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RESEARCH ARTICLE

Bird composition of different valley habitats after land-use changes in Northern Honduras

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Abstract

The northern coast of Honduras is potentially covered with tropical rainforests, reaching from the Caribbean Sea up to the cloud forests of the Pico Bonito summits. Therefore, it was blessed with the mega-diverse avifauna of the Central American humid neotropics. Although local bird species have been generally well documented, there are hardly any updates on the biodiversity of northern Honduras. Thus, this study contributes to our knowledge of the natural shift of bird life, following up the Cangrejal River with its different slight land use intensification in the region. Standardized bird records along the valley are analyzed, reaching from the beaches of La Ceiba up to the managed rainforests of El Toncontíns in the lower montane rainforests. Nine points were checked over the course of at least 6 days, taking point counts between 16 March and 20 June 2005. A NMDS of the joined nine point-lists elucidates four main groups, namely the beach/city ecosystems, open habitats along the river banks, slightly cleared forests (park landscape), and a mature rainforest. In total, 115 bird species, from 102 genera and 44 families, were found in 2005. As methods are limited, results can represent merely a prodromus of bird composition of neotropical valleys of the Central American isthmus. However, avi-diversity is affected by forest degradation and increasing land-use changes. Since deforestation is still soaring in the region, bird species composition should be monitored, as it will be as dynamic as land use changes in the region.

Keywords

Biodiversity, biogeography, disturbed forests, ornithology, river, rural landscape, shore birds

Introduction

The northern Caribbean coast of Honduras belongs to the per-humid tropics (Lauer et al. 1996), is therefore potentially covered with evergreen rainforests (Holdridge 1962, 1967; Ellenberg 1979) and blessed with a famous mega-diverse neotropical avifauna (e.g., Howell and Webb 2001; Anderson 2009; Anderson and Naka 2011; Gallardo et al. 2015). Although Honduras is one of the less studied countries in Central America, there are, however, manifold compendia (Monroe Jr 1968; Marcus 1983; Bonta 2003), checklists (Beall 1997; Principe 1999; Bonta and Anderson 2002; Adams and Ruiz 2017), and field guides for birds (Howell and Webb 2001; Gallardo et al. 2015; Remsen Jr et al. 2017). However, there are just a few studies on raptors and comparisons of bird canopy assemblages (Anderson 2001, 2009; Anderson and Naka 2011) but hardly any standardized information on bird life of the whole region. Systematic biogeographic studies, for instance, about the natural elevational species shift in the valleys and mountains or information about the dynamics after land-use changes, e.g., after forest degradation or deforestation, are widely missing for Honduras. Instead, there are some occasional unsystematic observations uploaded on the internet platform "eBird" (EBird 2020). Also, amazing local bird lists of engaged tourist lodges that total up to 423 bird species at one location are continuously actualized (Adams and Ruiz 2017). There are also bird checklists concerning the two big national parks of the region, provided by AVIBASE (2020). However, access to the rugged mountainous areas is difficult and inventories are only possible with huge efforts. In other parts of the Central American isthmus, especially in Costa Rica, there are more studies about bird life and about the elevational shift of birds (Young et al. 1998; Blake and Loiselle 2000, 2001).

The Río Cangrejal valley is one of these poorly studied valleys, although easily reached by a road that leads from the city of La Ceiba southwards into the mountains. It is located between the two national parks of Sierra Nombre de Dios and Pico Bonito, where mountain ridges reach up to 1,725 m and 2,435 m a.s.l. respectively, which are still providing intact nature-like rainforests (Fig. 1). As the highest peaks are just 15 km from the sea, the region has a spectacular geo-diversity with many different habitats and eco-niches. However, meanwhile the bottom of the valley is anthropogenically modified and forests are increasingly disturbed, converged into fields and pastures (Fig. 1). Nevertheless, the region is still dominated by forests that are used in a rather extensive ecological way (Kukkonen et al. 2008; Kukkonen and Hohnwald 2009). These mountains also provide important environmental services like fresh water supply, recreation possibilities, white-water rafting and other facilities of eco-tourism (waterfalls). Due to these reasons, montane forests have been protected as national parks since 1987 and 1993, respectively, by law. The biodiversity of the valley is therefore also of economic interest (photographing, birdwatching), and eco-tourism is already taking advantages of these common properties by conducting white-water rafting, horse riding, hiking, and birdwatching. What has not been so clear until now is to what extent the disturbance has influenced nature

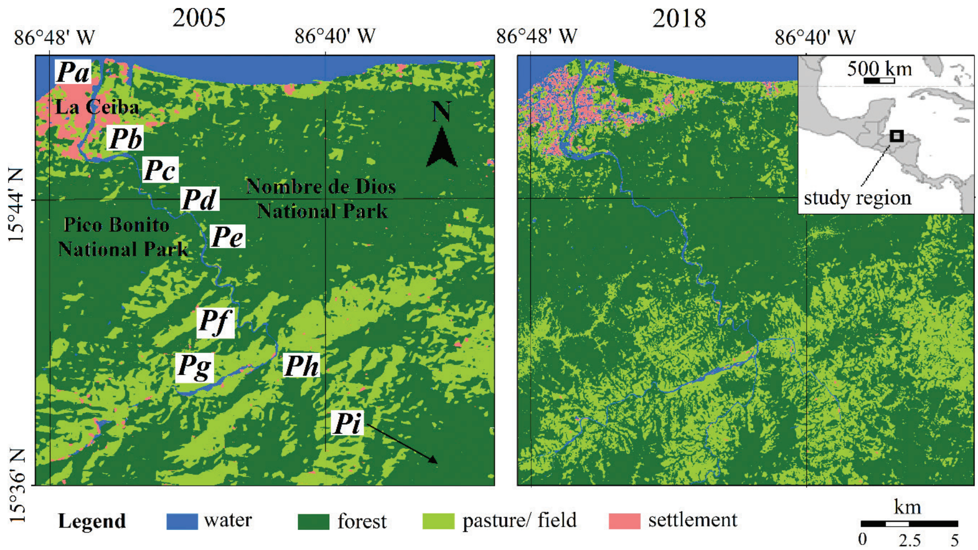

Figure 1. Study region with the nine study points (*Pa-Pi*) in the lower Río Cangrejal-watershed, northern Honduras, including land-use maps of 2005 and 2018 for comparison.

along the river habitats and to which altitude the protected bird species from the national park would descend and enter into the more disturbed areas at the bottom of the valley. Thus, although the Río Cangrejal is frequently visited by naturalists and birdwatchers, monitoring of the region and publication remains poor (Marcus 1983; Frederick et al. 1997; Anderson et al. 2004). Even more, tourists and scientists have been threatened by a growing number of crimes in Honduras in recent years, so that information on biodiversity might get scarcer still. Thus, the purpose of this paper is to report about some bird records, to provide a systematic prodrome of an avifauna of a steep Central American valley, and to document species shifts due to modest land-use changes.

Methods

Audio-visual bird observations were carried out along the Río Cangrejal valley in the hinterland of La Ceiba, department Atlántida, northern Honduras. Bird records of 28 observation days, between 16 March and 20 June 2005, were carried out, using a 10 × 42 binocular. Birds were mainly checked along the road "Carretera de la Cuenca" that leads from La Ceiba south along the river up to Río Viejo. One examined branch of the road follows the Río Yaruca south-eastwards to the villages of Yaruca, El Toncontíns, and El Urraco (Fig. 1; Table 1). Bird lists were set up at nine points (*Pa-Pi*) which were located approximately 2 to 3 km apart from each other. The beach (point a= *Pa*), i.e., from the jetty "Muelle Turistico Reynaldo Canales" to the western estuary of the Río Cangrejal river, and the city centre of La Ceiba (172,000 inhabitants in 2007; Brinkhoff 2020) have been visited on eight

Table 1. Geography of the study points: Name of the study points with other included locations, altitude [m] a.b.s.l., number of observation days, coordinates, and description of habitats along the Río Cangrejal valley, northern Honduras.

Study points	Altitude	Days	Coordinates	Habitats, geography
***Pa* La Ceiba**, city, beach, Barra Vieja	0–16	8	15°47'23"N, 86°47'44"W 15°47'53"N, 86°46'37"W 15°45'43"N, 86°46'56"W	Sea, sandy beach, jetty, beach esplanade, broad river estuary, middle sized city, parks
***Pb* Stone pit**, small power plant	19–62	12	15°45'18"N, 86°46'51"W 15°45'07"N, 86°46'07"W 15°45'04"N, 86°45'27"W	Broad valley, braided river, river banks, pastures, open habitats, shrubs, gravel stone pit
***Pc* El Bejuco**, riverbank	63–73	12	15°44'45"N, 86°45'21"W 15°44'13"N, 86°45'13"W 15°43'55"N, 86°44'59"W	Narrow valley, open habitats on river banks, secondary forests, forests uphill
***Pd* El Naranjo**, tourist lodges	78–128	12	15°43'32"N, 86°44'26"W 15°43'32"N, 86°43'44"W 15°43'07"N, 86°43'28"W	V-shaped valley, rocky riverbed, forested parcels of land, grassy patches shaded by old trees, thickets, old secondary vegetation, mature forests on slopes
***Pe* Las Mangas**, north of the bridge	139–149	8	15°42'56"N, 86°43'24"W 15°42'38"N, 86°43'25"W 15°42'08"N, 86°43'13"W	V-shaped valley, villages, rocky riverbed, pastures, shady groves, copses, older secondary vegetation, mature forests in national parks on slopes
***Pf* El Pital**, El Portillo, crest	200–420	6	15°41'24"N, 86°42'42"W 15°40'13"N, 86°42'23"W 15°41'53"N, 86°41'52"W	Steeper road, mountainous area, older secondary vegetation, parcels with gardens and plantations, disturbed older forests, mature forests on slopes
***Pg* Río Viejo**	268–367	8	15°39'46"N, 86°41'57"W 15°39'09"N, 86°42'23"W 15°39'46"N, 86°41'26"W	Broad valley, village, hedges, pastures, braided river, open habitats, scattered trees
***Ph* Yaruca**	276–312	6	15°39'46"N, 86°41'05"W 15°39'17"N, 86°40'16"W 15°40'16"N, 86°39'26"W	Broad valley, villages, pastures, scattered trees, open habitats
***Pi* El Toncontíns**, timberhuts, El Urraco	329–753	6	15°38'52"N, 86°39'44"W 15°36'28"N, 86°39'00"W 15°36'31"N, 86°37'01"W	Broad valley, pastures, secondary vegetation, disturbed forests, secondary vegetation, forested hills, at El Toncontíns timber huts: mature nature-like forests

days (15–16 March; 20–22 March; 25–26 March; 16 April). On six occasions (19 March; 6, 20, 21 April; and 20, 29 May), point-counts *sensu* Fischer et al. (2005) were carried out at the points *Pb* to *Ph*, in which all observed birds were noted during a 15 minute stop, respectively. For *Pi*, bird records between El Toncontíns and El Urraco of six days (19 March; 13–15 April; 18–19 April) were summarized, including afternoon and morning trips in the rainforests around the timber huts of El Toncontíns (14–15 April). Some additional single bird observations along the road on other days were assigned on the next respective study point. As the study was done 15 years ago, former habitat description is given in Table 1, as land use might have changed. Species accumulation curves, done with the aid of Excel (Windows 10 Home, Microsoft), of the nine study points are shown in Fig. 2. A few further noteworthy single observations are stated more in detail, giving the date, location and a special remark. Further status information on each species is added according to Beall (1997), Frederick et al. (1997), Bonta and Anderson (2002), Ordoñez and House (2008), and IUCN (2020). The order of bird classes is used as in Chesser et al. (2017) and Gill et al. (2020), the order of families and species according to the Honduran species lists (Dickinson and Remsen 2013; Dickinson and Christidis

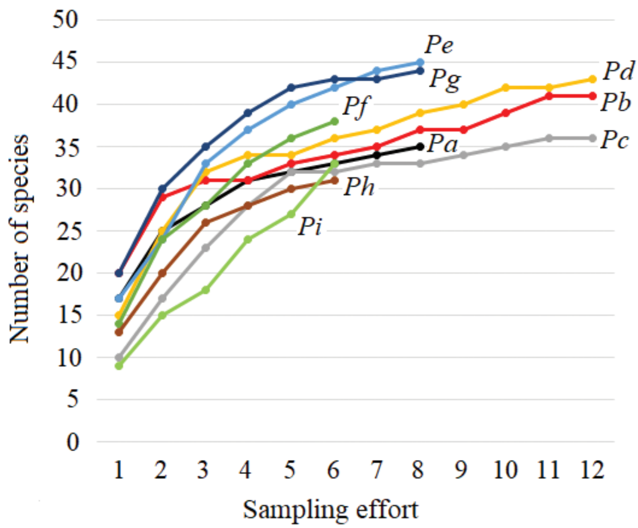

Figure 2. Species accumulation curves of the nine study points along the Río Cangrejal valley, northern Honduras. Sampling efforts are mainly daily species lists.

2014; del Hoyo and Collar 2014, 2016; Lepage and Warnier 2020). For the analysis of species composition of the different points, presence and absence data records were used to conduct a NMDS-analysis. It was done by using the "vegan" package of the statistical platform "R" (R Core Team 2013; Oksanen et al. 2019). According to the NMDS, the nine species list of the respective study points are therefore assigned into four main groups ($p < 0.0001$).

For the two land-use maps, we used Landsat 7 ETM+ images of April-May 2005 and May 2018. Due to an error of the Landsat 7 sensor since 2003, there is a failure of the scan-line-corrector (SLC), leading to line-shaped data gaps (Maxwell et al. 2007). These black stripes are found in 20% of all Landsat 7 satellite images, and were filled up with images of subsequent years (2006, 2007, and 2019). Categories were just roughly split into four classes to detect deforestation in the region (water, forests, pasture/fields, settlements).

Results

During the study time, 115 bird species, belonging to 102 genera and 44 families and 15 classes were reconfirmed in the Río Cangrejal watershed in this study. Table 2 illustrates the total bird list, providing also some information on the conservation status and all localities of the respective species.

Thirty-seven species were recorded at La Ceiba (*Pa*), whereas 41 (*Pb*), 36 (*Pc*), 43(*Pd*), 45 (*Pe*), 38 (*Pf*), 44 (*Pg*), 31 (*Ph*), and 33 (*Pi*) species were found at the respective other points, resulting in a mean diversity of 38.7 species/ point (SD 5.1).

Table 2. Recorded bird species along the Río Cangrejal valley, northern Honduras, between March and June 2005. Status according to Principe (1999). A= accidental; N= native, breeding; V= visitor, non-breeding; W= widespread visitor, locally breeding; 1= common; 2= uncommon. NT= nearly threatened according to Bonta and Anderson (2002) and IUCN (2020). *= out of its common range. Point counts: Study points from *Pa* until *Pi* (a-i), where the respective species was found.

Taxon name	English name	Status	Point counts
Galliformes			
Cracidae			
Ortalis vetula (Wagler, 1830)	Plain Chachalaca	N1	c, e, g, i
Apodiformes			
Apodidae			
Streptoprocne zonaris (Shaw, 1796)	White-collared Swift	N1	b, d–g, i
Chaetura pelagica (Linnaeus, 1758)	Chimney Swift	V2 NT	a–c
Chaetura vauxi (Townsend JK, 1839)	Vaux's Swift	N1	e–h
Trochilidae			
Phaethornis longirostris (Delattre, 1843)	Long-billed Hermit	N1	d, i
Amazilia tzacatl (de la Llave, 1833)	Rufous-tailed Hummingbird	N1	e, h
Cuculiformes			
Cuculidae			
Crotophaga sulcirostris (Swainson, 1827)	Groove-billed Ani	N1	b, f
Piaya cayana (Linnaeus, 1766)	Squirrel Cuckoo	N1	a, d, f, h, i
Columbiformes			
Columbidae			
Columba livia (Gmelin JF, 1789)	Rock Pigeon	N1	a
Patagioenas cayennensis (Bonnaterre, 1792)	Pale-vented Pigeon	N1	f
Columbina inca (Lesson, 1847)	Inca Dove	N1*	a–c, e, f
Columbina talpacoti (Temminck, 1810)	Ruddy Ground-Dove	N1	b, c
Leptotila verreauxi (Bonaparte, 1855)	White-tipped Dove	N1	d–g, i
Leptotila cassinii (Lawrence, 1867)	Grey-chested Dove	N2	d, f, g, i
Gruiformes			
Rallidae			
Aramides cajaneus (Statius Muller, 1776)	Gray-necked Wood-Rail	N1	a, b
Charadriiformes			
Jacanidae			
Jacana spinosa (Linnaeus, 1758)	Northern Jacana	N1	a
Scolopacidae			
Numenius phaeopus (Linnaeus, 1758)	Whimbrel	V1	a
Calidris minutilla (Vieillot, 1819)	Least Sandpiper	V1	a
Actitis macularius (Linnaeus, 1766)	Spotted Sandpiper	V1	b, c, e, g
Tringa flavipes (Gmelin JF, 1789)	Lesser Yellowlegs	V1	b, f
Tringa melanoleuca (Gmelin JF, 1789)	Greater Yellowlegs	V1	b
Laridae			
Leucophaeus atricilla (Linnaeus, 1758)	Laughing Gull	N1	a, b
Sternula antillarum (Lesson, 1847)	Least Tern	N1	a
Thalasseus maximus (Boddaert, 1783)	Royal Tern	N1	a
Thalasseus sandvicensis (Latham, 1787)	Sandwich Tern	N1	a
Ciconiiformes			
Threskiornithidae			
Platalea ajaja (Linnaeus, 1758)	Roseate Spoonbill	N2	a
Suliformes			
Fregatidae			
Fregata magnificens (Mathews, 1914)	Magnificent Frigatebird	N1	a
Sulidae			
Sula leucogaster (Boddaert, 1783)	Brown Booby	N1	a
Anhingidae			
Anhinga anhinga (Linnaeus, 1766)	Anhinga	N1	a
Phalacrocoracidae			
Phalacrocorax brasilianus (Gmelin JF, 1789)	Neotropic Cormorant	N1	a–e

Taxon name	English name	Status	Point counts
Pelecaniformes			
Pelecanidae			
Pelecanus occidentalis (Linnaeus, 1766)	Brown Pelican	N1	a
Ardeidae			
Ardea alba (Linnaeus, 1758)	Western Great Egret	N1	a–c
Egretta caerulea (Linnaeus, 1758)	Little Blue Heron	N2	b, c, e, g, h
Egretta thula (Molina, 1782)	Snowy Egret	N1	a–c
Egretta tricolor (Statius Muller, 1776)	Tricolored Heron	N2	a–c
Butorides striata (Linnaeus, 1758)	Striated Heron	N1	a–c
Accipitriformes			
Pandionidae			
Pandion haliaetus (Linnaeus, 1758)	Osprey	N1	a
Accipitridae			
Chondrohierax uncinatus (Temminck, 1822)	Hook-billed Kite	N2	e, i
Elanoides forficatus (Linnaeus, 1758)	Swallow-tailed Kite	N1	a
Ictinia plumbea (Gmelin JF, 1788)	Plumbeous Kite	N2	g, h
Pseudastur albicollis (Latham, 1790)	White Hawk	N1	f
Cathartidae			
Coragyps atratus (Bechstein, 1793)	Black Vulture	N1	a–i
Cathartes aura (Linnaeus, 1758)	Turkey Vulture	N1	a–i
Strigiformes			
Strigidae			
Glaucidium brasilianum (Gmelin JF, 1788)	Ferruginous Pygmy-Owl	N1	a
Coraciiformes			
Alcedinidae			
Megaceryle torquata (Linnaeus, 1766)	Ringed Kingfisher	N1	a–e
Chloroceryle amazona (Latham, 1790)	Amazon Kingfisher	N2	a, b, d, e, g
Momotidae			
Momotus lessonii (Lesson, 1842)	Lesson's Motmot	N1	d, e
Eumomota superciliosa (Sandbach, 1837)	Turqoise-browed Motmot	N1	d, h, i
Piciformes			
Picidae			
Melanerpes aurifrons (Wagler, 1829)	Golden-fronted Woodpecker	N1	g, h
Ramphastidae			
Pteroglossus torquatus (Gmelin JF, 1788)	Collared Aracari	N1	d–f, i
Ramphastos sulfuratus (Lesson, 1830)	Keel-billed Toucan	N1	d, f
Galbulidae			
Galbula ruficauda (Cuvier, 1816)	Rufous-tailed Jacamar	N2	f
Psittaciformes			
Psittacidae			
Pionus senilis (von Spix, 1824)	White-crowned Parrot	N1	d, e
Eupsittula astec (Souancé, 1857)	Aztec Parakeet	N1	b, d–h
Passeriformes			
Thamnophilidae			
Thamnophilus doliatus (Linnaeus, 1764)	Barred Antshrike	N1	e, g, i
Pipridae			
Manacus candei (Parzudaki, 1841)	White-collared Manakin	N1	f, h, i
Ceratopipra mentalis (Sclater, 1857)	Red-capped Manakin	N1	d, f, h, i
Tityridae			
Tityra semifasciata (von Spix, 1825)	Masked Tityra	N1	d, g
Pachyramphus aglaiae (Lafresnaye, 1839)	Rose-throated Becard	N1	d, g
Tyrannidae			
Tolmomyias sulphurescens (von Spix, 1825)	Yellow-olive Flycatcher	N1	g, i
Contopus cinereus (von Spix, 1825)	Tropical Pewee	N1	d–f, h, i
Sayornis nigricans (Swainson, 1827)	Black Phoebe	N1	c–e, g, h
Myiarchus crinitus (Linnaeus, 1758)	Great Crested Flycatcher	V1	e, f, h
Pitangus sulphuratus (Linnaeus, 1766)	Great Kiskadee	N1	a–h
Myiozetetes similis (von Spix, 1825)	Social Flycatcher	N1	b–e, g
Myiodynastes luteiventris (Sclater, 1859)	Sulphur-bellied Flycatcher	N1	d, g, h

Taxon name	English name	Status	Point counts
Legatus leucophaius (Vieillot, 1818)	Piratic Flycatcher	N1	b, c, f, g
Tyrannus savana (Daudin, 1802)	Fork-tailed Flycatcher	N1*	b–g
Tyrannus melancholicus (Vieillot, 1819)	Tropical Kingbird	N1	a–h
Corvidae			
Cyanocorax morio (Wagler, 1829)	Brown Jay	N1	b–d, f, g, i
Hirundinidae			
Stelgidopteryx serripennis (Audubon, 1838)	Northern Rough-winged Swallow	N1	b–h
Petrochelidon pyrrhonota (Vieillot, 1817)	Cliff Swallow	V2	e
Progne chalybea (Gmelin JF, 1789)	Gray-breasted Martin	N1	a–c
Riparia riparia (Linnaeus, 1758)	Bank Swallow	W2	b, c
Hirundo rustica (Linnaeus, 1758)	Barn Swallow	N1	a
Polioptilidae			
Ramphocaenus melanurus (Vieillot, 1819)	Trilling Gnatwren	N1	c–e, i
Troglodytidae			
Troglodytes aedon (Vieillot, 1809)	House Wren	N1	a–i
Pheugopedius maculipectus (Lafresnaye, 1845)	Spot-breasted Wren	N1	b–d, g, i
Thryophilus rufalbus (Lafresnaye, 1845)	Rufous-and-white Wren	N2	d, i
Mimidae			
Dumetella carolinensis (Linnaeus, 1766)	Gray Catbird	V1	f
Turdidae			
Hylocichla mustelina (Gmelin, 1789)	Wood Thrush	V1 NT	f
Turdus grayi (Bonaparte, 1838)	Clay-colored Thrush	N1	b–d
Passeridae			
Passer domesticus (Linnaeus, 1758)	House Sparrow	N1	a
Fringillidae			
Euphonia gouldi (Sclater, 1857)	Olive-backed Euphonia	N1	e, i
Passerellidae			
Arremonops conirostris (Bonaparte, 1850)	Black-Striped Sparrow	*A	c
Icteridae			
Psarocolius wagleri (Gray GR, 1844)	Chestnut-headed Oropendula	N1	d–g, i
Icterus prosthemelas (Strickland, 1850)	Black-cowled Oriole	N1	e, g, h
Icterus pectoralis (Wagler, 1829)	Spot-breasted Oriole	N1*	g
Molothrus aeneus (Wagler, 1829)	Bronzed Cowbird	N1	b
Dives dives (Deppe, 1830)	Melodious Blackbird	N1	b–f
Quiscalus mexicanus (Gmelin JF, 1788)	Great-tailed Grackle	N1	b, c, e–h
Parulidae			
Parkesia noveboracensis (Gmelin JF, 1789)	Northern Waterthrush	V1	a
Mniotilta varia (Linnaeus, 1766)	Black-and-white Warbler	V1	d
Setophaga petechia (Linnaeus, 1766)	Mangrove Warbler	N2	b
Setophaga pensylvanica (Linnaeus, 1766)	Chestnut-sided Warbler	N1	d, h, i
Basileuterus rufifrons (Swainson, 1838)	Rufous-capped Warbler	N2	f, i
Cardinalidae			
Piranga rubra (Linnaeus, 1758)	Summer Tanager	N1	g
Piranga leucoptera (Trudeau, 1840)	White-winged Tanager	N1	i
Caryothraustes poliogaster (Du Bus, 1847)	Black-faced Grosbeak	N1	e, f, g, i
Pheucticus ludovicianus (Linnaeus, 1766)	Rose-breasted Grosbeak	V1	f, g, i
Cyanoloxia cyanoides (Lafresnaye, 1847)	Blue-black Grosbeak	N1	b, c, e
Passerina ciris (Linnaeus, 1758)	Painted Bunting	N1	e, g, h
Thraupidae			
Tachyphonus luctuosus (d'Orbigny & Lafresnaye, 1837)	White-shouldered Tanager	*A	d, i
Ramphocelus sanguinolentus (Lesson, 1831)	Crimson-collared Tanager	N1	d
Ramphocelus passerinii (Bonaparte, 1831)	Scarlet-rumped Tanager	N1	g
Tangara episcopus (Linnaeus, 1766)	Blue-gray Tanager	N1	b–i
Tangara abbas (Deppe, 1830)	Yellow-winged Tanager	N2	e, g–i
Stilpnia larvata (Du Bus, 1846)	Golden-hooded Tanager	N1	h, i
Cyanerpes cyaneus (Linnaeus, 1766)	Red-legged Honeycreeper	N1	d–g
Volatinia jacarina (Linnaeus, 1766)	Blue-Black Grasquit	N1	a–g
Sporophila morelleti (Bonaparte, 1850)	White-collared Seedeater	N1	b, c, e, g, h
Tiaris olivaceus (Linnaeus, 1766)	Yellow-faced Grasquit	N1	g, h
Saltator maximus (Statius Muller, 1776)	Buff-throated Saltator	N1	c, g–i

Fourteen migrant species were discovered (V+W in Table 2). In the following section, three single remarkable observations are listed:

Little Blue Heron *Egretta caerulea* (Linnaeus, 1758)

Two juvenile (whitish) and one adult individual were observed at *Pd* on 20 March, which is somehow remarkable as the next known hatcheries are only known from the Cayman Islands and Tonalá (south Mexico), both some 700 km away.

Lesser Yellowlegs *Tringa flavipes* (Gmelin JF, 1789)

This migrating species was not observed as expected at the coast but foraging on a muddy road in the mountains at 270 m a.s.l. at *Pf* on 15 March.

Ferruginous Pygmy-Owl *Glaucidium brasilianum* (Gmelin JF, 1788)

One individual has been discovered in an unusual habitat of the city centre of La Ceiba at the Av. Morazan/ Calle 15, on 20 June at noon.

Fig. 3 shows the NMDS of the nine species lists, illustrating a significant differentiation into four main groups– the city/beach group (*G1*), the river banks (*G2*), the degraded forests (*G3*), and the rainforest group (*G4*; Fig. 3). It also elucidates the isolation of *G1*, which can be explained by the manifold waterfowl and migrating birds such as *H. rustica* and *Pandion haliaetus* (Linnaeus, 1758) which are migrating westwards along the coast, to North America during spring time. These bird species do not enter often into the valley and do not exceed *Pb* (Fig. 3). However, some waders like the two Yellowlegs enter up into the lower Río Cangrejal valley, but *Pa* still remains quite different. The main group formed by the NMDS is *G2*, comprising also *Pd*. The group can be explained by the similar disturbed vegetation types along the river banks. Thus, secondary vegetation, gardens, shrubby pastures, and other open habitats with scattered trees or grassy river banks bring about the typical bird composition of open-habitats. As groves will be closer in the middle of the valley and show rainforest-like vegetation structures, biodiversity enhances, also resembling *Pi*. *Pf* is located 200 m higher than other points of *G2*, as the road is leading over a pass and is therefore providing much more forested habitats. *Pg* and *Ph* are different from *Pa-Pe* as the river gets another character, by carrying much more, and wilder, water (white-water tourism) than above the river confluence near Río Viejo. This might also be the reason that *Phalacrocorax brasilianus* (Gmelin JF, 1789) is no longer found south of the constriction of the valley. For the same reason, *Ph* seems to be most different in *G2*, as the eastern river branch is carrying less water than the main Río Cangrejal. *Pi* assembles the bird observations of the upper valley around El Urraco and the timber huts in El Toncontíns and reflects the higher biodiversity of the more intact and nature-like rainforest habitats, referring to *G3* that is also less disturbed but also incorporated pasturelands and tree islands.

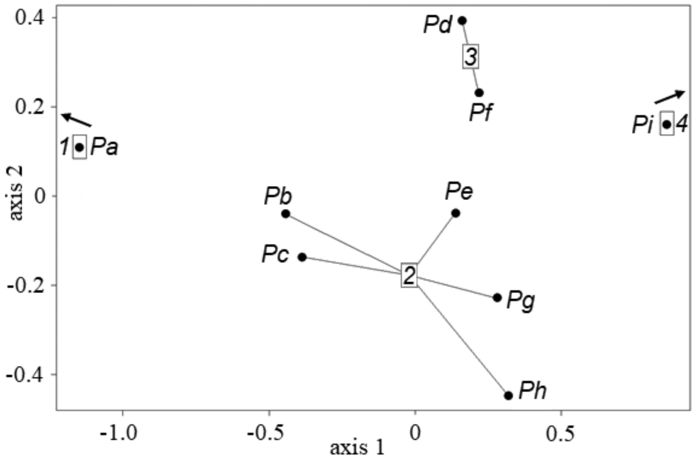

Figure 3. NMDS of the nine study points within the Río Cangrejal river watershed, northern Honduras. The arrows indicate hypothetical development of the species composition, if inventory methods would be intensified.

Discussion

The results reflect the expected impoverished diversity in comparison to intact rainforests (Adams and Ruiz 2017; EBird 2020) and national parks, where up to 435 bird species are found at one location (Lepage and Warnier 2020). They show the uniform composition of open habitats and disturbed forests along river banks and the rather quick shift from the sea to the lower mountain rainforests of a steep Caribbean valley. As the region suffered from a moderate alteration into a tessellated landscape, it also includes the well-known invasion of common neotropical generalists (Hohnwald 2009; Moura et al. 2013). However, some bird species come from natural surrounding forests at the hill sites, particularly *Streptoprocne zonaris* (Shaw, 1796), *Tachyphonus luctuosus* (d'Orbigny & Lafresnaye, 1837), and *Ramphocelus sanguinolentus* (Lesson, 1831). But no indicator species of cloud forests like *Pharomachrus mocinno* (de la Llave, 1832), *Geotrygon albifacies* (Sclater PL, 1858), or *Xiphorhynchus erythropygius* (Sclater PL, 1860), that are supposed to live at the summits of the Pico Bonito mountain ridges (Howell and Webb 2001; Gallardo et al. 2015), were observed.

As the intention of this study was neither to detect new species for the region nor to complete species lists of special or unique habitats but rather to document the scarcely studied species of the remaining degraded landscapes, species numbers must remain low. Therefore, the slightly to heavily disturbed environments, studied rather from a geographical point of view, do not provide any rare species, or further surprises, or extraordinarily high count levels. Thus, the results stand in contrast to intensive birding that often includes mist-netting, microphones and other intensive methods (Blake and Loiselle 2000, 2001; Lepage and Warnier 2020). However, point counts are known to be a valuable complement to mist-net studies, if certain methodological pitfalls are considered (Blake and Loiselle 2000; Robinson et al. 2018). Other reasons for the low species numbers might be the limited time frame with missing night trips or the fact that remaining habitat patches are too small and subdivided to sustain a more diverse avifauna (Young et al. 1998). Another technical reason might be that point-count-methods are less appropriated in the humid tropics in general, and they might need other standards than in Central Europe (Fischer et al. 2005). Bird counts here were recorded between field work of a forest project in the Río Cangrejal watershed (Kukkonen et al. 2008; Kukkonen and Hohnwald 2009) and often there was no time to track down calls or to follow shy bird species (Robinson et al. 2018). Thus, species accumulation curves in Fig. 2 elucidate that especially the bird diversity of older rainforests, for instance *Pi*, *Pf*, and *Pe*, are not yet representatively acquired. However, several curves (e.g., *Pc-Pd*) suggest soon approaching saturation levels. At least, 115 of the 604 detected species in the department Atlántida, and 363 of the National Park Nombre de Dios and 401 of the Pico Bonito national park (AVIBASE 2020) could be reconfirmed for the valley and two of "accidentally" occurring species (status A in Table 2) reaching its northern distribution frontiers. At least five species were registered to a small extent out of their known main distribution range (Howell and Webb 2001; IUCN 2020; Table 2). In all, it is concluded that the presented data are sufficiently reliable to perform a prodromus of the bird diversity and species composition of a rather steep neotropical valley of the Central American Isthmus.

Although the applied methods are surely just about comprehensive enough to detach the commonest bird species at the locations (Gotelli and Colwell 2001; Robinson et al. 2018), the NMDS unambiguously shows the different species compositions within the lower Río Cangrejal valley during spring time (March-June; Fig. 3). Species lists will certainly be easy to be stocked up by intensified methods and extending updates from the valley can be verified at the internet platform eBirds (EBird 2020). There, meanwhile, 15 points along the Río Cangrejal valley with mainly added up species lists are well documented. Points with up to 15 checklists are comparable with the findings of this study. However, there is amazing year-round monitoring of up to 130 observation days, counting 216 bird species in the middle of the valley. High counts are the Río Cangrejal delta with 239 bird species from 485 year-round checklists, 216 species at the Omega jungle lodge (130 expert lists), 151 at the Pico Bonito national park (Visitors Centre, La Roca trail; 32 added up checklists), 138 species at Las Mangas (with just 10 expert lists), 132 species of the Pico Bonito national park (section El Naranjo, 16 expert lists), and 132 species at the CREDIA Botanical Garden in La Ceiba (with year-round 337 checklists; EBird 2020). However, one advantage of this study is the rather systematic approach with a fixed design that can be easily replicated in subsequent years.

However, expanding the lists by experts or spending more time or putting microphones at the respective points will not necessarily decrease similarities between the central valley points (*Pb-Ph*). The contrary is more probable: if more observation time is spent at all points, the number of common species certainly will also increase. Just in the cases of the *Pa* and *Pi*, differences surely will enhance with intensified sampling methods (arrows in Fig. 3). Comparing these lists with the results of this study is problematic, as methods are different and time and knowledge of the observers play an important role (Robinson et al. 2018). But results resemble data from intensive elevational studies in Costa Rica, where habitat disturbance and size are as important as altitude (Young et al. 1998; Blake and Loiselle 2000, 2001). Comparing the study sides (Cangrejal, Tilarán, La Selva, Braulio Carillo) elucidate many common characteristics such as the lower mountainous environments, the Caribbean eastern slopes, and the humid tropical life zones. However, there are also some ecological differences in the settings of the inventories, as they were sustained by intensive mist-netting and were located at slightly higher regions with less anthropogenic disturbances (Tilarán 650–1,700 m a.s.l.; La Selva 50–500 m, and 500–2,000 m Braulio Carillo). Therefore, these studies could be seen as an elevational continuation of this study. However, mountains in Honduras reach much higher maximum altitudes and are located 630–680 km further NNW. Other differences are that the Costa Rican study regions are located far away from the Caribbean coast (77–135 km) and thus completely lack the sea waterfowl diversity.

There are some ecological gradients within the data which might have some effects on bird compositions. For instance, there is a north-south gradient, thus a humidity as well as a slight hypsometric gradient that might explain some minor species shifts. However, passing the Río Cangrejal watershed, semi-arid valleys with a much more xeric vegetation replace the rainforest biome and might be quite different (Holdridge 1962). Thus, patchy land use patterns of old forests, secondary forests, pastures, fields, town areas, and its different grades of habitat naturalness might have much higher impacts on species compositions than any other ecological gradient. There had been some short day-trips into the national park and the mountain rainforests during the forest project but for the lack of time, there was no chance to carry out bird surveys. The same is true for the Cangrejal delta, so that important data for the complete species shift of the lowest and uppermost valley are still missing which would be interesting for future studies. Forest field work with horses did also not allow for the detection, or follow-up, of shy, rare, and nocturnal bird species. Additionally, surveys of the summits would be also of great interest to complete the biodiversity patterns.

Different swallow species seem to avoid using the same habitats, as *H. rustica*, e.g., was just observed at the coast, while *Stelgidopteryx serripennis* (Audubon, 1838) stayed in the upper parts of the valley and *Riparia riparia* (Linnaeus, 1758) just at the lower valley (*Pb*). The four individuals of *Petrochelidon pyrrhonota* (Vieillot, 1817) appeared at El Naranjo (*Pd*). There was an example of reported mass migration of *H. rustica* in northern Honduras (Anderson et al. 2004). However, own observation here showed very even migration of averagely 10 single individuals/minute, along the coast.

Management of FSC-certificated forests, but actually also conventional managed forests, is carried out in extensive and ecologically acceptable ways (Kukkonen et al. 2008; Kukkonen and Hohnwald 2009; Bieri and Nygren 2011), which is also convenient for birds and other local wildlife. Thus, during field work, also *Boa imperator* Daudin, 1803 (Boidae, ca. 1.8 m long) and *Atropoides mexicanus* Duméril, Bibron & Duméril, 1854 (Viperidae, photo available) were observed in these forests (cf. Marineros 2000). For nature conservation, it is important to maintain or install biocorridors within the Cangrejal valley, especially between the two national parks to guarantee gene flows among populations. For most bird species, the extensively used landscapes are no further problem to pass or overfly. Understory birds like, for instance, some forest tinamous (Tinamidae), quails (Phasianidae) and rails (Rallidae) but actually also for ground mammals (e.g., *Panthera onca* and *Leopardus pardalis* both Linnaeus, 1758), forest amphibians and reptiles etc., would profit from several small forest corridors. The lower valley, with its secondary vegetation, is less useful for the species, as the busy city is too close and the road until Las Mangas too continuously settled. Thus, the best option would be a biocorridor south of the Cangrejal bridge, between El Pital and Río Viejo (between 15°40'16"N, 86°42'06"W and 15°39'58"N, 86°41'21"W), as the road leads up into the mountains, getting narrower and apart from the river, so that animals could pass over more easily the two alleged obstacles.

However, outside the managed forests, deforestation activities expanded in slow but continuous rates, in the whole Cangrejal watershed, especially in the south-east of the Cangrejal region (Fig. 1). The figure also elucidates, along with the much higher resolution in 2018, that deforestation has entered both national parks, which seems to be a quietly accepted habit in the valley. For conservation issues this might be the most critical point and governments should clarify and control land titles, and strictly insist on once established national park borders. Further, the higher resolution also elucidates that within the agricultural areas, there are many smaller forest patches that might maintain a considerable part of the biodiversity in the landscape or can deal as stepping stones for animal migration. However, deforestation soars in the region and the future of indigenous forest biodiversity in northern Honduras has to be seen with concern. But as the rich bird diversity might attract more ecotourists and birdwatchers, the unique natural resource "biodiversity" might get more important in future. Local agricultural production hardly produces enough income to make a satisfying living in the region (Nygren and Myatt-Hirvonen 2009), and ecotourism might be one idea to improve the smallholders' situation or, at least, to valorize their agricultural products. However, tourist infrastructure and safety in northern Honduras would then have to be improved. For nature conservation, all the aforementioned issues should be discussed with politicians, NGOs, landowners and smallholders, to create a sustainable joint future for the people and bird life of the beautiful and unique Río Cangrejal valley.

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