

We determined sex, snout-vent length (SVL), tail length, number of ventrals, subcaudals, supralabials, infralabials, preoculars, postoculars, temporals, loreals, and dorsal scale rows; and color pattern of dorsum and venter. We compared these data to those found in the literature.

### Results

**Phylogenetic analyses.**—Both ML and BI methods produced identical phylogenetic groupings (Figs. 3 and 4). Although some of these clades are organized differently in relation to one another the monophyly of *Pituophis* is well supported, which is congruent with the findings by Pyron and Burbrink (2009), though the latter study used only single samples for each species. Both of

our two *Pituophis* specimens have the same mtDNA haplotype, and both phylogenetic methods place them within the *P. catenifer sayi* / *P. ruthveni* clade.

Morphological data for UF-Herpetology 157954 include 226 ventrals, 55 subcaudals, 8/8 (left/right) supralabials, 11/11 infralabials, 1/1 preoculars, 7/7 postoculars, 4 temporals, 1/1 loreals, 27–30–24 dorsal scale rows, 34 body blotches, 8 tail blotches, parietal stripe present, and heavily patterned venter. Data for UF-Herpetology 163092 include 212 ventrals, 57 subcaudals, 8/8 (left/right) supralabials, 11/11 infralabials, 1/1 preoculars, 7/7 postoculars, 4 temporals, 1/1 loreals, 27–31–23 dorsal scale rows, 32 body blotches, and 11 tail blotches.

## Discussion

Our ML and BI phylogenies produced identical main phylogenetic groupings (Figs. 3 and 4) as those found in the ML analysis by Rodriguez-Robles and De Jesus-Escobar (2000). However, we found no support for some relationships, and no support values are provided on the original ML tree by Rodriguez-Robles and De Jesus-Escobar (2000). Our two *Pituophis* specimens were placed within a well-supported *P. catenifer sayi* / *P. ruthveni* clade, the same group of specimens (except for our Florida specimens) uncovered by Rodriguez-Robles and De Jesus-Escobar (2000). *Pituophis catenifer sayi* and *P. ruthveni* were also found to be sister taxa based on a combined mtDNA and single nuclear (nDNA) (Pyron and Burbrink 2009) and phenetic morphological similarity (Reichling 1995) analyses. Nonetheless, we found no molecular support for the recognition of *P. ruthveni* as a separate species. One of the limitations of our and Rodriguez-Robles and De Jesus-Escobar's (2000) molecular studies is the use of only a single locus (ND4 region), and adding additional mtDNA and unlinked nDNA genes might provide needed data for distinguishing between these two named taxa. *Pituophis ruthveni* is currently recognized as a separate species because it occurs in allopatric populations and is believed to be diagnosable using color pattern characters, the most diagnostic being 28–38 dark dorsal body blotches and the blotches obscuring the ground coloration anteriorly (Collins 1991; Reichling 1995; Rodriguez-Robles and De Jesus-Escobar 2000). Our two *Pituophis* specimens exhibit these three characters, thus we categorized them as *P. ruthveni*.

Before our specimens were found, *Pituophis ruthveni* was not known to be kept at Zoo Miami, therefore this species is not representative of a zoo-mediated introduction pathway and was likely released by an outside person. Other species such as the Reticulated python, *Malayopython reticulatus* (see Kaiser et al. 2013; Reynolds et al. 2014), and Pacific Coast giant musk turtle, *Staurotypus salvinii*, are other examples of reptile species that have been illegally released on zoo property, the latter possibly established (Smith et al. 2011). Although we are

currently uncertain if *P. ruthveni* is established in the vast protected undeveloped habitats surrounding public access areas, an adult male and gravid female were found suggesting reproduction might have taken place in the wild.

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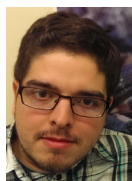
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