MANU

The Biodiversity of Southeastern Peru

La Biodiversidad del Sureste del Peru

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Annotated Checklist of the Amphibians and Reptiles of Pakitza, Manu National Park Reserve Zone, with Comments on the Herpetofauna of Madre de Dios, Peru

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ABSTRACT

One hundred and twenty eight species of amphibians and reptiles were collected during the BIOLAT project at Pakitza, Manu National Park, Madre de Dios, Perú. The recorded herpetofauna includes the following species diversity: 1 salamander, 67 frogs, 5 turtles, 1 crocodilian, 1 amphisbaenian, 22 lizards, and 31 snakes. Of these, 10 species (7 frogs, 1 lizard and 2 snakes) are either new or unassignable to species. Species were recorded from 14 habitat types and 55% occur in dissected alluvial terrace forests, 47% in old alluvial terrace forests and 37% in upper floodplain flooded forests. Forest leaf litter was the most frequent of the 15 microhabitats used; 26% of the amphibian species and 42% of the reptile species were recorded in forest litter. Based on long-term sampling at four sites in Madre de Dios, the herpetofauna of that region consists of 113 species of amphibians and 118 species of reptiles. In a pairwise comparison of faunas at all four sites, the Pakitza amphibian fauna was more similar to that from Cocha Cashu, while the Pakitza reptile fauna shared more species with that from Tambopata. Some of the between-site differences (especially for snakes) detected in this analysis are attributed to inadequate sampling; others apparently are the consequence of physiographic, ecological and historic differences between sites. Predictive tools developed from such studies facilitate decisions related to the conservation and maintenance of tropical diversity on both a regional and local scale.

RESUMEN

Ciento veinte y ocho especies de anfibios y reptiles fueron colectados en Pakitza, Parque Nacional de Manu, Madre de Dios, Perú a través del proyecto BIOLAT. El registro de la diversidad de la herpetofauna incluye las siguientes especies: 1 salamandra, 67 ranas, 5 tortugas, 1 cocodrilo, 1 anfisbaénido, 22 lagartijas, y 31 culebras. De éstas, 10 especies (7 ranas, 1 lagartija y 2 culebras) serían nuevas o aún no designadas. Las especies fueron registradas en 14 tipos de hábitat: el 55% ocurre en las bosques de terraza con quebradas, el 47% en los bosques de terraza aluvial viejo y el 37% en los bosques altamente inundables. La hojarasca en el bosque fue la más frecuentada por las especies de los 15 microhábitats; el 26% fue anfibios y el 42% reptiles. Basados en los muestros largos hechos en cuatro localidades de Madre de Dios, la herpetofauna de esa regíon consiste de 113 especies de anfibios y 118 especies de reptiles. En una comparacíon de la herpetofauna, a manera de pares de las cuatros localidades, la fauna de anfibios de Pakitza fue más similar a la de Cocha Cashu, mientras que la fauna de reptiles de Pakitza compartió más especies con Tambopata. Algunas diferencias entre las localidades (especialmente por las culebras), encontradas en este análisis, se atribuyeron al inadecuado muestreo. Otras diferencias entre los localidades, aparentemente son a consecuencia de la fisiografía, ecología e historia. Estos estudios pueden desarrollar ayudas predictivas para facilitar las decisiones relacionadas en la conservación y al mantenimiento de la diversidad tropical a escala regional y local.

INTRODUCTION

The amphibians and reptiles of the lowland wet forests of southeastern Peru became the focus of several independent investigations beginning in 1979. Studies have been done at four different localities in the department of Madre de Dios in Amazonian Peru. Two published surveys document the herpetofauna at Cocha Cashu in Manu National Park (Rodríguez and Cadle, 1990) and at Cuzco Amazónico (Duellman and Salas, 1991). Studies not yet published include a long-term study of the herpetofauna at the Tambopata Reserve by R. W. McDiarmid and R. B. Cocroft and one on species collected in the Pampas del Heath area by W. E. Duellman and V. R. Morales. As a result of these and a few other investigations many new species from this area have been described recently (e.g., *Hyla koecklini* and *H. allenorum* Duellman and Trueb, 1989; *Scinax chiquitana* de la Riva, 1990, *S. pedromedinae* Henle, 1991, and *S. icterica* by Duellman and Wiens, 1993; *Dendrobates biolat* Morales, 1992; *Epipedobates macero* Rodríquez and Myers, 1993) and we know of several others in preparation. As a result, the herpetofauna of lowland Madre de Dios, Peru may be better known than any comparable area in Amazonian South America. This is amazing as virtually nothing was know about the composition of the amphibian and reptile fauna in this region prior to 1980.

The Biological Diversity in Latin America Project (BIOLAT) began to work on the biodiversity of this region in the Reserve Zone adjacent to Manu National Park. Studies focused on the biota in about 4,000 hectares of lowland forest near a guard station on the east side of the Rio Manu (11° 56' 39" S latitude, 071° 16' 59" W longitude). The station, Pakitza, consists of a few wooden buildings in a cleared area on a dissected terrace at about 325 m elevation. High points on this terrace may be as much as 50 -- 75 m above the present river bed. Rainfall data are not available for the site but they probably are similar to those for Cocha Cashu (2,160 mm of rain a year, Erwin, 1991, Figure 3). Erwin (1991) and others (this volume) described the area in some detail. Herein, we summarize our work on the herpetofauna as part of the integrated study of the biodiversity of the Pakitza site.

METHODS AND MATERIALS

This report is based on amphibians and reptiles collected or observed by us or colleagues working with the BIOLAT program in the vicinity of Pakitza between 1987 and 1993. The BIOLAT project began an inventory of the biological diversity of Pakitza in September 1987. George Middendorf and VRM were with the first group to work at Pakitza and together they recorded 25 species of amphibians and 30 of reptiles during 28 days. VRM returned to Pakitza the following June. Because very little rain had fallen and conditions were quite dry, he collected only 11 species in a brief (12 day) period. VRM and RWM worked the site together in the dry season in September of 1988 and again in the wet season in January and February of 1989; together they collected 59 and 54 species on the respective trips. These additions brought the known fauna at Pakitza to 58 species of amphibians and 48 species of reptiles. The most diverse collection (62 species) was obtained during two weeks in the wet season in February, 1990 when VRM worked the site with Blga. María E. Guevara (Phycology). Another collection was made by Robert P. Reynolds and the BIOLAT group in February and March of 1992; they collected 56 species and added 4 frog and 3 snake species to the list. The final sample from the Pakitza area was made in early July, 1993 by Reynolds and another BIOLAT group; that trip recorded 25 species (not including larvae) of which 2 snakes were new to the site.

Collected materials were divided equally and are in the collections of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (MHNSM) and the National Museum of Natural History (USNM). Tape-recorded calls of many of the frog species also are on file in the sound archives in the Division of Amphibians and Reptiles, National Museum of Natural History, Washington, D.C.

Some species of reptiles (e.g., *Podocnemis unifilis*, *Caiman crocodilus*) were frequently seen along the Rio Manu but, because they are protected by international agreements and relatively difficult to sample, the few representatives of these that were captured, were identified, marked and released. For most other species, we made an effort to sample representatives of each. With only a few exceptions (e.g., *Caiman crocodilus*), the species reported in this compilation are based on voucher specimens collected during the project.

Analyses comparing the amphibian and reptile faunas among the four Madre de Dios sites were done with programs SUDIST.BAS (distance indices for SU, sampling unit, resemblance) and CLUSTER.BAS (cluster analysis for classification of SUs) using an index of similarity (IS) = (2W/A+B), where W is the number of species shared between each locality, A is the number of species at locality A, and B is the number at locality B. The Index of Similarity we used was IS' = 1 - IS with values ranging from 0 - 1. When SI' is equal to 0, all species are shared between sites; when SI' equals 1, there are no species known from both sites (i.e., totally different faunas). Details about these analyses were discussed by Ludwig and Reynolds (1988).

THE HERPETOFAUNA

The taxonomy and classification used in our compilation of the Pakitza herpetofauna follows the summaries by Frost (1985, and updated through 1993) and a recent monograph on *Leptodactylus* by Heyer (1994) for amphibians; the checklists and keys by Peters and Donoso-Barros (1970) for amphisbaenians and lizards, and by Peters and Orejas-Miranda for snakes (1970), as updated by Vanzolini (1986), Frost and Etheridge (1989) and Frost (1992); the checklist by King and Burke (1989) for crocodilians and turtles. A total of 68 species of amphibians and 60 species of reptiles were sampled at Pakitza on eight different occasions during the BIOLAT project; total field time amounted to about 21 weeks scattered across all months except August, November, and December (Table 1). John E. Cadle (see Rodríquez and Cadle, 1990) made a small collection of amphibians and reptiles at Pakitza in 1984. Other than a few poorly preserved specimens in bottles at the guard station at Pakitza, the Cadle material and our collections are the first records to our knowledge from this site. When species reported from Pakitza by Rodríquez and Cadle (1990), but not collected by us in our list, are added to the compilation, the known Pakitza herpetofauna includes 69 species of amphibians and 61 species of reptiles. This list does not included specimens collected from the areas surrounding Pakitza, even though we expect that many of them occur there.

As with most other projects designed to sample the entire herpetofauna at a site, considerable more time and effort must be put into the Pakitza area before the number of recorded species reaches the numeric diversity predicted from samples taken at comparable sites elsewhere in Madre de Dios. Nevertheless, our efforts have disclosed some species that are rare or previously unrecorded from the area (e.g., *Cochranella midas*, *Dendrophidion* sp., *Rhadinaea occipitalis*, *Bothrops brazili*, *Micrurus* sp.) and small samples of a few species (e.g., *Hyla*, *Eleutherodactylus*, *Chiasmocleis*) that apparently are new to science.

HABITAT USE

Erwin (1991) identified 12 distinct forest types distributed between seasonally flooded and non-flooded forests that were accessible by trail from the Pakitza station. Each was characterized by soil type, drainage, topography, and vegetation. Erwin also recognized several kinds of open habitats (e.g., tree falls, river margins, camp clearings, etc.) and a few specific habitats defined primarily by single plant species (e.g., caña brava along the river, bamboo thickets, etc.). These different forest types and associated open areas together with certain aquatic elements comprise the primary habitats at Pakitza. Erwin defined these habitats to aid in understanding carabid beetle diversity at Pakitza. While the habitat grain for vertebrate species often is quite different from that for insects and not well understood for most tropical species of amphibians and reptiles, we recognized many of the same habitats for our analysis at Pakitza.

TABLE 1. Number of species of amphibians and reptiles collected on eight visits to Pakitza, Madre de Dios, Perú.

Amphibians and Reptiles	Sampling Visits							
	1	2	3	4	5	6	7	8
AMPHIBIA								
Caudata				1	1	1		1
Anura	25	8	39	37	39	27	33	13
REPTILIA								
Testudines	2		1	3	1	2	2	1
Crocodilia	1		1					
Amphisbaenia	1							
Sauria	14	1	11	8	9	7	9	5
Serpentes	12	2	7	5	12	6	12	5
TOTAL	55	11	59	54	62	43	56	25

1 = 1-28 October 1987; George Middendorf and Víctor R. Morales.
2 = 18-28 June 1988; Víctor R. Morales.
3 = 5-24 September 1988; Víctor R. Morales and Roy W. McDiarmid.
4 = 22 Jan-1 Feb 1989; Víctor R. Morales and Roy W. McDiarmid.
5 = 4-28 February 1990; Víctor R. Morales and María E. Guevara.
6 = 19 April-13 May 1991; Víctor R. Morales and María E. Guevara.
7 = 13 February-10 March 1992; Robert P. Reynolds.
8 = 2-8 July 1993; Robert P. Reynolds.

For each specimen located during the survey, we recorded the habitat in which it was collected/observed. If we could not assign an individual to a specific habitat type, we referred it to the next larger unit, e.g., if we could not distinguish between old alluvial terrace forest and dissected alluvial terrace forest at the site where a specimen was collected, we recorded the specimen from alluvial terrace forest or simply upland forest accordingly. We used the following scheme and abbreviations to refer to habitat:

Upland, Non-flooded Forest (UF)

Old alluvial terrace forest - rapidly drained upland forests; on sandy clay (reddish, beige or gray) over red lateritic clay; *UFo* without bamboo and *UFob* with bamboo.

Dissected alluvial terrace forest - upland forests on terraces dissected by streams with steep banks; surface soil sandy and well drained; *UFd*

Seasonally Flooded Forest (FF)

Upper floodplain forest - forests with periodic but not annual flooding; with recurrent deposition of alluvium; plant diversity and density high; *FFu*

Lower floodplain forest - forests along the Rio Manu subject to seasonal flooding; lower extent - bare sand, fine-grained alluvium over sand, or washed clay with grasses or willows; upper extent - short-stature forest of low diversity on gray leached alluvium; *FFl*

Oxbow palm swamp forest - internally drained, isolated swamp forests, often in old oxbow lakes; intermittent standing or slow moving, clear, acidic water; palms common; *OSFp*

Oxbow hardwood swamp forest - low forest of *Ficus* and *Laetia*, along old oxbows; soil of dense, fine gray clay; water up to meter deep during wet season; *OSFh*

Ridgetop hardwood swamp forest - depressions on flat-topped ridges with short forest on hummocks, bamboo in understory; internal drainage, water accumulating during wet season to 0.5 meters, dries each year; over gray clay; *RSF*

Open Areas/Clearings in Forest (OA)

Camp clearing - approximately two hectares of open area with several small, wooden buildings; vegetation of low weeds and grass, periodically cut; OAc

Mud/sand banks along river - shoreline along Rio Manu; OAr

Clearing edge/forest margin - OAm

Aquatic Habitats

Riverine - aquatic portions of Rio Manu; depth and width variable, seasonally flooded; mosaic of broad sandy/stony beaches, extensive silty shores, and steep clay banks; AR

Streams - smaller streams and quebradas that cut through the upland and seasonally flooded forests; substrate rock, cobble, sand, or silt; AS

Lagoon - permanent water lagoon,.Cocha Chica, formed by a deep (former?) channel of the Quebrada Pachija; grassy belt around lagoon surrounded on three sides by forest; AL

The presence of species in the major habitats as represented in our samples is shown in Table 2. The distributions by habitat generally reflect the amount and kinds of each type at Pakitza, and their proximity to camp and access by trail. Review of these distributions allows the following generalizations: 55% of the species were found at least once in dissected alluvial terrace forests, 47% in old alluvial terrace forests. and 37% in upper floodplain flooded forest. About half of the Pakitza species have been recorded in more than one habitat. Only three of the 63 species known from single habitats are known from more than 10 specimens (i.e., common), and two of these (*Scinax rubra* and *Thecadactylus rapicauda*) are known only from open areas in and around camp. We suspect that many of the species that some might call "habitat specialists" will be shown to be more widely distributed as more material is collected. The majority (92%) of species (63) recorded from one habitat is known from 5 or fewer specimens. However, a few species (*Bufo guttatus*, *Cochranella midas*, some species of *Leptodactylus*, some microhylids, certain species of Teiidae, *Xenopholis scalaris*) may be restricted to specific habitats.

MICROHABITAT USE

Species of amphibians and reptiles seemingly occupy more distinct microhabitats in tropical compared to temperate forests. Whether this is primarily a consequence of the higher species diversity in tropical latitudes or actually reflects an increased complexity of tropical forests and a concomitant response on the part of species in the community (i.e., more specialists) remains to be demonstrated. In order to understand better the ecological distribution of amphibians and reptiles in this area, we attempted to assign each specimen observed or collected to a specific microhabitat. The microhabitats that we recognized for specimens sampled at Pakitza were: **aquatic** - actually in water (aw), on margin of river, stream, or pond margin (am), or on twigs or leaves floating in water (af); **hole** (h) - in or near holes in ground or ones formed by roots of bushes and trees; **leaf litter** - in or on litter in forest (fl) or camp clearing (cl); **low arboreal** - in bushes or low trees 0.5 to 2.0 m above ground on leaf (lal), on horizontal branch (lab), on stem (las), or inside bamboo (lai); high arboreal - in bushes or trees 2.0 m above ground on leaf (hal), on trunk (hat), or on branch (hab); open ground (og) in camp area; in or on buildings (b) in camp. The ecological distribution of species by microhabitat in which individuals were collected is shown in Table 2.

TABLE 2. Amphibian and reptile species collected in the vicinity of Pakitza, Madre de Dios, by habitat and microhabitat. Activity (ACTIV) — N = Nocturnal, D = Diurnal; Relative Abundance (ABUND) — U = Uncommon, C = Common, A = Abundant. Macrohabitat (MACRO) — Upland Forest (UF) on old alluvial UFo, with bamboo UFob, or dissected alluvial UFd terrace; Flooded Forest (FF) on upper FFu or lower FFl floodplain; Oxbow Swamp Forest (OSF) with palms OSFp or hardwood OSFh; Ridgetop Swamp Forest (RSF); Open Areas in camp clearing (OAc), along river (OAr) or forest margin (OAm); Aquatic (A) riverine Ar, stream As, and lagoon Al habitats. Microhabitat (MICRO) — aquatic in water aw, along margins am, and on floating debris af; leaf litter in forest fl and in camp cl; low arboreal on leaf lal, on branch lab, inside bamboo lai, and on stem las; high arboreal on leaf hal, on branch hab, on trunk hat; hole in ground ho; building in camp b; open ground og.

TAXON	ACTIV	ABUND	MACRO	MICRO
AMPHIBIA - CAUDATA				
Plethodontidae				
Bolitoglossa altamazonica	N	C	FFu,UFd	lal,lai
AMPHIBIA - ANURA				
Bufonidae				
Bufo guttatus	N	U	OAr	og
Bufo marinus	N	C	FFu,OAc&r,UFd&o	fl,og
Bufo cf typhonius	D	U	FFl,UFo	fl
Dendrobatidae				
Colostethus trilineatus	D	C	FFu,UFd,UFo	fl
Colostethus sp.	D	C	FFu,UFd,UFo	fl
Dendrobates biolat	D	C	FFu,UFd,UFo	lai
Epipedobates femoralis	D	U	UFd,UFo	fl
Epipedobates pictus	D	C	OAm,UFd,UFo	fl
Epipedobates trivittatus	D	C	OAm,FFu,UFd&o	fl
Centrolenidae				
Cochranella midas	N	U	UFo	lal
Hylidae				
Hemiphractus scutatus	N	U	UFd	fl
Hyla acreana	N	U	OAm	lab
Hyla boans	N	U	FFu,OAm,UFd	hab,lab
Hyla calcarata	N	U	FFu	lab
Hyla fasciata	N	C	FFu,OSFp	lab
Hyla granosa	N	U	OSFp,RSF	lal
Hyla lanciformis	N	U	OAm,FFu,UFd	lab
Hyla leali	N	U	OSFh,OSFp,UFo	lal
Hyla leucophyllata	N	U	OSFp	lab

TAXON	ACTIV	ABUND	MACRO	MICRO
Hyla minuta	N	A	UFd,UFo	lal
Hyla parviceps	N	A	OAm,OSFh,UFd&o	lal
Hyla rhodopepla	N	A	RSF,UFd,UFo	lal
Hyla sarayacuensis	N	U	UFd	lal
Hyla "sp. A"	N	A	RSF,UFd	lal
Hyla "sp. B"	N	A	OAM,UFd	lal
Osteocephalus leprieurii	N	C	FFu,UFd,UFo	lab
Phrynohyas coriacea	N	U	OAm	lab
Phrynohyas venulosa	N	U	UFo	lab
Phyllomedusa atelopoides	N	U	UFd	fl
Phyllomedusa palliata	N	U	UFd,UFo	lab
Phyllomedusa tomopterna	N	U	OAm,UFd,UFo	hab
Phyllomedusa vaillanti	N	U	FFu,OSFp	lab
Phyllomedusa sp.	N	U	FFu,UFo	hab
Scarthyla ostinodactyla	D	U	OSFp	af,lal
Scinax chiquitana	N	C	UFd	lab
Scinax pedromedinai	D,N	U	UFd	lab
Scinax cf rubra	N	C	OAc	lab,lai
Leptodactylidae				
Adenomera andreae	N	C	OAc,UFo	el
Ceratophrys cornuta	N	U	FFu,OSFp,UFd&o	fl
Edalorhina perezi	D	C	FFu,OSFp,UFd&o	ho
Eleutherodactylus altamazonicus	N	U	UFo	lal
Eleutherodactylus croceoinguinis	N	U	UFo	fl
Eleutherodactylus cruralis	D	U	UFo	fl
Eleutherodactylus diadematus	N	U	FFu	las
Eleutherodactylus fenestratus	N	C	FFu,OAc,UFd&o	el
Eleutherodactylus ockendeni	N	U	UFd,UFo	lal
Eleutherodactylus peruvianus	N	A	FFu,OSFp,UFd,o,ob	fl,lab
Eleutherodactylus toftae	D	U	FFu,UFd,UFo	lab
Eleutherodactylus ventrimarmoratus	N	U	FFu,UFo	lab
Eleutherodactylus "sp. A"	N	U	OAc,UFo	hal
Eleutherodactylus "sp. B"	N	U	OSFp,UFo	lab
Ischnocnema quixensis	D	U	UFd	fl
Leptodactylus bolivianus	N	U	FFu,UFd,UFo	fl
Leptodactylus knudseni	N	U	UFd	fl
Leptodactylus leptodactyloides	N	U	FFu,UFd,UFo	fl,ho
Leptodactylus mystaceus	N	U	FFu	fl
Leptodactylus pentadactylus	N	C	FFu,OAm,UFd&o	ho
Leptodactylus petersi	N	U	OSFp	ho
Leptodactylus rhodomystax	N	C	FFu,UFd,UFo	fl
Leptodactylus rhodonotus	N	U	FFu,UFd,UFo	fl
Lithodytes lineatus	N	U	UFd,UFo	ho
Physalaemus petersi	N	U	FFu,UFd,UFo	fl
Phyllonastes myrmecoides	D	U	UFd	fl
Microhylidae				
Chiasmocleis ventrimaculata	N	U	UFd,UFo	af
Chismocleis sp.	N	U	UFo	am
Ctenophryne geayi	N	U	UFd	ho
Hamptophryne boliviana	N	A	OAm,OSFp,UFd&o	fl,am

REPTILIA - TESTUDINES				
Chelidae				
Phrynops geoffroanus	N	U	OAm,UFo	aw
Phrynops gibbus	N	U	UFd	aw
Platemys platycephala	N	U	OAm,RSF,UFd&o	aw
Pelomedusidae				
Podocnemis unifilis	D	U	Ar,Al	aw
Testudinidae				
Geochelone denticulata	D	U	OAm,UFd,UFo&od	fl
REPTILIA - CROCODILIA				
Alligatoridae				
Caiman crocodilus	N	U	Ar	aw
REPTILIA - AMPHISBAENIA				
Amphisbaenidae				
Amphisbaena fuliginosa	D	U	UFo	aw/fl?
REPTILIA - SAURIA				
Gekkonidae				
Gonatodes hasemani	D	U	OAc	b
Gonatodes humeralis	D	U	OAc,OSFp,UFd	b
Pseudogonatodes guianensis	D	U	FFu	fl
Thecadactylus rapicauda	N	C	OAc	b, lab
Hoplocercidae				
Enyalioides palpebralis	D	U	UFd,UFo	lab,las
Polychridae				
Anolis bombiceps	D	C	FFu,UFd,UFo	fl,lab,lat
Anolis fuscoauratus	D	C	FFu,UFd,UFo	fl,lab
Anolis punctatus	D	U	OAc,UFd,UFo	lab,hat
Scincidae				
Mabuya bistriata	D	U	UFd	fl
Teiidae				
Alopoglossus angulatus	D	U	UFd	fl
Ameiva ameiva	D	U	OAc	og
Bachia trisanale	D	U	UFo	fl
Kentropyx pelviceps	D	U	UFo	fl
Neusticurus ecpleopus	D	U	FFd	fl
Prionodactylus argulus	D	U	FFu,OAc,UFd&o	fl
Prionodactylus eigenmanni	D	U	FFu,UFd,UFo	fl
Tupinambis nigropunctatus	D	U	OAm	og
Tropiduridae				
Stenocercus roseiventris	D	U	FFu	fl
Stenocercus sp.	D	U	FFu	fl
Tropidurus flaviceps	D	U	FFu	hab
Tropidurus plica	D	U	OAm	las
Tropidurus umbra	D	U	FFu	las
REPTILIA - SERPENTES				
Boidae				
Corallus hortulanus	N	U	OAm,OSFp	lab
Epicrates cenchria	N	U	OSFp	lab
Colubridae				
Chironius exoletus	N?	U	UFd	las
Chironius fuscus	D	U	UFd	lab

Chironius scurrulus	D	U	FFu	fl
Clelia clelia	N	U	OAm,FFu,UFd	lab
Dendrophidion sp.	D	U	FFu	fl
Dipsas catesbyi	N	U	FFu,UFo	lab
Drepanoides anomalus	N	U	FFu	fl
Drymarchon corais	D	U	FFu	fl
Helicops angulatus	N	U	OAc,OAr,UFd	am
Helicops polylepis	N	U	OAr	am
Imantodes cenchoa	N	U	FFu,UFd,UFo	lab,las
Leptodeira annulata	N	U	FFu,UFd,UFo	fl,lab,lai
Liophis cobella	N	U	UFd	lab
Liophis typhlus	D	U	UFd	fl
Oxybelis fulgidus	D	U	UFd	lab
Oxyrhopus melanogenys	N	U	FFu,OAc,UFd	fl
Oxyrhopus petola	N	U	OAc	og
Rhadinaea brevirostris	D	U	UFd	fl
Rhadinaea occipitalis	D	U	UFd	fl
Tantilla melanocephala	N?	U	UFo	fl
Xenodon severus	D	U	FFl,FFu,UFd	fl
Xenopholis scalaris	N	U	UFd	fl
Elapidae				
Micrurus lemniscatus	N	U	UFo	og
Micrurus spixii	D	U	UFd	fl
Micrurus surinamensis	N	U	OAm,UFo	fl
Micrurus sp.	D,N	U	FFu,OAm	fl
Viperidae				
Bothriopsis bilineata	N	U	UFo	lab
Bothrops atrox	N	U	FFu,OAc,UFo	fl
Bothrops brazili	N	U	OAm	og

We recognize that our attempts to assign each specimen to a microhabitat (Table 2) may give a misleading impression of the ecology of the species, especially considering the relatively small sample sizes and inadequate sampling periods. For example, an individual frog may occur in several different microhabitats during its life. Adults of certain species of treefrogs spend most of their life in the forest canopy but periodically come to forest ponds to breed. Thus, during a relatively short period (e.g., 3 days) a single individual might move from the high canopy to a forest pond, call while floating in the water or from surrounding vegetation, sit on a branch in low vegetation, climb up the stem of a small forest tree and eventually return to the canopy. Depending on sampling method and timing, that individual might have been encountered in any of four or five distinct microhabitats, and if it were observed only at the breeding pond, we might be mislead into considering the species aquatic, when in fact it is arboreal. In spite of these concerns, we believe that only by noting the microhabitat for every observation will we begin to understand the ecology of poorly known species. Some specific examples will help to illustrate this point.

Two of the four species of microhylid frogs were almost exclusively found only at breeding sites. Each was recorded as aquatic, either floating (af) or at the margins (am) of the pond, but neither is an "aquatic" species in the sense of some of the turtles. The problem was that we seldom or never collected the species in microhabitats other than at the breeding ponds. Based on our experience with the species or related forms at other sites, we know that these frogs occur in leaf litter or in holes in the forest floor but we did not change the observation. How many other species were scored for a microhabitat in which they seldom or rarely occur, is unknown.

Early on, we decided to score the actual microhabitat for each observation unless there was clear evidence that the occurrence was not natural (i.e., specimen moved to a place to escape disturbance). The single specimen of *Tropidurus flaviceps* was found "swimming" in Quebrada Fortaleza, east of Zone 2 (Erwin, 1991). Apparently, the lizard had fallen or jumped from a overhanging limb of a large tree and landed in the water about the time that an ichthyological team was seining the stream. In this instance we recorded the specimen as hab (high arboreal branch), not aw (aquatic), based on experience with the species elsewhere and the assumption that it was in the water because it had been disturbed. Likewise, we also decided to record the microhabitat only for individuals that were active. Observations of snakes on a branch or leaf of tree at night were not scored as low arboreal for that individual unless there was clear evidence of activity. Sometimes this was difficult to determine but we made the decision on a case by case basis. The single specimen of *Chironius exoletus* appeared to be active when encountered at night but previous experience suggested that species of *Chironius* are diurnal and usually terrestrial. However, we could not rule out our observation, so we recorded it as N? and las in Table 2. Because some species (e.g., many snakes) are rare or rarely encountered, gaining insight into their ecology and behavior will only be possible by combining observations derived from different studies at different sites. Thus, observations of activity and microhabitat use must be made carefully and described adequately when published. If these recommendations are followed, we eventually will come to understand the use of habitat by many tropical species.

ACTIVITY AND ABUNDANCE

We recorded the time of activity of each specimen collected and assigned each species to a nocturnal or diurnal category. Individuals had to be active when observed to be assigned to a category. We also attempted to assign each species to one of three categories of relative abundance based on the percentage of specimens of a species relative to the total Pakitza sample. The total number of adult specimens collected was about 1,117 specimens; for these calculations we did not include tadpoles or eggs in the total sample. We assigned relative abundances for species observed but not collected (e.g., riverine turtles and crocodilians) in the Reserve Zone near Pakitza based on our collective impressions of their relative abundances.

Calculated percentages of relative abundance based on our collections ranged from 0.1% to about 7.0%. We arbitrarily assigned a species to the uncommon (U) category if it comprised less than 1.0% of the total sample; examples of uncommon species include *Hemiphractus scutatus*, known from a single specimen collected in eight visits, and *Leptodactylus bolivianus*, represented by 10 collected specimens. A species was common (C) when its relative abundance was between 1.0 and 3.3% of the total sample; common species include *Anolis bombiceps* with 11 specimens collected and *Colostethus trilineatus* with 37 specimens. A species was abundant (A) when it contributed between 3.8 and 7.0% of the total sample. We considered *Hyla* "species A" with 43 specimens and *Hyla parviceps* with 78 specimens to be abundant.

We acknowledge that relative abundance values, as we have defined them, may not reflect adequately the abundance of species at Pakitza. For example, we did not sample equally across habitats or proportionally to the percentage that each habitat contributed to the total environment. Rather, we attempted to standardize our work during day and night sampling along trails radiating from the camp. Distant habitats (e.g., oxbow palm and hardwood swamp forests) were less frequently sampled, especially at night, and some were not accessible by foot during certain sampling periods (e.g., trails flooded during wet season). Other habitats (e.g., Cocha Chica lagoon, ridgetop hardwood swamp forests) were discovered late in the study and therefore not sampled proportional to habitats known and accessible by trail early in the study. Finally, vagaries of amphibian and reptile activity relative to wet and dry seasons on the Rio Manu also were reflected in our sampling. Many frogs were found only during the wet season and then located only by their calls. In contrast, lizard density and diversity seemed to be higher during the dry season. Although most sampling was by visual encounters along trails, we frequently used calls to find males of certain species (e.g., dendrobatids, *Eleutherodactylus*) and to locate breeding sites for others (e.g., hylids and microhylids). Even though we attempted to standardize our sampling procedures within habitats, estimates of abundance for some species may not be reflective of their relative abundance. For example, some abundant species (e.g., *Hyla* "sp. B") were collected in only one habitat and rarely outside of a large chorus, while other species were frequently heard but rarely (e.g., *Hyla lanciformis*) or never (*Phrynohyas* cf *resinifictrix*) collected. Because individuals (frogs and persons doing the sampling) are often attracted to a chorus from considerable distances, these temporary aggregations pose considerable problems for comparative analyses of relative densities. For example, we did not collect all specimens of all species from a chorus, and were selective as to how many specimens of each species were collected. In contrast, all specimens encountered along a trail were sampled and scored for a specific microhabitat within each habitat. In spite of these confounding problems, we think that the relative abundance data provide some knowledge about the activity, abundance, and diversity of the Pakitza herpetofauna.

SPECIES COMPOSITION

The herpetofauna of the Pakitza site includes 128 species of amphibians and reptiles. The microhabitats with the highest percentage of species are *forest leaf litter* with 26% of the amphibians (N=18) and 45% of the reptiles (N=27); *low arboreal on branch* with 28% (N=19) amphibians and 23% (N=14) reptiles; and *low arboreal on leaf* with 19% (N=13) amphibians and 3% (N=2) reptiles. Only about 4% of the herpetofauna (5 species of reptiles) occurs in the *aquatic* microhabitat.

Amphibians comprise about 53% of the total Pakitza herpetofauna and most of these are frogs (Table 2). One species of salamander (*Bolitoglossa altamazonica*) was found on four trips during both the wet and early dry seasons; most (17 of 19 specimens) were collected from the same stretch of trail in upper floodplain forest near the camp. A caecilian, *Oscaecilia bassleri* has been reported from Pakitza (Rodríquez and Cadle, 1990) based on a few specimens in the station collection that purportedly came from the immediate vicinity of the station. We did not include it on our list as no specimens were collected or positively known from Pakitza. We suspect that *Oscaecilia bassleri* and possibly other species of caecilian known from Madre de Dios (e.g., *Siphonops annulatus*) occur at Pakitza; their fossorial existence makes them unlikely candidates to be discovered during routine herpetofaunal sampling.

Of the 67 species of frogs in six families recorded from Pakitza, approximately 49% were taken in the *low arboreal* and 34% in *forest leaf litter* microhabitats. The remainder was distributed across five other microhabitats. The families with the highest species diversity are Hylidae (N=27) and Leptodactylidae (N=26). The greatest spread of microhabitats occupied was by species of the Leptodactylidae. Several species (e.g., *Bufo guttatus*, *Hemiphractus scutatus*, *Eleutherodactylus diadematus*, *E.* "species A" and *Phyllonastes myrmecoides*) were collected on only one visit and presumed to be rare. Their occurrence in the southern peruvian Amazon seemingly is rare too.

Cochranella midas was the only Centrolenidae recorded along the Rio Manu. Three adults were collect along a tiny forest stream near camp in October, 1987. In September, 1988 a single tadpole was found at the same spot in the stream where the adults had been collected the previous year. None has been taken since that time.

Three species of frogs were removed from the stomachs of snakes. Two *Ceratophrys cornuta* were inside an adult *Drymarchon corais*. A specimen of *Ctenophryne geayi* was removed from a *Helicops angulatus* and a specimen of *Scinax chiquitana* from inside a *Leptodeira annulata*.

The reptile fauna of Pakitza has 60 species, including 5 turtles, 1 crocodilian, 1 amphisbaenian, 22 lizards and 31 snakes. As with amphibians, reptiles were most common in *forest leaf litter* (50% of species) and *low arboreal* (32% of species) microhabitats. Most of the species (N=19) found in the low arboreal microhabitat were taken on branches.

The most common turtle, *Platemys platycephala*, was collected in small to moderate-sized pools in upland forest, ridgetop swamp forest, and at the edge of the camp clearing but only in the rainy season. Two small specimens of *Podocnemis unifilis* were "collected" by a local boatman (Trip 1) as food and given to us to eat. Although common in some stretches of the river, these two plus a large female with eggs (43 cm carapace length) from trip 8 were the only specimens of this species taken near Pakitza during our study.

The most common reptiles collected at Pakitza were the lizards *Thecadactylus rapicauda* - collected on every trip except September, 1988; *Anolis fuscoauratus* - collected on every trip except in the dry season (June) of 1988 and the wet season (February) of 1990; and *Ameiva ameiva* - absent in the wet season (January and February) of 1989. *Amphisbaena fuliginosa* and *Tropidurus flaviceps* were only collected once during the study. *Imantodes cenchoa* and *Leptodeira annulata* were the most common snake; specimens were collected at night in both flooded and non-flooded upland forests. In contrast, several other snake species are reported from Pakitza from single specimens, among which are two pit vipers, *Bothriopsis bilineata* and *Bothrops brazili*. Other interesting and seemingly rare snakes collected at Pakitza are *Dendrophidion* sp., *Rhadinaea occipitalis*, and *Xenopholis scalaris*. Four species of coral snakes occur at Pakitza; *Micrurus surinamensis* and M. sp. (similar to some specimens of *M. annellatus*) were found in the camp area near a small pond; the other species, *M. spixii* and *M. lemniscatus*, were found in the forest. It is likely that *Lachesis muta* occurs at Pakitza; this species has a wide distribution and has been reported from Cocha Cashu, 20 km to the northeast of Pakitza.

COMMENTS ON THE MADRE DE DIOS HERPETOFAUNA

The lowland herpetofauna of Madre de Dios, Peru, is known primarily from moderately extensive collections made at four sites in the department: Cocha Cashu, Pakitza, Tambopata, and Cuzco Amazónico. All four of these sites are in the Madre de Dios river drainage and separated by a maximum distance of about 300 km.

Cocha Cashu is in Manu National Park, northeast of Pakitza on the Rio Manu; according to Terborgh (1983, 1990) Cocha Cashu is at 350 — 400 m elevation and receives about 2,160 mm of rain a year (also see Erwin, 1991, Figure 3). The forests are of two major types: upland (high ground) mature forest and late successional, seasonally flooded forest; a large swamp forest dominated by *Ficus trigona* lies near the center of the site and three successional forest habitats parallel the river (Gentry and Terborgh 1990; Terborgh 1983). The herpétofauna of Cocha Cashu has been reported by Rodríquez and Cadle, 1990.

The Tambopata Reserve lies at an elevation of about 290 m and receives about 2,600 mm of rainfall annually. Erwin (1985) recognized seven major forest types that in many ways are similar to those reported from the other three sites. McDiarmid and Cocroft have been working on the amphibians and reptiles in the vicinity of Explorer's Inn since 1979 and currently are preparing a detailed account of the herpetofauna at Tambopata.

The Cusco Amazónico Reserve is slightly lower (200 m) and has an intermediate average annual rainfall (approximately 2,400 mm) compared to the other sites. The major habitats are on a flat, alluvial floodplain and include terra firma and seasonally inundated forests. Compared to the other three sites, much of the habitat at Cusco Amazónico has been disturbed by humans. Palms are common but bamboo has not been found; *Heliconia* swamps also are extensive in contrast to Tambopata and Pakitza. Duellman and Koechlin (1991) described the site and Duellman and Salas (1991) reported on the herpetofauna.

The total amphibian fauna of the four Madre de Dios localities approximates 113 species. Of these, 40 species (35%) occur at all four sites and 7 species (6%) are known only from Pakitza. A pair wise comparison of the amphibian faunas among the four sites is shown in Table 3; the values are Indices of Similarity (IS') and range from 0 (all species shared) to 1 (no species in common). Relatively small differences (0.28 to 0.36) separated the indices for the amphibian comparison among the four localities. In this analysis Pakitza was most similar to Cocha Cashu (0.28) followed closely by Cusco Amazónico (0.29) and then Tambopata (0.36). Essentially no differences in the similarity indices existed between Cuzco Amazónico and Tambopata and between Cusco Amazónico and Cocha Cashu (0.31). The degree of similarity between the amphibian faunas of Tambopata and Cocha Cashu was lower (0.33) but not as low as that between Pakitza and Tambopata (0.36). A clustering analysis ranks the Pakitza and Cocha Cashu faunas most similar with a value of 0.27, followed by Pakitza-Cocha Cashu and Cusco Amazónico at 0.36 and these three faunas plus Tambopata at 0.41.

The amphibian faunal comparisons produced some expected results. The amphibian faunas from the geographically closest localities (Pakitza and Cocha Cashu) were most similar. Even though Pakitza has less seasonally flooded forest and almost no large, cocha (= oxbow lake) habitat readily accessible for easy sampling, enough of this kind of habitat was available to offset any differences due to habitat availability. It also should be mentioned that the Cocha Cashu list (Rodríguez and Cadle, 1990, Table 22.1) included species not found specifically at the Cocha Cashu site; four amphibian species recorded only across the river from Cocha Cashu in habitat more similar to the upland dissected forest at Pakitza were included in our analysis but the three species known only from Pakitza, were not. Their inclusion tended to make the two sites more similar.

However, it is not intuitively obvious why the greatest difference was between the Pakitza and Tambopata faunas. Perhaps the lack of many good breeding sites, especially ponds and cochas, and the preponderance and proximity of drier upland forest at Pakitza compared to Tambopata account for part of the difference. Only

26 species of pond breeding hylids have been recorded at Pakitza, whereas 38 species have been recorded from Tambopata. Also, the Tambopata site has been worked more extensively and more frequently early in the wet season than Pakitza

Table 3.- A comparison of similarities for amphibian (to the right of the 0 line) and reptile (to the left of the 0 line) faunas among four sites in Madre de Dios, Perú. Values are Indices of Similarity (see text for explanation). PAKT = Pakitza; CUAM = Cuzco Amazónico; TMBO = Tambopata; COCH = Cocha Cashu.

	PAKT	CUAM	TMBO	COCH
PAKT	0	0.29	0.36	0.28
CUAM	0.41	0	0.31	0.31
TMBO	0.32	0.27	0	0.33
COCH	0.39	0.43	0.40	0

and this may account for some of the difference. About 66% of the amphibian species recorded from Pakitza are know from 11 or fewer individuals, and many of these (21 species) are known from five or fewer specimens.

The reptile fauna of the four Madre de Dios localities includes about 118 species, of which only 25 (21%) occur at all four sites. Six species (5%) of reptiles recorded in the Madre de Dios sample are known only from specimens collected at Pakitza. In contrast to amphibians, the patterns of faunal similarity among sites for reptiles are different (Table 3), and the indices have a broader spread (IS' = 0.27 to 0.43). The known reptile fauna of Pakitza is most similar to that at Tambopata (0.32), followed by Cocha Cashu (0.39) and Cusco Amazónico (0.41). Considering all sites, the greatest difference in reptile faunas is between Cusco Amazónico and Cocha Cashu (0.43) and the sites with the most shared species of reptiles are Cusco Amazónico and Tambopata (0.27). A cluster analysis ranked by decreasing similarity (fewer shared species) places Cusco Amazónico and Tambopata together (IS' = 0.32), followed by Cusco Amazónico-Tambopata plus Pakitza (0.36) and Cusco Amazónico-Tambopata-Pakitza plus Cocha Cashu (0.41).

That the patters of similarity among the four sites differ between amphibians and reptiles is interesting but may, in part, be an artifact of sampling. Most of the early sampling at Cocha Cashu was by Lily Rodríguez and focused more on amphibians than reptiles. We suspect that recent sampling at Cocha Cashu (John Terborgh, pers. comm.) will increase the known reptile diversity considerably. This amphibian bias also may have occurred at the other sites but, we believe, to a lesser extent. Another factor influencing the reptile comparisons has to do with the difficulty of sampling snakes in tropical forests. Experience has shown that with this kind of survey, the percentage of a snake fauna that is sampled is always considerably lower than that of amphibians given the same duration and intensity of study. The key to sampling snakes is the study duration and the sampling intensity (hours of searching). The species accumulation curve for amphibians is always steeper than for snakes, and unrecorded species of snakes are much lees likely the longer the study.

On the other hand, some of the differences may be real. Certainly the paucity of certain aquatic species (crocodilians, some turtles and snakes) reflects differences in available habitat; there are no large cochas or extensive swamps at Pakitza. Also, the seemingly lower density, and possibly lower diversity, of low arboreal and terrestrial (leaf litter) frogs at Pakitza, as compared to the other sites, may contribute to the apparently lower diversity and possibly lower density of terrestrial, frog-eating snakes.

In summary, we submit that our comparisons among the four sites have provided some interesting insights into understanding the diversity of amphibians and reptiles in Amazonian lowlands of southeastern Peru. The comparisons also have raised several intriguing questions about the herpetofaunal diversity in tropical lowland forests and the factors that influence that diversity. How many of the observed differences are real, i.e., due to differences in history, habitat heterogeneity, and ecology of the species, and how many are artifacts of inadequate sampling with non-standardized methodologies? As rigorous, standardized sampling methods become more routine and long-term studies of faunas at single sites across seasons and habitats are completed, the kind of information needed to answer these questions will become available. One goal of our studies is to develop some predictions about the expected diversity of amphibians and reptiles at one site as a function of geographic proximity and habitat comparability to known sites. With such predictive tools, we should be able to make better informed decisions regarding the conservation and management of large areas of lowland forest, and to identify more easily local sites that are in need of protection because of their unique habitats and included species diversity. Only through these and similar approaches can we begin to identify species diversity and takes steps to maintain it. Clearly, lots of work on the herpetofauna of the Amazonian Basin remains to be done and we need to get on with it in an efficient and expeditious manner.

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