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Defaunation and Diversity of Terrestrial Vertebrates in a Tropical Dry Forest Fragment (Magdalena Valley, Colombia)

Defaunación y diversidad de vertebrados terrestres en un bosque seco tropical (valle del Magdalena, Colombia)

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ABSTRACT

Tropical dry forests are among the most threatened neotropical ecosystems and are critically endangered in Colombia. Land conversion, anthropogenic fires, fragmentation, and climate change pose severe threats to their fauna, further compromising their conservation. Nevertheless, remaining fragments act as crucial reservoirs of terrestrial vertebrates, which in turn play key roles in seed dispersal, predation, and maintaining ecosystem stability. This study aimed to quantify terrestrial vertebrate diversity, estimate defaunation, and explore relationships between faunal assemblages and vegetation structure and diversity in a tropical dry forest (TDF) fragment in the Magdalena inter-Andean valley, Colombia. To address this objective, camera trapping, bird surveys, and vegetation plots were combined. A total of 75 bird species (two of them endemic), eight mammal species, and one reptile species were recorded. Defaunation indices (birds = 0.40; mammals = 0.69) indicated significant biodiversity loss compared to El Quimbo, which represents a reference assemblage due to its relatively complete sampling and ecological comparability. Medium- and large-sized predators were not detected, whereas generalist and disturbance-tolerant species dominated in the study area. Two distinct faunal assemblages were identified, along with one compositionally distinct outlier sampling point associated with a permanent wetland microhabitat; the two assemblages differed in species richness and diversity, and neither showed correlations with vegetation structure or diversity. These findings indicate moderate defaunation in this forest fragment for both birds and mammals, with the mammal defaunation index approaching the threshold for high defaunation. They also highlight the urgency of studying and protecting TDF remnants through targeted conservation strategies aimed at mitigating defaunation and its effects.

Palabras clave:
Aves
Fototrampeo
Ecosistemas en peligro
Mamíferos
Relación vegetación-fauna

RESUMEN

El bosque seco tropical es uno de los ecosistemas neotropicales más amenazados y está en peligro crítico en Colombia. La conversión del hábitat, los incendios antrópicos, la fragmentación y el cambio climático representan grandes riesgos para su fauna y comprometen su conservación. Los fragmentos remanentes actúan como reservorios de vertebrados terrestres, esenciales en la dispersión de semillas, la depredación y la estabilidad del ecosistema. Este estudio cuantificó la diversidad de vertebrados terrestres, estimó la defaunación y exploró su relación con la estructura y diversidad de la vegetación en un fragmento de bosque seco tropical del valle interandino del río Magdalena, Colombia, integrando fototrampeo, censos de aves y parcelas de vegetación. Se registraron 75 especies de aves (dos de ellas endémicas), ocho de mamíferos y una de reptil. Los índices de defaunación (aves = 0,40; mamíferos = 0,69) evidenciaron una pérdida significativa de biodiversidad respecto al bosque del embalse El Quimbo, ensamblaje de referencia seleccionado por su comparabilidad ecológica y completitud de muestreo. No se detectaron depredadores medianos ni grandes, con predominio de especies generalistas tolerantes al disturbio. Se identificaron dos ensamblajes faunísticos distintos y un punto de muestreo atípico, asociado a un humedal; ambos difirieron en riqueza y diversidad, sin mostrar correlación con la estructura o la diversidad vegetal. Los resultados indican defaunación moderada para aves y mamíferos y destacan la urgencia de proteger los remanentes de bosque seco tropical mediante estrategias orientadas a mitigar la defaunación y sus efectos.

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Tropical dry forests (TDF) are among the most threatened ecosystems in the world, considered critically endangered in Colombia (Pizano and Garcia 2014; González-M et al. 2018). The current extent of the TDF in Colombia is barely 3% of its original coverage, showing a drastic reduction (Pizano and Garcia 2014). Remaining areas are concentrated in the Caribbean, Orinoquia, and the inter-Andean valleys of the Cauca and Magdalena rivers (González-M et al. 2018).

In Colombia, TDFs are home to 127-297 bird species (Losada-Prado and Molina-Martínez 2011; Vergara Paternina et al. 2017; Espejo and Morales 2019) and to ~19-39 mammal species (García-Herrera et al. 2015). Although the diversity of these forests is comparatively lower than other tropical forests in the country, they are characterized by high beta diversity, meaning high regional diversity and highly variable faunal assemblages (Pizano and Garcia 2014).

The main threats to TDF and their fauna include forest conversion for productive activities such as agriculture, cattle ranching, or tourism, as well as hunting, wildfires, and especially fragmentation (Pizano and Garcia 2014; González-M et al. 2018). Altogether, these threats can lead to defaunation, a process characterized by the local decline or extinction of vertebrate populations, particularly medium- to large-sized species, primarily as a consequence of anthropogenic pressures (Galetti and Dirzo 2013; Kurten 2013). Defaunation can impact multiple ecological processes, such as seed dispersal, predation, herbivory and plant recruitment, ultimately reshaping community structure, trophic interactions, and ecosystem functioning (Galetti and Dirzo 2013; Kurten 2013; Galetti et al. 2015; Pires and Galetti 2023).

Several studies have demonstrated that animal community composition and diversity are related to forest successional stage and vegetation structure and diversity (Morales-Díaz et al. 2019; Acevedo-Charry and Aide 2019). Variables such as vegetation richness, tree density, basal area, and maximum and average height, as well as structural heterogeneity, have shown to be associated with faunal communities and the abundance of specific animal groups (Morales-Díaz et al. 2019; Acevedo-Charry and Aide 2019). In this study, terrestrial vertebrate communities in a TDF fragment located in the Magdalena inter-Andean valley, in the municipality of Tocaima, Cundinamarca department (Colombia), were characterized. Due to the fragment's relatively small size (~35 ha), the surrounding pasture matrix lacking nearby large forest patches, and the forest's intermediate successional stage (Vásquez Gómez 2022; Marín Zuluaga 2023), the terrestrial vertebrate community was expected to be dominated by generalist and disturbance-tolerant species. Relatively low richness and diversity was also anticipated, as well as moderate levels of defaunation when compared to other TDF in the region. Additionally, the terrestrial vertebrate assemblage was predicted to vary in composition in response to changes in vegetation structure and diversity. Specifically, distinct animal communities with higher fauna diversity were anticipated in sites with greater habitat complexity and more advanced successional stages (Morales-Díaz et al. 2019; Acevedo-Charry and Aide 2019).

MATERIALS AND METHODS

Study area

The study was conducted in a 34.8 ha TDF patch (4°30´10´´ N and 74°38´57´´ W), surrounded by pastures for livestock and crops, and minimal connectivity with other forest fragments. This forest patch is located in the southwest of the Cundinamarca department, in the municipality of Tocaima, on the western slope of the Eastern Cordillera, at an elevation of 420-430 m. The area has an average annual precipitation of 1,051 mm, distributed bimodally, with two marked rainy seasons occurring during April-May and October-November, and an average temperature of 28 °C (Alcaldía de Tocaima 2020). This region is characterized by low slopes and alluvial soils used for productive activities such as agriculture and cattle ranching (Alcaldía de Tocaima 2020).

Sampling design and data collection

Eleven camera traps (Bushnell Trophycam e3 and KJK201; 16 MP resolution, high sensitivity and trigger speed $\leq$0.3 s) were deployed in the study area from April 14 to June 22, 2023 (69 days); however, two cameras recorded no animal detections during the sampling period and were therefore excluded from subsequent analyses resulting in a final dataset of nine camera traps. Cameras operated continuously (24 h), capturing three photographs per detection, with a delay interval of 30 s between consecutive triggers. Cameras were placed on tree trunks approximately

30 cm above the ground, along animal passageways, at average distances of 75.6 m (range: 38-372 m) (Burton et al. 2015). Image-dependent detection events were defined using a temporal threshold approach, whereby consecutive photographs of the same species captured by the same camera were considered independent only if separated by a minimum interval of one hour, following commonly used criteria in camera-trap studies (Burton et al. 2015).

In addition, *Ad libitum* bird sampling was carried out in the mornings (5:45 to 9:45) and afternoons (15:00 to 18:30) from April 14 to 17 (2023), with a sampling effort of 30 hours total. Surveys were performed by two observers while walking freely inside and along the border of the forest patch. Bird detections include both visual and acoustic identifications.

Taxonomic identification and endemism categorization were applied to all vertebrate species registered, including both camera trap detections and bird observations. Species were identified using field guides and validated against regional checklists. Endemism and conservation status were assessed according to the IUCN Red List.

To characterize vegetation structure of the forest fragment, data from five 500 m^2 (20x25 m) vegetation plots from a previous study conducted in February 2022 were used (Vásquez Gómez 2022; Marín Zuluaga 2023).

Statistical analysis

To assess the representativeness of camera trapping, species-sampling site and species-sampling day accumulation curves were constructed. The nonparametric Chao 1 richness index was also calculated to estimate expected richness.

The defaunation index was calculated separately for mammals and birds by comparing the assemblages recorded in the study site (focal assemblage) with those documented in El Quimbo reservoir (reference assemblage), following Giacomini and Galetti (2013). The El Quimbo reservoir forest was selected as the reference assemblage because it belongs to the Magdalena basin, occurs within the same life zone, and represents a comparatively less defaunated and ecologically comparable system. In addition, its fauna was extensively surveyed between 2018 and 2020, yielding 22,146 animal records through direct and indirect sampling methods (Enel Colombia and WSP Colombia 2022). This forest is located approximately 250 km from the study area and lies within the same life zone.

The defaunation index incorporates body mass as an indicator of species importance and can be applied using either abundance data or occurrence data (Giacomini and Galetti 2013). Accordingly, the mammal and bird defaunation indices were calculated independently and are interpreted as separate lines of evidence rather than directly comparable metrics. For mammals, N represents a relative abundance index based on the number of independent camera trap detection events, calculated as each species detection events divided by the total across all species. Bats (order: Chiroptera), and rodents (except those of the family: *Dasyproctidae*) were excluded from the analysis due to identification limitations in the photographs. For birds, occurrence data derived from camera traps and ad libitum records were coded as N = 1 for presence and N = 0 for absence, following the occurrence-based application of the index described by Giacomini and Galetti (2013). Defaunation index values were interpreted using three categories of intensity: low ($DI \leq 0.1$), moderate (DI = 0.1–0.7), and high (DI>0.7), following Benítez-López et al. (2019).

To identify patterns in community composition among camera traps, a non-metric multidimensional scaling (NMDS) analysis based on Bray-Curtis dissimilarity was performed using the number of independent detection events per species at each camera. To define compositional groups, hierarchical clustering using Ward's linkage method was applied to the Bray-Curtis dissimilarity matrix, and the cophenetic correlation coefficient was calculated to assess the goodness-of-fit of the clustering solution. Camera 7 was identified as a compositionally distinct outlier, separated from all remaining cameras in both the dendrogram and the ordination space, and is interpreted in the context of its local microhabitat conditions rather than as a discrete, replicated faunal group. To compare diversity among the identified groups, Shannon, Fisher's alpha, Fisher's species richness for a standardized sample of 100 individuals, and Simpson's inverse indices were calculated for each camera and summarized by groups across the NMDS-defined groups.

Finally, to evaluate the relationship between the composition and diversity of terrestrial vertebrates and vegetation characteristics, a second NMDS with environmental fit analysis (ENVFIT) was adjusted, using five of the 11 cameras initially installed, located near or within the permanent 500 m^2 vegetation plot. This analysis included the following vegetation structure and diversity variables (DBH $\geq$ 10 cm): number of individuals per plot, basal area (m^2), percentage of individuals with DBH greater than or equal to 40 cm, percentage of individuals less than 5 m height, number of species per plot, percentage of individuals with height greater than or equal to 15 m. Highly correlated variables were excluded from this analysis (Pearsons's $|r| \geq 0.8$), e.g., Quadratic Mean Diameter (Dq), Shannon index, or Fisher's Alpha. These variables were selected because they reflect the long-term structural attributes of the forest stand (DBH $\geq$ 10 cm), which remain largely stable across seasons in tropical dry forests. Statistical analyses were performed in *R Studio* (R Core Team 2020).

RESULTS AND DISCUSSION

In this study, the diversity and structure of a terrestrial vertebrate community in a TDF patch in the Magdalena inter-Andean valley using camera traps and ad libitum sampling were characterized. A total of 84 species were registered during the study, including 75 bird species, eight mammal species, and one reptile species, considering both ad libitum observations and camera trap records. Camera traps alone captured 3,114 photographs, corresponding to 591 independent records of 18 species: eight mammals (six natives), nine birds, and one reptile species. Mammals represented most camera trap records (53.7%), followed by birds (44.6%), and reptiles (1.7%) (Table 1 and Figure 1). A total of 95% of the camera trap records were identified to species level, and 85% of all detected individuals corresponded to five species, listed in descending order of detection frequency: Central American Agouti (*Dasyprocta punctata*), White-tipped Dove (*Leptotila verreauxi*), Gray-cowled Wood-Rail (*Aramides cajaneus*), Southern Opossum (*Didelphis marsupialis*), and Crab-eating Fox (*Cerdocyon thous*) (Figure 1). The two most recorded species (Central American Agouti and White-tipped Dove) accounted for almost half of the observed individuals (48%). No species recorded in the study were classified at any threat level higher than Least Concern (LC) (IUCN 2023).

Table 1. Species recorded by camera trapping in a TDF fragment in Tocaima, Cundinamarca (Colombia), between April and June 2023.

Class	Order	Family	Species/Sub-species	Registered individuals
Mammalia	Didelphimorphia	Didelphidae	*Didelphis marsupialis*	80
Mammalia	Pilosa	Myrmecophagidae	*Tamandua mexicana*	1
Mammalia	Rodentia	Dasyproctidae	*Dasyprocta punctata*	152
Mammalia	Rodentia	Cuniculidae	*Cuniculus paca*	13
Mammalia	Carnivora	Felidae	*Felis catus**	1
Mammalia	Carnivora	Canidae	*Canis lupus familiaris**	10
Mammalia	Carnivora	Canidae	*Cerdocyon thous*	39
Mammalia	Artiodactyla	Cervidae	*Mazama americana*	2
Aves	Anseriformes	Anatidae	*Dendrocygna autumnalis*	2
Aves	Columbiformes	Columbidae	*Leptotila verreauxi verreauxi*	132
Aves	Gruiformes	Rallidae	*Aramides cajaneus*	100
Aves	Eurypygiformes	Eurypygidae	*Eurypyga helias major*	1
Aves	Accipitriformes	Accipitridae	*Rupornis magnirotris magnirostris*	1
Aves	Coraciiformes	Momotidae	*Momotus subrufescens subrufescens*	18
Aves	Falconiformes	Falconidae	*Falco sparverius ochraceus*	1
Aves	Passeriformes	Turdidae	*Catharus ustulatus*	3
Aves	Passeriformes	Turdidae	*Turdus leucomelas albiventer*	1
Sauropsida	Squamata	Iguanidae	*Iguana iguana*	6
			Others	28
			Total	591

*Probable feral species.

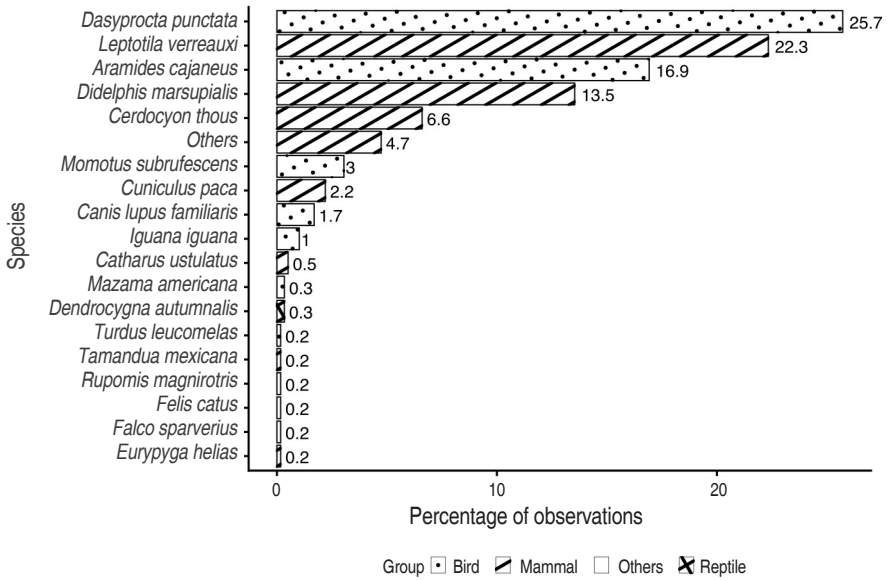


Figure 1. Percentage of individuals observed by species, recorded by camera trapping in a fragment of TDF in Tocaima, Cundinamarca (Colombia), between April and June 2023. Others represent mammal, bird, and reptile records that could not be identified to species level.

According to the Chao 1 *estimator*, cameratrap sampling completeness reached 75%, with 18 recorded species out of the 24 estimated. The *species accumulation* curves (species *per* site, Figure 2A; and species *per* sampling day, Figure 2B) showed a tendency to approach an asymptote, indicating a near stable pattern in observed richness. Together with the Chao 1 estimate, both approaches suggest that sampling was substantial, but an additional sampling effort could still detect some rare, low-density or difficult to detect species.

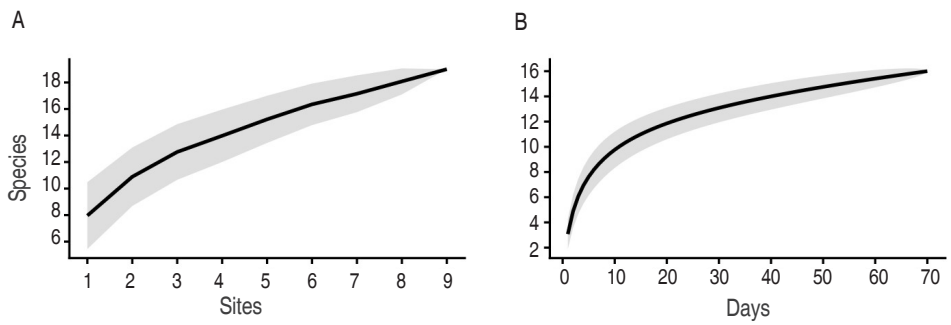


Figure 2. Accumulation curve of species recorded by camera trapping in a TDF fragment in Tocaima, Cundinamarca (Colombia), between April and June 2023. **A.** Species/sites curve, and **B.** Species/days curve.

Mammals

Eight mammal species belonging to five orders and seven families were recorded: *D. punctata, D. marsupialis, C. thous, Cuniculus paca, M. americana, T. mexicana, F. catus and C.l. familiaris.* In contrast, 17 native mammal species were documented in the El Quimbo reference assemblage, encompassing all the species registered in this study, except *C. paca*. Species richness was also lower than that reported on other TDFs in the Magdalena Valley, where between 13 and 21 species of native mammals have been reported (García-Herrera et al. 2015; Garcés et al. 2016). The defaunation index for the mammal

community was 0.69, indicating moderate defaunation and approaching the high defaunation threshold (>0.7) established by commonly used criteria (Benítez-López et al. 2019).

Consistent with this pattern, the moderate-to-high defaunation index, together with the absence of meso- and large carnivores, may reflec defaunation processes characteristic of disturbed tropical forests (Pires and Galetti 2023). The apparent absence of predators such as the Tayra (*Eira barbara*), Neotropical River Otter (*Lontra longicaudis*), Long-tailed Weasel (*Mustela frenata*), Crab-eating Raccoon (*Procyon cancrivorus*), Ocelot (*Leopardus pardalis*), and Jaguarundi (*Herpailurus yagouaroundi*) is particularly relevant given the high abundance of medium-sized prey species such as *D. punctata*, *D. marsupialis,* which are commonly reported in the diet of these carnivores (Dirzo et al. 2007; Pires and Galetti 2023). Mesopredators are generally sensitive to human disturbance and habitat fragmentation, often declining or disappearing as anthropogenic pressures intensify, primarily due to their low population densities, low reproductive rates, high energetic requirements, and extensive territorial range necessary for their survival (Dirzo et al. 2007).

In this context, the high proportion of independent detections of the Crab-eating Fox, as the only detected mesopredator, may further reflect a defaunated mammal assemblage. This opportunistic and disturbance tolerant canid has a generalist diet that includes small vertebrates, arthropods and fruits, and is not typically reported as a predator of mesofauna such as agoutis (Dasyproctidae) or opossums (Didelphidae) (Gómez-Ruiz et al. 2020). Therefore, its relative abundance in the study area may be attributable both to the absence of larger or more specialized carnivores and to its ecological flexibility, which allows it to exploit disturbed and fragmented habitats embedded within an agricultural matrix (Kosydar et al. 2014; Gómez-Ruiz et al. 2020). In parallel, the dominance of species such as the Central American Agouti and Southern Opossum, both considered tolerant of fragmentation and human disturbance, as well as other small-bodied generalist species, is consistent with patterns reported for disturbed and defaunated TDF (Kosydar et al. 2014; Pineda-Cendales et al. 2020).

Finally, the detection of dogs (*C. l. familiaris*) and cats (*F. catus*) within the forest, likely to represent feral or free-ranging individuals given the proximity of the study site to human settlements and agricultural areas, provides evidence of strong anthropogenic influence on the forest fragment, consistent with the observed pattern of mammal defaunation. The presence of these introduced predators can exacerbate defaunation processes through multiple pathways, including direct predation, fear mediated behavioral changes, disease transmission and competition with native predators (Doherty et al. 2017a, b).

Taken together, the moderate to high defaunation index, the dominance of small-bodied and disturbance-tolerant generalist species, and the virtual absence of carnivores suggests a simplified mammal assemblage with potentially reduced functional diversity and the alteration or loss of key ecological functions. This simplification likely reflects both the loss of top-down regulation associated with the absence of apex and strict mesopredator carnivores, and the capacity of opportunistic species to persist in a fragmented landscape dominated by an agricultural matrix.

Birds

A total of 75 bird species were recorded, with nine detected by camera traps and 72 through *ad libitum* sampling. The low camera trap detection of birds reflects the inherent bias of this method toward ground-dwelling species, with limited sensitivity for volant and arboreal taxa (Burton et al. 2015). These species belonged to 36 families and 18 orders, with Passeriformes being the most represented (41 species, 54.7% of the total). At the family level, Tyrannidae was the most represented family with 11 species (14.7%), followed by Thraupidae with nine species (12%). Two species, *Euphonia concinna* and *Ortalis columbiana*, are endemic to Colombia, while four others are near endemic: *Chlorostilbon gibsoni*, *Nystalus radiatus*, *Forpus conspicillatus* and *Cyanocorax affinis*. Additionally, 10 subspecies were classified as near-endemic, and two restricted to the Magdalena Valley dry forests: *Campylorhynchus griseus zimmeri* and *Melanospiza bicolor huilae*.

Compared to the El Quimbo reference assemblage, where 183 species were documented, the defaunation

index calculated for the bird community was 0.4, suggesting a moderately defaunated assemblage; however, this likely overestimates the magnitude of faunal loss, as the detection of 14 species not recorded in the reference assemblage and the ongoing accumulation of species during fieldwork both indicate that actual richness may be higher than documented. Moreover, species richness alone may obscure functionally relevant losses in assemblage composition. Large-bodied frugivores, including large psittacids (e.g., *Amazona ochrocephala*, *Psittacara wagleri* NT) and large-bodied pigeons (*Patagioenas* spp.), all well represented in El Quimbo, were not detected in the study area. As essential dispersers of large-seeded plant species, their reduction can shift plant community composition and alter forest regeneration dynamics (Galetti and Dirzo 2013; Galetti et al. 2015; Kurten 2013). Similarly, despite eight raptor species being recorded, the assemblage was dominated by small-bodied generalists, and large-bodied species were not detected, suggesting potential reductions in top-down trophic regulation. Together, these patterns indicate that functional diversity, particularly for processes dependent on large-bodied species, may be more severely compromised than species richness alone suggests.

Patterns of terrestrial vertebrate community composition and association with vegetation

NMDS ordination and hierarchical cluster analysis (Ward's linkage on Bray-Curtis dissimilarity; cophenetic correlation = 0.81) revealed a compositional gradient among the nine camera traps with animal records, with two compositional groups (Groups 1 and 2) and Camera 7 as an outlier sampling point separated from both groups in the dendrogram and the ordination space (Figure 3). Group 1 comprised six cameras (C2, C3, C4, C5, C9, C11) and recorded the highest mean number of individuals, but the lowest mean species richness per camera and Shannon diversity. Group 2 included two cameras (C1 and C6) and showed the highest total species richness (13 species), low mean individual counts, and intermediate Shannon diversity. Camera 7 recorded the highest absolute number of individuals among all sampling points yet exhibited the lowest diversity values. This pattern was consistent with the strong compositional dominance of only two species, the Gray-cowled Wood-Rail and the Central American Agouti, which together accounted for 91.2% of independent detections, while all remaining species each represented less than 1% of total observations. Diversity indices for both groups and Camera 7 are summarized in Table 2.

Table 2. Diversity indices for two compositional groups of cameras and the outlier sampling point (Camera 7) identified through NMDS ordination and hierarchical cluster analysis in a TDF fragment in Tocaima, Cundinamarca (Colombia), between April and June 2023.

	Group		
	1	2	Camera 7
Species richness	5.83±2.48	9.5±0.71	10.00
Total species	12.00	13.00	10.00
Fisher species (100 individual sample)	11.97±5.16	9.29±0.81	8.46
Shannon index	1.4±0.37	1.38±0.02	1.08
Inverse Simpson index (1/D)	3.44±1.06	2.74±0.31	2.38
Registered individuals	129.5±78.49	21.33±14.01	204

Values represent mean ± standard deviation. Camera 7 constitutes a single sampling unit; therefore, it does not present standard deviation, and its indices are reported descriptively only.

The compositional distinctiveness of camera 7 could be explained by the presence of a permanent headwater wetland and the availability of palm fruit resources recorded at this camera during the sampling period. The wetland likely concentrated the activity of the Gray-cowled Wood-Rail, a species closely associated with riparian and wetland microhabitats (Villegas-Retana and Picado-Masís 2021), while the availability of palm fruits may have attracted the Central American Agouti, a granivorous species known to actively exploit spatially concentrated food resources (Sánchez-Brenes and Monge 2021). Both resources are scarce and unevenly distributed in this landscape during the dry season, which may explain the markedly higher detection rates

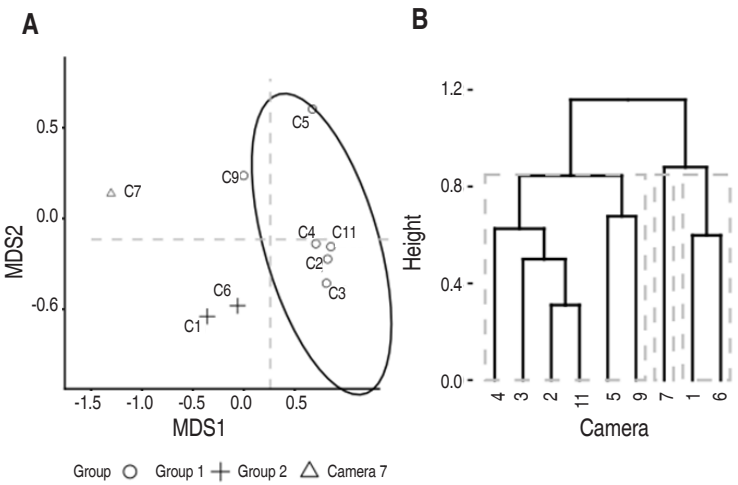


Figure 3. Non-metric multidimensional scaling analysis (NMDS) based onBray-Curtis dissimilarity (**A**) and hierarchical clustering dendrogram using Ward's linkage (**B**) of terrestrial vertebrate communities recorded by camera trapping in a TDF fragment in Tocaima, Cundinamarca (Colombia), between April and June (2023). Letters and numbers represent individual cameras. The ellipse indicates the 95% confidence region for Group 1; cameras C1 and C6 (Group 2) and Camera 7 fall outside this region, consistent with their separation in the dendrogram. "NMDS: stress = 0.053, non-metric R^2 = 0.997; hierarchical clustering: cophenetic correlation = 0.81.

at this station relative to the remaining cameras (Pineda-Cendales et al. 2020). This result underscores the structuring role of microhabitat heterogeneity on local vertebrate distribution TDFs.

No significant relationship was found between the vertebrate community composition and vegetation diversity or structure (*P*>0.2 for all variables; Figure 4). The lack of significant associations between vegetation attributes and vertebrate composition may reflect the predominance of disturbance-tolerant and ecologically flexible species across the study area. Under highly fragmented and degraded conditions, differences in vegetation structure among sampling sites may have limited influence on community composition, leading to relatively similar assemblages dominated by generalist species. Nevertheless, vegetation attributes such as basal area, stem density, and vertical structure remain closely linked to forest successional dynamics and habitat availability, both of which can shape vertebrate diversity and composition in tropical dry forests (Morales-Díaz et al. 2019; Acevedo-Charry and Aide 2019).

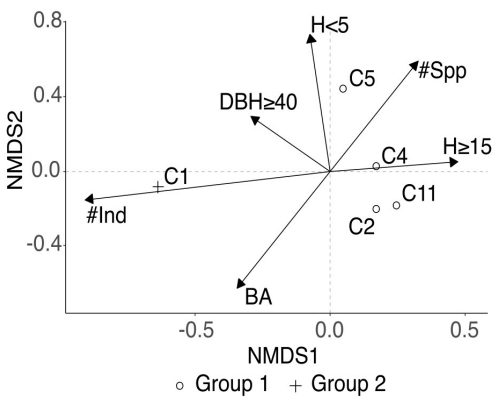


Figure 4. Non-metric multidimensional scaling analysis (NMDS) using Bray-Curtis distance of terrestrial vertebrate communities registered by camera trapping with adjustment for structural and diversity variables of vegetation (ENVFIT) in a TDF fragment in Tocaima, Cundinamarca (Colombia), between April and June (2023). #Ind: number of plant individuals per plot; BA: basal area (m^2); #Spp: number of species per plot; H<5: percentage of trees with height less than 5 m; H ≥ 15: percentage of trees with height greater than or equal to 15 m; DBH ≥ 40: percentage of trees with DBH greater than or equal to 40 cm.

Additionally, other environmental factors, such as water availability, may also play a key role in shaping faunal assemblages in TDF, where resources are often scarce and unevenly distributed (Pineda-Cendales et al. 2020). The less diverse group (Camera 7), represented by a single camera located in a headwater wetland, exhibited distinct environmental and vegetation conditions compared to other sites. These factors likely contributed to the higher number of detections and dominance of *A. cajaneus* and *D. punctata*, species expected due to their feeding habits and water availability (Sánchez-Brenes and Monge 2021; Villegas-Retana and Picado-Masís 2021). However, the inability to calculate a standard deviation for the second group limits the strength of this conclusion.

Several limitations should be considered when interpreting the species richness patterns and defaunation indices reported here. Regarding birds, ad libitum surveys were conducted over a considerably shorter period than the multi-year inventory available for the El Quimbo reference assemblage, and records were based on presence–absence data rather than abundance estimates, preventing direct comparisons of sampling completeness. For mammals, although the species accumulation curve approached an asymptote, the Chao1 estimator indicated only 75% sampling completeness, suggesting that additional effort could still yield undetected species. As a result, differences in richness and defaunation values may partially reflect unequal sampling effort, methodological inconsistencies, and imperfect detection, particularly for cryptic, arboreal, wide-ranging, or low-density species such as felids. Complementary methods, including standardized transects, point counts, or bioacoustic surveys, could further improve inventory completeness. In this regard, the absence of certain species should not be interpreted as definitive evidence of local extinction, especially given the small size of the forest fragment, which may represent only a portion of their home range. Therefore, the defaunation patterns reported here should be understood as a conservative approximation of faunal change within the studied fragment, rather than as an exhaustive estimate of vertebrate loss. Despite these limitations, this study provides relevant information on vertebrate assemblages and defaunation patterns in tropical dry forest fragments, an ecosystem that remains highly threatened and comparatively understudied in Colombia and the Neotropics.

CONCLUSION

This study found a moderately to highly depauperated bird and mammal community in a TDF patch in the Magdalena river valley. Despite the sampling limitations noted above, the observed patterns consistently indicate a defaunated assemblage dominated by disturbance-tolerant species, posing a significant threat to ecosystem stability and long-term conservation. The lack of key species compromises essential ecosystem functions such as seed dispersal, predation, and prey population control. Although no relationship was found between the fauna groups and vegetation diversity and structure, the observed pattern suggests a potential ecological link that warrants further investigation in the TDF of the Magdalena Valley. This study underscores the importance of investigating tropical dry forest fragments, particularly to support the development of strategies aimed at preventing and mitigating defaunation and its associated consequences, including the enhancement of landscape connectivity. Furthermore, a deeper understanding of the mechanisms underlying faunal loss in these endangered ecosystems is essential for guiding effective conservation and management actions.

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CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

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