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ARTÍCULO CIENTÍFICO
Temática: Diversidad

BIODIVERSITY ASSESSMENT AT THE SOUTHEASTERN SIDE OF DARIEN NATIONAL PARK, PANAMA

EVALUACIÓN DE LA BIODIVERSIDAD EN EL LADO SURESTE DEL PARQUE NACIONAL DARIÉN, PANAMÁ

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INFORMACIÓN SOBRE EL ARTÍCULO

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ABSTRACT. This study reports on biodiversity observed in the southeast of Darien province, Panama including Punta Cocalito next to the Pacific side of the Panama-Colombian border, observations along the Tuira river, Púcuro, and the intersection of the Cituro and Cupe river at the central-east Darien. Since the early 1900s, taxonomic review of these areas has been poor. Using *Ad-libitum* observations, Orion Camera System, and mist-nets, we confirm 18 species of medium sized and volant mammals, 161 species of birds, 34 orchids, six frogs and three snakes, with a first record of the copper parrot snake *Leptophis cupreus*. We confirm the southeastern Darien as an important biodiversity hotspot, threatened by anthropogenic activities and actions for the conservation of biodiversity in that area is urged.

KEYWORDS: Biodiversity, Conservation, Darien, Panama.

RESUMEN. Este estudio informa sobre la biodiversidad presente en el lado sureste de la provincia de Darién, incluyendo punta Cocalito en la frontera entre Panamá y Colombia en la costa del Pacífico, parte del río Tuira, Púcuro y la intersección de los ríos Cituro y Cupe que cruzan el centro este de Darién. La mayoría de estos lugares han sido pobremente estudiados a nivel taxonómico desde principios del siglo XX. Utilizando observaciones *Ad-libitum*, Sistema de Cámaras Orión y redes de niebla, confirmamos 18 especies de mamíferos de tamaño mediano y voladores, 161 especies de aves, 34 orquídeas, seis ranas y tres serpientes, con un primer registro de la serpiente loro de cobre *Leptophis cupreus*. Consideramos el lado este de Darién como un importante punto de biodiversidad, especialmente el bosque de Cocalito. El centro oriental de Darién está amenazado por las actividades antropogénicas y se instan acciones de conservación para la biodiversidad.

PALABRAS CLAVES: Biodiversidad, Conservación, Darién, Panamá.

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INTRODUCTION

Diversity documentation is an important practice for understanding wildlife abundance. It investigates species distribution relationships as influenced by those different factors, such as geographical barriers and food resources, that can encourage animals to survive or change (Magurran and McGill, 2013). Knowledge of biodiversity is also important to quantify the presence of original fauna in an area: it can inform us as to what to expect in a given habitat, and how anthropogenic changes may or may not be affecting that habitat's wildlife (Naeem *et al*., 2016; Bovendorp *et al*., 2019). Such information is crucial to conservation practices and strategies for the preservation of biodiversity (Noss *et al*., 2015). Although Panama's biodiversity has been very well reported by naturalists from the beginning of the 19th Century (Heckadon-Moreno, 1998) to the present (Méndez-Carvajal, 2014; Meyer *et al*., 2015), a few places in the east of Panama have remained unknown to science due to lack of exploration, or because of the deterrent effect of local political conflicts (Fagua *et al*., 2019). The country's Darien National Park is Central America's biggest biodiversity hotspot, and hosts species that are sometimes in migration from South to Central America (Méndez-Carvajal, 2014; Meyer *et al*., 2015). Darien has been studied at a botanical level, as an important case for the study of anthropogenic disturbance, and of the effects of logging and regenerative projects in newly fragmented habitats (Meyer *et al*., 2015; Mateo-Vega *et al*., 2019). Studies of the Darien Forest have identified several species new to science, and the forest is not only Panama's most diverse province for non-human primate species, but also as the region with the greatest diversity of primates in the entire Mesoamerican region (Estrada *et al*., 2006; Rylands *et al*., 2006; Méndez-Carvajal, 2019). Previous works on Darien's biodiversity have focused on problems of parasites and transmission of zoonotic diseases between human and non-human primates, such as malaria and yellow fever **(**Courtney, 1950; Dunn and Lambrecht, 1963; Porter *et al*., 1966). However new assessments of biodiversity are important to understand the impact of human activities such as clearing forest to cultivate plantain crops or build cattle ranches. These anthropogenic activities play a key role in the defaunation process in Darien, generating further biodiversity loss (Bovendorp *et al*., 2019). In this research, our aim was to assess the biodiversity of eastern side of Darien, specially to visit the most easterly human settlement on Panamanian territory at Darien province, searching for the existence of the hooded spider monkey *Ateles geoffroyi grisescens* (Elliot, 1913), a non-human primate that has been unreported since the late 1950s and which is categorized as Deficient Data (DD) according to the IUCN Redlist of Threatened Species (Méndez-Carvajal *et al*., 2017; Méndez-Carvajal and Cortes-Ortíz, 2020).

METHODS

Study area. We conducted *Ad-libitum* observations (Altman, 1974), from May 19 to May 29, 2016. Our team was composed of four of the present authors: Pedro G. Méndez-Carvajal (PGMC), a mammal specialist; Abel Batista (AB), a herpetologist; Ovidio Jaramillo (OJ), a bird specialist; and Bonarge Rodríguez-Beitia (BRB), an orchid specialist. We added two guests to document the expedition: Barbara Rethoré and Julien Chapuis from Conserv-Action, France. We were assisted by the Panamanian frontier police (SENAFRONT), and the Environmental Ministry of Panama (MiAmbiente). The first observation area was near the town of Cocalito. From this base we conducted walks on three trails, the first of which was along the Cocalito river (N 07°17'31.3"; W 77°57'55.7"), the second to the waterfall inside the vegetation zone and back to the Cocalito area (N 07°18'26.0"; W 77°58'59.4"), and the third from north to west along the town of Cocalito, where we set up two mist-nets (N 07°17' 39.9"; W 77°58'15.1"), staying there from May 20 to 23, 2016. On a second trip, we made observations at Boca de Cupe from May 24 to 26, 2016 (N 07°59'44.7"; W 77°36'13.9"). We also navigated along the Tuira river detecting mammals and birds in the gallery forest, regarding methods used by Haldin and Ulfvens (1987) and Adebayo and Halidu (2019), and then while walking along the Cruce de Mono trail. Other places visited were Bajo Lepe (N 07°59'44.7"; W 77°36'13.9"), part of the Cupe river and the Cituro river intersection (N 07°57'31.9"; W 77°36'46.2") (Figure 1).

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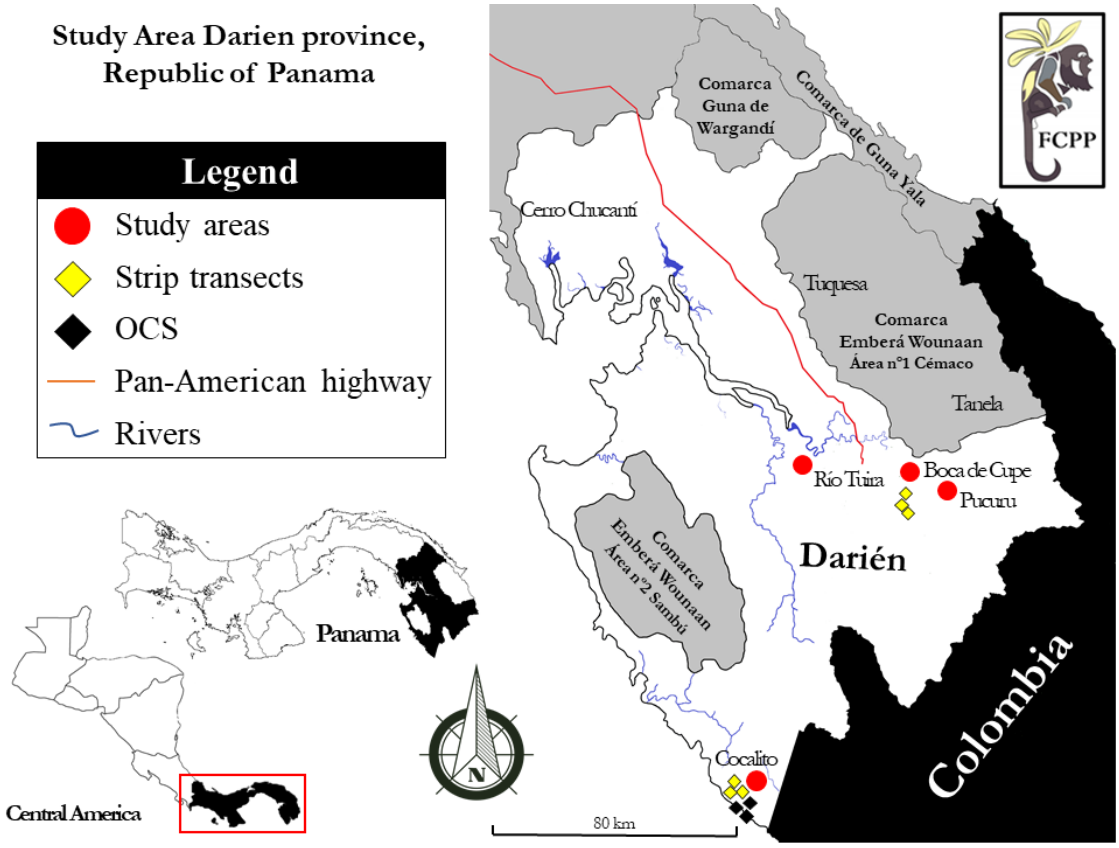

Figure 1. Study area map, Darien province, Republic of Panama.

We made our observations by listening to vocalizations (Brockelman and Ali, 1987), walking three transects (2 km long and 40 m wide), with 0.5 km/hr average speed inside the nearby forest and/or gallery forest (Glanz, 1990). Using binoculars (10x42) we observed, over the course of two separate periods (from 0700 to 1300 hrs, and from 1500 to 1700 hrs), signs of mammal and bird presence including feces, smell, and tracks as suggested by Wilson *et al*. (1996), and Ross and Reeve (2003). When possible, five camera traps were set up, two at ground level and three at heights of up to 12 meters (four days 24 hrs). These traps employed the Orion Camera System, using a model Bushnell Trophy Cam 119436 (N 07°18'10.1"; W 77°57'26.6") (Méndez-Carvajal, 2014) (Figure 1). To determine specific richness we used as a reference the biggest taxonomic group surveyed (birds), to obtain dominance and equity of the birds in each of the study sites and in general, test the Margalef diversity index (DMg) (DMg <2 low wealth, DMg> 5 high wealth), the Shannon-Wiener index (H´) (H´ <2 equals low diversity and H´> 3 represents high diversity), the Simpson index (D) (The closer the value of D is to 1, the lower the habitat diversity and the closer the value of D is to 0, the greater the habitat diversity) (Shannon and Weaver, 1949). To discover the similarity difference in bird diversity, we used the Jaccard similarity coefficient and the Whittaker index (Villarreal *et al.*, 2006; Magurran and McGill, 2013).

RESULTS

Mammal Diversity

Diversity in the mammal list was obtained by PGMC, who confirmed the presence of six Orders of the 13 reported in Panama (Artiodactyla, Perissodactyla, Carnivora, Rodentia, Chiroptera, and Primates), composed of 11 Families; Atelidae, Callitrichidae, Cebidae, Cervidae, Dasyproctidae, Felidae, Mustelidae, Phyllostomidae, Tapiridae, Tayassuidae and Vespertilionidae, totaling 17 Genuses and 18 medium-sized and volant mammal species (Table 1).

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Table 1. Detection of mammals using Strip Transects, OCS, and Mist-net at southeastern Darien, Panama.

Locations	Location	Species detected	No. Ind. Detected	Densities Ind./km2	IUCN Category
Cocalito River T1	07° 17' 31.3" N	**Artiodactyla**	group	n/a	
	77° 57' 55.7" W	**Tayassuidae**	2	0.02	
		Tayassu pecari			VU
		Pecari tajacu			LC
		Perissodactyla			
		Tapiridae			EN
		Tapirus bairdii			
Cocalito waterfall T2	07° 18' 26.0" N	**Carnivora**			
	77° 58' 59.4" W	**Felidae**			
		Panthera onca	1	0.01	NT
		Mustelidae			
		Lontra longicaudis	1	0.01	NT
Cocalito T3	07° 18' 10.1" N	**Artiodactyla**			LC
	77° 57' 26.6" W	**Cervidae**		0.01	
		Odocoileus virginianus			LC
		Rodentia		0.01	
		Dasyproctidae			
		Dasyprocta punctata			
Cocalito OCS 1	07° 17' 36.5" N 77° 58' 15.7" W	no picture	n/a	0	0
Cocalito OCS 2	07° 18' 3.1" N 77° 58' 11.7" W	no picture	n/a	0	0
Cocalito OCS 3	07° 17' 42.1" N 77° 58' 17.7" W	no picture	n/a	0	0
Cocalito Mist-nets (2)	07° 17' 39.9" N	**Chiroptera**			
	77° 58' 15.1" W	**Verpertilionidae**			
		Myotis nigricans	1	0.008	LC
		Phillostomidae			
		Artibeus jamaicensis	2	0.016	LC
		Phyllostomus discolor	1	0.008	LC
		Uroderma bilobatum	6	0.05	LC
		Carollia perspicillata	1	0.008	LC
Boca de Cupe T1	07° 59' 44.7" N	**Primates**	5	0.008	NT
	77° 36' 13.9" W	**Callittrichidae**			
		Saguinus geoffroyi			
Cupe and Cituro rivers intersection T2	07° 57' 31.9" N	**Primates**			
	77° 36'46.2" W	**Callittrichidae**	3	0.001	NT
		S. geoffroyi			
		Atelidae			LC
		Alouatta palliata eaquatorialis		X	CR
		Ateles fusciceps rufiventris		X	
		Cebidae			EN
		Cebus capucinus			
		Artiodactyla		X	DD
		Cervidae			
		Mazama temama	1	0.002	
Cituro river T3	07° 58' 42.1" N	**Primates**			
	77° 36' 29.7" W	**Callittrichidae**			NT
		S.geoffroyi	10	0.02	

Birds Diversity

Field observations by OJ obtained sightings of 45 Families of birds, with 130 Genuses, and a total of 161 species (Table 2). Although we were not able to count individuals for this preliminary survey, we present here an index of diversity and a per area comparison of bird families and species. A total of 161 species belonging to 45 Families were identified. In the Cocalito observation

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area, the identification of 131 species distributed in 42 families was made; for the Púcuro area, 48 species distributed in 29 families were identified; and in Boca de Cupe, 109 species belonging to 36 families were found (Table 2; Table 3).

Table 2. List of bird species recorded on southeastern side of Darien province, Panama.

Family	Species	Common name	C	P	BC	IUCN/E
Accipitridae	*Buteo platypterus*	Broad-winged Hawk	*x*			LC
	Buteogallus anthracinus	Common Black Hawk	*x*	*x*	*x*	LC
	Elanoides forficatus	Swallow-tailed Kite	*x*	*x*	*x*	LC
	Harpagus bidentatus	Double-toothed Kite	*x*			LC
	Ictinia plumbea	Plumbeous Kite			*x*	LC
	Pseudastur albicollis	White Hawk	*x*			LC
	Rupornis magnirostris	Roadside Hawk	*x*	*x*	*x*	LC
	Spizaetus tyrannus	Black Hawk-Eagle	*x*			LC
Alcedinidae	*Chloroceryle amazona*	Amazon Kingfisher	*x*	*x*	*x*	LC
	Chloroceryle americana	Green Kingfisher	*x*	*x*	*x*	LC
	Chloroceryle inda	Green-and-rufous Kingfisher	*x*			LC
	Megaceryle torquata	Ringed Kingfisher	*x*	*x*	*x*	LC
Apodidae	*Streptoprocne zonaris*	White-collared Swift	*x*			LC
Ardeidae	*Ardea alba*	Great Egret	*x*			LC
	Ardea cocoi	Cocoi Heron	*x*	*x*		LC
	Bubulcus ibis	Cattle Egret	*x*			LC
	Egretta caerulea	Little Blue Heron	*x*		*x*	LC
	Nyctanassa violacea	Yellow-crowned Night-Heron	*x*	*x*	*x*	LC
	Tigrisoma fasciatum	Fasciated Tiger-Heron	*x*			LC
	Tigrisoma lineatum	Rufescent Tiger-Heron	*x*		*x*	LC
Bucconidae	*Nystalus radiatus*	Barred Puffbird			*x*	LC
	Notharchus hyperrhynchus	White-necked Puffbird			*x*	LC
	Notharchus pectoralis	Black-breasted Puffbird	*x*			LC
	Notharchus tectus	Pied Puffbird	*x*	*x*	*x*	LC
	Malacoptila panamensis	White-whiskered Puffbird	*x*		*x*	LC
Cardinalidae	*Chlorothraupis olivacea*	Lemon-spectacled Tanager	*x*			LC
Cathartidae	*Cathartes aura*	Turkey Vulture	*x*	*x*	*x*	LC
	Coragyps atratus	Black Vulture	*x*	*x*	*x*	LC
Corvidae	*Cyanocorax affinis*	Black-chested Jay	*x*	*x*	*x*	LC
Cotingidae	*Cotinga nattererii*	Blue Cotinga	*x*			LC
	Lipaugus unirufus	Rufous Piha	*x*			LC
	Querula purpurata	Purple-throated Fruitcrow			*x*	LC
Columbidae	*Claravis pretiosa*	Blue Ground-Dove	*x*	*x*		LC
	Columbina talpacoti	Ruddy Ground-Dove	*x*		*x*	LC
	Patagioenas cayennensis	Pale-vented Pigeon	*x*		*x*	LC
Cracidae	*Ortalis cinereiceps*	Gray-headed Chachalaca		*x*	*x*	LC

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	Penelope purpurascens	Crested Guan	*x*			LC
Cuculidae	*Crotophaga ani*	Smooth-billed Ani	*x*	*x*	*x*	LC
	Crotophaga major	Greater Ani	*x*	*x*	*x*	LC
	Piaya cayana	Squirrel Cuckoo	*x*		*x*	LC
	Tapera naevia	Striped Cuckoo			*x*	LC
Emberizidae	*Arremonops conirostris*	Black-striped Sparrow	*x*		*x*	LC
Falconidae	*Falco rufigularis*	Bat Falcon			*x*	LC
	Herpetotheres cachinnans	Laughing Falcon			*x*	LC
	Ibycter americanus	Red-throated Caracara	*x*	*x*	*x*	LC
Fregatidae	*Fregata magnificens*	Magnificent Frigatebird	*x*			LC
Fringillidae	*Euphonia fulvicrissa*	Fulvous-vented Euphonia	*x*			LC
	Euphonia laniirostris	Thick-billed Euphonia	*x*			LC
	Euphonia luteicapilla	Yellow-crowned Euphonia	*x*	*x*	*x*	LC
Formicariidae	*Formicarius analis*	Black-faced Antthrush	*x*			LC
Furnariidae	*Dendrocincla fuliginosa*	Plain-brown Woodcreeper	*x*			LC
	Xiphorhynchus lachrymosus	Black-striped Woodcreeper	*x*		*x*	LC
	Xiphorhynchus susurrans	Cocoa Woodcreeper	*x*	*x*	*x*	LC
Galbulidae	*Brachygalba salmoni*	Dusky-backed Jacamar		*x*		LC/E
	Jacamerops aureus	Great Jacamar	*x*			LC
Grallariidae	*Hylopezus perspicillatus*	Streak-chested Antpitta			*x*	LC
Hirundinidae	*Progne chalybea*	Gray-breasted Martin	*x*		*x*	LC
	Stelgidopteryx ruficollis	Southern Rough-winged Swallow	*x*	*x*	*x*	LC
	Tachycineta albilinea	Mangrove Swallow	*x*	*x*	*x*	LC
Icteridae	*Cacicus cela*	Yellow-rumped Cacique			*x*	LC
	Cacicus uropygialis	Scarlet-rumped Cacique	*x*		*x*	LC
	Icterus chrysater	Yellow-backed Oriole			*x*	LC
	Psarocolius guatimozinus	Black Oropendola			*x*	E
	Psarocolius wagleri	Chestnut-headed Oropendola	*x*	*x*	*x*	LC
	Quiscalus mexicanus	Great-tailed Grackle	*x*	*x*	*x*	LC
Laridae	*Leucophaeus atricilla*	Laughing Gull	*x*			LC
Momotidae	*Momotus subrufescens*	Whooping Motmot	*x*	*x*	*x*	LC
Parulidae	*Myiothlypis fulvicauda*	Buff-rumped Warbler	*x*	*x*	*x*	LC
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican	*x*			LC
Phalocrocoracidae	*Phalacrocorax brasilianus*	Neotropic Cormorant	*x*	*x*	*x*	LC
Picidae	*Celeus loricatus*	Cinnamon Woodpecker	*x*			LC
	Dryocopus lineatus	Lineated Woodpecker	*x*		*x*	
	Melanerpes pucherani	Black-cheeked Woodpecker	*x*			LC
	Melanerpes rubricapillus	Red-crowned Woodpecker	*x*		*x*	LC
Pipridae	*Ceratopipra erythrocephala*	Golden-headed Manakin	*x*		*x*	LC
	Lepidothrix coronata	Blue-crowned Manakin	*x*			LC
	Manacus vitellinus	Golden-collared Manakin	*x*		*x*	LC/E
Polioptilidae	*Polioptila plumbea*	Tropical Gnatcatcher	*x*		*x*	LC
Psittacidae	*Amazona autumnalis*	Red-lored Parrot		*x*		LC

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	Amazona farinosa	Mealy Parrot			*x*	NT
	Ara ararauna	Blue-and-yellow Macaw	*x*	*x*	*x*	LC
	Ara chloropterus	Red-and-green Macaw	*x*		*x*	LC
	Brotogeris jugularis	Orange-chinned Parakeet	*x*	*x*	*x*	LC
	Pionus menstruus	Blue-headed Parrot	*x*	*x*	*x*	LC
	Pyrilia haematotis	Brown-hooded Parrot	*x*		*x*	LC
Ramphastidae	*Pteroglossus torquatus*	Collared Aracari	*x*	*x*	*x*	LC
	Ramphastos ambiguus	Black-mandibled Toucan	*x*	*x*	*x*	NT
	Ramphastos sulfuratus	Keel-billed Toucan	*x*	*x*	*x*	LC
Scolopacidae	*Actitis macularius*	Spotted Sandpiper		*x*	*x*	LC
Strigidae	*Glaucidium costaricanum*	Costa Rican Pygmy-Owl	*x*			LC
Sulidae	*Sula leucogaster*	Brown Booby	*x*			LC
Thamnophilidae	*Cercomacra tyrannina*	Dusky Antbird			*x*	LC
	Cymbilaimus lineatus	Fasciated Antshrike			*x*	LC
	Epinecrophylla fulviventris	Checker-throated Antwren			*x*	LC
	Gymnocichla nudiceps	Bare-crowned Antbird			*x*	LC
	Gymnopithys bicolor	Bicolored Antbird	*x*		*x*	LC
	Hylophylax naevioides	Spotted Antbird	*x*		*x*	LC
	Microrhopias quixensis	Dot-winged Antwren	*x*		*x*	LC
	Myrmotherula axillaris	White-flanked Antwren			*x*	LC
	Myrmotherula pacifica	Pacific Antwren	*x*			LC
	Phaenostictus mcleannani	Ocellated Antbird	*x*		*x*	LC
	Poliocrania exsul	Chestnut-backed Antbird	*x*	*x*	*x*	LC
	Taraba major	Great Antshrike			*x*	LC
	Thamnophilus atrinucha	Black-crowned Antshrike	*x*			LC
	Thamnophilus nigriceps	Black Antshrike			*x*	LC/E
Thraupidae	*Cyanerpes caeruleus*	Purple Honeycreeper	*x*			LC
	Cyanerpes cyaneus	Red-legged Honeycreeper	*x*			LC
	Dacnis cayana	Blue Dacnis	*x*			LC
	Hemithraupis flavicollis	Yellow-backed Tanager	*x*			LC
	Heterospingus xanthopygius	Scarlet-browed Tanager	*x*			LC
	Mitrospingus cassinii	Dusky-faced Tanager	*x*		*x*	LC
	Ramphocelus dimidiatus	Crimson-backed Tanager	*x*	*x*	*x*	LC
	Ramphocelus flammigerus	Flame-rumped Tanager	*x*		*x*	LC
	Saltator maximus	Buff-throated Saltator	*x*		*x*	LC
	Sporophila corvina	Variable Seedeater	*x*		*x*	LC
	Tangara inornata	Plain-colored Tanager	*x*			LC
	Tangara larvata	Golden-hooded Tanager	*x*			LC
	Thraupis episcopus	Blue-gray Tanager	*x*	*x*		LC
	Thraupis palmarum	Palm Tanager	*x*		*x*	LC
Tinamidae	*Crypturellus soui*	Little Tinamou	*x*	*x*	*x*	LC
	Tinamus major	Great Tinamou	*x*		*x*	NT
Tityridae	*Pachyramphus cinnamomeus*	Cinnamon Becard	*x*		*x*	LC

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	Tityra semifasciata	Masked Tityra	*x*		*x*	LC
Trochilidae	*Phaethornis striigularis*	Stripe-throated Hermit	*x*			LC
	Phaethornis longirostris	Long-billed Hermit	*x*	*x*	*x*	LC
	Phaethornis anthophilus	Pale-bellied Hermit	*x*			LC
	Glaucis hirsutus	Rufous-breasted Hermit			*x*	LC
	Amazilia tzacatl	Rufous-tailed Hummingbird	*x*		*x*	LC
Troglodytidae	*Cantorchilus nigricapillus*	Bay Wren	*x*		*x*	LC
	Henicorhina leucosticta	White-breasted Wood-Wren	*x*		*x*	LC
	Microcerculus marginatus	Southern Nightingale-Wren	*x*		*x*	LC
	Troglodytes aedon	House Wren	*x*	*x*	*x*	LC
Trogonidae	*Trogon caligatus*	Gartered Trogon			*x*	
	Trogon massena	Slaty-tailed Trogon	*x*			
	Trogon rufus	Black-throated Trogon	*x*			
Turdidae	*Turdus grayi*	Clay-colored Thrush			*x*	LC
Tyrannidae	*Attila spadiceus*	Bright-rumped Attila	*x*		*x*	LC
	Camptostoma obsoletum	Southern Beardless-Tyrannulet	*x*			LC
	Colonia colonus	Long-tailed Tyrant		*x*	*x*	LC
	Elaenia flavogaster	Yellow-bellied Elaenia	*x*		*x*	LC
	Legatus leucophaius	Piratic Flycatcher	*x*		*x*	LC
	Mionectes oleagineus	Ochre-bellied Flycatcher	*x*			LC
	Myiarchus tuberculifer	Dusky-capped Flycatcher			*x*	LC
	Myiodynastes maculatus	Streaked Flycatcher			*x*	LC
	Myiopagis gaimardii	Forest Elaenia	*x*		*x*	LC
	Myiornis atricapillus	Black-capped Pygmy-Tyrant	*x*	*x*	*x*	LC
	Myiozetetes cayanensis	Rusty-margined Flycatcher	*x*	*x*	*x*	LC
	Myiozetetes granadensis	Gray-capped Flycatcher	*x*		*x*	LC
	Oncostoma olivaceum	Southern Bentbill	*x*			LC/E
	Ornithion brunneicapillus	Brown-capped Tyrannulet	*x*	*x*	*x*	LC
	Phyllomyias griseiceps	Sooty-headed Tyrannulet			*x*	LC
	Pitangus lictor	Lesser Kiskadee	*x*			LC
	Pitangus sulphuratus	Great Kiskadee	*x*	*x*	*x*	LC
	Rhynchocyclus olivaceus	Black-headed Tody-Flycatcher	*x*		*x*	LC
	Terenotriccus erythrurus	Ruddy-tailed Flycatcher	*x*			LC
	Todirostrum nigriceps	Black-headed Tody-Flycatcher	*x*			LC
	Tolmomyias flaviventris	Yellow-breasted Flycatcher		*x*	*x*	LC
	Tyrannulus elatus	Yellow-crowned Tyrannulet	*x*			LC
	Tyrannus melancholicus	Tropical Kingbird	*x*	*x*	*x*	LC
	Zimmerius vilissimus	Paltry Tyrannulet	*x*		*x*	LC
Vireonidae	*Pachysylvia decurtata*	Lesser Greenlet	*x*		*x*	LC

Note: C: Cocalito; **P:** Púcuro; **BC:** Boca de Cupe; **E:** Endemic.

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Table 3. Species richness, diversity, equality, and dominance per each surveyed area at southeastern Darien, Panama.

Index	Cocalito	Púcuro	Boca de Cupe
Diversity	0.945	0.946	0.941
Dominancy	0.055	0.054	0.059
Shannon-Weiner	4.73	4.35	4.62
Margaleff	8.410	7.233	7.461

Amphibians and Reptiles Diversity

Amphibians and reptiles identified by AB are listed here with acronyms of their appropriate IUCN conservation category: from the Anura Order: Boquete rocket frog *Silverstoneia* sp. aff *nubicola* (NT), Darien stubfoot toad *Atelopus certus* (CR), cane toad *Rhinella horribilis* (LC), Boulenger's snouted frog *Scinax boulengeri* (VU), veined tree frog *Trachycephalus typhonius* (LC), and American white lipped frog *Leptodactylus labialis* (LC). From the Squamata Order, AB identified: Gekkonidae; common smooth-scaled gecko *Lepidodactylus lugubris* (LC). From *Colubridae* Family obtained *a* mussurana snake *Clelia clelia* (LC), copper parrot snakes *Leptophis cupreus* (LC), blunthead tree snake *Imantodes cenchoa* (LC), eyelash viper *Bothriechis schlegelii* (LC) (Figure 2 and 3).

Figure 2. Amphibians from Cocalito, May 2016. ***A)*** *Silverstoneia sp. aff nubicola);* ***B)*** *Atelopus certus;* ***C)*** *Rhinella horribilis;* ***D)*** *Scinax boulengeri;* ***E)****Trachycephalus typhonius;* ***F)*** *Leptodactylus labialis.*

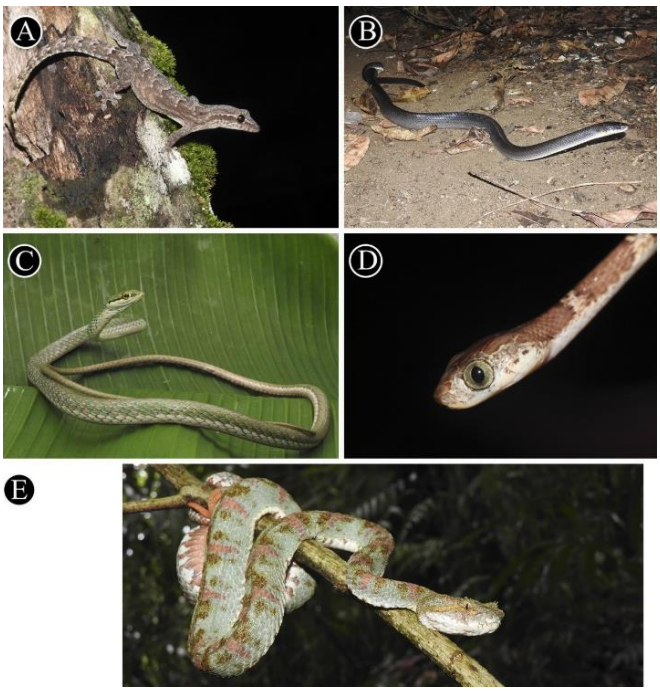

Figure 3. Reptiles at Southeastern Darien, May 2016. ***A)*** *Lepidodactylus lugubris;* ***B)*** *Clelia clelia;* ***C)*** *Leptophis cupreus;* ***D)*** *Imantodes cenchoa;* ***E)*** *Bothriechis schlegelii.*

Orchids Diversity

Observations by BRB identified plants from the Order Asparagales, Family Orchideaceae, identifying the following orchids: *Rodriguezia lanceolata* (LC), *Sarcoglottis hunteriana* (LC) (terrestre), *Oeceoclades maculate* (LC) (terrestre), *Brassavola nodosa*, *Brassia caudata*, *Bulbophyllum oerstedii*, *Catasetum viridiflavum*, *Caukarthron bilamellatum*, *Coryanthes* spp., *Ericina pusilla*, *Pleurothallis corniculata*, *Dichaea panamensis*, *Dimeranda elegans*, *Scaphyglottis minutiflora*, *S. bidentata*, *Elleanthus* spp., *Maxillaria brunnea*, *M. angustisegmenta*, *Prostechea chacaoensis*, *Lepanthes* spp., *Lockhartia acuta*, *L. pittieri*, *Camaridium camaridii*, *Notylia pentachne*, *Lophiaris* spp., (rio), *Lophiaris* spp., (montaña), *Oncidium nudum*, *Pleurothallis* spp., *Sobralia fenzliana*, *Trichosalpinx blaishdellii*, *Trigonidium egertonianum*, *Vanilla planifolia* (EN), *Xylobium powellii* (Figure 4).

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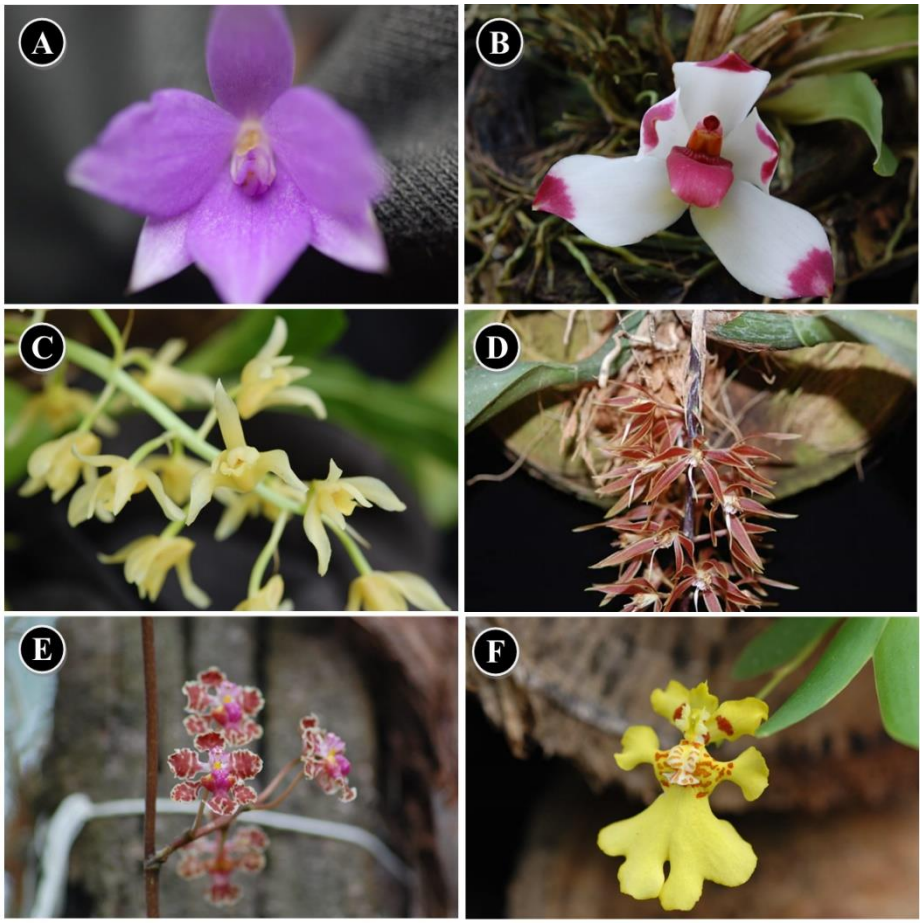

Figure 4. Orchids from Southeastern Darien, May 2016. *A) Dimeranda emarginata; B) Pescatorea dayana; C) Xylobium powellii; D) Macradenia brassavolae; E) Lopharis crispiflora; F) Erycina pusilla.*

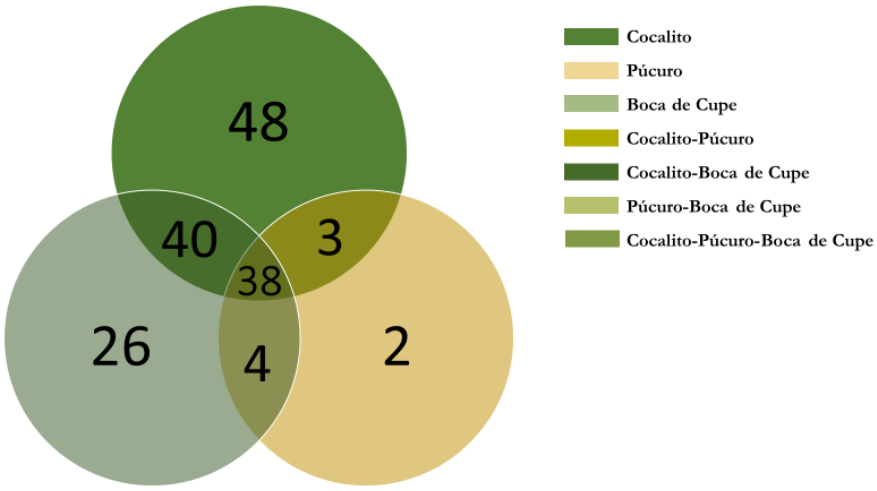

Figure 5. Venn's diagram showing the bird species richness in three areas surveyed at Darien southeastern side of Panama, being Cocalito the most diverse and respective number of species shared with Púcuro and Boca de Cupe.

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DISCUSSION

The survey confirmed the presence of primates reported before in the area as *Alouatta palliata aequatorialis*, *Cebus capucinus*, *Saguinus geoffroyi* all decreasing by hunting as declared by local people, and eventually used as pets, which has led them to partial extirpation as was found for the Darien black spider monkey *Ateles fusciceps* in Colombia and Ecuador (Estrada *et al*., 2017; Tirira *et al*., 2017; Méndez-Carvajal, 2019). The threats to these populations are due to the presence of established Embera-Wounaan communities in the areas on both the Panama and Colombian sides of the border, contrasting with the healthy and safe conditions observed on hill tops in other parts of Darien such as the Maje Mountain Chain (Chucantí) (Méndez-Carvajal, 2012a). A total investment of 3,196 hours of effort was dedicated to our main objective, the documentation of the presence/absence of the Hooded spider monkey *A. g. grisescens*, which was not found in this survey. Most of the mammal species detected in these areas are used as a protein resource, like the collared peccary *Pecari tajacu* and the white-lipped peccary *Tayassu pecari,* confirming the southeasternmost distribution for the country to the Pacific regarding previous reports from Moreno and Meyer (2015). Two species of deer were found in the area, the white-tail deer *Odocoileus virginianus,* and the Central-American red brocket deer *Mazama temama*: this is similar to other areas in Panama, such as the Panama Canal Watershed (Wright *et al*., 2000; Méndez-Carvajal, 2012b). Detection of the Baird's tapir *Tapirus bairdii* made an important contribution to its conservation, since the area had not been surveyed before, and detection of this species on the Pacific side of Panama was poor (Meyer *et al*., 2013). We can confirm that the *Tapirus bairdii* is found in the Cocalito river and surrounding areas, apparently in good habitat conditions for its conservation. We found no evidence that this species is under hunting pressure as local people rely more on fishing for survival. People from Cocalito also stated that they have been hunting *A.f.rufiventris,* reaching the local extirpation point 14 years ago: we fear that the same could happen with Ecuadorian howler monkey *A.p.aequatorialis* which was not heard or detected in any regular way. The detection of the jaguar, *Panthera onca,* in Cocalito represents the southeasternmost point on the Pacific side of Panama: this data has not been reported before (Moreno *et al.*, 2015; 2016; Fort *et al.*, 2018). In Panama, several areas of Darien and northern Colon province have been considered as conflicts zones for jaguar preying on cattle and being hunted by ranchers, leading the jaguar to be classified as Critically Endangered (Moreno and Olmos, 2008). From the Chiroptera group, we remark on the dominance of *Uroderma bilobatum,* for bats species at the eastern Pacific side of Panama, confirming similarities with species reported for other parts of western Darien province (González *et al.*, 2004; Rodríguez-Herrera *et al*., 2016).

Despite the fact that most of the birds detected are under IUCN Redlist Threatened Species as 'Least Concern', we should remember that according to the categories of Panamanian law that allow species to be listed as 'Endangered' and 'Critically Endangered', 35% of the families reported here present at least one species under "Decreasing Tendency", including Cotingidae, Cracidae, Cuculidae, Hirundinidae, Momotidae, Parulidae, Picidae, Poliptilidae, Psittacidae, Ramphastidae, Scolopacidae, Strigidae, Sulidae, and Thamnophilidae. Few studies have been conducted in the lowland areas in the east of Darien but high endemism and vulnerability have, nevertheless, been declared for the area by the IUCN (Wege, 1996; Renjifo *et al*., 2017). Five of the species detected are endemic throughout Panama-Colombia: *Brachygalba salmoni, Manacus vitellinus, Psarocolius guatimozinus, Oncostoma olivaceum* and *Thamnophilus nigriceps.* Three of them are NT, these are: *Amazona farinosa Ramphastos ambiguus, and Tinamus major*. From amphibians and reptiles detections, most of the species were already listed for Darien, but one of them is a new snake record for Panama and Mesoamerica; the *Leptophis cupreus,* expanding its distribution 200 km from the previously recorded sites in the Colombian Chocó (Batista and Wilson, 2017). Orchids species detected have been reported before in Panama, but in contrast to the Pacific coast, the forest of Bajo Lepe exhibited greater diversity and should be thoroughly surveyed in future.

The total number of species detected obtained a DMG index (8.7), i.e. DMG> 5, indicative of high biodiversity. It also presents H´ (4.82) that is H´> 3 and a D of 0.05, suggesting high diversity and fairness in the families identified. The similarity between Cocalito and Púcuro according to the Jaccard index was 30.88%, with 41

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species shared at both sites, but according to the Venn diagram only three are exclusive to these two sites. A test of the similarity between Cocalito and Boca de Cupe obtained a Jaccard index of 37.74%, with a total of 80 shared species, while the Venn diagram indicates that 40 of these species are unique to their sites, and that the similarity (according to Jaccard) between Púcuro and Boca de Cupe is 35.96%, with a total of 41 shared species. The Venn diagram indicates that of these 41, only four are found in these sites. Of the 161 species identified, 48 are found only in the Cocalito area (29.8%), 26 in Boca de Cupe (16.1) and two in Púcuro (1.2%), again according to the Venn Diagram. The total number of species found in these three sites (Cocalito, Púcuro, and Boca de Cupe) is 38, accounting for up to 23% of identifiable species (Table 3; Figure 5). The eastern part of Darien province can be still considered an area with high biological diversity. However, that diversity is facing several threats: the cultivation of palm oil and plantain crops, commercial exploitation of local timber resources, and the proposal of the highway projects to complete the Pan-American Highway between Central and South America. Conservation initiatives such as informative talks, and the distribution of t-shirts with educational messages in the Spanish, Embera, Wounaan and Guna languages have been undertaken by the present authors. Through these activities, local people were called on to value their local resources and to avoid further destruction of the forest cover. Our expedition reported on other forms of biodiversity of interest to our understanding of the habitat diversity and ecology, allowing a better idea about forest transition in relation to human development and resulting threats to conservation in this important ecological site.

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