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ECOLOGY OF SOME TUMBESIAN TERRESTRIAL BIRDS, WITH NOTES ON BREEDING BIOLOGY

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Abstract · The Tumbesian region of Peru and Ecuador, located within a global biodiversity hotspot, is home to a large number of endemic and little-known species. Endemic terrestrial birds (tinamous, cracids, and doves) are at increased risk of extinction due to restricted distribution and exposure to habitat conversion. In this study, we used 24 camera traps in Cerros de Amotape National Park (northwestern Peru) to record terrestrial birds at three sites, each representing a different forest type: dry, evergreen, and transitional forests. After 4318 camera-days of results, we obtained 334 independent events of 23 species. We describe habitat association and daily and seasonal activity patterns for *Crypturellus transfasciatus, Penelope purpurascens*, and four dove species (*Claravis pretiosa, Leptotila pallida, L. verreauxi,* and *L. ochraceiventris*), with opportunistic anecdotes of breeding biology and behavior. We also provide a bird conservation assessment for the region. Our results are discussed and compared with the current knowledge of Tumbesian birds.

Resumen · Ecología de algunas aves terrestres tumbesinas, con comentarios sobre su biología reproductiva.
La región tumbesina de Perú y Ecuador, ubicada dentro de un *hotspot* de biodiversidad mundial, alberga una gran cantidad de especies endémicas y poco conocidas. Las aves endémicas (tinamúes, crácidos y palomas), tienen un mayor riesgo de extinción debido a la distribución restringida y la exposición a amenazas humanas. En este estudio, utilizamos 24 cámaras trampa en el Parque Nacional Cerros de Amotape (noroeste Peruano) para registrar aves en tres sitios, cada uno representando un tipo de bosque diferente: seco, perennifolio y bosque de transición. Después de 4318 días de cámara, obtuvimos 334 eventos independientes de 23 especies. Describimos las asociaciones de hábitat y patrones de actividad diarios y estacionales de *Crypturellus transfasciatus*, *Penelope purpurascens* y cuatro especies de palomas (*Claravis pretiosa*, *Leptotila pallida, L. verreauxi* y *L. ochraceiventris*), con anécdotas oportunistas de la biología y el comportamiento de la reproducción. También proporcionamos una evaluación de la conservación de aves de la región. Nuestros resultados se discuten y comparan con el conocimiento actual de las aves tumbesinas.

Key words: *Crypturellus transfasciatus* · Daily activity · Doves · Seasonal activity · Tumbesian avifauna

INTRODUCTION

The Tumbesian region of northwestern Peru and southwestern Ecuador exhibits high endemism due to its restricted distribution, harboring poorly known species (Best and Kessler 1995, Olson and Dinerstein 2002, Linares-Palomino et al. 2011). It is also recognized as a globally important ecoregion within the Tumbes-Choco-Magdalena Hotspot (Mittermeier et al. 2004). This region is losing connectivity from Ecuadorian forests due to deforestation for farming and agriculture, causing local species extinctions (Knowlton & Graham 2011, Barrera et al. 2012). In addition, presence of exotic species such as dogs and cattle within and outside protected areas is common in the Tumbesian region (Garcia-Olaechea et al. 2021), which may be endangering native fauna. Therefore, it is important to document biology of poorly known endemic species before they become at risk. Such documentation is imperative to develop management strategies to reverse current trends of these species dwindling in number (Barrera et al. 2012).

Tumbes is ranked fourth globally when considering the number of endemic species harbored within a given Endemic Bird Area (EBA; Stattersfield et al. 1998). Of the 272 total avian species harbored in the Tumbes Center (Sánchez et al. 2012), 21.5% (N = 59) species are endemic to this 130,000 km^2 region (Stattersfield et al. 1998, BirdLife 2019). In some cases, our knowledge of Tumbesian bird conservation is in good standing; for example, BirdLife (2019) provides background of the Tumbesian region's capacity for harboring endemic birds. In other cases, relatively little is known for Tumbesian endemics such as the Near-threatened Pale-browed Tinamou (*Crypturellus transfasciatus*) or the Vulnerable Ochre-bellied Dove (*Leptotila ochraceiventris*) outside various anecdotal observations (e.g., Marchant 1960, Barrio et al. 2015) or an account in a general reference (e.g., Gibbs et al. 2001). Recent work in Tumbes involves exhaustive notes on avian breeding biology (e.g., Greeney et al. 2020), as

Table 1. Annotated list of 23 avian species photo-trapped in Parque Nacional Cerros de Amotape (northwestern Peru), September - December 2012 (dry season) and January - April 2013 (rainy season). Category of threat (BirdLife 2019): [NT] = Near Threatened, [VU] = Vulnerable, [E] = Tumbesian Endemic. Forest types: Dry, Trans = Transitional, Evgr = Evergreen.

Common name	Latin name	# Stations	# Ind. Events	Dry	Trans	Evgr
Pale-browed tinamou[NT, E]	*Crypturellus transfasciatus*	12	159	X	X	
Cocoi heron	*Ardea cocoi*	3	13		X	X
Fasciated tiger-heron	*Tigrisoma fasciatum*	1	1			X
Wood stork	*Mycteria americana*	1	1		X	
Black vulture	*Coragyps atratus*	1	1			X
Turkey vulture	*Cathartes aura*	2	2		X	
King vulture	*Sarcoramphus papa*	1	1			X
Great black hawk	*Buteogallus urubitinga*	5	7	X	X	
Crested guan	*Penelope purpurascens*	2	3			X
Rufous-necked wood rail	*Aramides axillaris*	2	2		X	
Blue Ground-Dove	*Claravis pretiosa*	3	11	X	X	X
Pallid dove	*Leptotila pallida*	4	17			X
White-tipped dove	*Leptotila verreauxi*	9	33	X	X	
Ochre-bellied dove[VU, E]	*Leptotila ochraceiventris*	7	55		X	X
Groove-billed ani	*Crotophaga sulcirostris*	1	1	X		
Whooping motmot	*Momotus subrufescens*	2	2		X	
Greater antshrike	*Taraba major*	1	1	X		
Watkins' antpitta[NT, E]	*Grallaria watkinsi*	1	1	X		
Black-tailed flycatcher	*Myobius atricaudus*	1	1			X
Pale-vented thrush	*Turdus maculirostris*	1	1		X	
Plumbeous-backed thrush[E]	*Turdus reevei*	1	1		X	
White-tailed jay[E]	*Cyanocorax mystcalis*	1	1	X		
Gray-and-gold warbler[E]	*Myiothlypis fraseri*	1	1			X
Overexposed Leptotila	*L. pallida / verreauxi / ochraceiventris*	3	19	X	X	

well as camera trap inventories, which are essential to help sample shy and cryptic species that would otherwise go undetected in this region (e.g., Davila et al. 2019).

Even though birds are usually recorded and studied through different methods (e.g., counts, mist netting), camera trapping has been used effectively to augment inventories of shy terrestrial avifauna that would otherwise go undetected (Brooks et al. 2018), as well as recording rare and threatened avifauna (e.g., Dinata et al. 2008, Srbek-Araujo et al. 2012). Thus, camera-trap studies are vital for studying biology and ecology of lesser-known species by capturing certain aspects of their ecology (e.g., habitat association, breeding biology, daily and seasonal activity patterns), which contributes to our knowledge of avian life histories (O'Brien & Kinnaird 2008, Brooks et al. 2018). In many cases, cameras are placed with a focus on another taxonomic groups (e.g., carnivores), and in such opportunities researchers should not ignore the value of by-catch photos (Brooks et al. 2018).

Tinamous, cracids, and doves, loosely categorized hereafter as 'terrestrial birds', represent 8.5% of endemic species within the Tumbesian region (Stattersfield et al. 1998, BirdLife 2019). Herein we describe habitat association, daily and seasonal activity patterns, and various aspects of breeding biology and behavior of poorly known Tumbesian terrestrial birds, while discussing avian conservation in the region. These observations are bycatch camera-trap photographs from the study of Hurtado & Pacheco (2015).

METHODS

Study sites. The Parque Nacional Cerros de Amotape (PNCA) is located in the Tumbesian region of northwestern Peru (03° 50'S; 80°16'W) and has two distinct ecoregions: Pacific tropical evergreen forest and Equatorial dry forest. Evergreen forest harbors high tropical diversity, similar to Amazonia (Cabrera & Willink 1980, Mittermeier et al. 2004), whereas dry forest has high diversity and endemism from different taxonomic groups (Best & Kessler 1995, Linares-Palomino et al. 2011). Temperature at PNCA averages 25°C throughout the year and the annual mean precipitation is ~611 mm (Hurtado & Pacheco 2015).

Additionally, this protected area is part of the Amotapes-Manglares Biosphere Reserve (AMBR), which together with three other protected areas makes AMBR the largest remnant of protected Tumbesian forest (Stattersfield et al. 1998). Three major forest types can be distinguished in the study area: dry, transitional, and evergreen forest (Ponte 1998, Linares-Palomino et al. 2011); one locality per forest type was selected for sampling (Figure 1).

La Angostura, 100–350 m (03°46'S; 80°21'W): Dry forest, with foliage including *Prosopis pallida* and *Vachellia macracantha* in lower areas, and *Ceiba trichistandra*, *Cordia lutea* and *Loxopterygium huasango* on hillsides.

El Caucho, 350–600 m (03°50'S; 80°16'W): Transitional forest between La Angostura dry forest and Campo Verde evergreen forest, with foliage including *C. trichistandra*, *Cavanillesia platanifolia*, *Ficus jacobii*, *Triplaris cumingiana*, *Bougainvillea peruviana*, *Tessaria integri-folia*, *Inga feuillei*, and *Cecropia peltata*.

Campo Verde, 600–850 m (03°50'S; 80°10'W): Dense evergreen forest with rough topography and high humidity, with foliage including *Centrolobium ochroxylum*, *Cordia eriostigma*, *Tabebuia chrysantha*, *T. cumingiana*, *Gallesia integrifolia*, *F. jacobii* and *Cedrela fissilis*.

Sampling techniques. A set of 24 unbaited camera trap stations (Figure 1) were placed from September - December 2012 (dry season) and January - April 2013 (rainy season). All camera stations ran continuously during the entire survey period. Each station had one camera trap (Bushnell trophy cam-standard edition) set ≥1 km from other stations to increase independence of events, placed at an average height of 30 cm above ground level and set to take three photos at
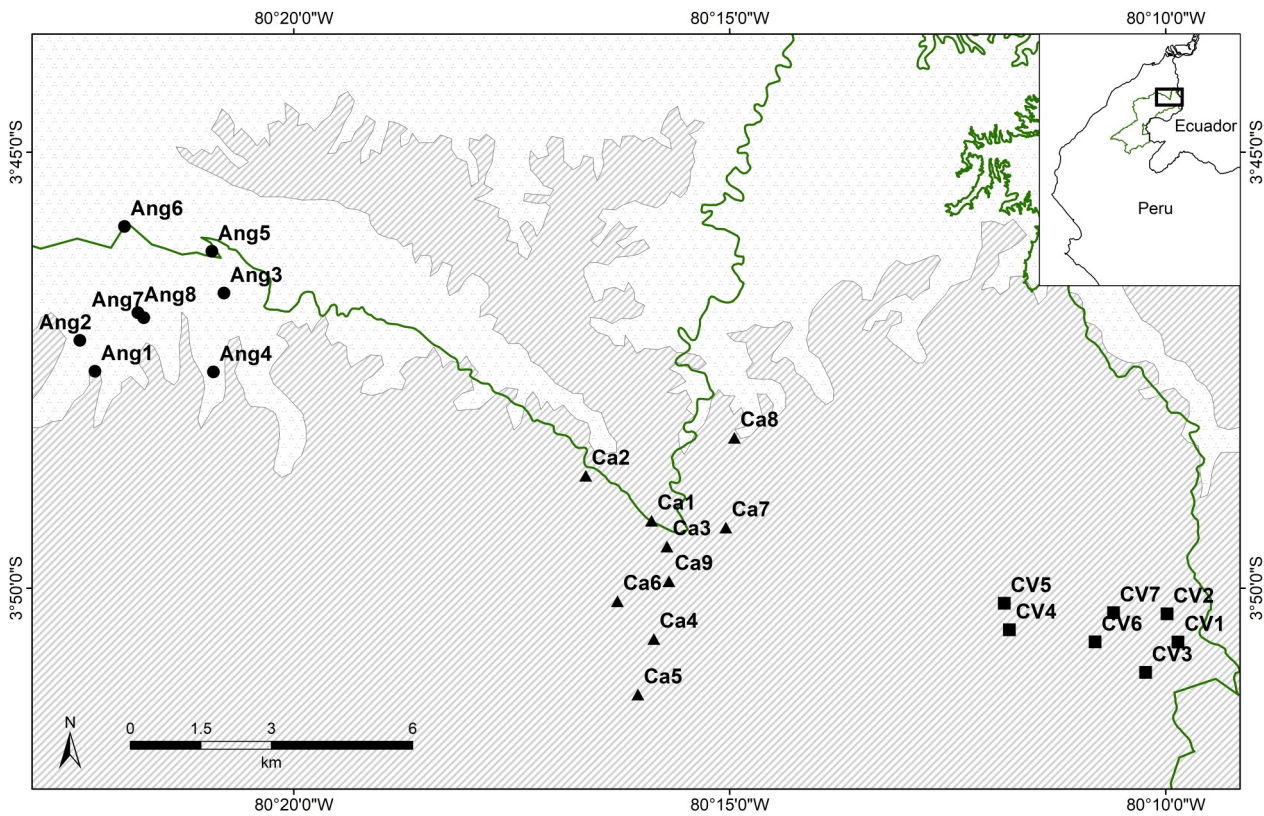
Figure 1. Camera trap locations within the Parque Nacional Cerros de Amotape (northwestern Peru) in the Tumbesian region. Dotted background represents the Tumbes/Piura dry forests and hatch represents the eastern cordillera montane forests. Each sampling locality is shown with a different symbol and letters: Circle, Ang = La Angostura, Triangle, Ca = El Caucho, and square, CV = Campo Verde.

one-second intervals after each detection. Some of the trails were also used by humans and dogs. The total area covered with the camera traps set in the three localities was 16 km².

Analyses. All bird records were extracted from mammal (Hurtado & Pacheco 2015) and lizard records for analyses. The sampling unit for the cameras was one camera-day. Capture success rate was computed as: independent events (photo-captures) / camera-days effort x 100% = success rate. Species identifications, taxonomy, and Tumbesian endemics were identified following primarily Schulenberg et al. (2010), Stattersfield et al. (1998) and BirdLife (2019). Habitat was not detailed qualitatively; brief physiognomic descriptions noting architectural attributes are provided based on photographs with birds. Activity pattern of birds with > 17 independent events were obtained by fitting a Kernel circular distribution to the data (Rowcliffe et al. 2014). These analyses were performed in R (R Core Team 2016) with the package activity (Rowcliffe et al. 2016).

RESULTS

We recorded 23 avian species, representing 15 families, in all three types of forest: 8 species in the dry forest, of which 4 species were exclusive to that forest type; 12 in transitional forest, of which 6 species were exclusive; and 10 species in evergreen forest, of which 7 species were exclusive (Table 1). There were 334 independent events from 4318 camera-days of sampling effort, yielding an overall capture success rate of 7.7%. Capture success rate was much higher in transitional

forest (N = 213, 12.9%) than in dry forest (N = 53, 4.1%) or evergreen forest (N = 70, 5%), which had similar values.

Species accounts:

Pale-browed Tinamou (*Crypturellus transfasciatus*). This Near-threatened Tumbesian endemic was by far the most frequently recorded species in the study, with 159 independent events at 12 different camera stations (Table 1). A total of 23 independent events (e.g., Figure 2a) were recorded at six dry forest camera stations, and 136 events at six transitional forest stations (Table 1). Although represented at nearly all stations for dry and transitional forests, tinamous were absent from the evergreen forest stations. Elevation at the dry forest averaged 201 m (elevation range = 90-375 m) and features were typically comprised of deciduous forest edge, often having a dense understory and occasionally abundant leaf litter. Transitional forest averaged 499 m (elevation range = 371-587m), with well stratified, sloped forest with leaf litter, occasionally with an edge feature (e.g., game trails).

Overall, tinamous were detected more frequently during the wet season (93% of independent events), with most records occurring during the courtship season of February and March (c.f., Brooks 2015; Figure 3a). One observation of courtship took place on 10 February as follows (recorded hrs : min; photographic sequence capturing these events available at: http://www.hmnsmedia.org/tinamoucourtship pix): 17:54 h - individual #1 walking, 18:01 h - individual #1 begins calling, 18:12 h - individual #2 appears, 18:14 h - indi-
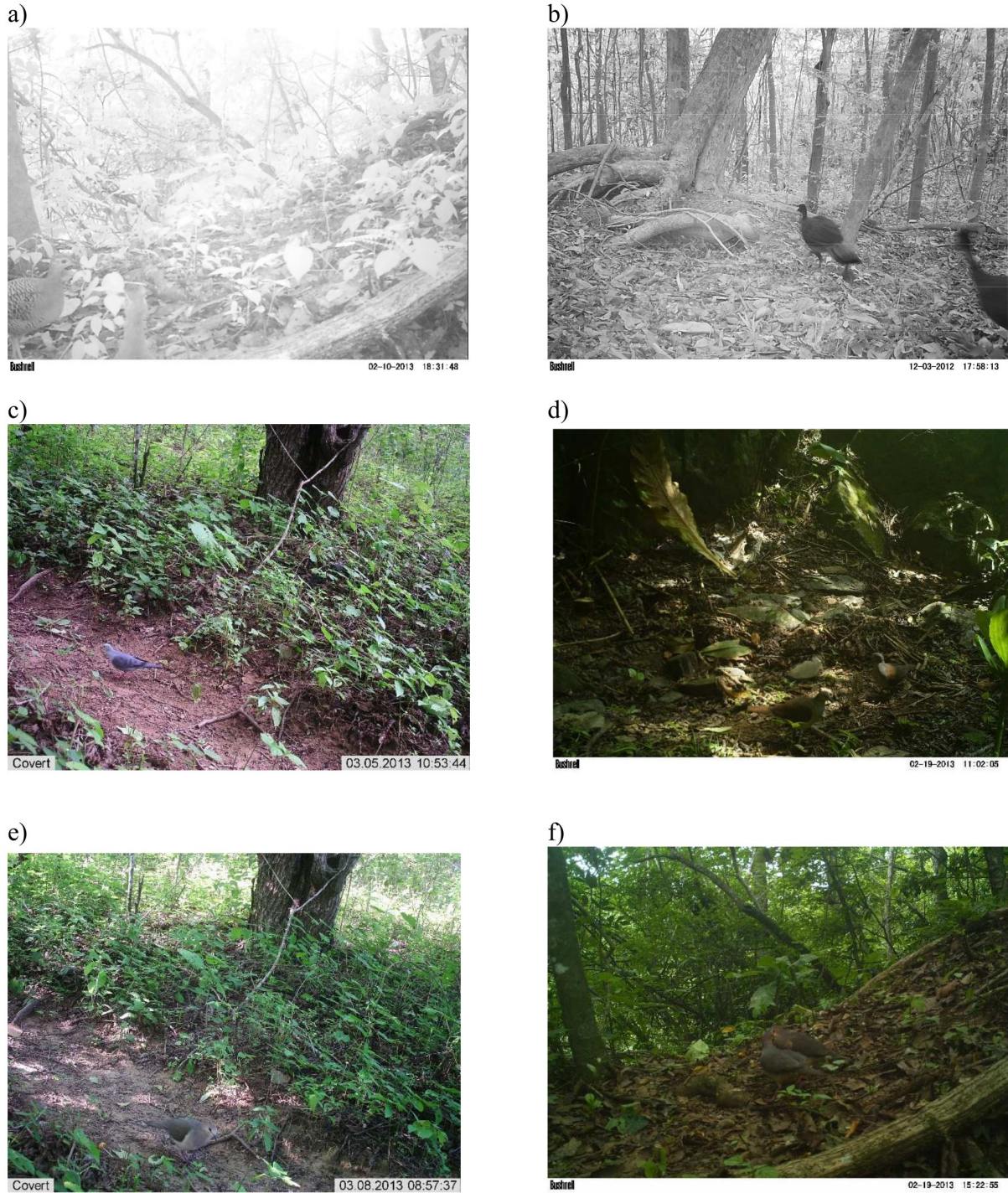
Figure 2. a) Pale-browed Tinamou (*Crypturellus transfasciatus*) pair courtship on 10 February 2013, b) adult pair of Crested Guans (*Penelope purpurascens*) walking with chick behind tail of lead bird on 3 December 2012, c) adult male Blue Ground-Dove (*Claravis pretiosa*), d) two Pallid Doves (*Leptotila pallida*) in the same frame, e) White-tipped Dove (*L. verreauxi*), and f) Ochre-bellied Dove (*L. ochraceiventris*) male feeding female during courtship at Parque Nacional Cerros de Amotape (northwestern Peru).

vidual #2 leaves, 18:31 h - individual #2 returns (Figure 2a), precopulatory behavior commences (e.g., circling; c.f., Brooks 2015), 18:36 h - both leave. On the morning of 12 February (36 hours later), one adult followed another 1.5 m behind, and at mid-day on 23 February one individual walked towards another as it stood still. Tinamous were mostly solitary, except on 9.4% (N = 15) of all occasions, when two adults were within camera frame. These pairs were observed during courtship season from late January – mid March (c.f., Brooks 2015), with the majority (N = 11, 73%) observed during February.

Each of the 159 independent events involved tinamous

walking, often along forest edge; this behavior could be accompanied by foraging (N = 21, 13%), wing-flapping/stretching (N = 4, 3%) or preening/piloerecting feathers (N = 2, 1%). Daily activity patterns were mostly crepuscular, exploding at dawn between 06:00-08:00 h, which accounted for one-third (33%) of the daily diel (24 h) cycle. Activity continued at lower levels throughout the day, until a second, lower activity peak at 17:00-18:00 h, then terminating completely by 19:00 h (Figure 3b).

Crested Guan (*Penelope purpurascens*). This species was recorded at two different camera stations in closed ever-
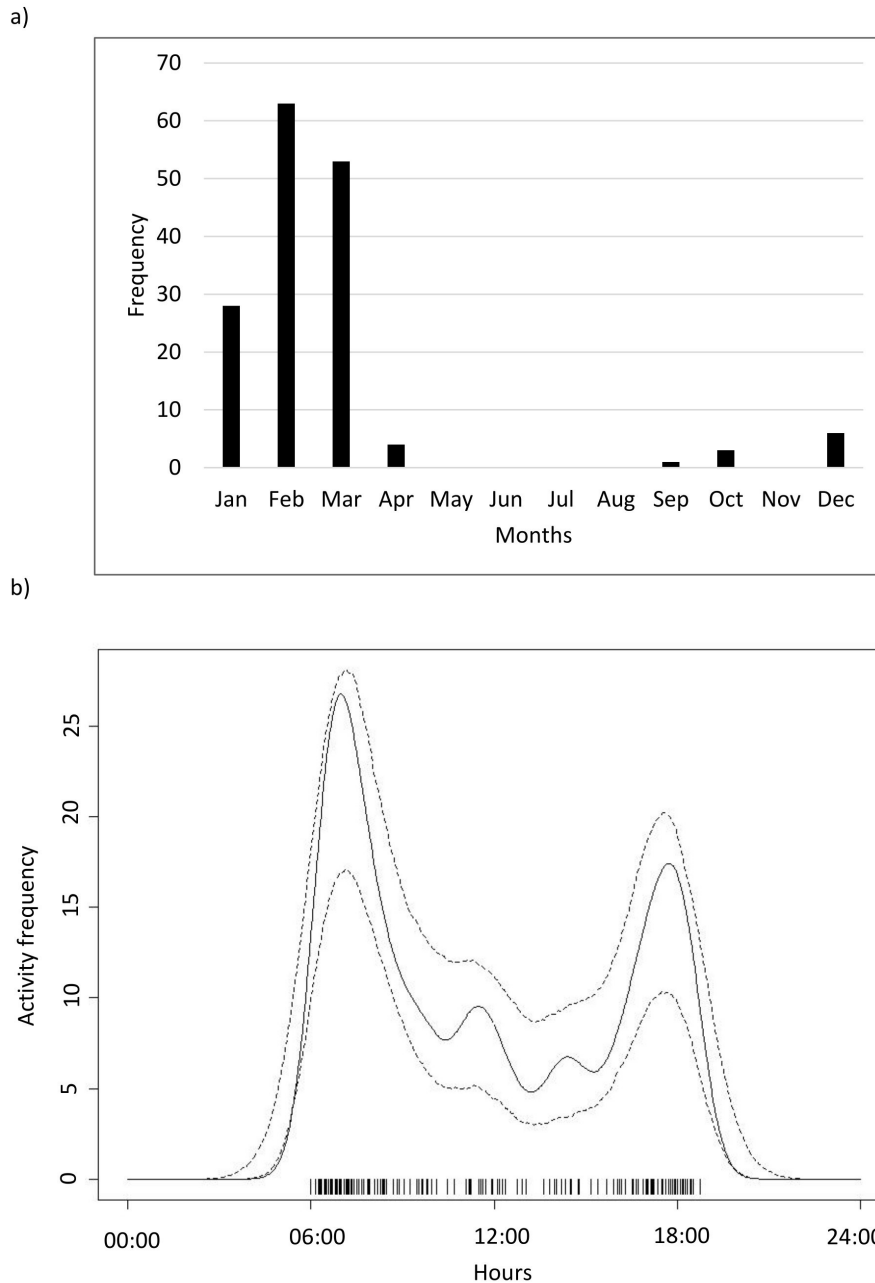
a)

b)

Figure 3. a) Monthly detection measured by frequency (independent events), and b) daily diel cycle (continuous line); 95% confidence intervals (dotted line) measured by activity frequency of Pale-browed Tinamous (*Crypturellus transfasciatus*) at Parque Nacional Cerros de Amotape (northwestern Peru). Each vertical bar in the x-axis represents one independent detection.

green forest (Table 1), with habitat features including large broadleaf trees, extensive leaf litter with little plant understory, ranging 657-722 m with some sloped terrain. Guans were active walking between mid-day and dusk. On 3 December 2012, two adults (presumed male and female parents) walked in front and behind a single chick estimated to be 3-4 weeks old (Figure 2b). On 28 February and 11 March 2013, two and one adults were recorded, respectively.

Blue Ground-Dove (*Claravis pretiosa*). This species was recorded in 11 independent events at three different camera stations (Table 1; Figure 2c), represented by two events each in dry and transitional forests, and seven events in evergreen forest. This was the only species recorded in all three forest types. The dry forest was 162 m and featured a dense green understory and forest edge. The transitional forest was 575 m and featured well-stratified, sloped forest with leaf litter. The evergreen forest was 722 m, with a closed canopy and

extensive leaf litter.

All 11 records were of solitary adults that were recorded during the middle of the rainy season (2 February − 31 March). All events involved a dove walking, with 55% (N = 6) also foraging. Ground doves had an initial burst of activity at dawn (06:14-06:32 h) and were recorded active until as late as 20:38 h.

Pallid Dove (*Leptotila pallida*). There were 17 independent events of this species at four different evergreen forest camera stations (Table 1). Evergreen forest averaged 673 m (elevation range = 649-693 m) and featured primarily closed humid forest with an understory comprised of vegetation and rocks, to lacking an understory with extensive leaf litter, as well as rocky mostly dry creek beds with some vegetation.

Pallid Doves were detected exclusively during the wet season, with most records occurring during February courtship activity (c.f., Gibbs et al. 2001; Figure 4a). They were
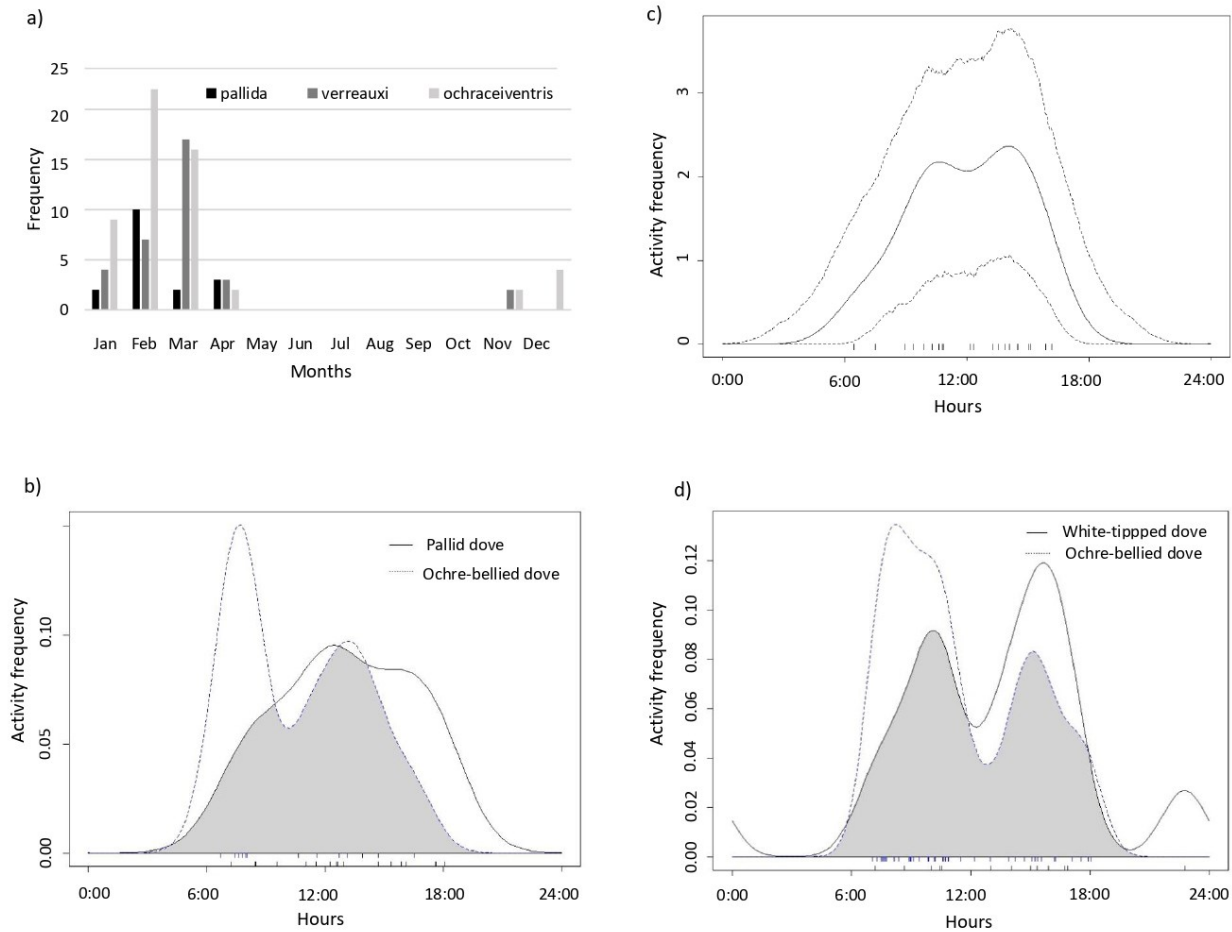
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Figure 4. a) Monthly detection measured by frequency (independent events) of White-tipped (*Leptotila verreauxi*), Ochre-bellied (*L. ochraceiventris*) and Pallid (*L. pallida*) Doves at Parque Nacional Cerros de Amotape, b) daily diel cycles of Pallid (continuous line) and Ochre-bellied (dotted line) Doves in evergreen forest, c) daily diel cycle of White-tipped Dove in dry forest (continuous line); 95% confidence intervals (dotted line), d) daily diel cycles of White-tipped (continuous line) and Ochre-bellied (dotted line) Doves in transitional forest. The gray areas in 4b and 4d represents activity overlap between the two species. Each vertical bar in the x-axis represents one independent detection.

mostly solitary, except for 11% (N = 2) of all records, when two adults (presumably bonded pair) were within camera frame during mid-February (Figure 2d).

Each of the 17 independent events involved an individual walking. Daily activity patterns were mostly during daylight between 06:00-19:00 h, with increased activity around noon (Figure 4b).

White-tipped Dove (*Leptotila verreauxi*). There were 33 independent events of this species at nine different camera stations (Table 1; Fig. 2e). A total of 20 independent events were recorded at four dry forest stations and 13 events at five transitional forest stations (Table 1). The dry forest averaged 166 m (elevation range = 91-260 m) and was comprised of deciduous forest edge featuring a dense understory. The transitional forest averaged 429 m (elevation range = 282-575), with the most frequent feature being well stratified, sloped forest with leaf litter, occasionally with an edge feature.

Similar to the pattern of the Blue Ground-Dove, White-tipped Doves were detected more frequently during the wet season (94% of independent events), with most records occurring during March's courtship season (c.f., Gibbs et al. 2001; Figure 4a). All records were of solitary individuals.

Each of the 33 independent events involved an individual walking, and this behavior was sometimes accompanied by

foraging (N = 12, 36%). Daily activity patterns at the dry forest site were primarily between 09:00-16:00 h, accounting for 80% of the daily diel cycle (Figure 4c). In contrast, daily activity patterns at the transitional forest were bimodal, exploding at 10:00 h before peaking later between 15:00-17:00 h, which cumulatively accounted for 64% of the daily diel cycle (Figure 4d). While the majority of the activity was during daylight, one individual was recorded at night (22:45 h) at the transitional site.

Ochre-bellied Dove (*Leptotila ochraceiventris*). This Vulnerable Tumbesian endemic was recorded in 55 independent events at seven different camera stations (Table 1). A total of 42 events at five transitional forest stations, and 13 events at two evergreen forest stations (Table 1). The transitional forest averaged 519 m (elevation range = 371-587), featuring well stratified, sloped forest with leaf litter; occasionally with an understory harboring plants such as ferns, or bare patches proximal to forest edge with many exposed roots, leaf litter, and rocks. The evergreen forest averaged 663 m (elevation range = 649-676) and was primarily comprised of creek lined with damp rocks and vegetation.

Similar to the pattern with the aforementioned species, Ochre-bellied Doves were detected with greater frequency during the wet season (89% of independent events), with most records occurring during the courtship season of Febru-

ary and March (c.f., Gibbs et al. 2001; Figure 4a). They were invariably solitary, except for a single event when a male fed a female during courtship on 19 February (Figure 2f). The remaining 54 independent events involved an individual walking, and this behavior was occasionally accompanied by foraging (N = 4, 7%).

Daily activity patterns at the transitional forest site were mostly during daylight, between 07:00-18:00 h, exploding at 07:00 h and continuing through 11:00 h, which accounted for 59% of the daily diel cycle (Figure 4d). Activity continued at lower levels throughout the day until a second, lower activity peak during mid-afternoon, terminating completely by dark at 19:00 h (Figure 4d). Activity patterns at the evergreen forest site were similar, with a bimodal pattern more intense during the first peak (07:00-09:00 h) than the second (13:00-15:00 h; Figure 4b).

Conservation assessment. Of the 23 species recorded, 35% were noteworthy in terms of conservation status (Table 1). These include six Tumbesian endemics (Pale-browed Tinamou, Ochre-bellied Dove, Watkins's Antpitta, Plumbeous-backed Thrush, White-tailed Jay, Gray-and-gold Warbler), of which one was Vulnerable (Ochre-bellied Dove) and two were Near-threatened species (Pale-browed Tinamou and Watkins's Antpitta). Additionally, the King Vulture (*Sarcoramphus papa*) and Crested Guan (*Penelope purpurascens*) were recorded, both of which are considered rare in Tumbesian Peru (Schulenberg et al. 2007, Sanchez et al. 2012).

Men carrying guns were recorded at all three study areas, but were not recorded at camera stations with the highest numbers of avian photo-captures (e.g., Ang2, Ang8, Ca4). While these observations would suggest that the sites with highest avian abundance are not associated with areas where men carry guns, the common belief for this region is that the firearms are used for protection and for taking the occasional bird (J. Flanagan pers. comm.). Additionally, although hunters were not recorded at trap station Ang4, cattle were present, which may have attributed to the fewer photo captures experienced at this particular station. We also registered 21 independent events of dogs at all three study areas, including 6 of the 24 (25%) camera stations. In most occasions, dogs were accompanied by people and most records (86%) were close to human settlements.

DISCUSSION

Perhaps the most valuable contribution of this study is providing information to the mostly unknown biology of the Pale-browed Tinamou. Novel information for this species included seasonal activity, courtship and social dynamics, and daily activity patterns. Of particular note, we found the breeding season to initiate with courtship activity (c.f., Brooks 2015) in late January – mid March (majority during February). This is consistent with Barrio et al. (2015), who observed three small chicks in late March at El Angolo Hunting Reserve, and with Greeney et al. (2020), who observed two incubating adults in mid-February and late March, and four clutches of young mid-April - early July in various Tumbesian localities. However, our observations contrast with the findings of Marchant (1960), who indicated breeding initiates as early as November in Guayas Province,

southwestern Ecuador. All of these sites are near our study area. The pre-copulatory behavior (i.e., circling behavior) observed was similar to that of other congeners (e.g., *C. soui*; Brooks 2015), as well as tinamou in other genera (e.g., *T. tao*; Solano-Ugalde 2018).

The record of the Crested Guan family afforded two notable observations: courtship and incubation initiated around the late dry season, and both parents participated in caring for the chick. Multiple authors indicate that the breeding season for this species typically begins during the middle of the wet season, especially in Central America (c.f., Gonzalez-G. et al. 2001). However, Rowley (1966) reports a nest from Oaxaca, Mexico during the early dry season. Moreover, some records from Venezuela and northern Colombia indicate the breeding season begins earlier, with calling (Paul Schwartz pers. comm.; Hilty & Brown 1986) and nesting (Pérez-F. & Pinedo-A. 2002) in the mid and late dry season, respectively, which is more consistent with our record. The observation of dual parental care is concordant with observations in other congeners (e.g., *P. perspicax*; Rios et al. 2006).

The Blue Ground-Dove was the only species in the study recorded in all three forest types (dry, transitional, and evergreen forests). This is not too surprising in light of the broad ecological flexibility pigeons and doves display as a family (Gibbs et al. 2001). In contrast, the three species of *Leptotila* were largely restricted to different forest types. The lowest dwelling White-tipped Dove is found in dry/transitional forest, being ecologically replaced by the highest dwelling Pallid Dove, which is restricted to the evergreen forest. Ochre-bellied is the mid-elevation species and is associated with evergreen and transitional forests, where they were present at the same camera stations within 3-4 h of both Pallid and White-tipped Doves, respectively. Moreover, all *Leptotila* were mostly seasonally present at the same time, especially during the rainy season (January – April; Figure 4a).

Despite the temporal overlap shared between Ochre-bellied and White-tipped Doves, the latter species appears to exhibit a potential niche shift when sympatric with the Ochre-bellied Dove. When White-tipped Doves are the sole congener at a dry forest study site, activity occurs between 09:00-16:00 h (Figure 4c); however, when sympatric with Ochre-bellied Doves, activity becomes strongly bimodal (Figure 4d). Otherwise, all three species of *Leptotila* shared similar behavior of a predominantly solitary lifestyle, primarily walking accompanied by occasional foraging, concordant with Gibbs et al. (2001).

In our study, 26% of the species recorded by photo-trap were Tumbesian endemics. Another Tumbesian photo-trap study recorded 29% endemic species of 35 birds recorded (Davila et al. 2019), and a full avian assessment proximal to our study area found 21% endemic of 196 species recorded (Barrio et al. 2015). The variation in the number of endemic species recorded is likely biased due to methods, specifically photo-trapping (e.g., herein, Davila et al. 2019) versus inventory incorporating mist-netting, point counts and other methods (e.g., Sánchez et al. 2012, Barrio et al. 2015).

We highlight the importance of incorporating camera trapping to avifauna sampling in order to obtain detailed observations of terrestrial and secretive birds. Without detailed studies, such as those utilizing camera trapping, much important life- and natural history information would remain unknown. This includes the most basic ecological information

including activity patterns, reproductive behavior and preferred habitat, information vital for producing sound and relevant management plans.

Cerros de Amotape National Park still harbors endemic and vulnerable species, and hunting is illegal (SERNANP 2012). Unfortunately, constant forest clearing for farming, agriculture, and urban development in the surroundings may endanger the area by isolating it from other forest patches (Knowlton & Graham 2011). It is imperative to monitor avian population trends and continue to protect these forests if these unique endemic species are to persist in the future.

ACKNOWLEDGMENTS

REFERENCES

Barrera, R, M Marigorda, R Linares & I Minaya (2012) Plan Maestro del Parque Nacional Cerros de Amotape. Instituto Nacional de Recursos Naturales (INRENA), Tumbes, Peru.

Barrio, J, D Garcia-Olaechea, & A. More (2015) The Avifauna of El Angolo Hunting Reserve, north-west Peru: natural history notes. *Bulletin of the British Ornithologists' Club* 135: 6-20.

Best, BJ, & M Kessler-M (1995) *Biodiversity and conservation in Tumbesian Ecuador and Peru*. BirdLife International, Cambridge, UK.

BirdLife (2019) *Endemic Bird Areas factsheet: Tumbesian region*. Available at http://www.birdlife.org [Accessed 18 June 2019]

Brooks, DM (2015) Behavior, reproduction, and development in Little Tinamou (*Crypturellus soui*). *The Wilson Journal of Ornithology* 127: 761-765.

Brooks, DM, Adul & SM Cheyne (2018) A camera-trap survey of avifauna in a Bornean peat-swamp forest. *The Wilson Journal of Ornithology* 130: 969-980.

Cabrera, A & A Willink (1980) *Biogeografía de América Latina*. 2nd ed. Biology Series, Secretary General of the Organization of the American States, Washington DC, USA.

Davila, DC, I Sánchez, J Vallejos, RD Appleton & RP Piana (2019) Diversity and seasonality of birds in the Peruvian northwest. *Ornitologia Neotropical* 30: 1-7.

Dinata, Y, A Nugroho, IA Haidir & M Linkie (2008) Camera trapping rare and threatened avifauna in west-central Sumatra. *Bird Conservation International* 18: 30–37.

García-Olaechea, A, Z Vega & CM Hurtado (2021) Noteworthy records and updated richness of medium to large-sized mammals in arid and semi-arid ecosystems of northern Peru and southern Ecuador. *Journal of Arid Environments* 188: 104471.

Gibbs, D, E Barnes & J Cox (2001) *A guide to the pigeons and doves of the world.* Yale Univ. Press, New Haven, Conneticuit, USA.

Gonzalez-G, F, DM Brooks & SD Strahl (2001) Estado de conservación de los Crácidos en México y Centroamérica. Pp. 1-50 *in* Brooks, DM, & F Gonzalez-G (eds). *Biology and conservation of cracids in the new millenium.* Miscellaneous Publications of the Houston Museum of Natural Science, no. 2. Houston Museum of Natural Science, Houston, Texas, USA.

Greeney, HF, F Angulo, RC Dobbs, S Crespo, ET Miller, D Caceres, RA

Gelis, B Angulo & LA Salagaje (2020) Notes on the breeding biology of the Tumbesian avifauna in southwest Ecuador and northwest Peru. *Revista Ecuatoriana de Ornitologia* 6: 1-54.

Hilty, SL & WL Brown (1986) *A guide to the birds of Colombia.* Princeton Univ. Press, Princeton, New Jersey, USA.

Hurtado, CM & V Pacheco (2015) New mammalian records in the Parque Nacional Cerros de Amotape, northwestern Peru. *Revista Peruana Biologia* 22: 77-86.

Knowlton, JL & CH Graham (2011) Species interactions are disrupted by habitat degradation in the highly threatened Tumbesian region of Ecuador. *Ecological Applications* 21.8: 2974-2986.

Linares-Palomino, R, AT Oliveira-Filho & RT Pennington (2011) Neotropical seasonally dry forests: diversity, endemism and biogeography of woody plants. Pp. 3-21 *in* Dirzo, R, H Mooney, G Ceballos & H Young. (eds). *Seasonally dry tropical forests: ecology and conservation.* Island Press, Washing-ton, D.C., USA.

Marchant, S (1960) The breeding of some southwestern Ecuadorian birds. *Ibis* 102: 349-382.

Mittermeier, RA, PG Gil, M Hoffmann, J Pilgrim, TM Brooks, CG Mittermeier, J Lamoreux & GAB Da Fonseca (2004) *Hotspots revisited: earth's biologically richest and most endangered terrestrial ecoregions.* Univ. Chicago Press, Chicago, Illinois, USA.

O'Brien, TG & MF Kinnaird (2008) A picture is worth a thousand words: the application of camera trapping to the study of birds. *Bird Conservation International* 18: 144-162.

Olson, D & E Dinerstein (2002) The global 200: priority eco-regions for global conservation. *Annals of the Missouri Botanical Garden* 89: 125-126.

Pérez-F, MT & IE Pinedo-A (2002) Natural history of the Crested Guan (*Penelope purpurascens*) in Bolivar, Colombia. *Bulletin of the Cracid Specialist Group* 15: 16-19.

Ponte, M (1998) Inventario y análisis florístico de la estructura del bosque. Pp. 43-65 *in* Wust, W (ed.). *La Zona Reservada de Tumbes: biodiversidad y diagnóstico socioeconómico.* Fondo Nacional por Las Áreas Protegidas por el estado (PROFONANPE), Lima, Peru.

R Core Team (2016) *R: a language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria.

Rios, MM, MC Muñoz & GA Londoño (2006) Historia natural de la Pava Caucana (*Penelope perspicax*). *Ornitologia Colombiana* 4: 16-27.

Rowley, JS (1966) Beeeding records of birds of the Sierra Madre del Sur, Oaxaca, Mexico. *Proceedings of the Western Foundation of Vertebrate Zoology* 1: 107-204.

Sánchez, C, JR Saucier, PM Benham, DF Lane, RE Gibbons, T Valqui, SA Figeroa, CJ Schmitt, C Sánchez, BK Schmidt & CM Milenski (2012) New and noteworthy records from northwestern Peru, Department of Tumbes. *Boletín de Unión de Ornitólogos Peruana* 7: 18-36.

Schulenberg, TS, DF Stotz, DF Lane, JP O'Neill & TA Parker III (2010) *Birds of Peru: revised and updated ed.* Princeton Univ. Press, Princeton, New Jersey, USA.

SERNANP. 2012. Plan Maestro del Parque Nacional Cerros de Amotape. Periodo 2012-2017. http://old.sernanp.gob.pe/sernanp/archivosbibliotecapublicacionesPN_CERROS_AMOTAPE/Plan%20Maestro%202012-2017%20PN20Cerros20de20Amotape20ok.pdf [Accessed 6 October 2020].

Solano-Ugalde, A, L Ordóñez-Delgado, C Vits & JF Freile (2018) Breeding biology of Gray Tinamou (*Tinamus tao*) in southeastern Ecuador. *The Wilson Journal of Ornithology* 130: 427-436.

Srbek-Araujo, AC, LF Silveira & AG Chiarello (2012) The Red-billed Curassow (*Crax blumenbachii*): social organization, and daily activity patterns. *The Wilson Journal of Ornithology* 124: 321–327.

Stattersfield, AJ, MJ Crosby, AJ Long & DC Wege (1998) Endemic bird areas of the world: priorities for biodiversity conservation. Birdlife International, Cambridge, UK.